FINAL Technical Appendices

Exeter River Great Dam Removal Feasibility and Impact Study

Exeter, New Hampshire

Prepared for **Town of Exeter, NH**

Prepared by ***VHB*/Vanasse Hangen Brustlin, Inc.**
Bedford, New Hampshire

In association with Weston & Sampson Engineers, Inc.
Kleinschmidt Associates
Field Geology Services
Tom Ballestero, PhD

FINAL - October 2013

Funding for this project was provided in part by a grant from the NH Department of Environmental Services with funding from the US Environmental Protection Agency under Section 319 of the Clean Water Act, by the National Oceanic and Atmospheric Administration, National Marine Fisheries Service, The Gulf of Maine Council and the Town of Exeter.

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Appendix A

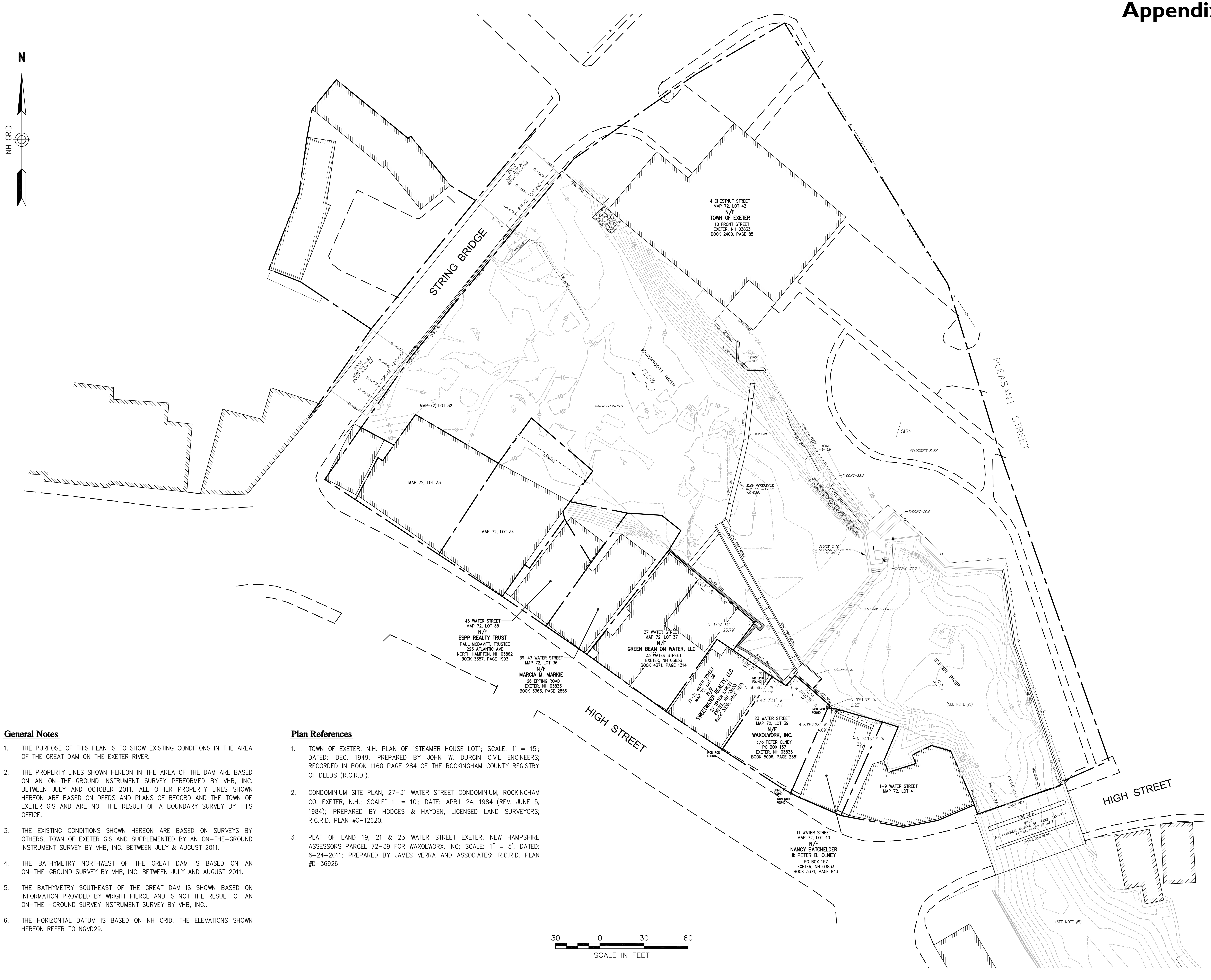
Existing Conditions Survey

Appendix A

VHB
Vanasse Hangen Brustlin, Inc.

Transportation
Land Development
Environmental Services

Six Bedford Farms, Suite 607
Bedford, New Hampshire 03110
603-644-0888 • 603-644-2385



Legend

- DRAIN MANHOLE
- CATCH BASIN
- SEWER MANHOLE
- ELECTRIC MANHOLE
- TELEPHONE MANHOLE
- MANHOLE
- HH – HANDHOLE
- BOLLARD
- WATER GATE
- FIRE HYDRANT
- GAS GATE
- STREET SIGN
- LIGHT POLE
- UTILITY POLE
- GUY POLE
- GUY WIRE
- MONITORING WELL
- EDGE OF PAVEMENT
- CC — CONCRETE CURB
- VGC — VERTICAL GRANITE CURB
- SGE — SLOPED GRANITE EDGE
- BB — BITUMINOUS BERM
- GUARD RAIL
- DRAINAGE LINE
- SEWER LINE
- OHW — OVERHEAD WIRE
- E — UNDERGROUND ELECTRIC
- T — TELEPHONE LINE
- G — GAS LINE
- W — WATER LINE
- STONE WALL
- TREE LINE
- 100'BZ — 100–FT BUFFER ZONE
- 100'RA — 100–FT RIVERFRONT AREA
- 200'RA — 200–FT RIVERFRONT AREA
- AF1–100 — LIMIT MEAN ANNUAL HIGH WATER
- BF1–100 — LIMIT OF BANK
- WF1–100 — VEGETATED WETLAND BOUNDARY

General Notes

1. THE PURPOSE OF THIS PLAN IS TO SHOW EXISTING CONDITIONS IN THE AREA OF THE GREAT DAM ON THE EXETER RIVER.
2. THE PROPERTY LINES SHOWN HEREON IN THE AREA OF THE DAM ARE BASED ON AN ON–THE–GROUND INSTRUMENT SURVEY PERFORMED BY VHB, INC. BETWEEN JULY AND OCTOBER 2011. ALL OTHER PROPERTY LINES SHOWN HEREON ARE BASED ON DEEDS AND PLANS OF RECORD AND THE TOWN OF EXETER GIS AND ARE NOT THE RESULT OF A BOUNDARY SURVEY BY THIS OFFICE.
3. THE EXISTING CONDITIONS SHOWN HEREON ARE BASED ON SURVEYS BY OTHERS, TOWN OF EXETER GIS AND SUPPLEMENTED BY AN ON–THE–GROUND INSTRUMENT SURVEY BY VHB, INC. BETWEEN JULY & AUGUST 2011.
4. THE BATHYMETRY NORTHWEST OF THE GREAT DAM IS BASED ON AN ON–THE–GROUND SURVEY BY VHB, INC. BETWEEN JULY AND AUGUST 2011.
5. THE BATHYMETRY SOUTHEAST OF THE GREAT DAM IS SHOWN BASED ON INFORMATION PROVIDED BY WRIGHT PIERCE AND IS NOT THE RESULT OF AN ON–THE –GROUND SURVEY INSTRUMENT SURVEY BY VHB, INC..
6. THE HORIZONTAL DATUM IS BASED ON NH GRID. THE ELEVATIONS SHOWN HEREON REFER TO NGVD29.

Plan References

1. TOWN OF EXETER, N.H. PLAN OF "STEAMER HOUSE LOT"; SCALE: 1' = 15'; DATED: DEC. 1949; PREPARED BY JOHN W. DURGIN CIVIL ENGINEERS; RECORDED IN BOOK 1160 PAGE 284 OF THE ROCKINGHAM COUNTY REGISTRY OF DEEDS (R.C.R.D.).
2. CONDOMINIUM SITE PLAN, 27–31 WATER STREET CONDOMINIUM, ROCKINGHAM CO. EXETER, N.H.; SCALE" 1" = 10'; DATE: APRIL 24, 1984 (REV. JUNE 5, 1984); PREPARED BY HODGES & HAYDEN, LICENSED LAND SURVEYORS; R.C.R.D. PLAN #C–12620.
3. PLAT OF LAND 19, 21 & 23 WATER STREET EXETER, NEW HAMPSHIRE ASSESSORS PARCEL 72–39 FOR WAXOLWORX, INC; SCALE: 1" = 5'; DATED: 6–24–2011; PREPARED BY JAMES VERRA AND ASSOCIATES; R.C.R.D. PLAN #D–36926

No.	Revision	Date	Appvd.
1	REMOVE SPOT ELEVATIONS	10/09/2012	JAC

Designed by | Drawn by | Checked by

CAD checked by | Approved by

Scale 1" = 30' | Date JANUARY 26, 2012

Project Title

Exeter River
Great Dam Romoval

Exeter, New Hampshire

Issued for

Drawing Title

Existing Conditions
Plan of Land

Drawing Number

Sheet 1 of 1

Project Number
52151.00

52151.00–EXIST.DWG

Appendix B

Great Dam O&M Plan

Town of Exeter
Operation & Maintenance Plan
Great Dam - Exeter, NH
Dam #082.01

Seasonal Operation:

Period	Operational Goals & Considerations
April 1 through June 30	The water level will be maintained at approximately 6 inches above the concrete spillway crest, insofar as reasonable and diligent monitoring, gate operations and gate capacity will allow. This period is the primary upstream migration period for anadromous fish. NH Fish & Game recommends that the water level be maintained approximately 6 inches above the elevation of the concrete spillway for efficient migration. May is also typically the month when the river becomes the primary source for drinking water supply. The heavy spring rains associated with snowmelt generally provide the greatest susceptibility to upstream flooding, so diligent monitoring and timely operations are crucial.
July 1 through October 30	The water level will be maintained at approximately 2 inches above the concrete spillway crest, insofar as reasonable and diligent monitoring, gate operations and gate capacity will allow. Try to maintain an adequate pool level for drinking water supply, recreation and downstream fish passage. Generally, two inches of flow over the spillway will provide the necessary flow for downstream passage. Heavy rains associated with hurricanes or severe thunderstorms can cause flooding; however, extensive periods without rainfall can cause drought.
November 1 through March 31	The water level will be maintained at approximately the level of the concrete spillway crest, insofar as reasonable and diligent monitoring, gate operations and gate capacity allow. Drinking water, recreation and fish passage considerations are less important during this period. Operations should be geared toward keeping the water level at or near the elevation of the spillway crest, although ice formation on the gate outlet or stem may prevent gate operations.

Contact information related to the operation of the dam:

Dam Owner: Town of Exeter

Dam Owner Designates	Contact	Office Phone	Cell (*Dispatch)
Lead Operator	Jay Perkins, Highway Supt	(603) 773-6157	(603) 512-1974
Alternate Operator	Scott Lebeau, General Fore	(603) 773-6157	(603) 944-3238
Emergency Operator	Brian Comeau, Fire Chief	(603) 773-6131	(603) 772-1212*

Contact information for other interested parties:

Organization	Contact	Office Phone	Cell
Exeter Elms Campground	Dana Anderson	(603) 778-7631	(603) 828-4390
Exeter Mills	John O'Connor	(781) 404-4240	(617) 571-2679
Town of Exeter	Russ Dean, Town Manager	(603) 778-0591	(603) 498-6989
Town of Exeter	Jennifer Perry, Director DPW	(603) 773-6157	(603) 770-6322
Exeter Water/Sewer Dept	Michael Jeffers, Managing Engr	(603) 773-6157	(603) 327-7903
Exeter Water Plant	Paul Roy, Operations Supervisor	(603) 773-6169	(603) 501-8220
NHDES Dam Bureau	Steve Doyon	(603) 271-3406	(603) 731-0146
NH Fish & Game	Cheri Patterson	(603) 868-1095	
Phillips-Exeter Academy	Roger Wakeman	(603) 777-3292	(603) 502-9631

Operational Protocols:

A representative of the dam owner will visit the dam as often as necessary to ensure that the appropriate operational goals contained in the Seasonal Operation section are being met. When the low level gate is open visits will be made on a daily basis. At each visit the date, time, water level and gate opening shall be recorded in an observation logbook. In addition, any deficiencies noted or maintenance completed should be recorded in the logbook. Operations made that cause the water level to vary significantly from the goals established in the Seasonal Operation section may need to be coordinated with other water users.

To meet the seasonal goals defined above the Town of Exeter will operate the gated low level outlet at the dam, to the extent possible, to reduce both high and low water situations. It should be noted that the maximum capacity of the low level gate is approximately 310 cubic feet per second with the water level 2" to 8" above the spillway crest (the highest desirable operating range). Therefore, at river flows larger than this value the water elevation upstream of the dam must necessarily rise to keep pace. Attached to this document are rating curves for both the overflow spillway and the single low level gated outlet. These tools, along with the observation log, should be used to help determine when and to what degree the gate should be operated.

In addition to the operational resources noted above, the operator may gain insight into potential conditions at the Exeter River dam by tracking flows at the Exeter River stream gage near Haigh Road in Brentwood, NH and by monitoring developing weather conditions and forecasts issued by the National Weather Service and/or local media. NHDES Dam Bureau staff can provide additional insight into dam operations when needed.

The low level gate operating wheel is chained and locked while not in operation. Exeter DPW EN6 key is needed to open the lock.

When conditions require operation of the low level gate at Great Dam, consideration will also be given to the operation of gates at the Exeter Reservoir Dam and Colcords Pond Dam. Refer to the Operation and Maintenance Plans for those facilities for detailed information.

Operation and maintenance of the fish ladder and lower dam (weir) is the responsibility of NH Fish & Game Department. No modifications shall be made to the fish ladder and/or lower dam (weir) by Town personnel.

General Procedures:

High water: When the water level exceeds or is expected to exceed the target elevation as indicated in the Seasonal Operation section, the operator will manipulate the gate to keep the level at or near the (approximate target range) specified target elevation. If anticipated meteorological conditions warrant, the water level may be drawn down 1” to 2” range (above dam crest) below the seasonal target elevation in advance of additional inflow during fish migration periods (April 1 through October 30). Since the maximum capacity of the low level gate is approximately 350 cfs, inflows above this value will cause water levels to rise.

Low water: As the water level drops, either due to an open gate or low inflow conditions, the gate will be closed as necessary to achieve the approximate target elevation as indicated in the Seasonal Operation section. In addition, the operator will work with NHF&G and other water users, to prevent waste through the fish passage system or for other reasons.

Potential damage due to cresting of water over abutments:

Cresting of water over the abutments could lead to scouring of embankments adjacent to the abutments. In this emergency situation, effective water barriers (sandbags, etc.) shall be used to confine flow and protect embankments.

Maintenance Program:

At each visit:

- Record the information noted in the Operational Protocols section (date, time, water level, gate opening, and gate operations) into the logbook.
- Note any maintenance deficiencies in the logbook and address as necessary. Example deficiencies may include, but are not limited to, the presence of floating debris that restricts flow over the spillway or through the low level gate, leakage/seepage through concrete sections or abutments, undesirable vegetative growth on the abutments, damaged gate mechanisms and erosion of earthen abutment areas.

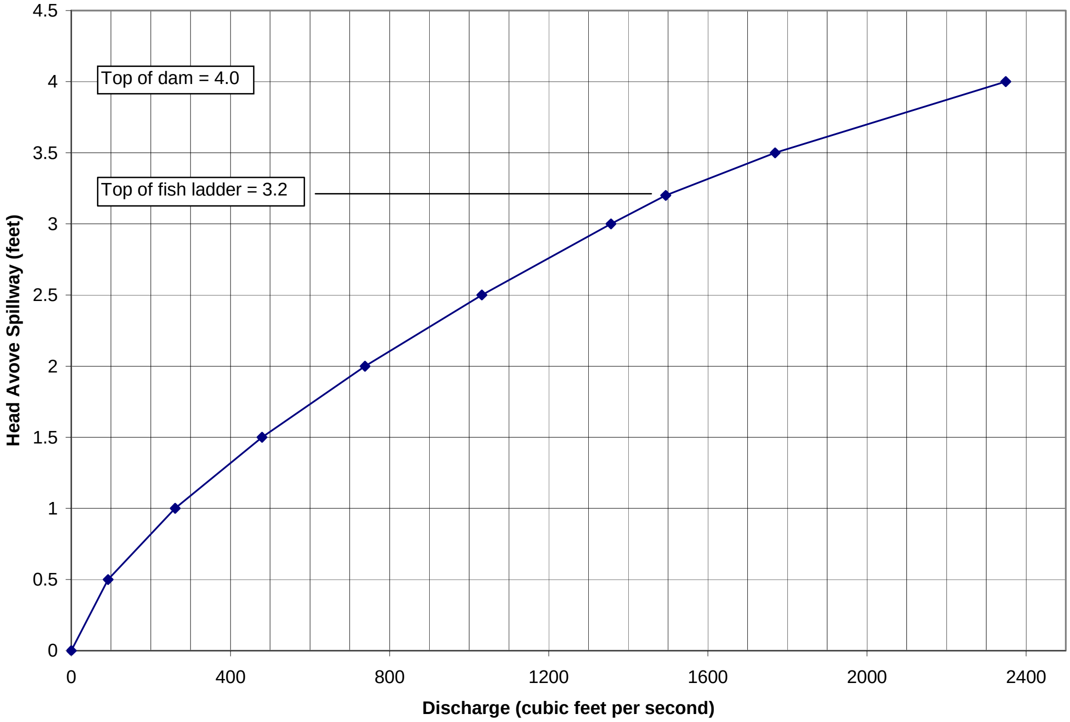
Semi-annually:

- Remove any undesirable vegetation growing on abutment areas.
- Check for and repair any erosion to earthen sections of both abutments.
- Inspect the gate operating mechanism and any visible portions of the gate panel and repair as necessary.
- Inspect previously identified seepage areas and compare findings with past inspections. Estimate leakage/seepage amount and note in logbook.
- Inspect all safety equipment, rails, stays and harnesses and repair or replace as necessary.

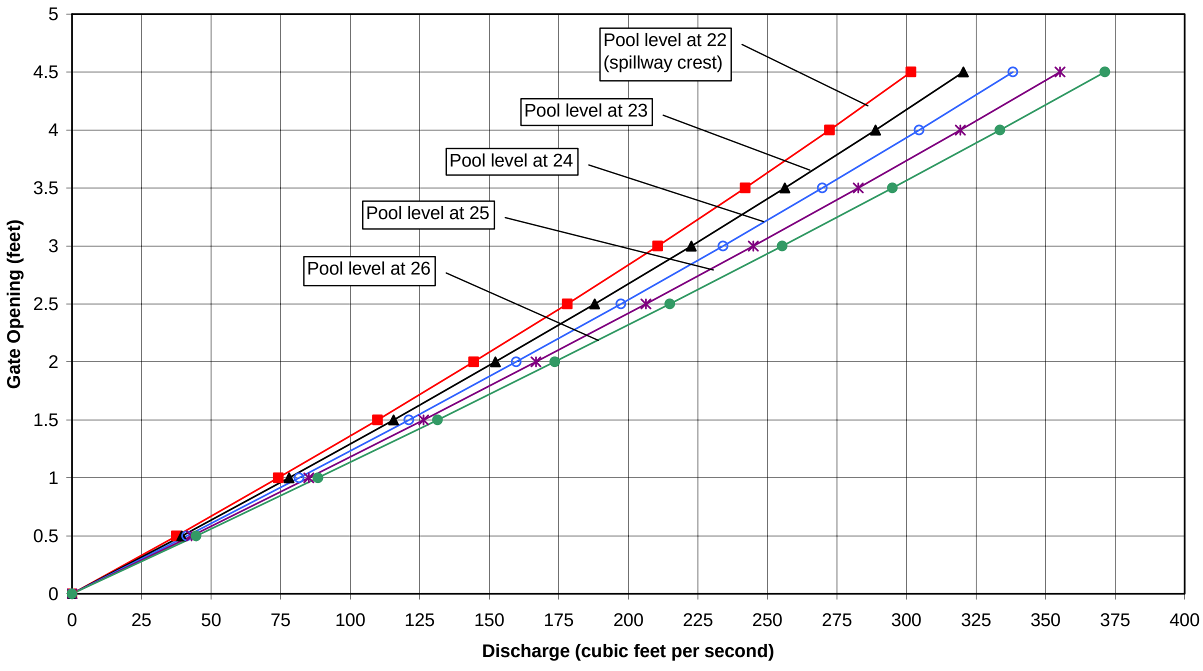
Annually:

- Perform a detailed visual inspection of the entire dam and schedule such maintenance or repairs as may be required.
- Adjust and lubricate the gate operating mechanism.
- Consult with NH Fish & Game on the operation and condition of the fish ladder.
- Consult with NH Fish & Game and NHDES if water levels need to be lowered below the crest of the dam.

Exeter River Dam - Spillway Rating Curve



Exeter River Dam - Gate Rating Curves



FLOOD RESPONSE PLAN
Exeter River Dam (Great Dam)
Exeter, NH

It is the intent of this flood response plan to supplement the existing Operation & Maintenance Plan for Great Dam in the event of major flooding.

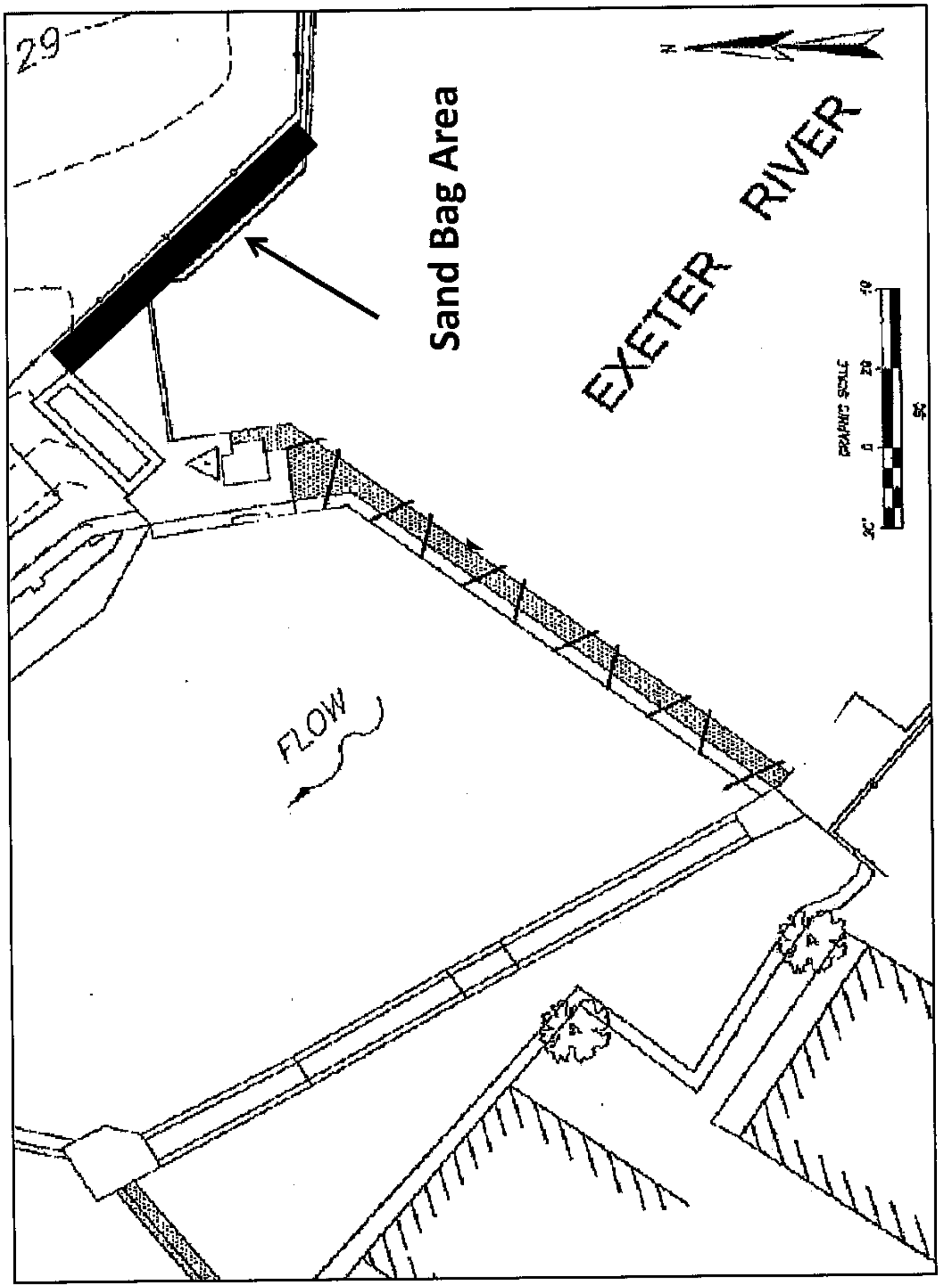
When this response plan is required, the Town's Emergency Operations Center (EOC) will be in operation. As such, the response will be managed through the EOC. Responsibilities are as assigned in the existing Operations & Management Plan.

The EOC will continually monitor river elevations through reports from the field. The EOC will utilize weather forecasts along with supplemental information from the Haigh Road gage in determining the appropriate response.

Sand bagging operations will start if the river heights are expected to over-top the northeast abutment.

Sand bagging operations are as follows:

- Approximately 10,000 nylon sand bags are stored in the emergency response container at the Department of Public Works (DPW).
- DPW will supply the sand.
- A garage bay at the DPW will be utilized for filling sand bags.
- If additional help is required for the bagging operations, then the EOC will call in necessary personnel or request volunteer help through various media communications as necessary.
- DPW will transport the sand bags to the required area.
- Sand bagging operations will be initially concentrated in the area as shown on the accompanying sketch.
- Sand bags will be stacked to the height of the existing penstock.
- Barricades and tape will be used to keep the general public away from hazardous areas.


29
Sand Bag Area
EXETER RIVER
FLOW

NHDAMS DATA SHEET

Dam#:	082.23	Name:	EXETER RIVER FISH LADDER		
Haz Cl:	AA	Town:	EXETER		
Status:	ACTIVE	River:	EXETER RIVER		
Status date:	1999	NATDAM #	NH01828	FERC #:	FERC HAZC

Dam Owner:	NH FISH & GAME DEPARTMENT	Class Own:	S
Represent:	MR MARK KIROUAC	Tel#:	603-271-1134
Street:	11 HAZEN DRIVE		
Mail Town:	CONCORD	State: NH	Zip: 03302

Emer Cont: MR MARK KIROUAC

Emer Cont Tel#: 603-271-1134

Email: MKIROUAC@WILDLIFE.STATE.NH.US

Height:	5.5 ft	Unop Disch w/1' frbrd:	cfs	Drop Inlet:	N
Length:	150 ft	Max Unop Disch:	4334 cfs	Uncontrolled spill:	Y
Impnd:	1 acre	Total Disch:	3360 cfs	Stoplogs:	Y
Perm Stor:	4 acft	Design Storm:	2797 cfs	Gate:	N
Max Stor:	4 acft	Q100:	3099 cfs	Pond drain:	Y
Drain Area:	102.7 sqmi	Free Board:	0.5 ft	Type pipe:	
Drain Area:	65728 acres	Emer Spill:	N		

Basin:	PISC	County:	ROCK	Type Const:	CONCRETE
Quad:	185	Tax Map		Dam Use:	CONSERV/AG
Huc8:	PISC	Lot numbers:		Year orig Permit	2000
Huc10:				Year orig Const:	1914
Plans on file:	N			Year last Reconst:	
Bathy map:	N	Dam Designer:			

Lat Deg:	42	Lon Deg:	-70
Lat Min:	58	Lon Min:	56
Lat Sec:	52	Lon Sec:	40

Physical Loc: downstream of #082.01

Last Insp:	11/8/1999	Insp By:	NLM
Next Insp YR:	2005		

Comment:

10/16/2005

AN EMPTY FIELD MEANS DATA NOT YET ENTERED OR NOT YET AVAILABLE

ALL DATA SUBJECT TO CONTINUOUS CHANGE AND REVIEW

Operation and Maintenance Plan
Exeter River F&G Dam
Exeter, NH

I. <u>Seasonal Operation</u>

This is a run of the river dam. There is no seasonal operation.

II. <u>Emergency Operation</u>

There is no gate to operate during emergency.

III. <u>Maintenance Operation</u>

Monthly – The dam is checked monthly. Any floating debris is removed.

Annually – The dam is checked for cracks, deterioration, movement etc. Any deteriorated stoplogs are replaced.

IV. <u>Emergency Contact Person</u>

Mr. Doug Grout   Work phone 868-1095

The State of New Hampshire
Department of Environmental Services

September 9 2009

NH FISH & GAME DEPARTMENT
MR RICK FINK DIR FAC & LAND
11 HAZEN DRIVE
CONCORD NH 03301

Dear Dam Owner:

In response to recent changes in the New Hampshire law defining a dam, as it relates to the jurisdiction of the New Hampshire Department of Environmental Services, it has been determined that your dam, as referenced above, is now exempt from future regulation related to dam safety. This exemption, which becomes effective on September 11, 2009, is due to the fact that your structure has a maximum height of less than 6 feet. The exact language of the amended statute is reproduced below.

> *RSA 482:2 II (a) "Dam" means any artificial barrier, including appurtenant works which impounds or diverts water and which has a height of 6 feet or more, or is located at the outlet of a great pond. A roadway culvert shall not be considered a dam if its invert is at the natural bed of the water course, it has adequate discharge capacity, and it does not impound water under normal circumstances. Artificial barriers which create surface impoundments for liquid industrial or liquid commercial wastes, septage, or sewage, regardless of height or storage capacity shall be considered dams.*

If at some time in the future you plan to reconfigure your dam to meet any of the criteria of the amended definition you will once again be subject to the statutes and administrative rules pertinent to dams and dam safety, so please contact our office for appropriate guidance. Being exempt from dam related rules does not preclude you from following the applicable requirements of other state programs or local regulations. It is recommended that you continue to exercise good maintenance and operations practices for this structure, including consulting with qualified consultants, contractors or other professionals when considering repairs or alterations.

The correspondence file for this structure will be retained and labeled as "exempt" in the inactive section of the Dam Bureau's file storage area. You may visit us at any time to view or copy the contents of the file.

If you have any questions, please contact the Dam Safety & Inspection Section of the Dam Bureau at 603-271-3406 or write to us at the address noted below. Our normal business hours are from 8:00 a.m. through 4:00 p.m., Monday through Friday.

Sincerely,

Chuck Corliss for SD

Steve Doyon, P.E.
Administrator
Dam Safety Section

P.O. Box 95, 29 Hazen Drive, Concord, New Hampshire 03302-0095
Telephone: (603) 271-3503 • Fax: (603) 271-7894 • TDD Access: Relay NH 1-800-735-2964
DES Web site: www.des.nh.gov

SITE EVALUATION FOR 2006 MAY FLOODING

DAM: 082.23 HAZCL AA CNTY: ROCK NAME EXETER RIVER FISH LADDER
TOWN: EXETER Physical Location: downstream of #082.01
RIVER: EXETER RIVER Last insp: 11/8/1999
Comment:

HEIGHT: 5.5 LENGTH: 150 EMERSPILL: N GATE: N
IMPND: 1 D A sq mi: 102.7 STOPLOGS: Y Type Prin Spll:
PONDDRAIN: Y TYPE outlet PIPE:

Dam Owner NH FISH & GAME DEPARTMENT Tel 603-271-1134
Rep: MR MARK KIROUAC
11 HAZEN DRIVE
CONCORD NH 03302

Emer Contact: MR MARK KIROUAC Em Cont Tel: 603-271-1134

Alt Emr Cont: Alt Cont Tel:

Does the dam appear to have been overtopped as a result of this May flooding? (Y) or N

If Y how much - What is the estimated debris line? ? Great Dam was overtopping by 4" on right u/s concrete cutoff wall

What is the current water level? over spillway

As related to May flooding - Sinkholes, Settlement, Seepage, Erosion, Vegetation? Conduit tell. F&G on site checking ladder - no obvious damage.

Any recent repairs as a result of May flooding? NO

Overall Condition of Dam good

Does this dam need a follow up? Y or (N)

Did you have contact with the owner? yes Cheri Patterson NHFG onsite

Inspector: Grace Levergood Date of site visit: 5/19/06

Oct: insp: GEL

SITE EVALUATION FOR 2005 MID OCTOBER FLOOD

DAM: 082.23 HAZCL AA NAME EXETER RIVER FISH LADDER

TOWN: EXETER Physical Location: D/S of #82.01

RIVER: EXETER RIVER Last insp: 11/8/1999 Status date: 1999

Comment:

HEIGHT: 5.5 LENGTH: 150 EMERSPILL: N GATE: N

IMPND: 1 D A sq mi: 102.7 STOPLOGS: Y TYPE outlet PIPE:

PONDDRAIN: Y DROPINLET: N

Dam Owner NH FISH & GAME DEPARTMENT Tel 603-271-1134

Rep: MR MARK KIROUAC
CONCORD NH 03302

Emer Contact: MR MARK KIROUAC Em Cont Tel: 603-271-1134

Does the dam appear to have been overtopped? yes

Designed for overtopping - weir in Exeter River

Sinkholes, Settlement, Seepage, Erosion, Vegetation?

none

Overall Condition of Dam Good

Did you have contact with the owner?

Inspector: Grace Levergood Date of site visit: 10/14/05

McGrath, Nancy L.

From:	Levergood, Grace
Sent:	Thursday, September 30, 2004 1:32 PM
To:	McGrath, Nancy L.; Blaney, Jeffrey; Doyon, Steve; Guinn, Dale; McCarthy, Bethann
Cc:	Stout, Wendy; Gallagher, Jim
Subject:	FW: Mark Kirouac

08223

FYI, the new contact at NHF&G is Mark Kirouac not Chuck Minor. Grace

-----Original Message-----
From: Timmins, Gail
Sent: Thursday, September 30, 2004 1:29 PM
To: Leung, Jimmy; Levergood, Grace
Subject: Mark Kirouac

KIROUAC, MARK R.

FISH AND GAME COMMISSION

PUBLIC WORKS PROJECT MGR III

(603) 271-1134
mkirouac@wildlife.state.nh.us

Gail M. Timmins
NH Dept. of Environmental Services
Dam Bureau, Maintenance Section
PO Box 95, 29 Hazen Drive, Room 306C
Concord, NH 03302-0095
(603) 271-7868 or 271-1962
Fax: (603) 271-6910
email: gtimmins@des.state.nh.us
contact web page: www.des.state.nh.us/dam/

Lake level base info for Exeter River Fish Ladder dam #082.23 in Exeter

Drainage area (sq mi):	103.00	65,920.00 acres
Lake area (ac):	1.00	
Net drainage area:	65,919.00 acres	

1" runoff from net DA: 5,493.25 ac/ft (1'/12")(net da in acres)

RISE PER INCH RUNOFF: **5493.25 ft/in** (net da in ac)/(lake area in ac)

(1" runoff from net DA raises level by)

1" on lake has storage of: 0.50 cf/s/d

(.504 sf/sec/day)(lake area in ac)

storage area for one-day inflow

(43560 sf/ac)/(86,400 sec/day)=0.504 sf/sec/day)

Jan 2003 by NLM

The da and surface area are taken from the nhdams database

Appendix C

NHDES Letters of Deficiency

NHDES

State of New Hampshire
DEPARTMENT OF ENVIRONMENTAL SERVICES
6 Hazen Drive, P.O. Box 95, Concord, NH 03302-0095
(603) 271-3503 FAX (603) 271-2867

July 25, 2000

Letter of Deficiency
DAM #082.01

Mr. Keith Noyes
Town of Exeter
Public Works Dept.
10 Front Street
Exeter, NH 03833

RE: Exeter River Dam, Exeter

Dear Mr. Noyes:

The Department of Environmental Services, Dam Bureau (DES) consistently strives to enhance the safety of dams in New Hampshire through its dam safety program. One of the many instruments that play a part in reaching this goal is our inspection program. DES is forwarding this correspondence to you to advise you that in accordance with RSA 482:12 and Env-Wr 502.02, an inspection of the subject dam was conducted on September 28, 1999. During this visual inspection and/or file review, the following deficiencies were observed:

1. The dam cannot pass the routed 50-year design storm event with one foot of freeboard and no operations.

   Upon review of the hydrology and hydraulics for the dam, it was concluded that the dam could only pass 43% of the routed 50-year storm event with one foot of freeboard and no operations. Should the town seek an upgrade to the discharge capacity of the dam, the 100-year storm would be the required design storm event. The dam is capable of passing 38% of the estimated 100-year storm flow. It should be noted that the Route 101C (Clifford Road) bridge crossing located 225 feet upstream might reduce the storm flow over the dam by serving as an upstream control point. The town may want to investigate removing the upper portion of penstock to allow use of the gates. Removal of the concrete weir at the spillway lip would also increase the discharge capacity of the dam. It has been estimated that with operation of the penstock gates and removal of the concrete weir, the dam would be able to pass 96% of the 100-year storm event with one foot of freeboard.

2. There is no operation and maintenance plan on file with the DES; and

3. There was minor brush within 15 feet of the concrete abutments.

DES believes that the above deficiencies can be corrected by performing the following items by the indicated schedule:

September 1, 2000:

1. Prepare and submit a written operational procedure plan. The plan should describe the control of impoundment levels, monitoring and maintenance procedures, and identify emergency contact personnel;

Letter of Deficiency
Dam #082.01
July 25, 2000
Pg. 2

2. Remove brush within 15 feet of the concrete abutments; and

December 1, 2000:

3. Provide a plan and schedule to upgrade the discharge capacity of the dam to meet the 100-year design storm flow with one foot of freeboard remaining on the dam.

DES recommends that the Town of Exeter apply for grant money under the FEMA Hazard Mitigation Grant Program. Since this dam has experienced flooding in the past and currently has inadequate discharge capacity, any upgrades to improve discharge capacity may be eligible for funding under this program.

DES is requesting that you complete and submit the attached "Intent to Complete Repairs" form, within 30 days of receipt of this letter, that will provide for correction of the identified deficiencies by the date(s) indicated above. If you believe changes to the items of work or dates are necessary, please make the changes directly on the form and provide a brief explanation. We have enclosed a self addressed stamped envelope for you to return this form.

Our intent in sending you this correspondence is to make you aware of items that DES believes warrant your attention to insure the continued safe operation of your dam. It is our hope that, through the submittal of the attached form and a commitment to keeping a well-maintained dam, you will voluntarily comply with the requested items of work. If we do not receive the intent form or a similarly adequate written reply, we will assume that you are in agreement with our findings and recommendations and DES will carry out follow-up inspections accordingly.

If you have any questions or comments regarding this Letter of Deficiency or would like to be present at future inspections, please contact me at 271-3406, or write to the Water Division at the address listed on the top of the previous page.

Sincerely,

Grace Levergood

Grace E. Levergood, P.E.
Dam Safety Engineer

Attachments Guideline for an O&M plan, DB13
cc: Gretchen Rule
Certified # 7099 3400 0002 9772 3422
GEL/was/h:/safety/wendy/lod/082-01lod.doc

State of New Hampshir
) ·ARTMENT OF ENVIRONMEN1 _ SERVICES
6 Hazen Drive, P.O. Box 95, Concord, NH 03302-0095
(603) 271-3503 FAX (603) 271-2867

Intent to Complete Repairs
DAM #082.01
DAM Exeter River Dam

Department of Environmental Services
State Dam Safety Program
Dam Bureau
P.O. Box 2008
64 N. Main Street
Concord, NH 03302-2008

RE: Letter of Deficiency: Issued on July 25, 2000

Dear Dam Safety Program:

In response to the above referenced Letter of Deficiency (LOD), I concur with the Department of Environmental Service's recommendations, and specifically agree to complete the following items by the indicated schedule.

DATE: September 1, 2000

1. Prepare and submit a written operational procedure plan. The plan should describe the control of impoundment levels, monitoring and maintenance procedures, and identify emergency contact personnel;

1. Remove brush within 15 feet of the concrete abutments; and

DATE: December 1, 2000

3. Provide a plan and schedule to upgrade the discharge capacity of the dam to meet the 100-year design storm flow with one foot of freeboard remaining on the dam. If this plan includes the installation of flashboards designed to fail, DES will require approval of the flashpin design.

In lieu of the above, you may propose adjustments to the content or schedule associated with the requested repairs/work. (please state reasons for proposal and use reverse side if more space is needed).

Signature of Owner:_____________________

____
(print name)

Date:_________________

Engineer: GEL

U.S. P[ost]al Service
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City, State, ZIP+4: EXETER NH 03833

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WWTS-10D-82.01

1. Article Addressed to:

MR KEITH NOYES
TOWN OF EXETER
PUBLIC WORKS DEPT
10 FRONT ST
EXETER NH 03833

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The State of New Hampshire

Department of Environmental Services

NHDES

Michael P. Nolin
Commissioner

June 1, 2004

Mr. Keith Noyes
10 Front Street
Exeter, NH 03833

RE: Exeter River Dam #082.01 (Great Dam), Exeter, NH

Dear Mr. Noyes:

The meeting held on May 6, 2004 at your office proved to be beneficial towards our understanding of the balance that the Town must maintain when operating the Great Dam. It is our understanding that the upstream impoundment is needed to maintain the Town's water supply as well as provide water for fire suppression systems upstream. We also realize that flooding upstream has been an issue to some landowners along the Exeter River, Little River and Scammon Brook. In order for the Town to investigate and find a solution that will address all three issues of inadequate discharge capacity, upstream flooding and water supply, DES will extend the deadline for item #3 of the 7/25/2000 Letter of Deficiency (LOD). A correction to Item #3 of the 7/25/2000 LOD was mentioned at the meeting and should be noted. The dam must be able to pass the 50-year storm event with one foot of freeboard with no manual operations rather than the 100-year storm event.

We also discussed the operation and maintenance plan (O&M) that was submitted to this office on April 15, 2004. We have reviewed the plan and have suggested edits on the enclosed copy. As we discussed during our meeting, it is preferable to operate the gates based on river flows and not solely on forecasted rainfall events. We understand that the Town is moving forward and investigating ways to improve access to river stage data. Please reconsider your operations protocol, make the appropriate edits and resubmit the plan to this office.

We would like to encourage the Town to move forward to perform an internal inspection of the concrete penstock. In light of the recent leak noted in early April, this inspection may help prevent complications with the aging penstock.

Revisions to the 7/25/2000 LOD are as follows:

<u>By November 1, 2004</u>:

1) Demonstrate to DES that an engineering firm has been retained to perform the following tasks or assessments:
    a. Provide a plan and schedule to upgrade the discharge capacity of the dam to meet the 50-year design storm flow (4400 cfs) with one foot of freeboard remaining on the dam.

    b. Assess the condition of the concrete penstock. This assessment should include an internal inspection of the conduit, gates, pipe penetrations and concrete wall plug.

P.O. Box 95, 29 Hazen Drive, Concord, New Hampshire 03302-0095
Telephone: (603) 271-3503 • Fax: (603) 271-7894 • TDD Access: Relay NH 1-800-735-2964
DES Web site: **www.des.nh.gov**

Exeter River
Dam #082.01
June 1, 2004
pg. 2

By November 1, 2005:

2) Implement recommendations that result from the completion of item #1, above, and as approved by DES.

If you have any further questions, please feel free to contact me at (603)271-3406.

Sincerely,

Grace Levergood, P.E.
Dam Safety Engineer

Enclosures: Copy of O&M w/edits, 7/25/2000 LOD
cc: Brian Griset, Griset and Sons Environmental and Boundary Consultants
GEL/was/h:/safety/dam/letter/08201geltr2.doc

The State of New Hampshire
Department of Environmental Services

Thomas S. Burack, Commissioner

Ms. Jennifer R. Perry, P.E.
Public Works Director
Town of Exeter
10 Front Street
Exeter, NH 03833

March 2, 2009

Part on file
12/31/09
WAS

RE: Exeter River Dam #082.01 (Great Dam), Exeter, NH

Dear Ms. Perry:

The Department of Environmental Services (DES) has received your letter dated February 19, 2009 requesting a time extension on the Town's decision to repair the dam. We understand that the town would like additional time to investigate the feasibility of dam removal at this site. Revisions to the 7/25/2000 LOD are as follows:

By December 31. 2009:

1. Make a determination whether the Town wants to pursue dam repair or dam removal. Notify DES of the Towns decision.
2. Repair the 3 leaks noted discharging from the downstream wall of the concrete headworks structure.

If dam repair:
By March 1, 2010:

3. Demonstrate to DES that an engineering firm has been retained to provide a plan and schedule to upgrade the discharge capacity of the dam to meet the 50-year design storm flow (4400 cfs) with one foot of freeboard remaining on the dam.

By December 31, 2010:

4. Implement recommendations that result from the completion of item #3, above, and as approved by DES.
5. Repair the left concrete abutment wall, near the fishway, which is badly deteriorated and shows signs of leakage.

If dam removal:
By December 31, 2010:

6. Complete the application process for removal of the dam.

By December 31, 2011:

7. Complete removal of the dam

If you have any further questions, please feel free to contact me by phone at (603)271-1971, by email at grace.levergood@des.nh.gov or by mail at the address noted.

Sincerely,

Grace Levergood

Grace Levergood, P.E.
Dam Safety Engineer

ec: Deb Loiselle, DES River Restoration Coordinator
Ted Diers, DES Coastal Program Coordinator

GEL/was/h:/damfiles/08201/letters/20090302 08201 lod extension letter.doc

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NAS-680

1. Article Addressed to:

Ms Jennifer R Perry PE
Public Works Director
Town of Exeter
10 Front St
Exeter NH 03833

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A. Signature
X LeeAnn Simpson ☒ Agent ☐ Addressee

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Vanasse Hangen Brustlin, Inc.

Appendix D

Exeter River Geomorphic Assessment (Excerpt)

Exeter River Geomorphic Assessment and Watershed-based Plan

Fordway Brook, Upper Exeter River, Dudley-Bloody Brook, and Lower Exeter River

March 20, 2009

Prepared by:
Bear Creek Environmental, LLC.
297 East Bear Swamp Road
Middlesex, VT 05602

and

Fitzgerald Environmental Associates, LLC.
316 River Road
Colchester, VT 05446

Prepared under contract to:
New Hampshire Department of Environmental Services

and

Town of Exeter

Town of Exeter

Reach LE01

The downstream limit of the Lower Exeter River study area is found at the Great Dam in the Town of Exeter, immediately downstream of the High Street crossing (Figure 8.2). At this point, the drainage area to the river is 108.5 square miles. The first reach, LE01, extends 0.6 miles to the confluence with the Little River just upstream of Gilman Park. Due to the backwater effect of the Great Dam, this stretch of river is impounded and is not governed by fluvial geomorphic processes. Channel geometry data originally collected for stream typing and RGA/RHA scores were not used to develop sensitivity ratings for FEH and other corridor planning purposes, and should not be compared to non-impounded reaches upstream of LE03. Rather, an administrative judgment was used to determine RGA and RHA scores. An RGA score of “good” and an RHA score of “fair” were selected for this reach.

The NWI data indicate that this reach is composed of two major wetland types. Throughout the impounded area within the channel, the wetlands are a riverine system with an unconsolidated bottom. This wetland type extends from the Great Dam up into reach LE04 to the crossing of Route 108. Along the channel margins, the palustrine wetlands are well-forested with a mixture of evergreen and broad-leaved deciduous tree and shrub species, and are seasonally flooded during higher flow events in the river. Many areas of limited buffer (less than 25 feet width) were noted during the field surveys, especially along the west bank (Figure 8.3). These areas contribute to degraded habitat and elevated stream temperatures; however the wide channel and open canopy results in naturally high thermal loading.

Figure 8.2 High Street crossing upstream of Great Dam

Figure 8.3 Lack of healthy riparian buffer

Reach LE02

Reach LE02 begins at the confluence with the Little River entering from the west (Figure 8.4), and extends upstream for 1.2 miles to the upstream reach break just east of Lary Lane. The backwater effect of the Great Dam extends upstream through this stretch of river

(Figure 8.5), therefore this reach was considered impounded and not governed by fluvial geomorphic processes. As in LE01, channel geometry data originally collected for stream typing and RGA score were not used to develop sensitivity ratings for FEH and other corridor planning purposes. An administrative judgment was used for the overall reach scores, resulting in RGA and RHA scores of "good".

Figure 8.4 Little River confluence with Exeter River

Figure 8.5 Backwater effect of Great Dam in LE02

As in LE01, the NWI data describe two major types of wetlands for this reach. The riverine system present in LE01 is found throughout the impounded channel, extending into reaches LE03 and LE04 to the west. Palustrine wetlands outside the channel boundaries are well-forested with broad-leaved deciduous species, and are seasonally flooded during higher flow events in the river. Lands conserved by Phillips Exeter Academy (PEA) surround the entire length of this reach, and extensive wetlands provide further obstacles to development in the vicinity of the channel. The FEH corridor summary indicated that over 90 percent of the FEH corridor is protected against future development by a combination of wetlands and conserved lands.

Reach LE03

Reach LE03 begins just south of the end of Lary Lane, and extends upstream to the eastern edge of the Exeter Elms Campground. LE03 is a short reach (2,057 feet) having very similar characteristics to LE02. The backwater effect continues through this short stretch of river. Therefore, an administrative judgment was used for the overall reach scores, resulting in an RGA score of "good" and an RHA score of "fair".

The wetland complexes described in LE02 extend throughout this reach. Lands conserved by PEA are found adjacent the channel to the south, and the extensive wetlands further protect against structural development near the channel. The FEH corridor summary indicated that nearly 100 percent of the FEH corridor is protected against future development by either conserved land or wetlands.

Reach LE04

The eastern end of reach LE04 is found approximately 1.3 river miles downstream of the Route 108 crossing. LE04 is a long reach, extending upstream 2.2 miles to a river crossing at Linden Street. The lentic conditions associated with the backwater effect of the Great Dam extend through the lower section of the reach (Figure 8.6); perhaps up as far as the Route 108 crossing (Wright-Pierce, 2007). Channel geometry data was collected at two cross-sections; one downstream and one upstream of Route 108. The channel geometry values and resulting stream typing were very similar. Therefore all data collected for this reach above and below the crossing were summarized together. LE04 has a very high sinuosity value (2.0), and combined with the low width-to-depth values found at both cross-sections (<12), it has been classified as an E-type channel. The bottom substrate is fine-grained (90% silt), reflecting the depositional nature of the sediment regime.

Two areas of bank erosion were noted along the east banks. One area is found where the adjacent Exeter Elms campsites have impacted the riparian buffer (Figure 8.7), resulting in decreased resistance of the channel boundary to high flow events. Minor bank erosion was also noted upstream of the Route 108 crossing where the channel parallels the road. One neck cutoff was noted in the lower reach where the natural migration pattern of the channel, in combination with a large debris jam, has diverted moderate to high flow through a side channel to the east. This feature is not an indication of human-induced change in channel planform.

Figure 8.6 Backwater effect of Great Dam in lower LE04

Figure 8.7 Bank erosion along campsites in LE04

The wetland complexes described in downstream reaches extend throughout this reach. The riverine wetlands associated with the impounded sections of the channel end at Route 108, further indicating a hydro-ecological boundary at this point. Extensive areas of conserved lands and wetlands provide significant obstacles to development in the vicinity of the channel throughout this reach. The FEH corridor summary indicated that nearly 70 percent of the FEH corridor is protected against future development.

The channel in LE04 is physically stable (channel evolution stage is I). Minor bank erosion did not significantly lower the RGA score ("good"), and no channel incision was noted in the cross-sectional geometry, indicating good floodplain access during high flow events. Habitat was assessed as "fair" due to limited scour and depositional features, and minor buffer impacts. The formation of habitat features (e.g., pools and riffles) is likely limited by the backwater effect in the lower reach, and contributed to the marginal habitat rating.

Reach LE05

LE05 is a very short reach (1,064 feet) found upstream of the Linden Street crossing. The elevation change at this point represents the upstream boundary of any potential backwater effect that could occur during high flows on the lower river. Channel geometry data collected at one cross-section (Figure 8.8) indicated B-type channel geometry with a subclass slope of C (< 2%). Stable riffle features were present, and no channel incision or departure in form was noted. A small increase in sand substrate was noted in the bed substrate; however this is likely due to the presence of extensive sand-bottomed channels upstream of LE05.

One large bank failure was noted along the north bank where adjacent homes have encroached upon the channel corridor and impacted the buffer (Figure 8.9). The soils associated with the failure are non-cohesive and are likely fill from the residential development in the 1970's. Armoring and encroachment along the north bank limit the ability of the channel to migrate laterally; however given the valley setting and slope, a straight channel is likely natural. Nearly 80 percent of the north bank lacks a riparian buffer greater than 25 feet, which is contributing to increased bank erosion, thermal loading, and generally degraded habitat conditions.

Figure 8.8 Channel cross section in LE05

Figure 8.9 Bank failure in upper LE05 at trailer park

Despite the bank erosion described above, the channel in LE05 exhibits equilibrium conditions (channel evolution stage is I; RGA score was "good"). No channel incision was noted in the cross-sectional geometry; however the reach lacks a well-defined floodplain due to the confined valley setting. Habitat was assessed as "fair", reflecting the lack of woody debris and formation of scour and depositional features. In addition, bank armoring and the lack of native woody vegetation on the north bank adversely affect LWD loading and cover, and prevent the formation of undercut banks.

Reach LE06

The eastern (downstream) end of reach LE06 is found approximately 900 feet upstream of the Linden Street crossing, and extends 0.7 miles upstream to the western end of the trailer park. The channel is bordered to the north by the trailer park, with many residences found within the FEMA designated floodway. Based on a review of historic aerial photography, the trailer park was constructed throughout the 1970's and 1980's. Channel geometry data collected at one cross-section (Figure 8.10) in the lower reach indicated C-type channel geometry. Minor incision was noted (incision ratio = 1.2), likely resulting from encroachment on the floodplain and corridor over the past 30 years. Reduced floodplain access has likely led to increased stream power and minor vertical instability; however the cohesive marine clays that underlie the channel bed and banks are extremely resistant to erosion. A review of historical aerial photography suggests that the channel location has not significantly migrated since the 1960's. The surficial bed substrate is composed primarily of fine-grained sediment, indicating the depositional processes typical of this valley setting. The adjacent trailer park is the source of numerous impacts to channel stability. The lack of woody vegetation along the north bank is reducing boundary resistance (despite the cohesive clay soils) and degrading aquatic habitat, especially along the sharp bend in the upper reach (Figure 8.11). One large bank failure was noted along the north bank in less cohesive soils in the upper reach; this feature could threaten adjacent properties in the long-term if erosion continues. Although lateral channel migration is limited in much of the reach due to the cohesive soils, even minor bank erosion has the potential to strongly impact downstream aquatic habitat. Fine-grained, clay soil particles released from the banks stay in suspension for long distances and impact downstream biological habitat, as well as water quality for municipal supply.

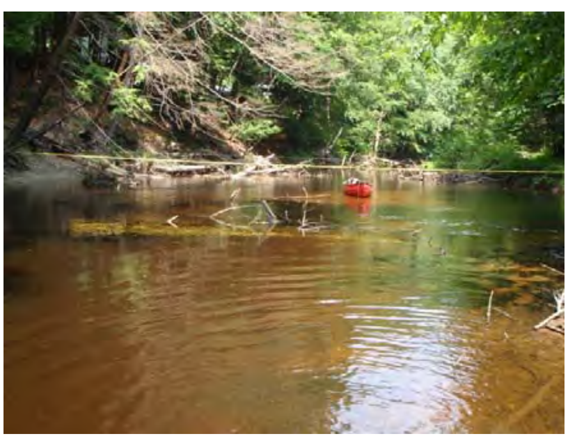

Figure 8.10 Channel cross section in LE06

Figure 8.11 Buffer impacts from adjacent trailer park

Two stormwater outfalls originating from the trailer park on the north bank were noted and are aggravating bank erosion. One outfall is perched along the steep side slope leading down to the river, causing gully formation (Figure 8.12) and increased sediment supply to the channel.

Figure 8.12 Stormwater outfall from trailer park

The channel in LE06 has been assessed at stage II of channel evolution, indicating that some floodplain function has been lost due to incision. LE06 was one of two reaches in the Lower Exeter River subwatershed that received an RGA score of “fair”. Minor channel incision, the presence of a flood chute in the lower reach (indicating the initiation of minor planform adjustments), and the bank erosion contributed to the lower rating. Habitat was also assessed as “fair” due to the lack of scour and depositional features, and impacts to the banks and buffers. LWD densities were high for this reach, as upstream reach LE07 has a healthy riparian buffer and may supply wood to the reach during channel forming events.

Reach LE07

LE07 is found from the trailer park limits up to a clearing for a gas line crossing from Powder Mill Road to the River Woods residential complex. The reach has a total length of approximately one mile, and is dissected by one crossing for the B&M railroad in the lower reach. Channel geometry data collected at one cross-section (Figure 8.13) indicated E-type channel geometry with dune-ripple bedform. Excellent formation of bed features needed for good aquatic habitat was noted, including high LWD density (Figure 8.14). Minor channel incision was observed at the cross-section; however no severe departures in form or stream type were noted. The surficial bed substrate is composed primarily of fine-grained sediment, reflecting the depositional processes typical of this setting.

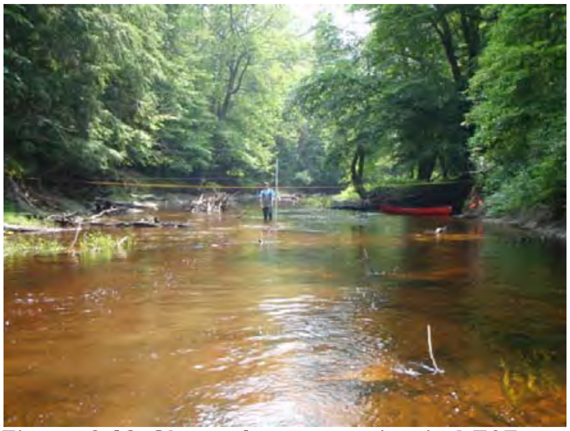
Figure 8.13 Channel cross section in LE07


Figure 8.14 Large debris jam in upper LE07

Areas of extensive erosion were noted in the lower reach where approximately 500 feet of the south bank lacks a buffer greater than 25 feet (Figure 8.15). While a narrow strip of trees is still present along the channel margin, ongoing erosion could worsen in the future without buffer plantings. As in reach LE06, extensive lateral channel migration is limited in LE07 due to the cohesive soils that underlie the bed and banks. However, one minor flood chute was noted in the lower reach upstream of the B&M railroad crossing. This bridge is a floodplain constriction and may have induced the formation of the flood chute by constricting high flow events (causing temporary backwater effects).

One stormwater outfall originating from the River Woods complex to the north of the river has formed a gully adjacent the channel (Figure 8.16). This outfall is causing increased supply of fine sediment to the channel, and threatens the excellent biotic habitat observed throughout the reach. River Woods, a housing community adjacent to the river, has hired an engineer and a soil scientist to address the problem, which may lead to the design and construction of a stormwater BMP to control runoff from the extensive area of impervious cover upslope.


Figure 8.15 Lack of buffer and bank erosion in LE07


Figure 8.16 Stormwater outfall gully from River Woods

Due to the bank erosion described above, and the minor incision noted at the cross-section, the channel in LE07 has been assessed at stage II of channel evolution. However, the RGA score was calculated to be "good", and the channel had greater physical stability than downstream reach LE06. Habitat was assessed as "good", reflecting the high density of woody debris and good formation of scour and depositional features. With the exception of discrete areas of buffer and bank impacts, the healthy riparian conditions allow for numerous, well-covered undercut banks. Many schools of small mouth bass were observed in the pools and glides during the field observations under low flow conditions in July, 2008.

Reach LE08

Reach LE08 is a short reach (1,428 feet) that begins at the change in confinement just downstream of the gas line crossing that intersects Powder Mill Road and ends 90 feet downstream of the Kingston Road crossing. The lower half of this reach is widened and slow-moving (Figure 8.17). There, the bank scour can be attributed to a bedrock ledge found mid-reach. The slight change in slope increases velocity, resulting in the formation of scour pools below where the substrate becomes unconsolidated and sandy. Upstream of the grade control the substrate remains coarse, and the dominant substrate in the reach is cobble (30%). Geometry in this reach is indicative of C-type channels and the bedform is riffle-pool. Above the grade control there is a portion of the reach where the buffer has been reduced to less than 25 feet. This section of the north bank comprises approximately 25% of the reach. The south bank is well buffered and predominately between 100 and 150 feet in length. Two mid-channel bars were observed on the upper end of this reach.

Figure 8.17 The widened area downstream of the grade control

The geomorphic rating of this reach was influenced by the widening observed in the upper and lower sections of this reach as well as some aggradation in the form of mid-channel bars. However, the combined impact of stressors to the stability of the reach remained low and the RGA score was "good." The aggradational processes follow the D-type channel evolution model. The channel evolution stage was assessed at stage IIc. Downstream of the grade control a historic mill sluice or canal was observed off the south bank (Figure 8.18).

Figure 8.18 A mill sluice or canal observed off the right bank downstream of the grade control

It is likely that this site was chosen because of the change in slope associated with the grade control. The thermal loading associated with the open canopy, channel widening, and the lack of good cover in the form of undercut banks and woody debris reduced the overall habitat condition (RHA score "fair").

Segment LE09-A

This segment begins downstream of the Kingston Road (Route 111) Crossing and extends 1,819 feet upstream until the channel dimensions change significantly at the segment break. Immediately upstream of the Kingston Road crossing there was a small grade control (Figure 8.19). The first 350 feet of this segment was coarse-bottomed (Figure 8.20). However, this area was assessed as a separate segment because of its short length. The rest of the segment had channel dimensions that were indicative of E-type channel geometry and a riffle-pool bedform. The dominant substrate for this segment was sand (65%) and the sinuosity was low (<1.2). The north corridor had two areas of low buffer width. These impacts were associated with houses along Kingston Road.

Figure 8.19 Grade control upstream of Kingston Road crossing

Figure 8.20 Kingston Road crossing with coarse substrate and riffle-pool bedform

The overall geomorphic condition of this segment is "good". The segment has natural slope changes on the upstream and downstream ends that are causing only minor aggradation. The banks were stable throughout the upper segment where the corridor was largely forested. The healthy buffer in the upper segment is a source for the large amount of woody debris in the channel (LWD = 145 pieces/mile). However, the low buffer widths downstream and limited bed substrate cover reduced the overall RHA score to "fair."

Segment LE09-B

LE09-B is very similar to the lower section of LE09-A. It extends for 765 feet from the change in channel dimensions to the reach break with LE10. The substrate in this segment is mostly coarse gravel (35%), but cobble and bedrock also make up a large portion of the distribution, with 21% and 20%, respectfully. The geometry is indicative of a B-type channel, with a subclass slope that is less than 2.0% (B_c-type). The channel is experiencing minor widening, but overall had good access to adjacent floodplain along the inside of the one major meander bend to the southeast. Only minor bank erosion indicates that the high width to depth ratio (WDR = 35) may be natural for the narrow valley setting. A small bedrock grade control was observed mid-segment (Figure 8.21). Downstream of this ledge feature there is a well formed and complete riffle. Upstream of the grade control a calm, shallow backwater was observed. Minor aggradation of fine sediment observed in this area.

Figure 8.21 An upstream view of the grade control

At the reach break with LE10 the riparian buffer is less than 25 feet (Figure 8.22). A lawn is maintained within close proximity of the channel for approximately 125 feet. Just downstream of this some erosion was observed on the south and north banks in the area where the channel meanders to the south. This is one likely source of the sediment that is trapped on the upstream end of the grade control. There was limited woody debris found in this segment (LWD = 55 pieces/mile). Since this segment is largely a transport-based system, woody debris is likely transported downstream in large storm events. The overall habitat condition of this reach was rated "fair" because of the low density of woody debris in addition to the areas where buffer and bank integrity was impacted. Some widening and associated with the bank stability caused the geomorphic condition decrease slightly, but still remain in the "good" category. The channel showed little evidence of present or historical incision (CEM stage I).

Figure 8.22 Area of low buffer observed in the upper segment

Segment LE10-A

Segment LE10-A is 1,183 feet in length, and extends from the reach break with LE09 up to approximately 700 feet downstream of the Pickpocket Dam. The channel has C-type channel geometry and the bedform is predominately riffle-pool. The dominant substrate type is cobble (43%). LE10-A is currently being influenced by the Pickpocket Dam upstream and also recovering from the presence of a historic mill that once impacted the channel. Two large abutments and a stone foundation on the north bank remain from the historic mill (Figure 8.23). When in operation, the mill likely caused a large amount of sediment to settle out upstream. Since the mill's removal (or destruction in a large flood) the sediment has been carried downstream. Where the valley wall does not confine the channel, a small floodplain has redeveloped.

The reestablishment of a floodplain in the lower portion of this segment has been beneficial to the overall geomorphic stability of this reach. This floodplain redevelopment is indicative of stage IV of the channel evolution model. The riffles are complete and well formed (Figure 8.24) and the cross-section taken on this segment showed a defined bench and accessible floodplain. Aggradation does not appear to be a serious problem and currently only some widening has lowered the geomorphic rating (RGA score = "good"). The habitat condition in this reach is negatively influenced by some buffer impacts on the north bank as well as the armoring associated with the mill that was once located in this segment. The south bank was very stable and the south corridor was excellent (>200 feet). In summary the overall habitat was considered to be "fair." Woody debris was not as abundant as it was in the slower moving E-type reaches because the swift moving current quickly flushes out debris in large storm events (LWD = 49/mile).

Figure 8.23 Foundation of historic mill observed on the north bank mid-segment

Figure 8.24 A well formed riffle upstream of the bridge abutments

<u>Towns of Exeter and Brentwood</u>

Segment LE10-B

LE10-B is about 700 feet in length and extends from the segment break upstream to the Pickpocket dam. This segment, like LE10-A, has seen several impacts to its natural geomorphic state. Widening, aggradation and changes in planform are the dominant processes. The presence of an historic mill in downstream segment A likely led to the aggradation in this segment. Reduced channel-forming discharge due to Pickpocket Dam has caused aggraded material to remain in this segment. Some widening was observed immediately downstream of the dam along the north bank where Pickpocket Rd. has encroached upon the floodplain (Figure 8.25). The lower end of this segment has braided flows, steep riffles, and several diagonal bars (Figure 8.26). Over time the sediment aggraded in this reach should continue to move downstream, resulting in a more stable planform. The stream type is B_C with a high width-to-depth ratio (WDR = 32.0). The subclass slope c indicates a channel slope of less than 2%. The bedform of this reach is riffle-pool and the dominant substrate is cobble (62%).

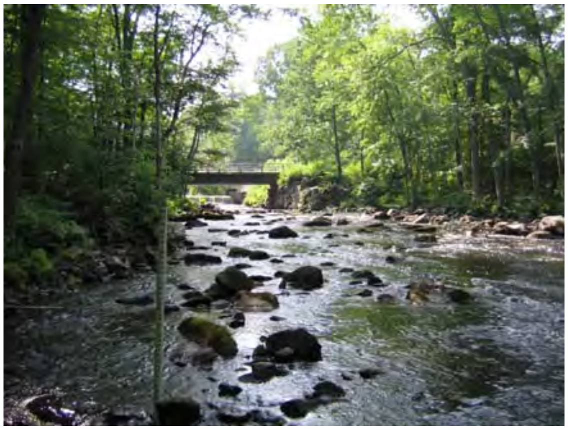

Figure 8.25 Widening downstream of Pickpocket Dam

Figure 8.26 Diagonal bar in lower portion of segment

The significant widening observed in the upper segment and the changes in planform of the lower reach influenced the geomorphic rating of this reach (RGA score = "fair"). These shifts in planform are characteristic of stage IIc of the D-type CEM. The unstable geomorphic state of this reach is a product of the past and present river uses. These impacts extend to the overall habitat condition of the segment (RHA score = "fair"). Some encroachment on the upper end of the segment and the buffer impacts on the north bank lowered the overall RHA rating.

Reach LE11

Reach LE11 begins at the Pickpocket Dam and extends 0.6 miles upstream to the reach break with LE12 just north of Stevens Road. Due to the backwater effect of Pickpocket Dam (Figures 8.27 and 8.28), this stretch of river is impounded and is not governed by fluvial geomorphic processes. Due to the severe impoundment conditions, an administrative judgment was not possible to determine RGA and RHA scores. Reference stream typing was also not possible, as the width of the impoundment made it difficult to estimate the natural, pre-dam channel and floodplain morphology. Therefore, an FEH corridor was not developed for this reach.

Figure 8.27 Impounded conditions above Pickpocket Dam

Figure 8.28 Pickpocket Dam

The NWI data indicate that this reach is dominated by one wetland type. This palustrine wetland type is "permanently flooded" due to the downstream dam, and has an unconsolidated bottom due to the shifting water levels and fine sediment deposition within the wetland body. Much of the impoundment is surrounded by a healthy buffer comprised of a mixture of evergreen and broad-leaved trees and shrubs. One area along the south bank in the upper reach lacks a healthy buffer (approximately 250 feet in length) due to residential development stemming from Stevens Road.

<u>Town of Brentwood</u>

Reach LE12

The upstream limit of the Lower Exeter River study area is found at the confluence with the Little River (Figure 8.29). At this point, the drainage area to the river is 74.8 square miles. This reach was accessed for Phase 2 surveys by canoeing downstream from the Haigh Road crossing, located approximately one mile upstream of the Little River. Due to the backwater effect of the Pickpocket Dam, this stretch of river is impounded and is not governed by fluvial geomorphic processes. Channel geometry data originally collected for stream typing and RGA/RHA scoring were not used to develop sensitivity ratings for FEH and other corridor planning purposes, and should not be compared to non-impounded reaches downstream of LE11. An administrative judgment was used to determine RGA and RHA scores of "good" for this reach. Habitat data collected for banks and buffers, LWD densities, debris jams, and undercut banks in upper LE12 suggest that good habitat existed in the reach prior to the flooding caused by the dam.

Figure 8.29 Confluence with Little River in LE12

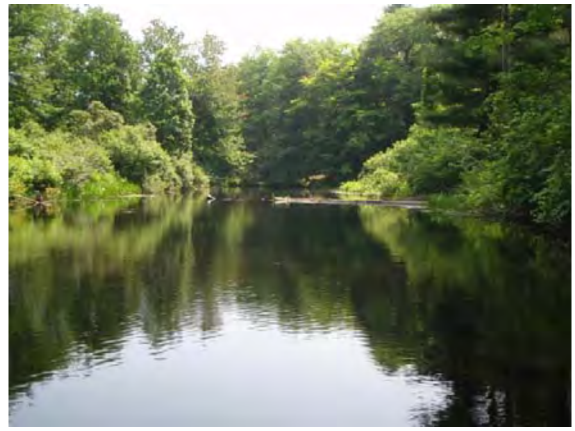

Figure 8.30 Healthy riparian buffer conditions in LE12

Lower Exeter River Phase 2 Summary

The NWI data for the reach indicate multiple types of palustrine wetlands, yet dominated by "permanently flooded" wetlands due to backwater effect from the dam. Along the channel margins, the palustrine wetlands are well-forested with a mixture of evergreen and broad-leaved deciduous species, and are seasonally flooded during higher flow events in the river. Nearly the entire reach is flanked by a healthy buffer comprised of a mixture of evergreen and broad-leaved trees and shrubs (Figure 8.30).

Table 8.2
Lower Exeter River Stream Type and Channel Evolution Stage

Segment ID	Entrench-ment Ratio	Width to Depth Ratio	Reference Stream Type	Existing Stream Type	Channel Evolution Stage	Active Adjustment Processes
LE01	Partially Assessed – influenced by Great Dam Impoundment					
LE02	Partially Assessed – influenced by Great Dam Impoundment					
LE03	Partially Assessed – influenced by Great Dam Impoundment					
LE04	23.9	10.9	E6	E6	FI	Planform
LE05	1.5	13.2	Bc3	Bc3	FI	Aggradation
LE06	4.7	16.7	C5	C5	FII	Degradation Widening
LE07	9.3	11.1	E5	E5	FII	Degradation
LE08	3.0	20.6	C3	C3	DIIc	Aggradation Widening
LE09-A	4.9	12.2	E5	E5	FI	Aggradation
LE09-B	1.5	34.9	Bc4	Bc4	FI	Widening
LE10-A	3.0	19.2	C3	C3	FIV	None
LE10-B	1.9	32.0	Bc3	Bc3	DIIc	**Aggradation Widening Planform**
LE11	Partially Assessed – influenced by Pickpocket Dam Impoundment					
LE12	Partially Assessed – influenced by Pickpocket Dam Impoundment					

Bold Red lettering - denotes extreme adjustment process
Bold Black lettering – denotes major adjustment process
Black lettering (no bold) – denotes minor adjustment process

Table 8.3 RGA and RHA Scores for Fully Assessed Phase 2 Segments				
Segment ID	**RHA Score**	**RHA Condition**	**RGA Score**	**RGA Condition**
LE04	0.62	Fair	0.74	Good
LE05	0.54	Fair	0.71	Good
LE06	0.58	Fair	0.63	Fair
LE07	0.77	Good	0.65	Good
LE08	0.60	Fair	0.65	Good
LE09-A	0.59	Fair	0.68	Good
LE09-B	0.60	Fair	0.73	Good
LE10-A	0.64	Fair	0.66	Good
LE10-B	0.54	Fair	0.43	Fair

8.3 Lower Exeter River Bridge and Culvert Assessment

Table 8.4 summarizes the data collected for 7 bridges in the Lower Exeter River subwatershed. The final column of the table includes a prioritization of structures for replacement or retrofit based on a review of the following four criteria: structure width in relation to bankfull channel width; structure flood capacity; aquatic organism passage; geomorphic compatibility. Two bridges in the Lower Exeter River subwatershed were not evaluated for geomorphic compatibility because they are located in an impounded reach (LE01). The geomorphic screening tool is not applicable to non fluvial systems. None of the bridges on the Lower Exeter River were rated as incompatible with geomorphic screening tool. All of the bridges have been given a low priority rating, and none were selected for flood capacity modeling (Appendix C). Included in Appendix C is an explanation of how structures were selected for flood capacity modeling based on the field data for geomorphic compatibility, aquatic organism passage, and local knowledge.

Figure 8.32 depicts the aquatic organism passage barriers for the Lower Exeter River subwatershed, including dams and grade controls. Two human made grade controls were identified as reducing aquatic organism passage.

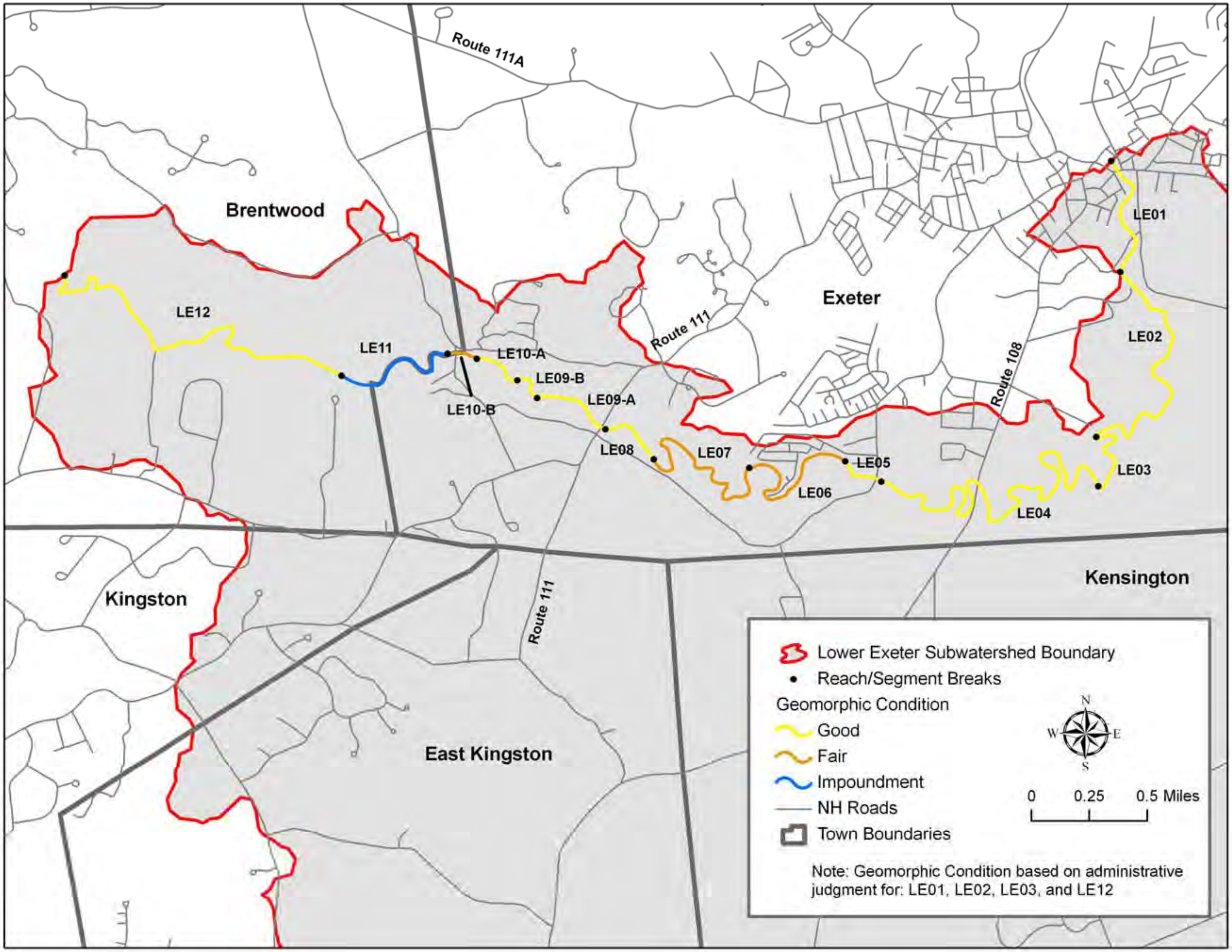

Figure 8.31 Geomorphic condition of assessed reaches in the Lower Exeter subwatershed

Table 8.4
Lower Exeter River Crossings

Reach/ Segment No.	Road Name, Town	Structure Type	Condition/ Observation	Percent Bankfull Channel Width	Structure Capacity for Flood Events (Percent Capacity)[1]		Aquatic Organism Passage (AOP)[2]	Geomorphic Compatibility[3]	Priority for Replacement or Retrofit
					25 Year	50 Year			
LE01	High Street, Exeter	Bridge	Very low clearance due to impoundment; No observable problems - bridge appears new	53%	----	----	NA	I[4]	Low
LE01	NA (Trail), Exeter	Bridge	No problems observed; Bridge serves PE Academy athletic fields	69%	----	----	NA	I	Low
LE04	Rt. 108, Exeter	Bridge	Located on sharp channel bend; moderate erosion upstream and downstream; Structurally stable	161%	----	----	NA	Partially compatible	Low
LE05	Linden Street, Exeter	Bridge	Stable crossing with minimal erosion; Large pool downstream; Very high clearance	112%	----	----	NA	Fully compatible	Low
LE07	B&M Railroad Crossing, Exeter	Bridge	High bank erosion upstream south bank; Moderate channel bend upstream	155%	----	----	NA	Mostly compatible	Low
LE09-A	Kingston Road, Exeter	Bridge	Minor channel constriction; No major scour – mostly stable	60%	----	----	NA	Mostly compatible	Low

Table 8.4
Lower Exeter River Crossings

Reach/ Segment No.	Road Name, Town	Structure Type	Condition/ Observation	Percent Bankfull Channel Width	Structure Capacity for Flood Events (Percent Capacity)[1]		Aquatic Organism Passage (AOP)[2]	Geomorphic Compatibility[3]	Priority for Replacement or Retrofit
					25 Year	50 Year			
LE10-B	Cross Road, Exeter	Bridge	Moderate constriction; Minor channel widening downstream; Bridge appears new and stable	54%	----	----	NA	Mostly compatible	Low

[1] No watershed hydrology data developed for the Lower Exeter River subwatershed as no structures were incompatible [2] Aquatic Organisms Passage ratings not applicable to bridges [3] Scores and ratings developed with the VTANR Geomorphic Compatibility Screening Tool; [4]Screening tool not applicable for non-fluvial (impounded) reaches.

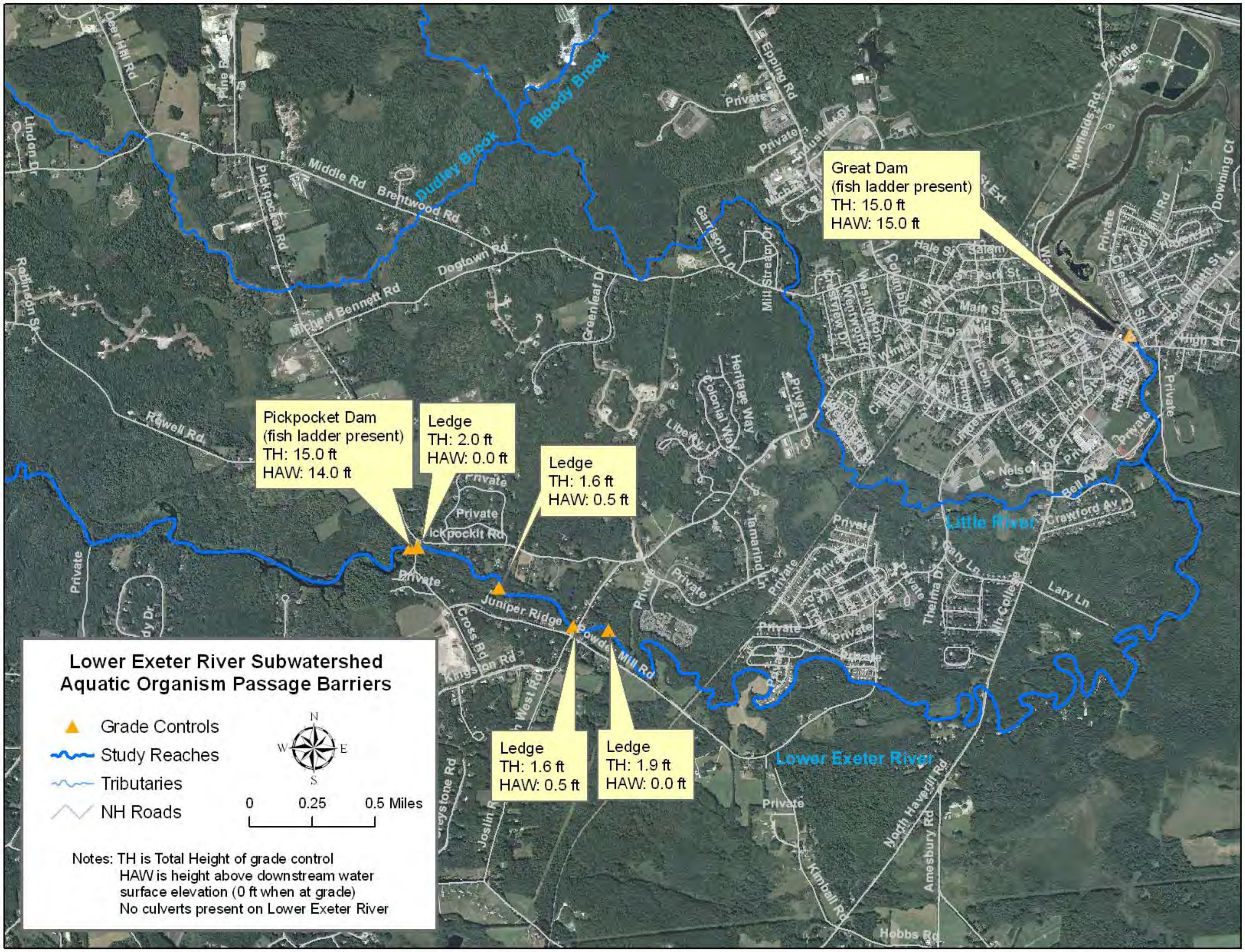

Figure 8.32 Aquatic organism passage barriers in the Lower Exeter subwatershed

8.4 Lower Exeter River Corridor Planning

8.4.1 Stressor Maps

Stressor, departure and sensitivity maps are presented here as a means of displaying the effects of all significant physical processes occurring within the Lower Exeter River subwatershed that were observed during the Phase 2 SGA. Stressor maps are included in Appendix D. These maps also provide an indication of the degree to which the channel adjustment processes within the watershed have been altered, at both the watershed scale and the reach scale. The analysis of existing and historic departures from equilibrium conditions along a stream network allows for the prediction of future channel adjustments within the watershed. This is helpful in developing and prioritizing potential protection and restoration projects.

Land Cover

Similar to the Dudley-Bloody Brook subwatershed, the Lower Exeter River subwatershed has significant amounts of urban land cover in the eastern portion around the Exeter village. In addition, the trailer park west of Linden Street represents a concentrated area of suburban land cover in close proximity to the channel. The Exeter River Vulnerability Analysis (Geosyntec, 2008) found that the Lower Exeter River subwatershed had the third highest degree of impervious cover (7.1%). This represents a low to moderate degree of impervious cover, below levels typically associated with degraded stream conditions at the national level (CWP, 2003), but above the 5% impact threshold noted in urbanizing watersheds around Burlington, Vermont (Fitzgerald, 2007). In addition, a USGS study of the New Hampshire Seacoast showed a degree of impairment at the 7% impervious level (Deacon et al, 2005). Expansive areas of wetlands also exist in the subwatershed, especially to the south of the river in the subwatershed draining to Great Brook.

Hydrologic Regime Stressors

The Hydrologic Regime Stressors map summarizes the watershed scale land use changes that contribute to localized increased storm flows. The Lower Exeter River subwatershed has some areas of dense road networks serving suburban development. Five subwatersheds associated with these areas have road densities greater than 5 miles per square mile (LE01, LE05, LE05, LE08, and LE10). Of the remaining subwatersheds, three have moderate road densities (4-5 miles per square mile) and four have low road densities (<3 miles per square mile). A summary of wetland loss allows for an interpretation of loss of hydrologic attenuation of surface runoff at the reach and watershed scales. In the Lower Exeter River subwatershed, four subwatersheds have lost between 20 and 40 percent of the original wetland area due to agricultural or urban land uses (LE04, LE06, LE07, and LE10). This degree of wetland loss has been shown to impact water quality in the seacoast region of New Hampshire and Massachusetts (Kennedy, 1991). In addition, three subwatersheds have lost greater than 50 percent of their original wetland areas (LE01, LE05, and LE08). Wetland loss at this magnitude may be contributing to the minor vertical instability observed in adjacent and downstream river reaches due to increased runoff.

Sediment Load Indicators

The Lower Exeter River Sediment Load map indicates that four subwatersheds may have increased potential for delivery of fine sediment from agricultural lands: LE04 (Great Brook), LE07, LE08, and LE10. Due to some areas of misclassification in the native data source (NOAA, 2008), the coverage of agricultural lands is likely overestimated in subwatersheds LE08 and LE10. However, significant and expansive areas of agricultural lands are indeed found to the south of the river in LE04 and LE07. The E-type channels found along the Lower Exeter River are very efficient at transporting fine sediment downstream, and bar formation was lacking for reaches LE04, LE07, LE09-A, and LE12. A high degree of sediment deposition was observed in two areas associated with current or historical in-stream structural stressors: downstream of the Pickpocket Dam (LE10-B; >10 features per mile) due to historical deposition and minor bank erosion; downstream of a historic mill site in LE09-B. Bank erosion is concentrated in the lower watershed where stormwater outfalls and urban encroachment impact the channel. Reaches LE06 and LE07 had areas of minor to moderate bank erosion, particularly on the north bank where impacts from the adjacent trailer park were greatest. Minor bank erosion was noted along the south where the river parallels Route 108, and downstream of the crossing in areas impacted by the adjacent campground.

Channel Slope and Depth Modifiers

Corridor encroachment and development has been highlighted on the Slope and Depth Modifiers map for areas where natural channel sinuosity has been impacted. In these areas, increased channel slopes may cause reduced floodplain function because the channel has greater capacity to hold larger flow events within the channel, rather than spilling onto the floodplain. Extensive channel encroachment was noted in LE01 in the village of Exeter, and in LE05 and LE06 (adjacent trailer park). Beaver dams are absent in this subwatershed. Numerous grade controls exist in the upper reaches of the subwatershed that control vertical stability. In addition to Pickpocket Dam (which is likely built on a natural grade control), four ledges were noted in the upper subwatershed that provide controls on channel slope and depth. A review of the 1962 and 1974 aerial photographs did not indicate any areas of obvious historical channel straightening.

Two dams are found along the Lower Exeter River. Given the limited topographic relief in the lower watershed, both dams have had a strong influence on the character of the river for miles upstream. A review of the each dam, with a brief discussion of dam influence on fluvial geomorphic equilibrium conditions of the river, is provided below.

- The Great Dam is located on the Great Falls in the village of Exeter immediately downstream of the Route 111 crossing. The use of the falls for water power dates back to the 1630's when the first gristmills were being constructed in the area (Tardiff, 2007). The present-day dam dates back to 1828 and has been operated by the Town of Exeter since 1981. The backwater effect of the dam extends approximately 3.5 miles upstream to the Route 108 crossing (Wright-Pierce, 2007). A fish ladder is present on the dam to encourage the passage of diadromous fishes to upstream reaches. The impacts of the upstream impoundment on aquatic life use has been well-documented (TNC, 2006; NHDES, 2008), and the dam has been implicated as a possible cause of flooding upstream. No significant impacts of the dam on fluvial geomorphic conditions were noted during the Phase 2 surveys. While the extensive impoundment has clearly degraded the natural habitat features of the Lower Exeter River, no significant channel adjustments (e.g., sediment deposition and widening) were noted near Route 108. Given the dam's long history and the agricultural legacy of the watershed, there is likely a high degree of fine sediment deposition in channel bed in the lower impoundment. The fate of sediment stored within the impoundment would need to be thoroughly examined if dam removal is considered in the future for fisheries restoration. Removal of the Great Dam for restoration of habitat connectivity in the watershed would also allow the river to redevelop a natural channel morphology (and habitat features) in response to a restored flow regime.

- Pickpocket Dam is located immediately upstream of Pickpocket Road on the Exeter-Brentwood town line. The use of Pickpocket falls for water power dates back to the 1650's when the first sawmill was constructed (Tardiff, 2007). A paper mill was operated at the site on and off for approximately 100 years during 1700 and 1800's. The backwater effect of the dam extends approximately 2.3 miles upstream. A fish ladder is present on the dam to encourage the passage of diadromous fishes to upstream reaches. As with the Great Dam, Pickpocket has clearly degraded the natural habitat features of the river for a great length upstream. No significant channel adjustments were observed in upstream reach LE12 at the lentic-lotic boundary downstream of Haigh Road. Due to the channel adjustments noted in downstream segment LE10-B, sediment storage and transport to downstream reaches would need to be considered if dam removal is considered in the future.

Riparian and Boundary Conditions

The Riparian and Boundary Conditions map highlights areas where human alterations to the river boundaries have increased or decreased the resistance of the banks and bed to channel adjustments. Many reaches in the lower subwatershed have extensive impacts to the riparian buffer due to adjacent development. These impacts were evident in LE01 in the village area; however the relative effect of this impact may be lower due to the backwater conditions associated with the Great Dam impoundment. The impacts on riparian buffer are most severe and quantifiable in LE05 and LE06 on the north bank.

Although severe lateral channel migration is limited in these locations due to the cohesive soils, even minor bank erosion has the potential to strongly impact downstream aquatic habitat. Fine-grained, clay soil particles released from the banks stay in suspension for long distances and impact downstream biological habitat, as well as water quality for municipal supply. Despite a high degree of corridor and floodplain development along the Lower Exeter River, bank armoring is very limited. This is likely due to the cohesive soil makeup of the banks; the only areas where armoring was noted was where till parent material borders the channel.

8.4.2 Departure Analysis

Reference Sediment Regime mapping for the Lower Exeter River indicates that most reaches would have equilibrium conditions. Under these conditions there is a balance between the sediment originating from upslope sources and the capacity of the channel to store and transport the incoming sediment. Three high-gradient reaches associated with confined valley settings (LE05, LE09-B, and LE10-B) would tend to have greater capacity for sediment transport. Existing Sediment Regime mapping indicates that departures have occurred in two segments: LE06 and LE10-B. In LE06, a combination of increased stormwater runoff and corridor encroachment has reduced floodplain function. In LE10-B, which is located immediately downstream of Pickpocket Dam, channel widening and planform changes are resulting an unnaturally high degree of sediment export to downstream reaches.

8.4.3 Sensitivity Analysis

Stream sensitivities are generally high in the Lower Exeter River subwatershed due to characteristics inherent to low-gradient, E-type channels. In these settings, alluvial channels that lack natural controls on channel stability (e.g., grade controls) tend to respond to watershed and reach-scale stressors more readily than coarse-bottomed, headwaters channels. Due to the impacts on channel stability noted in LE06, the stream sensitivity rating has increased to "extreme". Three coarse-bottomed segments with limited impacts to channel stability (LE05, LE08, and LE10-A) have been classified as moderately sensitive due to their natural bed armoring. The remaining segments have been given a high sensitivity rating.

8.4.4 FEH Zones

A summary of the FEH zones developed for the Lower Exeter River subwatershed is included in Appendix E. Included in Appendix E is: 1) a complete summary of the methods used to develop FEH zones, 2) a summary table comparing the stream channel sensitivity assigned to each corridor with the degree of protection afforded by wetlands and conserved lands within the corridor, and 3) maps depicting the FEH corridors, sensitivity ratings, and other aspects related to corridor protection.

8.5 Lower Exeter River Project Identification

The site level projects that were developed for the Lower Exeter River subwatershed are provided below in Table 8.5. The project strategy, technical feasibility, and priority for each project are listed by project number and reach. A total of 16 projects were identified to promote the restoration or protection of channel stability and aquatic habitat. Photographs of these projects are included in Appendix F. The table summarizes key information for each project, including the project strategy, technical feasibility, and priority based on scientific data and stakeholder input. The 16 projects are further broken down by category as follows: 4 active geomorphic restoration; 10 passive geomorphic restoration; 2 stormwater mitigation. The active geomorphic restoration projects include 2 streambank stabilization projects in the Town of Exeter.

The project locations and categories identified for the Lower Exeter River subwatershed are depicted below in Figure 8.33. Four high priority projects have been identified. All high priority projects are located in the Town of Exeter and are associated with suburban development in the stream corridor west of Linden Street. The high priority projects include:

- **Bank stabilization** immediately west of Linden Street (project #7);
- **Stormwater management** for runoff originating from the trailer park (project #9);
- **Streamside plantings** south of the trailer park (project #10);
- **Stormwater management** for runoff originating from River Woods Development (project #13)

Table 8.5
Lower Exeter River Site Level Opportunities for Restoration and Protection

Project #, Location, Reach	Type of Project	Site Description Including Stressors and Constraints	Project or Strategy Description	Hazard Mitigation Priority	Ecological Benefits Priority	Project Benefits	Costs	Local Stakeholder Knowledge	Potential Partners
#1 Great Dam 42.98178 N 70.94515 W Reach LE01[A]	Active Restoration	Great Dam is a significant barrier to aquatic organism passage; Dam is maintained by Town of Exeter	Remove dam to restore aquatic organism passage; Channel restoration in upstream reaches would also be necessary	Moderate	Moderate	Increased AOP and potential for ~3.5 miles of restored habitat upstream	Very high construction & permitting costs for structure removal and channel restoration		NHDES, Town of Exeter, ERLAC, NHFGD
#2 East of River St and Franklin St in Exeter 42.97639 N 70.94298 W Reach LE01[A]	Passive Restoration & Drinking Water Protection	Areas of limited woody vegetation along river edge, especially on west bank (2,740 ft with buffer less than 25ft wide), contributing to degraded habitat and elevated stream temps; wide channel with open canopy has naturally high thermal loading	Plant stream buffer with native woody vegetation in residential areas lacking canopy cover; Coordinate with adjacent landowners to assess interest and cooperation	Low	Moderate	Improved biotic habitat within reach (overhanging vegetation) and downstream (shading for lower water temp.)	Relatively low costs for native plant materials and labor	Aligns with local goals (buffers and water quality); however, landowner outreach will be needed	ERLAC, Town of Exeter, Adjacent Landowners
#3 East of Route 108 in Exeter 42.96051 N 70.95014 W Reach LE04	Passive Restoration & Drinking Water Protection	Areas of limited woody vegetation along river edge, especially on east bank along Exeter Elms Campground (2,340 ft with buffer less than 25ft wide), contributing to degraded habitat	Plant stream buffer with native woody vegetation in residential areas and camp sites lacking cover; Coordinate with adjacent landowners to assess interest and cooperation	Low	Moderate	Improved biotic habitat within reach (overhanging vegetation) and downstream (shading for lower water temp.)	Relatively low costs for native plant materials and labor	Aligns with local goals (buffers and water quality); however, landowner outreach will be needed	ERLAC, Town of Exeter, Adjacent Landowners

Table 8.5
Lower Exeter River Site Level Opportunities for Restoration and Protection

Project #, Location, Reach	Type of Project	Site Description Including Stressors and Constraints	Project or Strategy Description	Hazard Mitigation Priority	Ecological Benefits Priority	Project Benefits	Costs	Local Stakeholder Knowledge	Potential Partners
#4 West of Route 108 in Exeter Reach LE04	Passive Restoration & Drinking Water Protection	Approx. 12 acres of corridor upstream of Rt. 108 crossing on both banks is unprotected from future development; North corridor was active agricultural land in 1960's and 70's	Protect corridor and floodplain against future development through conservation easements; FEH would protect area of interest	Moderate	Moderate	Protected floodplains allow for ongoing attenuation of fine sediment and floodwaters.	Needs further investigation; Town of Exeter may own extensive lands on north bank	Aligns with local buffer and flood protection goals; south bank is privately owned; north bank is under conservation; conservation would protect local drinking water supplies	ERLAC, Southeast Land Trust of New Hampshire (SLTNH)
#5 East of Route 108 in Exeter 42.95932 N 70.95381 W Reach LE04	Passive Restoration & Drinking Water Protection	Limited woody vegetation and high use campsites contributing to degraded habitat	Plant stream buffer with native woody vegetation along camp sites lacking cove; Need to coordinate with campsite owner to assess interest in project	Low	Moderate	Improved biotic habitat within reach (overhanging vegetation) and downstream (shading for lower water temp.)	Relatively low costs for native plant materials and labor		ERLAC, Town of Exeter, NHFGD, Adjacent Landowner
#6 East of Route 108 in Exeter 42.95923 N 70.95422 W Reach LE04	Active Restoration	Limited woody vegetation and high use campsites contributing to bank erosion along south bank in middle and lower reach	Stabilize stream banks along high use campsites in conjunction with buffer planting; combination of wood and rock to stabilize toe of slope; Coordinate with campsite owner	Moderate	Moderate	Reduced fine sediment loading to channel and downstream areas; Potentially reduced property loss from erosion	Moderate costs if machinery is needed to anchor materials; hand-building may be possible		
#7 West of Linden Street in Exeter 42.96204 N 70.96583 W Reach LE05	Active Restoration & Drinking Water Protection	North bank is developed and lacks woody vegetation; Large slope failure in upper reach supplies sediment to channel; Banks armored in lower reach	Stabilize north bank with aggressive plantings (e.g., willows); Establish native tree species in lower reach where banks are armored; Coordinate with adjacent landowners	High	High	Reduced fine sediment to channel and downstream areas; reduced property loss from erosion		Aligns with local buffer and water quality goals; landowner negations may be cost and time prohibitive	NHDES, ERLAC, Town of Exeter, Homeowners Association, Student Conserv. Association

Table 8.5
Lower Exeter River Site Level Opportunities for Restoration and Protection

Project #, Location, Reach	Type of Project	Site Description Including Stressors and Constraints	Project or Strategy Description	Hazard Mitigation Priority	Ecological Benefits Priority	Project Benefits	Costs	Local Stakeholder Knowledge	Potential Partners
#8 North of Linden Street in Exeter Reach LE06	Passive Restoration & Drinking Water Protection	Portions of the south river corridor may be unprotected against development by the 100yr floodway; Flood chutes exist north of newly built home	Confirm protection status of lower south corridor; If unprotected, secure conservation easements to avoid future conflicts; FEH overlay would protect area of interest	Moderate	Low	Protected floodplains allow for ongoing attenuation of fine sediment and floodwaters.	Potentially high costs for easements due to private ownership; Needs further investigation	Aligns with local buffer and water quality goals; landowner negations may be cost and time prohibitive	ERLAC, SLTNH
#9 South of Friar Tuck Drive in Exeter 42.96211 N 70.97138 W Reach LE06	Stormwater Management	Stormwater outfall in lower reach along north bank is causing erosion and downstream scour; Increased sediment supply to channel	Provide small detention or infiltration structure (e.g., rain garden) upslope of outfall; Investigate storm drain network upslope and location for BMP; Determine need to stabilize gully on bank	High	High	Reduced fine sediment loading to channel and downstream areas; Reduced property loss from long term gully advance	Moderate costs to install LID BMP (Approx cost persqft: Raingarden: $10; Gravel Wetland: $10-15)	Aligns with local buffer and water quality goals; landowner negations may be cost and time prohibitive	NHDES, ERLAC, Town of Exeter, Adjacent Landowners, Homeowners Association
#10 South of Little John Drive in Exeter 42.96181 N 70.97287 W Reach LE06	Passive Restoration & Drinking Water Protection	North bank is developed and lacks woody vegetation; Bank erosion occurring along 220 feet adjacent homes due to reduced boundary resistance	Establish native tree species along north bank; Investigate need for long-term bank stabilization using bio-engineering approach	High	High	Reduced fine sediment loading to channel and downstream areas; Reduced property loss from high flow events and ongoing erosion	Relatively low costs for native plant materials and labor	Aligns with local buffer and water quality goals; landowner negations may be cost and time prohibitive	ERLAC, Town of Exeter, Adjacent Landowners, Homeowners Association, Student Conserv. Association, NHFGD
#11 Northeast of Powder Mill Road in Exeter Reach LE07	Passive Restoration	Portions of the river corridor upstream of the rail crossing may be unprotected against development by the 100yr floodway; Flood chute exists west (upstream) of crossing	Confirm protection status of lower south corridor; If unprotected, secure conservation easements to avoid future conflicts; FEH overlay would protect area of interest	Moderate	Moderate	Protected floodplains allow for ongoing attenuation of fine sediment and floodwaters.	Potentially high costs for easements due to private ownership	Aligns with local buffer and flood protection goals;	ERLAC, SLTNH

Table 8.5
Lower Exeter River Site Level Opportunities for Restoration and Protection

Project #, Location, Reach	Type of Project	Site Description Including Stressors and Constraints	Project or Strategy Description	Hazard Mitigation Priority	Ecological Benefits Priority	Project Benefits	Costs	Local Stakeholder Knowledge	Potential Partners
#12 Northeast of Powder Mill Road in Exeter 42.96087 N 70.97580 W Reach LE07	Passive Restoration & Drinking Water Protection	Approx. 500 ft of south bank in lower reach lacks buffer >25ft. Ongoing bank erosion could worsen without increased boundary resistance in long-term; Farm ditch has formed gully at confluence with river	Plant stream buffer with native woody vegetation along field edge; Investigate need to stabilize ditch/gully to reduce sediment loading; Coordinate with adjacent landowner	Moderate	Moderate	Improved biotic habitat within reach (overhanging vegetation) and downstream (shading for lower water temp.)	Relatively low costs for native plant materials and labor	Aligns with local buffer and water quality goals; landowner outreach will be needed	NHDES, ERLAC, Town of Exeter, NHFGD, Adjacent Landowners
#13 South of Riverwoods in Exeter 42.96371 N 70.98147 W Reach LE07	Stormwater Management	Stormwater outfall in middle of reach along north bank is causing gully formation, increasing sediment supply to channel	Develop stormwater mitigation plan for River Woods impervious cover runoff; Initial investigation of site by engineer and soil scientist occurred in Nov, 2008	Moderate	High	Reduced fine sediment to channel and downstream areas; improved downstream water quality	High costs for design and construction of BMPs due to large amount of impervious cover	Aligns with local stormwater management priorities; landowner negotiations will be needed	NHDES, ERLAC, Town of Exeter, Adjacent Landowners
#14 East of Route 111 in Exeter 42.96371 N 70.98747 W Reach LE08	Passive Restoration	Approx. 400 ft of north bank in upper reach lacks buffer >25ft. Single parcel owner in area of interest.	Plant stream buffer with native woody vegetation; Coordinate with adjacent landowner	Low	Low	Improved biotic habitat within reach (overhanging vegetation) and downstream (shading)	Relatively low costs for native plant materials and labor		NHDES, ERLAC, Town of Exeter, NHFGD, Adjacent Landowner
#15 East of Pickpocket Road along Exeter-Brentwood town line Segment LE10-B	Passive Restoration	Severe aggradation and widening, with some bank erosion; River protection afforded by100yr floodway doesn't extend beyond channel boundaries; Boundaries could become more unstable in future; Only 2 landowners, one on each side	Implement FEH corridor protection to avoid future conflicts due to lateral adjustments.	Moderate	Moderate	Protected floodplains allow for attenuation of fine sediment and floodwaters; Reduced conflicts with erosion and property damage	None		NHDES, ERLAC, Town of Exeter

Table 8.5
Lower Exeter River Site Level Opportunities for Restoration and Protection

Project #, Location, Reach	Type of Project	Site Description Including Stressors and Constraints	Project or Strategy Description	Hazard Mitigation Priority	Ecological Benefits Priority	Project Benefits	Costs	Local Stakeholder Knowledge	Potential Partners
#16 Pickpocket Dam 42.96982 N 71.00117 W Segment LE10-B	Active Restoration	Pickpocket Dam is a significant barrier to aquatic organism passage; Dam is maintained by Town of Exeter	Remove dam to restore aquatic organism passage; Channel restoration in upstream reaches would also be necessary	Moderate	Moderate	Increased AOP and potential for ~2.3 miles of restored habitat upstream	Very high construction & permitting costs for structure removal and channel restoration		NHDES, Town of Exeter, ERLAC, NHFGD

[A] Administrative judgment used for determining stream type, RGA and RHA condition for impounded reaches and segments.

Additional Notes for Reaches/Segments with No Identified Projects:

- LE02, LE03: No restoration projects identified for these reaches due to the existing protection afforded the FEH corridor by conserved lands and wetlands (90 - 100% of corridor). Channel boundaries and buffers are well vegetated.
- LE09, LE10-A: No restoration projects have been identified for these reaches due to the existing protection afforded the corridor by wetlands and steep valley side slopes. FEH implementation would further ensure long-term protection. Channel boundaries and buffers are well vegetated, with only minor areas of reduced vegetation. Channel is stable with little to no bank erosion.
- LE11: The reach immediately upstream of Pickpocket Dam had no RGA or RHA data collected for it because the reach is not governed by fluvial processes. Therefore no projects were identified for this reach, and no FEH corridor was developed.
- LE12: No restoration projects identified for this reach due to the existing protection afforded the FEH corridor by conserved lands and wetlands (~70% of corridor). Channel boundaries and buffers are well vegetated.

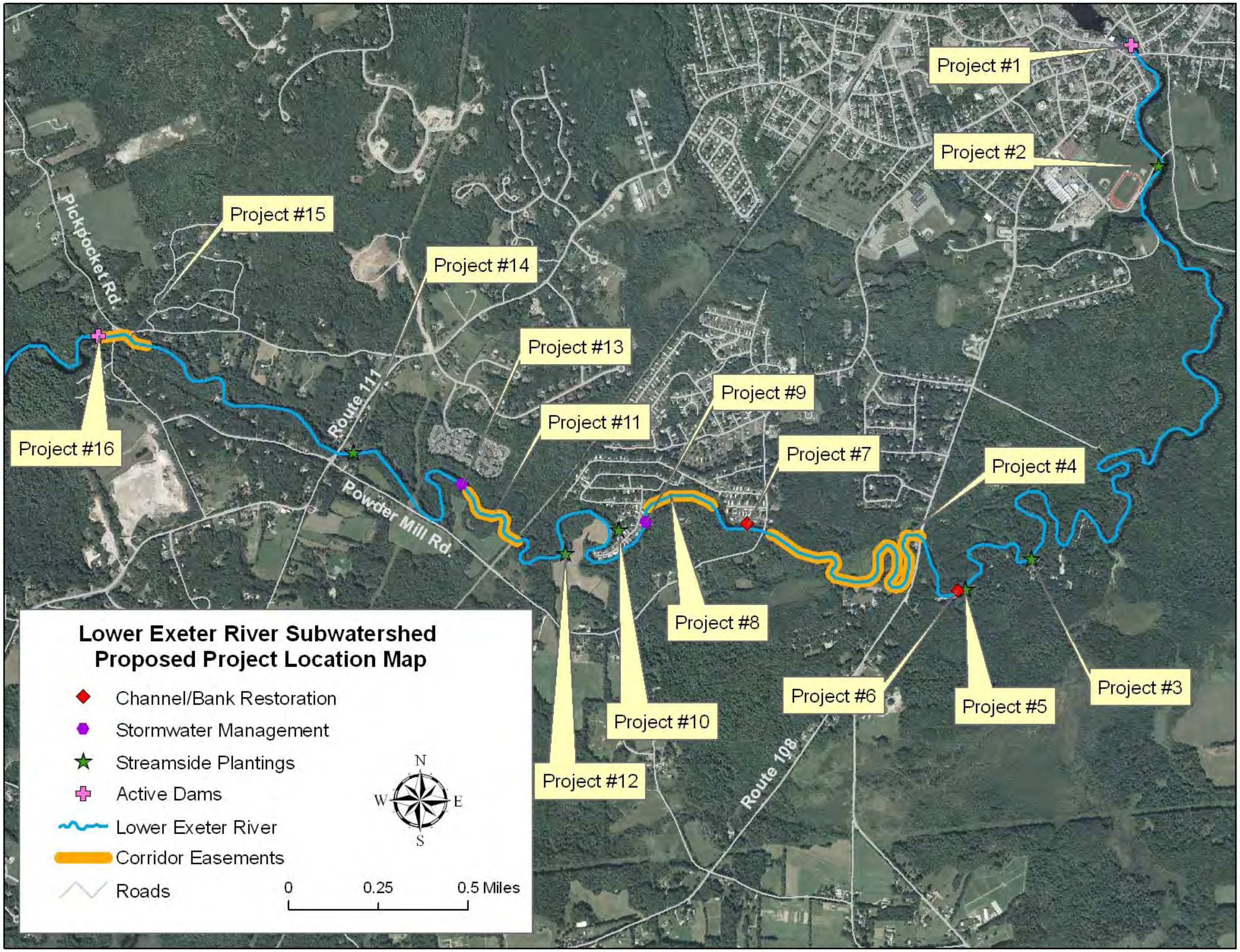

Figure 8.33 Proposed project location map for Lower Exeter River Subwatershed

Appendix E

Exeter River Hydrological Analyses (W&S Reports)

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Portsmouth, NH 03801
(603) 431-3937

MEMORANDUM

TO:	**Pete Walker (VHB)**
FROM:	**Andrew Walker, Kevin MacKinnon**
DAY/DATE:	**January 4, 2011**
PROJECT:	**Great Dam Removal Feasibility Study** **Exeter, New Hampshire**
SUBJECT:	***Exeter River Design Flows***

Introduction

Under Task 4.1 of the Great Dam Removal Feasibility Study, Weston & Sampson was tasked with determining the 2-, 5-, 10-, 25-, 50-, 100, and 500-year design flows for the Exeter River watershed at the Great Dam. These design flows are to be used in HEC-RAS simulations and other quantitative and qualitative analyses of the potential impacts of a removal of the Great Dam.

Approach

Weston & Sampson estimated the design flows by applying the Log Pearson Type III distribution to a record of peak streamflow (greatest discharge rate in a given water year, October 1st to September 30th) for the Exeter River that was synthesized from the peak streamflow records of the nearby Parker River. While the USGS operates a streamflow gage (USGS 01073587) in the Exeter River, its limited record of only 13 years (1997-2009) is not sufficient to properly estimate design flows, requiring the synthesis of a long-term record based on the streamflow record of a nearby basin. USGS gages in several nearby basins, shown in Figure 1, were considered. Ultimately the Parker River gage (USGS 01101000) was found to be most closely correlated to peak streamflow in the Exeter River. Based upon that close correlation, Weston & Sampson developed a linear relationship to translate Parker River peak streamflow to Exeter River peak streamflow. This 64-year synthesized record of peak streamflow in the Exeter River was fit to the Log Pearson Type III distribution to yield the 2-, 5-, 10-, 25-, 50-, 100-, 200-, and 500-year design flows. Guided by the NOAA publication FS-2011-01, "Flood Frequency Estimates for New England River Restoration Projects: Considering Climate Change in Project Design," Weston & Sampson further adjusted these design flows to reflect the growing impact of climate change on peak streamflow events in the Exeter River watershed.

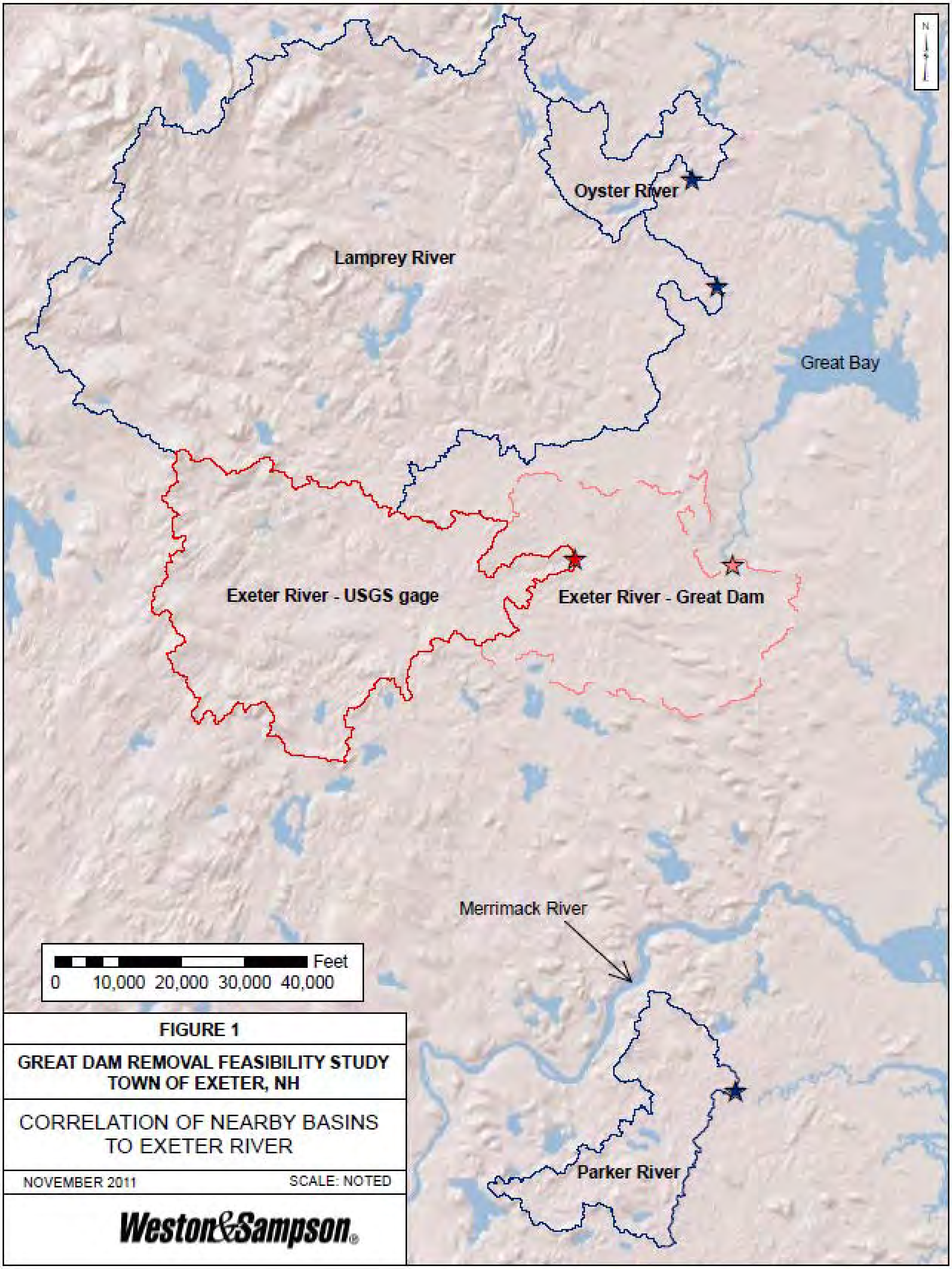


FIGURE 1

GREAT DAM REMOVAL FEASIBILITY STUDY
TOWN OF EXETER, NH

CORRELATION OF NEARBY BASINS TO EXETER RIVER

NOVEMBER 2011 SCALE: NOTED

Weston&Sampson

Methodology

Given the limited record of peak streamflow discharge rates in the Exeter River watershed, Weston & Sampson synthesized a long-term record for the Exeter River from which to estimate more reliable design flows. Ideally, design flows are estimated from streamflow records taken at the site of interest or elsewhere within the watershed of interest. However, given the limited record of peak streamflow measurements taken in the Exeter River watershed and the above average frequency of high flow events that occurred during the 13-year period of record, estimating design flows from the limited USGS gage 01073587 ("the Exeter gage") resulted in very biased, high design flows. For instance, fitting the Log Pearson Type III to the 13-year peak streamflow record taken by the Exeter gage, results in a 10-year design flood of 3,116 cfs and a 100-year design flood of 7,223 cfs. During the Mother's Day storm of May 2006, the Exeter gage recorded a peak streamflow of 3,520 cfs, indicating an event slightly higher than the 10-year flood. However, that same storm produced peak flows in other watersheds throughout the coastal New Hampshire area in excess of the 100-year or even 500-year recurrence interval (Olson, 2007). The neighboring Lamprey River USGS gage has been operating since 1934. Of the 15 highest peak streamflows in its record, 11 have occurred since 1970. Of the 10 highest peak streamflows in the record, six have occurred since 1996. This pattern exemplifies the bias in streamflow records in the region over the past 13, caused by an unusually high frequency of record floods compared to longer-term records. The biased, high design flows estimated from the 13-year record of the Exeter gage suggests the need for synthesis of a longer record of peak streamflow in the Exeter River based on streamflow data gathered in a nearby basin.

Weston & Sampson analyzed the applicability of USGS gages in several nearby basins for their ability to represent the long-term flow peak streamflow record of the Exeter River. Streamflow gages in the Lamprey, Oyster, and Parker Rivers were selected from more than one hundred potential gages. All three of these gages are located in close proximity to the Exeter River watershed, suggesting a similar meteorological record as well as similar hydrologic characteristics. Research conducted by the USGS, culminating in SIR 2008-5206, "Estimation of Flood Discharges at Selected Recurrent Intervals for Streams in New Hampshire," analyzed 110 hydrologic characteristics at 117 streamflow gages in or near New Hampshire for their correlation with peak streamflow events at those gages. According to the 2008 USGS publication, the four characteristics deemed most relevant to the estimation of design flows are Drainage Area, Average April Precipitation, Percent Wetlands, and Main Channel Slope. The values of these characteristics are provided in Table 1 for the Exeter River watershed and the three nearby basins selected for further analysis.

Table 1: Characteristics of Nearby Watersheds

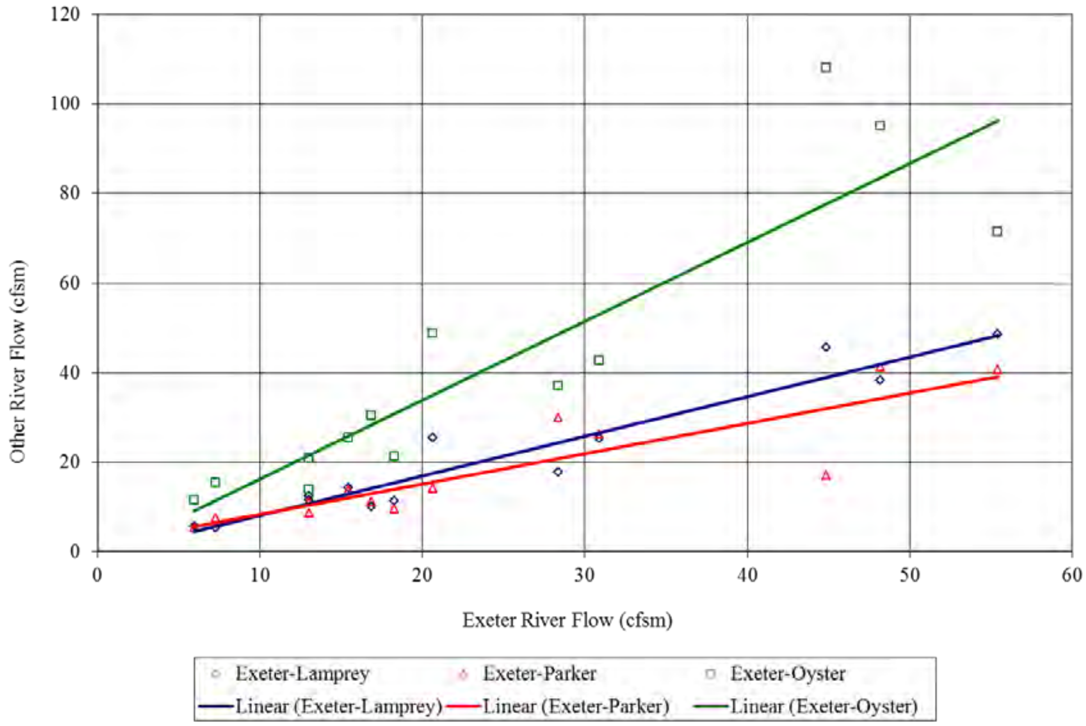
Characteristic	Exeter	Lamprey	Parker	Oyster
Drainage Area (sq. mi.)	63.5	185	21.4	12.2
Average April Precip. (in.)	4.06	4.07	4.32	4.18
Percent Wetlands	13.7	7.79	20.5	9.60
Main Channel Slope (ft./mi.)	7.09	9.36	5.43	17.9
Hydraulically Regulated	yes	yes	no	no
USGS Gage	01073587	01073500	01101000	01073000

With the exception of Drainage Area, these simple characteristics suggest that the Lamprey, Oyster, and Parker River watersheds are particularly well-suited to comparisons with the Exeter River watershed. However, in general, when synthesizing streamflow records from a nearby basin or elsewhere in the same basin, it is advisable to use a streamflow record from a drainage basin between 0.8 and 1.2 times the area of the target basin. A review of the 117 streamflow gages identified by SIR 2008-5206 revealed fewer than ten streamflow gages with a similar drainage area to the Exeter River gage. None of those streamflow gages were located in the seacoast New Hampshire region and possessed a long-term record of peak streamflow. Preliminary analysis of the peak streamflow records for those gages suggested that none of them were particularly well correlated to the Exeter River gage.

Given the strong influence of location and a shared meteorological record, only the Lamprey, Parker, and Oyster River gages were analyzed further. In addition to a shared meteorological record, all three watersheds contain a USGS gage with more than 50 continuous years of peak streamflow records. The Lamprey River gage (USGS gage 01073500) and its watershed are located immediately north of the Exeter River watershed and have been used repeatedly as a means of estimating streamflow in the Exeter River, including, among others, a 1981 review of hydroelectric potential at Great Dam by Charles Osgood at UNH as well as the 2005-2007 review of potential rehabilitation designs for Great Dam. The Oyster River watershed, monitored by USGS gage 01073000, is located immediately north of the Lamprey River watershed, and, unlike the Lamprey River, is relatively unregulated by dams. The Parker River gage is located just south of the Merrimack River in Byfield, Massachusetts. The Parker River watershed is also relatively unregulated by dams and most closely matches the size of the Exeter River watershed.

The long-term Lamprey, Oyster, and Parker River peak streamflow records were correlated with the limited Exeter River peak streamflow record using several measures of statistical correlation. There are many statistical methodologies to assess the correlation between two datasets, each with its own strengths, weaknesses, and assumptions. Two of the more common assumptions regard the monotony and linearity of the relationship between the two datasets being assessed. The first assumption, a monotonic relationship, is typified by a dependent dataset that generally increases or decreases (not both) as the independent dataset increases. The rate of this increase or decrease may vary linearly, exponentially, as a power function, or otherwise. The second common assumption, a linear relationship, is merely a type of monotonic relationship in which the dependent variable generally increases or decreases at a constant rate as the independent variable increases. The presence of a monotonic or linear relationship between two datasets being correlation can be detected graphically. As shown in Figure 2, all three long-term records under consideration do generally exhibit both monotonic and linear relationships when compared to the Exeter gage record: the streamflow in each of the rivers increases at a constant linear rate as streamflow in the Exeter River increases.

Figure 2: Linear Relationship between Peak Streamflow Data from Exeter River Gage and Gages in Nearby Basins



Given the linear relationships shown in Figure 2, Weston & Sampson evaluated the statistical correlation between the record of peak streamflow in the Exeter River and the corresponding records taken in each of the three nearby basins using three measures of statistical correlation – Pearson's R which assumes linearity, as well as Kendall's Tau and Spearman's Rho which assume monotony. Table 2 indicates the results of those correlation tests.

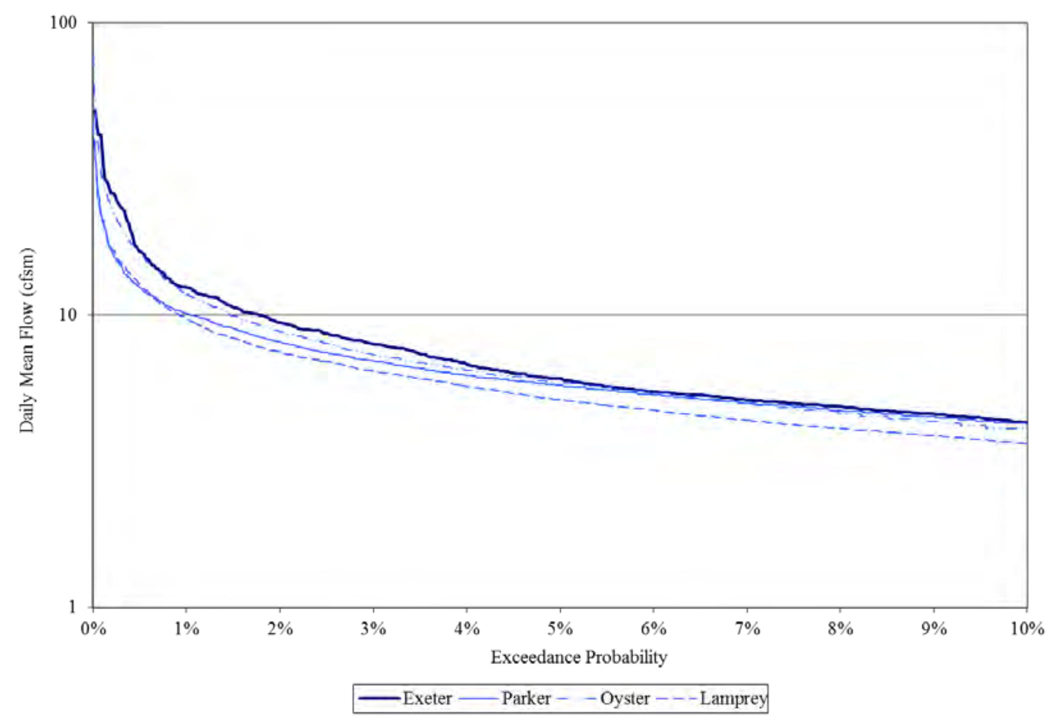
Table 2: Correlation of Exeter River Peak Streamflow with Nearby Basins

Measure of Correlation	*Nearby Basin*		
	Lamprey	**Parker**	**Oyster**
Pearson's R	0.960	0.882	0.899
Kendall's Tau	0.872	0.918	0.897
Spearman's Rho	0.890	0.929	0.940

As indicated by Table 2, three measures of correlation applied to the peak streamflow records of the Exeter River and of nearby basins do not agree on a single basin that is best correlated to the Exeter River. Given that discord, Weston & Sampson reviewed the strengths and weaknesses of the measures of correlation themselves and their applicability to the present analysis. Pearson's R, the most commonly-used measure of correlation, is relatively susceptible to a small number of outlier data points due to its relatively stringent assumption of linearity and because of its assumption that both the independent and dependent datasets fit a normal distribution (Helsel & Hirsch, 2002). The USGS has long ago recognized that peak streamflow data are not well fitted to the normal distribution, but rather to the Log Pearson Type III distribution (U.S. Interagency Advisory Committee on Water Data, 1982). The susceptibility of Pearson's R is of particular concern in this case as the peak streamflow record from the Exeter gage contains only 13 data points. In fact, the peak streamflow data point for 2007 appears to be just such an outlier; the Exeter-Parker correlation is particularly affected. If that single value were removed from consideration, Pearson's R for correlation between the Exeter and Parker Rivers would increase from 0.882 to 0.966. In contrast to Pearson's R, Kendall's Tau and Spearman's Rho require only a monotonic rather than a linear relationship and do not assume that the datasets fit any particular distribution. The latter two measures of correlation are based on the rank of each pair of data points within their respective datasets rather than on the value of those data points. For this reason, Kendall's Tau and Spearman's Rho are significantly more resilient to the effects of outliers (Helsel & Hirsch, 2002), which is particularly important given the limited record of the Exeter gage and the 2007 outlier. Given the strengths and weaknesses of the three measures of correlation, Kendall's Tau and Spearman's Rho were deemed most applicable to an analysis of peak streamflow records in the Exeter River and nearby basins.

Based on those two measures, the Oyster River gage and Parker River gage appear most closely correlated to peak streamflow in the Exeter River. In fact, based on Kendall's Tau and Spearman's Rho both the Oyster and Parker River gage records show excellent correlation with the Exeter River gage. However, no combination of measures of statistical correlation can replace visual review of the data (Helsel and Hirsch, 2002). To determine which of the Parker and Oyster River gages would provide a more robust means of estimating design flows at Great Dam, Weston & Sampson visually reviewed the correlation between mean daily streamflow at the Exeter gage and mean daily streamflow at the three nearby gages for those days with discharge rates in the top 10th percentile. As Figure 3 indicates, during days of high discharge, particularly in the 1st-10th percentile, the Parker River gage is particularly well-correlated to the Exeter River gage. Based on the measures of correlation, Kendall's Tau and Spearman's Rho, and on a visual review of mean daily streamflow in all four rivers, Weston & Sampson determined that the Exeter River record of peak streamflow events from the period of record (1997-2009) is most closely correlated with the corresponding record of the Parker River gage.

Figure 3: Exceedance Probability of Mean Daily Streamflow at the Exeter River gage and Gages in Nearby Basins



Estimating Design Flows

Weston & Sampson estimated the 2-, 5-, 10-, 25-, 50-, 100-, 200-, and 500-year design flows by first developing a synthetic peak streamflow record for the Exeter River by applying Ordinary Least Squares (OLS) linear regression methodology to the Parker River record and then by fitting that synthesized record of peak streamflow to the Log Pearson Type III distribution.

OLS linear regression is one means of defining the relationship between two continuous variables, allowing one to predict the value, and in some cases the variation, in the unmeasured dependent variable (Exeter River peak streamflow) from the measured independent variable (Parker River flow). Prediction of the dependent variable value using OLS requires two assumptions: that the two variables are linearly related and that the data used to relate the two variables is representative of the data of interest (U.S. Interagency Advisory Committee on Water Data, 1982). The first assumption was established previously, as shown in Figure 2. Given the correlation between the Exeter and Parker peak streamflow records, discussed in the previous section, the 13 data points from 1997-2009 also appear to be typical of peak streamflow values in both rivers with one exception: the 2007 peak streamflow value. Removal of that single data point from the correlation analyses between the Exeter and Parker records resulted in a significant increase in several measures of correlation, suggesting that the 2007 peak streamflow event was not typical of the relationship between the flood hydrology of the two rivers of interest. For that reason, Weston & Sampson employed OLS linear regression on the remaining 12 pairs of peak streamflow data only, yielding the relationship:

$$Q_E = 3.449 * Q_P + 99.059$$

Where QE is the peak streamflow value in cubic feet per second at the location of the Exeter River gage and
QP is the peak streamflow value in cubic feet per second at the location of the Parker River gage

Based on that relationship, Weston & Sampson developed a synthetic 64-year (1946-2009) record of annual peak streamflow values for the Exeter River at the location of the Exeter River gage, USGS 01073587. As the current study is focused on the impacts of a potential removal of Great Dam, this initial synthesized record was modified using basin averaging to reflect the larger watershed area downstream at Great Dam. All values in the initial synthesized record of peak streamflow at the Exeter River gage were multiplied by the ratio of the Great Dam watershed area to the Exeter River gage watershed area, 107.3 to 63.5 square miles or 1.690.

Results

This modified synthetic record of peak streamflow at Great Dam from 1946 through 2009 was subsequently fit to the Log Pearson Type III distribution to estimate the 2-, 5-, 10-, 25-, 50-, 100-, 200-, and 500-year design flows. The resulting estimated design flows are shown in Table 3:

Table 3: Great Dam Design Flows

Dataset	*Design Flow (cubic feet per second)*							
	2-year	**5-year**	**10-year**	**25-year**	**50-year**	**100-year**	**200-year**	**500-year**
Original Exeter River record (1997-2009)	2,068	3,776	5,266	7,614	9,736	12,206	15,077	19,595
Modified Synthetic record (1946-2009)	1,427	2,225	2,891	3,914	4,823	5,873	7,086	8,986

As indicated in Table 3, the design flows estimated from the modified synthetic record of peak streamflow at Great Dam are consequently lower than the same design flows estimated from the original 13-year peak streamflow record of USGS 0107357 at Haigh Road. This pattern is consistent with earlier observations that design flows estimated from the limited Exeter River gage record were biased high due to the limited number of data points and the above average frequency of high flow events that occurred during the 13-year period of record. The 64-year record of peak streamflow at Great Dam, synthesized from the Parker River gage record, provides a robust estimate of the design flows at Great Dam.

Climate Change Adjustments

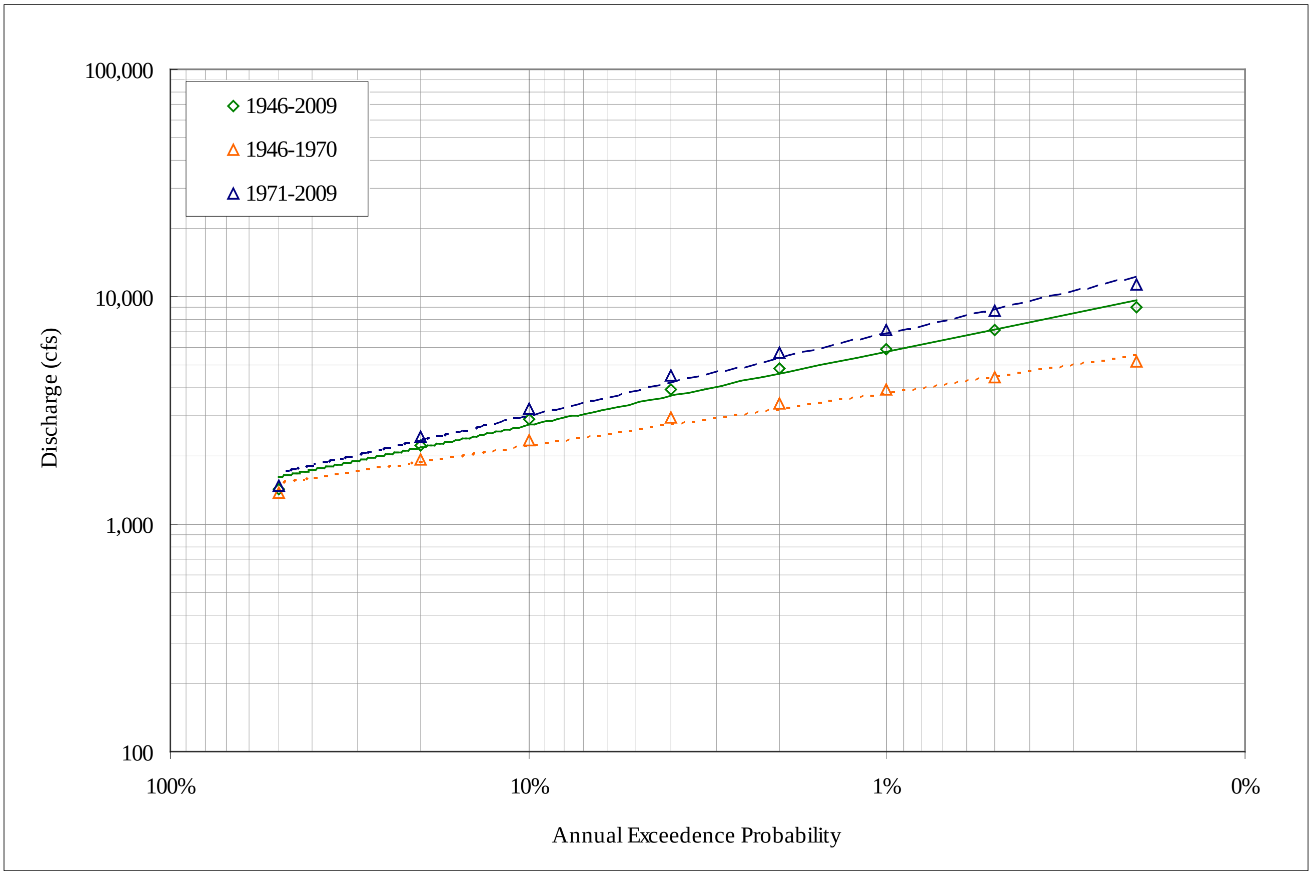
Weston & Sampson further adjusted the design flows indicated in Table 3 to reflect the growing impact of climate change, as guided by the NOAA publication FS-2011-01, "Flood Frequency Estimates for New England River Restoration Projects: Considering Climate Change in Project Design." According to NOAA FS-2011-01, over the past decade, numerous academic and governmental studies have identified an increase in the frequency and magnitude of significant flood events throughout the United States, including New England. As these events grow in magnitude and frequency, so too must the design flows that guide the design and construction of American infrastructure. NOAA cites several studies that find this increase in flooding occurred, not as a slow progression over many years or decades, but rather as a step change that occurred in approximately 1970 (NOAA Fisheries Service, 2011). For this reason, NOAA recommends that river restoration projects recognize the potential impacts of this step change in New England climate by comparing design flows estimated from streamflow records pre- and post-1970. Design flows estimated from the modified synthetic record for Great Dam, split into two time periods in this way, are shown in Table 4:

Table 4: Great Dam Design Flows Incorporating Climate Change

Dataset	*Design Flow (cubic feet per second)*							
	2-year	**5-year**	**10-year**	**25-year**	**50-year**	**100-year**	**200-year**	**500-year**
Modified Synthetic record (1946-2009)	1,427	2,225	2,891	3,914	4,823	5,873	7,086	8,987
Modified Synthetic record (1946-1970)	1,375	1,940	2,356	2,928	3,391	3,885	4,416	5,179
Modified Synthetic record (1971-2009)	1,481	2,427	3,245	4,539	5,718	7,109	8,745	11,366

Based on the design flows estimated from the synthesized streamflow record prior to and after 1970, the Parker and correspondingly the Exeter River would appear to exhibit the same pattern identified for rivers throughout New England. While the discharge values of smaller design floods, such as the 2-year event, are relatively similar, the post-1970 values quickly outpace their pre-1970 counterparts as shown in Figure 4. In fact, for events greater to or equal to the 100-year flood, the post-1970 design flow estimate is more than double the pre-1970 estimate.

Figure 4: Great Dam Design Flows Incorporating Climate Change



Weston & Sampson recognizes the importance of incorporating the impact of climate change on the magnitude and frequency of floods into New England river restoration projects, such as the Great Dam Removal Feasibility Study. For that reason, Weston & Sampson has employed the design flows estimated from the synthetic streamflow record at Great Dam for the period 1971-2009 to evaluate the potential impacts of removing Great Dam.

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References

Helsel, D.R. and R. M. Hirsch, 2002. Statistical Methods in Water Resources Techniques of Water Resources Investigations, Book 4, chapter A3: U.S. Geological Survey, Reston, Virginia.

NOAA Fisheries Service, 2011. Flood Frequency Estimates for New England River Restoration Projects: Considering Climate Change in Project Design: National Oceanic and Atmospheric Administration, National Marine Fisheries Service.

Olson, S.A., 2009. Estimation of flood discharges at selected recurrence intervals for streams in New Hampshire: U.S. Geological Survey Scientific Investigations Report 2008–5206: U.S. Geological Survey, Reston, Virginia.

U.S. Interagency Advisory Committee on Water Data, 1982. Guidelines for determining flood flow frequency, Bulletin 17-B of the Hydrology Subcommittee: U.S. Geological Survey, Office of Water Data Coordination: Reston, Virginia.

Town of Exeter, New Hampshire

March 2013

Weston&Sampson

Rainfall-Runoff Model Design Flow Report

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EXECUTIVE SUMMARY

Weston & Sampson conducted a hydrologic analysis of the Exeter River Watershed to develop estimates of the 2-, 10-, 50-, and 100-year design flows for Great Dam in support of the Great Dam Removal Feasibility Study. The 50-year design flow, once approved by the NHDES Dam Bureau, will become the Spillway Design Flood for Great Dam and consequently the discharge rate to which future dam modification geometries will be designed. The hydrologic analysis was conducted in accordance with New Hampshire Code of Administrative Rules Env-Wr 403.05 – "Hydrologic Investigations."

To determine the Great Dam design flows in accordance with Env-Wr 403.05, Weston & Sampson developed a rainfall-runoff model to simulate the reaction of the Exeter River Watershed ("the Watershed") to specific rainfall events. Weston & Sampson estimated the various watershed parameters, required by the model, from publically available geospatial datasets and from field observations gathered during other recent projects for the Town of Exeter. The methods used to estimate those parameters were discussed in depth with NHDES Dam Bureau personnel to ensure their appropriate selection and application. Once completed, the model was used to simulate rainfall events equivalent to the 2-, 10-, 50-, and 100-year recurrence interval depths most recently released through the collaboration of the Northeast Regional Climate Center and the National Resources Conservation Service.

The results of the modeling effort suggest that the 50-year recurrence interval design flow is 5,858 cfs. This value compares favorably to the estimate of 5,718 cfs developed previously by Weston & Sampson using USGS statistical analysis methods (Bulletin 17B) on historical streamflow data.

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1.0 INTRODUCTION & METHODOLOGY

Weston & Sampson conducted a hydrologic analysis of the Exeter River Watershed to develop estimates of the 2-, 10-, 50-, and 100-year design flows for Great Dam in support of the Great Dam Removal Feasibility Study. The 50-year design flow, once approved by the NHDES Dam Bureau, will become the Spillway Design Flood for Great Dam and consequently the discharge rate to which future dam modification geometries will be designed. The hydrologic analysis was conducted in accordance with New Hampshire Code of Administrative Rules Env-Wr 403.05 – "Hydrologic Investigations."

To determine the Great Dam design flows in accordance with Env-Wr 403.05, Weston & Sampson developed a rainfall-runoff model to simulate the reaction of the Exeter River Watershed ("the Watershed") to specific rainfall events. The rainfall-runoff model ("the model") was constructed using the Army Corps of Engineers Hydrologic Engineering Center's software package HEC-HMS v.3.4, which generally employs the TR-20 methodology developed by the Soil Conservation Service (SCS) of the US Department of Agriculture. These methodologies were developed to estimate the response of a watershed(s) to specified rainfall depths and distributions based on a few defining watershed characteristics. Weston & Sampson estimated these watershed parameters from publically available geospatial datasets and from field observations gathered during other recent projects for the Town of Exeter. The model was then used to simulate rainfall events equivalent to the 2-, 10-, 50-, and 100-year recurrence interval depths most recently released through the collaboration of the Northeast Regional Climate Center and the National Resources Conservation Service. The resulting runoff hydrographs and peak discharge values were finally compared against the design flow estimates reported in Weston & Sampson's Technical Memorandum of January 4th, 2012.

The following report summarizes the development and results of that analysis and is submitted to the New Hampshire Dam Bureau for review such that the 50-year design flow may be accepted as Great Dam's Spillway Design Flood for design purposes.

2.0 MODEL DEVELOPMENT

2.1 Overview

The rainfall-runoff model was developed within the HEC-HMS software platform using the TR-20 methodology that has represented the widespread standard in rainfall-runoff estimation for more than three decades. TR-20 methodology estimates a watershed’s response to specific rainfall events from a relatively small number of watershed parameters, including: drainage area, development and land use characteristics, hydrologic soil groups, NRCS runoff coefficient (curve number), initial abstraction, and time of concentration. Weston & Sampson estimated each of these parameters by analyzing publically available geospatial datasets and from field observations made by Weston & Sampson staff during recent work for the Town of Exeter for the Great Dam Removal Feasibility Study and other projects. The estimation of each of the watershed parameters that served as input to the rainfall-runoff model is discussed in the following sub-sections. A map of the Exeter River Watershed, Figure 1, is attached in Appendix A. A table summarizing the watershed parameters that were incorporated into the rainfall-runoff model, Table 1, is attached in Appendix B.

2.2 Drainage Area

When developing a rainfall-runoff model of any watershed, it is often necessary to break a watershed up into multiple sub-basins in order to adequately capture the nuances of its hydrology. Most watersheds, particularly relatively large watersheds like that of the Exeter River, are not homogenous. Different areas of a watershed may be hydrologically different from one another, resulting in dramatically different runoff patterns. TR-20 guidance documents suggest that for rural watersheds, sub-basins range in size from 1 to 2000 acres.

Weston & Sampson delineated the 107.3 mi^2 Exeter River Watershed upstream of Great Dam into 53 distinct sub-basins, yielding an average sub-basin area of approximately 1,300 acres. Those 53 sub-basins were delineated by modifying the sub-basin mapping conducted by the NH Geological Survey (NHGS) of the NH Department of Environmental Services during their recent *Stressed Basins Project*. During completion of the Stressed Basins Project, the NHGS subdivided the entire state of New Hampshire into thousands of discrete geographic units with an average size of 0.5 mi^2 or 320 acres. Those units were delineated for every stream confluence and for the outlet of all waterbodies of more than 5 acres. While this sub-basin mapping is not yet available online, Weston & Sampson obtained the geospatial mapping of these sub-basin units for the Exeter River Watershed through email correspondence with Rick Chormann and Gregory Barker of the NHGS on April 12, 2012.

As the NHGS sub-basins were developed in support of a statewide application, Weston & Sampson reviewed the delineation of the NHGS sub-basins located within the Exeter River Watershed for any discrepancies on a more local scale. Weston & Sampson conducted a first pass review by overlaying the NHGS sub-basins over standard USGS topographic maps, identifying fifteen to twenty areas that appeared to be delineated erroneously. Some examples of these areas include: the boundary between ER11 and ET2 sub-basins, the southwest edge of PP2, the boundary between YB1 and GB3, the northwest edge of SS1, and the outer edges of BB1 among others. In general, these questionable boundaries occurred in areas of relatively low topographic relief, sometimes through the middle of extensive wetland complexes, in which sub-basin delineations is particularly susceptible to slight changes or errors in topographic mapping. Based on personal communication with Rick Chormman of the NHGS, Weston & Sampson learned that the NHGS catchments were delineated based on the 1-Arc Second Digital Elevation Model (DEM) available from the USGS. Elevation contours developed from this DEM are of greater density and precision than the 10- or 20-foot interval contours that appear on standard USGS topographic quadrangles. Given the method of their delineation, it is not surprising that discrepancies appear when the NHGS sub-basins are overlaid on the inferior USGS topographic quadrangles.

Weston & Sampson reviewed the fifteen to twenty discrepancies, identified during the initial review, in greater detail. The discrepancies were first reviewed against the NHD Waterways shapefile to ensure that the sub-basin delineation was supported by the reported Stream Order. The discrepancies were then compared against publically available orthographic and/or bird's eye images to look for flow patterns or differences in water quality that would confirm or deny the appropriateness of the NHGS delineation. Lastly, the discrepancies were reviewed against the finer resolution DEM employed by the NHGS. Based on this detailed review of the NHD Waterways shapefile, aerial images, bird's eye images, and the 1-Arc Second DEM, Weston & Sampson found no location in the Exeter River Watershed in which a NHGS sub-basin was clearly delineated erroneously. Given these circumstances and the superiority of the data used by NHGS to delineate their 600+ sub-catchments, Weston & Sampson accepted the NHGS sub-catchments as the best available data.

This Exeter River watershed subset of the statewide mapping effort consisted of more than 600 individual hydrologic units. In order to facilitate the development of the rainfall-runoff model, Weston & Sampson consolidated these units by comparing the delineation of these NHGS units against the drainage patterns of the Exeter River Watershed as noted on USGS topographic maps and the NHD Waterways shapefile and merged units of similar hydrologic character. While many of the 600+ NHGS sub-basins were merged, at no time were sub-basin boundaries altered. Ultimately, Weston & Sampson modified the NHGS mapping to represent the Exeter River Watershed with 53 sub-basins as shown in Figure 1 (attached in Appendix A). These sub-basins ranged in area from 0.87 mi^2 to 3.66 mi^2 with an average area of 2.02 mi^2. The total area of these 53 sub-basins, 107.3 mi^2, precisely matches the drainage area reported in Weston & Sampson's Technical Memorandum dated January 4th, 2012, regarding the estimation of Great Dam design flows using statistical analyses of historical streamflow data.

2.3 Sub-Basin Loss

The TR-20 methodology, the "SCS Curve Number" method, estimates both the quantity and timing of runoff from watershed sub-basins in response to specified rainfall events. To determine the quantity of runoff from each sub-basin, TR-55 employs a runoff coefficient, the NRCS Curve Number to determine the depth of rainfall that is initially absorbed by the land, the Initial Abstraction. The NRCS Curve Number is a function of hydrologic soil grouping and land cover type. Hydrologic soil grouping estimates the drainage capacity of the soil and is categorized into four levels A, B, C, and D, with 'A' type soils having a greater infiltration capacity than 'D' type soils. The Exeter River Watershed contains significant areas of all four hydrologic soil groupings. Land cover represents the type of development present. In the Exeter River Watershed, land cover types of "Forested," "Wetland," and "Residential" are typical though other land covers are present.

To estimate the Curve Number of each sub-basin, Weston & Sampson referred to the geospatial datasets of soil type and land cover available from the NRCS GeoSpatial Data Gateway, accessed on April 11th, 2012. Overlaying both the soil and land use maps for the Exeter River Watershed over the 53 sub-basins yielded roughly 19,000 polygons of distinct combinations of those three datasets. Weston & Sampson estimated the Curve Number associated with each of the 19,000 polygons by matching the combination of NRCS hydrologic soil grouping and land cover type of each polygon with an appropriate Curve Number value as identified in numerous sources. A table of the Curve Numbers that were associated by Weston & Sampson with each of those combinations of soil type and land cover are provided in Table 2 below.

The Curve Numbers associated with each of the 53 sub-basins in the Exeter River watershed were determined by areally-weighting the Curve Numbers of each of the nearly 19,000 polygons of distinct soil type and land cover combinations. The number of polygons contained within the 53 sub-basins ranged from a minimum of 105 to a maximum of 667. The Curve Numbers of the 53 sub-basins of the Exeter River Watershed that were employed in the rainfall-runoff model are shown in Table 1 (attached in Appendix B).

TR-20 methodology estimates the initial abstraction, I_a, of a sub-basin directly from its Curve Number, CN, with the equation: $I_a = 0.2 \times [(1000/CN) - 10]$. The initial abstraction, the depth of rainfall that would be expected to be absorbed into the ground rather than contribute to runoff, is also provided in Table 1 (attached in Appendix B) for each sub-basin.

Table 2: Curve Number Values for Soil Type/Land Cover Combinations

NRCS Land Cover	Hydrologic Soil Group			
	A	B	C	D
Residential	54	70	80	85
Industrial/Commercial	81	88	91	93
Mixed Urban	77	85	90	92
Transportation/Roads	98	98	98	98
RR Beds	98	98	98	98
Aux. Transportation	98	98	98	98
Playing Fields/Recreational	49	69	79	84
Agriculture	63	75	83	87
Farmsteads	59	74	82	86
Forested	36	60	73	79
Water	98	98	98	98
Wetlands	98	98	98	98
Idle/Other	49	69	79	84

2.4 Sub-Basin Transform

Rainfall that is not absorbed within the sub-basins, rainfall that is available for runoff, is characterized in TR-20 methodology (the SCS Unit Hydrograph method) by the parameter of Time of Concentration. The Time of Concentration for a sub-basin is the time it would take for runoff to travel along the longest flowpath (by time, not distance) from the far edge of that sub-basin to its mouth. While the Times of Concentration were originally estimated for the draft version of the rainfall-runoff model with the TR-55 multi-segment methodology developed by the NRCS, the Times of Concentration incorporated into the final version of the model were developed using the 1961 Mockus Lag equation as recommended by the NHDES at a June 2012 meeting.

As presented in the NRCS National Engineering Handbook, Part 630 Hydrology, Chapter 15 Time of Concentration, the 1961 Mockus lag equation defines Time of Concentration as follows:

$$T_c = \frac{l^{0.8}(S+1)^{0.7}}{1{,}140Y^{0.5}},$$

where T_c = Time of Concentration (hours)
l = length of the longest flowpath (feet)
S = maximum potential retention, approximated by a basin's CN (inches)
Y = average basin slope (%)

Weston & Sampson determined the length of the longest flow path in each of the 53 sub-basins by reviewing topographic contours and using GIS tools to trace its length to the nearest foot. Generally, the "longest" flowpath is meant to be the path from basin edge to basin mouth that would take a raindrop the longest time to travel. Due to shallow slopes or the lack of a defined channel or the presence of a wetland complex, this path may differ from the flowpath with the longest length. However, as the remaining variables in the 1961 Mockus lag equation are basin averages, these two versions of the "longest" flowpath are equivalent under this methodology.

The maximum potential retention is defined as S = (1000/*cn'*) – 10, where *cn'* is known as the retardance factor. The retardance factor is a measure of the surface conditions of a basin and, for most practical applications, may be approximated by the SCS Curve Number, CN, for those basins with Curve Numbers between 50 and 95. Weston & Sampson estimated S for each of each of the 53 sub-basins by applying the above equation to the Curve Numbers presented in Table 1 (attached in Appendix B).

According to the NRCS National Engineering Handbook, the average basin slope, Y, may be estimated in several ways of varying degrees of accuracy. Weston & Sampson estimated the average basin slope from the slope data included in the NRCS soil shapefile dataset discussed above in Section 2.3. The NRCS soil shapefile provides the approximate range of land surface slopes for each distinct polygon of soil type. An average slope for each distinct polygon could be determined by taking the average of the low and high end of the NRCS-provided range. By weighting the average slope of each of the 19,000 polygon combinations of soil, land cover, and sub-basins against its size relative to its sub-basin, Weston & Sampson estimated the average land surface slope for each of the 53 sub-basins. This method provided the most accurate estimate of average sub-basin slope given the available data.

Based on these three variables, length of the longest flowpath, maximum potential retention, and average basin slope, Weston & Sampson estimated the Time of Concentration for each of the 53 sub-basins within the Exeter River Watershed. In implementing the TR-20 method, the HEC-HMS modeling platform employs the parameter, "basin lag," instead of Time of Concentration. In the National Engineering Handbook, the NRCS defines basin lag as simply 60% of the Time of Concentration. Both the estimated Times of Concentration and the equivalent basin lag times for the 53 sub-basins used in the rainfall-runoff model are provided in Table 1 (attached in Appendix B). The worksheet used to calculate those estimates and three intermediate variables, discussed above, are attached in Appendix C1.

2.5 River Reach Lag

The parameters detailed in the previous sections, namely drainage area, SCS Curve Number, and Time of Concentration, are the only three parameters required to estimate the runoff hydrograph of a sub-basin using the NRCS' TR-20 method. However, as the Exeter River Watershed is 107.3 mi^2, and was delineated into 53 sub-basins, it was important to estimate the delay or lag time experienced by floodwaters as they move from the watershed headwaters downstream to Great Dam and incorporate that lag into the rainfall-runoff model. Based on the delineation of the 53 sub-basins and their position within the larger Exeter River Watershed, a total of 22 river reaches were required to connect each of the sub-basins with the mouth of the Exeter River.

While the lag times for each of the 22 reaches were originally estimated with the often-used Manning's Equation for open channel flow, the final model incorporated lag times determined using the Muskingum-Cunge 8-point method as recommended by the NHDES at a June 2012 meeting. The Muskingum-Cunge method is a relatively robust means of estimating the speed at which a flood wave travels downstream and retains its accuracy and consistency over a wide range of physical conditions. Unlike many other simpler methods, the Muskingum-Cunge method allows for the reach lag time to vary with flow rate. To do so, the Muskingum-Cunge method (M-C method) develops a stage-discharge relationship for each reach based on a typical cross-section and a channel roughness parameter for that reach. The standard M-C method uses a four point cross-section, in which the river channel is defined by two bank points and two channel bottom points. The M-C method also supports the use of a more complicated eight point cross-section in which the floodplain is defined in addition to the main channel. Weston & Sampson employed the eight point version of the Muskingum-Cunge method as significant floodplain flow would be expected during large flood events.

The eight point Muskingum-Cunge method of estimate reach lag requires several variables, including reach length, reach slope, the roughness coefficient Manning's n, and the eight points that define the typical cross-section. Weston & Sampson determined reach lengths by using GIS tools to trace the length the centerline of each reach to the nearest foot. The slope of each reach was determined by calculating the total vertical drop of the reach using topographic contours and dividing by the total length. A Manning's roughness coefficient was estimated for each reach based on typical values for streams with similar width, depth, sinuosity, and the presence or lack of boulders, bars, and organics as captured in aerial images. The eight points used to define a typical cross-section for each reach were estimated from topographic contours and aerial images. The eight points consist of four pairs of points that represent each side of the river channel bottom, the river bank, the edge of the floodplain, and a point on the valley wall. Weston & Sampson estimated the length between the channel bottom points from the top width visible in aerial images. The width between river banks was also estimate from aerial images, and the vertical distance between the channel bottom and the top of the river banks was estimated from the apparent depth in aerial images and the reach's relative location within the larger watershed. The edges of the reaches' floodplain were determined by both reviewing aerial images for changes in tree and plant cover as well as reviewing topographic contours for rapid change sin slope. The elevation of and distance between the edges of the delineated floodplains were in turn measured from the topographic contours. The elevation and distance between the fourth and final pair of points, representing the valley walls, were also determined from topographic contours.

In this manner, Weston & Sampson developed a representative cross-section for each of the 22 reaches. The eight cross-section points, along with the reach length, slope, and roughness coefficient, were subsequently incorporated into the HEC-HMS model. The values of those parameters for each river reach are attached in Appendix C2.

2.6 Impoundments & Wetlands

In addition to sub-basin lag time and the lag time associated with river reaches, the routing of runoff within the Exeter River Watershed is strongly influenced by the presence of numerous impoundments found upstream of dams, bridges, wetlands, and natural channel narrows. These impoundments and wetlands serve to delay and attenuate runoff from throughout the watershed and strongly influence the timing and peak rate of runoff at Great Dam. These impoundments and wetlands are generally not adequately captured by the standard sub-basin parameters used by TR-20. Instead, Weston & Sampson incorporated them into the model as "reservoirs." Ultimately, Weston & Sampson identified and modeled sixteen impoundments that appear to have a significant impact on flood routing in the Exeter River Watershed. A summary table of the naming scheme, location, hydraulic control, and any related wetland IDs for each impoundment is attached in Appendix C3.

Each of those impoundments or reservoirs was incorporated into the HEC-HMS model as defined by a stage-storage-discharge relationship. By defining the relationship between each of these three parameters, the HEC-HMS modeling platform is able to simulate how inflow and outflow rates to/from each impoundment affects its stage and how the changing stage affects the discharge rate from its control structure. The stage-storage-discharge relationships used to incorporate each of the sixteen impoundments into the model are attached in Appendix C4.

The stage-storage relationship for each impoundment was determined from topographic maps. Weston & Sampson employed GIS tools to calculate the surface area associated with the topographic contours, generally 2-4 contours, at or above the bankfull elevation at each impoundment. Using the equation for a trapezoidal prism, Weston & Sampson used the surface area at each contour and the vertical distance between contours to estimate the storage volume between each pair of contours. In many instances, it was necessary to estimate by interpolation the flood storage associated with water levels in between the available topographic contours.

The stage-discharge relationship for each impoundment was developed by applying the equation for a broad-crested weir to the control structure for each impoundment. The lengths and widths associated with those "weirs" were estimated from aerial imagery, bird's eye imagery, topographic mapping, information from the National Inventory of Dams (NID), and field measurements where available. For impoundments controlled by dams, this method consisted of:

1) Identifying primary and auxiliary spillways;
2) Approximating the elevations of those spillway crests from topographic mapping and USGS Digital Elevation Models;
3) Identifying the length of those spillways from the NID or estimating them from aerial imagery;
4) Estimate the elevation of the dam crest from topographic mapping and USGS Digital Elevation Models;
5) Identify the length of the dam crest from the NID or estimate the length from aerial imagery;
6) Measure the length, perpendicular to flow, for the next highest topographic contour; and
7) Apply the broad-crested weir discharge equation to the elevation and length information gathered during |Steps 1-6 and develop stage-discharge data pairs at 1-foot intervals.

The method used to develop stage-discharge relationships for impoundments controlled by bridges was quiet similar, except that Steps 1-3 were focused on the span beneath the bridge and Steps 4-6 were focused on the bridge deck itself. While applying the broad-crested weir equation is perfectly appropriate for flood-stage discharge at a dam, the appropriateness of its application to a bridge is less clear. In general, discharge beneath a bridge would be less than that of a weir of the same dimensions due to backwatering from the river channel immediately downstream of the bridge. Weston & Sampson accounted for this issue to some degree by using a lower coefficient of discharge, 2.6, than might be used for a dam crest; however, the discharge rates used to define bridge controlled impoundments are likely still overestimated to a modest degree. Given the purpose of the rainfall-runoff model, namely to estimate peak discharge rates downstream at Great Dam, overestimation of discharge from bridge-controlled impoundments would generally produce a conservatively high discharge downstream.

It could be argued that overestimating discharge rate from one area of the watershed relative to another area could serve to separate the timing of peak discharge from the two areas and ultimately yield a lower peak discharge downstream. Weston & Sampson reviewed the characteristics of the Exeter River rainfall-runoff model to ensure that that issue was not occurring. Weston & Sampson found that the Exeter River Watershed can be readily broken up into three major basins: the Little River basin in the northeast, the Great Brook Basin in the southeast, and the Exeter River Headwaters in the west. The Little River and Great Brook Basins are of similar size and hydrologic character and peak considerably earlier than the much larger, more remote Exeter River Headwaters. In addition, the Exeter River Headwaters drains down the main stem of the Exeter River, which is relatively more impounded than the two smaller basins. If discharge from bridge-controlled impoundments was modestly overestimated, the moment of peak discharge from the Exeter River Headwaters would be more heavily influenced than that of the two smaller basins and would occur closer to the other two peaks than it might otherwise. This pattern would serve to increase the estimated peak discharge downstream; developing the stage-storage-discharge relationships and modeling the significant impoundments of the Exeter River Watershed in the manner described above would produce a conservative estimate of peak discharge at Great Dam.

3.0 MODEL RESULTS

The calibrated rainfall-runoff model was subsequently used to estimate the 2-, 10-, 50-, and 100-year design flows for Great Dam. The design rainfall depths, assumed to fall homogenously over the entire Exeter River Watershed, were obtained for the approximate center of the Exeter River Watershed from the online tool developed by the Northeast Regional Climate Center and the National Resources Conservation Service.

Table 3: Design Rainfall Depths

Recurrence Interval	Rainfall Depth (in.) by Storm Duration									
(years)	5 min	15 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day
2-year	0.32	0.62	1.02	1.30	1.52	1.94	2.49	3.10	3.44	3.94
10-year	0.42	0.83	1.48	1.92	2.25	2.92	3.78	4.72	5.34	6.09
50-year	0.54	1.12	2.16	2.85	3.34	4.39	5.75	7.20	8.32	9.41
100-year	0.61	1.27	2.54	3.39	3.98	5.25	6.89	8.64	10.07	11.37

The rainfall depths, provided in Table 3, were incorporated into the HEC-HMS rainfall-runoff model as "frequency storms," which are used to develop a precipitation event where depths for various durations within the storm have a consistent exceedance probability. The 2-, 10-, 50-, and 100-year design events were modeled as 24-hour frequency storms with the peak rainfall intensity occurring at exactly halfway through the storm duration.

Executions of these four simulations of the HEC-HMS model were conducted without any significant issues. All of the input variables used to define the various sub-basins, reaches, impoundments, and rainfall events were compiled without triggering any "warnings" or "errors." Runoff routing calculations were completed for all sub-basins and impoundments without any warnings or errors as well. Two warnings were triggered as the HEC-HMS software calculated the stage-discharge relationship for two of the 22 river reaches. As noted in Section 2.5, the Muskingum-Cunge method that was selected to model the lag time associated with the river reaches calculates that stage-discharge relationship through an iterative process. In two instances, R-FB1, a section of Fordway Brook, and R-GB1, a section of Great Brook, the HEC-HMS model platform was unable to estimate that relationship to within an ideal tolerance and issued a "warning" to that effect. As noted in those warning messages, while the stage-discharge relationship was not resolved to within an ideal tolerance, the remaining discrepancies were less than 0.002 feet, an acceptable discrepancy given the assumptions behind many of the model input variables. The HEC-HMS model platform completed all remaining calculations without issue, yielding the design flow estimates provided in Table 4.

Table 4: Rainfall-Runoff Design Flow Results for Great Dam

Recurrence Interval	Design Flow at Great Dam (cfs)
(years)	Rainfall-Runoff Model
2-year	530
10-year	2,117
50-year	5,858
100-year	8,656

It should be noted that the design flows reported in Table 4 are derived from the sum of the modeled peak discharge hydrographs from the Pickpocket Dam impoundment, from the Little River Watershed, from the Great Brook Watershed, and from the minor direct drainages to the Exeter River between Pickpocket Dam and Great Dam. At flood stage, all of these sources drain directly, or nearly so in the case of Pickpocket Dam, into the Great Dam impoundment. While some reservoir routing is expected to occur through the Great Dam impoundment, it is not expected to impact, let alone increase, the estimated peak discharge rate at Great Dam. Similarly, the High Street bridge, located immediately upstream of Great Dam, would only serve to decrease flow at the dam during flood stage. As the primary purpose of this rainfall-runoff model was to estimate the 50-year recurrence interval design flow at Great Dam, not to estimate freeboard at the dam, the Great Dam impoundment was not included in the model. For future design of a dam modification alternative in support of the Great Dam Removal Feasibility Study, an existing, detailed, NHDES-approved HEC-RAS river channel model will be used to estimate freeboard and other necessary hydraulic characteristics at Great Dam.

4.0 DISCUSSION

The intent of this modeling effort is to use the methods prescribed by the New Hampshire Code of Administrative Rules Env-Wr 403.05 – "Hydrologic Investigations" to determine the design flows for four recurrence interval flood events for the Great Dam in Exeter, New Hampshire. Prior to this effort, an assumption was made by many, including the DES Dam Bureau that the 50-year flow event on file was determined using the methods described in Env-Wr 403.05. In fact, the magnitude of that 50-year design event was referenced by the NHDES in their 2004 Letter of Deficiency to the Town of Exeter, regarding the discharge capacity of Great Dam. Upon further examination by the DES during the course of this projcet, it was found that the 50-year design flow value was an estimate based upon an inspection report dated July 12, 2000, from Grace Levergood, P.E., Dam Safety Engineer with NHDES. This report presented peak flows for 50- and 100-year events, and the information was apparently developed using both USGS regression equations and peak flows calculated using data obtained from USGS stream gaging stations (Exeter River Study Interim 2005 Report, Wright-Pierce). The values on file for both the 50-year and 100-year recurrence intervals were reported to be 4,416 and 4,949 cfs respectively for a drainage area of 102.7 square miles, a point which is located between the dam and the confluence of the Little River. If these values are to be basin averaged for the actual dam location, with a drainage area of 107.3 square miles, the 50-year and 100-year recurrence interval discharge rates are 4,614 and 5,171 cfs, respectively.

In the fall of 2010, the Town of Exeter solicited for proposals from qualified engineering firms to conduct the Dam Removal Feasibility and Impact Analysis for the Great Dam in Exeter, NH. During the selection process, several stakeholders expressed an interest in accounting for climate change in the flow estimates. In response to this, the VHB/Weston & Sampson team proposed a methodology guided by the following NOAA publication FS-2011-01, "Flood Frequency Estimates for New England River Restoration Projects: Considering Climate Change in Project Design". According to NOAA FS-2011-01, over the past decade, numerous academic and governmental studies have identified an increase in the frequency and magnitude of significant flood events throughout the United States, including New England. As these events grow in magnitude and frequency, so too must the design flows that guide the design and construction of American infrastructure. NOAA cites several studies that find this increase in flooding occurred, not as a slow progression over many years or decades, but rather as a step change that occurred in approximately 1970 (NOAA Fisheries Service, 2011). For this reason, NOAA recommends that river restoration projects recognize the potential impacts of this step change in New England climate by comparing design flows estimated from streamflow records pre- and post-1970. The results of this analysis completed under the guidance of both NOAA FS-2011-01 and the USGS publication Bulletin 17B (Guidelines for Determining Flood Flow Frequency) were presented in a technical memo submitted to the Town of Exeter on January 4th, 2012. The results suggest that the 50-year and 100-year recurrence intervals are 5,718 and 7,109 cfs respectively.

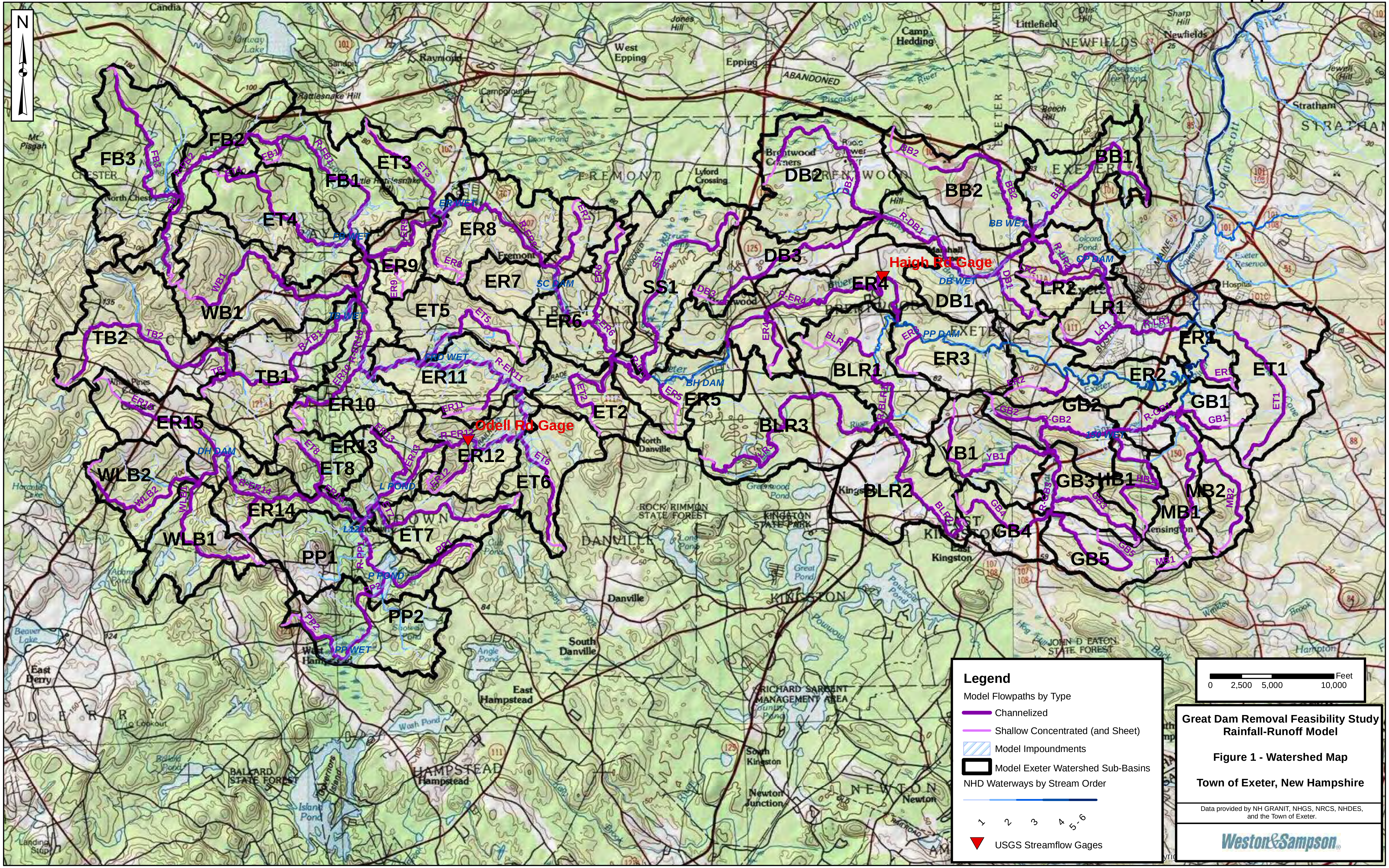
The modeling effort reported herein was conducted to calculate a 50-year design flow for the Great Dam, developed in compliance with NHDES guidelines. That design flow will be used in future efforts to assess the feasibility of a dam modification alternative as part of the Great Dam removal feasibility study. Table 5 below provides a summary of the aforementioned estimates of the various design flows.

Table 5: Summary of Design Flow Estimates at Great Dam from Various Studies

Recurrence Interval	Design Flow at Great Dam (cfs)		
(years)	DES Dam File	Rainfall-Runoff Model	Bulletin 17B (Post 1970)
2-year	-	530	1,481
10-year	-	2,117	3,245
50-year	4,614	5,858	5,718
100-year	5,171	8,656	7,109

APPENDIX A

Figure 1: Watershed Map


N
Legend
Model Flowpaths by Type
Channelized
Shallow Concentrated (and Sheet)
Model Impoundments
Model Exeter Watershed Sub-Basins
NHD Waterways by Stream Order
1 2 3 4 5 - 6
USGS Streamflow Gages
Feet
0 2,500 5,000 10,000
Great Dam Removal Feasibility Study
Rainfall-Runoff Model
Figure 1 - Watershed Map
Town of Exeter, New Hampshire
Data provided by NH GRANIT, NHGS, NRCS, NHDES, and the Town of Exeter.
Weston&Sampson
Haigh Rd Gage
Odell Rd Gage
FB3
FB2
FB1
ET3
ET4
ER8
ER9
ER7
ET5
ER6
SS1
DB3
DB2
BB2
BB1
ER4
DB1
LR2
LR1
WB1
TB2
TB1
ER11
ER10
ER15
ER13
ER12
ET8
ET2
ER5
BLR1
BLR3
ER3
ER2
ER1
ET1
GB2
GB1
YB1
GB3
HB1
MB2
MB1
BLR2
GB4
GB5
WLB2
WLB1
ER14
ET6
ET7
PP1
PP2
SC DAM
BH DAM
DH DAM
PP DAM
CP DAM
DB WET
BB WET
L POND
P POND
PP WET
ROCK RIMMON STATE FOREST
KINGSTON STATE PARK
RICHARD SARGENT MANAGEMENT AREA
JOHN D EATON STATE FOREST
BALLARD STATE FOREST
HAMPSTEAD
KINGSTON
NEWTON
DANVILLE
FREMONT
EXETER
STRATHAM
Candia
Raymond
West Epping
Epping
Brentwood Corners
Fremont
North Danville
Danville
South Danville
East Hampstead
Hampstead
Kingston
East Kingston
Newton Junction
Newton
South Kingston
East Derry
Newfields
Stratham

APPENDIX B

Table 1: Model Parameter Summary Table

NEW Model Parameter Summary Table

Sub-Basin ID	Area (mi^2)	Curve Number	Initial Abstraction (in.)	Time of Concentration (min.)
BB1	1.98	67.5	0.96	181
BB2	2.69	74.4	0.69	220
BLR1	2.51	67.3	0.97	105
BLR2	2.39	66.6	1.00	190
BLR3	3.66	60.6	1.30	346
DB1	2.60	69.3	0.89	90
DB2	3.33	71.5	0.80	199
DB3	1.87	68.3	0.93	198
ER1	0.95	72.6	0.75	84
ER10	2.29	65.8	1.04	123
ER11	2.22	65.7	1.04	86
ER12	1.81	66.3	1.02	78
ER13	1.40	69.3	0.89	104
ER14	1.31	63.1	1.17	118
ER15	2.00	74.0	0.70	134
ER2	2.23	69.3	0.89	89
ER3	2.01	70.1	0.86	59
ER4	3.53	63.8	1.13	81
ER5	1.61	62.2	1.21	87
ER6	2.10	63.4	1.16	177
ER7	1.66	63.0	1.17	98
ER8	2.34	58.5	1.42	107
ER9	0.99	67.4	0.97	55
ET1	2.72	70.2	0.85	193
ET2	1.25	69.8	0.87	117
ET3	1.72	67.3	0.97	112
ET4	2.47	67.6	0.96	155
ET5	1.77	71.2	0.81	178
ET6	1.69	66.2	1.02	146
ET7	1.44	66.0	1.03	136
ET8	1.12	63.4	1.16	117
FB1	2.20	70.1	0.85	32
FB2	2.02	71.5	0.80	79
FB3	3.38	68.6	0.92	131
GB1	1.36	73.5	0.72	91
GB2	1.40	73.0	0.74	67
GB3	1.12	74.0	0.70	94
GB4	1.07	74.2	0.70	113
GB5	1.31	76.8	0.60	110
HB1	0.87	71.2	0.81	126
LR1	1.84	72.4	0.76	153
LR2	1.48	68.8	0.91	95
MB1	1.55	64.1	1.12	236
MB2	1.04	67.1	0.98	190
PP1	2.71	70.2	0.85	86
PP2	2.43	68.4	0.92	149
SS1	2.97	69.0	0.90	241
TB1	2.80	70.2	0.85	47
TB2	3.48	68.2	0.93	178
WB1	3.18	65.7	1.04	187
WLB1	1.81	68.7	0.91	125
WLB2	1.65	70.6	0.83	133
YB1	1.92	72.8	0.75	162

APPENDIX C

Supporting Calculations and Documentation

Sub-Basin Lag Time Calculations

Sub-Basin	Flow Length, ft	Avg. Slope, %	SCS CN	SCS S	Tc, h	Tc, min	Basin Lag, h	Basin Lag, min
BB1	17874	6.4	67.5	4.8	3.01	180.5	1.81	108.3
BB2	20243	3.6	74.4	3.4	3.66	219.8	2.20	131.9
BLR1	8150	5.4	67.3	4.9	1.75	104.9	1.05	62.9
BLR2	16285	5.2	66.6	5.0	3.16	189.9	1.90	113.9
BLR3	27476	4.9	60.6	6.5	5.76	345.8	3.46	207.5
DB1	7601	5.9	69.3	4.4	1.51	90.4	0.90	54.2
DB2	19693	4.9	71.5	4.0	3.31	198.8	1.99	119.3
DB3	19742	5.9	68.3	4.6	3.31	198.4	1.98	119.0
ER1	4686	2.6	72.6	3.8	1.41	84.3	0.84	50.6
ER10	10975	6.9	65.8	5.2	2.04	122.7	1.23	73.6
ER11	6194	5.6	65.7	5.2	1.44	86.1	0.86	51.7
ER12	7485	8.9	66.3	5.1	1.31	78.4	0.78	47.0
ER13	12678	10.0	69.3	4.4	1.74	104.5	1.04	62.7
ER14	15691	15.1	63.1	5.8	1.97	118.4	1.18	71.0
ER15	16821	7.4	74.0	3.5	2.23	134.1	1.34	80.4
ER2	6512	4.7	69.3	4.4	1.48	88.9	0.89	53.4
ER3	5088	6.9	70.1	4.3	0.99	59.3	0.59	35.6
ER4	5994	6.6	63.8	5.7	1.35	81.1	0.81	48.6
ER5	5876	6.1	62.2	6.1	1.44	86.6	0.87	52.0
ER6	14972	6.2	63.4	5.8	2.94	176.6	1.77	105.9
ER7	7641	7.0	63.0	5.9	1.63	98.0	0.98	58.8
ER8	8096	8.1	58.5	7.1	1.78	107.1	1.07	64.3
ER9	4744	8.4	67.4	4.8	0.91	54.6	0.55	32.8
ET1	14692	3.5	70.2	4.2	3.22	193.1	1.93	115.9
ET2	12617	7.7	69.8	4.3	1.95	117.1	1.17	70.3
ET3	10284	7.0	67.3	4.9	1.86	111.5	1.12	66.9
ET4	16871	7.8	67.6	4.8	2.58	154.7	1.55	92.8
ET5	19892	6.4	71.2	4.1	2.96	177.6	1.78	106.6
ET6	16757	9.4	66.2	5.1	2.43	145.9	1.46	87.5
ET7	16415	10.6	66.0	5.2	2.27	136.2	1.36	81.7
ET8	13027	11.4	63.4	5.8	1.94	116.7	1.17	70.0
FB1	2908	9.8	70.1	4.3	0.53	31.7	0.32	19.0
FB2	9579	9.8	71.5	4.0	1.32	79.4	0.79	47.6
FB3	16253	9.8	68.6	4.6	2.18	130.8	1.31	78.5
GB1	5982	3.1	73.5	3.6	1.52	91.2	0.91	54.7
GB2	6962	7.5	73.0	3.7	1.12	67.3	0.67	40.4
GB3	9739	6.2	74.0	3.5	1.57	94.2	0.94	56.5
GB4	11825	5.8	74.2	3.5	1.89	113.3	1.13	68.0
GB5	13976	6.8	76.8	3.0	1.84	110.3	1.10	66.2
HB1	15116	8.2	71.2	4.0	2.09	125.6	1.26	75.4
LR1	12374	3.7	72.4	3.8	2.56	153.4	1.53	92.1
LR2	8138	6.1	68.8	4.5	1.58	94.9	0.95	57.0
MB1	19185	5.0	64.1	5.6	3.94	236.2	2.36	141.7
MB2	16756	5.3	67.1	4.9	3.17	190.3	1.90	114.2
PP1	10441	10.2	70.2	4.2	1.44	86.3	0.86	51.8
PP2	17063	8.2	68.4	4.6	2.48	149.0	1.49	89.4
SS1	22512	4.8	69.0	4.5	4.01	240.9	2.41	144.5
TB1	3670	6.3	70.2	4.3	0.79	47.5	0.47	28.5
TB2	23162	9.5	68.2	4.7	2.97	178.4	1.78	107.0
WB1	22583	9.4	65.7	5.2	3.12	187.2	1.87	112.3
WLB1	13578	8.1	68.7	4.6	2.08	124.7	1.25	74.8
WLB2	14258	6.9	70.6	4.2	2.22	133.0	1.33	79.8
YB1	16433	5.2	72.8	3.7	2.70	161.8	1.62	97.1

Muskingum-Cunge Reach Routing Parameters

Reach	Length, feet	Slope, ft/ft	Manning's n	1X, ft	1Y, ft	2X, ft	2Y, ft	3X, ft	3Y, ft	4X, ft	4Y, ft	5X, ft	5Y, ft	6X, ft	6Y, ft	7X, ft	7Y, ft	8X, ft	8Y, ft
R-BLR1	1029	0.01276	0.06	0	80	45	76	115	76	118	73	132	73	135	76	205	76	250	80
R-DB1	18268	0.00126	0.08	0	90	200	85	341	85	344	82	356	82	359	85	500	85	700	90
R-ER10	13167	0.00100	0.06	0	170	60	164	179	164	182.5	160.5	217.5	160.5	221	164	340	164	400	170
R-ER11	17074	0.00038	0.06	0	180	210	172	531.5	172	535	168.5	575	168.5	578.5	172	900	172	1110	180
R-ER12	13783	0.00119	0.06	0	180	60	172	394	172	397.5	168.5	442.5	168.5	446	172	780	172	840	180
R-ER13	10887	0.00211	0.04	0	210	65	203	89.5	203	92.5	200	127.5	200	130.5	203	155	203	220	210
R-ER14	14869	0.00508	0.04	0	230	25	226	42.5	226	45	223.5	75	223.5	77.5	226	95	226	120	230
R-ER15	14869	0.00154	0.05	0	310	80	305	115	305	117.5	302.5	142.5	302.5	145	305	180	305	260	310
R-ER4	25413	0.00181	0.04	0	90	65	80	115.5	80	120	75.5	180	75.5	184.5	80	235	80	300	90
R-ER5	5013	0.00065	0.05	0	140	90	130	143	130	147.5	125.5	202.5	125.5	207	130	260	130	350	140
R-ER6	13376	0.00074	0.06	0	150	155	140	243.5	140	247.5	136	312.5	136	316.5	140	405	140	560	150
R-ER8	14664	0.00090	0.06	0	160	100	154	194	154	197.5	150.5	252.5	150.5	256	154	350	154	450	160
R-ER9	9870	0.00033	0.05	0	160	65	155	116.5	155	120	151.5	170	151.5	173.5	155	225	155	290	160
R-FB1	20166	0.00439	0.08	0	210	50	200	221.5	200	224	197.5	236	197.5	238.5	200	410	200	460	210
R-FB2	9383	0.00734	0.1	0	310	65	300	138	300	140	298	150	298	152	300	225	300	290	310
R-GB1	7226	0.00136	0.06	0	30	145	25	805	25	808	22	822	22	825	25	1485	25	1630	30
R-GB2	9866	0.00399	0.08	0	40	130	29	181	29	183.5	26.5	196.5	26.5	199	29	250	29	380	40
R-GB3	6845	0.00144	0.05	0	90	360	85	405.5	85	407.5	83	432.5	83	434.5	85	480	85	840	90
R-LR1	10287	0.00191	0.04	0	30	55	25	111.5	25	115	21.5	145	21.5	148.5	25	205	25	260	30
R-LR2	11132	0.00236	0.05	0	70	60	65	99.5	65	102.5	62	127.5	62	130.5	65	170	65	230	70
R-PP1	7263	0.00045	0.05	0	220	50	213	89	213	92.5	209.5	117.5	209.5	121	213	160	213	210	220
R-TB1	17121	0.00537	0.06	0	190	155	180	260	180	263	177	277	177	280	180	385	180	540	190

Summary of Significant Impoundments within the Exeter River Watershed

Model ID	Description/Location	Hydraulic Control	Bankfull SA, acres	NHD Waterbody COMID(s)
CP DAM	Colcord Pond	Colcord Pond Dam	8.6	141034700
BB WET	Two Wetlands at Mouth of Bloody Bk & Tributary	Natural narrows D/S of Dudley Bk	33.8	141036790 & 141036793
DB WET	Wetland at Mouth of Dudley Bk	Rt. 111A/Brentwood Rd. Bridge	82.2	141036887
GB WET	Great Brook Wetland Complex	Rt. 150/Amesbury Rd. Bridge	16.1	141036969
PP DAM	Exeter River	Pickpocket Dam	35.3	N/A
BH DAM	Exeter River	Brentwood Hydro Dam	30.0	N/A
SC DAM	Exeter River	Scribner Road Dam	26.8	N/A
ER WET	Exeter River/Near-stream Wetland Complex	Natural narrows along Rt. 107 north of Fremont center	44.5	141036949
FB WET	Two Wetlands at Mouth of Fordway Bk & Tributary	Rt. 102/Chester Rd. Bridge	81.1	141036981 & 141036999
TB WET	Wetland at Mouth of Towle Brook	Private Road Bridge	19.0	141035012 & 141037059
FR WET	Extensive Wetland Complex on Exeter River	Fremont Rd. Bridge	620.7	141037101
L POND	Lily Pond	Philllips Rd. Bridge	13.3	141035253 & 141037150
L121	Wetland Complex on Exeter River	Rt. 121A/Main St. Bridge	59.7	141037157 & 141037171
P POND	Phillips Pond & D/S Wetland	Hampstead Rd. Bridge	93.2	141037171 & 141035435
PP WET	Wetland Complex in PP2	Depot Rd. Bridge	134.9	141037192
DH DAM	Deep Hole Pond, Exeter River	Deep Hole Pond Dam	16.0	141035267 & 141037154

Notes:

1) Flood Storage is the additional volume above normal pool and was calculated from WSEL and Surface Areas using the equation for the volume of a trapezoidal prism. See report for details.

2) Discharge was estimated using the equation for a broad-crested weir. Weir lengths and elevations were approximated from aerial imagery, topographic mapping, the NID, and field observations. See report for details.

Pickpocket Dam		
WSEL *(ft. NAVD88)*	Flood Storage *(acre-feet)*	Discharge *(cfs)*
60	0	0
61	273	351
62	546	993
63	819	1824
64	1091	2210
65	1364	3015
66	1637	4209
70	2729	10449

Colcord Pond Dam		
WSEL *(ft. NAVD88)*	Flood Storage *(acre-feet)*	Discharge *(cfs)*
43	0	0
44	18	68
45	35	191
46	53	351
47	71	540
48	89	755
49	106	992
50	124	1250
52	220	2162
54	315	4329
56	410	7823
58	505	12781
60	600	19338

Brentwood Hydro Dam		
WSEL *(ft. NAVD88)*	Flood Storage *(acre-feet)*	Discharge *(cfs)*
127	0	0
127.5	34	79
128	68	302
128.5	102	410
129.5	170	944
130	204	1105
132	957	2897
134	1709	6156
136	2462	10854
138	3214	17052
140	3967	24829

Phillips Pond		
WSEL *(ft. NAVD88)*	Flood Storage *(acre-feet)*	Discharge *(cfs)*
212	0	0
217	801	604
220	1282	2630

Phillips Pond Wetland (upstream)		
WSEL *(ft. NAVD88)*	Flood Storage *(acre-feet)*	Discharge *(cfs)*
246	0	0
250	732	324

Lily Pond		
WSEL *(ft. NAVD88)*	Flood Storage *(acre-feet)*	Discharge *(cfs)*
203	0	0
207	114	432
210	200	2458
220	486	14791

Rt. 121 Impoundment (Exeter River)		
WSEL *(ft. NAVD88)*	Flood Storage *(acre-feet)*	Discharge *(cfs)*
213	0	0
219	589	873
220	687	1653
230	1668	26319

Fordway Brook Wetland (mouth of FB)		
WSEL *(ft. NAVD88)*	Flood Storage *(acre-feet)*	Discharge *(cfs)*
160	0	0
162	269	92
164	538	259
166	808	476
168	1077	733
170	1346	1025
172	1615	3451
180	2692	28157

Deep Hole Pond Dam		
WSEL *(ft. NAVD88)*	Flood Storage *(acre-feet)*	Discharge *(cfs)*
300	0	0
302	141	76
304	282	591
310	705	13583

Scribner Road Dam		
WSEL *(ft. NAVD88)*	Flood Storage *(acre-feet)*	Discharge *(cfs)*
143	0	0
144	43	27
146	130	562
150	303	10962

Fremont Road Wetland (Exeter River)		
WSEL *(ft. NAVD88)*	Flood Storage *(acre-feet)*	Discharge *(cfs)*
173	0	0
174	830	68
175	1660	191
176	2490	351
177	3320	540
178	4150	604
180	5809	604

Towle Brook Wetland (mouth of TB)		
WSEL *(ft. NAVD88)*	Flood Storage *(acre-feet)*	Discharge *(cfs)*
164	0	0
165	22	46
166	45	130
167	67	239
168	89	367
169	112	513
170	134	595
172	213	3022
174	292	7459
176	370	13205
178	449	20010
180	528	27728

Exeter River Wetland (along Rt. 107)		
WSEL *(ft. NAVD88)*	Flood Storage *(acre-feet)*	Discharge *(cfs)*
156	0	0
160	412	224
162	1019	1621
164	1626	4800
166	2233	10159
168	2840	17873
170	3446	29576

Dudley Brook Wetland (mouth of DB)		
WSEL *(ft. NAVD88)*	Flood Storage *(acre-feet)*	Discharge *(cfs)*
78	0	0
79	244	49
80	487	137
81	731	253
82	975	389
83	1218	543
84	1462	714
86	1949	3803
88	2436	7517
90	2923	22545

Bloody Brook Wetland (mouth of BB)		
WSEL *(ft. NAVD88)*	Flood Storage *(acre-feet)*	Discharge *(cfs)*
76	0	0
78.5	261	107
80	418	823
90	3738	22200

Rt. 150 Wetland (Great Brook)		
WSEL *(ft. NAVD88)*	Flood Storage *(acre-feet)*	Discharge *(cfs)*
24	0	0
25	57	27
26	113	76
27	170	140
28	226	147
29	283	208
30	339	254
31	510	959
32	680	2666
34	1021	8699
36	1363	18749
38	1704	33318
40	2045	52697

Appendix F

Public Meeting Summary Information

Vanasse Hangen Brustlin, Inc.

Meeting Notes

Attendees:	See List	Date/Time:	September 14, 2011
		Project No.:	52151.00
Place:	Exeter Town Hall	Re:	Great Dam Removal Feasibility & Impact Analysis September 14, 2011 Public Meeting Information
		Notes taken by:	M. Becker/P. Walker

A public meeting was held on September 14, 2011 to discuss issues related to the possible removal of the Great Dam on the Exeter River in Exeter, NH. The Town of Exeter hosted this meeting with its partners, including the NH Department of Environmental Services. The main objective of the meeting was to update the public on the "Great Dam Removal Feasibility and Impact Study" which is being conducted by a consultant team led by VHB.

The meeting included time for members of the public to interact with specialists at six "information stations." This memorandum is intended to document the comments and information received at each of these stations. UNH graduate students served as recorders at each station to take notes during the session. Key discussions and questions are summarized below. In addition, a number of citizens took the opportunity to submit comments on the forms provided at the meeting which are also summarized in this document.

Notes from each of the Information Stations are listed below.

Station 1. Hydrology, Hydraulics, and Flooding

Participants: *Mike Hansen; VHB; Andrew Walker, W&S; Kevin MacKinnon, W&S; Paul Vlasich, Town of Exeter*
Recorder: *Helen Perivier, UNH (with help from Paul Vlasich, Town of Exeter)*

Questions/Comments Received:

- How come below dam isn't looked at on impacts because of flow differences?
- Will pipes under Squamscott River be affected?
- Clemson Pond Affected? There are a lot of contaminants there.
- What about the Penstock under the library?
- How does the mill fit in with their water use?'

- What will water flow be upstream? If someone finds that they have 15 feet of mud on what is at present lawn, will the town be prepared to help people restore their property?
- Will flow on Exeter River and Squamscott change? Ships used to come up to Exeter, will that be possible again?
- It helps out a lot when the town is proactive in dropping the water level before a big rain.
- Does the town actually measure the water level every day?
- I'm curious about what the river is going to look like when the dam is removed. There have been big floods upstream in a mobile home area that cut out chasms around 12 feet deep, which may be typical of what happens when you have a flood cutting through a river flood plain. Could something like that happen between the dam and Gilmore Pond and beyond if the dam is removed? We could get a lot of water running through this level flood plain.
- Will removing the dam help scour out sediment from downstream?
- Will canoeing improve downstream?
- Vernon Sherman, Executive Director of the Exeter Housing Authority: The Exeter Housing Authority has 85 units with 100 elderly and disabled people. We have had two 100-year floods within 20 feet in the last 15 years and the only reason why the building hasn't been touched is because it is 6 feet above the flood line on the maps. I want to know what will be the effects both with and without the dam at the time of a 100-year flood coinciding with high tide.
- If the dam is removed will the area which the water transverses be greater or smaller (not just in terms of water level, but also spreading horizontally)?
- A property owner close to dam says that one thing that will be gone is the impoundment. What would replace that body of water? Open space? A lot of time of year there's not much river and you can't even see it. Is this what we can expect with the dam removal?

Station 2. Water Supply Information Station
Participants: *Brian Goetz, W&S; Roger Wakeman, PEA and River Study Work Group*
Recorder: *Chris Keeley*

Questions/Comments Received:

- How deep is the pump station?
- What water rights does Philips-Exeter Academy have?
- How accessible is the water immediately adjacent to the river?
- What are the alternatives for water supply?
- How would removal affect wells?
- How will the water quality change if the dam is removed?
- Are there any drawings of the river before the dam was put in?
- How do shifts in technology better enable hydropower? I.e., if hydropower is not feasible today, how does hydropower feasibility change as technology improves?

Station 3. Dam Safety Information Station
Participants: *Steve Doyon, DES, Brian Graber, American Rivers, Deb Loiselle, NHDES*
Recorder: *Emily Troisi and Richard Brereton*

Questions/Comments Received:

- What is its hazard classification of the Great Dam/ is that based on the structural integrity of the dam or something else?
- What is structurally wrong with the Great Dam that would require its removal?
- How will the saturation of the historic floodplain change with dam removal, and how might that impact future flooding events?
- How is the river going to look if the dam is removed? Will the river become more narrow after the dam is removed?
- How far upstream will the effects of dam removal be noticeable?
- How accurate are modeling projections for dam in/out scenarios?
- What would be the cumulative flooding impacts if the Phillip's Dam and/or Pickpocket Dam failed with or without the presence of the Great Dam?
- Has the presence of the fish ladder had an impact on increasing flooding, and if so how much?
- How do you deliberately remove a dam? What is the actual physical process of dam removal? Is it quick or does it happen over a period of time?
- The town should be doing more to manage its water and has only just stepped up in the last three years to meet the needs of Exeter.
- Rumors in town that not all is being/ was done to increase dam capacity to allow flood waters to pass over the dam and the flood gate is far too small.
- Request to see the initial letter of deficiency (will be provided directly to individual by Deb Loiselle).
- Several comments from business owners along the river, Exeter residents, and non-residents about the changing aesthetic value. One local resident and one resident of Newmarket, in particular were distraught over the state of the Winnacut River dam removal in Greenland and the potential for Exeter to be transformed into a giant trash heap.
- Several land owners and business owners requested that opinions and experiences of other NH towns that have gone through the dam removal process be made available in some format.
- Concern about long-term impacts on current wetland resources. If the dam is removed, individual questioned whether or not the land adjacent to the river would be in wetland jurisdiction, or not; and whether it could be built upon. (Concerned citizen will be provided contact information for Tim Drew at NHDES)

Station 4. Water and Sediment Quality Information Station
Participants: *Sally Soule, NHDES and River Study Work Group and Bill Arcieri, VHB*
Recorder: *Matt Cardin*

Questions/Comments Received:

- How much sediment will end up in river downstream from the dam? Will the amount of sediment restrict rowing below the existing dam?
- Are the [historic] river-side dumping areas being looked at?

- What is the potential impact to groundwater levels for areas bordering the river once the dam is removed?
- Will there be an additional amount of sediment deposited into the Squamscott River?
- Will historic boat navigation (e.g. Schooners or ships) be re-gained or limited by the dam being removed?
- Will removal of the dam result in the removal of increased sediments and need for restoration, or sand and gravel stream beds for fish breeding? (on a sticky)

Station 5. Fish Passage, Natural Resources & Recreation Information Station

Participants: *Kevin Sullivan, NHF&G, Mike Dionne, NHF&G , Eric Derleth, USFWS, Kristen Murphy, Natural Resource Planner and River Study Work Group*
Recorders: *Emily Troisi and Matthew Magnusson*

Questions/Comments Received:

- What kind of effect will there be on the Exeter Elm Campground?
- There was concern over the recreational effects on the campground.
- If you take away the dam, do you lose deep pools for fish?
- What will be the recreational impact (fishing, swimming, boating) if water level is very low due to dam removal?
- Will lower water levels cause oxygen levels to decrease too low to support fish?
- What is the minimum level of water for fish to survive, especially if there are drought conditions?
- How will dam removal effect upstream and downstream eel passage?
- Are there significant amounts of freshwater mussels upstream of the dam? Any rarer species of mussels?
- Have any biodiversity studies of the river been performed?
- Are any of the fish that you can catch now in the river safe to eat?
- Is there a recreational upside to dam removal?
- Will lower water levels encourage increased beaver activity and damming?
- What can be learned from the Greenland example?
- What fish species traditionally went up river before the dam?
- Will removing the dam change sedimentation at Swazey Park (impacting recreational activity)?
- It was noted that in front of Swazey Park the river used to be dredged consistently.
- If the dam is removed, has anyone modeled how the wetlands will evolve over the next 1, 5, 10 years and how DES jurisdiction of river side resources will change as a result of changing wetlands.
- Concern over potential for development to occur in areas that are not developable as they are wetlands.
- Will there be changes to the Great Swamp in Kensington? These are important wetlands.
- How does the water table and vegetation along the river change as a result of dam removal?
- What has happened for other dams that have been removed in NH?

- Will something replace the current impoundment area, open space?
- What is your idea on the dam and fish passage?
- How does the dam affect fish breeding?
- Are they removing all dams in NH eventually?
- If you take the dam down, how will that affect fish upstream, resident fish, and fish that travel upstream?
- Do people care about fish as much as other issues?
- What is the difference in Greenland since the dam has been gone?

  *Note: This was the second reference to Greenland Dam (Winnicut River Dam)
- Do we know where all the streams are?
- What will water level impact be on local business and historical buildings
- Will it impact the powder mill?
- When did it change names to the Great Dam, it used to be called the Mill Dam?
- How will dam removal change flow in flood time?

Station 6. Historical & Archaeological Resources Information Station

Participants: *Rita Walsh, Joyce Clements, VHB, Eric Hutchins, NOAA & River Study Work Group*
Recorder: *Meg Gardner, UNH Tides Program and Joyce Clements, VHB*

Questions/Comments Received (recorded by Joyce Clements)

- Pete Richardson, River Study Committee (603.778.6272) reported a gunpowder mill on Powder Mill Road, east of the intersection with Route 111.
- Mary Dupre, mother of Selectman Julia Gilman also reported "a really old dam at Railroad Bridge and Route 111. At one point, there were four mills in this area (corn, saw, and gunpowder (2) [Hobart Gun Manufacturer]). Ms. Dupre stated that one of the powder mills dated to the Revolutionary Period, the other operating from ca 1812 to 1850. A nail slitting mill also was located here and a woolen mill. Mill area might have been called King's Fall, or Kingston Mills, after Thomas King who owned mills here in the late 1600s or early 1700s.
- Exeter Selectman, Julie Gilman, (96 High Street, Exeter) recommended conversations with Dan Foster, retired professor from Phillips Exeter Academy, who maintained the original collection prepared by the late Willie White (formerly of PEA). Julie recommended Bell's History of Exeter for context and historical background. According to Julie the Swanzey Park area was noted for shipbuilding but this area was filled when the Parkway was built, perhaps in the late nineteenth century. She suggests that the west side of the river, on the site of the Exeter Housing might be archaeologically sensitive. Development occurred in the 1970s.
- Mr. Don Robie, owner of Kimball Island will provide us with pictures and an article on the river confluence from two early newspaper articles. He has pictures of people standing and looking at ice jams in the river. Notes the presence of outhouses on the island. He purchased the Island in 1977. It originally was named for Emma Kimball. Will accommodate researchers during a site visit.
- One gentleman recalled activities and resources along the river, including trout, perch, hornpouts, alewife, lamprey eels, muskrats, and possibly mink. He referred to a boat house on

the river, prior to the population growth of the late 1940s. (These resources are the kinds of resources that would have attracted Native Americans to the area prior to European settlement).

Questions/Comments Received (recorded by Meg Gardner)

- How will dam removal impact the historical nature of the dam?
- How will all the information come together in the end once the study has been completed?
- Before it was a concrete dam, what was the dam made of? One man thought there was another dam before it was the current concrete one.
- Concern about what happened/ is happening with the Winnicut dam removal; doesn't want that to happen here.

General Comments (asked at the end of the meeting):

- One man commented that once the dam is removed, it cannot be put back; he doesn't want the town to regret removing the dam, it is part of the beauty of the town
- Curious about what has happened with other dam removals, regarding river flow, roads, and other factors. Concerned about what will happen.
- One man said: Seems to me that the impoundment behind the dam will be gone; will something replace where that open space is? A lot of seasons of the year there isn't much of a river below the dam and the vegetation around blocks the views. Is that what is to be expected if the dam is removed?
- What is the depth of the water at the dam right now?

COMMENTS SUBMITTED ON THE COMMENT FORM

Name: Kris Vaughn

What does the topography of the river bottom in the area of the dam tell us about what the river looked like before the dam was installed (was there a waterfall-like drop)? Will this give us an idea of how it would look after removal?

If there is a lot of silt behind the dam, do we know how far down the ledge/rock is (below the current average water level?

Name: W.R. Woodruff

Please keep the dam. The reflections of the buildings and town are a key part of the beauty and heritage of Exeter. The dam needs proper floodgates and responsible people to lower the water if heavy rain or snowmelt run-off is threatening. It is too late to comment and to rebuild a complete new flood control type dam if it removed. Keep the Dam!!!

Name: Chris Matlock

The Exeter River at reduced water levels as a consequence of dam removal will in all likelihood become a series of beaver impoundments all the way up to the next dam. There was no beaver in NE before the dam was put in originally due to overharvesting. There are beaver along the river already but they cannot establish flowages with the level at its current state. With the dam removed there will be an increase in the wetland marsh, but probably not a navigable river as we have now. Any increase in fish runs up from the Squamscott will probably be influenced.

Name: Mary B Dupre

Have some deed copies re the Mills at Kings Falls (between Rte 111 and where river edges Powder Mill Road (you have Neck Road)

Name: Julie Gilman

Include photos of before and after removal of other dams and upstream vegetation/wildlife changes.

Will identified or probable archeological sites be preserved, removed or left alone. If water level decreases and exposes sites is there any mitigation.

Be definitive about the impact on water table and wells, septic systems.

WRITTEN COMMUNICATION FROM CITIZENS

From: Bob Carbonneau [mailto:carbe47@comcast.net]
Sent: Monday, September 12, 2011 5:32 PM
To: Paul Vlasich
Subject: Letter re: Great Dam Removal Feasibility
Importance: High

Dear Mr. Vlasich:

This letter is regarding the September 14, 2011 Public Meeting on the Great Dam Removal Feasibility and Impact Analysis.

Unfortunately, I will be out of town on the 14th. However, I wanted to call to the attention of the study group a couple of points that I feel need to be considered.

The Carbonneau Family has been located in the lower Water/Dewey Street area since the early 1900's. My father was born in the house at 1 Dewey Street in 1910. In the 1930's he moved a barn/house from Water Street (location of the Phillips Academy Kindergarten today) to what is now known as 286 Water Street. It is the corner lot and was the site of my grandfather's shoemaker's shop before his passing in 1927. I grew up at and currently reside at 286 Water Street. As you can see the Carbonneau's have a long history in that area of town.

Over the years, we have seen many changes to the neighborhood. When growing up in the 60's my brother and I both worked part-time, directly across the street from our house, at the Exeter Highway Department (EHD). The EHD had storage areas for road salt, sand and old tar (pavement) as well as a gas pump. We were taught early on "not to eat the orange snow" that resulted when the Gas Works (on the corner of Green and Water Streets and also across the street on Water Street) was making gas all night during the dead of winter. The Gas Company had a large gas ball and gas storage container on the Water Street side (277), as well as a large gas storage container as you went up the hill on Green Street. These sites are currently the location of The Exeter Housing Authority (277 Water Street), the Phillips Academy Kindergarten, and a community park/cemetery. These areas were also the former sites of the Exeter Town Dump, the Exeter Coal Company (late 1800's), and a Federal Superfund Toxic Waste site (which was "dome/sealed" in the 1980's). It is not a surprise to us that oil like substances have been “bubbling up” in the Squamscott River on the Parkway.

Since the Great Dam was built by the Exeter Manufacturing Company, the water above the dam was called the Exeter River and below the dam, the Squamscott River (tidewater). When Mr. Sway donated the land to the Town of Exeter, in the early 1930's, for what is now known as the Swasey Parkway, the tidewater was very close to the edge of lower Water Street (from 225 to 316 Water St. - reference Exeter P.O. map of 1892). Some of the fill used to create the Swasey Parkway, as we know it today, came from leveling my grandfather/fathers' 286 Water property by removing the hills. The soil removed from 286 Water Street was primarily blue clay. It would be reasonable to assume that most of the fill used in the project to construct the Parkway was similar.

A bit of weather history if I may. When Exeter has been hit with hurricanes, the lower part of Water Street has had flooding issues, particularly at high tide (this is with the dam in place). Storm events that come to mind are the 1938 (Great New England Hurricane) and 1954 (Carol) hurricanes. Sometime since the 1960's the lagoons were built below the dam. I understand that currently, the catch basins (street) runoff is being pumped to the lagoons from a station behind 277 Water Street. This dynamic adds to the volume of quick flowing water.

In my opinion, I believe the removal of the Great Dam would be a huge mistake. In the event of heavy rains or hurricanes the lower Water Street area will receive significant water and environmental damage, especially at high tides. It is important to note that today, lower Water Street is comprised of a mix of residential, commercial, disabled/elderly housing, and higher education properties...also included are Law offices; a bakery; barber shop; Folsom's Tavern; the Academy's Data Center and Kindergarten/Daycare; the Exeter Housing Authority Complex (about 100 residents and Administrative Offices) and several private residences. It is anyone's guess as to what harm would come to the area during a significant weather event. Obviously, flood damage and/or evacuations of the elderly and children as well as the possibility of environmental problems with the toxic waste in the area may have wide ranging implications for the Town and State.

I would like to present a "layman's" option for the dam's future. I understand, that the original dam had about 1 foot added to its height. Instead of removing the dam, I recommend that three steps be taken as follows:

1. Return the height of the structure to its original height by removing the added foot;
2. Expand the size of the sluice; and
3. Install in the sluice the most up to date operational technology to manage, regulate and control the water flow as conditions fluctuate.

If these steps are taken, it should solve, to a great degree, the flooding above the dam on the Exeter River.

If the dam is removed. . .I believe the entire town will suffer from mosquito born illnesses like we have never seen, as well as new areas of flooding and a high risk of environmental damage from the old Gas Works sites.

I appreciate the opportunity to comment. To those participating in this review and decision.....Thank you for your service!

Sincerely,
Robert P. Carbonneau
286 Water Street
Exeter, NH 03833

Great Dam Feasibility Study and Impact Analysis
Response to Public Comments
May 23, 2012

Introduction

During a public meeting for the Great Dam Feasibility Study and Impact Analysis (the Study) on September 14, 2011, meeting attendees were encouraged to provide comments and ask questions about various aspects of the Study. To facilitate this discussion and exchange of information, project team members were available at topic-specific stations to record public comments and questions pertaining to the Study. The following table contains responses from Project Partners and the Study's consultants to the comments and questions received at each station.

Station 1: Hydrology, Hydraulics, and Flooding

Public Comment		Project Team Response
1-1	How come below dam isn't looked at on impacts because of flow differences?	The consulting team conducting the Study developed a model which extends a certain distance downstream. The preliminary results of this model show that there is no effect on water surface elevations or velocities downstream. This is an expected result, because this dam is operated as a run of the river* dam with an operable gate, which typically does not affect downstream flows. More information on these findings will be presented in the Study's final report, expected to be issued this summer.
1-2	Will pipes under the Squamscott River be affected?	The Town of Exeter's sewer system has a series of four pipes under the Squamscott River in the vicinity of Clemson Pond. Based on the results of the hydraulic model, impacts to this existing infrastructure are not expected.
1-3	Clemson Pond Affected? There are a lot of contaminants there.	The consultant has been tasked with conducting sampling of sediments to determine if there are contaminants present. Sampling was conducted in November 2011 and included a sampling station near Clemson Pond. These sampling results are consistent with previously-collected data and confirm that certain contaminants are present in sediments in this reach of the Squamscott River. Since the hydraulic modeling results suggests that the potential for scouring downstream of the dam is no greater than that under existing conditions, there should be no increased ecological risks if the dam is removed. The consultant is currently coordinating with the NH Department of Environmental Services (DES) to determine whether any further testing or analysis is necessary. The outcome of this coordination will be presented in the final assessment in the final report.
1-4	What about the Penstock under the library?	The penstock under the library supplies the mills with water that can be used for their cooling system, irrigation and fire suppression. Additional information about the penstock will be provided in the Study's final report.
1-5	How does the mill fit in with their water use?	The Town will perform a legal review of the mill's water withdrawal rights. As stated in item 1-4, the mill uses river water for cooling, irrigation and fire suppression. More information on this topic will be available in the final report.

Station 1: Hydrology, Hydraulics, and Flooding (continued)

Public Comment		Project Team Response
1-6	What will water flow be upstream? If someone finds that they have 15 feet of mud on what is at present lawn, will the town be prepared to help people restore their property?	Removal of the Great Dam would reduce the width of the upstream channel. Areas formerly in the river channel would naturally re-vegetate over time.
1-7	Will flow on Exeter River and Squamscott change? Ships used to come up to Exeter, will that be possible again?	As a run of the river* dam with an operable gate, the Great Dam only influences the depth of water upstream. The removal of the Great Dam would therefore have no direct influence on the depth of water downstream and would not improve or impact navigation in the tidal portion of the river.
1-8	It helps out a lot when the town is proactive in dropping the water level before a big rain.	This is current Town policy.
1-9	Does the town actually measure the water level every day?	Town staff measure and record water levels every business day. Water level observations are made on the weekends; however, the levels are not recorded.
1-10	I'm curious about what the river is going to look like when the dam is removed. There have been big floods upstream in a mobile home area that cut out chasms around 12 feet deep, which may be typical of what happens when you have a flood cutting through a river flood plain. Could something like that happen between the dam and Gilman Park and beyond if the dam is removed? We could get a lot of water running through this level flood plain.	A series of photographs taken during the November 2009 drawdown of the dam provides some insight into what the river would look like if the dam were to be removed. As part of the Study, the town may pursue additional visual renderings so that the public can better understand the aesthetic impact of the dam removal alternative.
1-11	Will removing the dam help scour out sediment from downstream?	Run of the river* dams typically do not influence downstream velocities or water depths, which would be primary factors in scour. Tidal forces within the Squamscott River will continue to exert a much greater influence on channel scour.
1-12	Will canoeing improve downstream?	As discussed in our response to Comment 1-10, removal of the dam will not change water depths or velocities downstream of the dam, so canoeing conditions would not be expected to change.
1-13	The Exeter Housing Authority has 85 units with 100 elderly and disabled people. We have had two 100-year floods within 20 feet in the last 15 years and the only reason why the building hasn't been touched is because it is 6 feet above the flood line on the maps. What will be the effects both with and without the dam at the time of a 100-year flood coinciding with high tide?	As part of the Study, the consultant has developed a model which extends a certain distance downstream. The preliminary results of this model show that there is no effect on water surface elevations or velocities downstream. This is an expected result, because this dam is operated as a run of the river* dam with an operable gate, which typically does not affect downstream flows. More information on these findings will be presented in the final report.

Station 1: Hydrology, Hydraulics, and Flooding (continued)

Public Comment		Project Team Response
1-14	If the dam is removed will the area which the water transverses be greater or smaller (not just in terms of water level, but also spreading horizontally)?	Generally speaking, the width of the river will be narrower than under its current impounded (the area influenced by damming of water) condition. The effect of this will vary along the length of the impoundment. The amount of change would be most noticeable near the dam, but would diminish upstream until the change becomes unnoticeable near the NH 108 bridge.
1-15	A property owner close to dam says that one thing that will be gone is the impoundment. What would replace that body of water? Open space? A lot of time of year there's not much river and you can't even see it. Is this what we can expect with the dam removal?	A series of photographs taken during the November 2009 drawdown of the dam provides some insight into what the river would look like if the dam were to be removed. As part of the Study, the town may pursue additional visual renderings so that the public can better understand the aesthetic impact of the dam removal alternative.

* A run of the river dam is built across a river or stream for the purposes of impounding water where the impoundment at normal flow levels is completely within the banks and all flow passes directly over the entire dam structure within the banks, excluding abutments, to a natural channel downstream.

Station 2: Water Supply

Public Comment		Project Team Response
2-1	How deep is the pump station?	The river intake is located in a deep section of the Exeter River across from the Gilman Park boat launch. The normal depth of the water at that location is approximately 13.75 feet. According to Town records the intake for the river pump station is approximately 7 feet below the normal water level. During the river drawdown in November 2009 the water level dropped 3.75 feet at the river pump station and the water supply was still able to pump water from the river. Also, please see the Water Supply Alternatives Study – Final Report for additional information: http://www.town.exeter.nh.us/river%20study/RIVER%20STUDY%202010.PDF
2-2	What water rights does Philips-Exeter Academy have?	Gillis v. Chase, 67 N.H. 162 (1891) – A NH landowner, whose property abuts a stream or a river, shall have the "right to divert the water for use to a reasonable extent…because each riparian proprietor having the right to a just and reasonable use of the water as it passes through and along his land…And as the reasonableness of the use is, to a considerable extent, a question of decree, and largely dependent on the circumstances of each case…".
2-3	How accessible is the water immediately adjacent to the river?	The Study will evaluate impacts of dam removal or modification on recreational river access such as boating, fishing, the local camp grounds, etc. Sites that have been specifically identified as high use areas are included as sensitive sites and will be directly looked at for impacts.

Station 2: Water Supply (continued)

Public Comment		Project Team Response
2-4	What are the alternatives for water supply?	The Water Supply Alternatives Study performed in 2009 presented an integrated management approach for the Town. The concept of having many water supply sources would create flexibility for high supply demands, system maintenance down time, source contamination and drought conditions. With the reactivation of the Stadium and Gilman Park wells and construction of a new groundwater treatment facility, approved by Town vote in 2012, the Town will move a step closer to having this integrated system in place. Therefore, the Town will not be as reliant on the river to meet a majority of their water demand as has been the case since the early 70's. Also, please see the Water Supply Alternatives Study – Final Report for additional information: http://www.town.exeter.nh.us/river%20study/RIVER%20STUDY%202010.PDF
2-5	How would removal affect wells?	The Study consultant has been tasked with conducting an analysis that will consider impacts to public and private wells in the vicinity of the dam. More information on this topic will be presented in the final report.
2-6	How will the water quality change if the dam is removed?	The consultant conducting the Study has been tasked with conducting an analysis that will review the likely effects on water quality in the river. Generally speaking, water quality would be expected to improve with the removal of the dam. More information will be presented in the final report.
2-7	Are there any drawings of the river before the dam was put in?	The Study team includes a historian and archaeologist to research the history of the dam and surrounding area. They have determined that it is likely that a dam existed in this location as early as 1640. We have not been able to locate any accurate depictions of the river prior to construction of a dam at this site.
2-8	How do shifts in technology better enable hydropower? If hydropower is not feasible today, will feasibility change as technology improves?	Hydropower is not currently financially feasible. Please see the Hydroelectric Review Assessment Final Report for additional information: http://town.exeter.nh.us/river%20study/Exeter%20Hydroelectric%20Report%20Review%2003-31-11%20Final.pdf

Station 3. Dam Safety

Public Comment		Project Team Response
3-1	What is the hazard classification of the Great Dam? Is that based on the structural integrity of the dam or something else?	DES assigns hazard classifications to dams based upon the criteria contained within its administrative rules. The condition of the dam has no bearing on that assignment. At present, DES maintains a classification of "Low" for the Great Dam. This classification has been consistent since at least 1977. The definition of a low hazard dam is reproduced below: Env-Wr 101.07 "Class A structure" means a dam that has a low hazard potential because it is in a location and of a size that failure or miss-operation of the dam would result in any of the following: (a) No probable loss of life; (b) Low economic loss to structures or property; (c) Structural damage to a town or city road or private road accessing property other than the dam owner's which could render the road impassable or otherwise interrupt public safety services; (d) The release of liquid industrial, agricultural, or commercial wastes, septage, or contaminated sediment if the storage capacity is less than 2 acre-feet and is located more than 250 feet from a water body or water course; or (e) Reversible environmental losses to environmentally-sensitive sites. In the case of the Great Dam, DES believes that a failure of the dam, its penstock or either of its abutments could lead to damages consistent with Env-Wr 101.07(b) and (c) to adjacent or downstream structures including buildings along the left abutment, the library at the downstream right abutment and the String Bridge just downstream. Further any dam that is 6 feet or greater in height AND impounds 50 acre-feet or more of storage must be classified, at a minimum, as a low hazard. Therefore, regardless of the assessment discussed above, the Great Dam would qualify as a low hazard because it is 15 feet in height and impounds a maximum storage of approximately 300 acre-feet.

Station 3. Dam Safety (continued)

Public Comment		Project Team Response
3-2	What is structurally wrong with the Great Dam that would require its removal?	DES is not aware of any structural deficiencies that threaten the safe operation of the dam under normal conditions. Other than a number of relatively minor issues associated with aging/cracked concrete and other typical repair and maintenance related conditions, the dam appears structurally sound. The most recent safety inspection occurred on November 18, 2011. At that inspection the following observations were made: *1. The wooden boards that line the upstream side of the penstock inlet have deteriorated and should be replaced.* *2. There is concrete deterioration on the top of the penstock inlet slab as well as on the right end of the upstream right concrete training wall. The seam between the concrete wall and the dry laid stone retaining wall is also irregular and should be patched, as necessary.* *3. The right upstream dry laid stone wall is supporting vegetative growth which should be removed.* *4. The invert and base slab of the low level gate section could not be observed well due to water flow, but this area should be inspected in a dry condition and repaired as appropriate as it appears that the surrounding concrete has worn down to the aggregate and is irregular.* *5. There is spalled concrete on the concrete structure that acts to support the inactive penstock gates. This deterioration should be repaired and sealed as appropriate. There is also deteriorated concrete on the upstream face of the dam approximately 2 feet to the right of the low level gate section.* *6. There is vegetation growing on the right embankment and the area around the right side of the penstock inlet structure which should be removed.* *7. The left concrete abutment and now inactive spillway section to the left of the fish ladder is badly deteriorated and shows signs of leakage. There is iron staining at the left end of the spillway due to subsurface runoff through the left abutment.* *There is a minor amount of floating debris that needs to be removed from the crest of the spillway.* However, the most significant deficiency associated with the Great Dam is its lack of discharge capacity. Current hydrologic and hydraulic analyses indicate that the dam is incapable of passing the runoff generated by the 50 year rainfall event without overtopping the dam's abutments. This condition is unsafe and could result in a failure of the dam. Existing low hazard dams are required to have the ability to pass the 50 year event with at least one (1) foot of remaining freeboard. Freeboard is the distance between the expected 50 year flood level and the lowest portion of the dam's crest that could be overtopped and lead to dam failure. Env-Wr 303.12 provides for other possible remedies for addressing deficient discharge capacity as well. Any remedy proposed to address the deficient discharge capacity will need to be supported by structural and stability assessments. At present, DES has indicated to the Town of Exeter that if it intends to keep the dam active it must upgrade the discharge capacity of the structure to pass the 50 year event with the required freeboard or otherwise provide a solution consistent with Env-Wr 303.12. Dam owners, by right of ownership, also have the option to either remove the dam or otherwise modify it so that it is no longer jurisdictional and subject to NH's dam safety regulations. DES has not, nor will it, require the removal of the Great Dam on the basis of dam safety concerns.

Station 3. Dam Safety (continued)

Public Comment		Project Team Response
3-3	How will saturation of the historic floodplain change with dam removal, and how might that impact future flooding events?	Saturation of the historic floodplain would be expected to decrease with the drawdown of the impoundment if the dam is removed. This would decrease the "antecedent moisture conditions" in the watershed, which would tend to decrease the amount of runoff associated with a rainfall event and thereby decrease the risk of flooding in the river. The magnitude of this effect is difficult to measure, but the consultant team will consider the point raised by this question in analyzing the results of our hydrological analysis.
3-4	How is the river going to look if the dam is removed? Will the river become narrower after the dam is removed?	A series of photographs taken during the November 2009 drawdown of the dam provides some insight into what the river would look like if the dam were to be removed. As part of the study, the town may pursue additional visual renderings so that the public can better understand the aesthetic impact of the dam removal alternative. Generally speaking, the width of the river will be narrower than under its current impounded condition. The effect of this will vary. The amount of change would be most noticeable near the dam, but would diminish as one moves upstream until the change became unnoticeable near the NH 108 Bridge crossing. More information on this topic will be presented in the final report.
3-5	How far upstream will the effects of dam removal be noticeable?	While analysis is still on-going, the preliminary results of the hydraulic model developed for the Study indicate that, under normal conditions, water levels will not change upstream of the NH 108 bridge. More information on this topic will be available in the final report.
3-6	How accurate are modeling projections for dam in/out scenarios?	The primary information produced by the hydraulic model is the elevation of the water surface at various points in the river. Generally speaking, these elevations are accurate to within a few inches. The accuracy of a hydraulic model is directly related to the amount of detail included in the model and the reliability of the hydrological information used as input. In this case, the model (also known as a "HEC-RAS" model) has more than 100 cross-sections which is considered extremely detailed for this length of river.
3-7	What would be the cumulative flooding impacts if the Phillip's Dam and/or Pickpocket Dam failed with or without the presence of the Great Dam?	This question is beyond the scope of the Study & beyond the dam removal impact area.
3-8	Has the presence of the fish ladder had an impact on increasing flooding, and if so how much?	The previous hydraulic analysis results indicate the installation of the one-foot high "cap" on the dam crest and the fish passage facility caused the water surface elevation to be approximately 1.4 feet higher, at the dam itself, during the 50-year flood relative to conditions prior to their installation. The results of this analysis also suggest that these modifications had a minimal impact in increasing flood water elevations upstream of the dam. Please see the Exeter River Phase 1 – Final Report for additional information and evaluation of the fish ladder: http://town.exeter.nh.us/river%20study/River%20Study%20Phase%201%20Final.07.pdf

Station 3. Dam Safety (continued)

Public Comment		Project Team Response
3-9	How do you deliberately remove a dam? What is the actual physical process of dam removal? Is it quick or does it happen over a period of time?	Removal of the dam would begin with a controlled lowering of the river over the dam during the deconstruction process in order to minimize environmental impact associated with excavation in flowing water (i.e., turbidity). For dams like the Great Dam, removal typically involves the use of heavy construction equipment to break apart the concrete material that forms the dam. This material would then be removed from the river and disposed of at an appropriate location. The riverbed would then be restored to a natural substrate. The amount of time required for such a demolition project can vary greatly, but typically ranges from several weeks to several months.
3-10	The town should be doing more to manage its water and has only just stepped up in the last three years to meet the needs of Exeter.	The town has made significant investments in water management during recent town meetings.
3-11	Rumors in town that not all is being/ was done to increase dam capacity to allow flood waters to pass over the dam and the flood gate is far too small.	The sluice gate is an inadequate means of flood control for major flooding events. Please see the Exeter River Phase 1 – Final Report for additional information: http://town.exeter.nh.us/river%20study/River%20Study%20Phase%201%20Final.07.pdf
3-12	Request to see the initial letter of deficiency	The Letter of Deficiency can be found on the town's website under the River Study Committee's page (www.town.exeter.nh.us). The most recent safety inspection occurred on November 18, 2011 and the observations noted as a result can be found under Comment Code 3-2. Another Letter of Deficiency will be submitted to the Town of Exeter in the near future as a result of this inspection. The most significant deficiency associated with the Great Dam is its lack of discharge capacity. Current hydrologic and hydraulic analyses indicate that the dam is incapable of passing the runoff generated by the 50 year rainfall event without overtopping the dam's abutments. This condition is extremely unsafe and could easily result in a failure of the dam. Existing low hazard dams are required to have the ability to pass the 50 year event with at least one (1) foot of remaining freeboard. Freeboard is the distance between the expected 50 year flood level and the lowest portion of the dam's crest that could be overtopped and lead to dam failure. Env-Wr 303.12 provides for other possible remedies for addressing deficient discharge capacity as well. Any remedy proposed to address the deficient discharge capacity will need to be supported by structural and stability assessments. (The Letter of Deficiency was amended in 2004; a copy of the amendment can also be found on the town's web site under the River Study Committee Page: www.town.exeter.nh.us .)
3-13	Several comments from participants about the changing aesthetic value. One local resident and one resident of Newmarket were distraught over the state of the Winnicut River dam removal in Greenland.	Public presentations of New Hampshire dam removal projects (including the Winnicut) will be prepared and presented in the fall of 2012. Also, please visit the NH DES Dam Removal & River Restoration Program web site: http://des.nh.gov/organization/divisions/water/dam/damremoval/index.htm

Station 3. Dam Safety (continued)

Public Comment		Project Team Response
3-14	Several land owners and business owners requested that opinions and experiences of other NH towns that have gone through the dam removal process be made available in some format.	Public presentations of New Hampshire dam removal projects (including the Winnicut) will be prepared and presented in the fall of 2012. Also, please visit the NH DES Dam Removal & River Restoration Program web site: http://des.nh.gov/organization/divisions/water/dam/damremoval/index.htm
3-15	Concern about long-term impacts on current wetland resources. If the dam is removed, individual questioned whether or not the land adjacent to the river would be in wetland jurisdiction, or not; and whether it could be built upon.	The Study will evaluate impacts to wetlands should the dam be removed. If the dam removal alternative is selected and the dam is removed, it is likely some areas along the river may transition to upland. Existing state and local regulations would apply to these lands accordingly. Tim Drew, NH DES, can provide more information about state regulations regarding shoreland areas and wetlands: timothy.drew@des.nh.gov.

Station 4. Water and Sediment Quality

Public Comment		Project Team Response
4-1	How much sediment will end up in river downstream from the dam? Will the amount of sediment restrict rowing below the existing dam?	The consultant conducting the Study will assess the potential for changes in sediment transport, including erosion and deposition. More information on this topic will be available in the final report.
4-2	Are the [historic] river-side dumping areas being looked at?	The consultants conducting the Study are aware of the Cross Road Landfill (Exeter Transfer Station) and a second historic landfill adjacent to the river at the intersection of the Powder Mill Road and the Amtrak Railroad line. Both sites were considered in developing a sediment sampling program, with sampling stations placed in the river just downstream of each site. Note that the hydraulic modeling results completed to date indicate that both of these sites are far enough upstream of the Great Dam such that they would not be directly affected by the dam removal alternative.
4-3	What is the impact to groundwater levels for areas bordering the river once the dam is removed?	The consultant conducting the Study will analyze possible impacts to groundwater conditions that could result from the dam removal. More information on this topic will be presented in the final report.
4-4	Will there be an additional amount of sediment deposited into the Squamscott River?	The Study's consultant will assesses potential changes in sediment transport, including erosion and deposition. More information will be available in the final report.
4-5	Will historic boat navigation (e.g. Schooners or ships) be re-gained or limited by the dam being removed?	As a run of the river dam with an operable gate, the Great Dam only influences the depth of water upstream. The removal of the Great Dam would therefore have no direct influence on the depth of water downstream and would not improve or impact navigation in the tidal portion of the river.
4-6	Will removal of the dam result in the removal of increased sediments and need for restoration, or sand and gravel stream beds for fish breeding?	The Study includes an analysis of likely changes in sediment transport in the river, which will be provided in the final project technical report. Generally speaking, however, the removal of the dam would represent a return to a more natural sediment transport regime which would improve habitat for fish breeding.

Station 5. Fish Passage, Natural Resources, and Recreation

Public Comment		Project Team Response
5-1	What kind of effect will there be on the Exeter Elm Campground?	The Study will provide information on how the river could change under the dam removal alternative, including the effect on water levels, aesthetics and recreation. Given its location within the floodplain of the river, the Study will provide information on the potential impacts to the Exeter Elms Campground.
5-2	There was concern over the recreational effects on the campground.	The Exeter River is a valuable recreational resource for the regional community and potential changes are an important issue to be considered when evaluating alternatives. The Study will address existing recreational use of the river and will discuss how this resource may change if the dam is removed.
5-3	If you take away the dam, do you lose deep pools for fish?	The removal of the dam may decrease the availability of deep pools in the impoundment area, but would not entirely remove such deep pools. Generally speaking, the removal of the dam would be expected to have an overall benefit to the fish community within the river. More discussion on this topic will be presented in the final technical report. Please also see our responses to Comment 5-6 below.
5-4	What will be the recreational impact (fishing, swimming, boating) if water level is very low due to dam removal?	The Exeter River is a valuable recreational resource for the regional community and potential changes are an important issue to be considered when evaluating alternatives. The Study will address existing recreational use of the river and will discuss how this resource may change if the dam is removed.
5-5	Will lower water levels cause oxygen levels to decrease too low to support fish?	Removal of the dam would be expected to increase dissolved oxygen (DO) levels in the river. Dissolved oxygen concentrations are primarily related to the temperature of the water and the opportunity for aeration and mixing. Dams typically increase stream temperatures and reduce aeration and mixing leading to lower DO concentrations.
5-6	What is the minimum level of water for fish to survive, especially if there are drought conditions?	The answer to this question depends on the species of fish under consideration. Certain species, such as bass and bluegill sunfish, find impounded conditions favorable and their representation in the community increases relative to a free-flowing river. These fish are less likely to tolerate reduced water depths that would be associated with the dam removal alternative. Many other fishes, including alewives, are river specialists and their continued survival depends on the variation in depths and velocities experienced in an un-impounded river. Note that the consultant study will address the effects of dam removal on fish populations in consultation with the NH Department of Fish and Game, the US Fish and Wildlife Service and the National Marine Fisheries Service. Generally speaking, dam removals produce important benefits to fish habitat, which is why these agencies support dam removal.
5-7	How will dam removal effect upstream and downstream eel passage?	Upstream and downstream passage of eels, river herring, and other fish can be expected to improve with the removal of the dam. The final report will include a detailed assessment of fish passage.

Station 5. Fish Passage, Natural Resources, and Recreation (continued)

Public Comment		Project Team Response
5-8	Are there significant amounts of freshwater mussels upstream of the dam? Any rarer species of mussels?	The project consultant is working with the NH Fish and Game Department (NH F & G) to determine the presence of freshwater mussels in the affected portion of the river. Additionally, both the NH F&G and the US Fish and Wildlife have been consulted regarding the presence of rare species of mussels. These agencies report that no rare species are present.
5-9	Have any biodiversity studies of the river been performed?	The Great Bay Restoration Compendium has some relevant information: http://des.nh.gov/organization/divisions/water/wmb/coastal/restoration/compendiums.htm as does this study: http://www.rpc-nh.org/coastal-conservation.htm
5-10	Are any of the fish that you can catch now in the river safe to eat?	For NH fish consumption guidelines, please see: http://www.wildlife.state.nh.us/Fishing/fish_consumption.htm
5-11	Is there a recreational upside to dam removal?	The Exeter River is a valuable recreational resource for the regional community and potential changes are an important issue to be considered when evaluating alternatives. The Study will address existing recreational use of the river and will discuss how this resource may change if the dam is removed.
5-12	Will lower water levels encourage increased beaver activity and damming?	Beaver activity is dependent on several factors including water depths. It is possible that the drawdown associated with the dam removal alternative could allow beaver activity in areas where it is not currently observed. This question will be further discussed in the final report.
5-13	What can be learned from the Greenland example?	Public presentations of New Hampshire dam removal projects (including the Winnicut) will be prepared and presented in the fall of 2012. Also, please visit the NH DES Dam Removal & River Restoration Program web site:http://des.nh.gov/organization/divisions/water/dam/damremoval/index.htm
5-14	What fish species traditionally went up river before the dam?	The presence of the dam has impacted native migratory species such as American shad, river herring, American eel and other native species by fragmenting marine and inland aquatic habitats. Although there is an existing fishway on the dam, the fishway does not work efficiently at all flows and for all fish species. Additionally, the impoundment impacts spawning and rearing habitat and degrades water quality, impacting the river's ability to fully support native species.
5-15	Will removing the dam change sedimentation at Swazey Park (impacting recreational activity)?	Run of the river dams (see definition pg. 3) typically do not influence downstream velocities or water depths, which would be primary factors in determining the sediment transport regime in the tidal portion of the river near Swazey Parkway. Tidal forces within this portion of the river will continue to exert a greater influence on channel morphology than changes in hydraulics and sediment inputs associated with dam removal. Downstream impacts are not expected if the dam is removed.
5-16	It was noted that in front of Swazey Park the river used to be dredged consistently.	An assessment of dredging activities is not part of the Study's scope.
5-17	If the dam is removed, has anyone modeled how the wetlands will evolve over the next 1, 5, 10 years and how DES jurisdiction of river side resources will change as a result of changing wetlands.	The Study includes an assessment of potential impacts to wetlands along the river corridor. A more detailed examination of this question will be presented in the final report.

Station 5. Fish Passage, Natural Resources, and Recreation (continued)

Public Comment		Project Team Response
5-18	Concern over potential for development to occur in areas that are not developable as they are wetlands.	The Study will evaluate impacts to wetlands should the dam be removed. If the dam removal alternative is selected and the dam is removed, it is likely some areas along the river may transition to upland. Existing state and local regulations would apply to these lands accordingly. Tim Drew, NH DES, can provide more information about state regulations regarding shoreland areas and wetlands: timothy.drew@des.nh.gov.
5-19	Will there be changes to the Great Swamp in Kensington? These are important wetlands.	The Study includes an assessment of potential impacts to wetlands along the river corridor. Preliminary results completed to date suggest that the potential for effect to the Great Swamp are negligible. A more detailed examination of this question will be provided in the final report.
5-20	How does the water table and vegetation along the river change as a result of dam removal?	An important focus of the Study is the development of a hydraulic model that will help in gaining an understanding of how water levels within and adjacent to the river would be affected if the dam is removed. Additionally, the Study will address possible effects on groundwater conditions and how these changes might affect vegetation along the river.
5-21	What has happened for other dams that have been removed in NH?	Public presentations about New Hampshire dam removal projects (including the Winnicut) will be prepared and presented in the fall of 2012. Also, please visit the NH DES Dam Removal & River Restoration Program web site: http://des.nh.gov/organization/divisions/water/dam/damremoval/index.htm
5-22	Will something replace the current impoundment area, open space?	Interpretation of the preliminary hydraulic modeling results indicates that the area adjacent to the river will continue to function as an active floodplain, with the river flooding this are during higher flows.
5-23	What is your idea on the dam and fish passage?	The Study includes an analysis of how dam removal will affect fish passage, and will be fully addressed in the project technical report, expected to be issued in the summer of 2012. The Exeter Dam is a partial barrier that inhibits diadromous (migratory between fresh and salt water) fish migrations in the Exeter River and has undermined recovery of native migratory species such as American shad, river herring, American eel and other native species by fragmenting marine and inland aquatic habitats. Although there is an existing fishway on the dam, the fishway does not work efficiently at all flows and for all fish species. Additionally, the impoundment impacts spawning and rearing habitat and degrades water quality, impacting the river's ability to fully support native species.
5-24	How does the dam affect fish breeding?	The Exeter Dam is a partial barrier that inhibits fish migrations in the Exeter River and has undermined recovery of native migratory species such as American shad, river herring, American eel and other native species by fragmenting marine and inland aquatic habitats. The existing fishway does not work efficiently at all flows and for all fish species. Additionally, the impoundment impacts spawning and rearing habitat and degrades water quality, impacting the river's ability to fully support native species.

Station 5. Fish Passage, Natural Resources, and Recreation (continued)

Public Comment		Project Team Response
5-25	Are they removing all dams in NH?	The decision to remove or keep a dam is up to the dam owner.
5-26	If you take the dam down, how will that affect fish upstream, resident fish, and fish that travel upstream?	The Study includes an analysis of how dam removal will affect fish passage, and will be addressed in the final project report. The Exeter Dam is a partial barrier that inhibits fish migrations in the Exeter River and has undermined recovery of native migratory species such as American shad, river herring, American eel and other native species by fragmenting marine and inland aquatic habitats. The existing fishway does not work efficiently at all flows and for all fish species. Additionally, the impoundment impacts spawning and rearing habitat and degrades water quality, impacting the river's ability to fully support native species.
5-27	Do people care about fish as much as other issues?	The impact of dam removal on fisheries was identified as an area of concern in early public meetings. Ultimately it will be up to the voters to decide which scenario with its associated impacts is the preferred alternative to meeting Dam Safety Bureau standards.
5-28	What is the difference in Greenland since the dam has been gone?	Public presentations of New Hampshire dam removal projects (including the Winnicut) will be prepared and presented in the fall of 2012. Also, please visit the NH DES Dam Removal & River Restoration Program web site: http://des.nh.gov/organization/divisions/water/dam/damremoval/index.htm
5-29	Do we know where all the streams are?	The location of tributary streams is known through the use of previous mapping studies such as the US Geological Service's topographic maps.
5-30	What will water level impact be on local business and historical buildings	Dam removal would be expected to lower water levels during flood events. A comprehensive discussion of the effects of the dam removal alternative on water levels in the river will be presented in final report.
5-31	Will it impact the powder mill?	The Powder Mill is located relatively far upstream and would not be directly affected by the dam removal alternative. This conclusion is supported by the hydraulic model prepared for the Study which shows that the primary impoundment is limited to the reach of the river near the NH 108 bridge crossing.
5-32	When did it change names to the Great Dam, it used to be called the Mill Dam?	It is common to see a dam known by several names including some which are known only locally. The historian working on this study has not found reference to the dam as the "Mill Dam." There is a reference (1828 deed from Exeter Mill and Water Power Company to the Exeter Manufacturing Company) to an earlier dam at the location of the current one which was called the "upper dam", referring to the Upper Falls (as opposed to the lower falls, which were on either side of Kimballs Island). An 1831 survey of the river notes the dam as the "Exeter Upper Falls Dam." The dam is referred to as the "Exeter River Dam" in 2008 (DES to Town of Exeter, NH, Notice of Decision on Determination of Lake Level, August 20, 2008); the document notes that the name "Great Dam" is used locally. Great Dam in general as its name appears to be 20th century only.
5-33	How will dam removal change flow in flood time?	The removal of the dam would be expected to lower water levels during flood events. A comprehensive discussion of the effects of the dam removal alternative on water levels in the river will be presented in the final report.

Station 6. Historical & Archaeological Resources

Public Comment		Project Team Response
6-1	A participant reported a gunpowder mill on Powder Mill Road, east of the intersection with Route 111.	VHB and the Exeter River Working Group thanks the commenter for their participation in the information gathering process. The project team will take their contribution into consideration when completing the Study.
6-2	A participant also reported "a really old dam at Railroad Bridge and Route 111. At one point, there were four mills in this area (corn, saw, and gunpowder (2) [Hobart Gun Manufacturer]). Ms. Dupre stated that one of the powder mills dated to the Revolutionary Period, the other operating from ca 1812 to 1850. A nail slitting mill also was located here and a woolen mill. Mill area might have been called King's Fall, or Kingston Mills, after Thomas King who owned mills here in the late 1600s or early 1700s.	VHB and the Exeter River Working Group thanks the commenter for their participation in the information gathering process. The project team will take their contribution into consideration when completing the Study.
6-3	Exeter Selectman, Julie Gilman, recommended conversations with Dan Foster, retired professor from Phillips Exeter Academy, who maintained the original collection prepared by the late Willie White (formerly of PEA). Julie recommended Bell's History of Exeter for context and historical background. According to Julie the Swazey Park area was noted for shipbuilding but this area was filled when the Parkway was built, perhaps in the late nineteenth century. She suggests that the west side of the river, on the site of the Exeter Housing might be archaeologically sensitive. Development occurred in the 1970s.	VHB and the Exeter River Working Group thanks the commenter for their participation in the information gathering process. The project team will take their contribution into consideration when completing the Study.

Station 6. Historical & Archaeological Resources (continued)

Public Comment		Project Team Response
6-4	A river abutter will provide us with pictures and an article on the river confluence from two early newspaper articles. He has pictures of people standing and looking at ice jams in the river. Notes the presence of outhouses on the island. He purchased the Island in 1977. It originally was named for Emma Kimball. Will accommodate researchers during a site visit.	VHB and the Exeter River Working Group thanks the commenter for their participation in the information gathering process. The project team will be sure to take their contribution into consideration when completing the Study.
6-5	One gentleman recalled activities and resources along the river, including trout, perch, hornpouts, alewife, lamprey eels, muskrats, and possibly mink. He referred to a boat house on the river, prior to the population growth of the late 1940s. (These resources are the kinds of resources that would have attracted Native Americans to the area prior to European settlement).	VHB and the Exeter River Working Group thanks the commenter for their participation in the information gathering process. The project team will be sure to take their contribution into consideration when completing the Study.
6-6	How will dam removal impact the historical nature of the dam?	The Study will include an assessment of impacts to historic properties including the dam. The historic evaluation will determine if dam removal would represent an "adverse effect" to the dam itself and the surrounding historic districts. This work is being conducted in consultation with the NH Division of Historical Resources and a number of interested "Consulting Parties" from the community. Section 106 of the National Historic Preservation Act requires that a Memorandum of Agreement be executed to address potential impacts and to spell out appropriate mitigation for any such impacts. This consultation is on-going. Further information will be included in the final report.
6-7	How will all the information come together in the end once the study has been completed?	Once the review of historic resources is completed, all relevant documents and reports will be posted on the town web site (with the exception of sensitive archaeological resources; by law, specific information about these resources cannot be made public, therefore, only a summary will be available). Historic resources information will also be included in the final report.
6-8	Before it was a concrete dam, what was the dam made of? One man thought there was another dam before it was the current concrete one.	There is no documentation as to what the earlier dam (or dams) were built of, but based on an understanding of historic dam building techniques, it can be assumed the previous dam was made of stone and/or timbers. Historical research conducted as part of this study indicates that there was a dam at the present location in 1827 (with earlier map evidence dating to 1802) with a dam likely in place as early as the 1640s. A new dam was pledged to be built in late 1828 or early 1829 by the Exeter Manufacturing Company. There is no documentation that this new dam was replaced at any point before 1914 when the current one was built; there is some indication that a previous dam owner considered rebuilding the dam in the 1890s, but no firm evidence of its reconstruction in the 1890s could be found.

Station 6. Historical & Archaeological Resources (continued)

Public Comment		Project Team Response
6-9	Concern about what's happening with the Winnicut dam removal; doesn't want that to happen here.	Public presentations about New Hampshire dam removal projects (including the Winnicut) will be prepared and presented in the fall of 2012. Also, please visit the NH DES Dam Removal & River Restoration Program web site: http://des.nh.gov/organization/divisions/water/dam/damremoval/index.htm
6-10	One man commented that once the dam is removed, it cannot be put back; he doesn't want the town to regret removing the dam, it is part of the beauty of the town	Comment noted
6-11	Curious about what has happened with other dam removals, regarding river flow, roads, and other factors. Concerned about what will happen.	Public presentations about New Hampshire dam removal projects (including the Winnicut) will be prepared and presented in the fall of 2012. Also, please visit the NH DES Dam Removal & River Restoration Program web site: http://des.nh.gov/organization/divisions/water/dam/damremoval/index.htm
6-12	One participant said: Seems to me that the impoundment behind the dam will be gone; will something replace where that open space is?; a lot of seasons of the year there isn't much of a river below the dam and the vegetation around blocks the views. Is that what is to be expected if the dam is removed?	A series of photographs taken during the November 2009 drawdown of the dam provides some insight into what the river would look like if the dam were to be removed. As part of the study, the consultant may be required to provide additional visual simulations so that the public can better understand the aesthetic impact of the dam removal alternative.
6-13	What is the depth of the water at the dam right now?	The depth of water at the dam depends on the flow, which varies depending on precipitation events. However, the depth of water at the dam currently ranges from about 7 to 9 feet.

Miscellaneous Public Comments (received in writing on comment forms)

Public Comment		Project Team Response
CF-1	What does the topography of the river bottom in the area of the dam tell us about what the river looked like before the dam was installed (was there a waterfall-like drop)? Will this give us an idea of how it would look after removal?	A series of photographs taken during the November 2009 drawdown of the dam provides some insight into what the river would look like if the dam were to be removed. As part of the study, the consultant may be required to provide additional visual simulations so that the public can better understand the aesthetic impact of the dam removal alternative.
CF-2	If there is a lot of silt behind the dam, do we know how far down the ledge/rock is (below the current average water level?	Based on visual observations during the dam drawdown in November 2009, as well as a review of geotechnical boring information produced during the reconstruction of the Great Bridge indicates that ledge is present at or near the stream bed surface.

Miscellaneous Public Comments (continued)

Public Comment		Project Team Response
CF-3	Please keep the dam. The reflections of the buildings and town are a key part of the beauty and heritage of Exeter. The dam needs proper floodgates and responsible people to lower the water if heavy rain or snowmelt run-off is threatening. It is too late to comment and to rebuild a complete new flood control type dam if it removed. Keep the Dam!!!	The Great Dam is a run of the river dam with an operable gate and is not a flood control dam.
CF-4	The Exeter River at reduced water levels as a consequence of dam removal could become a series of beaver impoundments all the way up to the next dam. There were no beaver in NE before the dam was put in originally due to over harvesting. There are beaver along the river already, but they cannot establish flowages with the level at its current state. With the dam removed there will be an increase in the wetland marsh, but probably not a navigable river as we have now. Any increase in fish runs up from the Squamscott will probably be influenced.	Beaver activity is dependent on several factors including water depths. It is possible that the drawdown associated with the dam removal alternative could allow beaver activity in areas where it is not currently observed. This question will be further discussed in the final report.
CF-5	A participant commented that they have some deed copies re the Mills at Kings Falls (between Rte 111 and where river edges Powder Mill Road.	VHB and the Exeter River Working Group thanks the commenter for their participation in the information gathering process. The project team will take their contribution into consideration when completing the Study.
CF-6	Include photos of before and after removal of other dams and upstream vegetation/wildlife changes.	Public presentations about New Hampshire dam removal projects (including the Winnicut) will be prepared and presented in the fall of 2012. Also, please visit the NH DES Dam Removal & River Restoration Program web site: http://des.nh.gov/organization/divisions/water/dam/damremoval/index.htm
CF-7	Will identified or probable archeological sites be preserved, removed or left alone. If water level decreases and exposes sites is there any mitigation.	The Study's consultant team includes a senior archaeologist responsible for evaluating areas of archaeological sensitivity that could be affected by dam removal or modification. This work is being conducted in consultation with the NH Division of Historical Resources and a number of interested "Consulting Parties" from the community. Section 106 of the National Historic Preservation Act requires that a Memorandum of Agreement be executed to address potential impacts and to spell out appropriate mitigation for impacts. Further information will be included in the final report.
CF-8	Be definitive about the impact on water table and wells, septic systems.	Potential impacts to private and public property are a critical consideration in evaluating alternatives for the Great Dam. The final report will provide as much information and as possible on these issues.

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Public Comments on the June 2013 Draft Technical Report, with Responses

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Comments of
Sean McDermott
3 Spruce Street, Exeter, NH

Dr. Becker,

My name is Sean McDermott. I live at 3 Spruce Street in Exeter. I have been following the study process and read select portions of the draft Exeter River dam removal feasibility study (June 2013). Below are my comments on the alternatives. My interests are principally the long term costs.

1. The scope of alternatives is quite good, particularly with the inclusion of full removal. Too often the removal is left out and engineered solutions are targeted. Unfortunately engineered alternatives, as covered in the draft, come with long term costs.

Response: The committee appreciates this comment, and agrees that the number and type of alternatives examined in this report is quite extensive. The cost estimates provided in Chapter 2 do address long term costs associated with each alternative.

2. Long term costs for engineered and no action alternatives are appropriately considered. Dam removal by nature would have no cost or minimal expenses over the 30 year window. That said, the summaries of costs are limited to known operations and maintenance. The unexpected costs, which by nature are difficult to capture, are not included. Specifically, what is the cost of partially or fully replacing the Obermeyer weir and flashboard system if alternative H is selected? In the event of failure, how rapidly can the structure be repaired? If the Town is unable to rapidly replace or replace the Obermeyer weir, what is the cost to upstream infrastructure that the Town may be required to cover? Such a failure could happen at any time. Although dam removal (option B) and the modification with Obermeyer weir (option H) are comparable in cost with similar environmental benefits, an understanding of the risk for failure should be part of the discussion.

Response: The cost analysis did consider "Life Cycle Costs" which attempt to estimate the costs associated with some of the factors cited in this comment. Specifically, Section 2.11.2 of the report did discuss the total costs of each alternative not only for operation and maintenance, but also included the likely costs for capitol replacement, including the potential for replacement of the Obermeyer flashboards and weir. (See the summary in Table 2.11-2.)

Some of the items cited in the comment are risk factors (e.g., effects of a failure), which cannot be precisely quantified. With proper maintenance, the likelihood of a failure of the Obermeyer system is very low. The length of time required to repair or replace a failed system component would of course vary depending on the actual component and mode of failure. In general, though, repair of any failure requiring replacement of the inflatable bladder would take weeks to months to complete. While this risk cannot be precisely quantified, it is not unreasonable to consider this factor in choosing a final alternative.

3. Long term costs of fish passage currently, presumably, covered by the state of New Hampshire. It was not clear if this cost was included in the analysis. Although an indirect cost, maintaining the dam requires an expenditure of time and resources to maintain and operate the fishway. There is no guarantee that state funds will be available to staff the fishway. Likewise, there is no guarantee that the Exeter River will remain a state priority for passing anadromous fish over the next 30 years. Only full dam removal (option B) is unaffected by this consideration. This factor should be part of the consideration for choosing an alternative.

Comments of
Sean McDermott
3 Spruce Street, Exeter, NH

<u>Response</u>: The current annual operation and maintenance costs for the Exeter River fish ladder at Great Dam, owned and operated by the NH Fish and Game Department, is $12,554/year. This includes personnel costs for monitoring and maintenance, equipment to maintain an operational fishway, and repairs. This would translate to a minimum cost of $376,620 over 30 years.

4. Full dam removal (option B) is projected to be the second most expensive option. Dam modification (option H) is a close third with similar water quality, fish passage and habitat benefits. However, compared to all the alternatives, dam removal comes with closure. No major future action related to the dam will be needed. No flood concerns associated with the dam; no structural failure; no insurance issues; no maintenance or operations. Additionally, removal of the dam eliminates the need for specialized training of town staff, which over 30 years may require repetition with staffing changes. All of this has implications for future costs to the Town and should be considered in the decision process.

<u>Response</u>: So noted.

5. Partial removal of the dam (option F) requires a new fish ladder. In addition to the long term costs of operations and maintenance, there is the risk that it won't attract fish. Hopefully the design considerations vetted the need for a training wall similar to the current structure. This would increase the overall cost.

In addition, lowering the head height by four feet may make a rock ramp viable. While a rock ramp would eliminate some O&M requirements and provide volitional fish passage year round, the long term performance of these structures are not fully vetted.

<u>Response</u>: We are confident that the new fish ladder can be designed to attract fish. The current concept would located the fish ladder entrance at river right where there is additional flow due to the low level gate – which could be modified to improve attraction flow. The entrance would also be set at the base of the dam unlike the current fish ladder; there is therefore no need for a training wall. The flow from the fish ladder entrance and the auxiliary flow provided by the low level outlet should adequately attract the migrating fish.

A rock ramp could be considered in lieu of a fish ladder, but it would likely be more expensive. Successful rock ramps are generally less than 5% slope, so an eight foot high dam (i.e. the existing downstream dam height minus the 4 foot breach proposed under Alternative F – Partial Removal) would require a ramp approximately 400 feet long. That would require a great deal of material, placement of which could be quite expensive and involve potential design issues.

6. Final selection of an alternative should not be simple cost (although see the next comment). If we as a Town intend to take on a large project, we should aspire to the broadest range of benefits. Stabilizing in place (Option G) does nothing for the Town except meet a narrow regulatory standard (not to belittle the requirement). We gain nothing for recreation, water quality or migratory fish, and next to nothing for flood mitigation. A great deal of money would be spent for a single goal. Dam removal (option B), and partial removal have similar potential benefits across a broad range of interests: fish passage, water quality, flood mitigation, etc. Although more expensive, more would be completed for improving the natural resources and the quality of life in Exeter.

Comments of
Sean McDermott
3 Spruce Street, Exeter, NH

<u>Response</u>: So noted.

7. Whatever option is selected, the availability of outside funding should be a top criteria. If state or federal funds are available for specific options but not others, the Town voters should be informed. Such funding could make otherwise expensive options palatable to local tax payers.

<u>Response</u>: The report has been updated to include a discussion of potential grant funding opportunities. Please see Section 2.11 of the final report.

The draft report appears to address the social, economic and environmental concerns surrounding this project. Long term costs, outside funding sources and a broad spectrum of benefits should inform the decision process for advancing a preferred alternative. Thank you

<u>Response</u>: The Exeter River Study Committee acknowledges and appreciates these comments. The commenter is encouraged to participate in future public discussions regarding the selection of an alternative.

Comments of
Allen Lampert
Franklin Street, Exeter, NH

I own property on Franklin Street and have worked and next to the river for 40 years. Having have suffered the effects of flooding and the negative economic impact, I feel removal will be the best long term course of action.

Allen Lampert

<u>Response</u>: The Exeter River Study Committee acknowledges and appreciates this comment. The commenter is encouraged to participate in future public discussions regarding the selection of an alternative.

Comments of
Tom Oxnard
Greenleaf Drive, Exeter, NH

Hi, I am writing in response to the article, and for public response to the Great Dam. I would vote to take the dam down, because of the huge financial losses and misery created by regular floods. I hope these financial costs have been factored in.

Tom Oxnard, Greenleaf Dr, Exeter

Response: The Exeter River Study Committee acknowledges and appreciates this comment. The commenter is encouraged to participate in future public discussions regarding the selection of an alternative.

Comments of
Dan Jones
181 Kingston Road, Exeter, NH

Dear Dr. Larsen Becker:

I have read with some interest the Executive Summary of the Committee Report with its attachments. My comments would be:

1. The fish ladder was rebuilt around 2010, not the earlier date mentioned in the introduction.

Response: The date in the report refers to the original installation of the fish ladder, which occurred in the late 1960s; the date cited in the report is therefore correct.

2. There is no discussion of the effect of the "Great Bridge" on the flooding upstream of the existing dam. In the "Mother's Day Flood," the flow could not pass under the bridge, while, of course, there was full flow over the dam below.

Response: The full text of the report and its appendices has a very detailed discussion of the river hydraulics, including the restriction presented by the Great Bridge. The hydraulic analysis considers this effect, so all of the numbers in the report are accurate, as are the findings outlined in the Executive Summary.

3. There is no discussion of the lack of management or the failure of the town to open the existing gate in advance of potential flooding. The dam suffered from creative neglect for many years under the prior town administration. I believe that it has since been the practice to open the gate and draw the impoundment down in anticipation of severe storms, with a reduction in flooding. Is an upgrade of the existing gate, or an exploration of the possibility of using the mill penstock in these cases included in the Stabilization option? Could the gate be enlarged?

Response: These issues are addressed in detail in the full technical report. We examined both upgrading the gate and using the penstock in great detail in this and previous studies. We found that increasing the size of the gates does not provide adequate hydraulic capacity (i.e., would not pass the 50 year flow) and therefore would not eliminate the safety concerns and would not meet dam safety rules. Similarly, using the penstock would not provide adequate hydraulic capacity, and faces other constraints as well. However, reconfiguring and increasing the size of the gates is included in several of the alternatives, most notably Alternative H – Dam Modification.

4. The report seems to treat the existing wetlands and wildlife habitat along the rivers as some sort of recent creation. They have been in existence since the original construction. Except for the white oak swamp I see very little concern in that direction.

Response: Certainly, the river valley contained extensive wetlands and wildlife habitat prior to the construction of a dam on the Exeter River; these wetlands and wildlife habitats will continue to exist if the dam is removed. However, those natural systems have adapted to the increased water levels and more frequent flooding produced by the dam. Natural community changes, including a potential loss of wetlands as discussed in the report, is a concern to many in the community as well as to the natural

resource agencies. It is appropriate to consider this effect in making a final decision about the fate of the dam.

5. The report describes the drop in water level upstream. I do not see an analysis of the gradual drop in ground water level and the effect on the surrounding area. We all know that the developers who are pushing for the removal anticipate that their land along the river will become less restricted.

Response: The effect of dam removal on groundwater levels in discussed in several sections of the technical report, most notably in the context of water supplies (Section 3.7.3) and wetlands and other natural resources (Section 3.11). If the dam removal alternative is selected and the dam is removed, it some areas along the river may eventually transition to upland, but these would tend to be areas located away from the river itself and not directly adjacent. Existing state and local regulations would apply to these lands accordingly. Tim Drew, NH DES, can provide more information about state regulations regarding shoreland areas and wetlands: timothy.drew@des.nh.gov.

6. Has there been a survey done of the extent of the flowage rights owned by the town?

Response: The Town is not aware of any survey of flowage rights. Such a survey is not considered a requirement before a decision can be made on which alternative to select.

7. I own much of the Exeter frontage on the Pickpocket mill pond. Is the State going to push for its removal too? I would gain several acres of dry land.

Response: The State does not have a preference regarding the alternative which a dam owner selects, as long as it meets Dam Safety Regulations. Dam removal is one means to achieving safety standards. The Pickpocket Dam is owned by the Town of Exeter and is currently under a Letter of Deficiency. It is the responsibility of the town, as the dam owner, to address the noted deficiencies and their choice to as to how they will comply with Dam Safety Regulations.

8. Has the committee looked at the mess that other dam removals have caused?

Response: The committee has received several public comments at the three public meetings that were held for this project regarding the outcome of other New Hampshire dam removal projects. As a result, public presentations of New Hampshire dam removal projects will be prepared and presented. The commenter is encouraged to attend the future public presentation to receive factual information and participate in discussions.

9. I believe that stabilization and improvement and management of the existing gates is the best way to preserve Exeter's heritage.

Response: These issues are addressed in detail in the full technical report. We examined both upgrading the gate and using the penstock in great detail in this and previous studies. We found that increasing the size of the gates does not provide adequate hydraulic capacity (i.e., would not pass the 50 year flow) and therefore would not eliminate the safety concerns and would not meet dam safety rules. Similarly, using the penstock would not provide adequate hydraulic capacity, and faces other

Comments of
Dan Jones
181 Kingston Road, Exeter, NH

constraints as well. However, reconfiguring and increasing the size of the gates is included in several of the alternatives, most notably Alternative H – Dam Modification.

10. Although Exeter may not have a specific figure added to the appraisal for river frontage, it does affect the market value which is the basis for the value placed on the parcel.

Response: The Town will continue its current property assessment process. The tax assessor does not assess riverfront property any differently than other property and the market dictates the value of property.

11. I do appreciate the amount of work done on this study. Unfortunately, my illness over the past year has kept me from getting too involved. I have previously served on both the Planning Board and as chairman of the Z.B.A. for five years. I was also on the Sounding Board which wrote a soil type based master plan, long since buried, in the 1970's. The town does have maps which delineate the soil types, and probably those areas saturated by the mill pond.

Response: The Exeter River Study Committee acknowledges and appreciates this comment. The commenter is encouraged to participate in future public discussions regarding the selection of an alternative.

Thank you for your attention,

Dan Jones
181 Kingston Rd.

Comments of
Carl and Sharon Anderson
Exeter, NH

Good morning Ms. Larsen.

My wife Sharon and I have lived in Exeter for more than 40yrs and have enjoyed the beauty and harshness of the Exeter River. To us the total removal of the dam is the most practical and cost effective way of dealing with all the present and future potential unknowns if the dam remains.

Respectfully yours,
Carl and Sharon Anderson

Response: The Exeter River Study Committee acknowledges and appreciates this comment. The commenter is encouraged to participate in future public discussions regarding the selection of an alternative.

Comments of
Bonnie Flythe
Exeter, NH

Hello,

I have read the reports on the town site about the Great Dam and now think that the town should remove it. This would apparently be the most sound (sic) *ecological move and would improve the quality of the water.*

I am not persuaded that it has sufficient historical importance to preserve it. With the dam removed residents would be restoring the river to its condition when the earliest residence lived here. It would be interesting to know what Native American archaeological sites existed along the banks, but that is unfortunately not possible. It does not seem to me that removing the dam will seriously harm the picturesque nature of the downtown area. From so many angles, Exeter is very attractive and at least part of that is the result of some relatively natural areas along the river bank.

Thank you for considering what I have to say.
Bonnie Flythe

Response: The Exeter River Study Committee acknowledges and appreciates this comment. The commenter is encouraged to participate in future public discussions regarding the selection of an alternative.

Comments of
Jeff Bouvier
1 Hillside Avenue, Exeter, NH

Dr. Larsen Becker,

My feedback for the Great Dam is to go with Option G, stabilize the existing dam. First and foremost, it is by far the cheapest option and should be the obvious choice based on cost. Cost should always be the primary driving force when it comes to spending of the tax payers dollars. Second for me is to leave Exeter as it is. A dam has been there for over 350 years and it should remain there. It is what made Exeter, Exeter. Without the river and the dam, Exeter would be a dramatically different town.

Sincerely,
Jeff Bouvier
1 Hillside Ave.
Exeter, NH

Response: The Exeter River Study Committee acknowledges and appreciates this comment. The commenter is encouraged to participate in future public discussions regarding the selection of an alternative. Please note that cost estimates have been updated in the final report in response to public comments and additional information. Additionally, a discussion of potential grant funding opportunities for the project has been added to the report.

Comments of
Jeff Bouvier
1 Hillside Avenue, Exeter, NH

We live on Crawford Ave in the Court St area which sees significant flooding. After reading the report summary on the town's website, it seemed that as a taxpayer with no impact from the river as a homeowner, the decision to anchor the existing dam would be the most cost effective approach. One of the questions at the end of the report asked about grants for dam removal. The answer was somewhat ambiguous talking about modification not removal. We have a vested interest on this topic and strongly support the removal of the dam due to flooding problems. We received heavy damage to our home during the mother's day flood, and have been forced to leave several other times during heavy rain storms. When this topic of dam removal was first brought to our attention a few years ago, there were conversations of federal money for dam removal, not modification. The last article in the Exeter News letter detailed the costs on the front page of the newspaper showing the least expensive project being anchoring the current dam. I'm not sure if this is misleading the public if public money is available, since most voters would vote for the cheapest alternative. There are many other positive features to restoring this river to its original beauty as many river projects are doing so throughout the country. However, the bottom line of our viewpoint is it would be nice to feel a bit more secure when heavy rain storms are predicted.

Philip Conlon

Response: The Exeter River Study Committee acknowledges and appreciates this comment. The commenter is encouraged to participate in future public discussions regarding the selection of an alternative. Please note that cost estimates have been updated in the final report in response to public comments and additional information. Additionally, a discussion of potential grant funding opportunities for the project has been added to the report.

Comments of
Brian Griset
26 Cullen Way, Exeter, NH

Great Dam Removal Feasibility and Impact Analysis-
Final Draft Report

Comments:

Brian Griset *August 13, 2013*
26 Cullen Way, Exeter, NH 03833
(603) 772-0978 Email: grisetandsons@comcast.net

Please accept the following comments on the final draft report and Executive Summary. As you are aware I have been involved in this project from the beginning on both the W&S Committee and River Advisory Committee as well as a private citizen and consultant. There are multiple areas of concern which are unaddressed or reflect inaccurate information.

Response: The Committee appreciates the detailed comments provided by Mr. Griset and acknowledges that some clarifications and additional information would benefit the report, as is the case for all draft reports of this nature. However, we respectfully contend that this comment overstates the issue. Additional responses to specific items are provided below, and the report has been updated in response to some of Mr. Griset's comments.

I would like to ask one question before I proceed. Is it the intension of the Committee and Consultants to actually update and correct the Final Report itself, rather than just adding "comments and answers" as a separate handout?

Response: The ERSC has issued responses to each of the comments received. Additionally, the final technical report has been updated as needed in response to public comments received on the June 2013 Draft Report.

Issues:

Methodology:

There is no consistency to the methodology or scope of work assigned to each alternative. As examples:

Dam Removal option:

Governmental Impacts: Positive

The report looks more globally and includes potential NEGATIVE infrastructure impacts (the 4 direct intakes into the river).

Comments of
Brian Griset
26 Cullen Way, Exeter, NH

However, there is no evaluation or quantification of the POSITIVE impacts and the cost savings directly resulting from the reduction in flooding and lowering of the overall water table. We currently have multiple completed and ongoing studies covering some of these issues.

Example 1:
I/I, Inflow and Infiltration has been a hot topic as demonstrated by the CSO discussions, Wastewater Treatment capacity and operating expense discussions and the current Jady Hill project. There has already been a second I/I project identified, Westside Dr. Sump pump usage for underwater basements has been discussed at length and a town wide solution has not been developed. On multiple occasions, in multiple forums, I have raised the issue and premise that the lowering of the water table should result in some change in the volume of water being discharged by sump pumps or I/I into the sewer lines which would lower total operating costs for its treatment. Further, any reduction in volume would allow for less capital expenditures to reduce this problem. Not even a mention of the potential cost savings is included in the Dam report. These costs savings from reduced operating and diminished future capital projects impacting W&S users are not quantified or even mentioned in the report or Executive Summary. An "estimated" credit should be established for these items, both O&M and capital cost.

<u>Response</u>: The commenter raises a reasonable point, but there is currently no accurate way to estimate these costs, so their inclusion in the cost estimate would be potentially misleading. The cost estimates as presented make a very significant effort to include all potential direct and indirect cost items in a balanced way so that the public will have a comprehensive view of the relative costs of each alternative. It is certainly appropriate to consider factors other than those included in the cost estimates when making a final decision on the best alternative. This potential benefit has been identified and discussed in a qualitative manner in the final report in a new section entitled "Other Potential Related Costs and Benefits."

Example 2:
Currently the Town, or taxpayers, expend funds from property taxes to maintain and operate the dam. Licensing fees, repair and maintenance costs, utilities and personnel costs are budgeted annually. These costs should be also quantified for the same time frame (30 years) used for future O & M future expenses for the other options and listed as a credit for the Dam removal option in determining total cost.

<u>Response</u>: The costs estimates already address the relative differences between the alternatives for operations and maintenance (O&M) costs. O&M costs are appropriately reflected in the cost estimates for the "build" alternatives. To include them as a credit for dam removal would essentially count them twice, which would not be appropriate.

Example 3:
Another example is reduced road maintenance costs due to frost heaving. Most of our roads were laid out prior to the 1960's when the dam alterations began raising and restricting water flow and the operation of the mill water source began to be reduced and discontinued. As a result, road bed elevations were constructed based upon that periods water table and frost parameters. Presently, low lying roads like Court St. and Powder Mill Rd. suffer extreme frost heaving resulting in higher maintenance costs and shorter life expectancies. An estimate should be requested from the Highway Superintendent and included as a credit.

Comments of
Brian Griset
26 Cullen Way, Exeter, NH

<u>Response</u>: Again, quantifying these types of indirect costs is extremely difficult, if not impossible, and is therefore not standard practice. The cost estimates as presented made a very significant effort to include all potential direct and indirect cost items in a balanced way so that the public would have a comprehensive view of the relative costs of each alternative. However, this potential benefit has been identified and discussed in a qualitative manner in the final report in a new section entitled "Other Potential Related Costs and Benefits."

Example 4:
I won't even go into the funds spent by this town for emergency management, past emergency responses, overtime, etc. but a general review and presentation of town wide annual cost savings should be included in the report showing the offset to any projected expenses.

<u>Response</u>: Available information on Federal Emergency Management Agency (FEMA) insurance claims and grants in Exeter was gathered and included the in the report. Based on additional discussions with the town in response to this comment, it was determined that there would be no accurate way to quantify the potential savings to the Town from decreased emergency operations if the dam were to be removed, and the Town expects these savings to be relatively small. However, it may be appropriate to consider this potential benefit if the dam were to be removed (Alternative B) or Modified (Alternative H). Therefore, this potential benefit has been identified and discussed in a qualitative manner in the final report in a new section entitled "Other Potential Related Costs and Benefits."

Private Property Owner Impacts: Positive

Example 1:
Currently FEMA is conducting studies to update FEMA flood maps based upon new rainfall information. It should be noted this data is based upon prior rainfall data, not projected future data related to Climate Change.

When making these updates the modeling will be based upon the rainfall data and <u>existing</u> infrastructure and topography. The projected net result is that the new FEMA mapping will incorporate an even greater geographic area in Exeter.

Since all property transfers now require flood zone certifications for transfer and mortgage purposes, we will see numerous new Exeter homeowners now required to purchase flood insurance. A current rate quote from last week for a $250,000 home with a $1,000 deductible in the 100 year flood plain is $458. A home in a 50 year flood plain will be even higher and will affect many homes currently paying a premium based upon the 100 year event.

With the dam removal option, immediately upon removal the Town of Exeter can request updating of the FEMA mapping to reflect the diminishing affects and geographic area of flooding. This would result in immediate cost savings to present and future home buyers and sellers.

Comments of
Brian Griset
26 Cullen Way, Exeter, NH

<u>Response</u>: Until new maps are available, any estimate would be speculative, but again, it is appropriate to consider this as an ancillary benefit of certain alternatives including Alternative B – Dam Removal. This potential benefit therefore has been identified in the final report in a new section entitled "Other Potential Related Costs and Benefits."

Example 2:
With a lowered water table back to natural conditions multiple areas in Town will see a reduction in moisture and water seepage into basements. This will likely lead the availability for use of these basements and the resulting drop in humidity will reduce cases of mold. Mold can be a significant health hazard to humans and can devalue a property for resale.

<u>Response</u>: Again, quantifying these types of indirect costs is extremely difficult, if not impossible, and is therefore not standard practice. The cost estimates as presented made a very significant effort to include all potential direct and indirect cost items in a balanced way so that the public would have a comprehensive view of the relative costs of each alternative.

Costs: Net Costs Required

Finally, on multiple occasions I have communicated the availability of grant funds for dam removal from multiple government and private sources. The executive summary of the report makes no mention of this. The full report, on page 84 of 274 has a one sentence disclaimer added at the end of their comparison chart simply stating government grant money is available. No source data, no amounts or limits, no reference list of agencies or private organizations. In 10 minutes on Google today I found a list of 20 programs and organizations, specifically for a dam removal project here in NH in 2007.

<u>Response</u>: In response to this and other comments received on the draft report, the consultant has developed a discussion of potential grant funding opportunities for the dam removal alternative as well as other build alternatives. This discussion was presented to the town in a memorandum from VHB to the Town dated September 24, 2013 and is summarized in Section 2.11 of the revised final report.

The report, and especially the Executive Summary and Tables, should reflect all cost savings, cost impacts, grant funding available and the resulting "net costs" for each alternative, including interest expenses of the bond.

As example, Alternative F has an initial cost of $1.3 Million with no available grant funding. A 10 year, with equal annual principal bond payments of $130,000 per year would incur total interest payments of $214,500.

Whereas, if dam removal and all related impacts, after all grant funding had a principal balance of $500,000 under the same terms, the interest impact would be $83,500, a differential of $131,000 in interest expense.

Comments of
Brian Griset
26 Cullen Way, Exeter, NH

If the report is purporting to reflect a 30 year look out period for impacts, this factor should be included in the tables for all alternatives.

<u>Response</u>: The Town and consultant believes that the including financing costs is not necessary to allow the public to make an informed decision on the various alternatives. Inclusion of bond cost is unlikely to change the costs of the various alternatives relative to one another.

Differing Methodology:

The methodology used in costing out impacts differs from that used in computing cost figures for the "Remain in Place" additional items.

The full report gives estimate ranges for the 4 intake modifications. As an example, River Intake is listed at $750,000 to $1,000,000 and the Mill intake at $250,000 to $500,000. All for projects combined have a range of $1,225,000 to $2,000,000. The combined cost number added to the Dam Removal option is $1,747,950 in the report. I have attempted to run a methodology, average, median, etc. to explain this number. I can't determine one. The number used is equal to 87% of the high estimate and 108% of the averaged cost.

<u>Response</u>: The calculation of this figure is in the draft report was detailed in Appendix H, Page H-6, in the sheet entitled "mitigation costs." Note that this cost was updated as a result of this and other comments on the draft report. The revised cost to the Town for retrofitting public water intake structures (i.e., the Exeter River Pump Station and the dry hydrant at Founder's Park) is now estimated to be approximately $392,408. (See Table H-10 of the final report.) Additionally, the cost to retrofit private intakes (i.e., the Exeter Mills intake at the penstock and the Phillips Exeter Academy intake) is estimated to be approximately $813,000. (See Table H-11 of the final report.)

I then compared the numbers and methodology for "the Remain in Place" only additional item, "water quality". In the full page report the range given was $250,000 to $1,000,000. The number used in the report is $550,000. In this case the number is only 55% of the high estimate and is not even the average but 88% of the average. This disparity in methodology I cannot explain as it inflates the costs for "Removal" but diminishes the costs for "Remain in Place". A consistent methodology should be used.

<u>Response</u>: The costs for retrofitting water intake structures are completely separate from the cost to address water quality issues. Thus, the methods used to arrive at the cost for these two items differ appropriately so that they will properly reflect the separate considerations involved in each issue.

For the Stabilize Option G and Modification Option H

In addition to the methodology issue I just stated above, I find it disturbing that even additional cost items stated as probable costs in the full report are not cost estimated out or even mentioned in the Executive Summary or in the presentation. As an example, on the "stabilize option" they state that additional costs are highly probable for abutment modification to prevent over-topping. No investigation, no analysis, no mention in the Executive Report tables.

Comments of
Brian Griset
26 Cullen Way, Exeter, NH

The last minute proposal for "Stabilize in Place" has been inadequately explored for total costs. Yet it is included in the report as if it has been studied to the same degree as the other options. Clearly, the average person will not be able to nor want to read a 274 page report plus the appendixes. In the Executive Summary, at the least a disclaimer should be included on this alternative stating that potential addition costs may occur from yet to be determined factors not considered by the Report.

<u>Response</u>: The cost estimates for each alternative, including Alternative G – Stabilize in Place, were completed with the same level of detail and are in compliance with the appropriate engineering standard of care.

From what I could determine for these two alternatives the existing and current expenses incurred by the town are not being adding into the calculation of O&M costs for determining the final 30 year cost. Not only should those costs be reflected as a credit on the "Removal Alternative", they should reflect as an expense on this and all other options.

<u>Response</u>: As discussed in our response to a previous comment, the costs estimates already address the differences among the alternatives relative to operations and maintenance (O&M) costs. See Tables 2.11-2 and 2.11-3 of the report, as well as the additional details provided in Appendix H. O&M costs are appropriately reflected in the cost estimates for the "build" alternatives. To include them as a credit for dam removal would essentially count them twice, which would be inappropriate.

Water Intake Assumptions:

Mill:
The report inaccurately states that the Mills has a deeded right (ownership) to the penstock. That is incorrect. The deed is silent on the ownership of the penstock but does transfer the land (Founder's Park and Library) to the Town. The only stated right reserved for the Mills is the right to access water for <u>fire protection</u>. The only obligation within the deed for the Town was that it could not do modifications which would deny the mill this "fire protection". I believe I even brought this up before the River Committee way back when it became an issue.

Updating these comments based upon a statement by Selectmen Don Clement, the Town recently found that there is another agreement which may grant additional rights to the Mill for air conditioning and irrigation. If this is so, then insuring their intake may be required.

<u>Response</u>: The Town will continue to work with Exeter Mills to address concerns relative to water supply and potential impacts to their intake. This comment references certain legal rights which are still under review by the Town's attorneys.

The numbers/estimate for adjusting the Mill intake state they are estimated on the high side due to the unavailability of engineering information. I have provided you with the contact information for Gene Lambert, past engineer for the Mills who is familiar with the present design of both the Mill intake and the dry hydrant. Updated estimates should be reflected in the report and Executive Summary.

Comments of
Brian Griset
26 Cullen Way, Exeter, NH

Response: The draft report relied on an analysis presented in the Town's study of water supply alternatives developed by Weston and Sampson in 2010, as well as additional information provided by Exeter Mills to Weston and Sampson in 2011 and 2012. In response to this comment, VHB contacted Mr. Lambert, who graciously provided some additional information which has been taken into consideration in reviewing the estimate for the mill intake retrofit. This supplemental information helped to confirm that the earlier opinion of cost for retrofitting the mill intake was appropriate.

Based upon review of the granite formation underlying the dam, it is apparent that the northern end of the outcrop is 1 foot lower than the remainder of the out crop. In addition, directly upstream of this area is a depression in the granite formation of sufficient depth to install an intake by extending the 8 inch ductile iron pipe to this location.

To insure adequate and additional availability of water for the mill and raise the lowest static level of the impoundment, I would suggest raising this 10-15 foot lower area of the granite outcrop by one foot to match the elevation of the remaining bedrock formation. It could be done in a way to simulate the natural granite formation and blend in for esthetics. This should not add much to the cost of the intake extension and would possibly eliminate any need to jack hammer or blast as recommended for other options.

Response: The approach suggested by Mr. Griset may prove to be a feasible in addressing the mill intake retrofit. A final design for any necessary intake retrofit would be undertaken once the community selects an alternative to pursue, whether it is dam removal or another alternative.

PEA:

For the dam removal option the report's methodology includes costs that the Town is potentially not legally liable for. As previously stated, the PEA property was originally owned by Gilman, one of the original mill owners and one of the partners who formed the Exeter Manufacturing Company and Exeter Water Company. In the incorporation documents for both you will see that all riparian and flowage rights were transferred to the owner of the dam.

The fact that PEA chose to install a dug well for irrigation verses a river intake reinforces that they are aware they have no legal rights to rely upon the river for watering purposes.

Response: This comment references certain legal rights which are still under review by the Town's attorneys. However, in response to this comment and informal feedback from the Academy, the cost for retrofitting the PEA withdrawal has been removed from the direct costs to the Town but is still presented in the study in a new section of Chapter 2 entitled, "Other Potential Related Costs and Benefits."

Comment/My Biggest issues:

While on the W&S Committee from 2005-2008, during those 4 years we implemented a strategic plan and encouraged DPW to institute those processes. It is clear that both the DPW and the Town Manager are not doing so.

Comments of
Brian Griset
26 Cullen Way, Exeter, NH

Using the "$800,000" river intake item as the example: I went and read the specific section of the Weston & Sampson 2010 report. I had already done a cursory review of the whole report previously. The report is supposed to be a strategic plan for our water needs. It essentially continues what the old W&S Committee started, a transition to a 100% groundwater source system to reduce costs and avoid catastrophic failures.

The approved groundwater plant was designed to be expandable to add additional sources after Gilman, Stadium and Lary Lane wells were online. These 3 could be permitted faster than other new sources that had been located. The 2010 report included a provisions, actually two, that allowed for an interim solution if the dam was removed prior to permitting of the new sources. The first, a $100,000 aeration system for the reservoir to allow year round withdrawals from the water works pond. Second was supposed to be a $65,000 extension to the intake pipe based upon our recommendation at that time. Instead, a $750,000 to $1,000,000 total restructuring of the intake system at the pump-house is being proposed.

If we are intending to remove surface water infrastructure from our system and go to a total groundwater system, and, the 2010 report estimates bringing a new well online will cost $1,000,000, why would we expend $1,000,000 (or even $800,000) retrofitting and upgrading a surface pump station when a $100,000 or $60,000 temporary "solution" is available?

<u>Response</u>: As discussed in response to comments above, the cost of addressing the retrofit of the Exeter River Pump Station as a result of partial or full dam removal has been updated in the final report. The original estimate presented in the June draft report was $948,500. The revised report now carries a cost for this item of $338,208. See Section 2.11 and Appendix H of the revised final report. This reduction was appropriate for two reasons: 1) The Town had already completed some of the work included in the estimate included in the draft report, and 2) Some of the costs included in the original estimate related to work needed regardless of the fate of the dam. The revised cost estimate is considered a reasonable amount for planning purposes and is more directly tied to the partial or full dam removal alternatives.

In essence, nobody is coordinating the game plan and explaining it to both the public or the consultants. No one is looking for the synergies to save the taxpayers and the ratepayers money. Nobody is looking at the total ramifications of each and every decision and how they impact the other decisions.

Right now the citizens are going to be facing the costs and decisions on projects 99% of the Town is unaware of. Here's a list of those items current issues being studied or planned for:

Mandatory
Flooding liabilities
Dam deficiencies
Section 401 Water Quality (dead river) and BMPs
Inflow/Infiltration
CSO's
New Sewer Treatment Plant

Comments of
Brian Griset
26 Cullen Way, Exeter, NH

Additional Provisions of Federal Sewer Permit
"Climate Adaptation Plan for Exeter" (additional flooding levels above those in Dam Report, forecast not even being considered by Dam report)
Infrastructure demands to deal with Climate Change Plan.
Interconnection Agreement with Stratham
Stormwater Separation, groundwater, non-source point pollution
Start Paying for Groundwater Treatment Plant
Start developing and permitting 2 additional wells. additional
Waterline Improvements specifically for Ground Water Treatment Plant NOT disclosed to public but required prior to putting GWTP on-line.
Sewer line improvements and replacement schedule
Undersized and failing Bridges- Court St., Linden St., String Bridge.

Wish List of Someone
Epping Road Corridor Gateway improvements
Portsmouth Ave Gateway improvements
Downtown TIFF
Downtown "Redevelopment"
Parking Garage
2nd Fire Station
Upgraded Communications system
Facilities Plan

Schools?????
Conservation land
Raynes Farm- again!

Summary: *Unless the Report is corrected, or people start speaking out and start looking into this by asking their own questions, the Selectmen might make the wrong choices for the warrant article and then it will be up to just the citizens to figure this out. In reviewing the draft report recently released, I have a few, no, many concerns.*

First, the report adds $1.74 Million to the actual $784,000 cost of dam removal specifically for "intake adjustments". Four are listed in the executive summary. First the river pump station at $800K- $1.0M. This is not for an extension of the intake pipe. They have proposed building a totally new intake consisting of a dry well in the river bank at a depth below the riverbed with a metal screen built into the side of the riverbank. A lot more expensive than our less than $60K modification of the pipe as a temporary measure until the groundwater sources could be brought on-line.

Second constructing a new dug well for PEA's athletic field irrigation at up to $250K which is not even our responsibility. PEA has no riparian rights to the river or is the Town required to maintain any level of water for their benefit. These water rights were stripped off by the original owners back in 1828. That is why PEA constructed a well instead of a river withdrawal in the first place. Third, the issue of the Mill's water right withdrawal is back. The engineers use a number between $250K- $500K claiming they do not know how the withdrawal is accomplished as there are no engineering drawings. Not only did I inform

Comments of
Brian Griset
26 Cullen Way, Exeter, NH

the committee on more than one occasion that Gene Lambert was the engineer at the time and had knowledge, I spoke with the Mill property manager and he stated he knew how it was constructed. Finally, they have added up to $250K for changing the intake for a dry hydrant in Founders Park once again claiming they have no knowledge of the actual intake.

In general, the report uses O&M expenditures to add some costs to some options but is silent on the costs and impact cost savings currently being expended in maintaining the dam. Even existing O&M savings by dam removal are ignored. Methodology for assumptions between the various options listed is not consistent and results in inflated costs for dam removal and understated or non stated additional costs for the other items.

Response: Please see our responses to similar comments above.

Finally, years ago when we first discussed this I gave the River Study Committee a list of federal, state and public/private institutions that gave grants for dam removal efforts. The Executive Summary is silent on this fact. At the meeting this issue was raised and the consultant and town engineer admitted to 50% funding availability. The day after in 10 minutes on-line I found a source listing, I believe, 16 organizations that participated in a 2007 NH dam removal project providing grant money totaling 92% of the costs, $40K was required from the dam owner.

Response: The Executive Summary and Chapter 2 of the final report have been updated with a discussion of grant funding opportunities.

Recommendation:

The benefits to Dam Removal, regardless of the real costs, far outweigh keeping it in place.

Environmentally it corrects all of the damage to the ecosystem that has occurred since 1968. It will bring back natural wildlife patterns, ranging from deer, to fish to birds and insects.

It corrects and reduces flooding and the resulting costs, not just now but in the future times based upon the Climate Change projections. We are planning for the future and that should not be forgotten.

It not only saves both taxpayers and Water and Sewer users current expenses, it but reduces future increases and the building of un-need additional infrastructure.

And most importantly, it protects the future lives and property of the many of Exeter's citizens who have been put at risk and suffered damages again and again in the past.

Response: The Exeter River Study Committee acknowledges and appreciates this comment. The commenter is encouraged to participate in future public discussions regarding the selection of an alternative.

Comments of
Mary E. Bourgault
Franklin Street, Exeter, NH

Hello - I want to comment on the dam. After reading the executive report, I favor Alternative H. I do not want to see the dam removed, nor lowered, etc. As a resident of Franklin St., it is in my interest to have the river level above the dam stay as it is. As a native of Exeter, I also think the cultural/historical aspects of the dam and its surroundings are the very core of the town's unique identity, and it is worth the cost to preserve it.

Thank you.
Mary E. Bourgault

Response: The Exeter River Study Committee acknowledges and appreciates this comment. The commenter is encouraged to participate in future public discussions regarding the selection of an alternative.

Comments of
Allan W. Corey, CPA
3 Kathleen Drive, Exeter, NH

Ms. Becker,

I would like to see the dam removed. If left standing in whole or part, it would only continue to cost tax payers money without purpose.

Sincerely,

Allan W. Corey, CPA
3 Kathleen Drive
Exeter, NH 03833

Response: The Exeter River Study Committee acknowledges and appreciates this comment. The commenter is encouraged to participate in future public discussions regarding the selection of an alternative.

Comments of
Alice Hill
1 Bell Avenue, Exeter, NH

My name is Alice Hill and I live at 1 Bell Ave. here in Exeter. Our home is right across the street by the little Exeter River. My husband and I are urging you to remove the Great Dam, keeping the spill way. Through all the ups AND down times of the river we feel there will be plenty of water and ice in the winter for recreational activities.

Thank you for your attention.

Alice Hill
1 Bell Ave., Exeter, NH

Response: The Exeter River Study Committee acknowledges and appreciates this comment. The commenter is encouraged to participate in future public discussions regarding the selection of an alternative.

Comments of
Atty. Mark Beliveau on Behalf of
Exeter Investment Company, Inc.
Donald Robie, President

Hi Mimi,

On behalf of my client, Exeter Investment Company, Inc., Donald Robie President, attached are comments, questions and proposed edits to the draft report. As you know, Exeter Investment Company is the owner of 4 String Bridge, also known as Kimball Island. You, the committee and consultants have worked long and hard and have done an outstanding job and deserve high praise for your efforts. Please let me know if you have any questions. Thank you.

Mark

Note: Comments are attached separately to this document as they are on the accompanying text.

Response: The Exeter River Study Committee acknowledges and appreciates this comment. The commenter is encouraged to participate in future public discussions regarding the selection of an alternative. Several changes and additions have been made to the final report in response to the specific comments offered by Atty. Beliveau.

Comments of
Timothy Miller
Exeter, NH

Comments Per The Seacoast Online Article Request;

My family and I would like to see the dam stay in place and be fixed to be brought up to standards.

Exeter Riverfront Residents 17+ Years

-The Millers
(Timothy)

Response: The Exeter River Study Committee acknowledges and appreciates this comment. The commenter is encouraged to participate in future public discussions regarding the selection of an alternative.

Comments of
John Richards

Dear Dr. Becker,

I have read Sean McDermott's comments and agree with them

Sent from my iPhone [John Richards]

<u>Response</u>: The Exeter River Study Committee acknowledges and appreciates this comment. The commenter is encouraged to participate in future public discussions regarding the selection of an alternative.

Comments of
Carol Gasses
Juniper Ridge Road, Exeter, NH

Mimi,

Per the article below, having been a resident of Exeter since 2007 and living along the Exeter River as a riparian (Juniper Ridge Road), I would like to see the dam returned to its primitive state. While people consider the dam historic, the fish (now needing to be stocked in my own lifetime) and the natural flow of the river came before any and all the dams in the Seacoast. I've walked the Juniper Ridge trail and have been both disappointed and shocked by the lack of knowledge of being a positive custodian of a riverfront property. I've witnessed the chemical covered lawns lacking any weeds and drastic erosion caused by excessive clearing and mowing! With that said, I believe strongly it is up to the community to come together to restore the once pristine environment in town that supported the aquatic life that we can only imagine in Alaska today. Every day holds the possibility of a pristine, historic Exeter riverfront restoration.

Working in the marketing profession for most of my professional life, I believe the audience will need a visual of what the removal of the dam will look like. Let's change the conversation from one of loss to one of historic restoration. I suggest a social media education blitz including images and mocked photos depicting a phased approach to riverfront restoration - and the less costly option in terms of funding! Instead of wording the dam removal as a perceived "loss" with the wording "dam removal" standing alone, I like the idea of calling the project Exeter Riverfront Restoration project -dam removal. Or, another catchy phrase that expresses a positive outcome and not the loss of something familiar. As they say in the world of sales, it is often safer to be complacent, than to make a decision. Images and a positive frame around the message, will allow residents to visualize the process and journey of our changing river waterfront whereby they can make the right decision.

On a much needed economic note, I believe the footprint of the summer activities within the community will then expand to include the riverfront in town near the surrounding businesses not isolated to the park.

Thanks!
Carol Gasses
channelbizgrowth@yahoo.com
Channel Biz Growth
603.778.7929
603.312.1256 (cell)

<u>Response</u>: The Exeter River Study Committee acknowledges and appreciates this comment. The commenter is encouraged to participate in future public discussions regarding the selection of an alternative.

> *Jeff McMenemy*
> *newsletter@seacoastonline.com*
> *August 13, 2013 2:00 AM*
> *EXETER — The co-chair of the town's River Study Committee's working group is urging residents to e-mail the committee their comments about what they want to see done with*

Comments of
Carol Gasses
Juniper Ridge Road, Exeter, NH

the town's Great Dam.

Mimi Larsen Becker, a co-chair of the working group and an University of New Hampshire professor, said the group has only received about 10 to 12 comments about the dam, which is located in the Exeter River in the center of the downtown.

"That's not very many," Becker said. "If people really are concerned it's important to understand we don't have an option to do nothing. We're currently in violation of safety standards and we are going to be held accountable."

Anyone with comments or feedback must e-mail them to Becker at mimilarsenbecker@comcast.net no later than Wednesday or comments may be mailed to the Town Manager's Office.

Asked why she believes the group hasn't received more comments, Becker said, "It's summer-time. Unfortunately our deadline is the 30th of September and we have to have the final report completed by then with all public comments and input."

The final report will also include updated cost estimates for the various options of how to deal with the dam, according to Becker, who said Sunday "additional figures have been obtained which will make the cost information much more specific and explicit."

She urged people to read the executive summary of the Great Dam Removal Impact Study, which is available online at exeternh.gov/sites/default/files/fileattachments/executive_summary.pdf

The state Department of Environmental Services issued a letter of deficiency in July 2000 stating Great Dam does not meet safety standards, which require low hazard dams to "withstand a 50-year storm event without overtopping the abutments," according to the executive summary.

The alternatives range from spending a total of $2.5 million for dam removal, $983,000 for stabilizing the dam in place, $3.5 million for partial removal or $1.7 million for dam modification, which would include installing an inflatable gate system.

Becker said the most realistic solutions she sees are complete dam removal or stabilizing the dam in place.

She doesn't believe the option to modify the dam would win the support of selectmen and town residents, who will ultimately make the decision.

"It's not very attractive to have that in the middle of the downtown," she said. But she emphasized that even when the committee completes its final report, it will not make any recommendations.

Comments of
Carol Gasses
Juniper Ridge Road, Exeter, NH

"We are not going to take a position. That's a job for the selectmen and people of Exeter," she said. "They are the deciders. They are going to have to pay for it and live with the results."

She also stressed that many of the options have other repercussions besides financial ones.

"If we leave the dam in, how are we going to deal with the water quality?" She asked.

The executive summary states that stabilizing the dam in place "would not mitigate flooding damage nor would it improve water quality in the river or provide enhanced fish passage."

But the report states that dam removal, partial removal and dam modification would "substantially" reduce the amount of flooding.

Totally removing the dam would also "alter the recreational experience on the river, but opportunities would still be plentiful, the report states.

And, unlike the option to stabilize the dam in place, there is likely federal or state money available to help pay for total dam removal, Becker said.

"Either people want to see it gone and the river made back into its natural state, although it will never be what it was 360 years ago, or they want it to stay," she said.

She also noted if people ask questions through their public comments, the committee will seek to answer those questions and include its response in the final report.

She acknowledged some people may have been put off because the report is "fat and technical," but said "it is in pretty plain English."

"If people do their homework, I think that for the most part the essential facts are there," she said. "I don't know of another study since I've lived here that's been subjected to the same kind of scrutiny."

Comments of
John Mueller
John C. Mueller Norwood Group

Hi Mimi,

My wife and I own 8+ acres on the river, ¼ mile downstream from the Pickpocket Dam. We are in favor of removal of the great dam. A restoration of the river flows, now that the dam is no longer supplying power, is an appropriate course of action. At the recent meeting, the sources of funding for the removal were discussed. Before the project is placed on the ballot, I would like to have greater clarity on the alternative sources of funding so that the pricetag is not seen as something that must be born entirely by the local taxpayer. If the options and alternatives about funding sources is not clarified, then the voters will most likely vote against the removal, as it is an expensive proposition.

Sincerely,
John Mueller
John C. Mueller Norwood Group

Response: The Exeter River Study Committee acknowledges and appreciates this comment. The commenter is encouraged to participate in future public discussions regarding the selection of an alternative. Please also note that the final report has been updated with a discussion of funding opportunities for the dam removal and other alternatives as well.

Comments of
Merkle/Clement/Olney
11 Water Street, Exeter, NH

Comment received of Xeroxed Notes via US Mail --originally submitted to Select board Chair, Don Clement and forwarded to Mimi Becker.

Great Dam Modification 8/5/13 11 Water Street: Merkle/Clement/Olney

Recent Studies of Great Dam seem to favor removal but:

- *Fishladder seems to work, but not optimally*
- *100 yr flood overflow to Founders Park exceeds dam height by 12", little damage downstream to tidal basin; little damage except @ Gr Bridge, L&L (Loaf & Ladle?)*
- *F.E.M.A. regs, depending on________________[word not decipherable] prevent constr. on empty lot.*
- *Width, seasonal flows, impoundment will be altered visually and practically by dam removal*
- *Structures near dam will be jeopardized by removal: foundations, footings exposed; hydraulic pressure increased*
- *Ownership of water rights by mill, Town (water & f.d.), PEA complicate cost*

2. Overtopping by more than 12" during flood event is threshold trigger.
<u>*Possible solutions:*</u>

1. *Remove Dam*
2. *Open emergency draw down prior to flood*
3. *Provide a surface, relief by-pass@ Founders Park*
4. *Provide rapid dam ht reduction @ flood (bladder)*
5. *Reduce Dam Height*

C. How flood mandate is satisfied has other implications for the future of downtown. Removing dam may not be best alternative for other town needs. Making small target changes may be preferable to bold modifications:

- *Unforeseen negative consequences: fire ponds, water ownership, wetlands drainage, low dry season flow, vegetation growth in former impoundments, foundation damage*
- *Visual, historic, symbolic significance of river in downtown will be affected.*
- *How can this be quantified, assessed?*
- *Best solution may be least costly, but long term benefits may trump initial costs anyway.*

D. SOLUTIONS Define before/after data collection (increasing in magnitude)

1. Retain existing dam with some repairs
- *Modify fishladder for better operation – retain it*
- *Keep current dam height, but limit freebd to 12" above rim*
- *Operate emergency sluices*

Comments of
Merkle/Clement/Olney
11 Water Street, Exeter, NH

- *Automate emergency sluices*
- *Emergency overflow @ Founders Park*
- *Announce goal of 12" overflow max*

2. Above, plus modify existing sluices
3. Above, plus install bladder release
4. Lowe dam 24", anchor dam, alter ladder
5. Remove Great Dam, leave Lower dam, buy back water rights, fund foundation damage
6. Remove Great & Lower Dams (all costs in #5 plus)

- *additional destruction costs*
- *additional vegetation maintenance*
- *additional silt scouring*
- *additional foundation damage*
- *NO impoundment except Tidal Basin*

E. F.E.M.A. problems for development of empty lot. 100 yr flood line incorrect. Jurisdiction line in dam impoundment.

Response: The Exeter River Study Committee acknowledges and appreciates this comment. The commenter is encouraged to participate in future public discussions regarding the selection of an alternative.

Comments of
Brad Rice

I do hope they remove it and return the natural flow of the river. It will not be effected (sic) *by drought as the damn* (sic) *only holds back a limited distance of the river closest to the damn* (sic). *The damn* (sic) *is not needed anymore. It will also help with flood zone in and around the Exeter area during the spring time snow melt and heavy rains. Nothing but good.*

Submitted by Brad Rice via the Town of Exeter's Facebook page.

Response: The Exeter River Study Committee acknowledges and appreciates this comment. The commenter is encouraged to participate in future public discussions regarding the selection of an alternative.

Comments of
Kris Vaughan and Eileen Cusick
348 Water Street, Exeter, NH

Greetings Mimi!

Thanks to you and the committee for the great work on the river/dam impact study and report! We REALLY appreciate the summary - very clear and concise! It would be nice to have a "perfect" solution! But overall we both think that removal wins out.

1) Unless the dam is removed, it will continue as an expense and environmental concern forever.
2) Despite some loss of wetland and swamp oak habitat, the overall environmental and flood protection advantages seem to favor removal.
3) Financially, the possibility of grant money for removal and the fact that it is only a one-time expense makes removal a sensible plan.
4) We've seen the effects of dam removal on the Kennebec River in Maine, and it has been a real success story!
5) The "H" option would be very expensive over time, and esthetic considerations may be a concern (are there models to look at)?

Hope all is well with you -- summer flies by too quickly!

<u>Response</u>: The Exeter River Study Committee acknowledges and appreciates this comment. The commenter is encouraged to participate in future public discussions regarding the selection of an alternative.

Appendix G

Kleinschmidt Associates Additional Alternatives Report

GREAT DAM MODIFICATION ALTERNATIVES ANALYSIS

Prepared for:

Vanasse Hangen Brustlin Inc.
Bedford, New Hampshire

Prepared by:

Kleinschmidt

Pittsfield, Maine 04967
www.KleinschmidtUSA.com

May 2013

GREAT DAM MODIFICATION ALTERNATIVES ANALYSIS

Prepared for:

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May 2013

GREAT DAM MODIFICATION ALTERNATIVES ANALYSIS

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EXECUTIVE SUMMARY

Vanasse Hangen Brustlin, Inc. (VHB) contracted with Kleinschmidt Associates (Kleinschmidt) to complete a Great Dam Modification Study for the Town of Exeter, NH. The Great Dam is not in compliance with New Hampshire Administrative Rule Env-Wr 303.11 which states that the dam must pass the 50 year storm event with one foot of freeboard. Therefore, Kleinschmidt investigated seven measures that could potentially improve the discharge capacity and/or the stability of the dam. These measures are:

- Extension of the existing spillway into Founder's Park.
- Creation of an additional spillway in Founder's Park.
- Partial removal of the Great Dam by lowering the spillway crest .
- Partial removal of the great dam by lowering the spillway crest with installation of a NHDES-approved mechanical flashboard system.
- Construction of a labyrinth spillway.
- Stabilization of the dam.
- NHDES Dam Bureau recommendation.

Based on this analysis, Kleinschmidt in collaboration with the Town of Exeter derived two alternatives for further investigation: stabilization of the dam using rock anchors (Alternative G) and partial removal with installation of an Obermeyer flashboard/gate system (Alternative H). Alternative G provides a relatively low cost alternative to bring the dam into compliance, but the Town will have to continue to manage flood damage caused by the dam and the ecological impacts of the dam will not be abated. Alternative H provides the Town the most flexibility with controlling the flow over the dam, but is a high cost alternative that requires an increase in operation and maintenance. Alternative G does not require a waiver but will need substantial subsurface investigation to be permitted. Alternative H requires a waiver and will entail substantial permitting scrutiny.

GREAT DAM MODIFICATION ALTERNATIVES ANALYSIS

1.0 BACKGROUND INFORMATION

The Great Dam is a Class A (*i.e.* low) Hazard owned by the Town of Exeter. The dam is located in downtown Exeter between the High Street Bridge and the String Bridge. Great Dam is a reinforced concrete gravity dam consisting of a modified Ogee spillway approximately 80 ft long; a Denil-type fishway on the left abutment; a low level 4.5 ft by 5 ft slide gate on the right abutment; and a 14 ft by 7 ft penstock extending underneath Founder's Park (Appendix G-1). The dam spillway crest elevation is 22.5 ft (NGVD29) which is approximately 8 to 12 feet above the streambed on the downstream side. The left and right abutment elevations are 25.7 and 27.1 ft (NGVD29), respectively. To improve fish passage effectiveness, the fishway has an approximately 5 ft high weir extending across the river channel at the downstream entrance.

Great Dam cannot pass the 50 year flood event with a minimum of one foot of freeboard as required by New Hampshire Administrative Rule Env-Wr 303.11. The 50 year flood is 5,858 cubic feet per second (cfs) as determined by Weston and Sampson (2012) using the U.S. Army Corps of Engineers (USACE) Hydrologic Engineering Center – Hydrologic Modeling System (HEC-HMS) software. In 2006, the flood event on Mother's Day provided visual evidence of conditions at the dam during a storm of that magnitude. Peak water surface elevations were above El. 28 feet (NGVD29) which is more than three feet above the one foot freeboard requirement (Appendix G-1).

The Town of Exeter received a Letter of Deficiency (LOD) issued by the New Hampshire Department of Environmental Services (NHDES) Dam Bureau dated July 25, 2000 with extension amendments dated June 1, 2004 and March 2, 2009. According to the LOD and Administrative Rule Env-Wr 303.12, the Town is required to submit a plan that will bring the dam into compliance by one of the following actions:

- Increase the discharge capacity of the dam to pass the 50 year flood with one foot of freeboard and without manual/automatic operations.
- Submit a stability analysis showing that the dam is safe against sliding, overturning, or erosion by overtopping at the 50 year flood .
- Stabilize the dam such that it meets the required safety factors during a 50 year flood.

- Modify the dam so that the hazard classification is decreased and the dam passes the appropriate flood flow at the new classification (not applicable for Great Dam as it is already low hazard).

The purpose of this study is to develop two feasible dam modification plans that comply with NHDES Dam Bureau regulations. This study is part of a larger dam removal feasibility study and impacts analysis being completed by VHB.

1.1 EXISTING CONDITION STABILITY ANALYSIS

The stability of the Great Dam was determined using the methods outlined in the Engineering Guidelines for Evaluation of Hydropower Projects (2002), Chapter three, prepared by the Federal Energy Regulatory Commission (FERC). The NHDES Dam Bureau refers to these methods in their dam regulations. Stability calculations show that the Great Dam does not meet the factor of safety criteria for both sliding and overturning during the 50 year flood event based on the existing dam configuration and information available (Appendix G-2). Because the dam does not meet the required factors of safety, the dam must be modified to either pass the 50 year flood with one foot of freeboard or be stabilized to meet the required safety factors.

The uncertainty in these preliminary calculations is predicated on the lack of information regarding the structure. Kleinschmidt utilized the typical cross section drawn by the New Hampshire Water Resources Board dated October 11, 1939. This sketch showed an 11 foot high spillway founded on ledge. An additional foot was added to the spillway crest later when the flashboards were replaced with concrete. The force diagram was developed assuming the weakest part of the dam is the spillway. Because no information is available regarding the construction of the dam, FERC requires a zero cohesion factor must be used in the determination of the sliding factor of safety. While it is possible to back calculate a cohesion value based on historical flood events (*e.g.* Mother's Day Flood) to increase the factor of safety for sliding, the dam is also unsafe for overturning (*i.e.* not in 100% compression) so this exercise was deemed unnecessary.

1.2 EXISTING CONDITION HYDRAULIC ANALYSIS

The hydraulic characteristics of Great Dam were analyzed by Kleinschmidt using two approaches. The first approach was to develop rating curves that describe the potential effectiveness of measures to improve the discharge capacity. Kleinschmidt applied standard equations for the spillway and gates based on existing dam and channel geometry. The second approach was to utilize the existing USACE Hydrologic Engineering Center – River Analysis System (HEC-RAS) program developed by Weston and Sampson Engineers (2012) to analyze the proposed alternatives. Both approaches found that under high flow condition, the headpond level for the downstream fishway weir backwaters and submerges the Great Dam spillway reducing the discharge capacity of Great Dam resulting in higher upstream water levels.

For the Great Dam to be in compliance with NHDES Dam Bureau regulations, the maximum head pond elevation under the 50 year flood condition is El. 24.7 ft (NGVD29). At this water surface elevation, the spillway discharge capacity is only 1,136 cfs which is approximately 20% of the needed capacity (Figure 1). At approximately 2,000 cfs, the dam overtops the left abutment at El. 25.7. At these flows, we have assumed no flow through the low level gate, no submergence, the main spillway acts as an Ogee-type (coefficient of discharge is approximately 3.9), and a short spillway section next to the right abutment acts as a broad-crested spillway (coefficient of discharge is approximately 2.65). As the flows increase, the tailwater elevations which are affected by the fishway weir submerge the spillway resulting in higher upstream water levels. Therefore, a significant increase in discharge capacity is required to bring the Great Dam into compliance.

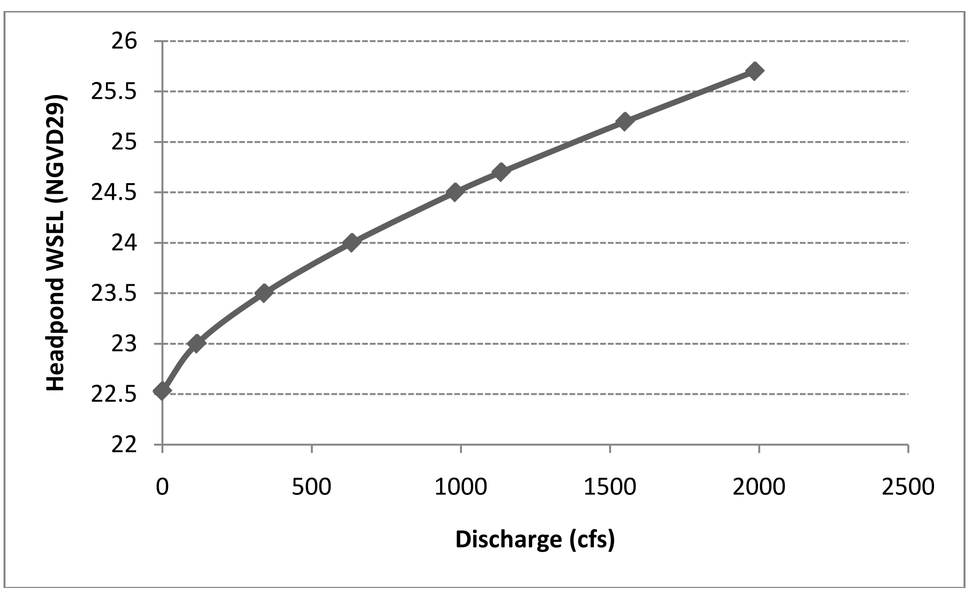

FIGURE 1 GREAT DAM EXISTING CONDITION DISCHARGE RATING CURVE

2.0 MEASURE ANALYSIS

Kleinschmidt was contracted to assess seven potential measures that could satisfy NHDES Dam Bureau regulations. The assessment involved analyzing the stability of the structure, constructability of the proposed measures, flexibility to manage future flood events, and overall cost of implementation. By definition, a measure is an action that can help improve the discharge capacity or stability of the dam, whereas an alternative is a measure or combination of measures that will bring the dam into compliance.

2.1 DESCRIPTION OF MEASURES

The measures investigated in this study include:

- Extension of the existing spillway into Founder's Park.
- Creation of an additional spillway in Founder's Park.
- Partial removal of the Great Dam by lowering the spillway crest.
- Partial removal of the great dam by lowering the spillway crest with installation of a NHDES-approved mechanical flashboard system.
- Construction of a labyrinth spillway.
- Stabilization of the dam.
- NHDES Dam Bureau recommendation.

2.1.1 EXTENSION OF THE EXISTING SPILLWAY INTO FOUNDER'S PARK

Founder's Park which is adjacent to the spillway section, is owned by the Town of Exeter, so that parcel of land provides an opportunity to extend the spillway of Great Dam to improve the discharge capacity. Kleinschmidt determined that in order to pass the required flow assuming existing conditions the spillway would need to be extended over 300 ft. We also assessed the required length after lowering the spillway (see Section 2.1.3) to pass the 50 yr flood flow. Based on this analysis, the spillway would have to be lowered and lengthened significantly to increase the discharge capacity to pass the 50 year storm. Maintaining the existing spillway crest elevation would require extending the spillway over 300 ft. Figure 2 summarizes the results of this analysis.

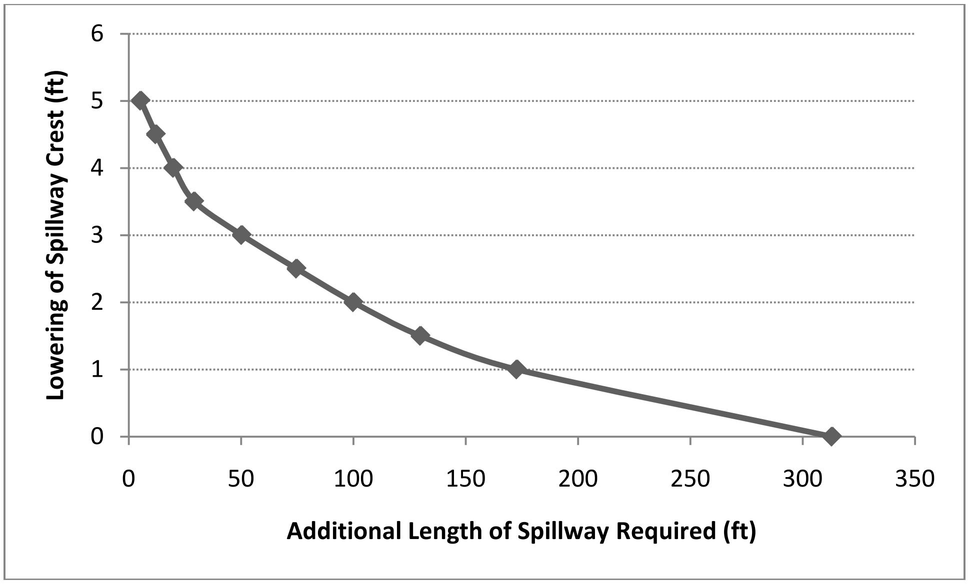

FIGURE 2 ADDITIONAL LENGTH OF SPILLWAY REQUIRED TO PASS THE 50 YR FLOOD AT VARIOUS DECREASES IN SPILLWAY HEIGHT.

2.1.2 CREATION OF AN ADDITIONAL SPILLWAY IN FOUNDER'S PARK

The creation of an additional spillway was investigated as a potential measure to improve the discharge capacity of Great Dam. As part of the right abutment there is a 14 foot wide by 7 foot tall penstock that extends underneath Founder's Park and the Public Library to an old mill building approximately 500 feet downstream. The owner of the renovated mill building has the water rights through the penstock; therefore, decommissioning of the penstock is not desirable. There is potential that the top of the penstock could be removed thus providing a side channel-type spillway while still maintaining water supply to the mill building There are many unknowns regarding these structures. Further, the added spillway length is not sufficient without lowering the spillway crest as well. This measure would also result in a significant loss of green space in Founder's Park.

2.1.3 PARTIAL REMOVAL OF THE GREAT DAM BY LOWERING THE SPILLWAY CREST

Hydraulic analysis showed that the existing spillway would have to be lowered by approximately 5 feet (Figure 2) to meet the NHDES requirements. This would result in a significant reduction to the head pond water surface elevations under normal conditions. The fishway would likely have to be demolished and rebuilt to maintain passage effectiveness.

2.1.4 Partial Removal of the Great Dam by Lowering the Spillway Crest with Installation of a NHDES-Approved Mechanical Flashboard System

For this measure, the spillway would still be lowered the 5 feet as noted above however, a flashboard system would be added to maintain the current headpond levels during normal flow conditions. The key benefit of this measure would be to maintain the normal head pond level and avoid impacts to the fishway. Such a flashboard system must be approved by the NHDES Dam Bureau and receive a waiver to their requirements. Any gate or flashboard system that does not have a failsafe mechanism to convey flood flow water under any condition is unacceptable. For example, sluice gates, slide gates, or automated gates would not be permitted because the opening of the gate is reliant on either a mechanical or electrical system that may fail under flood flow conditions.

Two potential flashboard systems that would likely receive a waiver are breakaway flashboards and inflatable flashboards. A breakaway flashboard is one where the supports are designed such that hydrostatic pressure at or slightly less than the design flood will cause the supports to fail allowing the spillway to convey the flood flow at the required levels. Though effective, breakaway flashboards require replacement costs after each flood and sometimes fail from debris or ice loads. An inflatable flashboard system consists of a rubber air bladder that is affixed to the spillway and is maintained in the up position by inflating with air. During flood conditions, the bladders are deflated allowing flood flows to pass. Once river flows return to normal, the bladders are re-inflated with a compressor. The system can be deflated by an operator simply pulling a release plug in the air system located at a safe distance from the dam. In addition to the cost of the bladders, and associated equipment and controls, this type of system requires substantial modifications to the spillway to accept the air bladders resulting in a much higher capital cost than the breakaway flashboards. These systems are however, more durable than breakaway flashboards.

2.1.5 Construction of a Labyrinth Spillway

Labyrinth spillways are a modification that can increase the hydraulic capacity of a dam while remaining within the existing footprint of the spillway. In the case of Great Dam, it was found that a labyrinth spillway would not provide the additional spill capacity needed to pass the 50 year flood flow without other modifications. Kleinschmidt completed hydraulic calculations based on Tullis et al (1995) for a 5 cycle labyrinth design that resulted in an increase of approximately 400 cfs from the existing configuration. Though the labyrinth configuration was not optimized for flow conveyance, the differential between the required discharge capacity and the benefit of the labyrinth spillway design does not justify further investigation.

2.1.6 Stabilization of the Dam

Gravity dams can be stabilized in place mainly by two methods: anchoring or buttressing (Paxson et al, 2011). Anchors are installed by drilling through the heel of the dam into the geologic material, partially filling the drill hole with epoxy-like grout to hold the anchor strands in place, and adding tension to the strands to hold the dam in place. Alternatively, buttressing involves adding mass (typically concrete) to the toe of the dam. In the case of Great Dam, the shallow depth to bedrock promotes the use of anchoring over buttressing. Buttressing also involves changing the hydraulics and aesthetics of the dam which will remain the same with anchor installation.

2.1.7 NHDES Dam Bureau Recommendation

The NHDES Dam Bureau did not provide additional measures to investigate as part of this study.

2.2 Measure Comparison

The investigated measures were compared to determine the benefits and drawbacks of each (Table 1). It should be noted that the comparison table does not consider Federal Emergency Management Agency (FEMA) National Flood Insurance Program (NFIP) ramifications. All of the investigated measures will require federal permitting and likely FEMA coordination. The comparison metrics are defined as:

- Constructability: Ease for contractor to complete the construction.
- Impact on Stability: Assumes no stabilization as part of the measure (except 2.1.6).
- Hydraulic Compliance: 50 yr flood event passes with 1 foot freeboard.
- Flexibility: The measure can accommodate future flows.
- Cost: Qualitative and comparative.
- Compatibility with the existing fishway configuration.

TABLE 1 MATRIX OF POTENTIAL DAM MODIFICATION MEASURES

MEASURE	CONSTRUCTABILITY	IMPACT ON STABILITY	HYDRAULIC COMPLIANCE	FLEXIBILITY	COST	COMPATIBLE WITH FISHWAY
Spillway Extension	Difficult	Improvement	No	None	Very High	Yes
Additional Spillway	Difficult	Improvement	No	None	High	Yes
Partial Removal	Easy	Improvement	Yes	None	Moderate	No
Flashboard System	Difficult	Decrease	Yes	Yes	High	Yes
Labyrinth Spillway	Moderate	Improvement	No	None	Very High	Yes
Dam Stabilization	Easy	Stable	N.A.	None	Low	Yes

3.0 ALTERNATIVES ANALYSIS

The objective of this study was to develop and analyze feasible Great Dam modification alternatives that satisfy the NHDES dam safety regulations. After investigating the potential measures, Kleinschmidt presented their findings to the Exeter River Working Group (ERWG) on April 4th, 2013. During that presentation and subsequent discussion, Kleinschmidt recommended pursuing partial dam removal with installation of an inflatable flashboard system. On April 10th, 2013 the ERWG held a conference call notifying Kleinschmidt of the two alternatives for further analysis: stabilizing the dam using rock anchors (Alternative G) and partial dam removal with installation of an inflatable flashboard/gate system (Alternative H).

3.1 ALTERNATIVE G – STABILIZE IN PLACE

Alternative G involves installing post tension anchors into bedrock (Appendix G-1). This will stabilize the Great Dam during a 50 year flood. The process of installing rock anchors includes drilling through the dam from the crest through the heel to a specified depth below the dam. Then tendon strands are inserted into the drill hole and set into place with epoxy/grout. After which, the strands are pulled into tension and locked off at the force needed to stabilize the dam. The drill hole is then covered to complete the installation.

The design life of post tension rock anchors is 75 to 100 years (FHWA 1999). However, failures have been documented with poorly installed systems, unsuitable geologic conditions, and unsatisfactory corrosion protection. Kleinschmidt recommends using fully bonded rock anchor strands (ASTM A416) to protect against corrosion. We assume that the dam is founded on bedrock and this geology is suitable to embed rock anchors. The nearest borehole data collected by the New Hampshire Department of Transportation during the reconstruction of High Street Bridge determined that bedrock is reached at a depth of 14 ft which supports this assumption. However, before the rock anchors can be installed, a significant amount of site investigation and material testing is required to bring the conceptual plan to final design. Some key questions that need to be answered include, but are not limited to:

- What is the depth to bedrock closer to the dam?
- What are the abutments tied into?
- What type of bedrock is beneath the dam?
- Is there a potential for erosion around the dam as a possible failure mode?

- How much reinforcement, if any, is in the dam?

3.1.1 Effect on Hydraulics

Alternative G does not change the hydraulics of the Exeter River. The rock anchors are embedded in the dam such that there will be no change in flow characteristics over the spillway and dam during flood events. Therefore, the Alternative A – no action/existing condition hydraulic analysis submitted by Weston and Sampson (2012) and described in the VHB Dam Removal Feasibility and Impact Study report is valid for the Alternative G (Appendix G-3).

3.1.2 Effect on Stability

The rock anchor conceptual design is based on the additional force needed to resist overturning and sliding of the dam (Appendix G-4). The required stabilizing force is 12,000 pounds per linear foot of dam based on the deficiency calculated in the existing condition stability analysis (Appendix G-2). Each post tension anchor strand can supply 35,000 pounds, thus 4 strand rock anchors spaced 10 feet on center are proposed. General rules of thumb for post tension anchors are a minimum embedment depth of 15 feet and maximum rock anchor spacing of double the dam height.

3.1.3 Opinion of Probable Cost

Kleinschmidt completed an opinion of probable cost (OPC) for Alternative G resulting in an initial investment of $423,000 (Appendix G-5) and a 30 year life cycle cost of $466,000 (Table 2). The $301,000 direct cost total for rock anchor installation was obtained from two sources: VHB's dam removal OPC and historical data from past rock anchor work Kleinschmidt has designed. In order to properly compare alternatives, we maintained many of the line items from the VHB OPC, though in some instances, the quantity was altered. For example, the repair/replace wall line item was halved because equipment access to the toe of the dam and fishway weir is not needed for rock anchor installation. Kleinschmidt also changed mobilization and contractor conditions to percentages instead of lump sum line items. The indirect costs were all industry standard percentages of the direct cost subtotal. The indirect costs were all percentages of the direct cost subtotal including a 20% contingency. Kleinschmidt assumed that the site investigation will not result in significant extra costs related to mitigating for erosion by overtopping during flood events.

Kleinschmidt used the National Institute of Standards and Technology (NIST) Life Cycle Cost Manual Handbook 135 (1995) with the 2012 supplement to determine the life cycle costs for the proposed dam stabilization. At this level of design, we utilized a simple method that accounts for initial investment, capital replacement, residual value, energy, and operation, maintenance, and repair. Because the design life of properly installed rock anchors is at least 75 years, we estimated a capital replacement cost of 40% of the initial investment value with the remainder as residual value for a 30 year LCC analysis. The rock anchors do not require energy, so that was left as a blank line item. The operation, maintenance, and repair annual cost was derived from conversations with the Exeter Public Works Department (PWD) which estimated an average of 140 labor hours with $500 in material costs. The labor hours consisted of regular and flood event operation and maintenance which include some overtime pay rates. The 2012 Office of Management and Budget long term discount rate is 2% and the Department of Energy discount rate is 3%. The 2013 supplement was not released by the time of publication of this report. The LCC time period was 30 years based on the available discount rate data from the supplement with a base date of 2013.

TABLE 2 LIFE CYCLE COST (LCC) ESTIMATE FOR ALTERNATIVE G

COST ITEM	BASE DATE (2013) COST	YEAR OF OCCURRENCE	DISCOUNT FACTOR[1]	PRESENT VALUE
Initial Investment	$423,000	Base Date	1	$423,000
Capital Replacement (40%)	$169,200	30	0.552	$93,398
Residual Value (60%)	$253,800	30	0.552	$140,098
Electricity (0 kWh at $0.15/kWh)	$0	Annual	19.8	$0
Operation, Maintenance, and Repair	$4,000	Annual	22.4	$89,600
Total LCC				**$466,000**

[1]NIST LCC Supplement 2012

3.2 ALTERNATIVE H – INFLATABLE FLASHBOARD/GATE SYSTEM

Alternative H involves partially removing the Great Dam and installing an Obermeyer inflatable flashboard and gate system (Appendix G-4). The partial dam removal will be substantial due to the need to convey a large flood in a confined space. Kleinschmidt has proposed removing a 4.5 foot by 75 foot section at the crest of the spillway and replacing it with the same size Obermeyer flashboard system. It is anticipated that this will consist of one section. In addition, the existing low level gate and associated structure will be demolished and replaced with 14 foot wide 7 foot tall Obermeyer gate. The Obermeyer flashboard and gate as well as the middle pier will have crest elevations of 22.5 feet (NGVD29) to maintain the functionality of the fishway. We assume that the fishway can withstand the dam demolition without the need for major repairs. Because this alternative removes such a substantial amount of mass from Great Dam, the dam does not meet the stability requirements even though the water surface elevations drop during the 50 year storm. Therefore, alternative H will require installation of rock anchors before the flashboard and gate system is installed.

An Obermeyer system consists of numerous components including a compressor house, an air delivery piping system, a rubber bladder, and hinged steel plates that protect the bladder and act as the crest of the dam (Photograph A5). There are three main benefits of the Obermeyer system:

- The steel plates protect the rubber bladders from ice and debris load.
- The stiffness of the plate allows the system to raise and lower the water surface elevation by partial deflation where a rubber dam without a steel plate can only be completely inflated or deflated.
- The Obermeyer can be designed to be failsafe (*i.e.* pull the plug and the force of the water will cause the bladders to deflate and the flood can pass).

This allows the town maximum flexibility controlling the water levels and may improve the fish passage effectiveness by better controlling the flow over the dam. Also, the size of the gate will allow the Town to rapidly drain the impoundment for maintenance activities.

Typically, these systems are installed for an operating hydro power facility that has a building to house the compressors and associated controls. Great Dam would require either building a new small building to house the compressors (ideally above the 100 year flood elevation) or have a local building (*e.g.* the public library) house the compressors. A common misconception with these types of systems is that the compressors have to be operating all the time. The compressors usage is a function of the amount of leakage in the system and the need for water level management. If the system is maintained properly and the normal pond level held relatively constant, the compressors do not need to be operated constantly. This minimizes depreciation and energy usage.

3.2.1 EFFECT ON HYDRAULICS

Alternative H will have an impact on the hydraulics of the Exeter River. This impact will be similar to alternatives B through F when flood flow water surface elevations are decreased (Appendix G-3). The unique aspect of Alternative H involves the ability of the town to pass a variety of flows without changing the impoundment water surface elevation. As shown in Figure 3, the side Obermeyer gate can be opened to pass up to approximately 775 cfs at normal head pond elevations (*i.e.* 22.5 ft NGVD29). The existing low level outlet at normal pond has a discharge capacity of approximately 225 cfs fully open. For larger events, the spillway flashboard panel can be lowered to pass flow (~1,500 cfs) enabling the Town to maintain the normal headpond level up to approximately the 10 year flood flow.

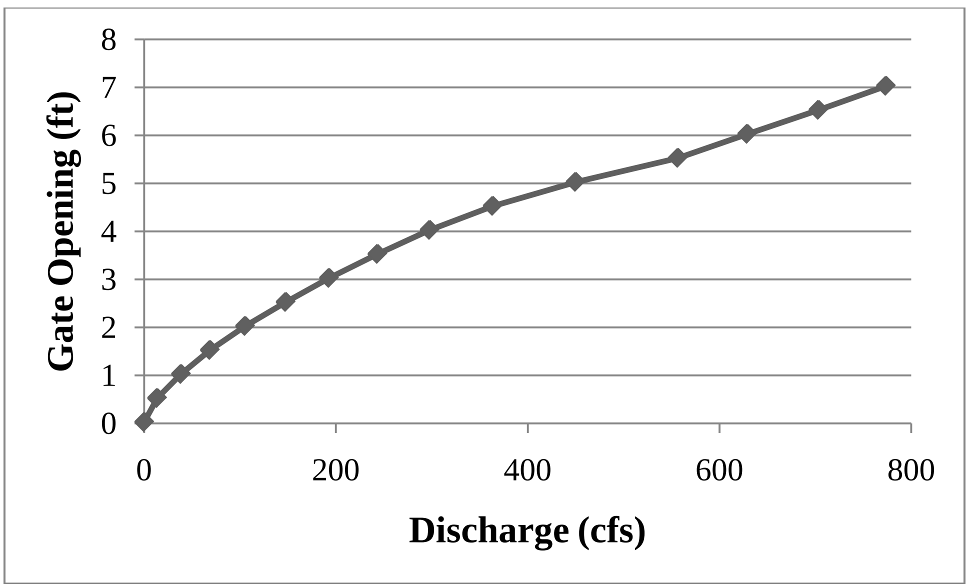

FIGURE 3 DISCHARGE CAPACITY OF THE SIDE GATE AT NORMAL HEAD POND LEVELS.

The HEC-RAS model provided by Weston & Sampson was used to determine the effect on river hydraulics for the entire river system during flood events. Normal pond conditions (*e.g.* median September flow) were not simulated because the system would be inflated and the existing hydraulic conditions would be maintained. The flexibility provided by the inflatable system was not modeled using HEC-RAS either. The dam geometry remained the same for each flood simulation (*i.e.* flashboard down/gate fully open). Similar to the other alternatives, the hydraulic conditions directly downstream of the dam do not change with Alternative H. The changes in hydraulics are largest at the dam and typically decrease in magnitude farther upstream (Table 3). These impacts include decreases in river depth and width due to better conveyance at the dam and increased velocity because there are less backwater effects from the dam.

TABLE 3 MODEL RESULTS FROM HYDRAULIC MODIFICATIONS AS A RESULT OF ALTERNATIVE H.

River	Reach	Location	River Stn (ft)	Flow	Relative Change Alternative H: River Depth (ft)	Relative Change Alternative H: River Width (ft)	Relative Change Alternative H: Vel. (ft/s)	Percent Change Alternative H: River Depth (ft)	Percent Change Alternative H: River Width (ft)	Percent Change Alternative H: Vel. (ft/s)
Exeter	Squamscott River to Great Dam	Upstream of String Bridge	348	2 yr	0.0	0.0	0.0	0%	0%	0%
				10 yr	0.0	0.0	0.0	0%	0%	0%
				50 yr	0.0	0.0	0.0	0%	0%	0%
				100 yr	0.0	0.0	0.0	0%	0%	0%
Exeter	Great Dam to Little River Confluence	Upstream of High St. Bridge	1256	2 yr	-2.4	-72	0.8	32%	35%	63%
				10 yr	-2.5	-50	0.9	25%	21%	41%
				50 yr	-2.2	-50	0.8	16%	31%	27%
				100 yr	-2.2	-168	0.8	18%	12%	30%
Exeter	Little River Confluence to Rt. 108 Bridge	700 ft Downstream of Rt. 108 Bridge	19403	2 yr	-0.2	-94	0.2	3%	4%	8%
				10 yr	-1.0	-299	0.7	14%	10%	44%
				50 yr	-1.4	-178	0.4	13%	7%	28%
				100 yr	-1.4	-263	0.3	14%	5%	37%
Exeter	Rt. 108 Bridge to Impoundment Limit	Upstream of Linden St. Bridge	25519	2 yr	0	-8.9	0	0%	5%	1%
				10 yr	-0.3	-30	0.1	4%	6%	4%
				50 yr	-0.3	-7.5	0.1	2%	1%	5%
				100 yr	0.1	1.6	-0.02	1%	0%	1%

River	Reach	Location	River Stn (ft)	Flow	Relative Change Alternative H River Depth (ft)	Relative Change Alternative H River Width (ft)	Relative Change Alternative H Vel. (ft/s)	Percent Change Alternative H River Depth (ft)	Percent Change Alternative H River Width (ft)	Percent Change Alternative H Vel. (ft/s)
Exeter	Impoundment Limit to Pickpocket Dam	Downstream face of Rt. 111 Bridge	35975	2 yr	0	0	0	0%	0%	0%
				10 yr	-0.04	-0.4	0	1%	0%	0%
				50 yr	-0.1	-1.1	0.1	1%	1%	1%
				100 yr	0	0.3	0	0%	0%	0%
Little	Mouth to Impoundment Limit	Downstream of Linden St. Bridge	5099	2 yr	-0.5	-27	0.3	16%	14%	20%
				10 yr	-1.6	-67	0.6	27%	20%	40%
				50 yr	-1.3	-270	0.4	15%	42%	19%
				100 yr	-1	-551	0.3	11%	47%	12%

3.2.2 Effect on Stability

As mentioned, removing mass from the dam will destabilize it, especially during normal pond elevations when the flashboard and gate is inflated. The Obermeyer components do not have the same mass as concrete. Therefore, rock anchors were designed to improve dam stability by resisting failure via sliding or overturning (Appendix G-4). The conceptual design involves installing 11 rock anchors along the spillway spaced 7.5 feet on center with two strands each and three strand rock anchors along the gate space 5 feet on center. Failure caused by erosion from overtopping is completely eliminated because flood flows are managed.

3.2.3 Opinion of Cost

Kleinschmidt completed an OPC for Alternative H resulting in an initial investment of $1,002,000 (Appendix G-5) and a 30 year life cycle cost of $1,577,000 (Table 4). The $752,000 direct cost total for partial dam removal, installation of the Obermeyer flashboard system, and rock anchor installation was obtained from three sources: VHB’s dam removal OPC, RS Means, and vendor quotes from an inflatable flashboard bid in 2012. In order to properly compare alternatives, we maintained many of the line items from the VHB OPC, though in some instances, the quantity was altered. For example, the concrete demolition was not expected to be as extensive as the dam removal alternative. Kleinschmidt also changed mobilization and contractor conditions to percentages instead of lump sum line items. The indirect costs were all industry standard percentages of the direct cost subtotal. The indirect costs were all percentages of the direct cost subtotal including a 20% contingency.

Kleinschmidt used the National Institute of Standards and Technology (NIST) Life Cycle Cost Manual Handbook 135 (1995) with the 2012 supplement to determine the life cycle costs for the proposed dam stabilization. At this level of design, we utilized a simple method that accounts for initial investment, capital replacement, residual value, energy, and operation, maintenance, and repair. Because the design life of properly installed Obermeyer system is 30 years, we estimated a capital replacement cost of 90% of the initial investment value with the remainder as residual value for a 30 year LCC analysis. This assumes that some of the parts (*i.e.* piping system) would maintain value. The energy usage was estimated by looking up average household energy usage rates in New Hampshire. The operation, maintenance, and repair annual cost was derived from the Exeter PWD existing O&M and adding another week of labor hours and another $500 in materials (see3.1.3). However, the reduction in flooding resulted in only a minor increase in the overall annual cost. The methods and parameters are the same as the Alternative G LCC analysis.

TABLE 4 LIFE CYCLE COST (LCC) ESTIMATE FOR ALTERNATIVE H

COST ITEM	BASE DATE (2013) COST	YEAR OF OCCURRENCE	DISCOUNT FACTOR[1]	PRESENT VALUE
Initial Investment	$1,002,000	Base Date	1	$1,002,000
Capital Replacement (90%)	$901,800	30	0.552	$497,794
Residual Value (10%)	$100,200	30	0.552	$55,310
Electricity (1500 kWh at $0.15/kWh)	$225	Annual	19.8	$4,455
Operation, Maintenance, and Repair	$4,800	Annual	22.4	$107,520
Total LCC				**$1,557,000**

[1]NIST LCC Supplement 2012

4.0 ADDITIONAL CONSIDERATIONS

Both Alternative G and Alternative H proposed in this study are viable options for the Town of Exeter to pursue to bring Great Dam into compliance. The following are some additional considerations.

4.1 ALTERNATIVE G – ROCK ANCHORS

Alternative G provides the Town a relatively inexpensive way to maintain the status quo while satisfying regulatory requirements. However, at this level of design there are uncertainties regarding this option. For example, the NHDES dam bureau will not completely eliminate erosion by overtopping as a failure mode without further investigation (Steve Doyon, personal communication). Therefore, the preliminary investigations (*e.g.* geotechnical borings) may produce results that could complicate the final design of the rock anchors and make the project more expensive. This is not anticipated, but it remains a possibility. No matter what is discovered during the preliminary investigations, stabilizing the dam is a feasible alternative. If erosion by overtopping is deemed a potential failure mode, then abutment modifications could be designed to mitigate this risk. These modifications would result in NFIP ramifications whereas the proposed rock anchor installation would not.

Another important consideration when stabilizing the dam in place is whether the Town is willing to accept the increased flooding risks and the ecological impacts. The discharge capacity of Great Dam is 20% of what it needs to be to pass the 50 year flood. Therefore, is the Town willing to accept flood damage as a relatively common occurrence? The flood risk can be managed better by increasing the size of the low level outlet in the headworks, but not nearly enough to pass the 50 year flood or even the 10 year event. The ecological impacts of dams are well established. In the case of the Great Dam, the water quality of the impoundment will likely continue to degrade (higher temperature/lower dissolved oxygen) with Alternative G.

4.2 ALTERNATIVE H – INFLATABLE FLASHBOARD/GATE SYSTEM

Alternative H involves the addition of mechanical and electrical components to the Great Dam. These components inherently will increase the need for operation, maintenance, and repair. In addition to the list of activities the Exeter PWD executes, here is a list of likely maintenance activities Alternative H would require:

- Air compressor oil check (weekly) and change (dependant on usage).
- Air compressor belt check (weekly) and change (dependant on usage).
- Obermeyer abutment seal check (yearly and after floods).
- Obermeyer air bladder check (yearly and after floods).
- Obermeyer restraining straps check (yearly and after floods).
- Inspect coalescing filter (yearly with periodic replacement).
- Inspect air dryer (yearly with periodic replacement).
- Torque main anchor bolts (every 12 to 18 months).
- Operate failsafe purge valves (every October).

In addition to these tasks, the systems requires energy to run the compressors, air dryers, provide lighting in the compressor house, and potentially heat the compressor house. In the case of the loss of electric supply, the system could run on a portable generator. However, this is not required because well maintained bladders will hold their air and the failsafe purge valves will not require electricity to function. In the unlikely case of catastrophic failure of the system, the impoundment would drain to the invert of the gate. If this occurs during high flows, the system would not be able to be fixed for weeks or even months. This could have large ramifications for the effectiveness of the fishway. As with Alternative G, the ecological impacts of the dam would remain.

5.0 REFERENCES

Engineering Guidelines for the Evaluation of Hydropower Projects. [Washington, DC]: Federal Energy Regulatory Commission, Office of Hydropower Licensing, 2013

Geotechnical Engineering Circular No. 4. (FHWA-IF-99-015) Ground Anchors and Anchored Systems U.S. Department of Transportation Federal Highway Administration, 1999

NIST Handbook 135. Life-Cycle Costing Manual for the Federal Energy Management Program. U.S. Department of Energy. 1995

NISTIR 85-3273-27. Energy Prices Indices and Discount Factors for Life-Cycle Cost Analysis. Annual Supplement to NIST Handbook 135 and NBS Special Publication 709. U.S. Department of Energy, 2012

Paxson, G.S., Campbell, D.B., Canino, M.C., and Landis, M.E. 2011. Dam Safety: Stability and Rehabilitation of “Smaller” Gravity Dams. Hydro Review Worldwide.

Tullis, J.P., Amanian, N, and Waldron, D. 1995. Design of Labyrinth Spillways. Journal of Hydraulic Engineering. 121: 247-255.

Weston & Sampson, Inc. 2012. Technical Memorandum entitled Exeter River Design Flows, by K. Mackinnon and A. Walker dated January 4, 2012.

Appendix G-1

Photographs

PHOTO G-1-1 **GREAT DAM LOOKING UPSTREAM FROM THE FISHWAY WEIR (COURTESY OF WESTON & SAMPSON ENGINEERS)**

PHOTOG-1-2 **GREAT DAM LOOKING DOWNSTREAM DURING A STAGED DRAWDOWN (COURTESY OF WESTON & SAMPSON ENGINEERS)**

PHOTO G-1-3 **GREAT DAM DURING THE MOTHER'S DAY FLOOD OF 2006 (COURTESY OF MICHAEL CHELMINSKI)**

PHOTO G-1-4 **INSTALLATION OF ROCK ANCHORS**

PHOTO G-1-5 OBERMEYER INFLATABLE FLASHBOARD SYSTEM AFTER INSTALLATION AND BEFORE COMMISSIONING

APPENDIX G-2

STABILITY CALCULATIONS

Kleinschmidt	Pittsfield, Maine Phone: 207.487.3328 www.KleinschmidtUSA.com	Page:	
		Project No.: 1153-012	
Project: Great Dam - Exeter, NH		By: EMT	Date: 4/23/2013
Subject: Existing Spillway Stability Analysis - 50 YR FLOOD		Checked: CSP	Date: 4/25/2013

TABULATION OF FORCES

VERTICAL FORCES

Dead Loads

Load	Height (ft)	Width (ft)	Length (ft)	Shape Factor	Weight (k/ft^3)	Vertical Forces (k) ↓ +	Vertical Forces (k) ↑ -	Arm (ft)	Moments (ft-k) ↺ +	Moments (ft-k) ↻ -
Concrete Weight										
C_1	10.5	3.5	1.0	1.0	0.150	5.5		6.85	37.8	
C_2	9.5	5.1	1.0	0.5	0.150	3.6		3.40	12.4	
C_3	1.0	1.5	1.0	1.0	0.150	0.2		6.85	1.5	
C_4					0.150	0.0			0.0	
C_5					0.150	0.0			0.0	
Soil Weight										
E_1					0.115	0.0			0.0	
E_2					0.115	0.0			0.0	
Water Weight										
W_1 over crest	5.9	2.0	1.0	0.5	0.0624	0.4		7.93	2.9	
W_2					0.0624	0.0			0.0	
TOTALS						**9.7**			**54.6**	

Uplift Pressure

Load	Height (ft)	Width (ft)	Length (ft)	Shape Factor	Weight (k/ft^3)	Vertical Forces (k) ↓ +	Vertical Forces (k) ↑ -	Arm (ft)	Moments (ft-k) ↺ +	Moments (ft-k) ↻ -
U_1 Uplift 1	10.7	8.6	1.0	1.0	0.0624		5.7	4.30		24.7
U_2 Uplift 2	7.1	8.6	1.0	0.5	0.0624		1.9	5.73		10.9
U_3 Uplift 3					0.0624		0.0			0.0
TOTALS							**7.6**			**35.6**

HORIZONTAL FORCES

Soil Pressure (At-Rest) Soil Friction Angle (ϕ) = 30 degrees k_o = (1 - sinϕ) = 0.50

Load	Height (ft)	Width (ft)	Length (ft)	Shape Factor	Weight (k/ft^3)	Horizontal Forces (k) ← +	Horizontal Forces (k) → -	Arm (ft)	Moments (ft-k) ↺ +	Moments (ft-k) ↻ -
P_{E1} silt	7.0	7.0	1.0	0.5	0.0526		0.6	2.33	0.0	1.5
P_{E2}							0.0		0.0	0.0
P_{E3}						0.0			0.0	0.0
TOTALS						**0.0**	**0.6**		**0.0**	**1.5**

Water Pressure

Load	Height (ft)	Width (ft)	Length (ft)	Shape Factor	Weight (k/ft^3)	Horizontal Forces (k) ← +	Horizontal Forces (k) → -	Arm (ft)	Moments (ft-k) ↺ +	Moments (ft-k) ↻ -
P_{W1} HW	12.0	5.8	1.0	1	0.0624		4.3	6.00	0.0	26.1
P_{W2} HW	12.0	12.0	1.0	0.5	0.0624		4.5	4.00	0.0	18.0
P_{W3} TW	6.4	6.4	1.0	0.5	0.0624	1.3		2.13	2.7	0.0
TOTALS						**1.3**	**8.8**		**2.7**	**44.0**

SUMMATION

Net Vertical Force, V = 2.1 k ↓

Net Moment About the Toe, M = -23.8 ft-k ↺

Net Horizontal Force, H = -8.2 k →

Kleinschmidt	Pittsfield, Maine Phone: 207.487.3328 www.KleinschmidtUSA.com	Page:	
		Project No.: 1153-012	
Project: Great Dam - Exeter, NH		By: EMT	Date: 4/23/2013
Subject: Existing Spillway Stability Analysis - 50 YR FLOOD		Checked: CSP	Date: 4/25/2013

STABILITY ANALYSIS

CRITERIA - FERC Chapter III

Required $F.S._{sliding}$ =	1.5	
Required $F.S._{flotation}$ =	1.0	
Max Fdn Bearing Pressure =		ksf
100 % of Base in Compression Required		

Base Length (B)	8.6	ft	
Base Width (W)	1.0	ft	
Base Area (A)	8.6	ft^2	(W · B)
Base Section Modulus (S)	12.3	ft^3	(W · B^2) / 6
Friction Angle at Failure Plane (ϕ_f)	45	degrees	
Friction Factor at Failure Plane ($\tan\phi_f$)	1.00		
Cohesion (c)	0	ksf	

SLIDING ANALYSIS

	V		H	
Σ Forces =	2.1 ↓	k	-8.2 →	k

$F.S._{sliding}$ =	0.26	($V\tan\phi_f$ + cA) / H	<< Does NOT meet sliding criteria >>

RESULTANT, FLOATATION, & BEARING ANALYSIS

	V		H			M	
Σ Forces =	2.1 ↓	k	-8.2 →	k	**Σ Moments =**	-23.8 ↻	ft-k

$F.S._{flotation}$ =	1.27		(V↓ / V↑)	OK - Meets Floatation Criteria
Kern between	2.9	ft. and	5.7 ft.	Measured from the Toe
Resultant, R at	-11.4	ft. from toe	(M/V)	<< Resultant OUTSIDE BASE >>
Eccentricity, e =	15.7	ft.	(B/2 - M/V)	Right of Base Centerline
Toe Pressure =	2.9	ksf	(V/A + Ve/S)	<< Exceeds Bearing Capacity >>
Heel Pressure =	-2.4	ksf	(V/A - Ve/S)	OK - Less than Bearing Capacity
	55%	of base in compression		<< Tension in Heel - Crack Develops >>

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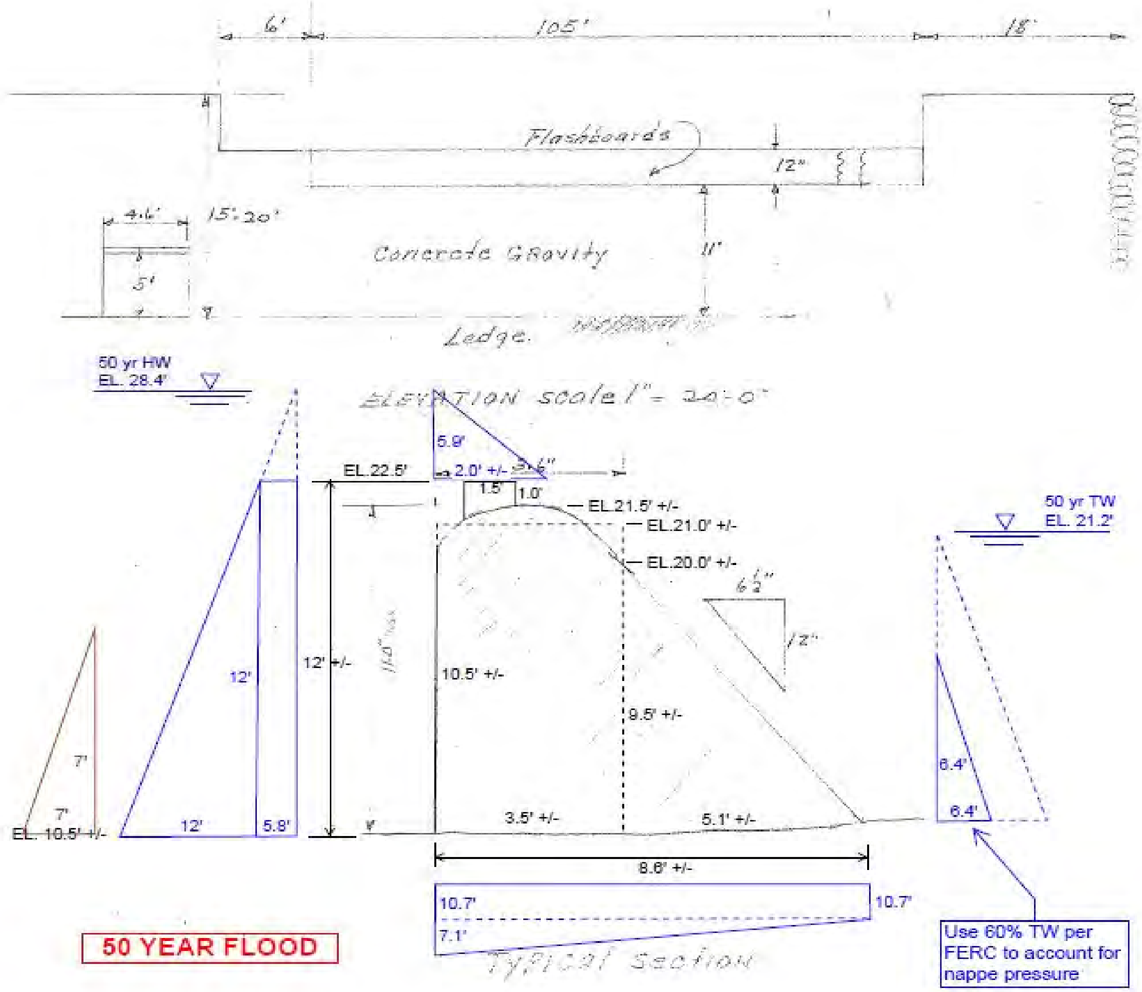
LOAD DIAGRAMS FOR STABILITY ANALYSIS



References:

1. NHDES H&H Report 2006
2. Wright Pierce Inspection Report and Photos, 2007

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TABULATION OF FORCES

VERTICAL FORCES

Dead Loads

Load		Height (ft)	Width (ft)	Length (ft)	Shape Factor	Weight (k/ft³)	Vertical Forces (k) ↓ +	Vertical Forces (k) ↑ -	Arm (ft)	Moments (ft-k) ↺ +	Moments (ft-k) ↻ -
Concrete Weight											
C_1		10.5	3.5	1.0	1.0	0.150	5.5		6.85	37.8	
C_2		9.5	5.1	1.0	0.5	0.150	3.6		3.40	12.4	
C_3		1.0	1.5	1.0	1.0	0.150	0.2		6.85	1.5	
C_4	**Anchors**						**12.0**		5.60	67.2	
C_5											
Soil Weight											
E_1						0.115	0.0			0.0	
E_2						0.115	0.0			0.0	
Water Weight											
W_1	over crest	5.9	2.0	1.0	0.5	0.0624	0.4		7.93	2.9	
W_2						0.0624	0.0			0.0	
	TOTALS						**21.7**			**121.8**	

Uplift Pressure

Load		Height (ft)	Width (ft)	Length (ft)	Shape Factor	Weight (k/ft³)	Vertical Forces (k) ↓ +	Vertical Forces (k) ↑ -	Arm (ft)	Moments (ft-k) ↺ +	Moments (ft-k) ↻ -
U_1	Uplift 1	10.7	8.6	1.0	1.0	0.0624		5.7	4.30		24.7
U_2	Uplift 2	7.1	8.6	1.0	0.5	0.0624		1.9	5.73		10.9
U_3	Uplift 3					0.0624		0.0			0.0
	TOTALS							**7.6**			**35.6**

HORIZONTAL FORCES

Soil Pressure (At-Rest) Soil Friction Angle (ϕ) = 30 degrees k_o = (1 - sinϕ) = 0.50

Load		Height (ft)	Width (ft)	Length (ft)	Shape Factor	Weight (k/ft³)	Horizontal Forces (k) ← +	Horizontal Forces (k) → -	Arm (ft)	Moments (ft-k) ↺ +	Moments (ft-k) ↻ -
P_{E1}	silt	7.0	7.0	1.0	0.5	0.0526		0.6	2.33	0.0	1.5
P_{E2}								0.0		0.0	0.0
P_{E3}							0.0			0.0	0.0
	TOTALS						**0.0**	**0.6**		**0.0**	**1.5**

Water Pressure

Load		Height (ft)	Width (ft)	Length (ft)	Shape Factor	Weight (k/ft³)	Horizontal Forces (k) ← +	Horizontal Forces (k) → -	Arm (ft)	Moments (ft-k) ↺ +	Moments (ft-k) ↻ -
P_{W1}	HW	12.0	5.8	1.0	1	0.0624		4.3	6.00	0.0	26.1
P_{W2}	HW	12.0	12.0	1.0	0.5	0.0624		4.5	4.00	0.0	18.0
P_{W3}	TW	6.4	6.4	1.0	0.5	0.0624	1.3		2.13	2.7	0.0
	TOTALS						**1.3**	**8.8**		**2.7**	**44.0**

SUMMATION

Net Vertical Force, V = **14.1** **k** ↓

Net Moment About the Toe, M = **43.4** **ft-k** ↺

Net Horizontal Force, H = **-8.2** **k** →

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STABILITY ANALYSIS

CRITERIA - FERC Chapter III

Required F.S.$_{sliding}$ = 1.5

Required F.S.$_{flotation}$ = 1.0

Max Fdn Bearing Pressure = ksf

100 % of Base in Compression Required

Base Length (B)	8.6	ft	
Base Width (W)	1.0	ft	
Base Area (A)	8.6	ft^2	(W · B)
Base Section Modulus (S)	12.3	ft^3	(W · B^2) / 6
Friction Angle at Failure Plane (ϕ_f)	45	degrees	
Friction Factor at Failure Plane (tanϕ_f)	1.00		
Cohesion (c)	0	ksf	0.0 psi

SLIDING ANALYSIS

	V		H		
Σ Forces =	**14.1** ↓	**k**	**-8.2** →	**k**	
F.S.$_{sliding}$ =	**1.72**		(Vtanϕ_f + cA) / H		OK - Meets Sliding Criteria

RESULTANT, FLOATATION, & BEARING ANALYSIS

	V		H		M	
Σ Forces =	**14.1** ↓	**k**	**-8.2** →	**k**	**Σ Moments = 43.4** ↺	**ft-k**

F.S.$_{flotation}$ =	**2.84**		(V↓ / V↑)	OK - Meets Floatation Criteria
Kern between	**2.9**	**ft. and**	**5.7 ft.**	Measured from the Toe
Resultant, R at	**3.1**	**ft. from toe**	(M/V)	Resultant within the kern
Eccentricity, e =	**1.2**	**ft.**	(B/2 - M/V)	Right of Base Centerline
Toe Pressure =	**3.0**	**ksf**	(V/A + Ve/S)	<< Exceeds Bearing Capacity >>
Heel Pressure =	**0.2**	**ksf**	(V/A - Ve/S)	<< Exceeds Bearing Capacity >>
	100%	**of base in compression**		OK - 100% Base in compression

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CRACKED BASE ANALYSIS

Crack Length	0.0	ft	
Base Length (B)	8.6	ft	
Base Width (W)	1.0	ft	
Base Area (A)	8.6	ft^2	(W · B)
Base Section Modulus (S)	12.3	ft^3	(W · B^2) / 6

Uplift Pressure

Load		Height (ft)	Width (ft)	Length (ft)	Shape Factor	Weight (k/ft^3)	Vertical Forces (k) ↓ +	Vertical Forces (k) ↑ -	Arm (ft)	Moments (ft-k) ↺ +	Moments (ft-k) ↻ -
U_1	Uplift 1	10.7	8.6	1.0	1.0	0.0624		5.7	4.30		24.7
U_2	Uplift 2	7.1	8.6	1.0	0.5	0.0624		1.9	5.73		10.9
U_3	Uplift 3	17.8	0.0	1.0	1.0	0.0624		0.0	8.60		0.0
	TOTALS							**7.6**			**35.6**

SLIDING ANALYSIS

Σ Forces = V: **14.1** k ↓ H: **-8.2** k →

F.S.$_{sliding}$ = **1.72** ($V\tan\phi_f$ + cA) / H OK - Meets Sliding Criteria

RESULTANT, FLOATATION, & BEARING ANALYSIS

Σ Forces = V: **14.1** k ↓ H: **-8.2** k → **Σ Moments =** M: **43.4** ft-k ↺

F.S.$_{flotation}$ =	**2.84**		(V↓ / V↑)	OK - Meets Floatation Criteria
Kern between	**2.9**	**ft. and 5.7 ft.**		Measured from the Toe
Resultant, R at	**3.1**	**ft. from toe**	(M/V)	Resultant within the kern
Eccentricity, e =	**1.2**	**ft.**	(B/2 - M/V)	Right of Base Centerline
Toe Pressure =	**3.0**	**ksf**	(V/A + Ve/S)	OK - Less than Bearing Capacity
Heel Pressure =	**0.2**	**ksf**	(V/A - Ve/S)	OK - Less than Bearing Capacity
	100%	**of base in compression**		OK - 100% Base in compression

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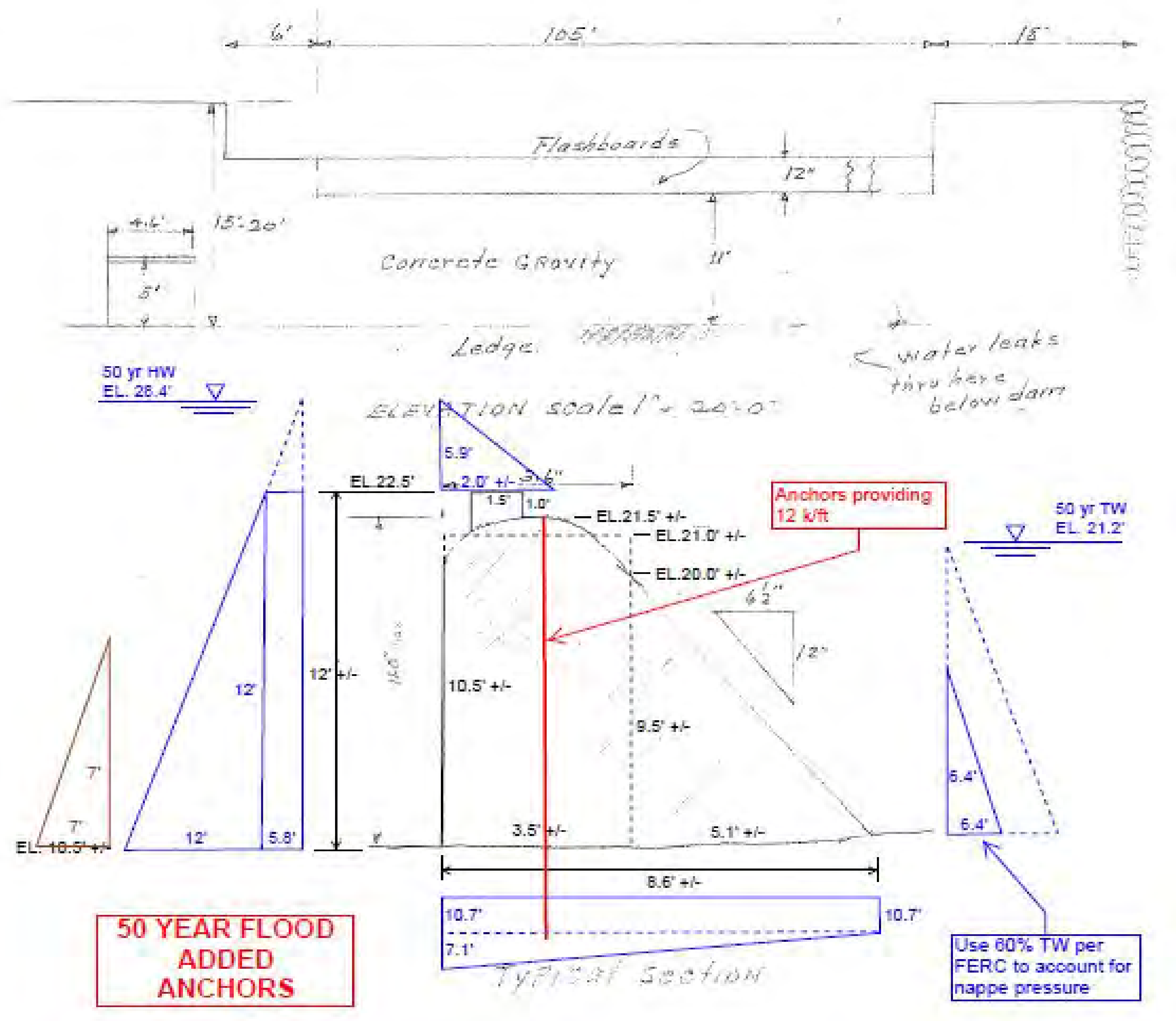
LOAD DIAGRAMS FOR STABILITY ANALYSES



References:

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TABULATION OF FORCES

VERTICAL FORCES

Dead Loads

Load		Height (ft)	Width (ft)	Length (ft)	Shape Factor	Weight (k/ft³)	Vertical Forces (k) ↓ +	Vertical Forces (k) ↑ -	Arm (ft)	Moments (ft-k) ↺ +	Moments (ft-k) ↻ -
Concrete Weight											
C_1		7.5	4.5	1.0	1.0	0.150	5.1		6.35	32.1	
C_2		7.5	4.1	1.0	0.5	0.150	2.3		2.73	6.3	
C_3	**Gate Weight**						0.3		6.35	1.9	
C_4	**Anchors**						**4.0**		5.10	20.4	
C_5											
Soil Weight											
E_1						0.115	0.0			0.0	
E_2						0.115	0.0			0.0	
Water Weight											
W_1	over crest	3.4	4.5	1.0	0.5	0.0624	0.5		7.10	3.4	
W_2	over crest	3.2	4.5	1.0	1.0	0.0624	0.9		6.35	5.7	
	TOTALS						**13.0**			**69.9**	

Uplift Pressure

Load		Height (ft)	Width (ft)	Length (ft)	Shape Factor	Weight (k/ft³)	Vertical Forces (k) ↓ +	Vertical Forces (k) ↑ -	Arm (ft)	Moments (ft-k) ↺ +	Moments (ft-k) ↻ -
U_1	Uplift 1	10.7	8.6	1.0	1.0	0.0624		5.7	4.30		24.7
U_2	Uplift 2	3.4	8.6	1.0	0.5	0.0624		0.9	5.73		5.2
U_3	Uplift 3					0.0624		0.0			0.0
	TOTALS							**6.7**			**29.9**

HORIZONTAL FORCES

Soil Pressure (At-Rest) Soil Friction Angle (ϕ) = 30 degrees k_o = (1 - sinϕ) = 0.50

Load		Height (ft)	Width (ft)	Length (ft)	Shape Factor	Weight (k/ft³)	Horizontal Forces (k) ← +	Horizontal Forces (k) → -	Arm (ft)	Moments (ft-k) ↺ +	Moments (ft-k) ↻ -
P_{E1}	silt	7.0	7.0	1.0	0.5	0.0526		0.6	2.33	0.0	1.5
P_{E2}								0.0		0.0	0.0
P_{E3}							0.0			0.0	0.0
	TOTALS						**0.0**	**0.6**		**0.0**	**1.5**

Water Pressure

Load		Height (ft)	Width (ft)	Length (ft)	Shape Factor	Weight (k/ft³)	Horizontal Forces (k) ← +	Horizontal Forces (k) → -	Arm (ft)	Moments (ft-k) ↺ +	Moments (ft-k) ↻ -
P_{W1}	HW	7.5	6.6	1.0	1.0	0.0624		3.1	3.75	0.0	11.6
P_{W2}	HW	7.5	7.5	1.0	0.5	0.0624		1.8	2.50	0.0	4.4
P_{W3}	TW	6.4	6.4	1.0	0.5	0.0624	1.3		2.13	2.7	0.0
	TOTALS						**1.3**	**4.8**		**2.7**	**16.0**

SUMMATION

Net Vertical Force, V = 6.4 k ↓

Net Moment About the Toe, M = 25.2 ft-k ↺

Net Horizontal Force, H = -4.2 k →

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STABILITY ANALYSIS

CRITERIA - FERC Chapter III

Required $F.S._{sliding}$ = 1.5

Required $F.S._{flotation}$ = 1.0

Max Fdn Bearing Pressure = ksf

100 % of Base in Compression Required

Base Length (B)	8.6	ft	
Base Width (W)	1.0	ft	
Base Area (A)	8.6	ft^2	(W · B)
Base Section Modulus (S)	12.3	ft^3	(W · B^2) / 6
Friction Angle at Failure Plane (ϕ_f)	45	degrees	
Friction Factor at Failure Plane ($\tan\phi_f$)	1.00		
Cohesion (c)	0	ksf	0.0 psi

SLIDING ANALYSIS

	V		H	
Σ Forces =	**6.4** k ↓		**-4.2** k →	
$F.S._{sliding}$ =	**1.52**	($V\tan\phi_f$ + cA) / H		OK - Meets Sliding Criteria

RESULTANT, FLOATATION, & BEARING ANALYSIS

	V		H		M
Σ Forces =	**6.4** k ↓		**-4.2** k →	**Σ Moments =**	**25.2** ft-k ↺

$F.S._{flotation}$ =	**1.96**	(V↓ / V↑)	OK - Meets Floatation Criteria
Kern between	**2.9** ft. **and** **5.7** ft.		Measured from the Toe
Resultant, R at	**3.9** ft. from toe	(M/V)	Resultant within the kern
Eccentricity, e =	**0.4** ft.	(B/2 - M/V)	Right of Base Centerline
Toe Pressure =	**0.9** ksf	(V/A + Ve/S)	<< Exceeds Bearing Capacity >>
Heel Pressure =	**0.6** ksf	(V/A - Ve/S)	<< Exceeds Bearing Capacity >>
	100% of base in compression		OK - 100% Base in compression

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Appendix G FILE 82.01

NEW HAMPSHIRE WATER RESOURCES BOARD
CONCORD, N. H.

PROJECT ....

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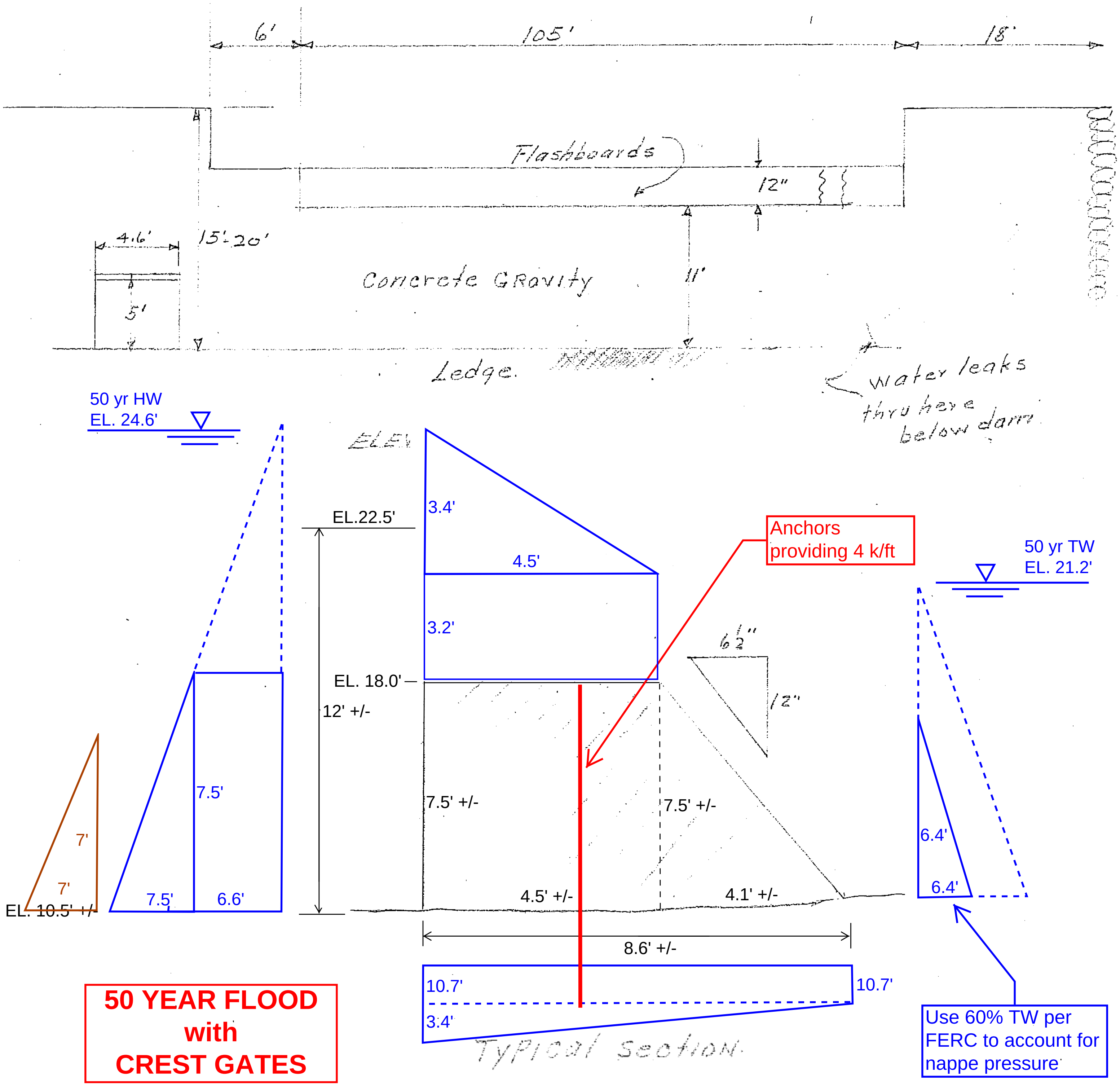

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TABULATION OF FORCES

VERTICAL FORCES

Dead Loads

Load	Height (ft)	Width (ft)	Length (ft)	Shape Factor	Weight (k/ft³)	Vertical Forces (k) ↓ +	Vertical Forces (k) ↑ -	Arm (ft)	Moments (ft-k) ↺ +	Moments (ft-k) ↻ -
Concrete Weight										
C_1	7.5	4.5	1.0	1.0	0.150	5.1		6.35	32.1	
C_2	7.5	4.1	1.0	0.5	0.150	2.3		2.73	6.3	
C_3 **Gate Weight**						0.3		7.10	2.1	
C_4 **Anchors**						**5.0**		5.10	25.5	
C_5										
Soil Weight										
E_1					0.115	0.0			0.0	
E_2					0.115	0.0			0.0	
Water Weight										
W_1 over gate	3.0	2.0	1.0	0.5	0.0624	0.2		7.93	1.5	
W_2					0.0624	0.0		8.60	0.0	
TOTALS						**12.9**			**67.6**	

Uplift Pressure

Load	Height (ft)	Width (ft)	Length (ft)	Shape Factor	Weight (k/ft³)	Vertical Forces (k) ↓ +	Vertical Forces (k) ↑ -	Arm (ft)	Moments (ft-k) ↺ +	Moments (ft-k) ↻ -
U_1 Uplift 1	4.0	8.6	1.0	1.0	0.0624		2.1	4.30		9.2
U_2 Uplift 2	8.0	8.6	1.0	0.5	0.0624		2.1	5.73		12.3
U_3 Uplift 3					0.0624		0.0			0.0
TOTALS							**4.3**			**21.5**

HORIZONTAL FORCES

Soil Pressure (At-Rest) Soil Friction Angle (ϕ) = 30 degrees k_o = (1 - sinϕ) = 0.50

Load	Height (ft)	Width (ft)	Length (ft)	Shape Factor	Weight (k/ft³)	Horizontal Forces (k) ← +	Horizontal Forces (k) → -	Arm (ft)	Moments (ft-k) ↺ +	Moments (ft-k) ↻ -
P_{E1} silt	7.0	7.0	1.0	0.5	0.0526		0.6	2.33	0.0	1.5
P_{E2}							0.0		0.0	0.0
P_{E3}						0.0			0.0	0.0
TOTALS						**0.0**	**0.6**		**0.0**	**1.5**

Water Pressure

Load	Height (ft)	Width (ft)	Length (ft)	Shape Factor	Weight (k/ft³)	Horizontal Forces (k) ← +	Horizontal Forces (k) → -	Arm (ft)	Moments (ft-k) ↺ +	Moments (ft-k) ↻ -
P_{W1} HW					0.0624		0.0	0.00	0.0	0.0
P_{W2} HW	12.0	12.0	1.0	0.5	0.0624		4.5	4.00	0.0	18.0
P_{W3} TW	4.0	4.0	1.0	0.5	0.0624	0.5		1.33	0.7	0.0
TOTALS						**0.5**	**4.5**		**0.7**	**18.0**

SUMMATION

Net Vertical Force, V = 8.6 k ↓

Net Moment About the Toe, M = 27.2 ft-k ↺

Net Horizontal Force, H = -4.6 k →

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STABILITY ANALYSIS

CRITERIA - FERC Chapter III

Required $F.S._{sliding}$ = 1.5

Required $F.S._{flotation}$ = 1.0

Max Fdn Bearing Pressure = ksf

100 % of Base in Compression Required

Base Length (B)	8.6	ft	
Base Width (W)	1.0	ft	
Base Area (A)	8.6	ft^2	(W · B)
Base Section Modulus (S)	12.3	ft^3	(W · B^2) / 6
Friction Angle at Failure Plane (ϕ_f)	45	degrees	
Friction Factor at Failure Plane ($\tan\phi_f$)	1.00		
Cohesion (c)	0	ksf	0.0 psi

SLIDING ANALYSIS

	V		H		
Σ Forces =	8.6 ↓	k	-4.6 →	k	
$F.S._{sliding}$ =	1.85		($V\tan\phi_f$ + cA) / H		OK - Meets Sliding Criteria

RESULTANT, FLOATATION, & BEARING ANALYSIS

	V		H		M	
Σ Forces =	8.6 ↓	k	-4.6 →	k	Σ Moments = 27.2 ↺	ft-k

$F.S._{flotation}$ =	2.99		(V↓ / V↑)	OK - Meets Floatation Criteria
Kern between	2.9	ft. and	5.7 ft.	Measured from the Toe
Resultant, R at	3.2	ft. from toe	(M/V)	Resultant within the kern
Eccentricity, e =	1.1	ft.	(B/2 - M/V)	Right of Base Centerline
Toe Pressure =	1.8	ksf	(V/A + Ve/S)	<< Exceeds Bearing Capacity >>
Heel Pressure =	0.2	ksf	(V/A - Ve/S)	<< Exceeds Bearing Capacity >>
	100%	of base in compression		OK - 100% Base in compression

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NEW HAMPSHIRE
WATER RESOURCES
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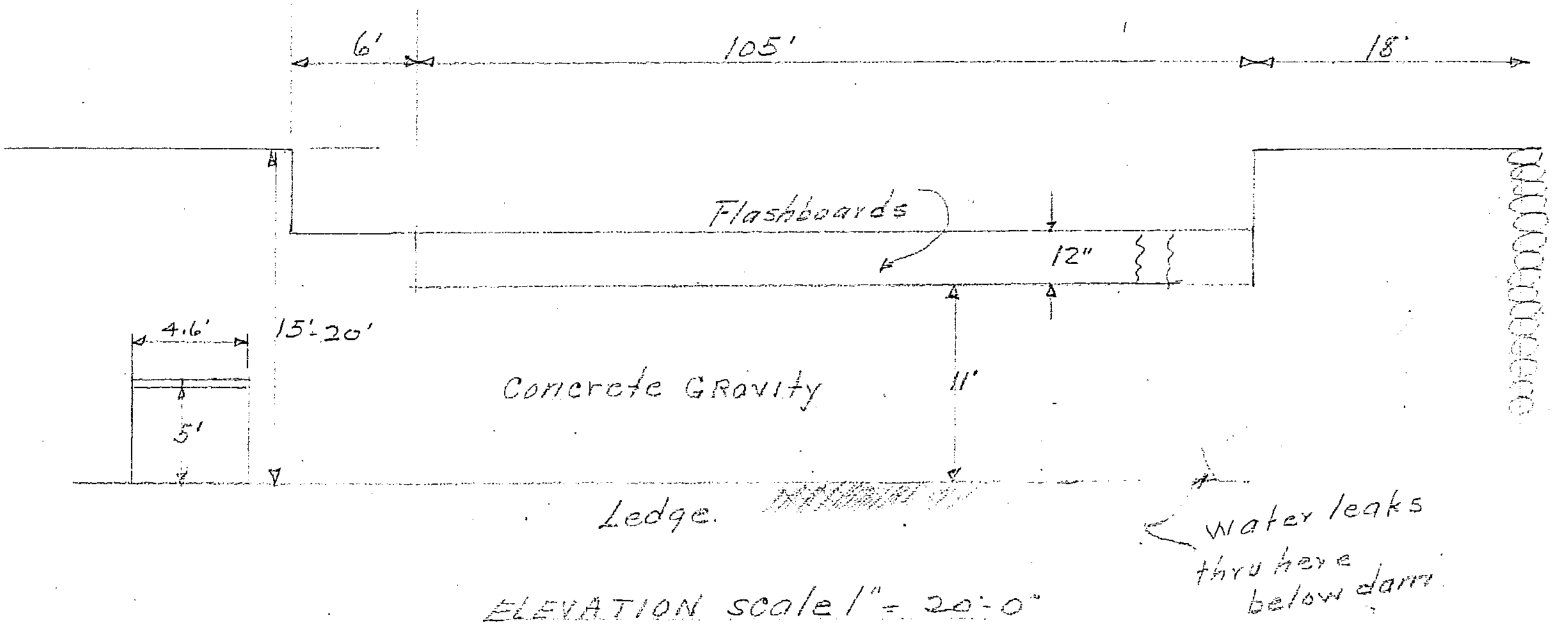
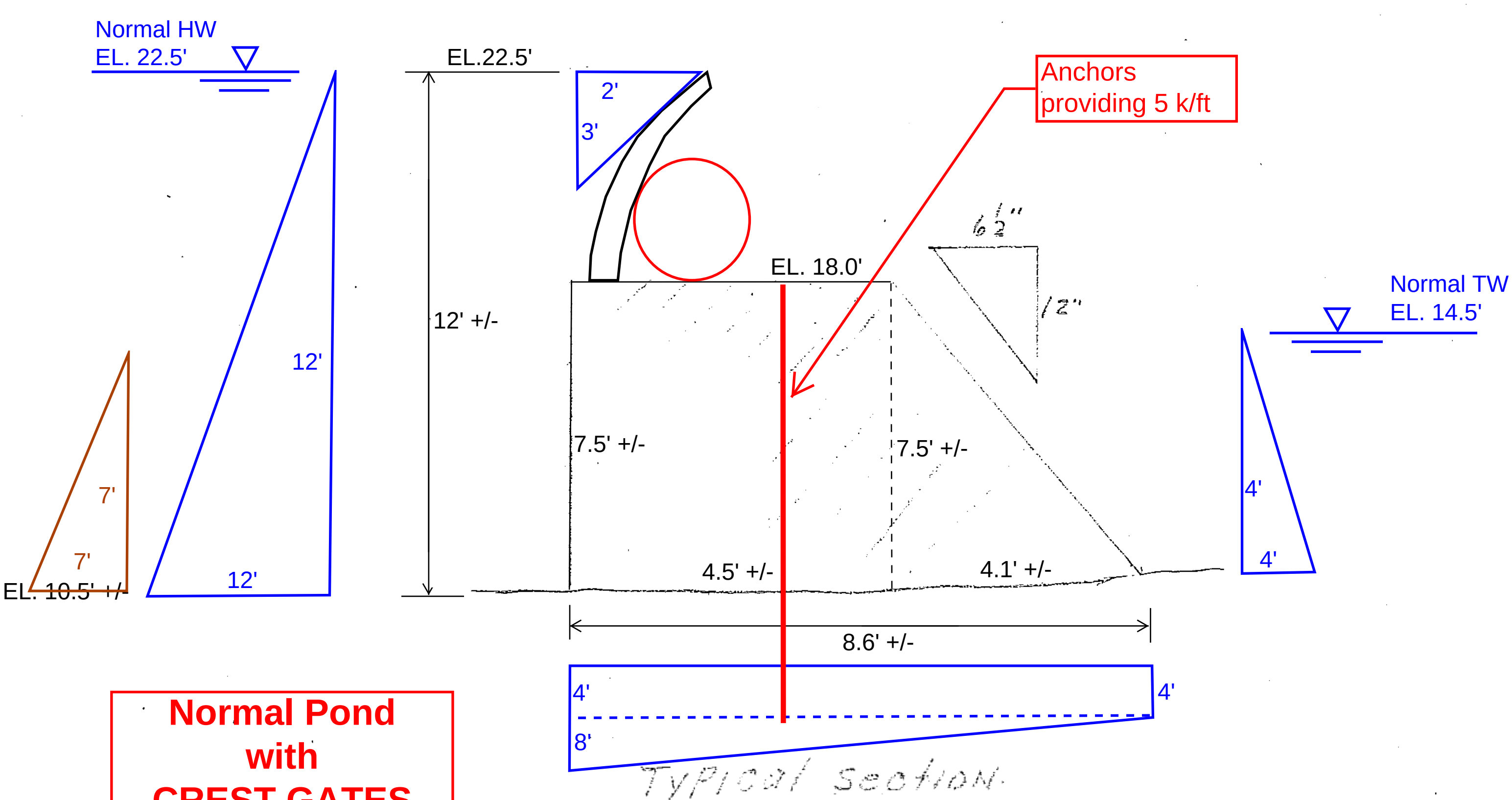
OCEAN EXETER RIVER EXETER MFG. Co.

COMPUTER G.S.W. CHECKER R.L.T. CONT. FROM ACC. CONT. ON ACC. SUMMARY ON ACC. DATE 10/11/39

82.01





Normal Pond with CREST GATES

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		Project No.: 1153-012	
Project: Great Dam - Exeter, NH		By: EMT	Date: 4/23/2013
Subject: Proposed Spillway with Deep Gate Stability Analysis - 50 YR FLOOD		Checked: CSP	Date: 4-25-13

TABULATION OF FORCES

VERTICAL FORCES

Dead Loads

Load		Height (ft)	Width (ft)	Length (ft)	Shape Factor	Weight (k/ft³)	Vertical Forces (k) ↓ +	Vertical Forces (k) ↑ -	Arm (ft)	Moments (ft-k) ↺ +	Moments (ft-k) ↻ -
Concrete Weight											
C_1		5.0	5.9	1.0	1.0	0.150	4.4		5.65	25.0	
C_2		5.0	2.7	1.0	0.5	0.150	1.0		1.80	1.8	
C_3	**Gate Weight**						0.5		5.10	2.6	
C_4	**Anchors**						**3.0**		4.00	12.0	
C_5											
Soil Weight											
E_1						0.115	0.0			0.0	
E_2						0.115	0.0			0.0	
Water Weight											
W_1	over crest	3.4	5.9	1.0	0.5	0.0624	0.6		6.63	4.2	
W_2	over crest	5.7	5.9	1.0	1.0	0.0624	2.1		5.65	11.9	
	TOTALS						**11.7**			**57.4**	

Uplift Pressure

Load		Height (ft)	Width (ft)	Length (ft)	Shape Factor	Weight (k/ft³)	Vertical Forces (k) ↓ +	Vertical Forces (k) ↑ -	Arm (ft)	Moments (ft-k) ↺ +	Moments (ft-k) ↻ -
U_1	Uplift 1	10.7	8.6	1.0	1.0	0.0624		5.7	4.30		24.7
U_2	Uplift 2	3.4	8.6	1.0	0.5	0.0624		0.9	5.73		5.2
U_3	Uplift 3					0.0624		0.0			0.0
	TOTALS							**6.7**			**29.9**

HORIZONTAL FORCES

Soil Pressure (At-Rest) Soil Friction Angle (ϕ) = 30 degrees k_o = (1 - sinϕ) = 0.50

Load		Height (ft)	Width (ft)	Length (ft)	Shape Factor	Weight (k/ft³)	Horizontal Forces (k) ← +	Horizontal Forces (k) → -	Arm (ft)	Moments (ft-k) ↺ +	Moments (ft-k) ↻ -
P_{E1}	silt	5.0	5.0	1.0	0.5	0.0526		0.3	1.67	0.0	0.5
P_{E2}								0.0		0.0	0.0
P_{E3}							0.0			0.0	0.0
	TOTALS						**0.0**	**0.3**		**0.0**	**0.5**

Water Pressure

Load		Height (ft)	Width (ft)	Length (ft)	Shape Factor	Weight (k/ft³)	Horizontal Forces (k) ← +	Horizontal Forces (k) → -	Arm (ft)	Moments (ft-k) ↺ +	Moments (ft-k) ↻ -
P_{W1}	HW	5.0	9.1	1.0	1.0	0.0624		2.8	2.50	0.0	7.1
P_{W2}	HW	5.0	5.0	1.0	0.5	0.0624		0.8	1.67	0.0	1.3
P_{W3}	TW	5.0	1.4	1.0	1.0	0.0624	0.4		2.50	1.1	0.0
P_{W4}	TW	5.0	5.0	1.0	0.5	0.0624	0.8		1.67	1.3	0.0
	TOTALS						**1.2**	**3.6**		**2.4**	**8.4**

SUMMATION

Net Vertical Force, V = 5.0 k ↓

Net Moment About the Toe, M = 20.9 ft-k ↺

Net Horizontal Force, H = -2.7 k →

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		Project No.: 1153-012	
Project: Great Dam - Exeter, NH		By: EMT	Date: 4/23/2013
Subject: Proposed Spillway with Deep Gate Stability Analysis - 50 YR FLOOD		Checked: CSP	Date: 4-25-13

STABILITY ANALYSIS

CRITERIA - FERC Chapter III

Required $F.S._{sliding}$ = 1.5

Required $F.S._{flotation}$ = 1.0

Max Fdn Bearing Pressure = ksf

100 % of Base in Compression Required

Base Length (B)	8.6	ft	
Base Width (W)	1.0	ft	
Base Area (A)	8.6	ft^2	(W · B)
Base Section Modulus (S)	12.3	ft^3	(W · B^2) / 6
Friction Angle at Failure Plane (ϕ_f)	45	degrees	
Friction Factor at Failure Plane ($\tan\phi_f$)	1.00		
Cohesion (c)	0	ksf	0.0 psi

SLIDING ANALYSIS

	V		H	
Σ Forces =	**5.0** ↓	**k**	**-2.7** →	**k**

$F.S._{sliding}$ = **1.83** $(V\tan\phi_f + cA) / H$ — OK - Meets Sliding Criteria

RESULTANT, FLOATATION, & BEARING ANALYSIS

	V		H			M	
Σ Forces =	**5.0** ↓	**k**	**-2.7** →	**k**	**Σ Moments =**	**20.9** ↺	**ft-k**

$F.S._{flotation}$ =	**1.75**		(V↓ / V↑)	OK - Meets Floatation Criteria
Kern between	**2.9**	**ft. and**	**5.7 ft.**	Measured from the Toe
Resultant, R at	**4.2**	**ft. from toe**	(M/V)	Resultant within the kern
Eccentricity, e =	**0.1**	**ft.**	(B/2 - M/V)	Right of Base Centerline
Toe Pressure =	**0.6**	**ksf**	(V/A + Ve/S)	<< Exceeds Bearing Capacity >>
Heel Pressure =	**0.5**	**ksf**	(V/A - Ve/S)	<< Exceeds Bearing Capacity >>
	100%	**of base in compression**		OK - 100% Base in compression

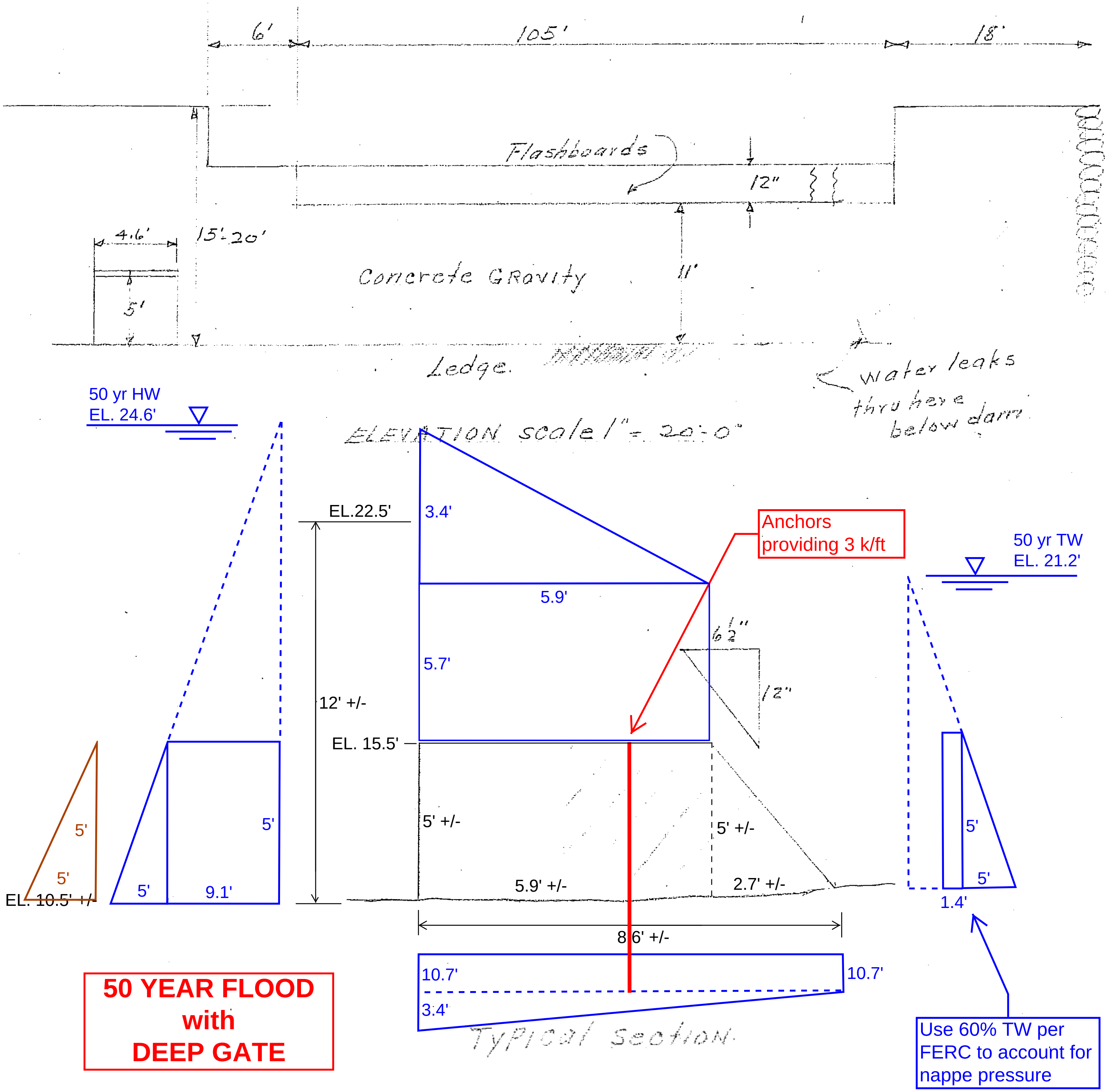
ORM E2 8252

NEW HAMPSHIRE WATER RESOURCES BOARD
CONCORD, N. H.

MICROFILMED MAR 1 2 1985

PROJECT .... FILE 82.01
SUBJECT EXETER RIVER E. TER. ACC.
OCEAN EXETER RIVER EXETER MFG. CO.
COMPUTER G.S.W. CHECKER R.L.T. CONT. FROM ACC. CONT. ON ACC. SUMMARY ON ACC. DATE 10/11/39

82.01



Kleinschmidt	Pittsfield, Maine Phone: 207.487.3328 www.KleinschmidtUSA.com	Page:	
		Project No.: 1153-012	
Project: Great Dam - Exeter, NH		By: EMT	Date: 4/23/2013
Subject: Proposed Spillway with Deep Gate Stability Analysis - NORMAL		Checked: CSP	Date: 4-25-13

TABULATION OF FORCES

VERTICAL FORCES

Dead Loads

Load	Height (ft)	Width (ft)	Length (ft)	Shape Factor	Weight (k/ft³)	Vertical Forces (k) ↓ +	Vertical Forces (k) ↑ -	Arm (ft)	Moments (ft-k) ↺ +	Moments (ft-k) ↻ -
Concrete Weight										
C_1	5.0	5.9	1.0	1.0	0.150	4.4		5.65	25.0	
C_2	5.0	2.7	1.0	0.5	0.150	1.0		1.80	1.8	
C_3 **Gate Weight**						0.5		6.80	3.4	
C_4 **Anchors**						**12.0**		4.00	48.0	
C_5										
Soil Weight										
E_1					0.115	0.0			0.0	
E_2					0.115	0.0			0.0	
Water Weight										
W_1 over gate	4.0	2.5	1.0	0.5	0.0624	0.3		7.77	2.4	
W_2					0.0624	0.0			0.0	
TOTALS						**18.2**			**80.6**	

Uplift Pressure

Load	Height (ft)	Width (ft)	Length (ft)	Shape Factor	Weight (k/ft³)	Vertical Forces (k) ↓ +	Vertical Forces (k) ↑ -	Arm (ft)	Moments (ft-k) ↺ +	Moments (ft-k) ↻ -
U_1 Uplift 1	4.0	8.6	1.0	1.0	0.0624		2.1	4.30		9.2
U_2 Uplift 2	8.0	8.6	1.0	0.5	0.0624		2.1	5.73		12.3
U_3 Uplift 3					0.0624		0.0			0.0
TOTALS							**4.3**			**21.5**

HORIZONTAL FORCES

Soil Pressure (At-Rest) Soil Friction Angle (ϕ) = 30 degrees k_o = (1 - sinϕ) = 0.50

Load	Height (ft)	Width (ft)	Length (ft)	Shape Factor	Weight (k/ft³)	Horizontal Forces (k) ← +	Horizontal Forces (k) → -	Arm (ft)	Moments (ft-k) ↺ +	Moments (ft-k) ↻ -
P_{E1} silt	7.0	7.0	1.0	0.5	0.0526		0.6	2.33	0.0	1.5
P_{E2}							0.0		0.0	0.0
P_{E3}						0.0			0.0	0.0
TOTALS						**0.0**	**0.6**		**0.0**	**1.5**

Water Pressure

Load	Height (ft)	Width (ft)	Length (ft)	Shape Factor	Weight (k/ft³)	Horizontal Forces (k) ← +	Horizontal Forces (k) → -	Arm (ft)	Moments (ft-k) ↺ +	Moments (ft-k) ↻ -
P_{W1}					0.0624		0.0	0.00	0.0	0.0
P_{W2} HW	12.0	12.0	1.0	0.5	0.0624		4.5	4.00	0.0	18.0
P_{W3} TW	4.0	4.0	1.0	0.5	0.0624	0.5		1.33	0.7	0.0
TOTALS						**0.5**	**4.5**		**0.7**	**18.0**

SUMMATION

Net Vertical Force, V = **14.0** k ↓

Net Moment About the Toe, M = **40.3** ft-k ↺

Net Horizontal Force, H = **-4.6** k →

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	Project No.: 1153-012	
Project: Great Dam - Exeter, NH	By: EMT	Date: 4/23/2013
Subject: Proposed Spillway with Deep Gate Stability Analysis - NORMAL	Checked: CSP	Date: 4-25-13

STABILITY ANALYSIS

CRITERIA - FERC Chapter III

Required F.S.$_{sliding}$ =	1.5	
Required F.S.$_{flotation}$ =	1.0	
Max Fdn Bearing Pressure =		ksf

100 % of Base in Compression Required

Base Length (B)	8.6	ft	
Base Width (W)	1.0	ft	
Base Area (A)	8.6	ft^2	(W · B)
Base Section Modulus (S)	12.3	ft^3	(W · B^2) / 6
Friction Angle at Failure Plane (ϕ_f)	45	degrees	
Friction Factor at Failure Plane ($\tan\phi_f$)	1.00		
Cohesion (c)	0	ksf	0.0 psi

SLIDING ANALYSIS

	V		H	
Σ Forces =	**14.0** ↓	**k**	**-4.6** →	**k**

F.S.$_{sliding}$ = **3.01** ($V\tan\phi_f$ + cA) / H — OK - Meets Sliding Criteria

RESULTANT, FLOATATION, & BEARING ANALYSIS

	V		H			M	
Σ Forces =	**14.0** ↓	**k**	**-4.6** →	**k**	**Σ Moments =**	**40.3** ↺	**ft-k**

F.S.$_{flotation}$ =	**4.25**		(V↓ / V↑)	OK - Meets Floatation Criteria
Kern between	**2.9**	**ft. and**	**5.7 ft.**	Measured from the Toe
Resultant, R at	**2.9**	**ft. from toe**	(M/V)	Resultant within the kern
Eccentricity, e =	**1.4**	**ft.**	(B/2 - M/V)	Right of Base Centerline
Toe Pressure =	**3.2**	**ksf**	(V/A + Ve/S)	<< Exceeds Bearing Capacity >>
Heel Pressure =	**0.0**	**ksf**	(V/A - Ve/S)	<< Exceeds Bearing Capacity >>
	100%	**of base in compression**		OK - 100% Base in compression

FORM E2 8252

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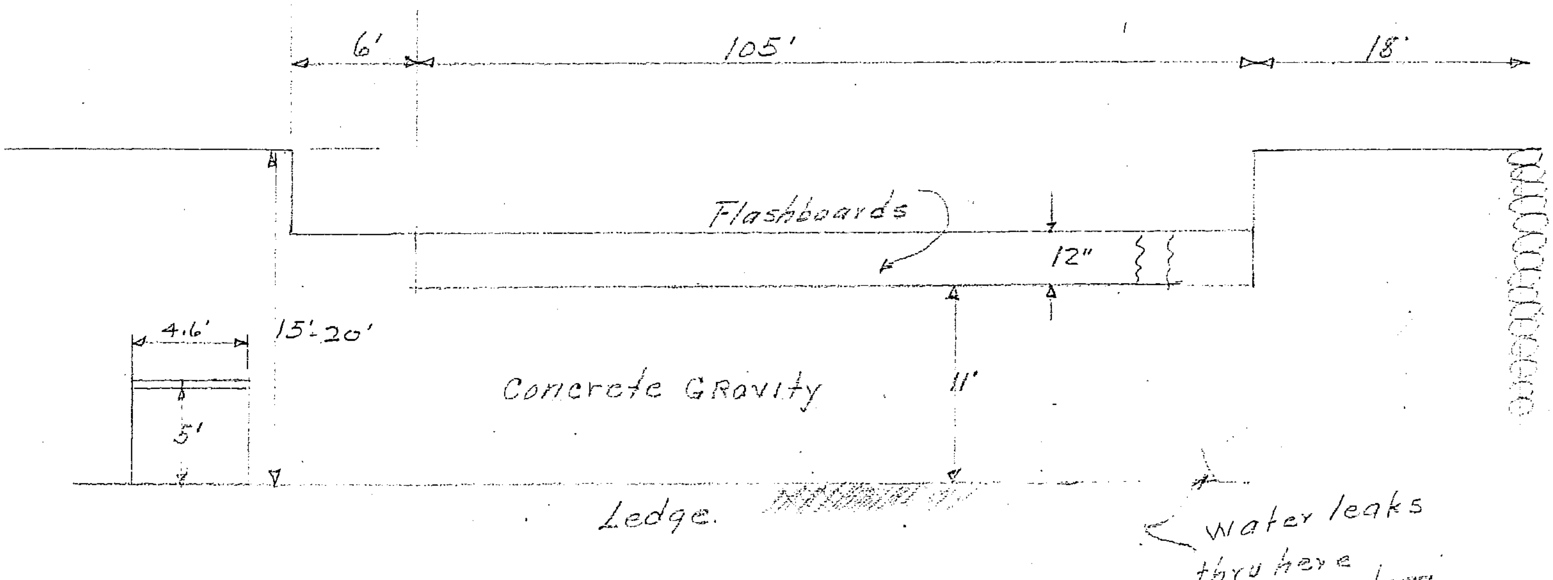
Appendix G

NEW HAMPSHIRE WATER RESOURCES BOARD CONCORD, N. H.

PROJECT		FILE 82.01
SUBJECT EXETER RIVER MAR 1 2 1985 EXETER		ACC.
OCEAN EXETER RIVER	EXETER MFG. Co.	
COMPUTER G.S.W.	CHECKER R.L.T.	CONT. FROM ACC. · CONT. ON ACC. · SUMMARY ON ACC. · DATE 10/11/39

82.01



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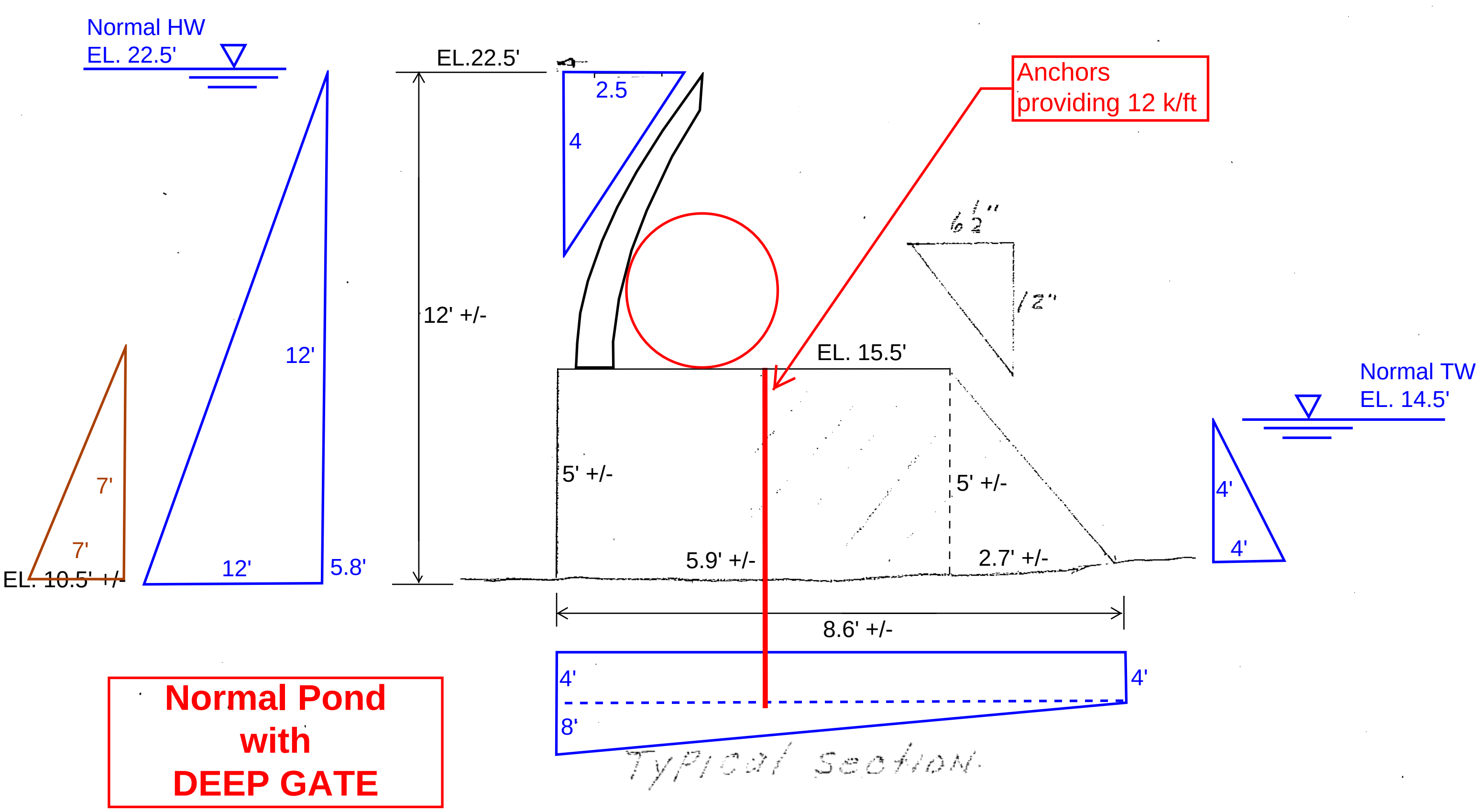


Typical Section.

APPENDIX G-3

HYDRAULICS

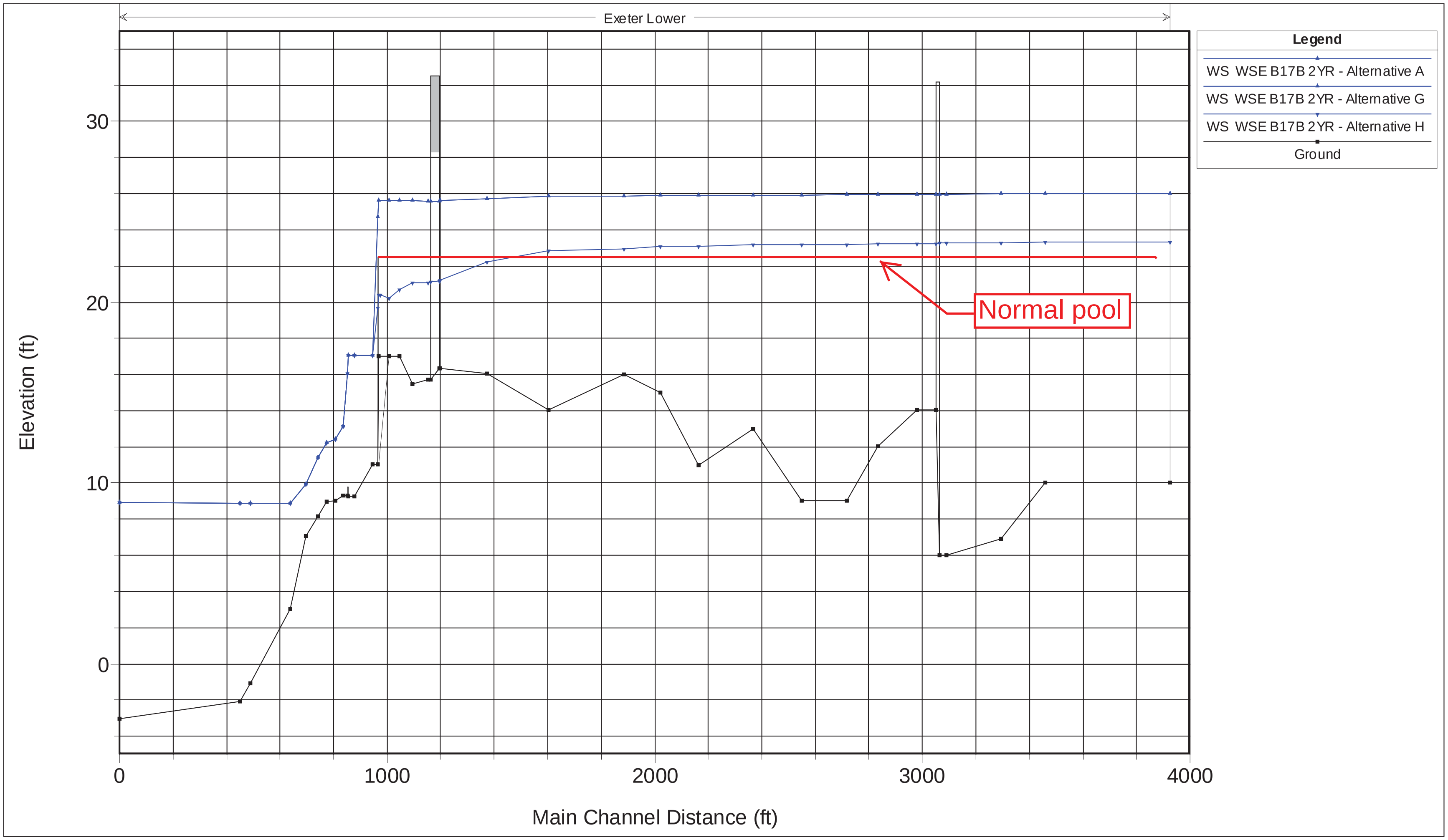


FIGURE G-3-1 WATER SURFACE PROFILE OF THE MODELED RIVER HYDRAULICS FOR THE 2 YEAR FLOOD EVENT FOR EXISTING CONDITIONS (ALTERNATIVE A), ROCK ANCHORS (ALTERNATIVE G), AND GATE/FLASHBOARD SYSTEM (ALTERNATIVE H).

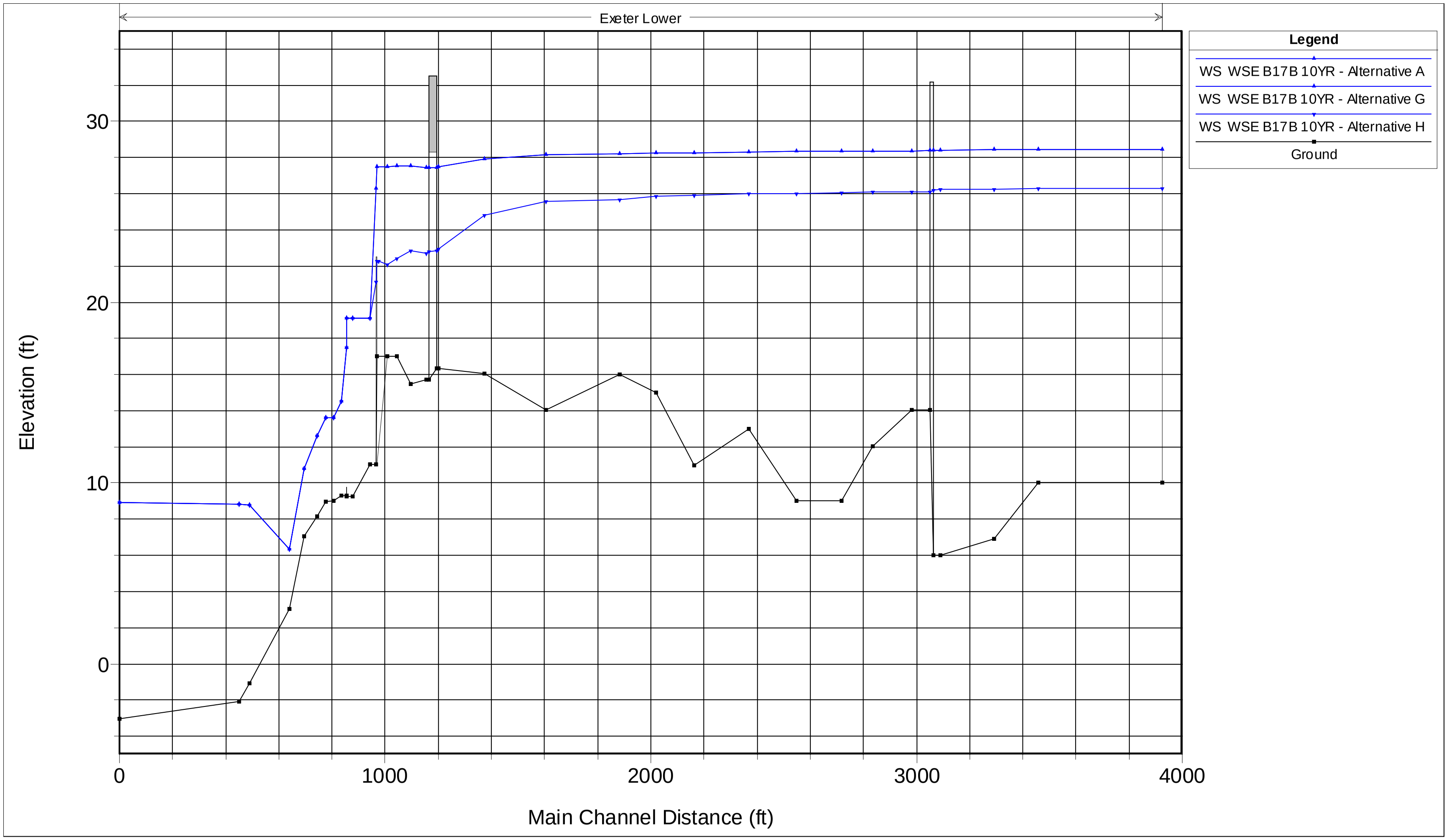


FIGURE G-3-2 WATER SURFACE PROFILE OF THE MODELED RIVER HYDRAULICS FOR THE 10 YEAR FLOOD EVENT FOR EXISTING CONDITIONS (ALTERNATIVE A), ROCK ANCHORS (ALTERNATIVE G), AND GATE/FLASHBOARD SYSTEM (ALTERNATIVE H).

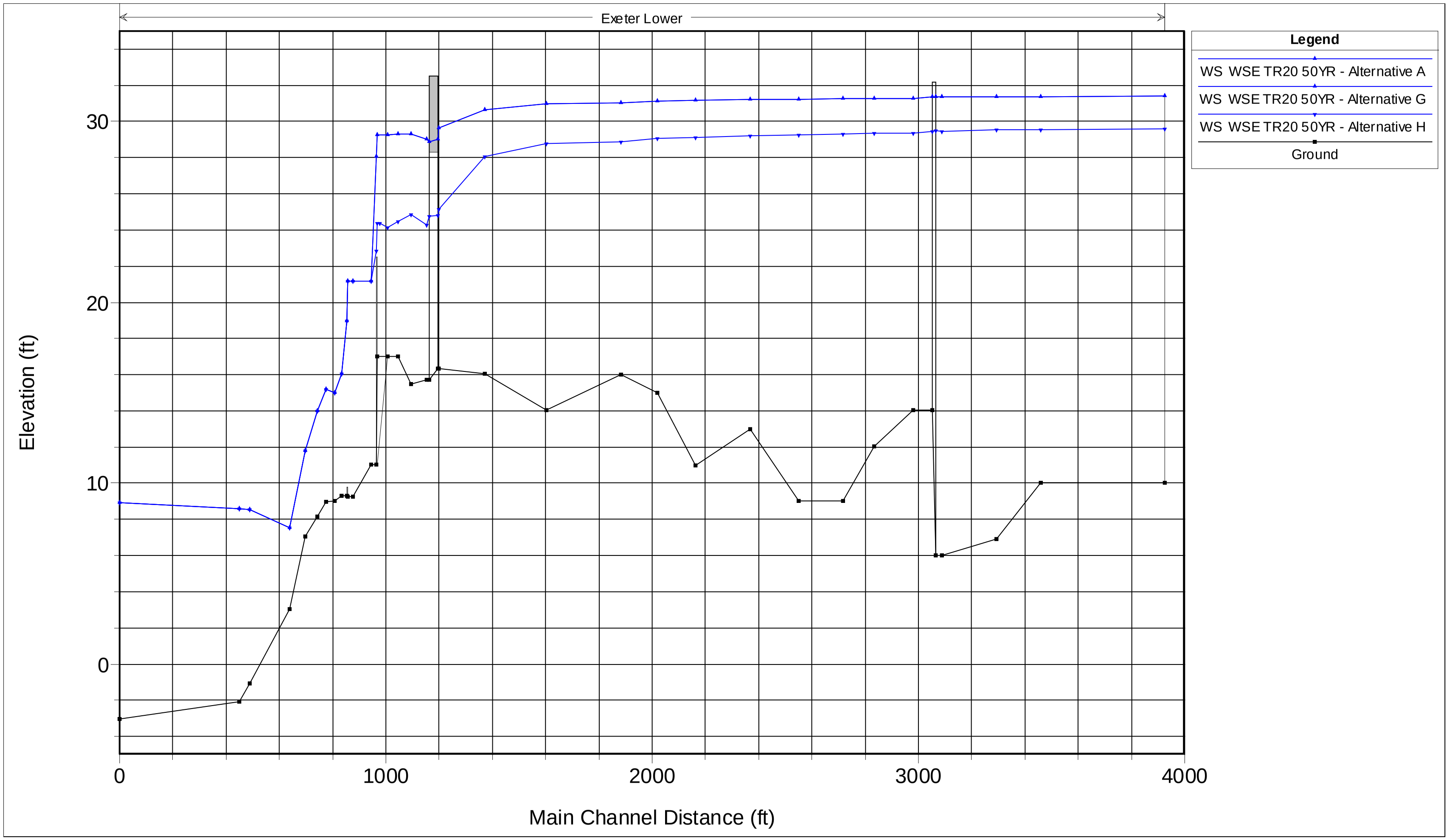


FIGURE G-3-3 WATER SURFACE PROFILE OF THE MODELED RIVER HYDRAULICS FOR THE 50 YEAR FLOOD EVENT FOR EXISTING CONDITIONS (ALTERNATIVE A), ROCK ANCHORS (ALTERNATIVE G), AND GATE/FLASHBOARD SYSTEM (ALTERNATIVE H).

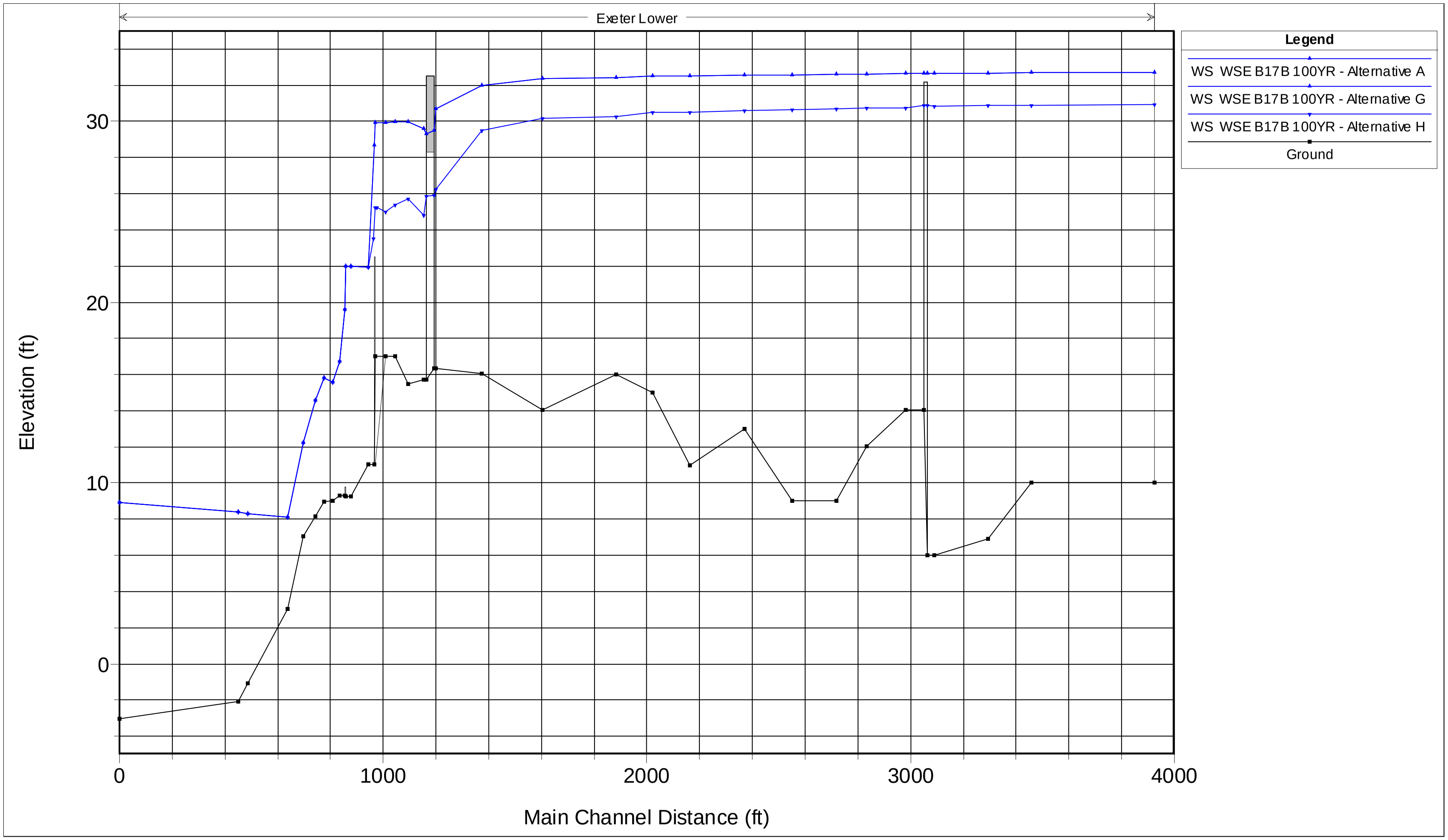
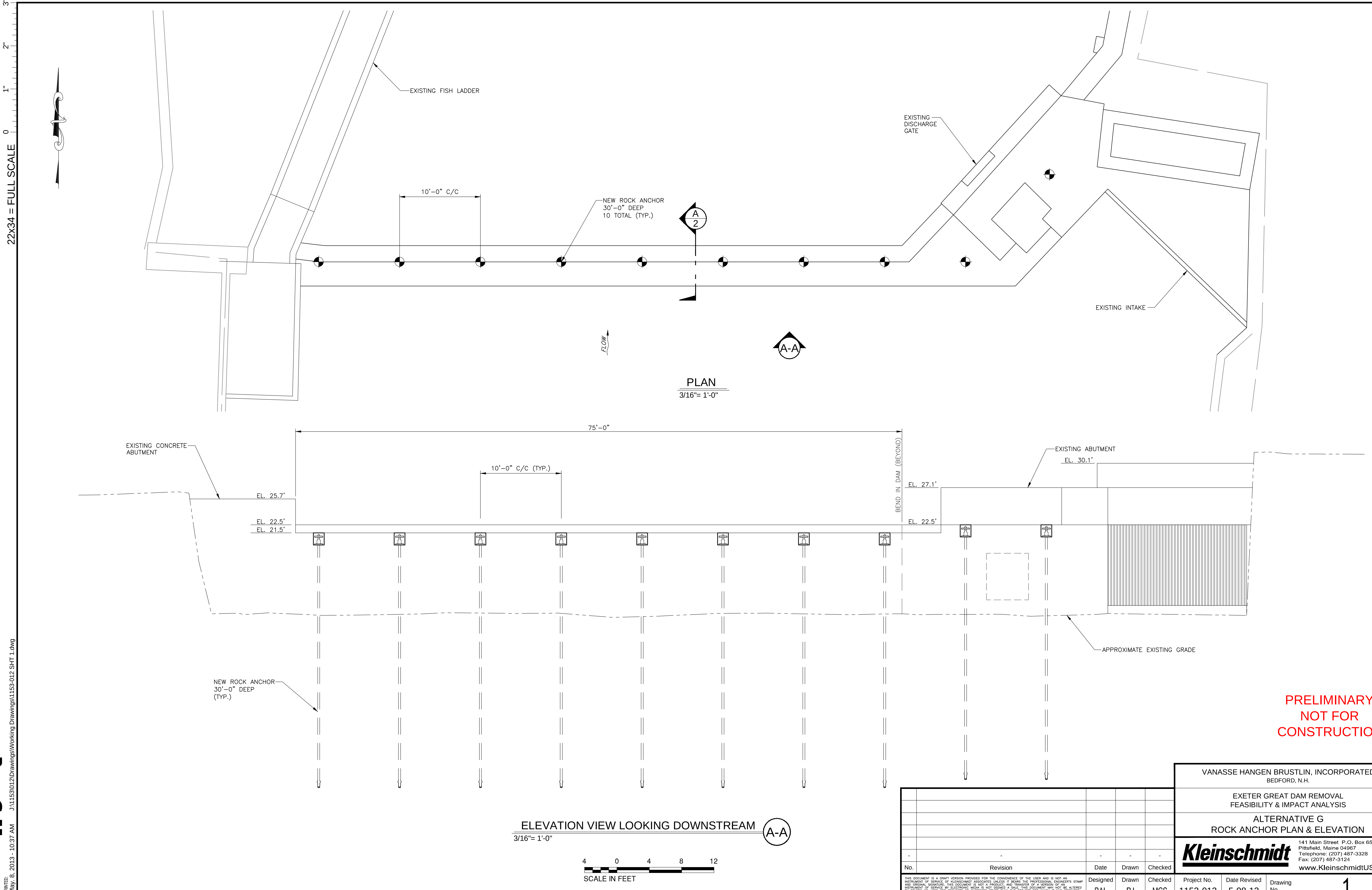


FIGURE G-3-4 WATER SURFACE PROFILE OF THE MODELED RIVER HYDRAULICS FOR THE 100 YEAR FLOOD EVENT FOR EXISTING CONDITIONS (ALTERNATIVE A), ROCK ANCHORS (ALTERNATIVE G), AND GATE/FLASHBOARD SYSTEM (ALTERNATIVE H).

APPENDIX G-4

DRAWINGS



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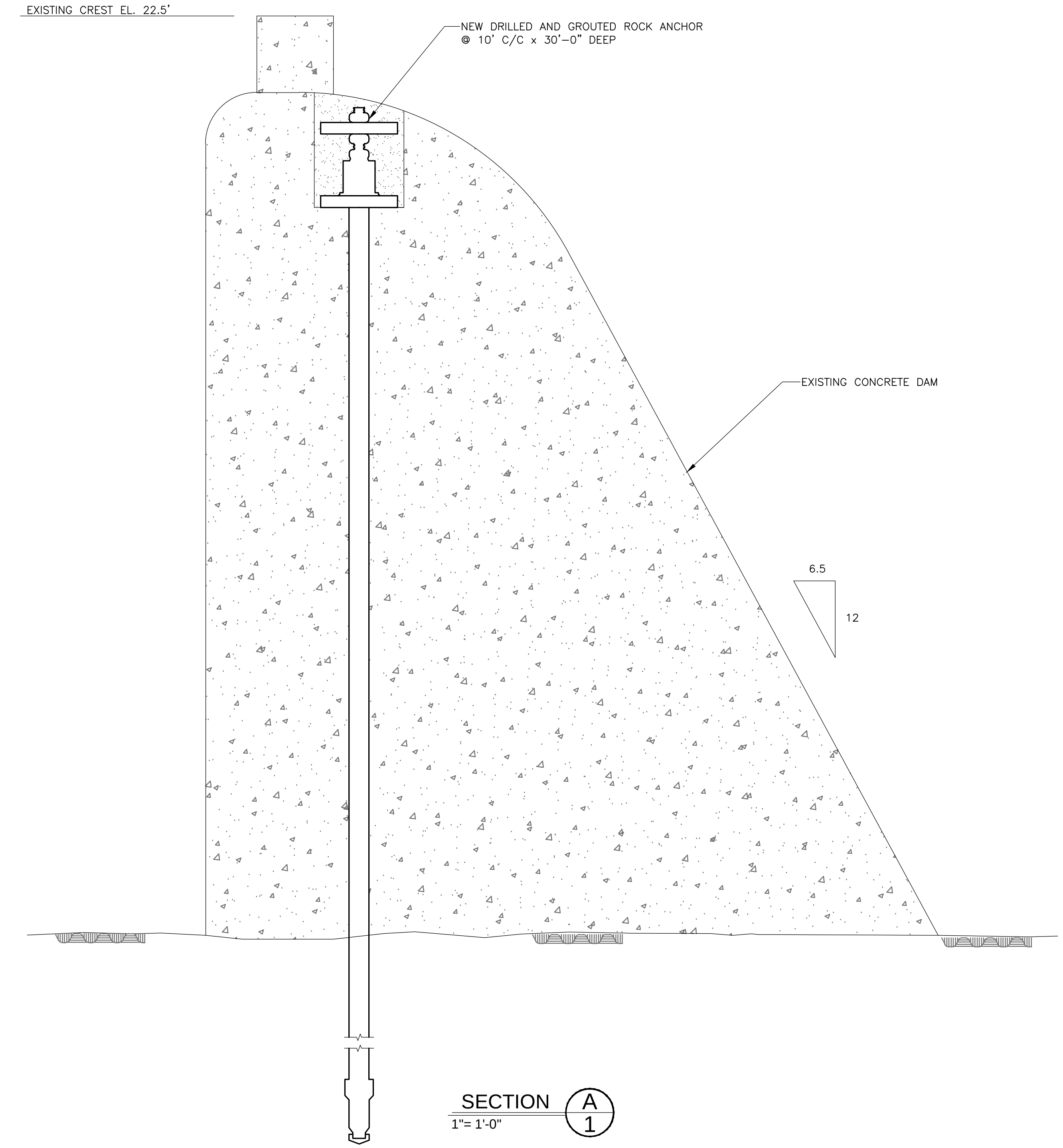

SECTION A/1
1"= 1'-0"

1 0 1 2
SCALE IN FEET

PRELIMINARY
NOT FOR
CONSTRUCTION

No.	Revision	Date	Drawn	Checked
-	-	-	-	-

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VANASSE HANGEN BRUSTLIN, INCORPORATED
BEDFORD, N.H.

EXETER GREAT DAM REMOVAL
FEASIBILITY & IMPACT ANALYSIS

ALTERNATIVE G
ROCK ANCHOR SECTION

Kleinschmidt
141 Main Street P.O. Box 650
Pittsfield, Maine 04967
Telephone: (207) 487-3328
Fax: (207) 487-3124
www.KleinschmidtUSA.com

Designed	Drawn	Checked	Project No.	Date Revised	Drawing No.
BAL	PJ	MCS	1153-012	5-08-13	2

22X34 = FULL SCALE
0 1" 2" 3"

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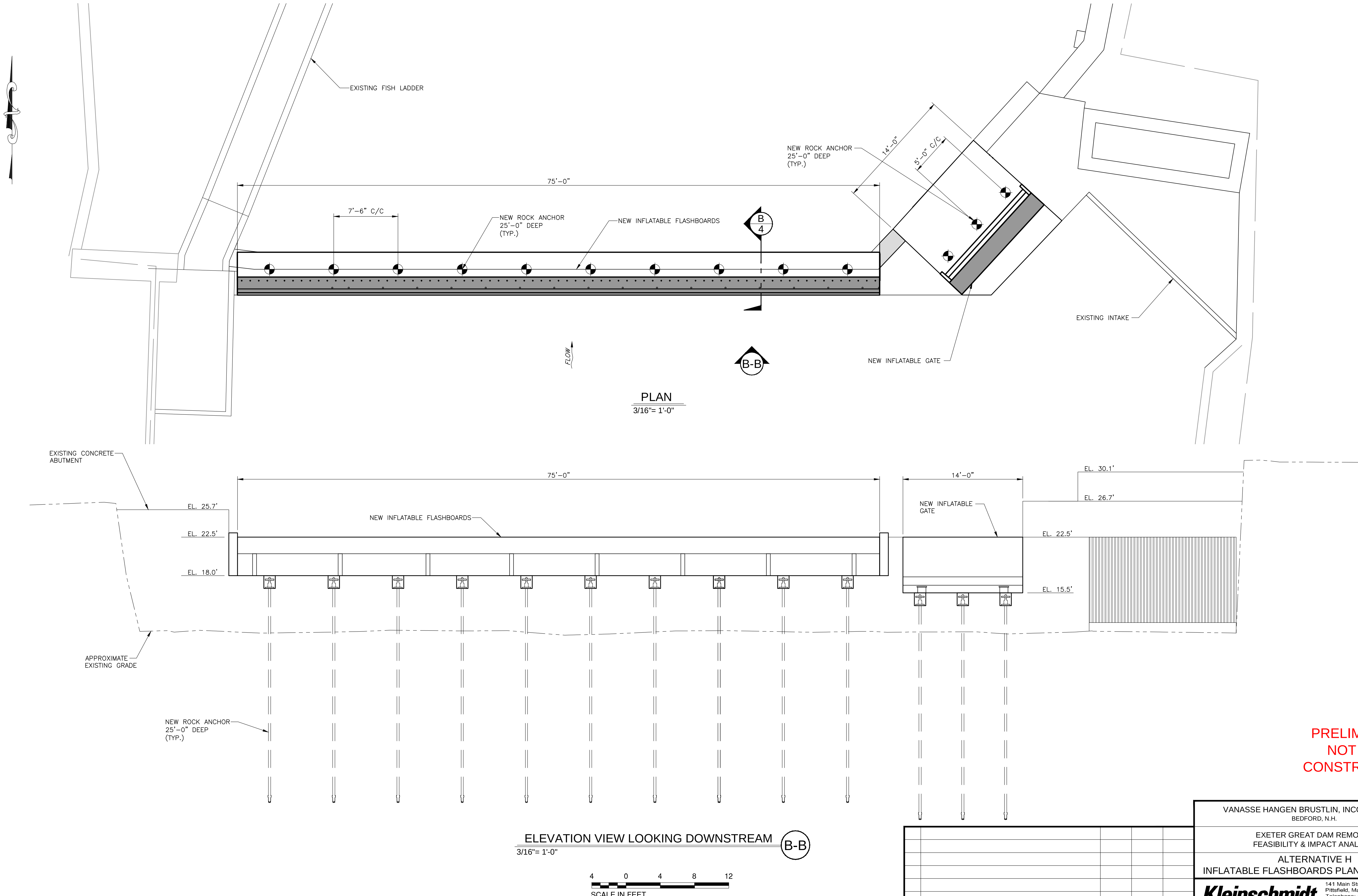

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CONSTRUCTION

22X34 = FULL SCALE

VANASSE HANGEN BRUSTLIN, INCORPORATED
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EXETER GREAT DAM REMOVAL
FEASIBILITY & IMPACT ANALYSIS

ALTERNATIVE H
INFLATABLE FLASHBOARDS PLAN & ELEVATION

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Pittsfield, Maine 04967
Telephone: (207) 487-3328
Fax: (207) 487-3124
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No.	Revision	Date	Drawn	Checked
-	-	-	-	-

Designed	Drawn	Checked	Project No.	Date Revised	Drawing No.
BAL	PJ	MCS	1153-012	5-08-13	3

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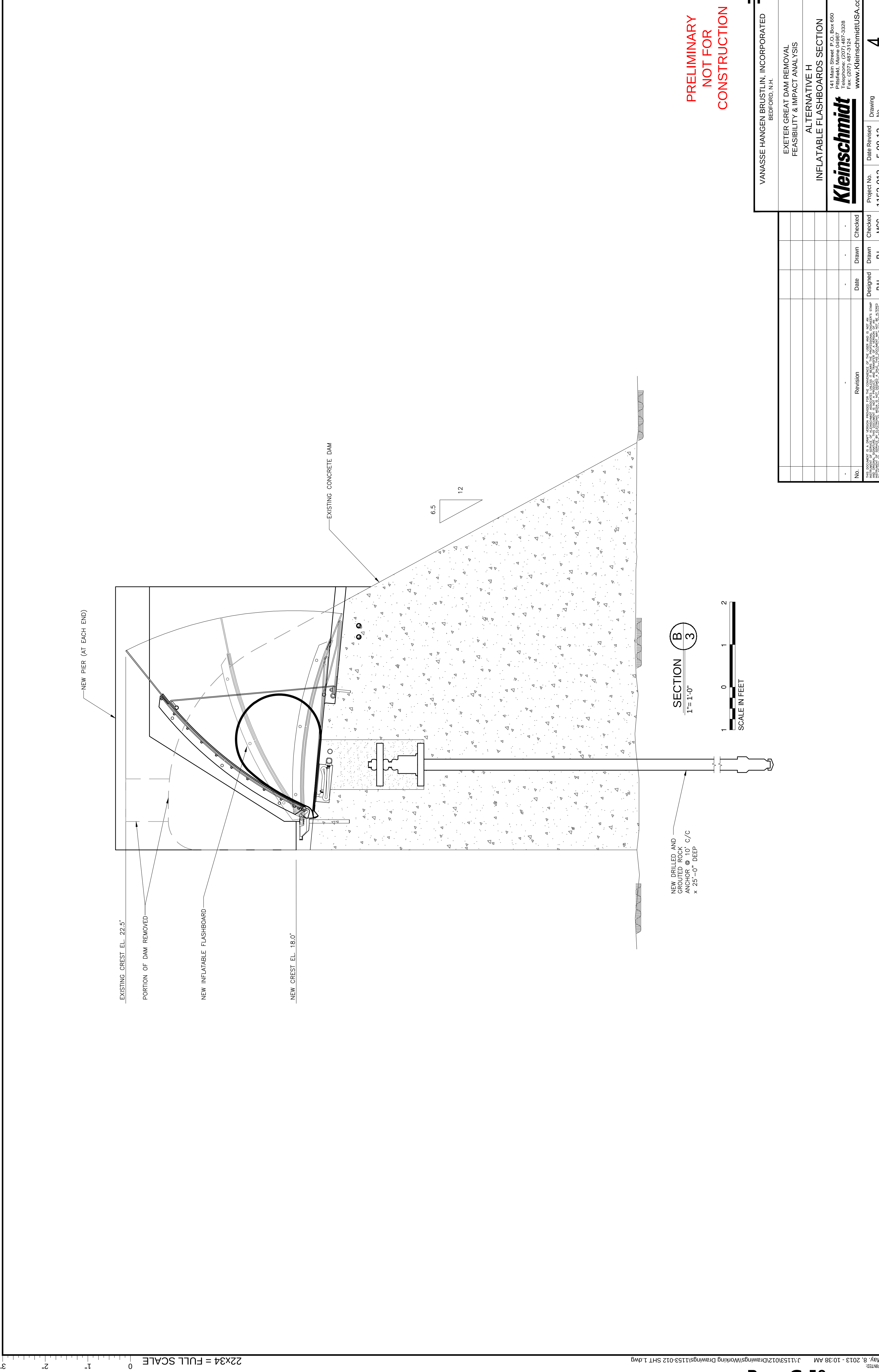
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Revision
Date
Drawn
Checked
Designed BAL
Drawn PJ
Checked MCS
Project No. 1153-012
Date Revised 5-08-13
Drawing No. 4
NEW PIER (AT EACH END)
EXISTING CONCRETE DAM
6.5
12
EXISTING CREST EL. 22.5'
PORTION OF DAM REMOVED
NEW INFLATABLE FLASHBOARD
NEW CREST EL. 18.0'
NEW DRILLED AND GROUTED ROCK ANCHOR @ 10' C/C x 25'-0" DEEP
SECTION B 3
1"=1'-0"
SCALE IN FEET
1 0 1 2
22X34 = FULL SCALE
PRINTED: May. 8, 2013 - 10:38 AM J:\1153\012\Drawings\Working Drawings\1153-012 SHT 1.dwg

Appendix G-5

Opinions of Probable Cost

ENGINEERS OPINION OF PROBABLE CONSTRUCTION COSTS
Exeter New Hampshire - Great Dam Removal Project
Alternative H - Inflatable Flashboard/Gate Installation

Item #	Description	Quantity	Units	Total Unit Cost	Total Costs
	Direct Costs				
1.0	**Dam Demolition and Reconstruction**				**$174,250**
1.1	Cofferdam/water management	1	LS	$100,000	$100,000
1.2	Concrete demolition	100	LF	$615	$61,500
1.3	Disposal	425	CY	$30	$12,750
2.0	**Rock Anchors**				**$36,250**
2.1	Rock anchors along dam crest (2 strand at 7.5ft oc)	10	EA	$2,500	$25,000
2.2	Rock anchors along dam along low level outlet (3 strand at 5 ft oc)	3	EA	$3,750	$11,250
3.0	**Inflatable Flashboard & Low Level Outlet (Obermeyer)**				**$273,850**
3.1	Obermeyer crest gate - procure and install	338	SF	$600	$202,500
3.2	Obermeyer low level outlet gate - procure and install	98	SF	$575	$56,350
3.3	Compressor house	1	LS	$15,000	$15,000
4.0	**General/Site Work**				**$79,000**
4.1	Construction access - gravel fill	400	CY	$20	$8,000
4.2	Construction easement	1	LS	$2,500	$2,500
4.3	Repair/replace wall	90	SY	$450	$40,500
4.4	Landscaping (loam seed fertilizer)	1	LS	$8,000	$8,000
4.5	Erosion and Sediment Control	1	LS	$20,000	$20,000
				Sub Total	**$564,000**
5.0	**Mobilization - (~20% of Sub-Total)**				**$113,000**
6.0	**General Contractor General Conditions - (~15% of Sub-Total)**				**$85,000**
				Direct Cost Total	**$762,000**
	Indirect Costs				
7.0	**Contingency - (~ 20% of Sub-Total)**				**$113,000**
8.0	**Engineering & Construction Admin - (~ 20% of Sub-Total)**				**$113,000**
9.0	**Permitting - (~ 5% of Sub-Total)**				**$28,000**
10.0	**Administration - (Not Included)**				**$0**
				Indirect Cost Total	**$254,000**
				Total	**$1,016,000**

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ENGINEERS OPINION OF PROBABLE CONSTRUCTION COSTS
Exeter New Hampshire - Great Dam Removal Project
Alternative G - Stabilize in Place

Item #	Description	Quantity	Units	Total Unit Cost	Total Costs
	Direct Costs				
1.0	**Dam Demolition and Reconstruction**				**$108,880**
1.1	Cofferdam/water management	1	LS	$100,000	$100,000
1.2	Concrete demolition	12	LF	$615	$7,380
1.3	Disposal	50	CY	$30	$1,500
2.0	**Rock Anchors**				**$60,000**
2.1	Rock anchors- at crest (4 strand at ~10ft oc)	10	EA	$6,000	$60,000
3.0	**General/Site Work**				**$50,750**
3.1	Construction access - gravel fill	200	CY	$20	$4,000
3.2	Construction easement	1	LS	$2,500	$2,500
3.3	Repair/replace wall	45	SY	$450	$20,250
3.4	Landscaping (loam seed fertilizer)	1	LS	$4,000	$4,000
3.5	Erosion and Sediment Control	1	LS	$20,000	$20,000
				Sub Total	**$220,000**
4.0	**Mobilization - (~20% of Sub-Total)**				**$44,000**
5.0	**General Contractor General Conditions - (~15% of Sub-Total)**				**$33,000**
				Direct Cost Total	**$297,000**
	Indirect Costs				
6.0	**Contingency - (~ 20% of Sub-Total)**				**$44,000**
7.0	**Engineering & Construction Admin - (~ 15% of Sub-Total)**				**$33,000**
8.0	**Site Investigations & Material Testing - (~ 15% of Sub-Total)**				**$33,000**
9.0	**Permitting - (~ 5% of Sub-Total)**				**$11,000**
10.0	**Administration - (Not Included)**				**$0**
				Indirect Cost Total	**$121,000**
				Total	**$418,000**

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Appendix H

Cost Estimate Details

Vanasse Hangen Brustlin, Inc.
Six Bedford Farms Drive, Suite 607
Bedford, New Hampshire 03110

Great Dam Removal Feasibility and Impact Analysis
Exeter, New Hampshire - Preliminary Conceptual Opinion of Cost

Table H-1. Alternative B - Dam Removal

Scope Item	Description & Reference	Quantity	Unit	Unit Price	Extension	Task Total
Construction & Permanent Easements	Construction Easement	1	LS	$2,500.00	$2,500.00	
	Permanent Easement	1	LS			
						$2,500
Mobilization and Demobilization	Contractor Startup (NHDOT Item No. 692)	1	LS	$60,000.00	$60,000.00	
						$60,000
Dam Removal/Disposal						
Demolition	RS Means 2013 Site Work & Landscape (Item 02 41 13.90 - 070)	350	LF	$615.00	$215,250.00	
Disposal	NHDOT Item 206.2	1500	CY	$30.00	$45,000.00	
Coffer Dam/Water Mangement	NHDOT Item 503.201	1	LS	$100,000.00	$100,000.00	
						$360,250
New Channel Shaping/Stream Restoration						
Reshape Channel	Channel Excavation (NHDOT Item No. 207.3)	1,000	CY	$12.00	$12,000.00	
						$12,000
Construction Access						
Gravel Fill	NHDOT 304.399 Temporary Crushed Gravel	400	CY	$20.00	$8,000.00	
Repair Repace Wall	NHDOT 512 Concrete Repairs (Area 40ft x 20ft)	90	SY	$450.00	$40,500.00	
Landscaping (Loam Seed Fertilizer)	NHDOT 650.2 Landscaping	1	U	$8,000.00	$8,000.00	
						$56,500
Erosion and Sediment Control						
Sediment Control	Miscellaneous Permanent and Temporary Erosion Controls (NHDOT Item No. 645)	1	LS	$20,000.00	$20,000.00	
						$20,000
Subtotal Construction						**$511,250**
Contingency	20 percent of construction total to cover unforseen issues.		Contract	20%		$102,250
Design & Permitting	Consultant Fees for Final Survey, Geotechnical Investigations, Design, and Permitting, Complex		Contract	15%		$76,688
Construction Observation	Field Engineer PM, Average (RS Means No. 01 31 13.20 0180)	8	Weeks	$2,050.00		$16,400
Long-term Monitoring/NHDES Report Preparation	Oversight and Management of the Project, Low Range (RS Means No. 01 11 31.20 0020)		Project	5%		$25,563
TOTAL						**$732,150**

Notes:

1 - Construction estimate completed using 2013 dollars.
2 - NHDOT Item Numbers are from the publication, *NHDOT Standard Specifications - 2010 Edition.*
3 - NHDOT Item Costs are taken from NHDOT Weighted Average Unit Prices Years 2012 Qtrs 4,3,2,1 and accessed via the internet.
4 - RS Means Item Numbers and Costs are taken from the publication, *Site Work & Landscape Cost Data, 32nd Annual Edition, 2013.*
5 - Homestead Dam removal construction cost used as reference

Vanasse Hangen Brustlin, Inc.
Six Bedford Farms Drive, Suite 607
Bedford, New Hampshire 03110

Great Dam Removal Feasibility and Impact Analysis
Exeter, New Hampshire - Preliminary Conceptual Opinion of Cost

Table H-2. Alternative F - Partial Removal

Scope Item	Description & Reference	Quantity	Unit	Unit Price	Extension	Task Total
Construction & Permanent Easements	Construction Easement	1	LS	$2,500.00	$2,500.00	
	Permanent Easement		LS			
						$2,500
Mobilization and Demobilization	Contractor Startup (NHDOT Item No. 692)	1	LS	$60,000.00	$60,000.00	
						$60,000
Dam Removal/Disposal						
Demolition	RS Means 2013 Site Work & Landscape (Item 02 41 13.90 - 070)	290	LF	$615.00	$178,350.00	
Disposal	NHDOT Item 206.2	1250	CY	$30.00	$37,500.00	
Coffer Dam/Water Mangement	NHDOT Item 503.201	1	LS	$80,000.00	$80,000.00	
						$295,850
Fish Ladder						
Construct New Fish Ladder		1	U	$500,000.00	$500,000.00	
						$500,000.00
New Channel Shaping/Stream Restoration						
Reshape Channel	Channel Excavation (NHDOT Item No. 207.3)	800	CY	$12.00	$9,600.00	
						$9,600
Construction Access						
Gravel Fill	NHDOT 304.399 Temporary Crushed Gravel	400	CY	$20.00	$8,000.00	
Repair Repace Wall	NHDOT 512 Concrete Repairs (Area 40ft x 20ft)	90	SY	$450.00	$40,500.00	
Landscaping (Loam Seed Fertilizer)	NHDOT 650.2 Landscaping	1	U	$8,000.00	$8,000.00	
						$56,500
Erosion and Sediment Control						
Sediment Control	Miscellaneous Permanent and Temporary Erosion Controls (NHDOT Item No. 645)	1	LS	$20,000.00	$20,000.00	
						$20,000
Subtotal Construction						**$944,450**
Contingency	20 percent of construction total to cover unforseen issues		Contract	20%		$188,890
Design & Permitting	Consultant Fees for Final Survey, Geotechnical Investigations, Design, and Permitting, Comple:		Contract	15%		$141,668
Construction Observation	Field Engineer PM, Average (RS Means No. 01 31 13.20 0180)	8	Weeks	$2,050.00		$16,400
Long-term Monitoring/NHDES Report Preparation	Oversight and Management of the Project, Low Range (RS Means No. 01 11 31.20 0020		Project	5%		$47,223
TOTAL						**$1,338,630**

Notes:

1 - Construction estimate completed using 2013 dollars

2 - NHDOT Item Numbers are from the publication, *NHDOT Standard Specifications - 2010 Edition.*

3 - NHDOT Item Costs are taken from NHDOT Weighted Average Unit Prices Years 2012 Qtrs 4,3,2,1 and accessed via the internet

4 - RS Means Item Numbers and Costs are taken from the publication, *Site Work & Landscape Cost Data, 32nd Annual Edition, 2013.*

5 - Homestead Dam removal construction cost used as reference

Table H-3

ENGINEERS OPINION OF PROBABLE CONSTRUCTION COSTS
Exeter New Hampshire - Great Dam Removal Project
Alternative H - Inflatable Flashboard/Gate Installation

Item #	Description	Quantity	Units	Total Unit Cost	Total Costs
	Direct Costs				
1.0	**Dam Demolition and Reconstruction**				**$174,250**
1.1	Cofferdam/water management	1	LS	$100,000	$100,000
1.2	Concrete demolition	100	LF	$615	$61,500
1.3	Disposal	425	CY	$30	$12,750
2.0	**Rock Anchors**				**$36,250**
2.1	Rock anchors along dam crest (2 strand at 7.5ft oc)	10	EA	$2,500	$25,000
2.2	Rock anchors along dam along low level outlet (3 strand at 5 ft oc)	3	EA	$3,750	$11,250
3.0	**Inflatable Flashboard & Low Level Outlet (Obermeyer)**				**$273,850**
3.1	Obermeyer crest gate - procure and install	338	SF	$600	$202,500
3.2	Obermeyer low level outlet gate - procure and install	98	SF	$575	$56,350
3.3	Compressor house	1	LS	$15,000	$15,000
4.0	**General/Site Work**				**$79,000**
4.1	Construction access - gravel fill	400	CY	$20	$8,000
4.2	Construction easement	1	LS	$2,500	$2,500
4.3	Repair/replace wall	90	SY	$450	$40,500
4.4	Landscaping (loam seed fertilizer)	1	LS	$8,000	$8,000
4.5	Erosion and Sediment Control	1	LS	$20,000	$20,000
				Sub Total	**$564,000**
5.0	**Mobilization - (~20% of Sub-Total)**				**$113,000**
6.0	**General Contractor General Conditions - (~15% of Sub-Total)**				**$85,000**
				Direct Cost Total	**$762,000**
	Indirect Costs				
7.0	**Contingency - (~ 20% of Sub-Total)**				**$113,000**
8.0	**Engineering & Construction Admin - (~ 20% of Sub-Total)**				**$113,000**
9.0	**Permitting - (~ 5% of Sub-Total)**				**$28,000**
10.0	**Administration - (Not Included)**				**$0**
				Indirect Cost Total	**$254,000**
				Total	**$1,016,000**

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Table H-4

ENGINEERS OPINION OF PROBABLE CONSTRUCTION COSTS
Exeter New Hampshire - Great Dam Removal Project
Alternative G - Stabilize in Place

Item #	Description	Quantity	Units	Total Unit Cost	Total Costs
	Direct Costs				
1.0	**Dam Demolition and Reconstruction**				**$108,880**
1.1	Cofferdam/water management	1	LS	$100,000	$100,000
1.2	Concrete demolition	12	LF	$615	$7,380
1.3	Disposal	50	CY	$30	$1,500
2.0	**Rock Anchors**				**$60,000**
2.1	Rock anchors- at crest (4 strand at ~10ft oc)	10	EA	$6,000	$60,000
3.0	**General/Site Work**				**$50,750**
3.1	Construction access - gravel fill	200	CY	$20	$4,000
3.2	Construction easement	1	LS	$2,500	$2,500
3.3	Repair/replace wall	45	SY	$450	$20,250
3.4	Landscaping (loam seed fertilizer)	1	LS	$4,000	$4,000
3.5	Erosion and Sediment Control	1	LS	$20,000	$20,000
				Sub Total	**$220,000**
4.0	**Mobilization - (~20% of Sub-Total)**				**$44,000**
5.0	**General Contractor General Conditions - (~15% of Sub-Total)**				**$33,000**
				Direct Cost Total	**$297,000**
	Indirect Costs				
6.0	**Contingency - (~ 20% of Sub-Total)**				**$44,000**
7.0	**Engineering & Construction Admin - (~ 15% of Sub-Total)**				**$33,000**
8.0	**Site Investigations & Material Testing - (~ 15% of Sub-Total)**				**$33,000**
9.0	**Permitting - (~ 5% of Sub-Total)**				**$11,000**
10.0	**Administration - (Not Included)**				**$0**
				Indirect Cost Total	**$121,000**
				Total	**$418,000**

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Vanasse Hangen Brustlin, Inc.

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Bedford, New Hampshire 03110

30-year Life Cycle Costs

Great Dam Removal Feasibility and Impact Analysis
Exeter, New Hampshire - Preliminary Conceptual Opinion of Cost

Table H-5. Operations, Maintenance and Capital Replacement Cost Estimate for Alternative F - Partial Removal

Cost Item	Base Date (2013) Cost	Year of Occurrence	Discount Factor[1]	Present Value
Initial Investment	**$1,338,630**	**Base Date**	**1**	**$1,338,630**
Capital Replacement (40%)	$535,452	30	0.552	$295,570
Electricity (0 kWh at $0.15/kWh)	$0	Annual	19.8	$0
Operation, Maintenance, and Repair	$4,000	Annual	22.4	$89,600
			Total	**$385,170**

Note:
1 - NIST LCC Supplement 2012

Table H-6. Operations, Maintenance and Capital Replacement Cost Estimate for Alternative G - Stabilize in Place

Cost Item	Base Date (2013) Cost	Year of Occurrence	Discount Factor[1]	Present Value
Initial Investment	**$418,000**	**Base Date**	**1**	**$418,000**
Capital Replacement (40%)	$167,200	30	0.552	$92,294
Electricity (0 kWh at $0.15/kWh)	$0	Annual	19.8	$0
Operation, Maintenance, and Repair	$4,000	Annual	22.4	$89,600
			Total	**$181,894**

Note:
1 - NIST LCC Supplement 2012

Table H-7. Operations, Maintenance and Capital Replacement Cost Estimate for Alternative H - Dam Modification

Cost Item	Base Date (2013) Cost	Year of Occurrence	Discount Factor[1]	Present Value
Initial Investment	**$1,016,000**	**Base Date**	**1**	**$1,002,000**
Capital Replacement (90%)	$914,400	30	0.552	$504,749
Electricity (1500 kWh at $0.15/kWh)	$225	Annual	19.8	$4,455
Operation, Maintenance, and Repair	$4,800	Annual	22.4	$107,520
			Total	**$616,724**

Note:
1 - NIST LCC Supplement 2012

Table H-8. Total O&M and Capital Replacement Costs, by Alternative

Alternative	Cost
Alt A - No Action	-
Alt B – Dam Removal	$0
Alt F – Partial Removal	$385,170
Alt G – Stabilize in Place	$181,894
Alt H – Dam Modification	$616,724

NOTE: Full LCC costs for Alternatives G and H were calculated by Kleinschmidt Associates. See Appendix G for more detail.

Vanasse Hangen Brustlin, Inc.

Six Bedford Farms Drive, Suite 607
Bedford, New Hampshire 03110

Water Infrastructure Costs

Great Dam Removal Feasibility and Impact Analysis
Exeter, New Hampshire - Preliminary Conceptual Opinion of Cost

Table H-9. Municipal Water Intake in the Exeter River, Planning Level Cost Estimate[1]

Source	Project Component	
CDM (2002)	Exeter River Pumping Station Rehabilitation (includes pumps, motors)	$400,000
	General Contractor's Overhead and Profit (15%)	$60,000
	Construction Contingency (20%)	$92,000
	Subtotal[2]	**$552,000**
WSE (2010)	Modifications to Intake	$90,000
	Modifications to Pump Chamber[3]	$20,000
	Raising electrical equipment above floodplain[3]	$50,000
	New Suction System	$20,000
	Design & Permitting	$80,000
	Construction Contingency (20%)	$52,000
	Subtotal[3]	**$312,000**
	TOTAL	**$864,000**

Notes:

1. Data is based on information from Kevin MacKinnon, Weston and Sampson, personal communication, July 18, 2013. Certain items were modified by VHB in consultation with the Town.

2. This subtotal includes recommended upgrades to the Exeter River Pumping Station which have been partially completed, and are not directly attributable to the potential Dam Removal or Partial Removal.

3. The cost associated with these line items was reduced from the amounts estimate by Weston & Sampson (2010) due to the fact that subsequent analysis indicated that the work would not be as extensive as originally estimated or because the work has been partially completed.

4. This subtotal represents the amount directly attributable to the potential Dam Removal or Partial Removal.

Table H-10. Cost of Retrofitting Public Water Intake Structures[1]

	Low (2009 $)	High (2009 $)	Low (2013 $)[4]	High (2013 $)[4]
Town Intake[1,2]	$312,000	$312,000	$338,208	**$338,208**
Dry Hydrant[3]	$25,000	$50,000	$27,100	**$54,200**
	$337,000	$362,000	$365,308	**$392,408**

Notes:

1. Costs reported in this table are based on data reported in Weston and Sampson, Water Supply Alternatives Study, January 2010.

2. Town Intake. See Detail in Table H-9. Cost to upgrade the existing Exeter River Pumping Station to accommodate a deeper intake at the existing station if the Great Dam is lowered and/or removed. This cost does

3. Dry Hydrant at the Exeter Library/Founder's Park. Potential cost associated with replacing this hydrant in Weston & Sampson (2010a) was estimated to be approximately $125,000 to $250,000. However, additional work completed as part of this Feasibility and Impact Study found that abandoning this hydrant and replacing it entirely should cost between $25,000 and $50,000.

4. Used CPI cumulative inflation of 8.4% to adjust 2009 dollars to 2013 dollars

Table H-11. Cost of Retrofitting Private Water Intake Structures[1]

	Low (2009 $)	High (2009 $)	Low (2013 $)[4]	High (2013 $)[4]
Exeter Mills Penstock[2]	$250,000	$500,000	$271,000	**$542,000**
PEA River Intake[3]	$100,000	$250,000	$108,400	**$271,000**
	$350,000	$750,000	$379,400	**$813,000**

Notes:

1. Costs reported in this table are from Weston and Sampson, Water Supply Alternatives Study, January 2010.

2. The Exeter Mills Water Intake. Potential cost associated with retrofitting this intake (at the penstock) was estimated to be approximately $250,000 to $500,000.

3. Phillips Exeter Academy Intake. Lowering this intake would cost approximately $100,000 to $250,000.

4. Used CPI cumulative inflation of 8.4% to adjust 2009 dollars to 2013 dollars

Vanasse Hangen Brustlin, Inc.

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Bedford, New Hampshire 03110

Other Mitigation Costs

Great Dam Removal Feasibility and Impact Analysis
Exeter, New Hampshire - Preliminary Conceptual Opinion of Cost

Table H-12. Cost of Environmental and Cultural Resource Mitigation Measures

Mitigation Measure	Approximate Cost	Comment/Explanation
Dam Documentation Study (State-level HABS/HAER Survey)	$30,000	This would cover the cost of fully documenting the dam according to NHDHR standards.
Phase IB Archaeological Study at Site	$15,000	Because the site is sensitive for archaeological resoruces, additional field testing must be completed.
Archaeological Monitoring Upstream	$25,000	Alternatives which could increase upstream erosion would need to monitoring river banks for archaeological resources
Fish Passage Field Study	$150,000	Dam modifications which could affect fish passage would need to conduct field studies to ensure proper function
Water Quality Study and Implementation	$250,000	Because the river water quality is impaired, some alternatives would need to implement additional water quality treatment measures. This cost is the differential cost relative to full dam removal for projects that provide some water quality benefit over the existing condition.
Water Quality Study and Implementation - Complex	$550,000	Because the river water quality is impaired, some alternatives would need to implement additional water quality treatment measures. This cost is the differential cost relative to full dam removal for projects that do not improve water quality.
Sediment Management Measures	$50,200	Certain alternatives would restore normal sediment transport to the river which would release sediments to downstream areas. This figure is intended to cover the costs of the following: 1) seeding of upstream exposed soils, 2) Installation and maintenance of a turbidity curtain at the PEA for a period of three years, and 3) Monitoring of downstream areas for sediment impacts once per year for a period of three years.

Table H-13. Total Cost of Mitigation, by Alternative

Alternative	Water Intake Retrofits[1]	HABS/HAER	Site Phase IB	Archaeological Monitoring	Fish Passage Field Study	Water Quality	Sediment Management	Total
Alt A - No Action	$0	$0	$0	$0	$0	$550,000	$0	**$550,000**
Alt B – Dam Removal	$392,408	$30,000	$15,000	$25,000	$0	$0	$50,200	**$512,608**
Alt F – Partial Removal	$392,408	$30,000	$15,000	$25,000	$150,000	$250,000	$50,200	**$912,608**
Alt G – Stabilize in Place	$0	$0	$15,000	$0	$0	$550,000	$0	**$565,000**
Alt H – Dam Modification	$0	$30,000	$15,000	$0	$150,000	$550,000	$50,200	**$795,200**

Notes:

1. Water intake retrofit costs include only two municipal intakes: Exeter River Pumping Station and the Library Dry Hydrant. Costs for retrofitting of private intakes are provided in Table H-3, but are not included in this table.

Vanasse Hangen Brustlin, Inc.

Six Bedford Farms Drive, Suite 607
Bedford, New Hampshire 03110

Summary of Costs by Alternative

Great Dam Removal Feasibility and Impact Analysis
Exeter, New Hampshire - Preliminary Conceptual Opinion of Cost
Total Costs including Construction, O&M and Mitigation

Table H-14. Initial Construction and Mitigation Costs

Alternative	Design, Permitting and Construction	Infrastructure and Environmental Mitigation	Total
Alt A - No Action	-	$550,000	**$550,000**
Alt B – Dam Removal	$732,150	$512,608	**$1,244,758**
Alt F – Partial Removal	$1,338,630	$912,608	**$2,251,238**
Alt G – Stabilize in Place	$418,000	$565,000	**$983,000**
Alt H – Dam Modification	$1,016,000	$795,200	**$1,811,200**

Table H-15. Total Costs including O&M and Replacement (30 Year Analysis)

Alternative	Initial Cost	O&M and Replacement Costs	Total
Alt A - No Action	$550,000	-	**$550,000**
Alt B – Dam Removal	$1,244,758	$0	**$1,244,758**
Alt F – Partial Removal	$2,251,238	$385,170	**$2,636,408**
Alt G – Stabilize in Place	$983,000	$181,894	**$1,164,894**
Alt H – Dam Modification	$1,811,200	$616,724	**$2,427,924**

Appendix I

Sediment Data: Grain Size & Chemical Analysis Results

Absolute Resource associates
124 Heritage Avenue Portsmouth NH 03801

Bill Arcieri
Vanasse Hangen Brustlin, Inc.
Six Bedford Farms Drive
Suite 607
Bedford, NH 03110

PO Number: None
Job ID: 22819
Date Received: 11/8/11

Project: Exeter Dam

Attached please find results for the analysis of the samples received on the date referenced above.

The following report has been re-issued to provided lower reporting limits for PAH compounds, as requested by the customer.

Unless otherwise noted in the attached report, the analyses performed met the requirements of Absolute Resource Associates' Quality Assurance Plan. The Standard Operating Procedures are based upon USEPA SW-846, USEPA Methods for Chemical Analysis of Water and Wastewater, Standard Methods for the Examination of Water and Wastewater and other recognized methodologies. The results contained in this report pertain only to the samples as indicated on the chain of custody.

Absolute Resource Associates maintains certification with the agencies listed below.

We appreciate the opportunity to provide laboratory services. If you have any questions regarding the enclosed report, please contact the laboratory and we will be glad to assist you.

Sincerely,
Absolute Resource Associates

(for)

Sue Sylvester
Principal, General Manager

Date of Approval: 7/18/2012
Total number of pages: 55

Absolute Resource Associates Certifications

New Hampshire	1732	Massachusetts	M-NH902
Maine	NH903		

Project ID: Exeter Dam
Lab ID: 22819

Appendix I

Sample Association Table

Field ID	Matrix	Date-Time Sampled	Lab#	Analysis
ER-1	Solid	11/7/2011 12:10	22819-001	
				Pesticides in soil by 8081
				PCBs in soil by 8082
				PAHs in solid by 8270
				Solid Digestion for ICP Analysis
				Arsenic in solids by 6010
				Barium in solids by 6010
				Cadmium in solids by 6010
				Chromium in solids by 6010
				Copper in solids by 6010
				Mercury in solids by 7471
				Nickel in solids by 6010
				Lead in solids by 6010
				Zinc in solids by 6010
				Percent Dry Matter for Sample Calc by SM2540B,G
				Grain Size - Hydrometer (subcontract)
				TOC in Solid by 9060A (subcontract)
				VOCs in solid by 8260 Petro & Haz Waste
ER-2	Solid	11/7/2011 9:45	22819-002	
				Pesticides in soil by 8081
				PCBs in soil by 8082
				PAHs in solid by 8270
				Solid Digestion for ICP Analysis
				Arsenic in solids by 6010
				Barium in solids by 6010
				Cadmium in solids by 6010
				Chromium in solids by 6010
				Copper in solids by 6010
				Mercury in solids by 7471
				Nickel in solids by 6010
				Lead in solids by 6010
				Zinc in solids by 6010
				Percent Dry Matter for Sample Calc by SM2540B,G
				Grain Size - Hydrometer (subcontract)
				TOC in Solid by 9060A (subcontract)
				VOCs in solid by 8260 Petro & Haz Waste
ER-3	Solid	11/7/2011 13:15	22819-003	
				Pesticides in soil by 8081
				PCBs in soil by 8082
				PAHs in solid by 8270
				Solid Digestion for ICP Analysis
				Arsenic in solids by 6010
				Barium in solids by 6010
				Cadmium in solids by 6010
				Chromium in solids by 6010
				Copper in solids by 6010
				Mercury in solids by 7471
				Nickel in solids by 6010
				Lead in solids by 6010
				Zinc in solids by 6010
				Percent Dry Matter for Sample Calc by SM2540B,G
				Grain Size - Hydrometer (subcontract)

Project ID: Exeter Dam

Lab ID: 22819

Sample Association Table

Field ID	Matrix	Date-Time Sampled	Lab#	Analysis
ER-3	Solid	11/7/2011 13:15	22819-003	
				TOC in Solid by 9060A (subcontract)
				VOCs in solid by 8260 Petro & Haz Waste
ER-4	Solid	11/7/2011 14:30	22819-004	
				Pesticides in soil by 8081
				PCBs in soil by 8082
				PAHs in solid by 8270
				Solid Digestion for ICP Analysis
				Arsenic in solids by 6010
				Barium in solids by 6010
				Cadmium in solids by 6010
				Chromium in solids by 6010
				Copper in solids by 6010
				Mercury in solids by 7471
				Nickel in solids by 6010
				Lead in solids by 6010
				Zinc in solids by 6010
				Percent Dry Matter for Sample Calc by SM2540B,G
				Grain Size - Hydrometer (subcontract)
				TOC in Solid by 9060A (subcontract)
				VOCs in solid by 8260 Petro & Haz Waste
ER-5	Solid	11/7/2011 15:40	22819-005	
				Pesticides in soil by 8081
				PCBs in soil by 8082
				PAHs in solid by 8270
				Solid Digestion for ICP Analysis
				Arsenic in solids by 6010
				Barium in solids by 6010
				Cadmium in solids by 6010
				Chromium in solids by 6010
				Copper in solids by 6010
				Mercury in solids by 7471
				Nickel in solids by 6010
				Lead in solids by 6010
				Zinc in solids by 6010
				Percent Dry Matter for Sample Calc by SM2540B,G
				Grain Size - Hydrometer (subcontract)
				TOC in Solid by 9060A (subcontract)
				VOCs in solid by 8260 Petro & Haz Waste
LR-1	Solid	11/7/2011 14:10	22819-006	
				Pesticides in soil by 8081
				PCBs in soil by 8082
				PAHs in solid by 8270
				Solid Digestion for ICP Analysis
				Arsenic in solids by 6010
				Barium in solids by 6010
				Cadmium in solids by 6010
				Chromium in solids by 6010
				Copper in solids by 6010
				Mercury in solids by 7471
				Nickel in solids by 6010
				Lead in solids by 6010

Project ID: Exeter Dam

Lab ID: 22819

Sample Association Table

Field ID	Matrix	Date-Time Sampled	Lab#	Analysis
LR-1	Solid	11/7/2011 14:10	22819-006	
				Zinc in solids by 6010
				Percent Dry Matter for Sample Calc by SM2540B,G
				Grain Size - Hydrometer (subcontract)
				TOC in Solid by 9060A (subcontract)
				VOCs in solid by 8260 Petro & Haz Waste

Project ID: Exeter Dam
Job ID: 22819

Sample#: 22819-001
Sample ID: ER-1
Matrix: Solid Percent Dry: 85.2% Results expressed on a dry weight basis.
Sampled: 11/7/11 12:10

Parameter	Result	Reporting Limit	Units	Instr Dil'n Factor	Analyst	Prep Date	Batch	Analysis Date	Analysis Time	Reference
dichlorodifluoromethane	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	17:50	SW5035A8260B
chloromethane	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	17:50	SW5035A8260B
vinyl chloride	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	17:50	SW5035A8260B
bromomethane	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	17:50	SW5035A8260B
chloroethane	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	17:50	SW5035A8260B
trichlorofluoromethane	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	17:50	SW5035A8260B
diethyl ether	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	17:50	SW5035A8260B
acetone	< 2	2	ug/g	1	LMM	11/15/11	4715	11/15/11	17:50	SW5035A8260B
1,1-dichloroethene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	17:50	SW5035A8260B
methylene chloride	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	17:50	SW5035A8260B
carbon disulfide	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	17:50	SW5035A8260B
methyl t-butyl ether (MTBE)	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	17:50	SW5035A8260B
trans-1,2-dichloroethene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	17:50	SW5035A8260B
isopropyl ether (DIPE)	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	17:50	SW5035A8260B
ethyl t-butyl ether (ETBE)	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	17:50	SW5035A8260B
1,1-dichloroethane	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	17:50	SW5035A8260B
t-butanol (TBA)	< 2	2	ug/g	1	LMM	11/15/11	4715	11/15/11	17:50	SW5035A8260B
2-butanone (MEK)	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	17:50	SW5035A8260B
2,2-dichloropropane	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	17:50	SW5035A8260B
cis-1,2-dichloroethene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	17:50	SW5035A8260B
chloroform	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	17:50	SW5035A8260B
bromochloromethane	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	17:50	SW5035A8260B
tetrahydrofuran (THF)	< 0.4	0.4	ug/g	1	LMM	11/15/11	4715	11/15/11	17:50	SW5035A8260B
1,1,1-trichloroethane	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	17:50	SW5035A8260B
1,1-dichloropropene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	17:50	SW5035A8260B
t-amyl-methyl ether (TAME)	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	17:50	SW5035A8260B
carbon tetrachloride	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	17:50	SW5035A8260B
1,2-dichloroethane	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	17:50	SW5035A8260B
benzene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	17:50	SW5035A8260B
trichloroethene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	17:50	SW5035A8260B
1,2-dichloropropane	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	17:50	SW5035A8260B
bromodichloromethane	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	17:50	SW5035A8260B
1,4-dioxane	< 2	2	ug/g	1	LMM	11/15/11	4715	11/15/11	17:50	SW5035A8260B
dibromomethane	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	17:50	SW5035A8260B
4-methyl-2-pentanone (MIBK)	< 0.4	0.4	ug/g	1	LMM	11/15/11	4715	11/15/11	17:50	SW5035A8260B
cis-1,3-dichloropropene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	17:50	SW5035A8260B
toluene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	17:50	SW5035A8260B
trans-1,3-dichloropropene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	17:50	SW5035A8260B
2-hexanone	< 0.4	0.4	ug/g	1	LMM	11/15/11	4715	11/15/11	17:50	SW5035A8260B
1,1,2-trichloroethane	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	17:50	SW5035A8260B
1,3-dichloropropane	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	17:50	SW5035A8260B
tetrachloroethene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	17:50	SW5035A8260B
dibromochloromethane	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	17:50	SW5035A8260B

Appendix I

Project ID: Exeter Dam
Job ID: 22819

Sample#: 22819-001
Sample ID: ER-1
Matrix: Solid   Percent Dry: 85.2% Results expressed on a dry weight basis.
Sampled: 11/7/11 12:10

Parameter	Result	Reporting Limit	Units	Instr Dil'n Factor	Analyst	Prep Date	Batch	Analysis Date	Analysis Time	Reference
1,2-dibromoethane (EDB)	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	17:50	SW5035A8260B
chlorobenzene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	17:50	SW5035A8260B
1,1,1,2-tetrachloroethane	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	17:50	SW5035A8260B
ethylbenzene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	17:50	SW5035A8260B
m&p-xylenes	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	17:50	SW5035A8260B
o-xylene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	17:50	SW5035A8260B
styrene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	17:50	SW5035A8260B
bromoform	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	17:50	SW5035A8260B
isopropylbenzene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	17:50	SW5035A8260B
1,1,2,2-tetrachloroethane	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	17:50	SW5035A8260B
1,2,3-trichloropropane	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	17:50	SW5035A8260B
n-propylbenzene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	17:50	SW5035A8260B
bromobenzene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	17:50	SW5035A8260B
1,3,5-trimethylbenzene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	17:50	SW5035A8260B
2-chlorotoluene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	17:50	SW5035A8260B
4-chlorotoluene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	17:50	SW5035A8260B
tert-butylbenzene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	17:50	SW5035A8260B
1,2,4-trimethylbenzene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	17:50	SW5035A8260B
sec-butylbenzene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	17:50	SW5035A8260B
1,3-dichlorobenzene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	17:50	SW5035A8260B
4-isopropyltoluene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	17:50	SW5035A8260B
1,4-dichlorobenzene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	17:50	SW5035A8260B
1,2-dichlorobenzene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	17:50	SW5035A8260B
n-butylbenzene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	17:50	SW5035A8260B
1,2-dibromo-3-chloropropane (DBCP)	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	17:50	SW5035A8260B
1,2,4-trichlorobenzene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	17:50	SW5035A8260B
1,3,5-trichlorobenzene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	17:50	SW5035A8260B
hexachlorobutadiene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	17:50	SW5035A8260B
naphthalene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	17:50	SW5035A8260B
1,2,3-trichlorobenzene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	17:50	SW5035A8260B
Surrogate Recovery		**Limits**								
dibromofluoromethane SUR	**112**	78-114	%	1	LMM	11/15/11	4715	11/15/11	17:50	SW5035A8260B
toluene-D8 SUR	**96**	88-110	%	1	LMM	11/15/11	4715	11/15/11	17:50	SW5035A8260B
4-bromofluorobenzene SUR	**95**	86-115	%	1	LMM	11/15/11	4715	11/15/11	17:50	SW5035A8260B
a,a,a-trifluorotoluene SUR	**96**	70-130	%	1	LMM	11/15/11	4715	11/15/11	17:50	SW5035A8260B

Absolute Resource associates

Project ID: Exeter Dam

Job ID: 22819

Appendix I

Sample#: 22819-002

Sample ID: ER-2

Matrix: Solid   Percent Dry: 72.2% Results expressed on a dry weight basis.

Sampled: 11/7/11 9:45

Parameter	Result	Reporting Limit	Units	Instr Dil'n Factor	Analyst	Prep Date	Batch	Analysis Date	Analysis Time	Reference
dichlorodifluoromethane	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:22	SW5035A8260B
chloromethane	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:22	SW5035A8260B
vinyl chloride	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:22	SW5035A8260B
bromomethane	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:22	SW5035A8260B
chloroethane	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:22	SW5035A8260B
trichlorofluoromethane	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:22	SW5035A8260B
diethyl ether	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:22	SW5035A8260B
acetone	< 3	3	ug/g	1	LMM	11/15/11	4715	11/15/11	18:22	SW5035A8260B
1,1-dichloroethene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:22	SW5035A8260B
methylene chloride	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:22	SW5035A8260B
carbon disulfide	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:22	SW5035A8260B
methyl t-butyl ether (MTBE)	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:22	SW5035A8260B
trans-1,2-dichloroethene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:22	SW5035A8260B
isopropyl ether (DIPE)	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:22	SW5035A8260B
ethyl t-butyl ether (ETBE)	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:22	SW5035A8260B
1,1-dichloroethane	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:22	SW5035A8260B
t-butanol (TBA)	< 3	3	ug/g	1	LMM	11/15/11	4715	11/15/11	18:22	SW5035A8260B
2-butanone (MEK)	< 0.4	0.4	ug/g	1	LMM	11/15/11	4715	11/15/11	18:22	SW5035A8260B
2,2-dichloropropane	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:22	SW5035A8260B
cis-1,2-dichloroethene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:22	SW5035A8260B
chloroform	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:22	SW5035A8260B
bromochloromethane	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:22	SW5035A8260B
tetrahydrofuran (THF)	< 0.7	0.7	ug/g	1	LMM	11/15/11	4715	11/15/11	18:22	SW5035A8260B
1,1,1-trichloroethane	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:22	SW5035A8260B
1,1-dichloropropene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:22	SW5035A8260B
t-amyl-methyl ether (TAME)	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:22	SW5035A8260B
carbon tetrachloride	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:22	SW5035A8260B
1,2-dichloroethane	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:22	SW5035A8260B
benzene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:22	SW5035A8260B
trichloroethene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:22	SW5035A8260B
1,2-dichloropropane	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:22	SW5035A8260B
bromodichloromethane	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:22	SW5035A8260B
1,4-dioxane	< 3	3	ug/g	1	LMM	11/15/11	4715	11/15/11	18:22	SW5035A8260B
dibromomethane	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:22	SW5035A8260B
4-methyl-2-pentanone (MIBK)	< 0.6	0.6	ug/g	1	LMM	11/15/11	4715	11/15/11	18:22	SW5035A8260B
cis-1,3-dichloropropene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:22	SW5035A8260B
toluene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:22	SW5035A8260B
trans-1,3-dichloropropene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:22	SW5035A8260B
2-hexanone	< 0.7	0.7	ug/g	1	LMM	11/15/11	4715	11/15/11	18:22	SW5035A8260B
1,1,2-trichloroethane	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:22	SW5035A8260B
1,3-dichloropropane	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:22	SW5035A8260B
tetrachloroethene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:22	SW5035A8260B
dibromochloromethane	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:22	SW5035A8260B

Absolute Resource associates

Project ID: Exeter Dam
Job ID: 22819

Sample#: 22819-002
Sample ID: ER-2
Matrix: Solid   Percent Dry: 72.2% Results expressed on a dry weight basis.
Sampled: 11/7/11 9:45

Parameter	Result	Reporting Limit	Units	Instr Dil'n Factor	Analyst	Prep Date	Batch	Analysis Date	Analysis Time	Reference
1,2-dibromoethane (EDB)	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:22	SW5035A8260B
chlorobenzene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:22	SW5035A8260B
1,1,1,2-tetrachloroethane	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:22	SW5035A8260B
ethylbenzene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:22	SW5035A8260B
m&p-xylenes	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:22	SW5035A8260B
o-xylene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:22	SW5035A8260B
styrene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:22	SW5035A8260B
bromoform	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:22	SW5035A8260B
isopropylbenzene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:22	SW5035A8260B
1,1,2,2-tetrachloroethane	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:22	SW5035A8260B
1,2,3-trichloropropane	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:22	SW5035A8260B
n-propylbenzene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:22	SW5035A8260B
bromobenzene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:22	SW5035A8260B
1,3,5-trimethylbenzene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:22	SW5035A8260B
2-chlorotoluene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:22	SW5035A8260B
4-chlorotoluene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:22	SW5035A8260B
tert-butylbenzene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:22	SW5035A8260B
1,2,4-trimethylbenzene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:22	SW5035A8260B
sec-butylbenzene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:22	SW5035A8260B
1,3-dichlorobenzene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:22	SW5035A8260B
4-isopropyltoluene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:22	SW5035A8260B
1,4-dichlorobenzene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:22	SW5035A8260B
1,2-dichlorobenzene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:22	SW5035A8260B
n-butylbenzene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:22	SW5035A8260B
1,2-dibromo-3-chloropropane (DBCP)	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:22	SW5035A8260B
1,2,4-trichlorobenzene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:22	SW5035A8260B
1,3,5-trichlorobenzene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:22	SW5035A8260B
hexachlorobutadiene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:22	SW5035A8260B
naphthalene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:22	SW5035A8260B
1,2,3-trichlorobenzene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:22	SW5035A8260B
Surrogate Recovery		**Limits**								
dibromofluoromethane SUR	**108**	78-114	%	1	LMM	11/15/11	4715	11/15/11	18:22	SW5035A8260B
toluene-D8 SUR	**96**	88-110	%	1	LMM	11/15/11	4715	11/15/11	18:22	SW5035A8260B
4-bromofluorobenzene SUR	**101**	86-115	%	1	LMM	11/15/11	4715	11/15/11	18:22	SW5035A8260B
a,a,a-trifluorotoluene SUR	**100**	70-130	%	1	LMM	11/15/11	4715	11/15/11	18:22	SW5035A8260B

Absolute Resource associates

Project ID: Exeter Dam
Job ID: 22819

Sample#: 22819-003
Sample ID: ER-3
Matrix: Solid   Percent Dry: 72.7% Results expressed on a dry weight basis.
Sampled: 11/7/11 13:15

Parameter	Result	Reporting Limit	Units	Instr Dil'n Factor	Analyst	Prep Date	Batch	Analysis Date	Analysis Time	Reference
dichlorodifluoromethane	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:53	SW5035A8260B
chloromethane	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:53	SW5035A8260B
vinyl chloride	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:53	SW5035A8260B
bromomethane	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:53	SW5035A8260B
chloroethane	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:53	SW5035A8260B
trichlorofluoromethane	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:53	SW5035A8260B
diethyl ether	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:53	SW5035A8260B
acetone	< 3	3	ug/g	1	LMM	11/15/11	4715	11/15/11	18:53	SW5035A8260B
1,1-dichloroethene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:53	SW5035A8260B
methylene chloride	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:53	SW5035A8260B
carbon disulfide	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:53	SW5035A8260B
methyl t-butyl ether (MTBE)	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:53	SW5035A8260B
trans-1,2-dichloroethene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:53	SW5035A8260B
isopropyl ether (DIPE)	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:53	SW5035A8260B
ethyl t-butyl ether (ETBE)	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:53	SW5035A8260B
1,1-dichloroethane	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:53	SW5035A8260B
t-butanol (TBA)	< 3	3	ug/g	1	LMM	11/15/11	4715	11/15/11	18:53	SW5035A8260B
2-butanone (MEK)	< 0.3	0.3	ug/g	1	LMM	11/15/11	4715	11/15/11	18:53	SW5035A8260B
2,2-dichloropropane	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:53	SW5035A8260B
cis-1,2-dichloroethene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:53	SW5035A8260B
chloroform	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:53	SW5035A8260B
bromochloromethane	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:53	SW5035A8260B
tetrahydrofuran (THF)	< 0.5	0.5	ug/g	1	LMM	11/15/11	4715	11/15/11	18:53	SW5035A8260B
1,1,1-trichloroethane	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:53	SW5035A8260B
1,1-dichloropropene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:53	SW5035A8260B
t-amyl-methyl ether (TAME)	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:53	SW5035A8260B
carbon tetrachloride	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:53	SW5035A8260B
1,2-dichloroethane	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:53	SW5035A8260B
benzene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:53	SW5035A8260B
trichloroethene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:53	SW5035A8260B
1,2-dichloropropane	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:53	SW5035A8260B
bromodichloromethane	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:53	SW5035A8260B
1,4-dioxane	< 3	3	ug/g	1	LMM	11/15/11	4715	11/15/11	18:53	SW5035A8260B
dibromomethane	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:53	SW5035A8260B
4-methyl-2-pentanone (MIBK)	< 0.5	0.5	ug/g	1	LMM	11/15/11	4715	11/15/11	18:53	SW5035A8260B
cis-1,3-dichloropropene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:53	SW5035A8260B
toluene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:53	SW5035A8260B
trans-1,3-dichloropropene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:53	SW5035A8260B
2-hexanone	< 0.5	0.5	ug/g	1	LMM	11/15/11	4715	11/15/11	18:53	SW5035A8260B
1,1,2-trichloroethane	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:53	SW5035A8260B
1,3-dichloropropane	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:53	SW5035A8260B
tetrachloroethene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:53	SW5035A8260B
dibromochloromethane	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:53	SW5035A8260B

Absolute Resource associates

Project ID: Exeter Dam
Job ID: 22819

Sample#: 22819-003
Sample ID: ER-3
Matrix: Solid   Percent Dry: 72.7% Results expressed on a dry weight basis.
Sampled: 11/7/11 13:15

Parameter	Result	Reporting Limit	Units	Instr Dil'n Factor	Analyst	Prep Date	Batch	Analysis Date	Analysis Time	Reference
1,2-dibromoethane (EDB)	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:53	SW5035A8260B
chlorobenzene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:53	SW5035A8260B
1,1,1,2-tetrachloroethane	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:53	SW5035A8260B
ethylbenzene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:53	SW5035A8260B
m&p-xylenes	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:53	SW5035A8260B
o-xylene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:53	SW5035A8260B
styrene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:53	SW5035A8260B
bromoform	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:53	SW5035A8260B
isopropylbenzene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:53	SW5035A8260B
1,1,2,2-tetrachloroethane	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:53	SW5035A8260B
1,2,3-trichloropropane	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:53	SW5035A8260B
n-propylbenzene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:53	SW5035A8260B
bromobenzene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:53	SW5035A8260B
1,3,5-trimethylbenzene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:53	SW5035A8260B
2-chlorotoluene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:53	SW5035A8260B
4-chlorotoluene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:53	SW5035A8260B
tert-butylbenzene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:53	SW5035A8260B
1,2,4-trimethylbenzene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:53	SW5035A8260B
sec-butylbenzene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:53	SW5035A8260B
1,3-dichlorobenzene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:53	SW5035A8260B
4-isopropyltoluene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:53	SW5035A8260B
1,4-dichlorobenzene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:53	SW5035A8260B
1,2-dichlorobenzene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:53	SW5035A8260B
n-butylbenzene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:53	SW5035A8260B
1,2-dibromo-3-chloropropane (DBCP)	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:53	SW5035A8260B
1,2,4-trichlorobenzene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:53	SW5035A8260B
1,3,5-trichlorobenzene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:53	SW5035A8260B
hexachlorobutadiene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:53	SW5035A8260B
naphthalene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:53	SW5035A8260B
1,2,3-trichlorobenzene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	18:53	SW5035A8260B
Surrogate Recovery		**Limits**								
dibromofluoromethane SUR	**103**	78-114	%	1	LMM	11/15/11	4715	11/15/11	18:53	SW5035A8260B
toluene-D8 SUR	**94**	88-110	%	1	LMM	11/15/11	4715	11/15/11	18:53	SW5035A8260B
4-bromofluorobenzene SUR	**94**	86-115	%	1	LMM	11/15/11	4715	11/15/11	18:53	SW5035A8260B
a,a,a-trifluorotoluene SUR	**107**	70-130	%	1	LMM	11/15/11	4715	11/15/11	18:53	SW5035A8260B

Absolute Resource associates

Project ID: Exeter Dam

Job ID: 22819

Appendix I

Sample#: 22819-004

Sample ID: ER-4

Matrix: Solid Percent Dry: 69.9% Results expressed on a dry weight basis.

Sampled: 11/7/11 14:30

Parameter	Result	Reporting Limit	Units	Instr Dil'n Factor	Analyst	Prep Date	Batch	Analysis Date	Analysis Time	Reference
dichlorodifluoromethane	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	19:24	SW5035A8260B
chloromethane	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	19:24	SW5035A8260B
vinyl chloride	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	19:24	SW5035A8260B
bromomethane	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	19:24	SW5035A8260B
chloroethane	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	19:24	SW5035A8260B
trichlorofluoromethane	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	19:24	SW5035A8260B
diethyl ether	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	19:24	SW5035A8260B
acetone	< 3	3	ug/g	1	LMM	11/15/11	4715	11/15/11	19:24	SW5035A8260B
1,1-dichloroethene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	19:24	SW5035A8260B
methylene chloride	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	19:24	SW5035A8260B
carbon disulfide	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	19:24	SW5035A8260B
methyl t-butyl ether (MTBE)	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	19:24	SW5035A8260B
trans-1,2-dichloroethene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	19:24	SW5035A8260B
isopropyl ether (DIPE)	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	19:24	SW5035A8260B
ethyl t-butyl ether (ETBE)	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	19:24	SW5035A8260B
1,1-dichloroethane	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	19:24	SW5035A8260B
t-butanol (TBA)	< 3	3	ug/g	1	LMM	11/15/11	4715	11/15/11	19:24	SW5035A8260B
2-butanone (MEK)	< 0.4	0.4	ug/g	1	LMM	11/15/11	4715	11/15/11	19:24	SW5035A8260B
2,2-dichloropropane	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	19:24	SW5035A8260B
cis-1,2-dichloroethene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	19:24	SW5035A8260B
chloroform	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	19:24	SW5035A8260B
bromochloromethane	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	19:24	SW5035A8260B
tetrahydrofuran (THF)	< 0.6	0.6	ug/g	1	LMM	11/15/11	4715	11/15/11	19:24	SW5035A8260B
1,1,1-trichloroethane	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	19:24	SW5035A8260B
1,1-dichloropropene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	19:24	SW5035A8260B
t-amyl-methyl ether (TAME)	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	19:24	SW5035A8260B
carbon tetrachloride	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	19:24	SW5035A8260B
1,2-dichloroethane	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	19:24	SW5035A8260B
benzene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	19:24	SW5035A8260B
trichloroethene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	19:24	SW5035A8260B
1,2-dichloropropane	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	19:24	SW5035A8260B
bromodichloromethane	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	19:24	SW5035A8260B
1,4-dioxane	< 3	3	ug/g	1	LMM	11/15/11	4715	11/15/11	19:24	SW5035A8260B
dibromomethane	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	19:24	SW5035A8260B
4-methyl-2-pentanone (MIBK)	< 0.6	0.6	ug/g	1	LMM	11/15/11	4715	11/15/11	19:24	SW5035A8260B
cis-1,3-dichloropropene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	19:24	SW5035A8260B
toluene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	19:24	SW5035A8260B
trans-1,3-dichloropropene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	19:24	SW5035A8260B
2-hexanone	< 0.6	0.6	ug/g	1	LMM	11/15/11	4715	11/15/11	19:24	SW5035A8260B
1,1,2-trichloroethane	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	19:24	SW5035A8260B
1,3-dichloropropane	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	19:24	SW5035A8260B
tetrachloroethene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	19:24	SW5035A8260B
dibromochloromethane	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	19:24	SW5035A8260B

Project ID: Exeter Dam
Job ID: 22819

Sample#: 22819-004
Sample ID: ER-4
Matrix: Solid   Percent Dry: 69.9% Results expressed on a dry weight basis.
Sampled: 11/7/11 14:30

Parameter	Result	Reporting Limit	Units	Instr Dil'n Factor	Analyst	Prep Date	Batch	Analysis Date	Analysis Time	Reference
1,2-dibromoethane (EDB)	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	19:24	SW5035A8260B
chlorobenzene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	19:24	SW5035A8260B
1,1,1,2-tetrachloroethane	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	19:24	SW5035A8260B
ethylbenzene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	19:24	SW5035A8260B
m&p-xylenes	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	19:24	SW5035A8260B
o-xylene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	19:24	SW5035A8260B
styrene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	19:24	SW5035A8260B
bromoform	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	19:24	SW5035A8260B
isopropylbenzene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	19:24	SW5035A8260B
1,1,2,2-tetrachloroethane	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	19:24	SW5035A8260B
1,2,3-trichloropropane	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	19:24	SW5035A8260B
n-propylbenzene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	19:24	SW5035A8260B
bromobenzene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	19:24	SW5035A8260B
1,3,5-trimethylbenzene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	19:24	SW5035A8260B
2-chlorotoluene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	19:24	SW5035A8260B
4-chlorotoluene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	19:24	SW5035A8260B
tert-butylbenzene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	19:24	SW5035A8260B
1,2,4-trimethylbenzene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	19:24	SW5035A8260B
sec-butylbenzene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	19:24	SW5035A8260B
1,3-dichlorobenzene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	19:24	SW5035A8260B
4-isopropyltoluene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	19:24	SW5035A8260B
1,4-dichlorobenzene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	19:24	SW5035A8260B
1,2-dichlorobenzene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	19:24	SW5035A8260B
n-butylbenzene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	19:24	SW5035A8260B
1,2-dibromo-3-chloropropane (DBCP)	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	19:24	SW5035A8260B
1,2,4-trichlorobenzene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	19:24	SW5035A8260B
1,3,5-trichlorobenzene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	19:24	SW5035A8260B
hexachlorobutadiene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	19:24	SW5035A8260B
naphthalene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	19:24	SW5035A8260B
1,2,3-trichlorobenzene	< 0.1	0.1	ug/g	1	LMM	11/15/11	4715	11/15/11	19:24	SW5035A8260B
Surrogate Recovery		**Limits**								
dibromofluoromethane SUR	**104**	78-114	%	1	LMM	11/15/11	4715	11/15/11	19:24	SW5035A8260B
toluene-D8 SUR	**93**	88-110	%	1	LMM	11/15/11	4715	11/15/11	19:24	SW5035A8260B
4-bromofluorobenzene SUR	**106**	86-115	%	1	LMM	11/15/11	4715	11/15/11	19:24	SW5035A8260B
a,a,a-trifluorotoluene SUR	**107**	70-130	%	1	LMM	11/15/11	4715	11/15/11	19:24	SW5035A8260B

Project ID: Exeter Dam

Appendix I

Job ID: 22819

Sample#: 22819-005

Sample ID: ER-5

Matrix: Solid   Percent Dry: 61.2% Results expressed on a dry weight basis.

Sampled: 11/7/11 15:40

Parameter	Result	Reporting Limit	Units	Instr Dil'n Factor	Analyst	Prep Date	Batch	Analysis Date	Analysis Time	Reference
dichlorodifluoromethane	< 0.2 M	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	19:56	SW5035A8260B
chloromethane	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	19:56	SW5035A8260B
vinyl chloride	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	19:56	SW5035A8260B
bromomethane	< 0.2 M	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	19:56	SW5035A8260B
chloroethane	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	19:56	SW5035A8260B
trichlorofluoromethane	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	19:56	SW5035A8260B
diethyl ether	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	19:56	SW5035A8260B
acetone	< 4	4	ug/g	1	LMM	11/15/11	4715	11/15/11	19:56	SW5035A8260B
1,1-dichloroethene	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	19:56	SW5035A8260B
methylene chloride	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	19:56	SW5035A8260B
carbon disulfide	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	19:56	SW5035A8260B
methyl t-butyl ether (MTBE)	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	19:56	SW5035A8260B
trans-1,2-dichloroethene	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	19:56	SW5035A8260B
isopropyl ether (DIPE)	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	19:56	SW5035A8260B
ethyl t-butyl ether (ETBE)	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	19:56	SW5035A8260B
1,1-dichloroethane	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	19:56	SW5035A8260B
t-butanol (TBA)	< 4	4	ug/g	1	LMM	11/15/11	4715	11/15/11	19:56	SW5035A8260B
2-butanone (MEK)	< 0.5	0.5	ug/g	1	LMM	11/15/11	4715	11/15/11	19:56	SW5035A8260B
2,2-dichloropropane	< 0.2 M	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	19:56	SW5035A8260B
cis-1,2-dichloroethene	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	19:56	SW5035A8260B
chloroform	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	19:56	SW5035A8260B
bromochloromethane	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	19:56	SW5035A8260B
tetrahydrofuran (THF)	< 0.8	0.8	ug/g	1	LMM	11/15/11	4715	11/15/11	19:56	SW5035A8260B
1,1,1-trichloroethane	< 0.2 M	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	19:56	SW5035A8260B
1,1-dichloropropene	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	19:56	SW5035A8260B
t-amyl-methyl ether (TAME)	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	19:56	SW5035A8260B
carbon tetrachloride	< 0.2 M	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	19:56	SW5035A8260B
1,2-dichloroethane	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	19:56	SW5035A8260B
benzene	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	19:56	SW5035A8260B
trichloroethene	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	19:56	SW5035A8260B
1,2-dichloropropane	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	19:56	SW5035A8260B
bromodichloromethane	< 0.2 M	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	19:56	SW5035A8260B
1,4-dioxane	< 4	4	ug/g	1	LMM	11/15/11	4715	11/15/11	19:56	SW5035A8260B
dibromomethane	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	19:56	SW5035A8260B
4-methyl-2-pentanone (MIBK)	< 0.7	0.7	ug/g	1	LMM	11/15/11	4715	11/15/11	19:56	SW5035A8260B
cis-1,3-dichloropropene	< 0.2 M	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	19:56	SW5035A8260B
toluene	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	19:56	SW5035A8260B
trans-1,3-dichloropropene	< 0.2 M	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	19:56	SW5035A8260B
2-hexanone	< 0.8	0.8	ug/g	1	LMM	11/15/11	4715	11/15/11	19:56	SW5035A8260B
1,1,2-trichloroethane	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	19:56	SW5035A8260B
1,3-dichloropropane	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	19:56	SW5035A8260B
tetrachloroethene	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	19:56	SW5035A8260B
dibromochloromethane	< 0.2 M	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	19:56	SW5035A8260B

Project ID: Exeter Dam
Job ID: 22819

Sample#: 22819-005
Sample ID: ER-5
Matrix: Solid   Percent Dry: 61.2% Results expressed on a dry weight basis.
Sampled: 11/7/11 15:40

Parameter	Result	Reporting Limit	Units	Instr Dil'n Factor	Analyst	Prep Date	Batch	Analysis Date	Analysis Time	Reference
1,2-dibromoethane (EDB)	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	19:56	SW5035A8260B
chlorobenzene	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	19:56	SW5035A8260B
1,1,1,2-tetrachloroethane	< 0.2 M	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	19:56	SW5035A8260B
ethylbenzene	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	19:56	SW5035A8260B
m&p-xylenes	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	19:56	SW5035A8260B
o-xylene	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	19:56	SW5035A8260B
styrene	< 0.2 M	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	19:56	SW5035A8260B
bromoform	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	19:56	SW5035A8260B
isopropylbenzene	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	19:56	SW5035A8260B
1,1,2,2-tetrachloroethane	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	19:56	SW5035A8260B
1,2,3-trichloropropane	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	19:56	SW5035A8260B
n-propylbenzene	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	19:56	SW5035A8260B
bromobenzene	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	19:56	SW5035A8260B
1,3,5-trimethylbenzene	< 0.2 M	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	19:56	SW5035A8260B
2-chlorotoluene	< 0.2 M	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	19:56	SW5035A8260B
4-chlorotoluene	< 0.2 M	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	19:56	SW5035A8260B
tert-butylbenzene	< 0.2 M	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	19:56	SW5035A8260B
1,2,4-trimethylbenzene	< 0.2 M	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	19:56	SW5035A8260B
sec-butylbenzene	< 0.2 M	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	19:56	SW5035A8260B
1,3-dichlorobenzene	< 0.2 M	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	19:56	SW5035A8260B
4-isopropyltoluene	< 0.2 M	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	19:56	SW5035A8260B
1,4-dichlorobenzene	< 0.2 M	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	19:56	SW5035A8260B
1,2-dichlorobenzene	< 0.2 M	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	19:56	SW5035A8260B
n-butylbenzene	< 0.2 M	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	19:56	SW5035A8260B
1,2-dibromo-3-chloropropane (DBCP)	< 0.2 M	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	19:56	SW5035A8260B
1,2,4-trichlorobenzene	< 0.2 M	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	19:56	SW5035A8260B
1,3,5-trichlorobenzene	< 0.2 M	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	19:56	SW5035A8260B
hexachlorobutadiene	< 0.2 M	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	19:56	SW5035A8260B
naphthalene	< 0.2 M	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	19:56	SW5035A8260B
1,2,3-trichlorobenzene	< 0.2 M	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	19:56	SW5035A8260B
Surrogate Recovery		**Limits**								
dibromofluoromethane SUR	**113**	78-114	%	1	LMM	11/15/11	4715	11/15/11	19:56	SW5035A8260B
toluene-D8 SUR	**91**	88-110	%	1	LMM	11/15/11	4715	11/15/11	19:56	SW5035A8260B
4-bromofluorobenzene SUR	**93**	86-115	%	1	LMM	11/15/11	4715	11/15/11	19:56	SW5035A8260B
a,a,a-trifluorotoluene SUR	**97**	70-130	%	1	LMM	11/15/11	4715	11/15/11	19:56	SW5035A8260B

M = The percent recovery for this analyte in the MS/D was outside the acceptance criteria. See QC report.

Appendix I

Project ID: Exeter Dam
Job ID: 22819

Sample#: 22819-006
Sample ID: LR-1
Matrix: Solid   Percent Dry: 57.5% Results expressed on a dry weight basis.
Sampled: 11/7/11 14:10

Parameter	Result	Reporting Limit	Units	Instr Dil'n Factor	Analyst	Prep Date	Batch	Analysis Date	Analysis Time	Reference
dichlorodifluoromethane	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	20:27	SW5035A8260B
chloromethane	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	20:27	SW5035A8260B
vinyl chloride	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	20:27	SW5035A8260B
bromomethane	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	20:27	SW5035A8260B
chloroethane	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	20:27	SW5035A8260B
trichlorofluoromethane	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	20:27	SW5035A8260B
diethyl ether	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	20:27	SW5035A8260B
acetone	< 5	5	ug/g	1	LMM	11/15/11	4715	11/15/11	20:27	SW5035A8260B
1,1-dichloroethene	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	20:27	SW5035A8260B
methylene chloride	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	20:27	SW5035A8260B
carbon disulfide	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	20:27	SW5035A8260B
methyl t-butyl ether (MTBE)	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	20:27	SW5035A8260B
trans-1,2-dichloroethene	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	20:27	SW5035A8260B
isopropyl ether (DIPE)	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	20:27	SW5035A8260B
ethyl t-butyl ether (ETBE)	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	20:27	SW5035A8260B
1,1-dichloroethane	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	20:27	SW5035A8260B
t-butanol (TBA)	< 5	5	ug/g	1	LMM	11/15/11	4715	11/15/11	20:27	SW5035A8260B
2-butanone (MEK)	< 0.5	0.5	ug/g	1	LMM	11/15/11	4715	11/15/11	20:27	SW5035A8260B
2,2-dichloropropane	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	20:27	SW5035A8260B
cis-1,2-dichloroethene	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	20:27	SW5035A8260B
chloroform	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	20:27	SW5035A8260B
bromochloromethane	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	20:27	SW5035A8260B
tetrahydrofuran (THF)	< 0.9	0.9	ug/g	1	LMM	11/15/11	4715	11/15/11	20:27	SW5035A8260B
1,1,1-trichloroethane	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	20:27	SW5035A8260B
1,1-dichloropropene	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	20:27	SW5035A8260B
t-amyl-methyl ether (TAME)	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	20:27	SW5035A8260B
carbon tetrachloride	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	20:27	SW5035A8260B
1,2-dichloroethane	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	20:27	SW5035A8260B
benzene	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	20:27	SW5035A8260B
trichloroethene	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	20:27	SW5035A8260B
1,2-dichloropropane	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	20:27	SW5035A8260B
bromodichloromethane	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	20:27	SW5035A8260B
1,4-dioxane	< 5	5	ug/g	1	LMM	11/15/11	4715	11/15/11	20:27	SW5035A8260B
dibromomethane	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	20:27	SW5035A8260B
4-methyl-2-pentanone (MIBK)	< 0.8	0.8	ug/g	1	LMM	11/15/11	4715	11/15/11	20:27	SW5035A8260B
cis-1,3-dichloropropene	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	20:27	SW5035A8260B
toluene	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	20:27	SW5035A8260B
trans-1,3-dichloropropene	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	20:27	SW5035A8260B
2-hexanone	< 0.9	0.9	ug/g	1	LMM	11/15/11	4715	11/15/11	20:27	SW5035A8260B
1,1,2-trichloroethane	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	20:27	SW5035A8260B
1,3-dichloropropane	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	20:27	SW5035A8260B
tetrachloroethene	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	20:27	SW5035A8260B
dibromochloromethane	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	20:27	SW5035A8260B

Absolute Resource associates

Project ID: Exeter Dam

Job ID: 22819

Appendix I

Sample#: 22819-006

Sample ID: LR-1

Matrix: Solid Percent Dry: 57.5% Results expressed on a dry weight basis.

Sampled: 11/7/11 14:10

Parameter	Result	Reporting Limit	Units	Instr Dil'n Factor	Analyst	Prep Date	Batch	Analysis Date	Analysis Time	Reference
1,2-dibromoethane (EDB)	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	20:27	SW5035A8260B
chlorobenzene	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	20:27	SW5035A8260B
1,1,1,2-tetrachloroethane	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	20:27	SW5035A8260B
ethylbenzene	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	20:27	SW5035A8260B
m&p-xylenes	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	20:27	SW5035A8260B
o-xylene	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	20:27	SW5035A8260B
styrene	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	20:27	SW5035A8260B
bromoform	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	20:27	SW5035A8260B
isopropylbenzene	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	20:27	SW5035A8260B
1,1,2,2-tetrachloroethane	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	20:27	SW5035A8260B
1,2,3-trichloropropane	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	20:27	SW5035A8260B
n-propylbenzene	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	20:27	SW5035A8260B
bromobenzene	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	20:27	SW5035A8260B
1,3,5-trimethylbenzene	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	20:27	SW5035A8260B
2-chlorotoluene	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	20:27	SW5035A8260B
4-chlorotoluene	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	20:27	SW5035A8260B
tert-butylbenzene	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	20:27	SW5035A8260B
1,2,4-trimethylbenzene	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	20:27	SW5035A8260B
sec-butylbenzene	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	20:27	SW5035A8260B
1,3-dichlorobenzene	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	20:27	SW5035A8260B
4-isopropyltoluene	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	20:27	SW5035A8260B
1,4-dichlorobenzene	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	20:27	SW5035A8260B
1,2-dichlorobenzene	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	20:27	SW5035A8260B
n-butylbenzene	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	20:27	SW5035A8260B
1,2-dibromo-3-chloropropane (DBCP)	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	20:27	SW5035A8260B
1,2,4-trichlorobenzene	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	20:27	SW5035A8260B
1,3,5-trichlorobenzene	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	20:27	SW5035A8260B
hexachlorobutadiene	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	20:27	SW5035A8260B
naphthalene	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	20:27	SW5035A8260B
1,2,3-trichlorobenzene	< 0.2	0.2	ug/g	1	LMM	11/15/11	4715	11/15/11	20:27	SW5035A8260B
Surrogate Recovery		**Limits**								
dibromofluoromethane SUR	**103**	78-114	%	1	LMM	11/15/11	4715	11/15/11	20:27	SW5035A8260B
toluene-D8 SUR	**92**	88-110	%	1	LMM	11/15/11	4715	11/15/11	20:27	SW5035A8260B
4-bromofluorobenzene SUR	**103**	86-115	%	1	LMM	11/15/11	4715	11/15/11	20:27	SW5035A8260B
a,a,a-trifluorotoluene SUR	**108**	70-130	%	1	LMM	11/15/11	4715	11/15/11	20:27	SW5035A8260B

Absolute Resource associates

Project ID: Exeter Dam

Appendix I

Job ID: 22819

Sample#: 22819-001
Sample ID: ER-1
Matrix: Solid   Percent Dry: 85.2% Results expressed on a dry weight basis.
Sampled: 11/7/11 12:10

Parameter	Result	Reporting Limit	Units	Instr Dil'n Factor	Analyst	Prep Date	Batch	Analysis Date	Analysis Time	Reference
naphthalene	< 0.02	0.02	ug/g	1	AJD	11/15/11	4713	11/16/11	20:07	SW3550B8270D
2-methylnaphthalene	< 0.01	0.01	ug/g	1	AJD	11/15/11	4713	11/16/11	20:07	SW3550B8270D
acenaphthylene	**0.07**	0.01	ug/g	1	AJD	11/15/11	4713	11/16/11	20:07	SW3550B8270D
acenaphthene	**0.04**	0.01	ug/g	1	AJD	11/15/11	4713	11/16/11	20:07	SW3550B8270D
dibenzofuran	**0.03**	0.02	ug/g	1	AJD	11/15/11	4713	11/16/11	20:07	SW3550B8270D
fluorene	**0.04**	0.02	ug/g	1	AJD	11/15/11	4713	11/16/11	20:07	SW3550B8270D
phenanthrene	**1.17**	0.02	ug/g	1	AJD	11/15/11	4713	11/16/11	20:07	SW3550B8270D
anthracene	**0.21**	0.02	ug/g	1	AJD	11/15/11	4713	11/16/11	20:07	SW3550B8270D
fluoranthene	**2.19**	0.02	ug/g	1	AJD	11/15/11	4713	11/16/11	20:07	SW3550B8270D
pyrene	**1.87**	0.02	ug/g	1	AJD	11/15/11	4713	11/16/11	20:07	SW3550B8270D
benzo(a)anthracene	**1.07**	0.02	ug/g	1	AJD	11/15/11	4713	11/16/11	20:07	SW3550B8270D
chrysene	**1.06**	0.02	ug/g	1	AJD	11/15/11	4713	11/16/11	20:07	SW3550B8270D
benzo(b)fluoranthene	**0.92**	0.01	ug/g	1	AJD	11/15/11	4713	11/16/11	20:07	SW3550B8270D
benzo(k)fluoranthene	**1.09**	0.01	ug/g	1	AJD	11/15/11	4713	11/16/11	20:07	SW3550B8270D
benzo(a)pyrene	**0.93**	0.02	ug/g	1	AJD	11/15/11	4713	11/16/11	20:07	SW3550B8270D
indeno(1,2,3-cd)pyrene	**0.22**	0.01	ug/g	1	AJD	11/15/11	4713	11/16/11	20:07	SW3550B8270D
dibenzo(a,h)anthracene	**0.11**	0.01	ug/g	1	AJD	11/15/11	4713	11/16/11	20:07	SW3550B8270D
benzo(g,h,i)perylene	**0.19**	0.02	ug/g	1	AJD	11/15/11	4713	11/16/11	20:07	SW3550B8270D
Surrogate Recovery		**Limits**								
2-fluorobiphenyl SUR	**54**	43-116	%	1	AJD	11/15/11	4713	11/16/11	20:07	SW3550B8270D
o-terphenyl SUR	**56**	33-141	%	1	AJD	11/15/11	4713	11/16/11	20:07	SW3550B8270D

Absolute Resource associates

Project ID: Exeter Dam
Job ID: 22819

Sample#: 22819-002
Sample ID: ER-2
Matrix: Solid   Percent Dry: 72.2% Results expressed on a dry weight basis.
Sampled: 11/7/11 9:45

Parameter	Result	Reporting Limit	Units	Instr Dil'n Factor	Analyst	Prep Date	Batch	Analysis Date	Analysis Time	Reference
naphthalene	< 0.03	0.03	ug/g	1	AJD	11/15/11	4713	11/16/11	19:29	SW3550B8270D
2-methylnaphthalene	< 0.01	0.01	ug/g	1	AJD	11/15/11	4713	11/16/11	19:29	SW3550B8270D
acenaphthylene	**0.01**	0.01	ug/g	1	AJD	11/15/11	4713	11/16/11	19:29	SW3550B8270D
acenaphthene	< 0.01	0.01	ug/g	1	AJD	11/15/11	4713	11/16/11	19:29	SW3550B8270D
dibenzofuran	< 0.03	0.03	ug/g	1	AJD	11/15/11	4713	11/16/11	19:29	SW3550B8270D
fluorene	< 0.03	0.03	ug/g	1	AJD	11/15/11	4713	11/16/11	19:29	SW3550B8270D
phenanthrene	**0.07**	0.03	ug/g	1	AJD	11/15/11	4713	11/16/11	19:29	SW3550B8270D
anthracene	< 0.03	0.03	ug/g	1	AJD	11/15/11	4713	11/16/11	19:29	SW3550B8270D
fluoranthene	**0.20**	0.03	ug/g	1	AJD	11/15/11	4713	11/16/11	19:29	SW3550B8270D
pyrene	**0.18**	0.03	ug/g	1	AJD	11/15/11	4713	11/16/11	19:29	SW3550B8270D
benzo(a)anthracene	**0.11**	0.03	ug/g	1	AJD	11/15/11	4713	11/16/11	19:29	SW3550B8270D
chrysene	**0.11**	0.03	ug/g	1	AJD	11/15/11	4713	11/16/11	19:29	SW3550B8270D
benzo(b)fluoranthene	**0.09**	0.01	ug/g	1	AJD	11/15/11	4713	11/16/11	19:29	SW3550B8270D
benzo(k)fluoranthene	**0.13**	0.01	ug/g	1	AJD	11/15/11	4713	11/16/11	19:29	SW3550B8270D
benzo(a)pyrene	**0.10**	0.03	ug/g	1	AJD	11/15/11	4713	11/16/11	19:29	SW3550B8270D
indeno(1,2,3-cd)pyrene	**0.03**	0.01	ug/g	1	AJD	11/15/11	4713	11/16/11	19:29	SW3550B8270D
dibenzo(a,h)anthracene	**0.01**	0.01	ug/g	1	AJD	11/15/11	4713	11/16/11	19:29	SW3550B8270D
benzo(g,h,i)perylene	< 0.03	0.03	ug/g	1	AJD	11/15/11	4713	11/16/11	19:29	SW3550B8270D
Surrogate Recovery		**Limits**								
2-fluorobiphenyl SUR	**46**	43-116	%	1	AJD	11/15/11	4713	11/16/11	19:29	SW3550B8270D
o-terphenyl SUR	**56**	33-141	%	1	AJD	11/15/11	4713	11/16/11	19:29	SW3550B8270D

Absolute Resource associates

Project ID: Exeter Dam
Job ID: 22819

Sample#: 22819-003
Sample ID: ER-3
Matrix: Solid   Percent Dry: 72.7% Results expressed on a dry weight basis.
Sampled: 11/7/11 13:15

Parameter	Result	Reporting Limit	Units	Instr Dil'n Factor	Analyst	Prep Date	Batch	Analysis Date	Analysis Time	Reference
naphthalene	< 0.03	0.03	ug/g	1	AJD	11/15/11	4713	11/16/11	13:09	SW3550B8270D
2-methylnaphthalene	< 0.01	0.01	ug/g	1	AJD	11/15/11	4713	11/16/11	13:09	SW3550B8270D
acenaphthylene	< 0.01	0.01	ug/g	1	AJD	11/15/11	4713	11/16/11	13:09	SW3550B8270D
acenaphthene	< 0.01	0.01	ug/g	1	AJD	11/15/11	4713	11/16/11	13:09	SW3550B8270D
dibenzofuran	< 0.03	0.03	ug/g	1	AJD	11/15/11	4713	11/16/11	13:09	SW3550B8270D
fluorene	< 0.03	0.03	ug/g	1	AJD	11/15/11	4713	11/16/11	13:09	SW3550B8270D
phenanthrene	< 0.03	0.03	ug/g	1	AJD	11/15/11	4713	11/16/11	13:09	SW3550B8270D
anthracene	< 0.03	0.03	ug/g	1	AJD	11/15/11	4713	11/16/11	13:09	SW3550B8270D
fluoranthene	< 0.03	0.03	ug/g	1	AJD	11/15/11	4713	11/16/11	13:09	SW3550B8270D
pyrene	< 0.03	0.03	ug/g	1	AJD	11/15/11	4713	11/16/11	13:09	SW3550B8270D
benzo(a)anthracene	< 0.03	0.03	ug/g	1	AJD	11/15/11	4713	11/16/11	13:09	SW3550B8270D
chrysene	< 0.03	0.03	ug/g	1	AJD	11/15/11	4713	11/16/11	13:09	SW3550B8270D
benzo(b)fluoranthene	< 0.01	0.01	ug/g	1	AJD	11/15/11	4713	11/16/11	13:09	SW3550B8270D
benzo(k)fluoranthene	< 0.01	0.01	ug/g	1	AJD	11/15/11	4713	11/16/11	13:09	SW3550B8270D
benzo(a)pyrene	< 0.03	0.03	ug/g	1	AJD	11/15/11	4713	11/16/11	13:09	SW3550B8270D
indeno(1,2,3-cd)pyrene	< 0.01	0.01	ug/g	1	AJD	11/15/11	4713	11/16/11	13:09	SW3550B8270D
dibenzo(a,h)anthracene	< 0.01	0.01	ug/g	1	AJD	11/15/11	4713	11/16/11	13:09	SW3550B8270D
benzo(g,h,i)perylene	< 0.03	0.03	ug/g	1	AJD	11/15/11	4713	11/16/11	13:09	SW3550B8270D
Surrogate Recovery		**Limits**								
2-fluorobiphenyl SUR	**53**	43-116	%	1	AJD	11/15/11	4713	11/16/11	13:09	SW3550B8270D
o-terphenyl SUR	**69**	33-141	%	1	AJD	11/15/11	4713	11/16/11	13:09	SW3550B8270D

Absolute Resource associates

Project ID: Exeter Dam
Job ID: 22819

Sample#: 22819-004
Sample ID: ER-4
Matrix: Solid   Percent Dry: 69.9% Results expressed on a dry weight basis.
Sampled: 11/7/11 14:30

Parameter	Result	Reporting Limit	Units	Instr Dil'n Factor	Analyst	Prep Date	Batch	Analysis Date	Analysis Time	Reference
naphthalene	< 0.03	0.03	ug/g	1	AJD	11/15/11	4713	11/16/11	12:32	SW3550B8270D
2-methylnaphthalene	< 0.01	0.01	ug/g	1	AJD	11/15/11	4713	11/16/11	12:32	SW3550B8270D
acenaphthylene	< 0.01	0.01	ug/g	1	AJD	11/15/11	4713	11/16/11	12:32	SW3550B8270D
acenaphthene	< 0.01	0.01	ug/g	1	AJD	11/15/11	4713	11/16/11	12:32	SW3550B8270D
dibenzofuran	< 0.03	0.03	ug/g	1	AJD	11/15/11	4713	11/16/11	12:32	SW3550B8270D
fluorene	< 0.03	0.03	ug/g	1	AJD	11/15/11	4713	11/16/11	12:32	SW3550B8270D
phenanthrene	< 0.03	0.03	ug/g	1	AJD	11/15/11	4713	11/16/11	12:32	SW3550B8270D
anthracene	< 0.03	0.03	ug/g	1	AJD	11/15/11	4713	11/16/11	12:32	SW3550B8270D
fluoranthene	< 0.03	0.03	ug/g	1	AJD	11/15/11	4713	11/16/11	12:32	SW3550B8270D
pyrene	< 0.03	0.03	ug/g	1	AJD	11/15/11	4713	11/16/11	12:32	SW3550B8270D
benzo(a)anthracene	< 0.03	0.03	ug/g	1	AJD	11/15/11	4713	11/16/11	12:32	SW3550B8270D
chrysene	< 0.03	0.03	ug/g	1	AJD	11/15/11	4713	11/16/11	12:32	SW3550B8270D
benzo(b)fluoranthene	< 0.01	0.01	ug/g	1	AJD	11/15/11	4713	11/16/11	12:32	SW3550B8270D
benzo(k)fluoranthene	< 0.01	0.01	ug/g	1	AJD	11/15/11	4713	11/16/11	12:32	SW3550B8270D
benzo(a)pyrene	< 0.03	0.03	ug/g	1	AJD	11/15/11	4713	11/16/11	12:32	SW3550B8270D
indeno(1,2,3-cd)pyrene	< 0.01	0.01	ug/g	1	AJD	11/15/11	4713	11/16/11	12:32	SW3550B8270D
dibenzo(a,h)anthracene	< 0.01	0.01	ug/g	1	AJD	11/15/11	4713	11/16/11	12:32	SW3550B8270D
benzo(g,h,i)perylene	< 0.03	0.03	ug/g	1	AJD	11/15/11	4713	11/16/11	12:32	SW3550B8270D
Surrogate Recovery		**Limits**								
2-fluorobiphenyl SUR	**51**	43-116	%	1	AJD	11/15/11	4713	11/16/11	12:32	SW3550B8270D
o-terphenyl SUR	**70**	33-141	%	1	AJD	11/15/11	4713	11/16/11	12:32	SW3550B8270D

Project ID: Exeter Dam

Job ID: 22819

Appendix I

Sample#: 22819-005

Sample ID: ER-5

Matrix: Solid   Percent Dry: 61.2% Results expressed on a dry weight basis.

Sampled: 11/7/11 15:40

Parameter	Result	Reporting Limit	Units	Instr Dil'n Factor	Analyst	Prep Date	Batch	Analysis Date	Analysis Time	Reference
naphthalene	< 0.03	0.03	ug/g	1	AJD	11/15/11	4713	11/16/11	18:13	SW3550B8270D
2-methylnaphthalene	< 0.01	0.01	ug/g	1	AJD	11/15/11	4713	11/16/11	18:13	SW3550B8270D
acenaphthylene	< 0.01	0.01	ug/g	1	AJD	11/15/11	4713	11/16/11	18:13	SW3550B8270D
acenaphthene	< 0.01	0.01	ug/g	1	AJD	11/15/11	4713	11/16/11	18:13	SW3550B8270D
dibenzofuran	< 0.03	0.03	ug/g	1	AJD	11/15/11	4713	11/16/11	18:13	SW3550B8270D
fluorene	< 0.03	0.03	ug/g	1	AJD	11/15/11	4713	11/16/11	18:13	SW3550B8270D
phenanthrene	< 0.03	0.03	ug/g	1	AJD	11/15/11	4713	11/16/11	18:13	SW3550B8270D
anthracene	< 0.03	0.03	ug/g	1	AJD	11/15/11	4713	11/16/11	18:13	SW3550B8270D
fluoranthene	< 0.03	0.03	ug/g	1	AJD	11/15/11	4713	11/16/11	18:13	SW3550B8270D
pyrene	< 0.03	0.03	ug/g	1	AJD	11/15/11	4713	11/16/11	18:13	SW3550B8270D
benzo(a)anthracene	< 0.03	0.03	ug/g	1	AJD	11/15/11	4713	11/16/11	18:13	SW3550B8270D
chrysene	< 0.03	0.03	ug/g	1	AJD	11/15/11	4713	11/16/11	18:13	SW3550B8270D
benzo(b)fluoranthene	< 0.01	0.01	ug/g	1	AJD	11/15/11	4713	11/16/11	18:13	SW3550B8270D
benzo(k)fluoranthene	< 0.01	0.01	ug/g	1	AJD	11/15/11	4713	11/16/11	18:13	SW3550B8270D
benzo(a)pyrene	< 0.03	0.03	ug/g	1	AJD	11/15/11	4713	11/16/11	18:13	SW3550B8270D
indeno(1,2,3-cd)pyrene	< 0.01 M	0.01	ug/g	1	AJD	11/15/11	4713	11/16/11	18:13	SW3550B8270D
dibenzo(a,h)anthracene	< 0.01 M	0.01	ug/g	1	AJD	11/15/11	4713	11/16/11	18:13	SW3550B8270D
benzo(g,h,i)perylene	< 0.03 M	0.03	ug/g	1	AJD	11/15/11	4713	11/16/11	18:13	SW3550B8270D
Surrogate Recovery		**Limits**								
2-fluorobiphenyl SUR	**45**	43-116	%	1	AJD	11/15/11	4713	11/16/11	18:13	SW3550B8270D
o-terphenyl SUR	**52**	33-141	%	1	AJD	11/15/11	4713	11/16/11	18:13	SW3550B8270D

M = The percent recovery for the MS/D was below the acceptance criteria. See QC report.

Project ID: Exeter Dam
Job ID: 22819

Sample#: 22819-006
Sample ID: LR-1
Matrix: Solid Percent Dry: 57.5% Results expressed on a dry weight basis.
Sampled: 11/7/11 14:10

Parameter	Result	Reporting Limit	Units	Instr Dil'n Factor	Analyst	Prep Date	Batch	Analysis Date	Analysis Time	Reference
naphthalene	< 0.03	0.03	ug/g	1	AJD	11/15/11	4713	11/16/11	18:51	SW3550B8270D
2-methylnaphthalene	< 0.01	0.01	ug/g	1	AJD	11/15/11	4713	11/16/11	18:51	SW3550B8270D
acenaphthylene	**0.02**	0.01	ug/g	1	AJD	11/15/11	4713	11/16/11	18:51	SW3550B8270D
acenaphthene	< 0.01	0.01	ug/g	1	AJD	11/15/11	4713	11/16/11	18:51	SW3550B8270D
dibenzofuran	< 0.03	0.03	ug/g	1	AJD	11/15/11	4713	11/16/11	18:51	SW3550B8270D
fluorene	< 0.03	0.03	ug/g	1	AJD	11/15/11	4713	11/16/11	18:51	SW3550B8270D
phenanthrene	**0.04**	0.03	ug/g	1	AJD	11/15/11	4713	11/16/11	18:51	SW3550B8270D
anthracene	< 0.03	0.03	ug/g	1	AJD	11/15/11	4713	11/16/11	18:51	SW3550B8270D
fluoranthene	**0.14**	0.03	ug/g	1	AJD	11/15/11	4713	11/16/11	18:51	SW3550B8270D
pyrene	**0.12**	0.03	ug/g	1	AJD	11/15/11	4713	11/16/11	18:51	SW3550B8270D
benzo(a)anthracene	**0.05**	0.03	ug/g	1	AJD	11/15/11	4713	11/16/11	18:51	SW3550B8270D
chrysene	**0.07**	0.03	ug/g	1	AJD	11/15/11	4713	11/16/11	18:51	SW3550B8270D
benzo(b)fluoranthene	**0.07**	0.01	ug/g	1	AJD	11/15/11	4713	11/16/11	18:51	SW3550B8270D
benzo(k)fluoranthene	**0.05**	0.01	ug/g	1	AJD	11/15/11	4713	11/16/11	18:51	SW3550B8270D
benzo(a)pyrene	**0.05**	0.03	ug/g	1	AJD	11/15/11	4713	11/16/11	18:51	SW3550B8270D
indeno(1,2,3-cd)pyrene	**0.02**	0.01	ug/g	1	AJD	11/15/11	4713	11/16/11	18:51	SW3550B8270D
dibenzo(a,h)anthracene	< 0.01	0.01	ug/g	1	AJD	11/15/11	4713	11/16/11	18:51	SW3550B8270D
benzo(g,h,i)perylene	< 0.03	0.03	ug/g	1	AJD	11/15/11	4713	11/16/11	18:51	SW3550B8270D
Surrogate Recovery		**Limits**								
2-fluorobiphenyl SUR	**54**	43-116	%	1	AJD	11/15/11	4713	11/16/11	18:51	SW3550B8270D
o-terphenyl SUR	**57**	33-141	%	1	AJD	11/15/11	4713	11/16/11	18:51	SW3550B8270D

Absolute Resource associates

Project ID: Exeter Dam
Job ID: 22819

Sample#: 22819-001
Sample ID: ER-1
Matrix: Solid Percent Dry: 85.2% Results expressed on a dry weight basis.
Sampled: 11/7/11 12:10

Parameter	Result	Reporting Limit	Units	Instr Dil'n Factor	Analyst	Prep Date	Batch	Analysis Date	Analysis Time	Reference
gamma-BHC (Lindane)	< 0.001	0.001	ug/g	1	JLZ	11/15/11	4714	11/23/11	14:07	SW3550B/8081B
Heptachlor	< 0.001	0.001	ug/g	1	JLZ	11/15/11	4714	11/23/11	14:07	SW3550B/8081B
Aldrin	< 0.001	0.001	ug/g	1	JLZ	11/15/11	4714	11/23/11	14:07	SW3550B/8081B
Heptachlor Epoxide	< 0.001	0.001	ug/g	1	JLZ	11/15/11	4714	11/23/11	14:07	SW3550B/8081B
Endosulfan I	< 0.001	0.001	ug/g	1	JLZ	11/15/11	4714	11/23/11	14:07	SW3550B/8081B
Dieldrin	< 0.001	0.001	ug/g	1	JLZ	11/15/11	4714	11/23/11	14:07	SW3550B/8081B
4,4'-DDE	< 0.001	0.001	ug/g	1	JLZ	11/15/11	4714	11/23/11	14:07	SW3550B/8081B
Endrin	< 0.001	0.001	ug/g	1	JLZ	11/15/11	4714	11/23/11	14:07	SW3550B/8081B
Endosulfan II	< 0.001	0.001	ug/g	1	JLZ	11/15/11	4714	11/23/11	14:07	SW3550B/8081B
4,4'-DDD	< 0.001	0.001	ug/g	1	JLZ	11/15/11	4714	11/23/11	14:07	SW3550B/8081B
4,4'-DDT	< 0.001 #	0.001	ug/g	1	JLZ	11/15/11	4714	11/23/11	14:07	SW3550B/8081B
Methoxychlor	< 0.001	0.001	ug/g	1	JLZ	11/15/11	4714	11/23/11	14:07	SW3550B/8081B
alpha-Chlordane	< 0.001	0.001	ug/g	1	JLZ	11/15/11	4714	11/23/11	14:07	SW3550B/8081B
gamma-Chlordane	< 0.001	0.001	ug/g	1	JLZ	11/15/11	4714	11/23/11	14:07	SW3550B/8081B
Toxaphene	< 0.01	0.01	ug/g	1	JLZ	11/15/11	4714	11/23/11	14:07	SW3550B/8081B
Surrogate Recovery		**Limits**								
tetrachloro-m-xylene SUR	**59**	30-150	%	1	JLZ	11/15/11	4714	11/23/11	14:07	SW3550B/8081B
decachlorobiphenyl SUR	**48**	30-150	%	1	JLZ	11/15/11	4714	11/23/11	14:07	SW3550B/8081B

 # The percent recovery for the LCS/D was below the acceptance criteria. The result is an estimate.

Project ID: Exeter Dam
Job ID: 22819

Sample#: 22819-002
Sample ID: ER-2
Matrix: Solid   Percent Dry: 72.2% Results expressed on a dry weight basis.
Sampled: 11/7/11 9:45

Parameter	Result	Reporting Limit	Units	Instr Dil'n Factor	Analyst	Prep Date	Batch	Analysis Date	Analysis Time	Reference
gamma-BHC (Lindane)	< 0.001	0.001	ug/g	1	JLZ	11/15/11	4714	11/23/11	14:48	SW3550B/8081B
Heptachlor	< 0.001	0.001	ug/g	1	JLZ	11/15/11	4714	11/23/11	14:48	SW3550B/8081B
Aldrin	< 0.001	0.001	ug/g	1	JLZ	11/15/11	4714	11/23/11	14:48	SW3550B/8081B
Heptachlor Epoxide	< 0.001	0.001	ug/g	1	JLZ	11/15/11	4714	11/23/11	14:48	SW3550B/8081B
Endosulfan I	< 0.001	0.001	ug/g	1	JLZ	11/15/11	4714	11/23/11	14:48	SW3550B/8081B
Dieldrin	< 0.001	0.001	ug/g	1	JLZ	11/15/11	4714	11/23/11	14:48	SW3550B/8081B
4,4'-DDE	< 0.001	0.001	ug/g	1	JLZ	11/15/11	4714	11/23/11	14:48	SW3550B/8081B
Endrin	< 0.001	0.001	ug/g	1	JLZ	11/15/11	4714	11/23/11	14:48	SW3550B/8081B
Endosulfan II	< 0.001	0.001	ug/g	1	JLZ	11/15/11	4714	11/23/11	14:48	SW3550B/8081B
4,4'-DDD	< 0.001	0.001	ug/g	1	JLZ	11/15/11	4714	11/23/11	14:48	SW3550B/8081B
4,4'-DDT	< 0.001 #	0.001	ug/g	1	JLZ	11/15/11	4714	11/23/11	14:48	SW3550B/8081B
Methoxychlor	< 0.001	0.001	ug/g	1	JLZ	11/15/11	4714	11/23/11	14:48	SW3550B/8081B
alpha-Chlordane	< 0.001	0.001	ug/g	1	JLZ	11/15/11	4714	11/23/11	14:48	SW3550B/8081B
gamma-Chlordane	< 0.001	0.001	ug/g	1	JLZ	11/15/11	4714	11/23/11	14:48	SW3550B/8081B
Toxaphene	< 0.02	0.02	ug/g	1	JLZ	11/15/11	4714	11/23/11	14:48	SW3550B/8081B
Surrogate Recovery		**Limits**								
tetrachloro-m-xylene SUR	**61**	30-150	%	1	JLZ	11/15/11	4714	11/23/11	14:48	SW3550B/8081B
decachlorobiphenyl SUR	**49**	30-150	%	1	JLZ	11/15/11	4714	11/23/11	14:48	SW3550B/8081B

 # The percent recovery for the LCS/D was below the acceptance criteria. The result is an estimate.

Project ID: Exeter Dam
Job ID: 22819

Sample#: 22819-003
Sample ID: ER-3
Matrix: Solid   Percent Dry: 72.7% Results expressed on a dry weight basis.
Sampled: 11/7/11 13:15

Parameter	Result	Reporting Limit	Units	Instr Dil'n Factor	Analyst	Prep Date	Batch	Analysis Date	Analysis Time	Reference
gamma-BHC (Lindane)	< 0.001	0.001	ug/g	1	JLZ	11/15/11	4714	11/23/11	12:43	SW3550B/8081B
Heptachlor	< 0.001	0.001	ug/g	1	JLZ	11/15/11	4714	11/23/11	12:43	SW3550B/8081B
Aldrin	< 0.001	0.001	ug/g	1	JLZ	11/15/11	4714	11/23/11	12:43	SW3550B/8081B
Heptachlor Epoxide	< 0.001	0.001	ug/g	1	JLZ	11/15/11	4714	11/23/11	12:43	SW3550B/8081B
Endosulfan I	< 0.001	0.001	ug/g	1	JLZ	11/15/11	4714	11/23/11	12:43	SW3550B/8081B
Dieldrin	< 0.001	0.001	ug/g	1	JLZ	11/15/11	4714	11/23/11	12:43	SW3550B/8081B
4,4'-DDE	< 0.001	0.001	ug/g	1	JLZ	11/15/11	4714	11/23/11	12:43	SW3550B/8081B
Endrin	< 0.001	0.001	ug/g	1	JLZ	11/15/11	4714	11/23/11	12:43	SW3550B/8081B
Endosulfan II	< 0.001	0.001	ug/g	1	JLZ	11/15/11	4714	11/23/11	12:43	SW3550B/8081B
4,4'-DDD	< 0.001	0.001	ug/g	1	JLZ	11/15/11	4714	11/23/11	12:43	SW3550B/8081B
4,4'-DDT	< 0.001 #	0.001	ug/g	1	JLZ	11/15/11	4714	11/23/11	12:43	SW3550B/8081B
Methoxychlor	< 0.001	0.001	ug/g	1	JLZ	11/15/11	4714	11/23/11	12:43	SW3550B/8081B
alpha-Chlordane	< 0.001	0.001	ug/g	1	JLZ	11/15/11	4714	11/23/11	12:43	SW3550B/8081B
gamma-Chlordane	< 0.001	0.001	ug/g	1	JLZ	11/15/11	4714	11/23/11	12:43	SW3550B/8081B
Toxaphene	< 0.02	0.02	ug/g	1	JLZ	11/15/11	4714	11/23/11	12:43	SW3550B/8081B
Surrogate Recovery		**Limits**								
tetrachloro-m-xylene SUR	**56**	30-150	%	1	JLZ	11/15/11	4714	11/23/11	12:43	SW3550B/8081B
decachlorobiphenyl SUR	**48**	30-150	%	1	JLZ	11/15/11	4714	11/23/11	12:43	SW3550B/8081B

 # The percent recovery for the LCS/D was below the acceptance criteria. The result is an estimate.

Project ID: Exeter Dam
Job ID: 22819

Sample#: 22819-004
Sample ID: ER-4
Matrix: Solid   Percent Dry: 69.9% Results expressed on a dry weight basis.
Sampled: 11/7/11 14:30

Parameter	Result	Reporting Limit	Units	Instr Dil'n Factor	Analyst	Prep Date	Batch	Analysis Date	Analysis Time	Reference
gamma-BHC (Lindane)	< 0.001	0.001	ug/g	1	JLZ	11/15/11	4714	11/23/11	11:39	SW3550B/8081B
Heptachlor	< 0.001	0.001	ug/g	1	JLZ	11/15/11	4714	11/23/11	11:39	SW3550B/8081B
Aldrin	< 0.001	0.001	ug/g	1	JLZ	11/15/11	4714	11/23/11	11:39	SW3550B/8081B
Heptachlor Epoxide	< 0.001	0.001	ug/g	1	JLZ	11/15/11	4714	11/23/11	11:39	SW3550B/8081B
Endosulfan I	< 0.001	0.001	ug/g	1	JLZ	11/15/11	4714	11/23/11	11:39	SW3550B/8081B
Dieldrin	< 0.001	0.001	ug/g	1	JLZ	11/15/11	4714	11/23/11	11:39	SW3550B/8081B
4,4'-DDE	< 0.001	0.001	ug/g	1	JLZ	11/15/11	4714	11/23/11	11:39	SW3550B/8081B
Endrin	< 0.001	0.001	ug/g	1	JLZ	11/15/11	4714	11/23/11	11:39	SW3550B/8081B
Endosulfan II	< 0.001	0.001	ug/g	1	JLZ	11/15/11	4714	11/23/11	11:39	SW3550B/8081B
4,4'-DDD	< 0.001	0.001	ug/g	1	JLZ	11/15/11	4714	11/23/11	11:39	SW3550B/8081B
4,4'-DDT	< 0.001 #	0.001	ug/g	1	JLZ	11/15/11	4714	11/23/11	11:39	SW3550B/8081B
Methoxychlor	< 0.001	0.001	ug/g	1	JLZ	11/15/11	4714	11/23/11	11:39	SW3550B/8081B
alpha-Chlordane	< 0.001	0.001	ug/g	1	JLZ	11/15/11	4714	11/23/11	11:39	SW3550B/8081B
gamma-Chlordane	< 0.001	0.001	ug/g	1	JLZ	11/15/11	4714	11/23/11	11:39	SW3550B/8081B
Toxaphene	< 0.02	0.02	ug/g	1	JLZ	11/15/11	4714	11/23/11	11:39	SW3550B/8081B
Surrogate Recovery		**Limits**								
tetrachloro-m-xylene SUR	**49**	30-150	%	1	JLZ	11/15/11	4714	11/23/11	11:39	SW3550B/8081B
decachlorobiphenyl SUR	**60**	30-150	%	1	JLZ	11/15/11	4714	11/23/11	11:39	SW3550B/8081B

 # The percent recovery for the LCS/D was below the acceptance criteria. The result is an estimate.

Absolute Resource associates

Appendix I

Project ID: Exeter Dam
Job ID: 22819

Sample#: 22819-005
Sample ID: ER-5
Matrix: Solid   Percent Dry: 61.2% Results expressed on a dry weight basis.
Sampled: 11/7/11 15:40

Parameter	Result		Reporting Limit	Units	Instr Dil'n Factor	Analyst	Prep Date	Batch	Analysis Date	Analysis Time	Reference
gamma-BHC (Lindane)	< 0.001		0.001	ug/g	1	JLZ	11/15/11	4714	11/23/11	13:27	SW3550B/8081B
Heptachlor	< 0.001		0.001	ug/g	1	JLZ	11/15/11	4714	11/23/11	13:27	SW3550B/8081B
Aldrin	< 0.001		0.001	ug/g	1	JLZ	11/15/11	4714	11/23/11	13:27	SW3550B/8081B
Heptachlor Epoxide	< 0.001		0.001	ug/g	1	JLZ	11/15/11	4714	11/23/11	13:27	SW3550B/8081B
Endosulfan I	< 0.001		0.001	ug/g	1	JLZ	11/15/11	4714	11/23/11	13:27	SW3550B/8081B
Dieldrin	< 0.001		0.001	ug/g	1	JLZ	11/15/11	4714	11/23/11	13:27	SW3550B/8081B
4,4'-DDE	< 0.001		0.001	ug/g	1	JLZ	11/15/11	4714	11/23/11	13:27	SW3550B/8081B
Endrin	< 0.001		0.001	ug/g	1	JLZ	11/15/11	4714	11/23/11	13:27	SW3550B/8081B
Endosulfan II	< 0.001	M	0.001	ug/g	1	JLZ	11/15/11	4714	11/23/11	13:27	SW3550B/8081B
4,4'-DDD	< 0.001		0.001	ug/g	1	JLZ	11/15/11	4714	11/23/11	13:27	SW3550B/8081B
4,4'-DDT	< 0.001	#	0.001	ug/g	1	JLZ	11/15/11	4714	11/23/11	13:27	SW3550B/8081B
Methoxychlor	< 0.001	M	0.001	ug/g	1	JLZ	11/15/11	4714	11/23/11	13:27	SW3550B/8081B
alpha-Chlordane	< 0.001		0.001	ug/g	1	JLZ	11/15/11	4714	11/23/11	13:27	SW3550B/8081B
gamma-Chlordane	< 0.001		0.001	ug/g	1	JLZ	11/15/11	4714	11/23/11	13:27	SW3550B/8081B
Toxaphene	< 0.02		0.02	ug/g	1	JLZ	11/15/11	4714	11/23/11	13:27	SW3550B/8081B
Surrogate Recovery			**Limits**								
tetrachloro-m-xylene SUR	**43**		30-150	%	1	JLZ	11/15/11	4714	11/23/11	13:27	SW3550B/8081B
decachlorobiphenyl SUR	**40**		30-150	%	1	JLZ	11/15/11	4714	11/23/11	13:27	SW3550B/8081B

 # The percent recovery for the LCS/D was below the acceptance criteria. The result is an estimate.
M = The percent recovery in the MS/D was below the acceptance criteria. See QC report.

Absolute Resource associates

Project ID: Exeter Dam
Job ID: 22819

Sample#: 22819-006
Sample ID: LR-1
Matrix: Solid   Percent Dry: 57.5% Results expressed on a dry weight basis.
Sampled: 11/7/11 14:10

Parameter	Result	Reporting Limit	Units	Instr Dil'n Factor	Analyst	Prep Date	Batch	Analysis Date	Analysis Time	Reference
gamma-BHC (Lindane)	< 0.001	0.001	ug/g	1	JLZ	11/15/11	4714	11/23/11	15:27	SW3550B/8081B
Heptachlor	< 0.001	0.001	ug/g	1	JLZ	11/15/11	4714	11/23/11	15:27	SW3550B/8081B
Aldrin	< 0.001	0.001	ug/g	1	JLZ	11/15/11	4714	11/23/11	15:27	SW3550B/8081B
Heptachlor Epoxide	< 0.001	0.001	ug/g	1	JLZ	11/15/11	4714	11/23/11	15:27	SW3550B/8081B
Endosulfan I	< 0.001	0.001	ug/g	1	JLZ	11/15/11	4714	11/23/11	15:27	SW3550B/8081B
Dieldrin	< 0.001	0.001	ug/g	1	JLZ	11/15/11	4714	11/23/11	15:27	SW3550B/8081B
4,4'-DDE	< 0.001	0.001	ug/g	1	JLZ	11/15/11	4714	11/23/11	15:27	SW3550B/8081B
Endrin	< 0.001	0.001	ug/g	1	JLZ	11/15/11	4714	11/23/11	15:27	SW3550B/8081B
Endosulfan II	< 0.001	0.001	ug/g	1	JLZ	11/15/11	4714	11/23/11	15:27	SW3550B/8081B
4,4'-DDD	< 0.001	0.001	ug/g	1	JLZ	11/15/11	4714	11/23/11	15:27	SW3550B/8081B
4,4'-DDT	< 0.001 #	0.001	ug/g	1	JLZ	11/15/11	4714	11/23/11	15:27	SW3550B/8081B
Methoxychlor	< 0.001	0.001	ug/g	1	JLZ	11/15/11	4714	11/23/11	15:27	SW3550B/8081B
alpha-Chlordane	< 0.001	0.001	ug/g	1	JLZ	11/15/11	4714	11/23/11	15:27	SW3550B/8081B
gamma-Chlordane	< 0.001	0.001	ug/g	1	JLZ	11/15/11	4714	11/23/11	15:27	SW3550B/8081B
Toxaphene	< 0.02	0.02	ug/g	1	JLZ	11/15/11	4714	11/23/11	15:27	SW3550B/8081B
Surrogate Recovery		**Limits**								
tetrachloro-m-xylene SUR	**61**	30-150	%	1	JLZ	11/15/11	4714	11/23/11	15:27	SW3550B/8081B
decachlorobiphenyl SUR	**50**	30-150	%	1	JLZ	11/15/11	4714	11/23/11	15:27	SW3550B/8081B

 # The percent recovery for the LCS/D was below the acceptance criteria. The result is an estimate.

Project ID: Exeter Dam
Job ID: 22819

Sample#: 22819-001
Sample ID: ER-1
Matrix: Solid Percent Dry: 85.2% Results expressed on a dry weight basis.
Sampled: 11/7/11 12:10

Parameter	Result	Reporting Limit	Units	Instr Dil'n Factor	Analyst	Prep Date	Batch	Analysis Date	Analysis Time	Reference
PCB-1016	< 0.01	0.01	ug/g	1	JLZ	11/10/11	4709	11/16/11	3:52	SW3550B/8082
PCB-1221	< 0.01	0.01	ug/g	1	JLZ	11/10/11	4709	11/16/11	3:52	SW3550B/8082
PCB-1232	< 0.01	0.01	ug/g	1	JLZ	11/10/11	4709	11/16/11	3:52	SW3550B/8082
PCB-1242	< 0.01	0.01	ug/g	1	JLZ	11/10/11	4709	11/16/11	3:52	SW3550B/8082
PCB-1248	< 0.01	0.01	ug/g	1	JLZ	11/10/11	4709	11/16/11	3:52	SW3550B/8082
PCB-1254	< 0.01	0.01	ug/g	1	JLZ	11/10/11	4709	11/16/11	3:52	SW3550B/8082
PCB-1260	< 0.01	0.01	ug/g	1	JLZ	11/10/11	4709	11/16/11	3:52	SW3550B/8082
Surrogate Recovery		**Limits**								
tetrachloro-m-xylene SUR	**52**	30-150	%	1	JLZ	11/10/11	4709	11/16/11	3:52	SW3550B/8082
decachlorobiphenyl SUR	**51**	30-150	%	1	JLZ	11/10/11	4709	11/16/11	3:52	SW3550B/8082

Sample#: 22819-002
Sample ID: ER-2
Matrix: Solid Percent Dry: 72.2% Results expressed on a dry weight basis.
Sampled: 11/7/11 9:45

Parameter	Result	Reporting Limit	Units	Instr Dil'n Factor	Analyst	Prep Date	Batch	Analysis Date	Analysis Time	Reference
PCB-1016	< 0.01	0.01	ug/g	1	JLZ	11/10/11	4709	11/17/11	22:39	SW3550B/8082
PCB-1221	< 0.01	0.01	ug/g	1	JLZ	11/10/11	4709	11/17/11	22:39	SW3550B/8082
PCB-1232	< 0.01	0.01	ug/g	1	JLZ	11/10/11	4709	11/17/11	22:39	SW3550B/8082
PCB-1242	< 0.01	0.01	ug/g	1	JLZ	11/10/11	4709	11/17/11	22:39	SW3550B/8082
PCB-1248	< 0.01	0.01	ug/g	1	JLZ	11/10/11	4709	11/17/11	22:39	SW3550B/8082
PCB-1254	< 0.01	0.01	ug/g	1	JLZ	11/10/11	4709	11/17/11	22:39	SW3550B/8082
PCB-1260	< 0.01	0.01	ug/g	1	JLZ	11/10/11	4709	11/17/11	22:39	SW3550B/8082
Surrogate Recovery		**Limits**								
tetrachloro-m-xylene SUR	**31**	30-150	%	1	JLZ	11/10/11	4709	11/17/11	22:39	SW3550B/8082
decachlorobiphenyl SUR	**35**	30-150	%	1	JLZ	11/10/11	4709	11/17/11	22:39	SW3550B/8082

Project ID: Exeter Dam
Job ID: 22819

Sample#: 22819-003
Sample ID: ER-3
Matrix: Solid   Percent Dry: 72.7% Results expressed on a dry weight basis.
Sampled: 11/7/11 13:15

Parameter	Result	Reporting Limit	Units	Instr Dil'n Factor	Analyst	Prep Date	Batch	Analysis Date	Analysis Time	Reference
PCB-1016	< 0.01	0.01	ug/g	1	JLZ	11/10/11	4709	11/16/11	4:53	SW3550B/8082
PCB-1221	< 0.01	0.01	ug/g	1	JLZ	11/10/11	4709	11/16/11	4:53	SW3550B/8082
PCB-1232	< 0.01	0.01	ug/g	1	JLZ	11/10/11	4709	11/16/11	4:53	SW3550B/8082
PCB-1242	< 0.01	0.01	ug/g	1	JLZ	11/10/11	4709	11/16/11	4:53	SW3550B/8082
PCB-1248	< 0.01	0.01	ug/g	1	JLZ	11/10/11	4709	11/16/11	4:53	SW3550B/8082
PCB-1254	< 0.01	0.01	ug/g	1	JLZ	11/10/11	4709	11/16/11	4:53	SW3550B/8082
PCB-1260	< 0.01	0.01	ug/g	1	JLZ	11/10/11	4709	11/16/11	4:53	SW3550B/8082
Surrogate Recovery		**Limits**								
tetrachloro-m-xylene SUR	**53**	30-150	%	1	JLZ	11/10/11	4709	11/16/11	4:53	SW3550B/8082
decachlorobiphenyl SUR	**46**	30-150	%	1	JLZ	11/10/11	4709	11/16/11	4:53	SW3550B/8082

Sample#: 22819-004
Sample ID: ER-4
Matrix: Solid   Percent Dry: 69.9% Results expressed on a dry weight basis.
Sampled: 11/7/11 14:30

Parameter	Result	Reporting Limit	Units	Instr Dil'n Factor	Analyst	Prep Date	Batch	Analysis Date	Analysis Time	Reference
PCB-1016	< 0.01	0.01	ug/g	1	JLZ	11/10/11	4709	11/16/11	5:24	SW3550B/8082
PCB-1221	< 0.01	0.01	ug/g	1	JLZ	11/10/11	4709	11/16/11	5:24	SW3550B/8082
PCB-1232	< 0.01	0.01	ug/g	1	JLZ	11/10/11	4709	11/16/11	5:24	SW3550B/8082
PCB-1242	< 0.01	0.01	ug/g	1	JLZ	11/10/11	4709	11/16/11	5:24	SW3550B/8082
PCB-1248	< 0.01	0.01	ug/g	1	JLZ	11/10/11	4709	11/16/11	5:24	SW3550B/8082
PCB-1254	< 0.01	0.01	ug/g	1	JLZ	11/10/11	4709	11/16/11	5:24	SW3550B/8082
PCB-1260	< 0.01	0.01	ug/g	1	JLZ	11/10/11	4709	11/16/11	5:24	SW3550B/8082
Surrogate Recovery		**Limits**								
tetrachloro-m-xylene SUR	**49**	30-150	%	1	JLZ	11/10/11	4709	11/16/11	5:24	SW3550B/8082
decachlorobiphenyl SUR	**50**	30-150	%	1	JLZ	11/10/11	4709	11/16/11	5:24	SW3550B/8082

Project ID: Exeter Dam
Job ID: 22819

Sample#: 22819-005
Sample ID: ER-5
Matrix: Solid Percent Dry: 61.2% Results expressed on a dry weight basis.
Sampled: 11/7/11 15:40

Parameter	Result	Reporting Limit	Units	Instr Dil'n Factor	Analyst	Prep Date	Batch	Analysis Date	Analysis Time	Reference
PCB-1016	< 0.02 M	0.02	ug/g	1	JLZ	11/17/11	4756	11/17/11	23:10	SW3550B/8082
PCB-1221	< 0.02	0.02	ug/g	1	JLZ	11/17/11	4756	11/17/11	23:10	SW3550B/8082
PCB-1232	< 0.02	0.02	ug/g	1	JLZ	11/17/11	4756	11/17/11	23:10	SW3550B/8082
PCB-1242	< 0.02	0.02	ug/g	1	JLZ	11/17/11	4756	11/17/11	23:10	SW3550B/8082
PCB-1248	< 0.02	0.02	ug/g	1	JLZ	11/17/11	4756	11/17/11	23:10	SW3550B/8082
PCB-1254	< 0.02	0.02	ug/g	1	JLZ	11/17/11	4756	11/17/11	23:10	SW3550B/8082
PCB-1260	< 0.02 M	0.02	ug/g	1	JLZ	11/17/11	4756	11/17/11	23:10	SW3550B/8082
Surrogate Recovery		**Limits**								
tetrachloro-m-xylene SUR	**48**	30-150	%	1	JLZ	11/17/11	4756	11/17/11	23:10	SW3550B/8082
decachlorobiphenyl SUR	**53**	30-150	%	1	JLZ	11/17/11	4756	11/17/11	23:10	SW3550B/8082

M = The percent recovery for the MSD was below the acceptance limits. The percent recovery was acceptable in the MS.

Sample#: 22819-006
Sample ID: LR-1
Matrix: Solid Percent Dry: 57.5% Results expressed on a dry weight basis.
Sampled: 11/7/11 14:10

Parameter	Result	Reporting Limit	Units	Instr Dil'n Factor	Analyst	Prep Date	Batch	Analysis Date	Analysis Time	Reference
PCB-1016	< 0.02	0.02	ug/g	1	JLZ	11/17/11	4756	11/21/11	21:02	SW3550B/8082
PCB-1221	< 0.02	0.02	ug/g	1	JLZ	11/17/11	4756	11/21/11	21:02	SW3550B/8082
PCB-1232	< 0.02	0.02	ug/g	1	JLZ	11/17/11	4756	11/21/11	21:02	SW3550B/8082
PCB-1242	< 0.02	0.02	ug/g	1	JLZ	11/17/11	4756	11/21/11	21:02	SW3550B/8082
PCB-1248	< 0.02	0.02	ug/g	1	JLZ	11/17/11	4756	11/21/11	21:02	SW3550B/8082
PCB-1254	< 0.02	0.02	ug/g	1	JLZ	11/17/11	4756	11/21/11	21:02	SW3550B/8082
PCB-1260	< 0.02	0.02	ug/g	1	JLZ	11/17/11	4756	11/21/11	21:02	SW3550B/8082
Surrogate Recovery		**Limits**								
tetrachloro-m-xylene SUR	**40**	30-150	%	1	JLZ	11/17/11	4756	11/21/11	21:02	SW3550B/8082
decachlorobiphenyl SUR	**42**	30-150	%	1	JLZ	11/17/11	4756	11/21/11	21:02	SW3550B/8082

Project ID: Exeter Dam
Job ID: 22819

Sample#: 22819-001
Sample ID: ER-1
Matrix: Solid Percent Dry: 85.2% Results expressed on a dry weight basis.
Sampled: 11/7/11 12:10

Parameter	Result	Reporting Limit	Units	Instr Dil'n Factor	Analyst	Prep Date	Batch	Analysis Date	Analysis Time	Reference
Arsenic	**3.1**	0.6	ug/g	1	BJS	11/15/11	4706	11/17/11	20:13	SW3051A6010C
Barium	**35**	3	ug/g	1	BJS	11/15/11	4706	11/17/11	20:13	SW3051A6010C
Cadmium	< 0.2	0.2	ug/g	1	BJS	11/15/11	4706	11/17/11	20:13	SW3051A6010C
Chromium	**97**	3	ug/g	1	BJS	11/15/11	4706	11/17/11	20:13	SW3051A6010C
Copper	**18**	3	ug/g	1	BJS	11/15/11	4706	11/17/11	20:13	SW3051A6010C
Lead	**11**	0.6	ug/g	1	BJS	11/15/11	4706	11/17/11	20:13	SW3051A6010C
Mercury	**0.11**	0.04	ug/g	1	BJS	11/16/11	4723	11/16/11	16:12	SW7471B
Nickel	**25**	3	ug/g	1	BJS	11/15/11	4706	11/17/11	20:13	SW3051A6010C
Zinc	**49**	3	ug/g	1	BJS	11/15/11	4706	11/17/11	20:13	SW3051A6010C

Sample#: 22819-002
Sample ID: ER-2
Matrix: Solid Percent Dry: 72.2% Results expressed on a dry weight basis.
Sampled: 11/7/11 9:45

Parameter	Result	Reporting Limit	Units	Instr Dil'n Factor	Analyst	Prep Date	Batch	Analysis Date	Analysis Time	Reference
Arsenic	**5.2**	0.6	ug/g	1	BJS	11/15/11	4706	11/17/11	20:20	SW3051A6010C
Barium	**76**	3	ug/g	1	BJS	11/15/11	4706	11/17/11	20:20	SW3051A6010C
Cadmium	< 0.2	0.2	ug/g	1	BJS	11/15/11	4706	11/17/11	20:20	SW3051A6010C
Chromium	**29**	3	ug/g	1	BJS	11/15/11	4706	11/17/11	20:20	SW3051A6010C
Copper	**18**	3	ug/g	1	BJS	11/15/11	4706	11/17/11	20:20	SW3051A6010C
Lead	**43**	0.6	ug/g	1	BJS	11/15/11	4706	11/17/11	20:20	SW3051A6010C
Mercury	**0.11**	0.05	ug/g	1	BJS	11/16/11	4723	11/16/11	16:14	SW7471B
Nickel	**19**	3	ug/g	1	BJS	11/15/11	4706	11/17/11	20:20	SW3051A6010C
Zinc	**46**	3	ug/g	1	BJS	11/15/11	4706	11/17/11	20:20	SW3051A6010C

Sample#: 22819-003
Sample ID: ER-3
Matrix: Solid Percent Dry: 72.7% Results expressed on a dry weight basis.
Sampled: 11/7/11 13:15

Parameter	Result	Reporting Limit	Units	Instr Dil'n Factor	Analyst	Prep Date	Batch	Analysis Date	Analysis Time	Reference
Arsenic	**4.0**	0.7	ug/g	1	BJS	11/15/11	4706	11/17/11	20:28	SW3051A6010C
Barium	**60**	3	ug/g	1	BJS	11/15/11	4706	11/17/11	20:28	SW3051A6010C
Cadmium	< 0.3	0.3	ug/g	1	BJS	11/15/11	4706	11/17/11	20:28	SW3051A6010C
Chromium	**33**	3	ug/g	1	BJS	11/15/11	4706	11/17/11	20:28	SW3051A6010C
Copper	**4**	3	ug/g	1	BJS	11/15/11	4706	11/17/11	20:28	SW3051A6010C
Lead	**9.2**	0.7	ug/g	1	BJS	11/15/11	4706	11/17/11	20:28	SW3051A6010C
Mercury	< 0.05	0.05	ug/g	1	BJS	11/16/11	4723	11/16/11	16:16	SW7471B
Nickel	**13**	3	ug/g	1	BJS	11/15/11	4706	11/17/11	20:28	SW3051A6010C
Zinc	**39**	3	ug/g	1	BJS	11/15/11	4706	11/17/11	20:28	SW3051A6010C

Absolute Resource associates

Project ID: Exeter Dam
Job ID: 22819

Sample#: 22819-004
Sample ID: ER-4
Matrix: Solid Percent Dry: 69.9% Results expressed on a dry weight basis.
Sampled: 11/7/11 14:30

Parameter	Result	Reporting Limit	Units	Instr Dil'n Factor	Analyst	Prep Date	Batch	Analysis Date	Analysis Time	Reference
Arsenic	**12**	0.7	ug/g	1	BJS	11/15/11	4706	11/17/11	20:36	SW3051A6010C
Barium	**110**	4	ug/g	1	BJS	11/15/11	4706	11/17/11	20:36	SW3051A6010C
Cadmium	< 0.3	0.3	ug/g	1	BJS	11/15/11	4706	11/17/11	20:36	SW3051A6010C
Chromium	**45**	4	ug/g	1	BJS	11/15/11	4706	11/17/11	20:36	SW3051A6010C
Copper	**32**	4	ug/g	1	BJS	11/15/11	4706	11/17/11	20:36	SW3051A6010C
Lead	**15**	0.7	ug/g	1	BJS	11/15/11	4706	11/17/11	20:36	SW3051A6010C
Mercury	< 0.05	0.05	ug/g	1	BJS	11/16/11	4723	11/16/11	16:18	SW7471B
Nickel	**26**	4	ug/g	1	BJS	11/15/11	4706	11/17/11	20:36	SW3051A6010C
Zinc	**98**	4	ug/g	1	BJS	11/15/11	4706	11/17/11	20:36	SW3051A6010C

Sample#: 22819-005
Sample ID: ER-5
Matrix: Solid Percent Dry: 61.2% Results expressed on a dry weight basis.
Sampled: 11/7/11 15:40

Parameter	Result	Reporting Limit	Units	Instr Dil'n Factor	Analyst	Prep Date	Batch	Analysis Date	Analysis Time	Reference
Arsenic	**1.7**	0.7	ug/g	1	BJS	11/15/11	4706	11/17/11	20:44	SW3051A6010C
Barium	**29**	4	ug/g	1	BJS	11/15/11	4706	11/17/11	20:44	SW3051A6010C
Cadmium	< 0.3	0.3	ug/g	1	BJS	11/15/11	4706	11/17/11	20:44	SW3051A6010C
Chromium	**13**	4	ug/g	1	BJS	11/15/11	4706	11/17/11	20:44	SW3051A6010C
Copper	< 4	4	ug/g	1	BJS	11/15/11	4706	11/17/11	20:44	SW3051A6010C
Lead	**3.4**	0.7	ug/g	1	BJS	11/15/11	4706	11/17/11	20:44	SW3051A6010C
Mercury	< 0.05	0.05	ug/g	1	BJS	11/16/11	4723	11/16/11	16:20	SW7471B
Nickel	**5**	4	ug/g	1	BJS	11/15/11	4706	11/17/11	20:44	SW3051A6010C
Zinc	**16**	4	ug/g	1	BJS	11/15/11	4706	11/17/11	20:44	SW3051A6010C

Sample#: 22819-006
Sample ID: LR-1
Matrix: Solid Percent Dry: 57.5% Results expressed on a dry weight basis.
Sampled: 11/7/11 14:10

Parameter	Result	Reporting Limit	Units	Instr Dil'n Factor	Analyst	Prep Date	Batch	Analysis Date	Analysis Time	Reference
Arsenic	**13**	0.8	ug/g	1	BJS	11/15/11	4706	11/17/11	21:06	SW3051A6010C
Barium	**120**	4	ug/g	1	BJS	11/15/11	4706	11/17/11	21:06	SW3051A6010C
Cadmium	< 0.3	0.3	ug/g	1	BJS	11/15/11	4706	11/17/11	21:06	SW3051A6010C
Chromium	**42**	4	ug/g	1	BJS	11/15/11	4706	11/17/11	21:06	SW3051A6010C
Copper	**19**	4	ug/g	1	BJS	11/15/11	4706	11/17/11	21:06	SW3051A6010C
Lead	**30**	0.8	ug/g	1	BJS	11/15/11	4706	11/17/11	21:06	SW3051A6010C
Mercury	**1.3**	0.06	ug/g	1	BJS	11/16/11	4723	11/16/11	16:25	SW7471B
Nickel	**23**	4	ug/g	1	BJS	11/15/11	4706	11/17/11	21:06	SW3051A6010C
Zinc	**81**	4	ug/g	1	BJS	11/15/11	4706	11/17/11	21:06	SW3051A6010C

Quality Control Report

Absolute Resource associates
124 Heritage Avenue Unit 10
Portsmouth, NH 03801
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Absolute Resource associates

Case Narrative
Lab # 22819

Sample Receiving and Chain of Custody Discrepancies

Samples were received in acceptable condition, at 2 degrees C, on ice, and in accordance with sample handling, preservation and integrity guidelines.

Calibration

No exceptions noted.

Method Blank

No exceptions noted.

Surrogate Recoveries

No exceptions noted.

Laboratory Control Sample Results

VOC: The MLCS4715 did not meet the acceptance criteria for dichlorodifluoromethane, chloromethane, bromomethane, 2,2-dichloropropane, carbon tetrachloride, and cis-1,3-dichloropropene. The MLCSD4715 did not meet the acceptance criteria for bromomethane and 2,2-dichloropropane. Since <10% of the compounds were outside of the acceptance criteria, reanalysis is not required.
Pest: The LCS/D4714 did not meet the acceptance criteria for 4,4'-DDT. This failure is considered a sporadic marginal failure. The reported results should be considered estimates.

Matrix Spike/Matrix Spike Duplicate/Duplicate Results

VOC: Several compounds were below the acceptance criteria. See QC page for specific percent recoveries. Matrix interference suspected.
PAH: Three compounds were below the acceptance criteria. See QC page for specific percent recoveries. Matrix interference suspected.
Pest: Two compounds were below the acceptance criteria. See QC page for specific percent recoveries. Matrix interference suspected.
PCB: The percent recoveries for PCB-1016 and PCB-1260 were below the acceptance criteria in the matrix spike duplicate. The recoveries were acceptable in the matrix spike. See QC page for specific percent recoveries. Matrix interference suspected.

Other

Reporting Limits: Dilutions performed during the analysis are noted on the result pages.

No other exceptions noted.

- QC Report -

Method	QC ID	Parameter	Associated Sample	Result	Units	Amt Added	%R	Limits	RPD	RPD Limit
SW5035A8260B	MB4715	dichlorodifluoromethane		< 0.1	ug/g					
		chloromethane		< 0.1	ug/g					
		vinyl chloride		< 0.1	ug/g					
		bromomethane		< 0.2	ug/g					
		chloroethane		< 0.1	ug/g					
		trichlorofluoromethane		< 0.1	ug/g					
		diethyl ether		< 0.5	ug/g					
		acetone		< 2.5	ug/g					
		1,1-dichloroethene		< 0.1	ug/g					
		methylene chloride		< 0.2	ug/g					
		carbon disulfide		< 0.1	ug/g					
		methyl t-butyl ether (MTBE)		< 0.1	ug/g					
		trans-1,2-dichloroethene		< 0.1	ug/g					
		isopropyl ether (DIPE)		< 0.1	ug/g					
		ethyl t-butyl ether (ETBE)		< 0.1	ug/g					
		1,1-dichloroethane		< 0.1	ug/g					
		t-butanol (TBA)		< 2.5	ug/g					
		2-butanone (MEK)		< 0.5	ug/g					
		2,2-dichloropropane		< 0.1	ug/g					
		cis-1,2-dichloroethene		< 0.1	ug/g					
		chloroform		< 0.1	ug/g					
		bromochloromethane		< 0.1	ug/g					
		tetrahydrofuran (THF)		< 0.5	ug/g					
		1,1,1-trichloroethane		< 0.1	ug/g					
		1,1-dichloropropene		< 0.1	ug/g					
		t-amyl-methyl ether (TAME)		< 0.1	ug/g					
		carbon tetrachloride		< 0.1	ug/g					
		1,2-dichloroethane		< 0.1	ug/g					
		benzene		< 0.1	ug/g					
		trichloroethene		< 0.1	ug/g					
		1,2-dichloropropane		< 0.1	ug/g					
		bromodichloromethane		< 0.1	ug/g					
		1,4-dioxane		< 2.5	ug/g					
		dibromomethane		< 0.1	ug/g					
		4-methyl-2-pentanone (MIBK)		< 0.5	ug/g					
		cis-1,3-dichloropropene		< 0.1	ug/g					
		toluene		< 0.1	ug/g					
		trans-1,3-dichloropropene		< 0.1	ug/g					
		2-hexanone		< 0.5	ug/g					
		1,1,2-trichloroethane		< 0.1	ug/g					
		1,3-dichloropropane		< 0.1	ug/g					
		tetrachloroethene		< 0.1	ug/g					
		dibromochloromethane		< 0.1	ug/g					
		1,2-dibromoethane (EDB)		< 0.1	ug/g					
		chlorobenzene		< 0.1	ug/g					
		1,1,1,2-tetrachloroethane		< 0.1	ug/g					
		ethylbenzene		< 0.1	ug/g					
		m&p-xylenes		< 0.1	ug/g					
		o-xylene		< 0.1	ug/g					
		styrene		< 0.1	ug/g					

Method	QC ID	Parameter	Associated Sample		Result	Units	Amt Added	%R	Limits		RPD	RPD Limit
SW5035A8260B	MB4715	bromoform		<	0.1	ug/g						
		isopropylbenzene		<	0.1	ug/g						
		1,1,2,2-tetrachloroethane		<	0.1	ug/g						
		1,2,3-trichloropropane		<	0.1	ug/g						
		n-propylbenzene		<	0.1	ug/g						
		bromobenzene		<	0.1	ug/g						
		1,3,5-trimethylbenzene		<	0.1	ug/g						
		2-chlorotoluene		<	0.1	ug/g						
		4-chlorotoluene		<	0.1	ug/g						
		tert-butylbenzene		<	0.1	ug/g						
		1,2,4-trimethylbenzene		<	0.1	ug/g						
		sec-butylbenzene		<	0.1	ug/g						
		1,3-dichlorobenzene		<	0.1	ug/g						
		4-isopropyltoluene		<	0.1	ug/g						
		1,4-dichlorobenzene		<	0.1	ug/g						
		1,2-dichlorobenzene		<	0.1	ug/g						
		n-butylbenzene		<	0.1	ug/g						
		1,2-dibromo-3-chloropropane		<	0.1	ug/g						
		1,2,4-trichlorobenzene		<	0.1	ug/g						
		1,3,5-trichlorobenzene		<	0.1	ug/g						
		hexachlorobutadiene		<	0.1	ug/g						
		naphthalene		<	0.2	ug/g						
		1,2,3-trichlorobenzene		<	0.1	ug/g						
		dibromofluoromethane SUR			92	%			78	114		
		toluene-D8 SUR			93	%			88	110		
		4-bromofluorobenzene SUR			108	%			86	115		
		a,a,a-trifluorotoluene SUR			85	%			70	130		

Method	QC ID	Parameter	Associated Sample	Result	Units	Amt Added	%R		Limits		RPD	RPD Limit
SW5035A8260B	MLCS4715	dichlorodifluoromethane		0.7	ug/g	1	68	*	70	130		
		chloromethane		0.7	ug/g	1	67	*	70	130		
		vinyl chloride		0.9	ug/g	1	88		70	130		
		bromomethane		0.5	ug/g	1	49	*	70	130		
		chloroethane		0.9	ug/g	1	91		70	130		
		trichlorofluoromethane		0.8	ug/g	1	76		70	130		
		diethyl ether		0.9	ug/g	1	87		70	130		
		acetone		< 2.5	ug/g	1	93					
		1,1-dichloroethene		0.7	ug/g	1	74		70	130		
		methylene chloride		0.9	ug/g	1	89		70	130		
		carbon disulfide		0.9	ug/g	1	87		70	130		
		methyl t-butyl ether (MTBE)		0.9	ug/g	1	91		70	130		
		trans-1,2-dichloroethene		0.8	ug/g	1	80		70	130		
		isopropyl ether (DIPE)		0.9	ug/g	1	89		70	130		
		ethyl t-butyl ether (ETBE)		0.9	ug/g	1	88		70	130		
		1,1-dichloroethane		0.8	ug/g	1	77		70	130		
		t-butanol (TBA)		5.7	ug/g	5	114		70	130		
		2-butanone (MEK)		0.9	ug/g	1	90		70	130		
		2,2-dichloropropane		0.6	ug/g	1	55	*	70	130		
		cis-1,2-dichloroethene		0.8	ug/g	1	79		70	130		
		chloroform		0.8	ug/g	1	83		70	130		
		bromochloromethane		0.8	ug/g	1	85		70	130		
		tetrahydrofuran (THF)		0.8	ug/g	1	82		70	130		
		1,1,1-trichloroethane		0.7	ug/g	1	70		70	130		
		1,1-dichloropropene		0.8	ug/g	1	78		70	130		
		t-amyl-methyl ether (TAME)		0.8	ug/g	1	85		70	130		
		carbon tetrachloride		0.7	ug/g	1	68	*	70	130		
		1,2-dichloroethane		0.9	ug/g	1	91		70	130		
		benzene		0.8	ug/g	1	78		70	130		
		trichloroethene		0.8	ug/g	1	75		70	130		
		1,2-dichloropropane		0.7	ug/g	1	73		70	130		
		bromodichloromethane		0.8	ug/g	1	76		70	130		
		1,4-dioxane		< 2.5	ug/g	2	91		70	130		
		dibromomethane		0.8	ug/g	1	82		70	130		
		4-methyl-2-pentanone (MIBK)		0.9	ug/g	1	95		70	130		
		cis-1,3-dichloropropene		0.7	ug/g	1	69	*	70	130		
		toluene		0.8	ug/g	1	83		70	130		
		trans-1,3-dichloropropene		0.8	ug/g	1	76		70	130		
		2-hexanone		0.8	ug/g	1	83		70	130		
		1,1,2-trichloroethane		0.9	ug/g	1	88		70	130		
		1,3-dichloropropane		1.0	ug/g	1	96		70	130		
		tetrachloroethene		0.9	ug/g	1	89		70	130		
		dibromochloromethane		0.8	ug/g	1	82		70	130		
		1,2-dibromoethane (EDB)		0.9	ug/g	1	90		70	130		
		chlorobenzene		1.0	ug/g	1	96		70	130		
		1,1,1,2-tetrachloroethane		0.8	ug/g	1	80		70	130		
		ethylbenzene		1.0	ug/g	1	96		70	130		
		m&p-xylenes		1.9	ug/g	2	95		70	130		
		o-xylene		1.0	ug/g	1	98		70	130		
		styrene		1.0	ug/g	1	96		70	130		
		bromoform		0.9	ug/g	1	94		70	130		

Method	QC ID	Parameter	Associated Sample	Result	Units	Amt Added	%R	Limits		RPD	RPD Limit
SW5035A8260B	MLCS4715	isopropylbenzene		0.9	ug/g	1	92	70	130		
		1,1,2,2-tetrachloroethane		1.1	ug/g	1	106	70	130		
		1,2,3-trichloropropane		1.1	ug/g	1	106	70	130		
		n-propylbenzene		1.1	ug/g	1	107	70	130		
		bromobenzene		1.1	ug/g	1	113	70	130		
		1,3,5-trimethylbenzene		1.1	ug/g	1	107	70	130		
		2-chlorotoluene		1.1	ug/g	1	109	70	130		
		4-chlorotoluene		1.1	ug/g	1	105	70	130		
		tert-butylbenzene		1.1	ug/g	1	108	70	130		
		1,2,4-trimethylbenzene		1.1	ug/g	1	107	70	130		
		sec-butylbenzene		1.0	ug/g	1	103	70	130		
		1,3-dichlorobenzene		1.0	ug/g	1	101	70	130		
		4-isopropyltoluene		1.0	ug/g	1	103	70	130		
		1,4-dichlorobenzene		1.0	ug/g	1	101	70	130		
		1,2-dichlorobenzene		1.0	ug/g	1	104	70	130		
		n-butylbenzene		0.9	ug/g	1	94	70	130		
		1,2-dibromo-3-chloropropane		0.8	ug/g	1	79	70	130		
		1,2,4-trichlorobenzene		1.0	ug/g	1	98	70	130		
		1,3,5-trichlorobenzene		1.1	ug/g	1	109	70	130		
		hexachlorobutadiene		1.0	ug/g	1	101	70	130		
		naphthalene		0.9	ug/g	1	94	70	130		
		1,2,3-trichlorobenzene		1.0	ug/g	1	102	70	130		
		dibromofluoromethane SUR		101	%			78	114		
		toluene-D8 SUR		94	%			88	110		
		4-bromofluorobenzene SUR		109	%			86	115		
		a,a,a-trifluorotoluene SUR		86	%			70	130		

Method	QC ID	Parameter	Associated Sample		Result	Units	Amt Added	%R		Limits		RPD		RPD Limit
SW5035A8260B	MLCSD4715	dichlorodifluoromethane			0.8	ug/g	1	82		70	130	18		30
		chloromethane			0.8	ug/g	1	79		70	130	16		30
		vinyl chloride			1.0	ug/g	1	98		70	130	11		30
		bromomethane			1.5	ug/g	1	149	*	70	130	101	*	30
		chloroethane			1.0	ug/g	1	102		70	130	11		30
		trichlorofluoromethane			0.9	ug/g	1	89		70	130	16		30
		diethyl ether			1.0	ug/g	1	99		70	130	13		30
		acetone		<	2.5	ug/g	1	111				18		30
		1,1-dichloroethene			0.8	ug/g	1	82		70	130	10		30
		methylene chloride			1.0	ug/g	1	99		70	130	11		30
		carbon disulfide			1.0	ug/g	1	102		70	130	16		30
		methyl t-butyl ether (MTBE)			1.0	ug/g	1	100		70	130	10		30
		trans-1,2-dichloroethene			0.9	ug/g	1	89		70	130	11		30
		isopropyl ether (DIPE)			0.9	ug/g	1	95		70	130	6		30
		ethyl t-butyl ether (ETBE)			1.0	ug/g	1	97		70	130	10		30
		1,1-dichloroethane			0.9	ug/g	1	86		70	130	12		30
		t-butanol (TBA)			5.9	ug/g	5	118		70	130	4		30
		2-butanone (MEK)			0.9	ug/g	1	91		70	130	1		30
		2,2-dichloropropane			0.6	ug/g	1	60	*	70	130	8		30
		cis-1,2-dichloroethene			0.9	ug/g	1	86		70	130	9		30
		chloroform			0.9	ug/g	1	90		70	130	8		30
		bromochloromethane			1.0	ug/g	1	95		70	130	11		30
		tetrahydrofuran (THF)			0.9	ug/g	1	87		70	130	6		30
		1,1,1-trichloroethane			0.8	ug/g	1	77		70	130	10		30
		1,1-dichloropropene			0.9	ug/g	1	88		70	130	12		30
		t-amyl-methyl ether (TAME)			0.9	ug/g	1	92		70	130	9		30
		carbon tetrachloride			0.7	ug/g	1	74		70	130	9		30
		1,2-dichloroethane			1.0	ug/g	1	97		70	130	6		30
		benzene			0.9	ug/g	1	87		70	130	11		30
		trichloroethene			0.9	ug/g	1	86		70	130	13		30
		1,2-dichloropropane			0.8	ug/g	1	82		70	130	11		30
		bromodichloromethane			0.9	ug/g	1	85		70	130	12		30
		1,4-dioxane		<	2.5	ug/g	2	98		70	130	8		30
		dibromomethane			0.8	ug/g	1	84		70	130	2		30
		4-methyl-2-pentanone (MIBK)			1.0	ug/g	1	96		70	130	1		30
		cis-1,3-dichloropropene			0.7	ug/g	1	74		70	130	6		30
		toluene			0.9	ug/g	1	90		70	130	8		30
		trans-1,3-dichloropropene			0.8	ug/g	1	81		70	130	6		30
		2-hexanone			0.9	ug/g	1	90		70	130	7		30
		1,1,2-trichloroethane			0.9	ug/g	1	88		70	130	0		30
		1,3-dichloropropane			1.0	ug/g	1	103		70	130	7		30
		tetrachloroethene			1.1	ug/g	1	107		70	130	19		30
		dibromochloromethane			0.9	ug/g	1	86		70	130	4		30
		1,2-dibromoethane (EDB)			1.0	ug/g	1	99		70	130	9		30
		chlorobenzene			1.0	ug/g	1	105		70	130	9		30
		1,1,1,2-tetrachloroethane			0.8	ug/g	1	80		70	130	0		30
		ethylbenzene			1.0	ug/g	1	104		70	130	8		30
		m&p-xylenes			2.1	ug/g	2	103		70	130	8		30
		o-xylene			1.0	ug/g	1	104		70	130	6		30
		styrene			1.0	ug/g	1	102		70	130	6		30
		bromoform			1.0	ug/g	1	101		70	130	7		30

Method	QC ID	Parameter	Associated Sample	Result	Units	Amt Added	%R	Limits		RPD	RPD Limit
SW5035A8260B	MLCSD4715	isopropylbenzene		1.0	ug/g	1	97	70	130	5	30
		1,1,2,2-tetrachloroethane		1.2	ug/g	1	116	70	130	9	30
		1,2,3-trichloropropane		1.2	ug/g	1	118	70	130	11	30
		n-propylbenzene		1.2	ug/g	1	120	70	130	12	30
		bromobenzene		1.2	ug/g	1	124	70	130	9	30
		1,3,5-trimethylbenzene		1.2	ug/g	1	121	70	130	12	30
		2-chlorotoluene		1.2	ug/g	1	119	70	130	9	30
		4-chlorotoluene		1.2	ug/g	1	117	70	130	11	30
		tert-butylbenzene		1.3	ug/g	1	128	70	130	17	30
		1,2,4-trimethylbenzene		1.2	ug/g	1	120	70	130	11	30
		sec-butylbenzene		1.2	ug/g	1	117	70	130	13	30
		1,3-dichlorobenzene		1.2	ug/g	1	116	70	130	14	30
		4-isopropyltoluene		1.2	ug/g	1	118	70	130	14	30
		1,4-dichlorobenzene		1.2	ug/g	1	117	70	130	15	30
		1,2-dichlorobenzene		1.2	ug/g	1	115	70	130	10	30
		n-butylbenzene		1.1	ug/g	1	111	70	130	17	30
		1,2-dibromo-3-chloropropane		0.9	ug/g	1	92	70	130	15	30
		1,2,4-trichlorobenzene		1.1	ug/g	1	112	70	130	13	30
		1,3,5-trichlorobenzene		1.3	ug/g	1	129	70	130	17	30
		hexachlorobutadiene		1.2	ug/g	1	124	70	130	21	30
		naphthalene		1.0	ug/g	1	104	70	130	10	30
		1,2,3-trichlorobenzene		1.2	ug/g	1	119	70	130	15	30
		dibromofluoromethane SUR		98	%			78	114		
		toluene-D8 SUR		94	%			88	110		
		4-bromofluorobenzene SUR		106	%			86	115		
		a,a,a-trifluorotoluene SUR		94	%			70	130		

Method	QC ID	Parameter	Associated Sample		Result	Units	Amt Added	%R		Limits		RPD	RPD Limit
SW5035A8260B	MS4715	dichlorodifluoromethane	22819-005		0.2	ug/g	0.75	33	*	70	130		
		chloromethane	22819-005		0.6	ug/g	0.75	76		70	130		
		vinyl chloride	22819-005		0.7	ug/g	0.75	87		70	130		
		bromomethane	22819-005		1.4	ug/g	0.75	181	*	70	130		
		chloroethane	22819-005		0.7	ug/g	0.75	93		70	130		
		trichlorofluoromethane	22819-005		0.5	ug/g	0.75	71		70	130		
		diethyl ether	22819-005		0.7	ug/g	0.75	97		70	130		
		acetone	22819-005	<	3.5	ug/g	0.75	94					
		1,1-dichloroethene	22819-005		0.5	ug/g	0.75	70		70	130		
		methylene chloride	22819-005		0.7	ug/g	0.75	87		70	130		
		carbon disulfide	22819-005		0.6	ug/g	0.75	81		70	130		
		methyl t-butyl ether (MTBE)	22819-005		0.7	ug/g	0.75	98		70	130		
		trans-1,2-dichloroethene	22819-005		0.6	ug/g	0.75	82		70	130		
		isopropyl ether (DIPE)	22819-005		0.7	ug/g	0.75	97		70	130		
		ethyl t-butyl ether (ETBE)	22819-005		0.7	ug/g	0.75	94		70	130		
		1,1-dichloroethane	22819-005		0.6	ug/g	0.75	83		70	130		
		t-butanol (TBA)	22819-005		4.7	ug/g	3.77	125		70	130		
		2-butanone (MEK)	22819-005		0.7	ug/g	0.75	91		70	130		
		2,2-dichloropropane	22819-005		0.4	ug/g	0.75	49	*	70	130		
		cis-1,2-dichloroethene	22819-005		0.6	ug/g	0.75	79		70	130		
		chloroform	22819-005		0.6	ug/g	0.75	83		70	130		
		bromochloromethane	22819-005		0.7	ug/g	0.75	88		70	130		
		tetrahydrofuran (THF)	22819-005	<	0.7	ug/g	0.75	84		70	130		
		1,1,1-trichloroethane	22819-005		0.5	ug/g	0.75	64	*	70	130		
		1,1-dichloropropene	22819-005		0.6	ug/g	0.75	76		70	130		
		t-amyl-methyl ether (TAME)	22819-005		0.7	ug/g	0.75	90		70	130		
		carbon tetrachloride	22819-005		0.5	ug/g	0.75	60	*	70	130		
		1,2-dichloroethane	22819-005		0.7	ug/g	0.75	89		70	130		
		benzene	22819-005		0.6	ug/g	0.75	78		70	130		
		trichloroethene	22819-005		0.5	ug/g	0.75	73		70	130		
		1,2-dichloropropane	22819-005		0.6	ug/g	0.75	75		70	130		
		bromodichloromethane	22819-005		0.5	ug/g	0.75	69	*	70	130		
		1,4-dioxane	22819-005	<	3.5	ug/g	1.50	77					
		dibromomethane	22819-005		0.6	ug/g	0.75	73		70	130		
		4-methyl-2-pentanone (MIBK)	22819-005		0.7	ug/g	0.75	95		70	130		
		cis-1,3-dichloropropene	22819-005		0.5	ug/g	0.75	61	*	70	130		
		toluene	22819-005		0.6	ug/g	0.75	78		70	130		
		trans-1,3-dichloropropene	22819-005		0.5	ug/g	0.75	65	*	70	130		
		2-hexanone	22819-005	<	0.7	ug/g	0.75	75		70	130		
		1,1,2-trichloroethane	22819-005		0.6	ug/g	0.75	82		70	130		
		1,3-dichloropropane	22819-005		0.7	ug/g	0.75	95		70	130		
		tetrachloroethene	22819-005		0.6	ug/g	0.75	79		70	130		
		dibromochloromethane	22819-005		0.5	ug/g	0.75	66	*	70	130		
		1,2-dibromoethane (EDB)	22819-005		0.6	ug/g	0.75	81		70	130		
		chlorobenzene	22819-005		0.7	ug/g	0.75	88		70	130		
		1,1,1,2-tetrachloroethane	22819-005		0.5	ug/g	0.75	64	*	70	130		
		ethylbenzene	22819-005		0.6	ug/g	0.75	85		70	130		
		m&p-xylenes	22819-005		1.2	ug/g	1.50	81		70	130		
		o-xylene	22819-005		0.6	ug/g	0.75	84		70	130		
		styrene	22819-005		0.5	ug/g	0.75	66	*	70	130		
		bromoform	22819-005		0.6	ug/g	0.75	73		70	130		

Method	QC ID	Parameter	Associated Sample	Result	Units	Amt Added	%R		Limits		RPD	RPD Limit
SW5035A8260B	MS4715	isopropylbenzene	22819-005	0.6	ug/g	0.75	79		70	130		
		1,1,2,2-tetrachloroethane	22819-005	0.8	ug/g	0.75	102		70	130		
		1,2,3-trichloropropane	22819-005	0.8	ug/g	0.75	103		70	130		
		n-propylbenzene	22819-005	0.7	ug/g	0.75	87		70	130		
		bromobenzene	22819-005	0.7	ug/g	0.75	95		70	130		
		1,3,5-trimethylbenzene	22819-005	0.6	ug/g	0.75	81		70	130		
		2-chlorotoluene	22819-005	0.6	ug/g	0.75	85		70	130		
		4-chlorotoluene	22819-005	0.6	ug/g	0.75	86		70	130		
		tert-butylbenzene	22819-005	0.7	ug/g	0.75	89		70	130		
		1,2,4-trimethylbenzene	22819-005	0.6	ug/g	0.75	83		70	130		
		sec-butylbenzene	22819-005	0.6	ug/g	0.75	81		70	130		
		1,3-dichlorobenzene	22819-005	0.6	ug/g	0.75	75		70	130		
		4-isopropyltoluene	22819-005	0.6	ug/g	0.75	79		70	130		
		1,4-dichlorobenzene	22819-005	0.6	ug/g	0.75	76		70	130		
		1,2-dichlorobenzene	22819-005	0.6	ug/g	0.75	78		70	130		
		n-butylbenzene	22819-005	0.5	ug/g	0.75	66	*	70	130		
		1,2-dibromo-3-chloropropane	22819-005	0.5	ug/g	0.75	61	*	70	130		
		1,2,4-trichlorobenzene	22819-005	0.4	ug/g	0.75	48	*	70	130		
		1,3,5-trichlorobenzene	22819-005	0.5	ug/g	0.75	62	*	70	130		
		hexachlorobutadiene	22819-005	0.5	ug/g	0.75	63	*	70	130		
		naphthalene	22819-005	0.4	ug/g	0.75	53	*	70	130		
		1,2,3-trichlorobenzene	22819-005	0.4	ug/g	0.75	54	*	70	130		
		dibromofluoromethane SUR	22819-005	96	%				78	114		
		toluene-D8 SUR	22819-005	94	%				88	110		
		4-bromofluorobenzene SUR	22819-005	109	%				86	115		
		a,a,a-trifluorotoluene SUR	22819-005	81	%				70	130		

Method	QC ID	Parameter	Associated Sample		Result	Units	Amt Added	%R		Limits		RPD		RPD Limit
SW5035A8260B	MSD4715	dichlorodifluoromethane	22819-005		0.6	ug/g	1.23	47	*	70	130	35	*	30
		chloromethane	22819-005		1.0	ug/g	1.23	78		70	130	3		30
		vinyl chloride	22819-005		1.2	ug/g	1.23	96		70	130	10		30
		bromomethane	22819-005		2.1	ug/g	1.23	168	*	70	130	7		30
		chloroethane	22819-005		1.2	ug/g	1.23	100		70	130	7		30
		trichlorofluoromethane	22819-005		1.0	ug/g	1.23	80		70	130	12		30
		diethyl ether	22819-005		1.2	ug/g	1.23	97		70	130	0		
		acetone	22819-005	<	4.7	ug/g	1.23	109				15		
		1,1-dichloroethene	22819-005		0.9	ug/g	1.23	75		70	130	7		30
		methylene chloride	22819-005		1.2	ug/g	1.23	93		70	130	7		30
		carbon disulfide	22819-005		1.1	ug/g	1.23	90		70	130	11		30
		methyl t-butyl ether (MTBE)	22819-005		1.2	ug/g	1.23	101		70	130	3		30
		trans-1,2-dichloroethene	22819-005		1.1	ug/g	1.23	87		70	130	6		30
		isopropyl ether (DIPE)	22819-005		1.2	ug/g	1.23	99		70	130	2		30
		ethyl t-butyl ether (ETBE)	22819-005		1.3	ug/g	1.23	101		70	130	7		30
		1,1-dichloroethane	22819-005		1.1	ug/g	1.23	87		70	130	5		30
		t-butanol (TBA)	22819-005		7.9	ug/g	6.16	128		70	130	2		30
		2-butanone (MEK)	22819-005		1.3	ug/g	1.23	100		70	130	9		
		2,2-dichloropropane	22819-005		0.7	ug/g	1.23	53	*	70	130	8		30
		cis-1,2-dichloroethene	22819-005		1.1	ug/g	1.23	86		70	130	8		30
		chloroform	22819-005		1.1	ug/g	1.23	90		70	130	8		30
		bromochloromethane	22819-005		1.1	ug/g	1.23	92		70	130	4		30
		tetrahydrofuran (THF)	22819-005		1.1	ug/g	1.23	91		70	130	8		
		1,1,1-trichloroethane	22819-005		0.9	ug/g	1.23	72		70	130	12		30
		1,1-dichloropropene	22819-005		1.0	ug/g	1.23	85		70	130	11		30
		t-amyl-methyl ether (TAME)	22819-005		1.1	ug/g	1.23	91		70	130	1		30
		carbon tetrachloride	22819-005		0.9	ug/g	1.23	71		70	130	17		30
		1,2-dichloroethane	22819-005		1.2	ug/g	1.23	95		70	130	7		30
		benzene	22819-005		1.1	ug/g	1.23	86		70	130	10		30
		trichloroethene	22819-005		1.0	ug/g	1.23	84		70	130	14		30
		1,2-dichloropropane	22819-005		1.0	ug/g	1.23	80		70	130	6		30
		bromodichloromethane	22819-005		1.0	ug/g	1.23	78		70	130	12		30
		1,4-dioxane	22819-005	<	4.7	ug/g	2.46	101		70	130	27		
		dibromomethane	22819-005		1.1	ug/g	1.23	85		70	130	15		30
		4-methyl-2-pentanone (MIBK)	22819-005		1.3	ug/g	1.23	103		70	130	8		
		cis-1,3-dichloropropene	22819-005		0.8	ug/g	1.23	67	*	70	130	9		30
		toluene	22819-005		1.1	ug/g	1.23	86		70	130	10		30
		trans-1,3-dichloropropene	22819-005		0.9	ug/g	1.23	74		70	130	13		30
		2-hexanone	22819-005		1.2	ug/g	1.23	86		70	130	14		
		1,1,2-trichloroethane	22819-005		1.1	ug/g	1.23	91		70	130	10		30
		1,3-dichloropropane	22819-005		1.3	ug/g	1.23	103		70	130	8		30
		tetrachloroethene	22819-005		1.2	ug/g	1.23	100		70	130	23		30
		dibromochloromethane	22819-005		1.0	ug/g	1.23	79		70	130	18		30
		1,2-dibromoethane (EDB)	22819-005		1.1	ug/g	1.23	90		70	130	11		30
		chlorobenzene	22819-005		1.3	ug/g	1.23	104		70	130	17		30
		1,1,1,2-tetrachloroethane	22819-005		1.0	ug/g	1.23	77		70	130	18		30
		ethylbenzene	22819-005		1.3	ug/g	1.23	102		70	130	18		30
		m&p-xylenes	22819-005		2.5	ug/g	2.46	102		70	130	23		30
		o-xylene	22819-005		1.3	ug/g	1.23	106		70	130	23		30
		styrene	22819-005		1.1	ug/g	1.23	90		70	130	31	*	30
		bromoform	22819-005		1.2	ug/g	1.23	92		70	130	23		30

Method	QC ID	Parameter	Associated Sample	Result	Units	Amt Added	%R	Limits		RPD		RPD Limit
SW5035A8260B	MSD4715	isopropylbenzene	22819-005	1.2	ug/g	1.23	100	70	130	23		30
		1,1,2,2-tetrachloroethane	22819-005	1.5	ug/g	1.23	118	70	130	15		30
		1,2,3-trichloropropane	22819-005	1.5	ug/g	1.23	123	70	130	18		30
		n-propylbenzene	22819-005	1.5	ug/g	1.23	118	70	130	30		30
		bromobenzene	22819-005	1.5	ug/g	1.23	124	70	130	26		30
		1,3,5-trimethylbenzene	22819-005	1.5	ug/g	1.23	118	70	130	37	*	30
		2-chlorotoluene	22819-005	1.5	ug/g	1.23	121	70	130	35	*	30
		4-chlorotoluene	22819-005	1.4	ug/g	1.23	117	70	130	31	*	30
		tert-butylbenzene	22819-005	1.6	ug/g	1.23	126	70	130	34	*	30
		1,2,4-trimethylbenzene	22819-005	1.5	ug/g	1.23	118	70	130	35	*	30
		sec-butylbenzene	22819-005	1.5	ug/g	1.23	119	70	130	38	*	30
		1,3-dichlorobenzene	22819-005	1.4	ug/g	1.23	111	70	130	39	*	30
		4-isopropyltoluene	22819-005	1.4	ug/g	1.23	117	70	130	39	*	30
		1,4-dichlorobenzene	22819-005	1.4	ug/g	1.23	110	70	130	37	*	30
		1,2-dichlorobenzene	22819-005	1.4	ug/g	1.23	112	70	130	36	*	30
		n-butylbenzene	22819-005	1.3	ug/g	1.23	104	70	130	45	*	30
		1,2-dibromo-3-chloropropane	22819-005	1.0	ug/g	1.23	80	70	130	27		30
		1,2,4-trichlorobenzene	22819-005	1.2	ug/g	1.23	91	70	130	62	*	30
		1,3,5-trichlorobenzene	22819-005	1.3	ug/g	1.23	107	70	130	53	*	30
		hexachlorobutadiene	22819-005	1.4	ug/g	1.23	112	70	130	56	*	30
		naphthalene	22819-005	1.1	ug/g	1.23	86	70	130	47		
		1,2,3-trichlorobenzene	22819-005	1.3	ug/g	1.23	99	70	130	59	*	30
		dibromofluoromethane SUR	22819-005	96	%			78	114			
		toluene-D8 SUR	22819-005	96	%			88	110			
		4-bromofluorobenzene SUR	22819-005	105	%			86	115			
		a,a,a-trifluorotoluene SUR	22819-005	92	%			70	130			

Method	QC ID	Parameter	Associated Sample		Result	Units	Amt Added	%R		Limits		RPD	RPD Limit
SW3550B/8081	BLK4714	gamma-BHC (Lindane)		<	0.001	ug/g							
		Heptachlor		<	0.001	ug/g							
		Aldrin		<	0.001	ug/g							
		Heptachlor Epoxide		<	0.001	ug/g							
		Endosulfan I		<	0.001	ug/g							
		Dieldrin		<	0.001	ug/g							
		4,4'-DDE		<	0.001	ug/g							
		Endrin		<	0.001	ug/g							
		Endosulfan II		<	0.001	ug/g							
		4,4'-DDD		<	0.001	ug/g							
		4,4'-DDT		<	0.001	ug/g							
		Methoxychlor		<	0.001	ug/g							
		alpha-Chlordane		<	0.001	ug/g							
		gamma-Chlordane		<	0.001	ug/g							
		Toxaphene		<	0.02	ug/g							
		tetrachloro-m-xylene SUR			57	%				30	150		
		decachlorobiphenyl SUR			59	%				30	150		
SW3550B/8081	LCS4714	gamma-BHC (Lindane)			0.017	ug/g	0.04	43		40	140		
		Heptachlor			0.016	ug/g	0.04	40		40	140		
		Aldrin			0.018	ug/g	0.04	44		40	140		
		Heptachlor Epoxide			0.019	ug/g	0.04	48		40	140		
		Endosulfan I			0.019	ug/g	0.04	47		40	140		
		Dieldrin			0.019	ug/g	0.04	48		40	140		
		4,4'-DDE			0.019	ug/g	0.04	48		40	140		
		Endrin			0.018	ug/g	0.04	45		40	140		
		Endosulfan II			0.018	ug/g	0.04	46		40	140		
		4,4'-DDD			0.022	ug/g	0.04	55		40	140		
		4,4'-DDT			0.009	ug/g	0.04	22	*	40	140		
		Methoxychlor			0.024	ug/g	0.04	60		40	140		
		alpha-Chlordane			0.029	ug/g	0.04	73		40	140		
		gamma-Chlordane			0.018	ug/g	0.04	45		40	140		
		Toxaphene		<	0.02	ug/g							
		tetrachloro-m-xylene SUR			52	%				30	150		
		decachlorobiphenyl SUR			56	%				30	150		

Method	QC ID	Parameter	Associated Sample		Result	Units	Amt Added	%R		Limits		RPD	RPD Limit
SW3550B/8081	LCSD4714	gamma-BHC (Lindane)			0.017	ug/g	0.04	41		40	140	4	30
		Heptachlor			0.016	ug/g	0.04	40		40	140	1	30
		Aldrin			0.017	ug/g	0.04	44		40	140	2	30
		Heptachlor Epoxide			0.018	ug/g	0.04	45		40	140	5	30
		Endosulfan I			0.018	ug/g	0.04	45		40	140	6	30
		Dieldrin			0.018	ug/g	0.04	45		40	140	7	30
		4,4'-DDE			0.018	ug/g	0.04	46		40	140	4	30
		Endrin			0.017	ug/g	0.04	43		40	140	5	30
		Endosulfan II			0.017	ug/g	0.04	42		40	140	8	30
		4,4'-DDD			0.020	ug/g	0.04	51		40	140	8	30
		4,4'-DDT			0.010	ug/g	0.04	25	*	40	140	10	30
		Methoxychlor			0.026	ug/g	0.04	66		40	140	10	30
		alpha-Chlordane			0.027	ug/g	0.04	68		40	140	6	30
		gamma-Chlordane			0.017	ug/g	0.04	42		40	140	7	30
		Toxaphene		<	0.02	ug/g							
		tetrachloro-m-xylene SUR			53	%				30	150		
		decachlorobiphenyl SUR			52	%				30	150		
SW3550B/8081	MS4714	gamma-BHC (Lindane)	22819-005		0.023	ug/g	0.032	71		30	150		
		Heptachlor	22819-005		0.022	ug/g	0.032	69		30	150		
		Aldrin	22819-005		0.023	ug/g	0.032	71		30	150		
		Heptachlor Epoxide	22819-005		0.023	ug/g	0.032	71		30	150		
		Endosulfan I	22819-005		0.022	ug/g	0.032	69		30	150		
		Dieldrin	22819-005		0.022	ug/g	0.032	70		30	150		
		4,4'-DDE	22819-005		0.022	ug/g	0.032	70		30	150		
		Endrin	22819-005		0.021	ug/g	0.032	65		30	150		
		Endosulfan II	22819-005		0.019	ug/g	0.032	58		30	150		
		4,4'-DDD	22819-005		0.023	ug/g	0.032	70		30	150		
		4,4'-DDT	22819-005		0.013	ug/g	0.032	40		30	150		
		Methoxychlor	22819-005		0.013	ug/g	0.032	41		30	150		
		alpha-Chlordane	22819-005		0.033	ug/g	0.032	103		30	150		
		gamma-Chlordane	22819-005		0.021	ug/g	0.032	65		30	150		
		Toxaphene	22819-005	<	0.03	ug/g							
		tetrachloro-m-xylene SUR	22819-005		51	%				30	150		
		decachlorobiphenyl SUR	22819-005		41	%				30	150		

Method	QC ID	Parameter	Associated Sample		Result	Units	Amt Added	%R	Limits		RPD	RPD Limit
SW3550B/8081	MSD4714	gamma-BHC (Lindane)	22819-005		0.024	ug/g	0.032	74	30	150	5	30
		Heptachlor	22819-005		0.022	ug/g	0.032	68	30	150	2	30
		Aldrin	22819-005		0.023	ug/g	0.032	73	30	150	2	30
		Heptachlor Epoxide	22819-005		0.024	ug/g	0.032	76	30	150	6	30
		Endosulfan I	22819-005		0.024	ug/g	0.032	73	30	150	6	30
		Dieldrin	22819-005		0.023	ug/g	0.032	73	30	150	4	30
		4,4'-DDE	22819-005		0.023	ug/g	0.032	72	30	150	3	30
		Endrin	22819-005		0.022	ug/g	0.032	68	30	150	5	30
		Endosulfan II	22819-005		0.020	ug/g	0.032	62	30	150	6	30
		4,4'-DDD	22819-005		0.025	ug/g	0.032	76	30	150	9	30
		4,4'-DDT	22819-005		0.011	ug/g	0.032	33	30	150	19	30
		Methoxychlor	22819-005		0.011	ug/g	0.032	35	30	150	17	30
		alpha-Chlordane	22819-005		0.035	ug/g	0.032	108	30	150	5	30
		gamma-Chlordane	22819-005		0.022	ug/g	0.032	69	30	150	5	30
		Toxaphene	22819-005	<	0.03	ug/g						
		tetrachloro-m-xylene SUR	22819-005		51	%			30	150		
		decachlorobiphenyl SUR	22819-005		43	%			30	150		

Method	QC ID	Parameter	Associated Sample		Result	Units	Amt Added	%R	Limits		RPD	RPD Limit
SW3550B/8082	BLK4709	PCB-1016		<	0.01	ug/g						
		PCB-1221		<	0.01	ug/g						
		PCB-1232		<	0.01	ug/g						
		PCB-1242		<	0.01	ug/g						
		PCB-1248		<	0.01	ug/g						
		PCB-1254		<	0.01	ug/g						
		PCB-1260		<	0.01	ug/g						
		tetrachloro-m-xylene SUR			56	%			30	150		
		decachlorobiphenyl SUR			64	%			30	150		
SW3550B/8082	LCS4709	PCB-1016			0.07	ug/g	0.1	67	40	140		
		PCB-1221		<	0.01	ug/g						
		PCB-1232		<	0.01	ug/g						
		PCB-1242		<	0.01	ug/g						
		PCB-1248		<	0.01	ug/g						
		PCB-1254		<	0.01	ug/g						
		PCB-1260			0.07	ug/g	0.1	67	40	140		
		tetrachloro-m-xylene SUR			48	%			30	150		
		decachlorobiphenyl SUR			62	%			30	150		
SW3550B/8082	LCSD4709	PCB-1016			0.06	ug/g	0.1	64	40	140	4	30
		PCB-1221		<	0.01	ug/g						
		PCB-1232		<	0.01	ug/g						
		PCB-1242		<	0.01	ug/g						
		PCB-1248		<	0.01	ug/g						
		PCB-1254		<	0.01	ug/g						
		PCB-1260			0.06	ug/g	0.1	63	40	140	6	30
		tetrachloro-m-xylene SUR			46	%			30	150		
		decachlorobiphenyl SUR			56	%			30	150		

Method	QC ID	Parameter	Associated Sample		Result	Units	Amt Added	%R		Limits		RPD	RPD Limit
SW3550B/8082	BLK4756	PCB-1016		<	0.01	ug/g							
		PCB-1221		<	0.01	ug/g							
		PCB-1232		<	0.01	ug/g							
		PCB-1242		<	0.01	ug/g							
		PCB-1248		<	0.01	ug/g							
		PCB-1254		<	0.01	ug/g							
		PCB-1260		<	0.01	ug/g							
		tetrachloro-m-xylene SUR			70	%				30	150		
		decachlorobiphenyl SUR			83	%				30	150		
SW3550B/8082	LCS4756	PCB-1016			0.1	ug/g	0.1	85		40	140		
		PCB-1221		<	0.01	ug/g							
		PCB-1232		<	0.01	ug/g							
		PCB-1242		<	0.01	ug/g							
		PCB-1248		<	0.01	ug/g							
		PCB-1254		<	0.01	ug/g							
		PCB-1260			0.1	ug/g	0.1	87		40	140		
		tetrachloro-m-xylene SUR			70	%				30	150		
		decachlorobiphenyl SUR			86	%				30	150		
SW3550B/8082	LCSD4756	PCB-1016			0.1	ug/g	0.1	89		40	140	5	30
		PCB-1221		<	0.01	ug/g							
		PCB-1232		<	0.01	ug/g							
		PCB-1242		<	0.01	ug/g							
		PCB-1248		<	0.01	ug/g							
		PCB-1254		<	0.01	ug/g							
		PCB-1260			0.1	ug/g	0.1	94		40	140	7	30
		tetrachloro-m-xylene SUR			71	%				30	150		
		decachlorobiphenyl SUR			88	%				30	150		
SW3550B/8082	MS4756	PCB-1016	22819-005		0.07	ug/g	0.154	48		40	140		
		PCB-1221	22819-005	<	0.02	ug/g							
		PCB-1232	22819-005	<	0.02	ug/g							
		PCB-1242	22819-005	<	0.02	ug/g							
		PCB-1248	22819-005	<	0.02	ug/g							
		PCB-1254	22819-005	<	0.02	ug/g							
		PCB-1260	22819-005		0.07	ug/g	0.154	46		40	140		
		tetrachloro-m-xylene SUR	22819-005		39	%				30	150		
		decachlorobiphenyl SUR	22819-005		46	%				30	150		
SW3550B/8082	MSD4756	PCB-1016	22819-005		0.06	ug/g	0.154	38	*	40	140	23	30
		PCB-1221	22819-005	<	0.02	ug/g							
		PCB-1232	22819-005	<	0.02	ug/g							
		PCB-1242	22819-005	<	0.02	ug/g							
		PCB-1248	22819-005	<	0.02	ug/g							
		PCB-1254	22819-005	<	0.02	ug/g							
		PCB-1260	22819-005		0.06	ug/g	0.154	38	*	40	140	18	30
		tetrachloro-m-xylene SUR	22819-005		31	%				30	150		
		decachlorobiphenyl SUR	22819-005		37	%				30	150		

Method	QC ID	Parameter	Associated Sample		Result	Units	Amt Added	%R	Limits		RPD	RPD Limit
SW3550B8270D	BLK4713	naphthalene		<	0.02	ug/g						
		2-methylnaphthalene		<	0.02	ug/g						
		acenaphthylene		<	0.02	ug/g						
		acenaphthene		<	0.02	ug/g						
		dibenzofuran		<	0.02	ug/g						
		fluorene		<	0.02	ug/g						
		phenanthrene		<	0.02	ug/g						
		anthracene		<	0.02	ug/g						
		fluoranthene		<	0.02	ug/g						
		pyrene		<	0.02	ug/g						
		benzo(a)anthracene		<	0.02	ug/g						
		chrysene		<	0.02	ug/g						
		benzo(b)fluoranthene		<	0.02	ug/g						
		benzo(k)fluoranthene		<	0.02	ug/g						
		benzo(a)pyrene		<	0.02	ug/g						
		indeno(1,2,3-cd)pyrene		<	0.02	ug/g						
		dibenzo(a,h)anthracene		<	0.02	ug/g						
		benzo(g,h,i)perylene		<	0.02	ug/g						
		2-fluorobiphenyl SUR			49	%			43	116		
		o-terphenyl SUR			73	%			33	141		
SW3550B8270D	LCS4713	naphthalene			1.0	ug/g	1.6	65	40	140		
		2-methylnaphthalene			1.1	ug/g	1.6	68	40	140		
		acenaphthylene			1.2	ug/g	1.6	76	40	140		
		acenaphthene			1.3	ug/g	1.6	79	40	140		
		dibenzofuran		<	0.02	ug/g						
		fluorene			1.2	ug/g	1.6	77	40	140		
		phenanthrene			1.4	ug/g	1.6	85	40	140		
		anthracene			1.3	ug/g	1.6	83	40	140		
		fluoranthene			1.4	ug/g	1.6	86	40	140		
		pyrene			1.3	ug/g	1.6	81	40	140		
		benzo(a)anthracene			1.3	ug/g	1.6	83	40	140		
		chrysene			1.3	ug/g	1.6	81	40	140		
		benzo(b)fluoranthene			1.1	ug/g	1.6	71	40	140		
		benzo(k)fluoranthene			1.3	ug/g	1.6	79	40	140		
		benzo(a)pyrene			1.0	ug/g	1.6	63	40	140		
		indeno(1,2,3-cd)pyrene			1.1	ug/g	1.6	71	40	140		
		dibenzo(a,h)anthracene			1.1	ug/g	1.6	71	40	140		
		benzo(g,h,i)perylene			1.1	ug/g	1.6	66	40	140		
		2-fluorobiphenyl SUR			55	%			43	116		
		o-terphenyl SUR			73	%			33	141		

Method	QC ID	Parameter	Associated Sample		Result	Units	Amt Added	%R		Limits		RPD	RPD Limit
SW3550B8270D	LCSD4713	naphthalene			1.1	ug/g	1.6	67		40	140	3	30
		2-methylnaphthalene			1.1	ug/g	1.6	70		40	140	3	30
		acenaphthylene			1.2	ug/g	1.6	78		40	140	3	30
		acenaphthene			1.3	ug/g	1.6	81		40	140	2	30
		dibenzofuran		<	0.02	ug/g							
		fluorene			1.2	ug/g	1.6	78		40	140	1	30
		phenanthrene			1.4	ug/g	1.6	86		40	140	2	30
		anthracene			1.3	ug/g	1.6	84		40	140	1	30
		fluoranthene			1.4	ug/g	1.6	85		40	140	1	30
		pyrene			1.3	ug/g	1.6	81		40	140	1	30
		benzo(a)anthracene			1.3	ug/g	1.6	83		40	140	0	30
		chrysene			1.3	ug/g	1.6	81		40	140	1	30
		benzo(b)fluoranthene			1.1	ug/g	1.6	71		40	140	1	30
		benzo(k)fluoranthene			1.3	ug/g	1.6	81		40	140	3	30
		benzo(a)pyrene			1.00	ug/g	1.6	62		40	140	1	30
		indeno(1,2,3-cd)pyrene			1.2	ug/g	1.6	74		40	140	3	30
		dibenzo(a,h)anthracene			1.2	ug/g	1.6	74		40	140	4	30
		benzo(g,h,i)perylene			1.1	ug/g	1.6	69		40	140	5	30
		2-fluorobiphenyl SUR			55	%				43	116		
		o-terphenyl SUR			71	%				33	141		
SW3550B8270D	MS4713	naphthalene	22819-005		1.7	ug/g	2.59	62		40	140		
		2-methylnaphthalene	22819-005		1.7	ug/g	2.59	67		40	140		
		acenaphthylene	22819-005		1.9	ug/g	2.59	72		40	140		
		acenaphthene	22819-005		2.0	ug/g	2.59	78		40	140		
		dibenzofuran	22819-005	<	0.03	ug/g							
		fluorene	22819-005		2.0	ug/g	2.59	77		40	140		
		phenanthrene	22819-005		2.1	ug/g	2.59	81		40	140		
		anthracene	22819-005		2.1	ug/g	2.59	80		40	140		
		fluoranthene	22819-005		2.0	ug/g	2.59	78		40	140		
		pyrene	22819-005		2.2	ug/g	2.59	85		40	140		
		benzo(a)anthracene	22819-005		2.1	ug/g	2.59	81		40	140		
		chrysene	22819-005		2.1	ug/g	2.59	80		40	140		
		benzo(b)fluoranthene	22819-005		2.2	ug/g	2.59	85		40	140		
		benzo(k)fluoranthene	22819-005		2.6	ug/g	2.59	98		40	140		
		benzo(a)pyrene	22819-005		2.0	ug/g	2.59	76		40	140		
		indeno(1,2,3-cd)pyrene	22819-005		0.78	ug/g	2.599	30	*	40	140		
		dibenzo(a,h)anthracene	22819-005		0.84	ug/g	2.599	32	*	40	140		
		benzo(g,h,i)perylene	22819-005		0.57	ug/g	2.599	22	*	40	140		
		2-fluorobiphenyl SUR	22819-005		50	%				43	116		
		o-terphenyl SUR	22819-005		58	%				33	141		

Method	QC ID	Parameter	Associated Sample		Result	Units	Amt Added	%R		Limits		RPD	RPD Limit
SW3550B8270D	MSD4713	naphthalene	22819-005		1.6	ug/g	2.55	60		40	140	5	30
		2-methylnaphthalene	22819-005		1.7	ug/g	2.55	65		40	140	5	30
		acenaphthylene	22819-005		1.7	ug/g	2.55	68		40	140	7	30
		acenaphthene	22819-005		1.9	ug/g	2.55	75		40	140	7	30
		dibenzofuran	22819-005	<	0.03	ug/g							
		fluorene	22819-005		1.9	ug/g	2.55	73		40	140	6	30
		phenanthrene	22819-005		2.0	ug/g	2.55	78		40	140	6	30
		anthracene	22819-005		2.0	ug/g	2.55	77		40	140	6	30
		fluoranthene	22819-005		1.9	ug/g	2.55	76		40	140	5	30
		pyrene	22819-005		2.1	ug/g	2.55	83		40	140	4	30
		benzo(a)anthracene	22819-005		2.0	ug/g	2.55	78		40	140	6	30
		chrysene	22819-005		2.0	ug/g	2.55	77		40	140	6	30
		benzo(b)fluoranthene	22819-005		1.8	ug/g	2.55	72		40	140	19	30
		benzo(k)fluoranthene	22819-005		2.7	ug/g	2.55	105		40	140	5	30
		benzo(a)pyrene	22819-005		1.9	ug/g	2.55	73		40	140	6	30
		indeno(1,2,3-cd)pyrene	22819-005		0.80	ug/g	2.55	31	*	40	140	3	30
		dibenzo(a,h)anthracene	22819-005		0.88	ug/g	2.55	34	*	40	140	4	30
		benzo(g,h,i)perylene	22819-005		0.62	ug/g	2.55	24	*	40	140	8	30
		2-fluorobiphenyl SUR	22819-005		51	%				43	116		
		o-terphenyl SUR	22819-005		57	%				33	141		

Method	QC ID	Parameter	Associated Sample	Result	Units	Amt Added	%R	Limits		RPD	RPD Limit
SW3051A6010C	BLK4706	Arsenic		< 0.50	ug/g						
		Barium		< 2.5	ug/g						
		Cadmium		< 0.20	ug/g						
		Chromium		< 2.5	ug/g						
		Copper		< 2.5	ug/g						
		Nickel		< 2.5	ug/g						
		Lead		< 0.50	ug/g						
		Zinc		< 2.5	ug/g						
SW3051A6010C	CRM4706	Arsenic		420	ug/g	400		292	508		
		Barium		26	ug/g	25		0	51.3		
		Cadmium		17	ug/g	15		8.71	22		
		Chromium		14	ug/g	14		2.45	24.7		
		Copper		730	ug/g	730		592	866		
		Nickel		17	ug/g	17		6.2	27.5		
		Lead		5100	ug/g	5100		3753	6469		
		Zinc		3200	ug/g	3000		2447	3575		
SW3051A6010C	CRMD4706	Arsenic		410	ug/g	400		292	508	2	35
		Barium		27	ug/g	25		0	51.3	3	35
		Cadmium		16	ug/g	15		8.71	22	7	35
		Chromium		14	ug/g	14		2.45	24.7	2	35
		Copper		760	ug/g	730		592	866	5	35
		Nickel		16	ug/g	17		6.2	27.5	3	35
		Lead		5400	ug/g	5100		3753	6469	6	35
		Zinc		3100	ug/g	3000		2447	3575	5	35
SW3051A6010C	MS4706	Arsenic	22819-005	38	ug/g	35	104	75	125		
		Barium	22819-005	69	ug/g	35	114	75	125		
		Cadmium	22819-005	37	ug/g	35	105	75	125		
		Chromium	22819-005	53	ug/g	35	112	75	125		
		Copper	22819-005	42	ug/g	35	114	75	125		
		Nickel	22819-005	38	ug/g	35	93	75	125		
		Lead	22819-005	40	ug/g	35	105	75	125		
		Zinc	22819-005	52	ug/g	35	101	75	125		
SW3051A6010C	MSD4706	Arsenic	22819-005	38	ug/g	35	105	75	125	1	35
		Barium	22819-005	71	ug/g	35	119	75	125	2	35
		Cadmium	22819-005	38	ug/g	35	107	75	125	1	35
		Chromium	22819-005	54	ug/g	35	115	75	125	2	35
		Copper	22819-005	42	ug/g	35	114	75	125	0	35
		Nickel	22819-005	38	ug/g	35	94	75	125	2	35
		Lead	22819-005	41	ug/g	35	106	75	125	1	35
		Zinc	22819-005	54	ug/g	35	106	75	125	3	35

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Absolute Resource associates

124 Heritage Avenue #10
Portsmouth, NH 03801
603-436-2001
absoluteresourceassociates.com

CHAIN-OF-CUSTODY RECORD AND ANALYSIS REQUEST

22819

Company Name: VHB, Inc.
Company Address: 6 Bedford Farms Drive, Suite 607 Bedford, NH
Report To: Bill Arcieri
Phone #: 603-644-0888
Invoice To: VHB

Project Name: Exeter Dam
Project #:
Project Location: (NH) MA ME VT ____ Other
Protocol: RCRA SDWA NPDES MCP NHDES OTHER
Reporting Limits: QAPP GW-1 S-1 EPA DW Other____
Quote #____ ☐ NH GREE/ODD Fund Pricing
PO #____

Lab Sample ID (Lab Use Only)	Field ID	# CONTAINERS	Matrix: WATER	Matrix: SOLID	Matrix: OTHER	HCl	HNO_3	H_2SO_4	NaOH	MeOH	OTHER (Specify)	DATE	TIME	SAMPLER
22819-01	ER-1	5		X								11/7	12:10pm	KW
02	ER-2	5		X								11/7	9:45am	KW
03	ER-3	5		X								11/7	1:15pm	KW
04	ER-4	5		X								11/7	2:30pm	KW
05	ER-5	5		X								11/7	3:40pm	KW
06	LR-1	5		X								11/7	2:10pm	KW
~~07~~ (→05)	ER-5	5		X								11/7	3:40pm	KW

ANALYSIS REQUEST

- ☐ VOC 8260 ☒ VOC 8260 NHDES ☐ VOC 8260 MADEP
- ☐ VOC 624 ☐ VOC BTEX ☐ MtBE, only ☐ VOC 8021VT
- ☐ VPH MADEP ☐ MEGRO ☐ GRO 8015
- ☐ VOC 524.2 ☐ VOC 524.2 NH List ☐ Gases-List:
- ☐ TPH ☐ DRO 8015 ☐ MEDRO ☐ EPH MADEP ☐ TPH Fingerprint
- ☒ 8270PAH ☐ 8270ABN ☐ 625 ☐ EDB 504.1
- ☒ 8082 PCB ☒ 8081 Pesticides ☐ 608 Pest/PCB
- ☐ O&G 1664 ☐ Mineral O&G SM5520F
- ☐ pH ☐ BOD ☐ Conductivity ☐ Turbidity
- ☐ TSS ☐ TDS ☐ TS ☐ TVS ☐ Alkalinity
- ☐ RCRA Metals ☐ Priority Pollutant Metals ☐ TAL Metals
- ☒ Total Metals-list: As, Ba, Cd, Cr, Cu, Pb, Hg, Ni, Zn
- ~~☐ Dissolved Metals-list:~~
- ☐ Ammonia ☐ COD ☐ TKN ☐ TN ☐ TON ☐ TOC
- ☐ T-Phosphorus ☐ Phenols ☐ Bacteria P/A ☐ Bacteria MPN
- ☐ Cyanide ☐ Sulfide ☐ Nitrate + Nitrite ☐ Ortho P
- ☐ Nitrate ☐ Nitrite ☐ Chloride ☐ Sulfate ☐ Bromide ☐ Fluoride
- ☐ Corrosivity ☐ Reactive CN ☐ Reactive S- ☐ Ignitibility/FP
- ☐ TCLP Metals ☐ TCLP VOC ☐ TCLP SVOC ☐ TCLP Pesticide
- Subcontract: ☒ Grain Size ☐ Herbicides ☐ Formaldehyde
- TOC
- Grab (G) or Composite (C)

All of these analyses were checked for samples 01 through 07. Grain Size and TOC are crossed out for sample 07, with the note "@ pubill".

TAT REQUESTED
Priority (24 hr)* ☐
Expedited (48 hr)* ☐
Standard (10 Business Days) ☐
*Date Needed ____

See absoluteresourceassociates.com for sample acceptance policy and current accreditation lists.

SPECIAL INSTRUCTIONS

REPORTING INSTRUCTIONS ☒ PDF (e-mail address) BARCIERI@VHB.com
☐ HARD COPY REQUIRED ☐ FAX (FAX#)____ ☐ OTHER (specify)____

RECEIVED ON ICE ☒ YES ☐ NO
TEMPERATURE 2 °C

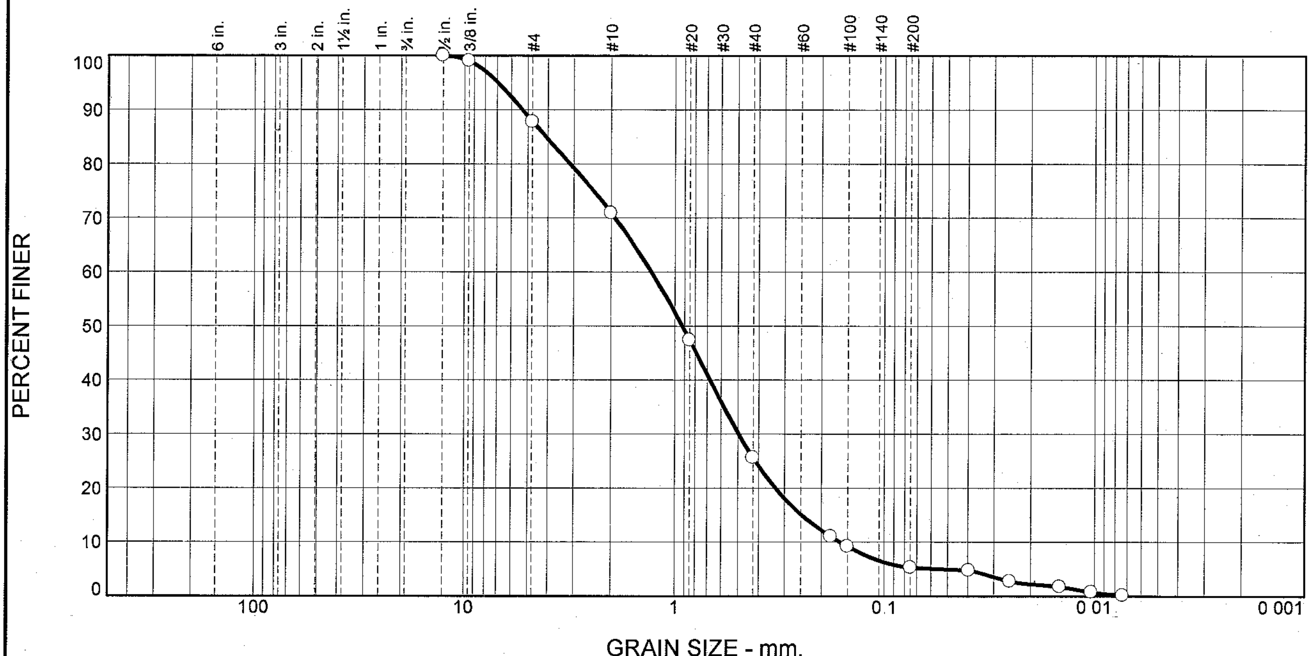
CUSTODY RECORD

	Date	Time		Date	Time
Relinquished by Sampler: [signature]	11/8	9:15 am	Received by:		
Relinquished by:			Received by:		
Relinquished by:			Received by Laboratory: [signature] Way Bill#:	11/8/11	9:15

QSD-01 Revision 10/6/11

ER-1: Downstream of the Dam

Particle Size Distribution Report



% Cobbles	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	12.2	16.9	45.3	20.3	5.3	

Test Results (ASTM D 422 & ASTM D 422)			
Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1/2	100.0		
3/8	99.0		
#4	87.8		
#10	70.9		
#20	47.4		
#40	25.6		
#80	11.0		
#100	9.2		
#200	5.3		
0.0396 mm.	4.8		
0.0252 mm.	2.7		
0.0146 mm.	1.7		
0.0103 mm.	0.7		
0.0073 mm.	0.1		

* (no specification provided)

Material Description

TBD

Atterberg Limits (ASTM D 4318)

PL= LL= PI=

Classification

USCS (D 2487)= AASHTO (M 145)=

Coefficients

D_{90}= 5.3086 D_{85}= 4.0996 D_{60}= 1.2931
D_{50}= 0.9220 D_{30}= 0.4966 D_{15}= 0.2479
D_{10}= 0.1628 C_u= 7.94 C_c= 1.17

Remarks

Date Received: 12-7-11 **Date Tested:** 12-19-11
Tested By: Scott TeBordo
Checked By: John Turner
Title: President

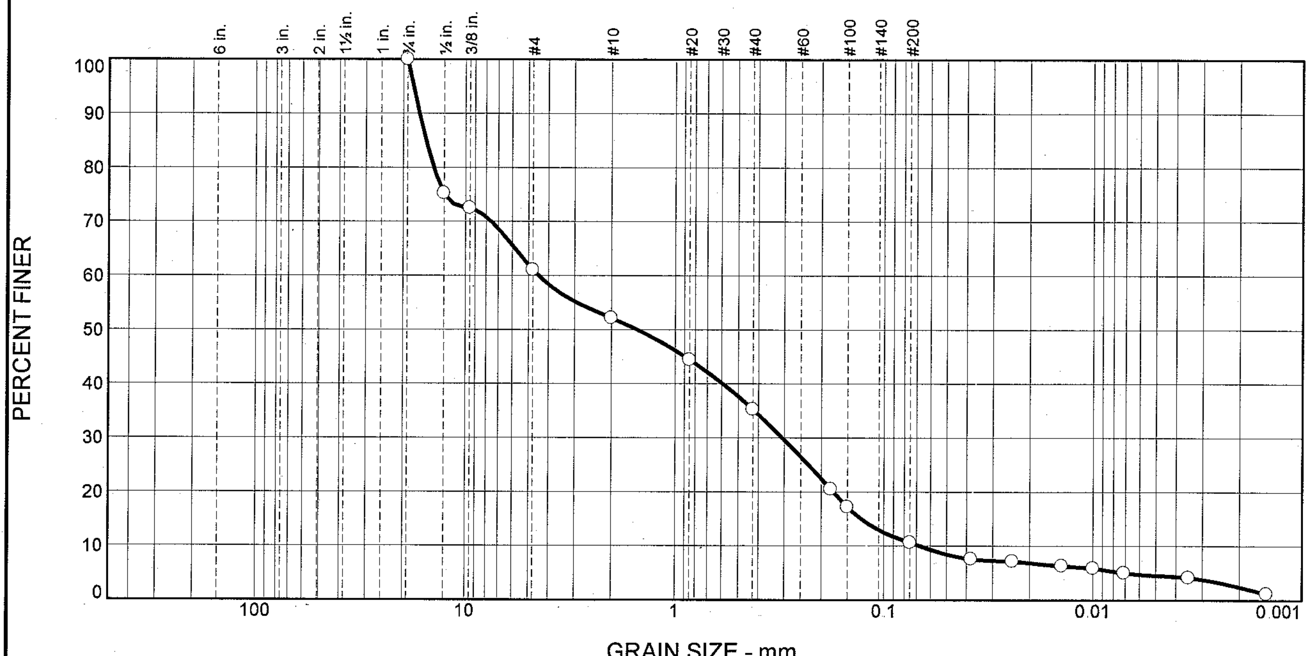
Location: 22819-01B ER-1: Downstream **Date Sampled:** 11-7-11
Sample Number: 11-927 **Depth:** Geo

JOHN TURNER
Dover, NH

Client: Absolute Resource Associates
Project: Misc. Testing
Project No: 11-LTS-014 **Figure** 016

ER-2: Immediately Upstream of the Dam

Particle Size Distribution Report



% Cobbles	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	39.0	8.9	16.9	24.6	6.1	4.5

Test Results (ASTM D 422 & ASTM D 422)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
3/4	100.0		
1/2	75.2		
3/8	72.5		
#4	61.0		
#10	52.1		
#20	44.4		
#40	35.2		
#80	20.5		
#100	17.2		
#200	10.6		
0.0381 mm.	7.6		
0.0242 mm.	7.1		
0.0141 mm.	6.3		
0.0100 mm.	5.9		
0.0071 mm.	5.0		
0.0035 mm.	4.1		
0.0015 mm.	1.2		

* (no specification provided)

Material Description

TBD

Atterberg Limits (ASTM D 4318)

PL= LL= PI=

Classification

USCS (D 2487)= AASHTO (M 145)=

Coefficients

D_{90}= 16.6853 D_{85}= 15.5138 D_{60}= 4.4689
D_{50}= 1.5156 D_{30}= 0.3065 D_{15}= 0.1287
D_{10}= 0.0676 C_u= 66.08 C_c= 0.31

Remarks

Date Received: 12-7-11 **Date Tested:** 12-19-11
Tested By: Scott TeBordo
Checked By: John Turner
Title: President

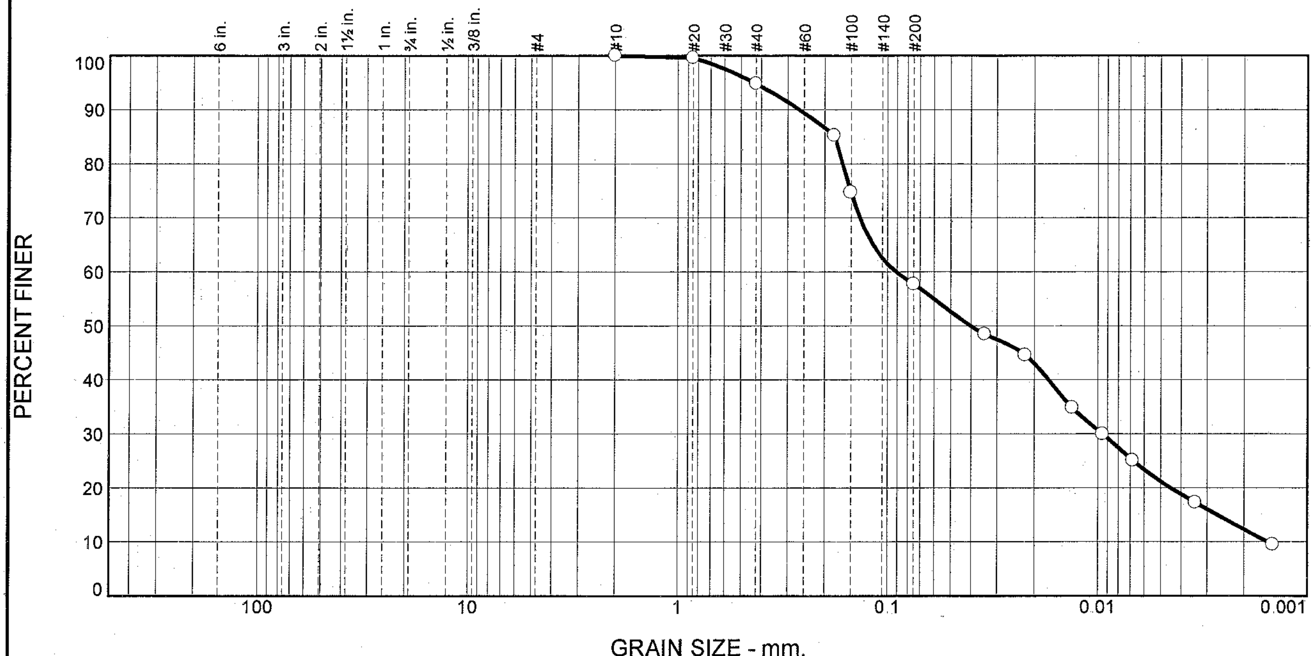
Location: 22819-02B ER-2: Just Above Dam
Sample Number: 11-928 **Depth:** GEO
Date Sampled: 11-7-11

JOHN TURNER
Dover, NH

Client: Absolute Resource Associates
Project: Misc. Testing
Project No: 11-LTS-014 **Figure** 017

ER-3: Upstream of Municipal Water Intake

Particle Size Distribution Report



% Cobbles	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	5.2	37.1	36.5	21.2

Test Results (ASTM D 422 & ASTM D 422)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
#10	100.0		
#20	99.6		
#40	94.8		
#80	85.3		
#100	74.7		
#200	57.7		
0.0343 mm.	48.5		
0.0220 mm.	44.6		
0.0132 mm.	34.8		
0.0095 mm.	29.9		
0.0068 mm.	25.1		
0.0034 mm.	17.3		
0.0015 mm.	9.5		

* (no specification provided)

Material Description

TBD

Atterberg Limits (ASTM D 4318)

PL= LL= PI=

Classification

USCS (D 2487)= AASHTO (M 145)=

Coefficients

D_{90}= 0.2638 D_{85}= 0.1791 D_{60}= 0.0911
D_{50}= 0.0403 D_{30}= 0.0095 D_{15}= 0.0027
D_{10}= 0.0015 C_u= 58.97 C_c= 0.64

Remarks

Date Received: 12-7-11 **Date Tested:** 12-19-11
Tested By: Scott TeBordo
Checked By: John Turner
Title: President

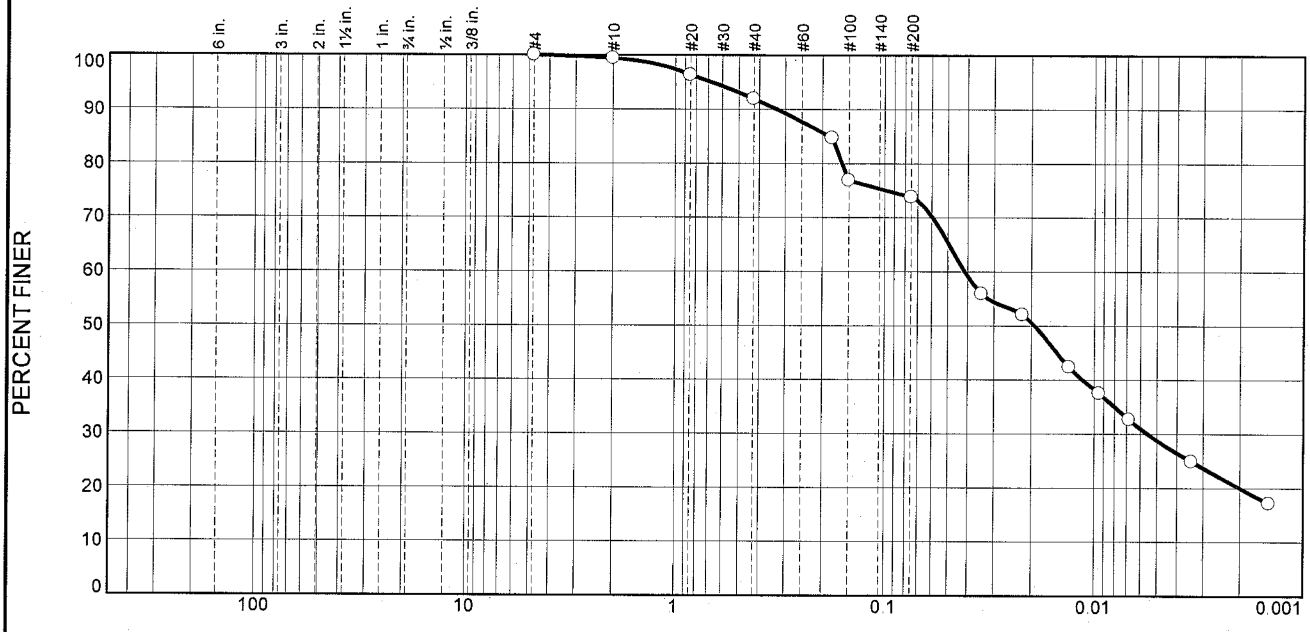
Location: 22819-03B ER-3
Sample Number: 11-929 **Depth:** GEO
Date Sampled: 11-7-11

JOHN TURNER
Dover, NH

Client: Absolute Resource Associates
Project: Misc. Testing
Project No: 11-LTS-014 **Figure** 018

ER-4: Upstream, near former landfill off Powder Mill Road

Particle Size Distribution Report



% Cobbles	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.6	7.5	18.1	45.0	28.8

Test Results (ASTM D 422 & ASTM D 422)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
#4	100.0		
#10	99.4		
#20	96.3		
#40	91.9		
#80	84.7		
#100	76.9		
#200	73.8		
0.0343 mm.	55.9		
0.0220 mm.	52.0		
0.0132 mm.	42.4		
0.0095 mm.	37.5		
0.0068 mm.	32.7		
0.0034 mm.	24.9		
0.0015 mm.	17.2		

* (no specification provided)

Material Description

TBD

Atterberg Limits (ASTM D 4318)

PL= LL= PI=

Classification

USCS (D 2487)= AASHTO (M 145)=

Coefficients

D_{90}= 0.3296 D_{85}= 0.1858 D_{60}= 0.0414
D_{50}= 0.0192 D_{30}= 0.0055 D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: 12-7-11 **Date Tested:** 12-19-11
Tested By: Scott TeBordo
Checked By: John Turner
Title: President

Location: 22819-04B
Sample Number: 11-930 **Depth:** GEO
Date Sampled: 11-7-11

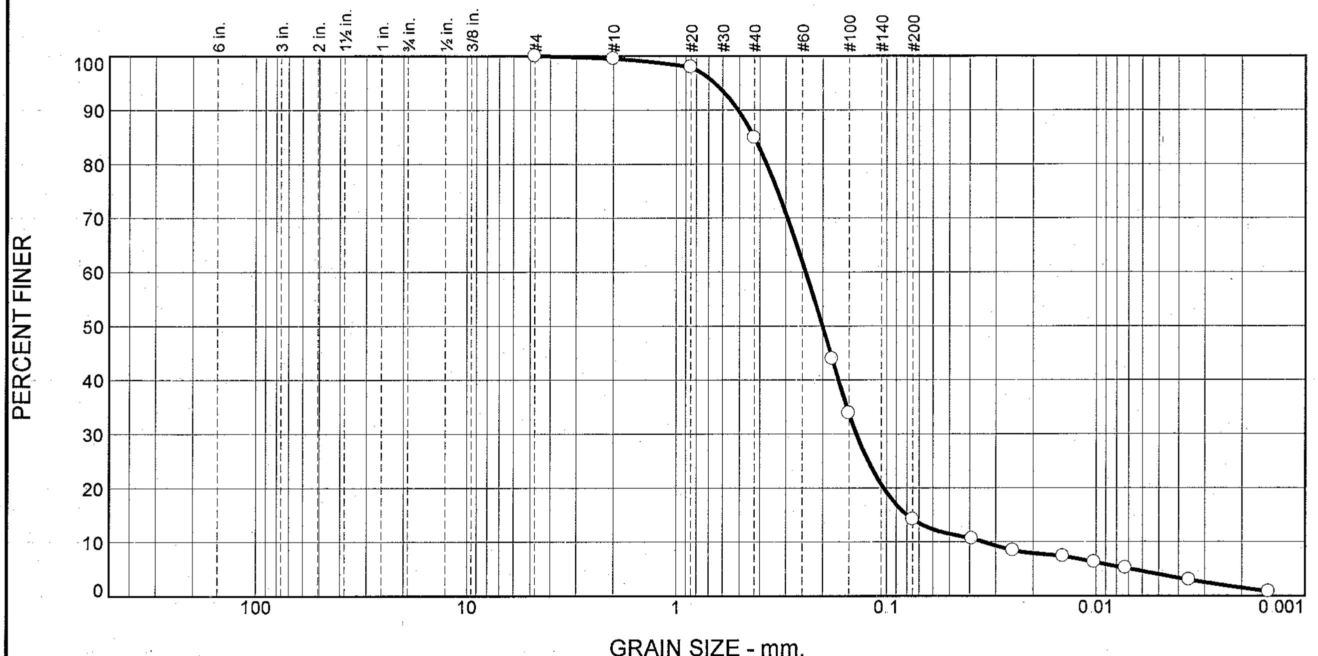
JOHN TURNER
Dover, NH

Client: Absolute Resource Associates
Project: Misc. Testing
Project No: 11-LTS-014 **Figure** 019

ER-5: Just Upstream of NH 111 Bridge

(5)

Particle Size Distribution Report



% Cobbles	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.5	14.6	70.7	10.2	4.0

Test Results (ASTM D 422 & ASTM D 422)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
#4	100.0		
#10	99.5		
#20	97.9		
#40	84.9		
#80	43.9		
#100	33.9		
#200	14.2		
0.0390 mm.	10.6		
0.0248 mm.	8.4		
0.0144 mm.	7.3		
0.0102 mm.	6.2		
0.0072 mm.	5.1		
0.0036 mm.	3.0		
0.0015 mm.	0.8		

* (no specification provided)

Material Description

TBD

Atterberg Limits (ASTM D 4318)

PL= LL= PI=

Classification

USCS (D 2487)= AASHTO (M 145)=

Coefficients

D_{90}= 0.5084 D_{85}= 0.4263 D_{60}= 0.2408
D_{50}= 0.2004 D_{30}= 0.1383 D_{15}= 0.0800
D_{10}= 0.0344 C_u= 7.00 C_c= 2.31

Remarks

Date Received: 12-7-11 **Date Tested:** 12-19-11
Tested By: Scott TeBordo
Checked By: John Turner
Title: President

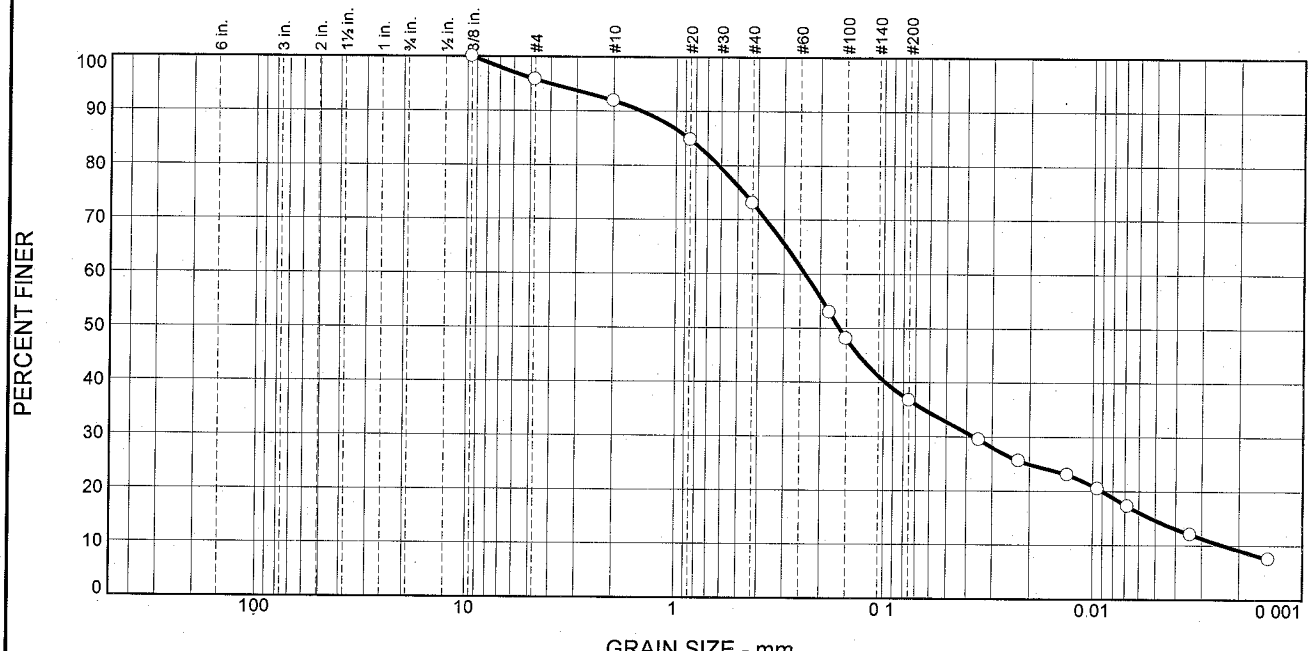
Location: 22819-05B ER-5
Sample Number: 11-931 **Depth:** GEO
Date Sampled: 11-7-11

JOHN TURNER
Dover, NH

Client: Absolute Resource Associates
Project: Misc. Testing
Project No: 11-LTS-014 **Figure** 020

LR-1: Little River

Particle Size Distribution Report



% Cobbles	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	4.2	3.9	18.8	36.4	22.1	14.6

Test Results (ASTM D 422 & ASTM D 422)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
3/8	100.0		
#4	95.8		
#10	91.9		
#20	84.7		
#40	73.1		
#80	52.9		
#100	48.1		
#200	36.7		
0.0348 mm.	29.4		
0.0225 mm.	25.6		
0.0132 mm.	23.0		
0.0094 mm.	20.4		
0.0068 mm.	17.2		
0.0034 mm.	12.1		
0.0014 mm.	7.5		

* (no specification provided)

Material Description

TBD

Atterberg Limits (ASTM D 4318)

PL= LL= PI=

Classification

USCS (D 2487)= AASHTO (M 145)=

Coefficients

D_{90}= 1.4621 D_{85}= 0.8675 D_{60}= 0.2366
D_{50}= 0.1617 D_{30}= 0.0369 D_{15}= 0.0052
D_{10}= 0.0024 C_u= 100.19 C_c= 2.44

Remarks

Date Received: 12-7-11 **Date Tested:** 12-19-11
Tested By: Scott TeBordo
Checked By: John Turner
Title: President

Location: 22819-06B LR-1
Sample Number: 11-932 **Depth:** GEO
Date Sampled: 11-7-11

JOHN TURNER
Dover, NH

Client: Absolute Resource Associates
Project: Misc. Testing
Project No: 11-LTS-014 **Figure** 021

Exeter River Sediment Quality Results

FIELD ID	ER-1	ER-2	ER-3	LR-1	ER-4	ER-5	Reporting Limits	Freshwater Criteria (1)		Saltwater Criteria		ER-1		ER-2		ER-3		LR-1		ER-4		ER-5	
SAMPLING DATE	11/7/2011	11/7/2011	11/7/2011	11/7/2011	11/7/2011	11/7/2011																	
Location	dwnstrm of dam	just above dam	upstrm near water intake	Little river Mouth	adjacent to old dumpt	upstream Rte 111																	
Sample Type	surface grab	surface grab	surface grab	surface grab	surface grab	surface grab		TEC	PEC	TEL	PEL	TEC-HQ	PEC-HQ	TEC-HQ	PEC-HQ	TEC-HQ	PEC-HQ	TEC-HQ	PEC-HQ	TEC-HQ	PEC-HQ	TEC-HQ	PEC-HQ
LAB SAMPLE ID	22819-001	22819-002	22819-003	22819-006	22819-004	22819-005		Consensus Effect Concentr.	Probable Effect Concentration	Threshold Effects Level	Probable Effects Level												
Metals (mg/kg)																							
Arsenic	3.1	5.2	4.0	13.0	12.0	1.7	0.7	9.79	33	7.24	41.6							1.8		1.2			
Barium	35	76	60	120	110	29	4.0	na	330	na	330												
Cadmium	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	0.3	0.99	4.98	0.68	4.21												
Chromium	97	29	33	42	45	13	4.0	43.4	111	52.3	160	1.9								1.0			
Copper	18	18	4	19.0	32	< 4	4.0	31.6	149	18.7	108							1.0		1.0			
Lead	11	43	9.2	30	15	3.4	0.7	35.8	128	30.2	112			1.4									
Mercury	0.110	0.110	< 0.05	1.30	< 0.05	< 0.05	0.05	0.18	1.06	0.13	0.70							7.2	1.9				
Nickel	25	19	13	23	26	5	4.0	22.7	48.6	15.9	42.8	1.6		1.2				1.0		1.1			
Zinc	49	46	39	81	98	81	4.0	121	459	124	271												
PAH's by 8270D ug/g																							
naphthalene	< 0.02	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	0.03	0.176	0.561	0.035	0.391												
2-methylnaphthalene	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.01	na	na	0.0202	0.201												
acenaphthylene	0.07	0.01	< 0.01	0.02	< 0.01	< 0.01	0.01	na	na	0.0059	0.13	11.9		1.69				3.4					
acenaphthene	0.04	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.01	na	na	0.0067	0.089	6.0											
dibenzofuran	0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	0.03	0.415	na	na	na												
fluorene	0.04	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	0.03	0.0774	0.536	0.0021	0.536	19.0											
phenanthrene	1.17	0.07	< 0.03	0.04	< 0.03	< 0.03	0.03	0.204	1.17	0.087	1.17	13.4											
anthracene	0.21	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	0.03	0.0572	0.845	0.049	0.845	4.3											
fluoranthene	2.19	0.2	< 0.03	0.14	< 0.03	< 0.03	0.03	0.423	2.23	0.113	2.23	19.4		1.8				1.2					
pyrene	1.87	0.18	< 0.03	0.12	< 0.03	< 0.03	0.03	0.195	1.52	0.153	1.52	12.2	1.23	1.2									
benzo(a)anthracene	1.07	0.11	< 0.03	0.05	< 0.03	< 0.03	0.03	0.108	1.05	0.075	1.05	14.3	1.02	1.5									
chrysene	1.06	0.11	< 0.03	0.07	< 0.03	< 0.03	0.03	0.166	1.29	0.108	1.29	9.8		1.02									
benzo(b)fluoranthene	0.92	0.09	< 0.01	0.07	< 0.01	< 0.01	0.01	0.0272*	na	na	na	33.8		3.31				2.60					
benzo(k)fluoranthene	1.09	0.13	< 0.01	0.05	< 0.01	< 0.01	0.01	0.0272*	na	na	na	40.1		4.78				1.80					
benzo(a)pyrene	0.93	0.1	< 0.03	0.05	< 0.03	< 0.03	0.03	0.15	1.45	0.089	1.45	10.4		1.12									
indeno(1,2,3-cd)pyrene	0.22	0.03	< 0.01	0.02	< 0.03	< 0.01M	0.01	0.017*	na	na	na	12.9		1.76				1.17					
dibenzo(a,h)anthracene	0.11	0.01	< 0.01	< 0.01	< 0.01	< 0.01M	0.01	0.033	na	0.006	0.33	18.3		1.67									
benzo(g,h,i)perylene	0.19	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03M	0.03	0.17	na	na	na	1.1											
Surrogate Recovery																							
2-fluorobiphenyl SUR	54	46	53	54	51	45	43 -116 %	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
o-terphenyl SUR	56	56	69	57	70	52	33- 141 %	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
Pesticides by 8081B (ug/kg)																							
gamma-BHC (Lindane)	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	1.0	2.37	5.0			na	na	na	na	na	na	na	na	na	na	na	na
Heptachlor	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	1.0	na	na			na	na	na	na	na	na	na	na	na	na	na	na
Aldrin	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	1.0	2.00	80.0			na	na	na	na	na	na	na	na	na	na	na	na
Heptachlor Epoxide	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	1.0	2.50	16.0			na	na	na	na	na	na	na	na	na	na	na	na
Endosulfan I	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	1.0	na	na			na	na	na	na	na	na	na	na	na	na	na	na
Dieldrin	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	1.0	1.90	61.8			na	na	na	na	na	na	na	na	na	na	na	na
4,4'-DDE	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	1.0	4.88	31.3	2.07	37.4	na	na	na	na	na	na	na	na	na	na	na	na
Endrin	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	1.0	2.22	207.0			na	na	na	na	na	na	na	na	na	na	na	na
Endosulfan II	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	1.0	na	na			na	na	na	na	na	na	na	na	na	na	na	na
4,4'-DDD	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	1.0	3.54	28.0	1.2	78	na	na	na	na	na	na	na	na	na	na	na	na
4,4'-DDT	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	1.0	4.16	62.9	1.2	48	na	na	na	na	na	na	na	na	na	na	na	na
Methoxychlor	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	1.0	na	na			na	na	na	na	na	na	na	na	na	na	na	na
alpha-Chlordane	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	1.0	3.24	17.6			na	na	na	na	na	na	na	na	na	na	na	na
gamma-Chlordane	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	1.0	3.24	17.6			na	na	na	na	na	na	na	na	na	na	na	na
Toxaphene	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	0.02	na	na			na	na	na	na	na	na	na	na	na	na	na	na
% recovery surrogate																							

\\nhbedata\PROJECTS\52151.00\reports\Sediment Analysis Report August 2012\Exeter Sediment SummaryTable -DES Format-July 2012 Rev October 2012 PJW.xls

tetrachloro-m-xylene SUR	59	61	56	61	49	43	30-150 %	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
decachlorobiphenyl SUR	48	49	48	50	60	40	30-150%	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
Total PCB's (ug/kg)	< 10	< 10	< 10	< 20	< 10	< 20	20.0	**59.8**	**676**			na	na	na	na	na	na	na	na	na	na	na	na

Notes: Values shaded in blue and **blue font** indicate that they exceed the suggested TEC/TEL levels; Values in **Red** font exceed the suggested PEC/PEL levels (1) The Freshwater and Saltwater Threshold Effect Concentrations (TEC's) and Probable Effect Concentrations (PEC's) are primarily based on the 2006 EPA Region III Sediment Screening Benchmarks at http://www.epa.gov/reg3hwmd/risk/eco/btag/sbv/screenbench.htm or those listed in the NOAA SQuiRT Tables, with a few exceptions as noted. The TEC levels indicated by a (*) represent those published seperately by the International Association of Great Lakes Research. (M) indicates tha the percent recovery for surrogate parameters for laboratory control matrix spike duplicate were outside previously specified acceptance critera.

VOC's (ug/g)	ER-1	ER-2	ER-3	LR-1	ER-4	ER-5	Reporting Limits	Freshwater Criteria (1)		Saltwater Criteria													
1,1,1,2-tetrachloroethane	< 0.1	< 0.1	< 0.1	< 0.2	< 0.1	< 0.2	0.1	na	na														
1,1,1-trichloroethane	< 0.1	< 0.1	< 0.1	< 0.2	< 0.1	< 0.2	0.1	0.0302	na														
1,1,2,2-tetrachloroethane	< 0.1	< 0.1	< 0.1	< 0.2	< 0.1	< 0.2	0.1	1.36	na														
1,1,2-trichloroethane	< 0.1	< 0.1	< 0.1	< 0.2	< 0.1	< 0.2	0.1	1.24	na														
1,1-dichloroethane	< 0.1	< 0.1	< 0.1	< 0.2	< 0.1	< 0.2	0.1	na	na														
1,1-dichloroethene	< 0.1	< 0.1	< 0.1	< 0.2	< 0.1	< 0.2	0.1	0.031	na														
1,1-dichloropropene	< 0.1	< 0.1	< 0.1	< 0.2	< 0.1	< 0.2	0.1	na	na														
1,2,3-trichlorobenzene	< 0.1	< 0.1	< 0.1	< 0.2	< 0.1	< 0.2	0.1	0.858	na														
1,2,3-trichloropropane	< 0.1	< 0.1	< 0.1	< 0.2	< 0.1	< 0.2	0.1	na	na														
1,2,4-trichlorobenzene	< 0.1	< 0.1	< 0.1	< 0.2	< 0.1	< 0.2	0.1	2.1	na														
1,2,4-trimethylbenzene	< 0.1	< 0.1	< 0.1	< 0.2	< 0.1	< 0.2	0.1	na	na														
1,2-dibromo-3-chloropropane (DB	< 0.1	< 0.1	< 0.1	< 0.2	< 0.1	< 0.2	0.1	na	na														
1,2-dibromoethane (EDB)	< 0.1	< 0.1	< 0.1	< 0.2	< 0.1	< 0.2	0.1	na	na														
1,2-dichlorobenzene	< 0.1	< 0.1	< 0.1	< 0.2	< 0.1	< 0.2	0.1	0.0165	na														
1,2-dichloroethane	< 0.1	< 0.1	< 0.1	< 0.2	< 0.1	< 0.2	0.1	na	na														
1,2-dichloropropane	< 0.1	< 0.1	< 0.1	< 0.2	< 0.1	< 0.2	0.1	na	na														
1,3,5-trichlorobenzene	< 0.1	< 0.1	< 0.1	< 0.2	< 0.1	< 0.2	0.1	na	na														
1,3,5-trimethylbenzene	< 0.1	< 0.1	< 0.1	< 0.2	< 0.1	< 0.2	0.1	na	na														
1,3-dichlorobenzene	< 0.1	< 0.1	< 0.1	< 0.2	< 0.1	< 0.2	0.1	4.43	na														
1,3-dichloropropane	< 0.1	< 0.1	< 0.1	< 0.2	< 0.1	< 0.2	0.1	na	na														
1,4-dichlorobenzene	< 0.1	< 0.1	< 0.1	< 0.2	< 0.1	< 0.2	0.1	na	na														
1,4-dioxane	< 2	< 3	< 3	< 5	< 3	< 4	2	na	na														
2,2-dichloropropane	< 0.1	< 0.1	< 0.1	< 0.2	< 0.1	< 0.2	0.1	na	na														
2-butanone (MEK)	< 0.2	< 0.4	< 0.3	< 0.5	< 0.4	< 0.5	0.2	na	na														
2-chlorotoluene	< 0.1	< 0.1	< 0.1	< 0.2	< 0.1	< 0.2	0.1	na	na														
2-hexanone	< 0.4	< 0.7	< 0.5	< 0.9	< 0.6	< 0.8	0.4	na	na														
4-chlorotoluene	< 0.1	< 0.1	< 0.1	< 0.2	< 0.1	< 0.2	0.1	na	na														
4-isopropyltoluene	< 0.1	< 0.1	< 0.1	< 0.2	< 0.1	< 0.2	0.1	na	na														
4-methyl-2-pentanone (MIBK)	< 0.4	< 0.6	< 0.5	< 0.8	< 0.6	< 0.7	0.4	na	na														
acetone	< 2	< 3	< 3	< 5	< 3	< 4	2	na	na														
benzene	< 0.1	< 0.1	< 0.1	< 0.2	< 0.1	< 0.2	0.1	na	na														
bromobenzene	< 0.1	< 0.1	< 0.1	< 0.2	< 0.1	< 0.2	0.1	na	na														
bromochloromethane	< 0.1	< 0.1	< 0.1	< 0.2	< 0.1	< 0.2	0.1	na	na														
bromodichloromethane	< 0.1	< 0.1	< 0.1	< 0.2	< 0.1	< 0.2	0.1	na	na														
bromoform	< 0.1	< 0.1	< 0.1	< 0.2	< 0.1	< 0.2	0.1	0.654	na														
bromomethane	< 0.1	< 0.1	< 0.1	< 0.2	< 0.1	< 0.2	0.1	na	na														
carbon disulfide	< 0.1	< 0.1	< 0.1	< 0.2	< 0.1	< 0.2	0.1	na	na														
carbon tetrachloride	< 0.1	< 0.1	< 0.1	< 0.2	< 0.1	< 0.2	0.1	na	na														
chlorobenzene	< 0.1	< 0.1	< 0.1	< 0.2	< 0.1	< 0.2	0.1	na	na														
chloroethane	< 0.1	< 0.1	< 0.1	< 0.2	< 0.1	< 0.2	0.1	na	na														
chloroform	< 0.1	< 0.1	< 0.1	< 0.2	< 0.1	< 0.2	0.1	na	na														
chloromethane	< 0.1	< 0.1	< 0.1	< 0.2	< 0.1	< 0.2	0.1	na	na														
cis-1,2-dichloroethene	< 0.1	< 0.1	< 0.1	< 0.2	< 0.1	< 0.2	0.1	na	na														
cis-1,3-dichloropropene	< 0.1	< 0.1	< 0.1	< 0.2	< 0.1	< 0.2	0.1	na	na														
dibromochloromethane	< 0.1	< 0.1	< 0.1	< 0.2	< 0.1	< 0.2	0.1	na	na														
dibromomethane	< 0.1	< 0.1	< 0.1	< 0.2	< 0.1	< 0.2	0.1	na	na														
dichlorodifluoromethane	< 0.1	< 0.1	< 0.1	< 0.2	< 0.1	< 0.2	0.1	na	na														
diethyl ether	< 0.1	< 0.1	< 0.1	< 0.2	< 0.1	< 0.2	0.1	na	na														
ethyl t-butyl ether (ETBE)	< 0.1	< 0.1	< 0.1	< 0.2	< 0.1	< 0.2	0.1	na	na														
ethylbenzene	< 0.1	< 0.1	< 0.1	< 0.2	< 0.1	< 0.2	0.1	na	na														
hexachlorobutadiene	< 0.1	< 0.1	< 0.1	< 0.2	< 0.1	< 0.2	0.1	na	na														

isopropyl ether (DIPE)	< 0.1	< 0.1	< 0.1	< 0.2	< 0.1	< 0.2	0.1	na	na														
isopropylbenzene	< 0.1	< 0.1	< 0.1	< 0.2	< 0.1	< 0.2	0.1	na	na														
m&p-xylenes	< 0.1	< 0.1	< 0.1	< 0.2	< 0.1	< 0.2	0.1	na	na														
methyl t-butyl ether (MTBE)	< 0.1	< 0.1	< 0.1	< 0.2	< 0.1	< 0.2	0.1	na	na														
methylene chloride	< 0.1	< 0.1	< 0.1	< 0.2	< 0.1	< 0.2	0.1	na	na														
naphthalene	< 0.1	< 0.1	< 0.1	< 0.2	< 0.1	< 0.2	0.1	na	na														
n-butylbenzene	< 0.1	< 0.1	< 0.1	< 0.2	< 0.1	< 0.2	0.1	na	na														
n-propylbenzene	< 0.1	< 0.1	< 0.1	< 0.2	< 0.1	< 0.2	0.1	na	na														

Notes: As indicated in the Sampling QAPP, the Reporting Limits can vary for certain VOC compounds and can vary between samples due to differences in the moisture content between samples. There were very few TEC/TEL limits in the EPA Region III BTAG data. The reporting limit for 1,2-dichlorobenzene in LR-1 and ER-5 was just below the suggested TEC level. The slightly higher reporting level was due to the higher moisture content in thse samples.

VOC's (ug/g) (cont.)	ER-1	ER-2	ER-3	LR-1	ER-4	ER-5	Reporting Limits	Freshwater Criteria (1)															
o-xylene	< 0.1	< 0.1	< 0.1	< 0.2	< 0.1	< 0.2	0.1	na	na														
styrene	< 0.1	< 0.1	< 0.1	< 0.2	< 0.1	< 0.2	0.1	na	na														
t-amyl-methyl ether (TAME)	< 0.1	< 0.1	< 0.1	< 0.2	< 0.1	< 0.2	0.1	na	na														
t-butanol (TBA)	< 2	< 3	< 3	< 5	< 3	< 4	2	na	na														
tert-butylbenzene	< 0.1	< 0.1	< 0.1	< 0.2	< 0.1	< 0.2	0.1	na	na														
tetrachloroethene	< 0.1	< 0.1	< 0.1	< 0.2	< 0.1	< 0.2	0.1	na	na														
tetrahydrofuran (THF)	< 0.4	< 0.7	< 0.5	< 0.9	< 0.6	< 0.8	0.4	na	na														
toluene	< 0.1	< 0.1	< 0.1	< 0.2	< 0.1	< 0.2	0.1	na	na														
trans-1,2-dichloroethene	< 0.1	< 0.1	< 0.1	< 0.2	< 0.1	< 0.2	0.1	na	na														
trans-1,3-dichloropropene	< 0.1	< 0.1	< 0.1	< 0.2	< 0.1	< 0.2	0.1	na	na														
trichloroethene	< 0.1	< 0.1	< 0.1	< 0.2	< 0.1	< 0.2	0.1	na	na														
trichlorofluoromethane	< 0.1	< 0.1	< 0.1	< 0.2	< 0.1	< 0.2	0.1	na	na														
vinyl chloride	< 0.1	< 0.1	< 0.1	< 0.2	< 0.1	< 0.2	0.1	na	na														
Surrogate Recovery																							
dibromofluoromethane SUR	112	108	103	103	104	113	78-114%																
toluene-D8 SUR	96	96	94	92	93	91	88-110%																
4-bromofluorobenzene SUR	95	101	94	103	106	93	86-115%																
a,a,a-trifluorotoluene SUR	96	100	107	108	107	97	70-130%																
PCB's (ug/g)																							
PCB-1016	< 0.01	< 0.01	< 0.01	< 0.02	< 0.01	< 0.02	0.01	0.06	0.676														
PCB-1221	< 0.01	< 0.01	< 0.01	< 0.02	< 0.01	< 0.02	0.01	0.06	0.676														
PCB-1232	< 0.01	< 0.01	< 0.01	< 0.02	< 0.01	< 0.02	0.01	0.06	0.676														
PCB-1242	< 0.01	< 0.01	< 0.01	< 0.02	< 0.01	< 0.02	0.01	0.06	0.676														
PCB-1248	< 0.01	< 0.01	< 0.01	< 0.02	< 0.01	< 0.02	0.01	0.06	0.676														
PCB-1254	< 0.01	< 0.01	< 0.01	< 0.02	< 0.01	< 0.02	0.01	0.06	0.676														
PCB-1260	< 0.01	< 0.01	< 0.01	< 0.02	< 0.01	< 0.02	0.01	0.06	0.676														
Surrogate Recovery																							
tetrachloro-m-xylene SUR	52	31	53	40	49	48	30-150%					na	na	na	na	na	na	na	na	na	na	na	na
decachlorobiphenyl SUR	51	35	46	42	50	53	30-150%					na	na	na	na	na	na	na	na	na	na	na	na
TOC's (ug/g)	2,830	10,800	6,800	33,600	< 540	22,300	500.0	**na**	**na**	na	na	na	na	na	na	na	na	na	na	na	na	na	na
Percent Dry Matter (%)	85.22	72.23	72.74	57.49	69.87	61.23	na	**na**	**na**	na	na	na	na	na	na	na	na	na	na	na	na	na	na
Particle Size Distrib. (%)	**ER-1**	**ER-2**	**ER-3**	**LR-1**	**ER-4**	**ER-5**																	
Grain Size																							
% Cobbles	0	0	0	0	0	0																	
% Gravel																							
Coarse	0	0	0	0	0	0																	
Fine	12.2	39	0	4.2	0	0																	
% Sand																							
Coarse	16.9	8.9	0	3.9	0.6	0.5																	
Medium	45.3	16.9	5.2	18.8	7.5	14.6																	
Fine	20.3	24.6	37.1	36.8	18.1	70.7																	
% Fines																							
Silt	5.3	6.1	36.2	22.1	45	10.2																	
clay	0	4.5	21.2	14.6	28.8	4																	
Sieve Size - % Finer																							
1/2 inch	100	100	100	100	100	100																	
3/8 inch	99	75.2	100	100	100	100																	

#4	88	72.5	100	95.8	100	100																	
#10	71	61	100	91.9	99.4	99.5																	
#20	47	52	99.6	84.7	96.3	97.9																	
#40	27	44	94.8	73.1	91.9	84.9																	
#80	11	35	85.3	52.9	84.7	43.9																	
#100	9	20	74.7	48.1	76.9	33.9																	
#200	5	11	57.7	36.7	73.8	14.2																	
0.0396 mm*	5	8	48.5	29.4	56.0	10.6																	
0.0252 mm*	3	7	44.6	25.6	52.0	8.4																	
0.0146 mm*	2	6	35.0	23.0	42.4	7.3																	
0.0103 mm*	1	6	30.0	20.4	37.5	6.2																	
0.0073 mm*	0.1	5	25.1	17.2	32.7	5.1																	
0.0035 mm*	0	4	17.3	12.1	24.9	3.0																	
0.0015 mm	0	1.2	9.5	7.5	17.2	1.0																	
Note: * sieve opening size varies slightly with each sample																							

Exeter River/Great Dam Removal Feasibility and Impact Analysis Quality Assurance Project Plan

October 5, 2011 (4th Revision)

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Prepared For:
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VHB Project Manager:	10/12/11 Signature / Date Peter J. Walker, VHB
VHB WQ/Sediment Sampling QA Officer:	10/12/11 Signature / Date William R. Arcieri, VHB
NHDES Dam Removal/Restoration Project Coordinator:	10/13/11 Signature / Date Deborah Loiselle, NHDES
NHDES 319 Program QA Coordinator:	10/13/11 Signature / Date Jillian McCarthy, NHDES
NHDES 319 Grant Coordinator:	10/14/11 Signature / Date Sally Soule, NHDES
NHDES QA Manager:	10/13/11 Signature / Date Vincent Perelli, NHDES
USEPA Project Manager:	Signature / Date Erik Beck, US EPA Region 1
USEPA QA Representative:	10/31/2011 Signature / Date Nora J. Conlon, Ph.D., US EPA Region 1

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Appendix A - NHDES Evaluation of Sediment Quality for Dam Removals, Oct 20, 2006.

Appendix B - Proposed Sediment Sample Field Observation Data Form

Appendix C - Absolute Resource Associates Quality Assurance Manual

3 – Distribution

Table 1 presents a list of people who will receive and review this QAPP and will receive a final copy of the approved QAPP and any subsequent revisions or amendments.

Table 1. QAPP Distribution List

QAPP Recipient Name	Project Role	Organization	Telephone number and Email address
Paul J. Vlasich, Jr.	Overall Project Manager/Town Engineer	Town of Exeter	603-773-6160 pvlasich@town.exeter.nh.us
Peter J. Walker	VHB Project Manager	VHB	603-644-0888 ext 2542 pwalker@vhb.com
William Arcieri	VHB WQ/Sediment Sampling QA Officer	VHB	603-644-0888 ext 2504 barcieri@vhb.com
Kevin MacKinnon, PG, CG	Hydraulic/Sediment Transport Modeling	Weston & Sampson	603-431-3937 mackinnk@wseinc.com
Deb Loiselle	NHDES Dam Removal/Restoration Project Coordinator	DES Dam Bureau	(603) 271-8870 deborah.loiselle@des.nh.gov
Sally Soule	NHDES 319 Grant Coordinator	DES Watershed Assistance Section	(603) 559-0032 sally.soule@des.nh.gov
Gregg Comstock	Water Quality Planning Section Supervisor	DES Watershed Management Bureau	603-271-2983 gregg.comstock@des.nh.gov
Jillian McCarthy	Program QA Coordinator	DES Watershed Assistance Section	(603) 271-8475 jillian.mccarthy@des.nh.gov
Jennifer Guerette	Lab QA Officer	Absolute Resource Associates	(603) 436-2001 jenniferg@absoluteresourceassociates.com
Vincent Perelli	NHDES Quality Assurance Manager	DES Planning, Prevention, and Assistance Unit	(603) 271-8989 vincent.perelli@des.nh.gov
Erik Beck	USEPA Project Manager	USEPA New England	(617) 918-1606 beck.erik@epa.gov
Nora J. Conlon, Ph.D.	USEPA Quality Assurance Representative	USEPA New England	(617) 918-8335 conlon.nora@epa.gov

4 – Project/ Task Organization

Project

The overall project goal is to evaluate the feasibility and potential environmental and human-related impacts associated with the possible removal of the Great Dam located on the Exeter River in downtown Exeter, New Hampshire. This QAPP describes the personnel roles, site locations, protocols and the quality control/quality assurance procedures that will be employed as part of the planned sediment sampling to be conducted on select locations within the river bed upstream and downstream of the dam.

Personnel

Town of Exeter

Paul J. Vlasich, Jr. – Town of Exeter Engineer, Project Manager

Mr. Vlasich will be responsible for managing this project from the Town's perspective to ensure the overall project goals and proposed work tasks are completed. Mr. Vlasich will serve as the primary contact for the consultant team, NHDES and the members of the Exeter River Study Committee. In addition, Mr. Vlasich will be responsible for providing any relevant sediment physical or quality data previously collected in the Exeter River as a result of prior studies.

New Hampshire Department of Environmental Services

Responsible for monitoring the use of the Section 319 grant award and to provide reasonable assurance that the project goals are achieved and that the proposed work tasks are completed in compliance with the terms of the grant agreement.

Sally Soule, NHDES 319 Grant Coordinator

Ms. Soule will serve as the NHDES Project Manager and will be responsible for assisting in the administrative tasks and help monitor the consultant's team progress in completion of the proposed tasks to ensure that the Section 319 Grant requirements are met.

Jillian McCarthy, 319 Program QA Coordinator

Ms. McCarthy is responsible for reviewing the Quality Assurance Project Plan (QAPP) to ensure that it is consistent with EPA protocols and guidance.

Vincent Perelli, NHDES QA Manager

Mr. Perelli is responsible for reviewing the QAPP to assess consistency with other similar sediment sampling studies and NHDES field sampling protocols.

Deborah Loiselle, NHDES Dam Bureau, River Restoration Coordinator
Ms. Loiselle will be responsible for overseeing the proposed work activities, including the sediment sampling efforts as outlined in this QAPP, are consistent with NHDES Dam Bureau policies and procedures for dam removal projects.

Gregg Comstock, NHDES Water Quality Planning Section Supervisor
Mr. Comstock is responsible for reviewing the QAPP in accordance with water quality standards.

Vanasse Hangen Brustlin, Inc.
VHB is responsible for preparing and submitting a project specific QAPP for review by NHDES and EPA outlining the planned sediment sampling protocols, quality assurance and quality control procedures, laboratory analyses and data analyses procedures.

Peter Walker, VHB Project Manager
Mr. Walker is the Manager of the consultant team and is responsible for assuring that the project work tasks are completed in accordance with the agreed upon scope of work, project timeline and budget.

Bill Arcieri, VHB Sediment Sampling QA Officer
Mr. Arcieri is responsible for developing and carrying out the sediment sampling protocols in accordance with the details outlined in this QAPP.

Weston & Sampson, Inc.

Kevin MacKinnon, PG, CG, Sediment Transport Analysis
Mr. MacKinnon will be responsible for performing a sediment transport analysis to assess the potential increased sediment movement downstream with the possible dam removed as a result of increased shear stress from changes in the flow conditions as determined through hydraulic modeling. The sediment grain size analysis performed as part of this sampling effort will be used in the modeling effort.

Absolute Resources Associates
Absolute Resource Laboratories will be responsible for performing the various laboratory analyses on the sediment samples collected as part of this project.

Jennifer Guerette, Absolute Resources Laboratory QA/QC Officer,
Ms. Guerette is responsible for establishing the QA/QC control protocols at Absolute Resources Laboratory for the various laboratory analyses that will be performed on this project.

Figure 1. Project organizational chart

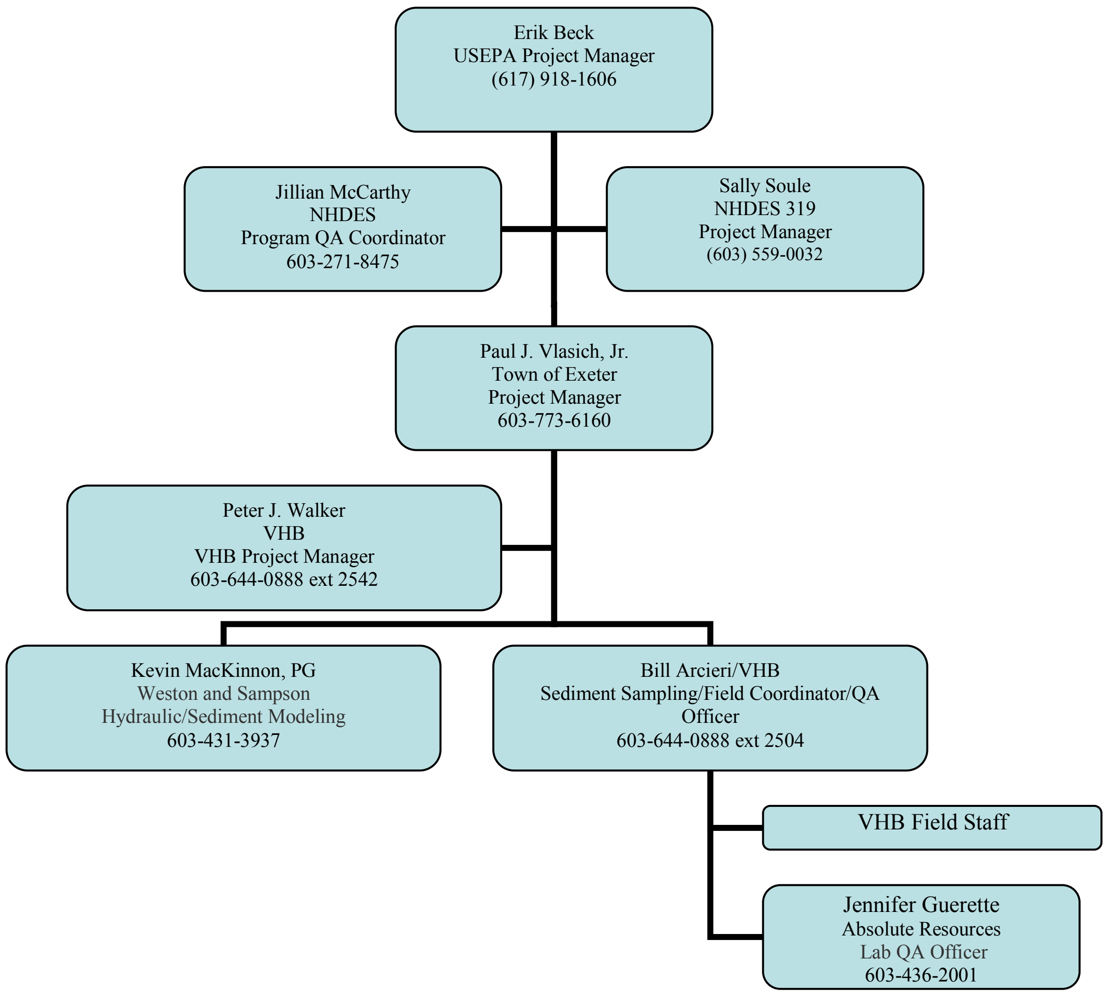

Table 2. Personnel Responsibilities and Qualifications

Name and Affiliation	Responsibilities	Qualifications
Mr. Paul Vlasich. Jr. Town of Exeter	Overall Project Manager for the Town of Exeter	Town Engineer, PE
Sally Soule NHDES Watershed Assistance Section	NHDES Project Manager per 319 Grant Award	On file at NHDES
Deb Loiselle NHDES Dam Bureau	Technical Review and Oversight for Work Activities and Products	On file at NHDES
Jillian McCarthy NHDES Watershed Assistance Section	Reviews QAPP preparation and other QA/QC activities	On file at NHDES
Gregg Comstock	Reviews QAPP in accordance with water quality standards	On file at NHDES
Peter Walker VHB	Project Manager for the Consultant Team	Project Manager
Bill Arcieri VHB	Sediment Sampling QA/QC Field Coordinator and Water Quality Assessment	CPESQ, CPSWQ
Kevin MacKinnon Weston & Sampson	Sediment Transport Modeling	Professional Geologist
Vincent Perelli NHDES QA Program Manager	Review/Approve Sediment Sampling QAPP	On file at NHDES
Jennifer Guerette Absolute Resource Associates	Review QAPP and Verify Sampling Protocols are Consistent with Lab Analysis Procedures	On file at Absolute
Nora J. Conlon, Ph.D. EPA QA Chemist EPA Region I Laboratory	Responsible for review and approval of QAPP	On file at EPA

5 – Problem Definition / Background

The current Exeter River Great Dam was constructed in 1914, according to the NH Department of Environmental Services Dam Bureau database, and has been owned by the Town of Exeter since 1981 for the purpose of recreation and water supply. The dam currently has known deficiencies, and associated safety and liability issues.

Based on inspections conducted by NHDES personnel, several deficiencies have been identified including deteriorated concrete, small leaks/seeps through the penstock intake, and the dam's inability to pass the runoff resulting from a 50-year precipitation event. Currently, the dam does not meet modern safety requirements, and NHDES has given the Town of Exeter future deadlines to either remove or modify the dam to meet safety requirements. In order to meet these safety requirements, the Town of Exeter will need to greatly modify the existing dam. Modifications to the dam will not solve all upstream flooding issues, and water quality and fish passage difficulties. A series of studies have been conducted on the Dam since 2006, however dam removal was not explored in great detail. Evaluating the feasibility and the potential consequences of dam removal is the primary focus of this current study.

The river reaches upstream of the dam including the Exeter River and the Little River are listed as impaired on the state's 303(d) due to water quality issues . The lower Exeter River from the Great Dam upstream to the Pickpocket Dam, a distance of approximately eight miles, has three reaches list for various water quality issues. These issues center on low dissolved oxygen levels during warm temperature and low flow periods and occasional elevated levels of *E. coli* bacteria. Similarly, the Little River is listed as impaired due to previous low dissolved oxygen measurements. According to the 2010 303(d) list, the source or cause for low dissolved oxygen is unknown, and although a Total Maximum Daily Load (TMDL) Study is considered warranted, it is categorized as a low priority with a proposed tentative schedule for completion in 2019 for both the Little and Exeter Rivers.

The focus of this QAPP relates to the planned sediment sampling in select locations within the river channel in order to characterize existing sediment quality conditions and the physical nature of these sediments in accordance with the NHDES Policy on Evaluation of Sediment Quality for Dam Removals (See Appendix A). It is anticipated that if the dam was removed, there may be increased potential for sediment to move downstream, which will be evaluated as part of this project as discussed below.

What Will Project Data Be Used For/What Decisions Will Be Made

The data provided by the project will be used to characterize the existing sediment quality in and around the dam and based on the sampling results, evaluate whether the possible dam removal may pose an adverse risk to water quality and aquatic life or human health downstream due to possible increased exposure to any elevated contaminant levels in the sediments and/or due to potential sediment movement downstream. The proposed sampling will include an analysis of particle size distribution which will be used to evaluate the potential for sediment movement downstream as part of the hydraulic modeling/sediment transport assessment effort.

Type of Data Needed

Consistent with the NHDES Policy on Sediment Quality for Dam Removals, sediment quality and particle size distribution data will be collected from river bed samples at select locations based on laboratory analysis of the following parameters:

- Total Organic Carbon (TOC) Method 9060
- Polynuclear aromatic hydrocarbons (PAHs) by USEPA Method 8270D
- Polychlorinated Biphenyls (PCBs) by USEPA Method 8082A
- Pesticides by USEPA Method 8081B
- Selected Metals (arsenic, barium, cadmium, chromium, copper, lead, nickel and zinc USEPA Method 6010C) and Mercury (USEPA Method 7471B)
- VOCs by USEPA Method 8260B
- Grain Size Distribution Analysis via sieve and hydrometer (silt and clay) by ASTM Method D-422, or comparable method

Who Will Use the Project Data

The data generated by this project will be used by the consultant team to evaluate whether the existing sediment quality may pose a hazard ?to aquatic life based on previously established threshold effect concentrations in accordance with the NHDES' Evaluation of Sediment Quality Guidance Document (April 2005). The data will also be used to evaluate whether the potential dam removal may result in adverse effects on water quality and benthic conditions downstream of the existing Great Dam location. This assessment will involve evaluating potential changes in the stream flow conditions (*i.e.,* velocities and depth) during peak flow events based on the anticipated riverine conditions with the dam hypothetically removed using hydraulic modeling techniques. The results of this assessment will be used to evaluate the potential for sediment transport downstream. The hydraulic modeling and sediment transport assessment will be performed by Kevin MacKinnon of Weston & Sampson.

The hydraulic model that will be used to predict water surface elevations and velocities under both existing and post-removal conditions and support the sediment transport assessment will consist of the U.S. Army Corps of Engineers Hydraulic Engineer Center's River Analysis System (HEC-RAS) Version 4.1. A number of data sources and observations will be used to validate/calibrate the model under existing conditions including observed high water elevations recorded during recent flood events and low water elevations measured during the drawdown of the Great Dam impoundment in the fall of 2009 as well as during the groundwater pumping test near Exeter River. Model input and predictive results will undergo technical review by Dr. Thomas Ballestero of the University of New Hampshire, as an expert in stream restoration and sediment transport.

Previous Data Surveys

The only other known sediment quality data previously collected in the vicinity of the Exeter Great Dam consists of data collected by AECOM in 2008/09 approximately 300 to 400 feet downstream of the dam in the tidally-influenced Squamscott River. This data was collected as part of a previous proposed outfall project in the Squamscott River funded by Unitil Corporation. The sediment chemistry data collected here is not expected to be representative of the sediment conditions in the impoundment upstream of the dam. Depending on the results of the hydraulic modeling /sediment transport analysis to be completed as part of this project, a subsequent assessment will be made as to whether this location could be affected by the potential dam removal and whether sediment quality data is relevant in terms of a potential increased risk to aquatic life or human health.

With respect to sediment transport modeling analysis, there are several existing data sources that will be used in modeling the channel geometry characteristics, including:

- Detailed bathymetry data for approximately 18,000 feet of the Exeter River upstream of the Great Dam taken during a 2005-2007 Wright Pierce-Woodlot Alternatives study of the Exeter River[1],

[1] Wright-Pierce and Woodlot Alternatives, Inc., March 2007. Exeter River Study Phase I Final Report for the Town of Exeter, NH

- Approximately 30 FEMA Flood Insurance Study cross-sections in both the Exeter and Little Rivers[2]
- Approximately 7 channel cross-sections on the Little River developed by Stantec in support of the development of the Linden Commons Subdivision along the Little River[3],
- Several dozen cross-sections developed by Bear Creek Environmental and the NHDES during a geomorphic assessment of the Exeter River[4],
- Six (6) additional cross-sections to be developed during this project to spot-check other data sources, and
- An on-going survey of significant road crossings, inline structures, and in-channel building foundations.

6 – Project / Task Description

The Exeter River/Great Dam Removal Feasibility and Impact Analysis is a study initiated by the Town of Exeter to evaluate the possible outcomes associated with dam removal and determine if dam removal is prudent, feasible, cost effective, and in the best interest of the Town. Issues to be explored include, but are not limited to: natural resources, water quality, hydraulics, infrastructure, economics, historic resources, endangered species, and recreation and flooding. In conjunction with previous studies which have focused on modifications to the dam, this project will provide vital information on dam removal, completing a full analysis of all alternatives. This will allow the Town of Exeter to make a fully informed decision leading to a preferred alternative.

The specific issue or task addressed in this QAPP relates to the proposed sampling of the river bed sediments to characterize the existing sediment quality and physical nature of these sediments. Table 3 below describes the project schedule timeline.

Table 3. Project Schedule Timeline

Activity	Dates (MM/DD/YYYY)		Product
	Anticipated Date(s) of Initiation	Anticipated Date(s) of Completion	
Existing Data Collection and Review	5/24/2011	7/22/2011	Technical Memo
Field Survey and Base Mapping	6/3/2011	9/2/2011	Topo Survey Map
Sediment Evaluation	7/5/2011	2/27/2012	
QAPP Preparation	7/5/2011	10/15/2011	Approved QAPP
Sediment Sampling	10/15/2011	11/22/2011	Sediment Data Rpt
Analyze Sediment Transport	11/8/2011	1/16/2012	Model Results
Sediment Management	1/17/2012	2/27/2012	Management Options
River Hydrologic/Hydraulic Analysis	8/15/2011	2/13/2012	HEC-RAS Model results
Cultural Resources	7/5/2011	5/14/2012	Phase 1 Survey
Wildlife and Natural Communities	1/17/2012	2/20/2012	Technical Analysis
Other Issues of Importance	7/5/2011	3/19/2012	Technical Analysis

[2] Personal Communication from Susan Greene, Zimmerman Associates at FEMA Engineering Library
[3] Stantec, March 2009, Hydrologic Study Report, Little River Number 1
[4] Bear Creek Environmental and Fitzgerald Environmental Associates, March 2009, Exeter River Geomorphic Assessment and Watershed Based Plan

Water Quality	11/22/2011	12/19/2011	Technical Analysis
Dam Deconstruction Alternatives and Impact Analysis	5/15/2012	7/23/2012	Summary Narrative, Plans, Estimates
Visual Assessment	7/24/2012	9/3/2012	Photo-simulations
Feasibility and Impact Analysis Report Preparation	7/5/2011	10/10/2012	Summary Report
Outreach and Coordination Meetings	7/8/2011	10/24/2012	Up to 9 mtgs

Based on EPA-NE Worksheet #10.

7 – Quality Objectives and Criteria

Table 4 summarizes the data quality, indicators, performance criteria and quality control activity/measurement related to the sediment sampling analysis only.

Table 4. Measurement Performance Criteria for Sediment Samples

Data Quality Indicators	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance
Precision-Overall	NA	Field Duplicates[1]
Precision-Lab	Generally <20% difference. See Lab SOP.	Lab Duplicates
Accuracy/Bias	Generally < 30% difference See Lab SOP.	Lab spikes and blanks
Comparability	Deviation from SOPs should not Influence more than 25% of data.	Data comparability check
Sensitivity	Reporting Limits > Action Levels	Laboratory fortified blanks
Data Completeness	100% of the planned soil samples collected and analyzed[1]	Data Completeness Check

Note: [1]Field duplicates are not planned due to limited available budget and decision to obtain greater spatial coverage.

Precision

Precision is the degree of agreement among repeated measurements of the same characteristic (parameter) under the same or similar conditions.

Precision measurement data include laboratory and field duplicate data expressed as relative percent difference (RPD). Duplicate precision is typically analyzed by calculating the RPD using the equation:

$RPD = [x_1 - x_2] / [(x_1 + x_2/2)] \times 100\%$

The sediment analysis laboratory (Absolute Resources) analyzes matrix duplicates every 20 samples or with each batch analyzed, whichever is more frequent.

With limited budget available for field sampling, it was determined that the sediment analysis would benefit more by collecting more samples and obtaining greater spatial coverage within the river impoundment rather than collecting field duplicates. Precision measurements will rely on the laboratory matrix duplicates. This has been discussed and accepted by NHDES personnel.

Accuracy and bias

Accuracy and bias are used interchangeably. Accuracy is the extent of the agreement between an observed value (sample result) and the true value of the parameter being measured. This is measured by occasionally spiking samples with known quantities of the constituent being tested and then conducting the analysis.

Absolute Resources analyzes laboratory-fortified blanks and matrix spikes every 20 samples or for each batch analyzed, whichever is more frequent.

$$\% \text{ Accuracy/ Bias} = \frac{\text{Spiked Sample Conc.} - \text{Unspiked Sample Conc.}}{\text{Spiked Conc. Added}} \times 100\%$$

Table 5 summarizes the measurement performance criteria for the various parameters that will be analyzed on this project.

Table 5. Measurement performance criteria for various parameters

Parameter	Precision	Accuracy	Reporting Limit
VOCs	Lower of+/- 20% or control limit	Tabulated Control limit	100-2000 ug/kg
PAHs (as SVOC's)	Lower of+/- 20% or control limit	Tabulated Control limit	20 -100 ug/kg
Pesticides	Lower of+/- 20% or control limit	Tabulated Control limit	1 ug/kg
PCBs	Lower of+/- 20% or control limit	Tabulated Control limit	50 ug/kg
TOC	Lower of+/- 20% or control limit	Tabulated Control limit	100 mg/kg
Metals-Soils	Lower of+/- 20% or control limit	+/- 10%	0.06 - 2.0 mg/kg

See Table 6 for additional details

Representativeness

Representativeness is a qualitative term that describes the extent to which a sampling design adequately reflects the environmental conditions of a site. Representativeness is assessed in both qualitative and quantitative terms. This QAPP covers the qualitative aspects of representativeness in terms of spatial coverage of the area with respect to the number and location of samples as well as the sampling techniques, sample handling protocols, and associated documentation. The planned sampling design, locations and methods are discussed in more detail in Sections 10 and 11 of this QAPP.

Comparability

Comparability is the extent to which results from one study can be compared directly to the results of a previous study or from different locations or events within the same study. Comparability is primarily achieved through using standardized sampling and analytical methods, units of reporting, and site selection procedures.

Comparability of data will be established through use of the following:

- Each sample will be collected following methods outlined in the Methods for Collection, Storage and Manipulation of Sediments for Chemical and Toxicological Analyses: Technical Manual (EPA-823-B-01-002) for parameters specified in the NHDES Evaluation of Sediment Quality for Dam Removals, October 20, 2006 Appendix A.
- Assessment and Interpretation of data will be consistent with sediment chemistry analyses guidance contained in the Evaluation of Sediment Quality Guidance Document, NHDES-WD-04-9 (April 2005). Document can be accessed via link: http://des.nh.gov/organization/commissioner/pip/publications/wd/documents/wd-04-9.pdf.
- Consistent reporting units for a specified procedure will be used.
- Method Detection Limits (MDLs) for all analytical parameters that were established in accordance with NHDES recommendations/requirements before the start of the analyses to meet the project requirements will be utilized.
- Absolute Resources will follow their National Environmental Laboratory Accreditation Program (NELAP) approved Quality Assurance Manual for all analysis procedures and quality control.

Sensitivity

Sensitivity is the ability of a method or instrument to produce a reliable response or detect an amount of contaminant of concern relative to the level of interest or concern. The sediment chemistry will be measured through appropriate laboratory instruments maintained by Absolute Resource Associates. Sensitivity of each instrument and parameter is generally in terms of the method detection and reporting limits, which are provided in Table 6 below in comparison to the sediment screening thresholds.

Completeness

Completeness is a measure of the number of samples you must take to be able to use the information, compared to the number of samples you originally planned to take. It is anticipated that all six samples will be collected to satisfy the project goals.

Threshold/Action Levels

For each contaminant, analytical results will be compared to the available threshold effect concentrations (TEC) and/or the probable effect concentrations (PEC) as provided in relevant reference documents including the most recent NOAA SQuiRT Tables (NOAA 2008)[5]. TEC values are screening thresholds below which adverse effects are unlikely. PEC values are screening thresholds above which adverse effects are likely.

[5] The 2008 NOAA SQuiRT Tables can be accessed via following web address ; http://response.restoration.noaa.gov/topic_subtopic_entry.php?RECORD_KEY(entry_subtopic_topic)=entry_id,subtopic_id,topic_id&entry_id(entry_subtopic_topic)=783&subtopic_id(entry_subtopic_topic)=5&topic_id(entry_subtopic_topic)=2

Table 6. Method Detection/Reporting Limits Relative to Available Sediment Screening Thresholds

Parameter	CAS. No.	Method	Method Detection Limit (MDL)[1]	Reporting Limits (RL)[1]	Sediment Screening Thresholds	
					Threshold Effect Concentration (TEC)[2]	Probable Effect Concentration (PEC)[2]
VOCs		8260B	8 -2000 ug/kg	100-2000 ug/kg	EPA Region III[3]	EPA Region III[3]
PAHs (as SVOCs)	Total				1,610 ug/kg	22,800 ug/kg
Benzo(g,h,i) perylene	191-24-2	8270D	40 ug/kg	50 ug/kg	290 ug/kg	6,300 ug/kg
Indeno(1,2,3-cd) pyrene	193-39-5		40 ug/kg	50 ug/kg	78 ug/kg	836.7 ug/kg
Anthracene	120-12-7		30 ug/kg	50 ug/kg	57.2 ug/kg	845 ug/kg
Benzo(a)anthracene	56-55-3		30 ug/kg	50 ug/kg	108 ug/kg	1,050 ug/kg
Benzo(a)pyrene	50-32-8		30 ug/kg	50 ug/kg	150 ug/kg	1,450 ug/kg
Chrysene	218-0-19		30 ug/kg	50 ug/kg	166 ug/kg	1,290 ug/kg
Dibenzo(a,h)anthracene	53-7-03		20 ug/kg[7]	20 ug/kg	33.0 ug/kg	330 ug/kg
Fluoranthene	206-44-0		60 ug/kg	100 ug/kg	423 ug/kg	2,230 ug/kg
Fluorene	86-7-37		40 ug/kg	50 ug/kg	77.4 ug/kg	536 ug/kg
Naphthalene	91-20-3		60 ug/kg	100 ug/kg	176 ug/kg	561 ug/kg
Phenanthrene	85-01-8		80 ug/kg	100 ug/kg	204 ug/kg	1,170 ug/kg
Pyrene	129-00-0		40 ug/kg	50 ug/kg	195 ug/kg	1,520 ug/kg
Pesticides		8081B				
4,4'-DDT	50-29-3		0.6 ug/kg	1 ug/kg	4.16 ug/kg	62.9 ug/kg
Lindane (gamma-BHC)	58-89-9		0.2 ug/kg	1 ug/kg	2.37 ug/kg	4.99 ug/kg
Dieldrin	60-57-1		0.2 ug/kg	1 ug/kg	1.90 ug/kg	61.8 ug/kg
Endrin	72-20-8		0.2 ug/kg	1 ug/kg	2.22 ug/kg	207 ug/kg
4,4'-DDE	72-55-9		0.3 ug/kg	1 ug/kg	4.88 ug/kg	31.3 ug/kg
4,4'-DDD	72-54-8		0.6 ug/kg	1 ug/kg	3.54 ug/kg	28.0 ug/kg
Heptachlorepoxide	102-45-73		0.2 ug/kg	1 ug/kg	2.47 ug/kg	16.0 ug/kg
Aldrin	309-00-2		0.2 ug/kg	1 ug/kg	2.0 ug/kg	80 ug/kg
Chlordane	5103-74-2		0.2 ug/kg	1 ug/kg	3.24 ug/kg	17.6 ug/kg
PCBs						
Total PCB	1336-36-3	8082A	6 ug/kg[4]	50 ug/kg[5]	59.8 ug/kg	676 ug/kg
TOC		9060		100 mg/kg	NA	NA
Sieve with hydrometer Subcontracted[5]		ASTM D422		#4, 10, 40, 200 and silt and clay	NA	NA
Metals						
Arsenic	7440-38-2	6010C	0.1 mg/kg	0.5 mg/kg	9.79 mg/kg	33 mg/kg
Barium	7440-39-3		2 mg/kg	2 mg/kg	na	330 mg/kg[6]
Cadmium	7440-43-9		0.02 mg/kg	0.2 mg/kg	0.99 mg/kg	4.98 mg/kg
Chromium	7440-47-3		0.1 mg/kg	2 mg/kg	43.4 mg/kg	111 mg/kg
Copper	7440-50-8		0.6 mg/kg	2 mg/kg	31.6 mg/kg	149 mg/kg
Lead	7439-92-1		0.2 mg/kg	0.5 mg/kg	35.8 mg/kg	128 mg/kg
Nickel	7440-02-0		0.1 mg/kg	2 mg/kg	22.7 mg/kg	48.6 mg/kg
Zinc	7440-66-6		1 mg/kg	2 mg/kg	121 mg/kg	459 mg/kg
Mercury	7439-97-6	SW7471B	0.001 mg/kg	0.06 mg/kg	0.18 mg/kg	1.06 mg/kg

Notes: [1]MDL based on low point in calibration provided by Absolute Resource Associates. (See Appendix C). Reported as dry weight.
[2] 2008 NOAA SQUIRT Tables. Reported as dry weight.
[3] EPA Region III has developed screening criteria to assess ecological risk associated with freshwater sediments: http://www.epa.gov/reg3hwmd/risk/eco/btag/sbv/fwsed/screenbench.htm
[4]Expressed as Aroclor
[5]Turner Consulting Testing Laboratories, Dover, NH
[6] Barium screening level based on EPA Eco-SSLs eco screening levels for soils

8 – Special Training / Certification

The sediment sample collection will be conducted and overseen by a qualified water resource scientist employed by VHB. Each sample will be collected in accordance with the protocols and guidance provided by NHDES (Evaluation of Sediment Quality Guidance Document, NHDES-WD-04-9) and EPA (EPA-823-B-01-002, 2001). VHB is responsible for the sediment sampling field personnel being familiar with the protocols outlined in this QAPP. VHB will go over and discuss the provisions of the QAPP with field personnel prior to sampling. This training will include operation and appropriate use of field equipment, procedures for taking samples, procedures for taking comprehensive and legible field notes, and understanding the appropriate need for accuracy and quality control in data collection. Field sampling personnel will initial all sampling forms acknowledging that they have discussed the sampling protocols with the Project Manager and understand the QA/QC procedures.

The laboratory performing the sediment analysis (Absolute Resources) is NELAP accredited. Details of the labs certifications and training requirements for laboratory personnel are found in the Quality Assurance Manual prepared by Absolute Resources.

9 – Documents and Records

The sections below describe the documents and records that will be prepared for each round of sampling by each project group. Section 21 describes the reports that will be prepared and Section 19 further discusses Data Management by each group.

Sediment Sampling/Analysis

All documents, records, and data will be stored electronically on VHB's computer system, in project specific folders. Files are to be backed up on a regular basis. Project files are archived and kept a minimum of ten years. Hard copies of field data, field documents, second hand data, or print outs of work in progress will be stored in a file folder located on VHB's premises. Electronic and paper hard copies of relevant files shall be given to the Town of Exeter and NHDES for their records upon request.

A copy of the approved QAPP will be electronically stored in NHDES's database and a hard copy will be retained in the project file. Major changes to the QAPP will be submitted to the Town of Exeter, EPA and NHDES for approval.

Field documents shall include chain-of-custody records, field notes, photographs and field logs. All field documents will be maintained by VHB. Team members will retain the original copies. Field notes must be completed on-site at the time the data collection occurs. The minimum required information on field notes to be included is as follows:

- Project Name
- Company
- VHB Project Manager
- Sampling Team Members
- Observation Notes
- Detailed location of sample, including hand-drawn sketch

- Time of Day
- Weather Conditions
- Equipment used including manufacturer, type, and serial number (if available)

A sample Sediment Sampling Field Notes form is attached in Appendix C.

Information for each sediment sample will be recorded in a field log and will include the following at a minimum:

- Date
- Time
- Initials of Sampler
- Weather Conditions
- Sample Identification number
- Location (GPS coordinates (northing/easting) w/sub-meter accuracy or field measured ties to permanent features)
- Water depth
- Approximate Sediment Depth (based on probing)
- Sediment description
- Sample Type (if more than one method is used to collect sample)
- Approximate length of sediment core
- Depth of penetration of the core, the volume of sediment recovered in tube

All lab analysis records will be organized, filed, and maintained according to the Quality Assurance Manual for Absolute Resources attached in Appendix C.

10 – Sampling Process Design

The NHDES Evaluation of Sediment Quality for Dam Removals recommends that a minimum of four (4) sampling locations be established as follows:

1) At a location immediately downstream of the dam,
2) At a location in the impoundment immediately upstream of the dam,
3) At a second location within the impoundment, and
4) At a location upstream of the effects of the impoundment.

As discussed earlier, six sampling locations are planned for this effort with five locations within or just upstream of the impoundment and one location just downstream of the dam as shown in Figure 2; Proposed Sediment Sampling Stations. The following four (4) locations are intended to satisfy the NHDES Policy:

- ER-1: Downstream of the dam
- ER-2: Immediately upstream of the dam
- ER-4: Upper impoundment (near old town landfill along the banks of the River)
- ER-5: Upstream of the effects of the impoundment (lower riffle area)

In addition, the following two (2) additional sediment sample locations are proposed to bracket key areas within the impoundment. Sample location (ER-3) is intended to evaluate sediment quality conditions at a location just upstream of the municipal raw water intake used as a drinking water supply source for the Town. The data from this location will help to assess likelihood of any sediment contaminants in the vicinity of the raw water intake. The other sampling location (LR-1) is intended to provide sediment quality data and sediment grain size data for the impounded portion of the Little River just upstream of its confluence with the Exeter River. The lower portion of the Little River is located in a relatively more urbanized area and could possibly have slightly different grain size and sediment chemistry properties than the Exeter River.

- ER-3: Approximately 50 -100 feet upstream of the Town's raw water intake.
- LR-1: Impounded portion of the Lower River.

The proposed sampling station locations shown on Figure 1 indicate general locations of the six sediment sampling locations. The exact locations will be determined in the field based on a review of the local site conditions, availability of access, river bed substrate, as well as potential equipment limitations. The final site selection will also depend on sufficient sediment deposits being available to collect sediment material for all proposed parameters including grain size distribution analysis. Prior to sample collection, an approximate depth of unconsolidated sediment deposits will be determined based on sediment probing using stainless steel rods. Each sample will consist of a grab sample taken from the upper six to eight inches of the streambed. The upper six to eight inches of sediment is generally considered to be the sediment horizon that is most vulnerable to potential movement downstream due to possible increased velocities during high flow events following the possible dam removal. For a screening level analysis this is considered sufficient for purposes of this feasibility study. Samples will be collected from the main portion of the channel or that portion of the channel that contains the greatest flow, otherwise referred to as the "thalweg." The final site selection will also depend on there being sufficient sediment deposits to sample for all proposed parameters including grain size distribution analysis via sieve and hydrometer by American Society for Testing and Materials (ASTM) Method D-422 (or a comparable method) will be collected for each of the six sediment samples. Table 7 summarizes the field sampling for this project.

Given the budget limitations, no additional field duplicates or trip blank measurements are anticipated as the accuracy and precision of the laboratory analysis will rely on matrix spike and matrix spike samples using in-situ river sediments as well as other laboratory quality control and assurance procedures that are done on a parameter-specific basis as discussed above (see Table 9). Any data qualifications as a result of laboratory fortified matrix spikes will be incorporated into the project sample reports.

Table 7. Sediment Sampling Field Collection Summary.

Parameter	No. of sampling locations	Samples per event per site	Number of sampling events	Additional sample volume collected at one station for MS/MSD[1]	Number of bottle blanks	Total number to lab
Sediment	6	1	1	1	NA	7[1]

1One set of containers will be for matrix spike / matrix spike duplicate for lab QA/QC purposes – See Table 9

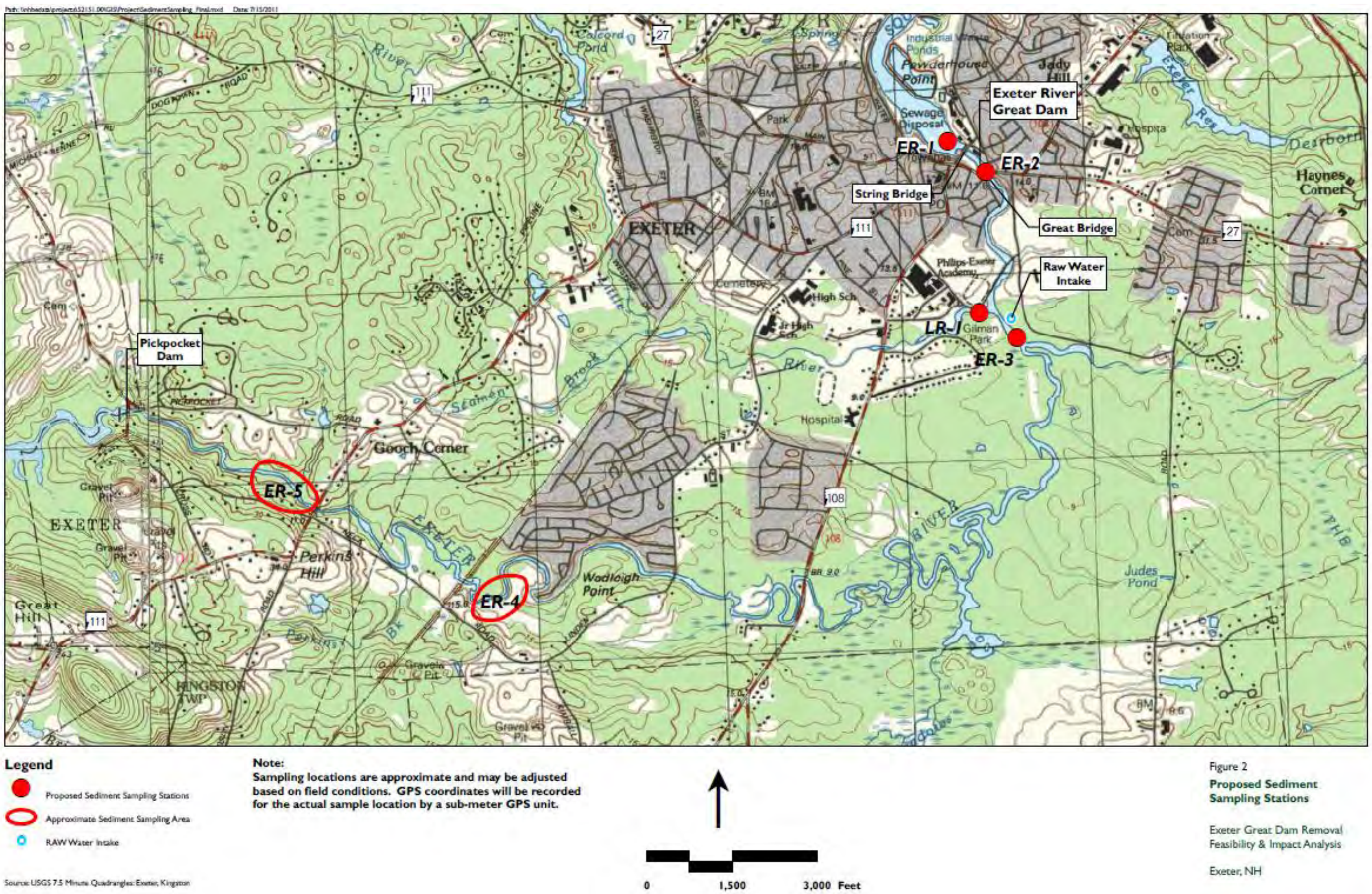

Figure 2
Proposed Sediment Sampling Stations

Exeter Great Dam Removal Feasibility & Impact Analysis

Exeter, NH

11 – Sampling Methods

Sediment Sampling/Analysis

The actual sediment sampling collection is anticipated to be conducted by hand using a stainless steel, sand or mud auger that will allow sediment to be collected from the upper 6 to 8 inches of the river bottom. The exact type of auger head, whether sand or mud will be determined based on visual assessment of the river bottom material. The auger head will be rinsed three times with ambient water prior to sampling and rinsed with de-ionized water after sampling using a bucket to collect rinsate. Once collected, the sample will be immediately transferred into a clean, stainless steel bowl to allow transfer to laboratory bottles using a stainless steel spatula. To minimize the potential loss of VOCs due to exposure and volatilization, the sediment samples for VOC analysis will be collected using a dedicated sterile syringe barrel sample that can be inserted into the sample matrix to retrieve an unexposed sample that can then be transferred directly into VOC vials by extruding the material from the syringe. The material used to fill the remaining bottles will be well mixed using the spatula to maintain homogeneity prior to transfer. The sampling collection methods will be consistent with EPA's Methods for Collection, Storage and Manipulation of Sediments for Chemical and Toxicological Analyses: Technical Manual EPA (EPA-823-B-01-002, 2001).

Prior to transferring to laboratory bottles, the sediment sample will be photographed and visually inspected to assess the homogeneity in terms of sediment texture, color or debris content. Observations will be recorded on a field data sheet for each station (See Appendix B). The sediment will be transferred to clean laboratory prepared bottles. The sample handling methods will be in accordance with the Absolute Resources Associates Quality Assurance Manual and SOPs as attached in Appendix C. Table 8 summarizes the sample requirements.

Table 8. Sample Requirements

Analytical parameter	Collection method	Sampling SOP	Sample volume	Container size and type	Preservation requirements	Max. holding time (preparation and analysis)
VOC	Grab	Appendix C	40 mL	Glass Vial	4°C, Methanol	14 days
PAHs	Grab	Appendix C	4 oz.	Amber Glass	4°C	14 days/40 days
Pesticides	Grab	Appendix C	4 oz.	Amber Glass	4°C	14 days/40 days
PCBs	Grab	Appendix C	4 oz	Clear Glass	4°C	14 days/40 days
TOC	Grab	Appendix C	2 oz.	Clear Glass	Cool, 4°C	28 days
Metals-Soils	Grab	Appendix C	4 oz	Clear Glass	Cool, 4°C	28 days.
Grain Size	Grab	Appendix C	1000 mL	Plastic jar	Na	Na

Note: [1]See sampling procedure described in Volatile Organic Compounds Method EPA 8260/8260B SOP's Appendix C attached in QAPP.

12 – Sample Handling and Custody

Sediment Sampling/Analysis

All equipment used to collect and handle samples will be initially rinsed by ambient waters and then rinsed thoroughly with de-ionized water before sampling. Appropriately cleaned sample bottles will be provided by the laboratory. These containers will be labeled with a waterproof adhesive label to which the appropriate data can be added, using a permanent ink pen capable of writing on wet surfaces. Additional sediment material will be collected at one sampling station to be determined in the field based on the amount of material available using extra laboratory prepared containers to allow for matrix spike and matrix spike duplicates to be performed by the laboratory.

The sample label will include: Project Name, Sample Name, Sample Location, Sampler Name, Date, Time, Preservative, and Test.

The container lids will be fastened securely. Storage, transport, and sample containers, including extra containers will be available in the event of loss or breakage. Any extra sample material and rinse water will be contained within a separate sealable container, and will be appropriately disposed of later, depending on the results of the lab analysis.

A field data sheet will be utilized for describing the sediment sample recovered and the conditions at each sample location. Each sample will be photographed. One person will be delegated responsibility for completing data sheets and will track the samples from the time they are collected until they delivered to the laboratory. Samples will be placed in coolers with ice. VHB shall deliver the coolers containing the sediment samples directly to the sediment-testing laboratory (Absolute Resources) in Portsmouth, NH, together with a completed Chain-of-Custody Form.

13 – Analytical Methods

Sediment Analysis

The laboratory performing the sediment analysis (Absolute Resources) is NELAP-certified (see Appendix C) and will use all the proper analytical methods accordingly. Information for analytical methods and corrective action in particular, for the sediment analyses is outlined in the Quality Assurance Manual and SOPs for Absolute Resources, attached in Appendix C. The analytical methods to be used for each of the parameters are identified in Table 6.0 on page 15.

14 – Quality Control

Sediment Sampling/Analysis

A duplicate or split sample is not planned due to the low number of planned samples, however, additional sediment material will be collected at one of the designated sample locations where more than adequate sediment material is available to allow for matrix spikes and matrix spike duplicates to be performed by the laboratory. The matrix spike and matrix spike duplicate analyses will allow an assessment as to whether sediment matrix itself may affect the analytical testing through comparison of the percent recovery of the various parameters.

Field QA/QC Assessment
QA/QC for field procedures will be addressed through implementation of a thorough inspection and audit process. This process will include routine observation and critique of the sample collection process by the field sampling coordinator. These inspections will include reviewing core collection techniques, preparation of and transcription of field notes, accuracy of the GPS used to record core sample locations and ability of the selected equipment to obtain adequate samples. Additionally, the field processing station and core sample processing procedures will be reviewed to assure that the station and protocols are appropriate. Activities reviewed will include sample login, field data entry, core segmenting and sample homogenization procedures, container labeling, and sample packaging for shipment. The Field QA Manager will be informed of any deficiencies in the data, including field QA/QC sample data, and will investigate potential sources of these deficiencies within the field processes.

If unacceptable conditions or data are realized, the VHB QA/QC Officer and/or VHB Project Manager will develop and initiate appropriate changes or modifications that will be documented in the appropriate field log and summarized in the final report. Corrective actions may include the following:

- Re-analyze samples if holding time and sample volume permit.
- Re-sampling and re-analyzing, if applicable.
- Evaluating and amending sampling and/or analytical procedures.
- Accepting data, while documenting a level of uncertainty.

Laboratory and Data Management QA/QC Assessment
The transfer of custody will be limited between VHB personnel, laboratory courier (if applicable), and fixed base laboratory personnel. The primary objective of custody requirements for this project is simply to track and document authorized personnel that handled samples during and post-sampling. Data verification of reports from the laboratory (Absolute Resources) will be reviewed in general accordance with that lab's typical protocols. Please see Quality Assurance Manual for Absolute Resources attached in Appendix C for information regarding the laboratory's data management QA/QC.

Data Verification and Validation
Verification and validation of the data will be performed to determine the usability of the data and to ensure results are generated in accordance with the procedures defined in this QAPP. The VHB Project Manager will be responsible to conduct a full-package review of the field process and data produced for the site and reports from the fixed base laboratory (Absolute Resources). The fixed base laboratory (Absolute Resources) Quality Assurance (QA) Officers will conduct validation and reporting consistent with the parameters of Absolute Resources Quality System Manual and SOPs attached in Appendix C. To facilitate data verification and validation, analytical results for all samples will be provided in a full data package in a scanned electronic media (.PDF) file and presented to the NHDES Watershed Assistance Section as part of the sediment analysis reporting. NHDES will review the package and compare the methodology and results to the requirements indentified in this QAPP. If either verification or validation by

the NHDES Watershed Assistance Section identifies deficiencies in data quality, the source of the deficiencies will be investigated and corrective action will be taken.

QA/QC Samples
Field duplicate or split samples are not planned for this feasibility analysis as the selected number of samples needed to be balanced between the spatial coverage needs and the limited available budget. If the results of this analysis indicate a potential contamination issue and additional future sampling has been determined to be the best course of action by the project team, this additional sampling will consider field duplicates. Table 9 summarizes the quality control factors for laboratory analysis. VHB will follow the EPA document Methods for Collection, Storage and Manipulation of Sediments (EPA-823-B-01-002) in collecting the actual samples. The following items are covered in this QAPP:

- QA procedures will be followed to ensure that the laboratory SOPs are followed and that contamination is neither introduced to nor lost from manipulated samples. Ex: Samples to be analyzed for trace metals will not come in contact with metal surfaces (except stainless steel).
- Sampling methodologies that will allow the collection of representative samples based upon data needs shall be used.
- EPA/NHDES-accepted sampling devices that minimize the disturbance or alteration to the sediment's chemical composition shall be used.
- Decontamination procedures that reduce cross-contamination potential between sampling points shall be employed.
- Proper sample containers and preservation techniques required by the sediment testing laboratory will be utilized to maximize the integrity of the samples.

Table 9. Summary of Laboratory Analytical QA/QC Activities

		Frequency of			
Analyte	**Lab fortified matrix spike**	**Lab fortified matrix spike duplicate**	**Lab fortified blank (QC standard)**	**Lab reagent blank**	**Independent calibration verification (QC standard)**
VOC 8260B	A lab fortified MS will be analyzed using excess sample volume from one sample location	A lab fortified MSD will be analyzed using the same excess sample volume	LFB will be analyzed to meet accuracy requirement.	A LFB will be analyzed for each batch of samples	Every 12 hours
PAHs 8270D	A lab fortified MS will be analyzed using excess sample volume from one sample location	A lab fortified MSD will be analyzed using the same excess sample volume	LFB will be analyzed to meet accuracy requirement.	A LFB will be analyzed for each batch of samples	Every 12 hours
Pesticides 8081B	A lab fortified MS will be analyzed using excess sample volume from one sample location	A lab fortified MSD will be analyzed using the same excess sample volume	LFB will be analyzed to meet accuracy requirement.	A LFB will be analyzed for each batch of samples	Every 12 hours
PCBs 8082A	A lab fortified MS will be analyzed using excess sample volume from one sample location	A lab fortified MSD will be analyzed using the same excess sample volume	LFB will be analyzed to meet accuracy requirement.	A LFB will be analyzed for each batch of samples	Every 12 hours

		Frequency of			
Analyte	**Lab fortified matrix spike**	**Lab fortified matrix spike duplicate**	**Lab fortified blank (QC standard)**	**Lab reagent blank**	**Independent calibration verification (QC standard)**
Metals-Soils	A lab fortified MS will be analyzed using excess sample volume from one sample location	A lab fortified MSD will be analyzed using the same excess sample volume	LFB will be analyzed to meet accuracy requirement.	A LFB will be analyzed for each batch of samples	Before sample analysis each day of use.

Note: Numeric QC Content is tested and compound specific and are included in Appendix C.

15 – Instrument / Equipment Testing, Inspection, Maintenance

Sediment Sampling/Analysis

Field sampling equipment including, but not limited to, a hand-held, stainless steel mud and sand auger will be inspected for signs of cracking and other signs of defects prior to field deployment by VHB. The auger kit will be inspected to ensure that all the parts to the kit are accounted for. Any malfunctioning, broken, or missing components or equipment will be repaired or replaced. Additional auger kits will be available from the manufacturer, rental agency, or other entity the equipment is supplied from.

The sediment testing laboratory (Absolute Resources) follows rigorous testing, inspection, maintenance, and calibration protocols. Details are provided in the Quality Assurance Manual and SOPs for Absolutes Resources attached in Appendix C. Table 10 summarizes the maintenance, testing, and inspection activities of instruments and equipment for this project.

Table 10. Instrument Equipment Maintenance, Testing, and Inspection

Equipment name	Activity	Frequency of activity	Acceptance criteria	Corrective action	Person responsible
Sediment Sampling Auger	Inspect/clean	Prior to each sample	No defects/ clean, unused plastic sleeve	Replace as necessary	VHB Field Staff
Trimble ProXT GPS units for station location	Record station coordinates	At each sample location	Min satellite coverage	Post-field Data Analysis	VHB GIS Specialist

Based on EPA-NE Worksheet #19.

16 – Instrument / Equipment Calibration and Frequency

There will be no field instruments or equipment used that will require calibration procedures. Sampling locations will be geo-referenced using a Trimble ProXT GPS Unit capable of achieving sub-meter horizontal accuracy. At minimum of 60 GPS positions will be collected at each location to ensure that at least 90% of the GPS data is sub-meter accuracy. GPS data will be post-processed using Trimble GPS Analyst with Trimble Delta Phase technology. The laboratory instrumentation used by Absolute Resource Associates will be calibrated in accordance with their Quality Assurance Manual (See Appendix C).

17 – Inspection / Acceptance Requirements for Supplies and Consumables

Sediment Sampling/Analysis

Supplies and consumables used for field sampling include sample bottles and stainless steel sample collection/mixing container with spatula. All bottles will be inspected by VHB field staff to ensure seals (if applicable) are intact and identify any signs of possible contamination. The mixing container and spatula will be inspected and cleaned regularly with de-ionized water by VHB field staff.

See Quality Assurance Manual and SOPs for Absolute Resources attached in Appendix C for the laboratory's Inspection/Acceptance Requirements for Supplies and Consumables Program Description.

18 – Non-Direct Measurements

Photographs will be taken of each sampling location and sediment core retrieved from each sampling location. NHDES SOPs for photo documentation will be followed. The coordinates of each sampling location will be determined using GPS equipment.

19 – Data Management

See Section 9 for additional information on document and record management. See Sections 20, 22 and 23 regarding data review, verification and validation, and assessments and response actions for the following items.

Sediment Sampling/Analysis

- VHB will record field observations and sampling location data on field data sheet (see Appendix B).
- VHB will check field notes and field logs for completeness
- Chain-of-Custody will be initiated in the field by VHB.
- Chain-of-Custody will be completed at the laboratory by VHB and the sediment analysis laboratory (Absolute Resources).
- VHB will copy all field documents for back up. See Section 9 for further details on storage.
- Field reports and laboratory data will be submitted to the VHB Project Manager. The VHB Project Manager shall review all field reports for completeness by making sure all entries on the data sheets are filled out. The VHB Project Manager will make sure that any questionable entries are verified by speaking to the sampling team or reviewing the field logbooks, and noting any unusual or anomalous data in the project files.
- VHB will incorporate field observations and measurements into a summary spreadsheet. Information such as sample ID, date and time of collection, water and sediment depth and other field data will be recorded. This spreadsheet will create a record for each sample and will include laboratory analytical data when received. The sample tracking system will allow the status of each sample to be identified during the data generation process. The VHB Project Manager will oversee the QA/QC check of this spreadsheet to verify it corresponds with the

field reports and laboratory data that is to be verified as discussed above. Only VHB personnel working on the project will be allowed to access this spreadsheet. See Section 9 for data storage.

- Full laboratory data reports will be supplied by Absolute Resources to VHB in hard copy and in a scanned electronic media (.pdf).
- VHB will incorporate the laboratory results into the summary spreadsheet set up as described above.
- Field and laboratory data and findings will be compiled and reported by VHB to the Town of Exeter and NHDES for analysis to determine whether additional remedial investigation or corrective action requirements are necessary. The data will be submitted per the final report.

20 – Assessment and Response Actions

Approved project-specific QAPPs and approved generic program QAPPs must be reviewed annually by the Lead Organization (in this case USEPA per Section 319 Grant), and this annual review must be documented in a letter to the appropriate approval authority. If minor revisions are made to the approved QAPP that do not require approval (*i.e.,* revisions that do not impact data quality), then these minor revisions must be documented in either a letter that outlines the revisions or in a revised QAPP document. Likewise, if minor revisions are made to the approved QAPP that do require approval, then these minor revisions must be documented in either a letter that outlines the revisions or in a revised QAPP document and must be submitted for review and re-approval. If extensive revisions are necessary (*i.e.*, greater than 10 pages and/or there are multiple impacts on data quality) requiring re-approval, then a revised QAPP document must be submitted for review and re-approval.

Sediment Sampling/Analysis

Following the one proposed round of field sampling, the VHB Quality Assurance Officer will assess whether field protocols of this QAPP have been followed. In addition, the laboratory results will be reviewed to assess whether the analytical results have met the laboratory QA/QC objectives. If the sediment sampling analyses were not successfully analyzed due to QA/QC issues, equipment failure or other unforeseen reasons, this will be brought to the attention of NHDES, the Town of Exeter and the Project Steering Committee to identify if and what corrective actions may be necessary, including the possibility of re-sampling.

Absolute Resources conducts internal audits on a regular basis as described in their Quality Assurance Manual and SOPs attached in Appendix C.

21 – Reports to Management

As part of the semi-annual reports required by the 319 Grant Agreement, the Town of Exeter will summarize data collection and analysis activities collected during each quarter of the project. These quarterly reports shall be submitted to NHDES.

Sediment Sampling/Analysis
VHB will prepare a sediment analysis report (technical memo) that summarizes field activities, presents the analytical results, compares the results to the projects screening levels, and recommends further analysis (if applicable).

The final sediment and analysis report will include a summary of the activities completed including:

- Actions that have been taken toward achieving project scope
- Field notes on the sampling locations and sediment cores collected
- Description of sediment recovered along with photographs
- Laboratory results including any data qualifications
- A discussion of the sampling results and an assessment of potential contamination issues based on the available screening thresholds as discussed in the NHDES Evaluation of Sediment Quality Policy and S1 soil standards.
- Identify any unresolved or uncompleted activities
- Description of any outstanding issues and how they are being resolved

22 – Data Review, Verification and Validation

Sediment Sampling/Analysis
Data review, verification and validation in the sediment laboratory will be handled as described in the Quality Assurance Manual and SOPs for Absolute Resources, attached in Appendix C. Samples containing less than 30% solids will be noted as qualified.

The VHB Project Manager will review all sediment data results and evaluate laboratory QC notes to assess usability for obtaining the stated objectives of the project based on the criteria established in Sections 5, 6 and the QC criteria in Section 14. The completeness, transcription errors and compliance with procedures will be evaluated by comparison of tabulated results to what has been proposed in the original project proposal and this QAPP. The specific activities include the generation of data. Omissions of data in spreadsheets will trigger a search of raw datasheets for missing data or possibly reanalysis of the questionable sample, if possible. If re-analysis is not possible or if data remain missing, invalid or otherwise affected entries will not be incorporated into the useable data set.

23 – Verification and Validation Procedures

Sediment Sampling/Analysis

Field reports and laboratory data are submitted to the VHB Project Manager. The VHB Project Manager shall review all field reports for completeness by making sure all entries on the data sheets are filled out. The VHB Project Manager will make sure that any questionable entries are verified by speaking to the sampling team or reviewing the field logbooks, and noting any unusual or anomalous data in the project files.

Data verification and validation procedures in the sediment laboratory will be handled as described in the Quality Assurance Manual and SOPs for Absolute Resources attached in Appendix C.

The VHB Project Manager will review the lab report to identify any notes regarding quality control issues or out of compliance issues that would classify the data as being "qualified" or subject to the quality assurance provisions. Any decisions made regarding the usability of the data will be left to the VHB Project Manager; however the VHB Project Manager may consult with project personnel, the Town of Exeter, NHDES, or with personnel from EPA-NE.

24 – Reconciliation with User Requirements

Sediment Sampling/Analysis

If the project objectives from Section 7 are met, then the user requirements have been met. If the project objectives have not been met, corrective action(s) as discussed in Section 23 will be established by the VHB Project Manager in consultation with NHDES and the Town of Exeter.

References

Buchman, M.F., 2008. NOAA Screening Quick Reference Tables, NOAA OR&R Report 08-1, Seattle, WA Office or Response and Restoration Division, National Oceanic and Restoration Division, National Oceanic and Atmospheric Administration.

EPA Region III. 2006. Freshwater Sediment Screening Benchmarks for Volatile, Semi-volatile, PAH's and other Organic Compounds. *http://www.epa.gov/reg3hwmd/risk/eco/btag/sbv/fwsed/screenbench.htm*

U.S. EPA. 2001. Methods for Collection, Storage and Manipulation of Sediments for Chemical and Toxicological Analyses: Technical Manual. EPA 823-B-01-002. U.S. Environmental Protection Agency, Office of Water, Washington, DC.

NHDES. 2006. Evaluation of Sediment Quality for Dam Removals. October 20, 2006.

NHDES. 2005. Evaluation of Sediment Quality Guidance Document. Prepared by Lori S. Siegel, Ph.D April 2005.

APPENDICES

Appendix A

NHDES Evaluation of Sediment Quality for Dam Removals

New Hampshire Department of Environmental Services

EVALUATION OF SEDIMENT QUALITY FOR DAM REMOVALS

The Department of Environmental Services (Department) requires at least four (4) sediment core samples taken to point of refusal and/or the estimated streambed elevation in the general locations listed below when evaluating potential removal of dams. Samples should be taken in areas determined to be conducive to the deposition and accumulation of fine sediment particles, such as near stream banks or immediately behind the dam(s).

General sample locations should be as follows:

- one (1) upstream of the effects of the impoundment
- one (1) in the impoundment
- one (1) in the impoundment adjacent to the dam
- one (1) downstream of the dam

As described in the attached Department Policy on Evaluation of Sediment Quality (NHDES-R-WD-02-9), sediment samples shall be collected in accordance with standard protocols (e.g., USEPA EPA-823-B-01-002, 2001). Please note that additional samples may be necessary if the analysis of these cores suggests that further sampling is justified, as per the Department sediment quality policy.

The sediment samples should be analyzed for both physical and chemical parameters. A State-certified laboratory shall complete the analytical work. The analysis shall include:

- Total organic carbon
- Grain size distribution via sieve and hydrometer by American Society for Testing and Materials (ASTM) Method D-422, or a comparable method
- Polynuclear aromatic hydrocarbons (PAHs) by USEPA Method 8270C
- Polychlorinated biphenyls (PCBs) by USEPA Method 8082
- Pesticides by USEPA Method 8081
- Selected metals (arsenic, barium, cadmium, chromium (total), copper, lead, mercury, nickel, zinc by USEPA Methods 6010 and 7174 (mercury only)
- VOCs by USEPA Method 8260B
- SVOCs by USEPA Method 8270C

If the responsible party for the dam has any questions regarding the above, feel free to contact the Ecological Risk Assessor, Watershed Management Bureau at 603-271-0699, email at lsiegel@des.state.nh.us or Deb Loiselle, River Restoration Coordinator, Dam Bureau at 603-271-8870, email River Restoration Coordinator.

October 20, 2006

Appendix B

Field Data Sheet for Sample Collection

Vanasse Hangen Brustlin, Inc.

Field Sampling Data Sheet

General Information:

Date and Time:	VHB Project #:
Location (Town/City):	Project Name:
Field Sampler:	Project Manager:
Photo #(s) and Direction:	

Weather Conditions:

Current Weather and Temperature:
Weather within previous 72 hrs:

Sample Information:

Sample ID #:
Sample Location (GPS Coordinates or field ties):
Water Depth:
Probing Depth:
Sediment Type:
Sediment Description:
Sample Type (composite, grab, etc.):
Approx. Length of Sediment Core:
Depth of penetration of the core recovered tube into the sediment:

Appendix C

Absolute Resources Associates Quality Assurance Manual

ABSOLUTE RESOURCE ASSOCIATES **QA-003**

Absolute Resource Associates, LLC
124 Heritage Ave., Unit # 10
Portsmouth, NH 03801
(603) 436-2001

LABORATORY
QUALITY ASSURANCE PLAN

For Environmental Analysis of Drinking Water, Wastewater, Sediment, Tissue and Solid Samples and the Sampling of Treatment System Samples

TITLE: Laboratory Quality Assurance Plan

Prepared By/Date: [signature] 8-9-11 Susan C. Sylvester sues@absoluteresourceassociates.com
(Lab Director)

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(Principal)

Section	Title	Revision No.	Date
1	Introduction	9	12/10
2	QA Organization and Personnel	11	8/11
3	Objectives	5	8/11
4	Standard Practices	7	12/10
5	Material and Apparatus	11	8/11
6	Sample Custody	8	8/11
7	Calibration Procedures and Frequency	10	12/10
8	Analytical Procedure	9	8/11
9	Data Reduction, Validation, Reporting	10	8/11
10	Records Management	9	8/11
11	Quality Control	7	8/11
12	Quality System Documents	6	8/11
13	Performance and System Audits	9	8/11
14	Preventive Maintenance	4	5/07
15	Corrective Action	8	8/11
16	Quality Assurance Reports to Director	4	5/07
17	Treatment System Sampling	0	1/05

Effective Date: 8/8/11
Supersedes No.: 1/98, 11/98, 01/01, 01/02, 1/03, 1/04,1/05, 2/07, 5/07, 9/09, 12/10 as noted above

1. INTRODUCTION

1.1. Purpose and Scope

1.1.1. This QA Manual (Manual) details the quality assurance program in effect at Absolute Resource Associates, LLC, referred to as "the company" in this document. It is meant to be a guidance document and source of information for laboratory personnel. The manual is divided into logical sections, each dealing with a different phase of laboratory operation, yet all sections interrelate and function together to form a complete quality assurance program. The manual is based on Good Laboratory Practices, the National Environmental Laboratory Accreditation Program, common sense and industry-accepted standard analytical practices.

1.1.2. The manual must be read and understood by all laboratory personnel as part of their training. The manual should also be referred to regularly as a source of information. A system of continuous updating is built into the manual to allow it to change as laboratory conditions change or as new regulations are promulgated. This manual is a controlled document, which means that its identity, development, distribution, and status must be known and traceable at all times. All personnel will be assigned a controlled copy.

1.1.3. The manual must be read and understood by all laboratory personnel as part of their training program. The manual should also be referred to regularly as a source of information. A system of continuous updating is built into the manual to allow it to change as laboratory conditions change or as new regulations are promulgated. This manual is a controlled document, which means that its identity, development, distribution, and status must be known and traceable at all times. All ARA personnel will be assigned a controlled copy.

1.1.4. Whenever a technician or analyst is in doubt as to proper procedures in a specific circumstance, the manual should be consulted. Omissions or errors should be immediately reported to the Quality Assurance Officer, for corrective action. IT IS THE RESPONSIBILITY OF EACH EMPLOYEE TO ENSURE THAT THE PROVISIONS OF THIS MANUAL ARE FOLLOWED. Disagreement with specific requirements or knowledge of changes causing deviation from the procedures should be discussed with the immediate supervisor before further work is completed. Laboratory personnel are encouraged to comment on the manual and make recommendations for more efficient procedures.

1.1.5. The latest revision of each section of the manual is the applicable rule. Therefore, revisions will be announced to all laboratory personnel. An uncontrolled copy of the manual is offered to clients and regulatory agencies as the definitive quality assurance program used at ARA.

1.2. QA Policy, Objectives of the Program and Standard of Service

1.2.1. ARA is committed to quality as priority number one in all aspects of our work. ARA quality assurance policy is based on the definition of quality as conformance to requirements; and further, on the premise that the requirements are governed by Company policies and standard operating procedures. This commitment recognizes the need for data to be representative of the environmental conditions under consideration, and for data to be generated within a system of functions that meet applicable regulatory compliance criteria. To this end, ARA has developed a company-wide Quality Assurance (QA) Plan and maintains an ongoing QA Program. The objective of the QA Program is to insure that no other concern will be permitted to interfere with the quality of data ARA provides to clients.

1.2.2. Our Quality Assurance Program contains provisions for establishing, maintaining and executing protocols which lead to results of known, appropriate and acceptable quality; documentation of these activities is an integral part of the QA program. Employees are trained in the objectives of the QA/QC program and are free to perform their responsibilities in accordance with the program. Any deviations from the policies and procedures outlined in this manual only occur with the written approval of the QA Officer, Technical Director, or Owner. When exceptions or deviations occur that will impact the quality of data to our customer, the reasons will be fully documented and completely disclosed to the customer. This communication occurs as soon as the laboratory has knowledge of the situation and has concluded an internal investigation of the facts.

1.3. Quality Assurance Documents

1.3.1. QA Manual

1.3.1.1. This document describes management policies related to operation of the analytical laboratories. It provides overall guidance regarding acceptable practices and discusses each element of the Quality Assurance Program. It functions as the Project QA manual where no other Quality Assurance Project Plan, Statement of Work or other contractually mandated project plan has been specified. Adherence to the practices described in this manual is required of all employees. This manual may be revised and/or superseded only with the written authority of the ARA QA Officer, Technical Director, or Owner. Copies of this manual are controlled and the QA Officer administers distribution.

1.3.2. Standard Operating Procedures

1.3.2.1. All procedures related to sample receipt, storage, preparation, analysis, disposal, reporting and safety shall be contained in written Standard Operating Procedures (SOPs). Each SOP shall contain the elements outlined in ARA SOP QA-0000, Preparation of SOPs. All sections shall be structured in a step-wise manner using numbered sections. All record-keeping requirements shall be described at each step in the SOP. Examples of forms used shall be included as tables or figures and referenced within the text, when applicable. Preparation of SOPs shall be the responsibility of every analyst. SOPs shall be assigned a number from the Inventory List for SOPs maintained by the Quality Assurance Department. This number shall become part of the document control number when the SOP is accepted for implementation. SOPs shall be reviewed and approved for implementation by the Technical Director and the QA Officer, at a minimum. Updates to SOPs may be done by hand, pending reissue of the document. The SOP is to be hand noted with the change and the change initialed and dated by the QA Officer and the Analyst. Electronic updates may also be made to an SOP by saving a new copy to the "SOP Work in Progress" folder with the appropriate REV# added to the name. Changes can only be made to this WIP copy of the SOP. A revised document shall be formally re-issued as soon as practicable.

1.3.3. Project QA Plans

1.3.3.1. Project QA manuals shall be implemented as required for regulatory or individual program compliance. These shall include such documents as Quality Assurance Project Plans (QAPPs). For those projects, which require specific QA/QC criteria, the client provides a QAPP, which has been approved by the program sponsor (often a regulatory agency, such as the EPA), to ARA.

1.3.4. Document Control, Distribution and Revision

1.3.4.1. In order for this document to achieve the goals outlined in Section 1.2, it is necessary that each ARA employee be familiar with the current provisions of this document. It is also necessary that this document represent a consensus among ARA management and operational personnel as to the quality level desired and the means to that end.

1.3.4.2. Prior to its publication as a controlled document, the Quality Assurance Officer and the Technical Director must approve this manual. To obtain such approval, the document proceeds through an iterative process of review. The signature page at the beginning of the manual represents acceptance.

1.3.4.3. Each time a revision is made to this manual, it must also be approved. The Quality Assurance Officer must approve each revision. If the revision constitutes a complete rewrite of the document, then review and approval by the Quality Assurance Officer, the Technical Director, and the Owner becomes necessary. The appropriate approval process will be decided in each case by the Quality Assurance Officer.

1.4. Terms and Definitions

1.4.1. Accuracy: The degree of agreement between a measured value and the true or expected value.

1.4.2. Aliquot: A measured portion of a sample taken for analysis that has been thoroughly mixed to achieve representativeness.

1.4.3. Analyte: The specific property or constituent an analysis is designed to determine.

1.4.4. Batch: A group of samples of similar matrix which are prepared or analyzed as together using the same lots of reagents within the same time frame. A batch contains up to 20 samples, within 24 hours.

1.4.5. Blank: A blank is an lab generated sample designed to detect and/or monitor the contribution of analyte and non-analyte contamination, instrumental background and reagent contamination within a batch.

1.4.6. Blind Sample: A sample submitted for analysis whose composition is known to the submitter but unknown to the analyst.

1.4.7. Calibration: The process of establishing the relationship between instrument response and known, traceable quantities of analytes of interest.

1.4.8. Comparability: Comparability is a qualitative parameter expressing the confidence with which one data set can be compared to another. Comparable data are produced through the use of standardized procedures and techniques.

1.4.9. Completeness: Measure of the amount of valid data obtained from a measurement system compared to the amount that was expected to be obtained under correct normal conditions.

1.4.10. Composite: A composite sample is a collection of individual samples obtained at regular intervals mixed in equal proportion for the purpose of generating an average concentration.

1.4.11. Contaminant of Concern: Project specific analyte identified by the customer or QAPP of interest for a particular project. Referred to in the DoD manual at Target Analyte.

1.4.12. Continuing Calibration: The process of analyzing known standards periodically to verify the stability and acceptability of an analytical system's calibration. The frequency required is defined in the SOP for each procedure.

1.4.13. Continuing Calibration Verification: A standard of known concentration, analyzed at routine intervals to verify the acceptability of a calibration curve over a period of time. The standard source is the same as the standard used for initial calibration.

1.4.14. Control Chart: A graphical plot of a series of test results, together with limits within which they are expected to lie when the system is in a state of statistical control.

1.4.15. Control Limit: A range within which specified measurement results must fall to signify compliance. Adherence to control limits may be mandatory, requiring corrective action if exceeded, or advisory. Their use is defined by project, QAPP or specific SOP .

1.4.16. Dry Weight: The weight of a sample corrected for moisture content. The weight after drying in an oven.

1.4.17. Duplicate Analysis: A second measurement made on the same sample (after preparation) to assist in the evaluation of precision of analysis.

1.4.18. Duplicate Sample: A second aliquot of the same sample that is treated the same as the original sample in order to determine the precision of the method.

1.4.19. Equipment Blank: Special type of field blank used primarily as a verification of equipment decontamination procedures. Purified water is poured over sampling equipment and submitted to the lab after decontamination.

1.4.20. Field Blank: A quality control sample used to assess the contamination effects on accuracy due to the combined activities of sampling and analysis. Typically, it is composed of analyte-free matrix (purified water) provided by the laboratory.

1.4.21. Field Duplicate: A second, separately collected sample, from the same location, for the same analysis as the original sample, in order to determine overall precision of the entire sampling and analysis process.

1.4.22. Field Sample: A portion of representative material received by the laboratory, that is contained in single or multiple containers and identified by a unique Field ID and sampling time.

1.4.23. Grab Sample: A discrete gathering of sample, by hand or machine, during one short sampling period.

1.4.24. Holding Time: The maximum amount of time, starting at the time of sample collection to start of sample preparation or analysis, that a sample is not expired according to method or regulatory requirements.

1.4.25. Homogeneity: The degree to which a property or constituent is uniformly distributed throughout a material.

1.4.26. Initial Calibration: The process of analyzing standards of analytes of interest, prepared at known concentrations, to define the quantitative response, linearity and dynamic range of the analytical system. Initial calibration is performed whenever the results of a continuing calibration do meet to the requirements of the SOP in use or at a frequency as specified in the method/SOP.

1.4.27. Initial Calibration Verification: A standard of known concentration analyzed after the initial calibration to verify accuracy. The standard source of this verification is different from the initial calibration curve's source.

1.4.28. Instrument (Calibration) Blank: An analytical control sample consisting of the same solvent/reagent matrix used to prepare the calibration standards without the analyte(s) added.

1.4.29. Internal Standards: Compounds added to every standard blank, matrix spike, matrix spike duplicate, and sample at a known concentration, prior to analysis for the purpose of adjusting the response factor used in quantifying analytes. Internal standards are used as the basis for quantitation of the target compounds, and are generally applicable to organic analyses.

1.4.30. Lab. Control Sample: A well-characterized sample with known concentrations of spiked or native constituents of interest. Aqueous and solid laboratory control samples are analyzed using the same preparation, reagents, and analytical methods employed as with field samples. Results are used to determine if the analysis is operating within accuracy and precision limits. An LCS standard is of a different lot or source than calibration standards.

1.4.31. LIMS: Laboratory Information Management System. It is a database used for sample tracking and associated laboratory data for the purpose of generating laboratory reports and process management information. Data are entered into this system either by direct entry or imported from instrumentation using spreadsheets. Data are combined, reduced, and formatted for management review and reporting to customers.

1.4.32. Lot: A quantity of a material of similar composition processed or manufactured at the same time.

1.4.33. Matrix: The predominant composition of a sample (soil, water, oil, etc.).

1.4.34. Matrix Spike: An aliquot of sample fortified (spiked) with known quantities of analyte and subjected to the entire procedure in order to indicate the effectiveness of the method in recovering the analyte from the matrix. Matrix spikes are performed as required by SOP or project specifications.

1.4.35. Matrix Spike Duplicate: A second aliquot of the sample that is treated as the original matrix spike sample. The relative percent difference between the matrix spike and matrix spike duplicate is calculated and used to assess precision of the method for the sample's specific matrix.

1.4.36. Method Blank: An aliquot of analyte-free matrix carried through the entire analytical procedure. The method blank is used to define the level of laboratory background contamination in the associated sample batch.

1.4.37. Method Detection Limit: A statistically determined concentration of analyte which may be detected by an analytical method, including all sample preparation steps. It is determined using a series of replicate spiked samples. The MDL is calculated by applying the student's t-test statistic times the standard deviation of the concentrations measured. The MDL is the minimum concentration of a substance that can be measured and reported with 99% confidence that the concentration is greater than zero.

1.4.38. Method of Standard Additions: A quantitation procedure where a standard is added at one or more levels to portions of a prepared sample. This technique compensates for many matrix interferences to the analyte's signal.

1.4.39. Performance Audit or Evaluation: A process to evaluate the proficiency of an analytical system by evaluating the results obtained on known test materials by an external vendor.

1.4.40. Precision: The degree of reproducibility of results. Precision is assessed by means of replicate analysis.

1.4.41. Protocol: A stated plan or regulation that clearly defines the objectives, methods and procedures for accomplishing a task.

1.4.42. QAPP: Quality Assurance Project Plan is a project-specific document that describes the policies, organization, objectives, functional activities, and specific QA and QC procedures designed to achieve specific data quality goals of a sampling and analysis plan.

1.4.43. Quality Assurance: A program for the systematic monitoring and evaluation of the various aspects of a project or service to ensure and document that standards of quality are being met. Quality Assurance activities include planning, quality control, assessment (auditing), reporting and corrective action.

1.4.44. Quality Control: A process which reviews the quality of all factors involved in production. Which places an emphasis on measured controls, process management, performance and integrity criteria. This includes documentation of competence, experience, and qualifications. As well as integrity, organizational culture and quality relationships. This system of checks and corrective measures, integrated with activities that directly generate and report analytical measurements, which serves to monitor and adjust the process to maintain conformance to predetermined requirements.

1.4.45. Rounding Rules: Reported results are shown using an appropriate number of significant figures, rounding is required to eliminate insignificant figures. If the figure following those to be retained is less than 5, the figure is dropped, and the retained figures are kept unchanged. If the figure following those to be retained is greater than or equal to 5, the figure is dropped, and the last retained figure is raised by 1. When calculations are performed (add, subtract, divide, multiply), all figures are carried through the calculations the final answer is rounded to the proper number of significant figures. The following illustrates rounding values to two significant figures.

Un-rounded	Rounded
43.2134	43
59.6	60
32.543	33
97.5000	98
43.499	43

1.4.46. Sample: A portion of material to be analyzed that is contained in single or multiple containers, designed to show the nature or quality of the whole.

1.4.47. Sample group: Multiple containers that all contain the same sample.

1.4.48. Sensitivity: The ability of an analytical system to produce a reliable response to an amount of analyte. The smaller the amount the more sensitive a method.

1.4.49. Significant Figures: All digits in a reported result expressed be known definitely. There are three rules on determining how many significant figures are in a number:

1.4.49.1. Non-zero digits are always significant.

1.4.49.2. Any zeros between two significant digits are significant.

1.4.49.3. A final zero or trailing zeros in the decimal portion ONLY are significant.

1.4.50. Split Sample: A portion or sub sample of a larger sample obtained in such a manner that it is believed not to differ significantly from other portions of the same sample.

1.4.51. Standard: A material that the properties of which are known with sufficient accuracy to permit its use to evaluate the same property in a sample.

1.4.52. Standard Operating Procedure: A procedure adopted for use when performing specific measurement or sampling operation. It may be an industry accepted standard method or one developed by the laboratory.

1.4.53. Surrogate Standards: Analytes added in known concentration to every blank, sample, matrix spike, matrix spike duplicate, and standard prior to any processing or preparation which behave similarly to the analytes of interest. Surrogate analyte recovery is used to evaluate method performance for each sample. Surrogates are generally restricted to multianalyte organic analyses.

1.4.54. Systems Audit: An on-site inspection or assessment of a laboratory's quality control system.

1.4.55. Target Analyte: An analyte that has been identified for inclusion in a procedure's list of calibrated compounds.

1.4.56. Traceability: The ability to determine the true value of a reference material (i.e. standard) through comparison to a recognized primary reference source such as the National Institute of Standards and Technology (NIST) or U.S.E.P.A. Also, the ability to independently reconstruct and review all aspects of the measurement system through available laboratory notebooks and documentation and reach the same results. This definition also applies to the traceability of a sample and its final result.

1.4.57. Trip Blank: A portion of analyte free water carried through the entire sample shipment process. It is used to detect sample contamination of the container and preservative during transport and storage of the sample prior to receipt at the laboratory. A sample container is filled with laboratory water, any preservative used in the sample is added. The trip blank is stored, shipped, and analyzed with its group of samples.

1.4.58. Validation: The process by which a sample, measurement or method is deemed useful for a specified purpose.

1.4.59. Warning Limits: The limits (typically ±2 standard deviations from the mean) shown on a control chart within which most results are expected to lie (within a 95% probability) while the system remains in a state of statistical control.

2. QA ORGANIZATION AND PERSONNEL

2.1. Introduction

2.1.1. It is important for efficient laboratory operation that all laboratory employees understand the operational structure, specific areas of responsibility and lines of authority within the organization.

2.1.2. It is equally important for laboratory personnel to understand that the structures of the Quality Organization may be separate from other laboratory operations but that the quality function is totally integrated into every aspect of laboratory operation. All laboratory personnel must have appropriate educational and technical background to perform their job responsibilities. The technical directors and the QA Officer must meet the qualification requirements specified in the TNI and DoD standards. This information must be documented in the employee files. Laboratory personnel are responsible for knowing and following proper methods and standard operating procedures; recording quality control information required by those procedures in the proper location; and suspending analyses when quality control criteria are not met.

2.1.3. The organizational structure of the analytical chemistry laboratory is provided in Figure 2-2. A primary analyst or technician who is responsible for operations on a daily basis heads each group. Primary analysts, laboratory technicians and laboratory assistants report to the Laboratory Director. Descriptions of jobs are included in employee files.

2.2. Laboratory Organization

2.2.1. It is the responsibility of each analyst and technician to perform their assigned tasks according to the applicable source methods, SOPs, QAPPs. This includes responsibility for performing quality control analyses as specified in the SOPs and for entering the QC data into the appropriate database. The analyst or technician is responsible for initiating corrective action and reporting any out-of-control analysis or problems encountered during the analysis or preparation to Laboratory Director, Technical Director, or the QA Officer.

2.2.2. The Laboratory Director, Technical Director, and the QA Officer shall ensure that analysts and technicians are instructed in the requirements of the QA Manual, QAPPs, SOPs and Protocols for the analytical method as well as compliance with the standards upon which the quality system is based, including but not limited to the most recent, approved versions of the TNI and DoD Quality Systems Manual. The QA Officer shall review sample QC data during scheduled internal audits designed to ensure that QC activities are being performed at the required frequency, that data are documented and that established corrective action procedures for out-of-control situations are followed and the results documented. It is the responsibility of the analyst to ensure that data have been reviewed and reported to the Laboratory Director. Management ensures that personnel have experience and are knowledgeable of the methods, procedures, reviews and work for which they are responsible.

2.2.2.1. If the event should arise that the Technical Director or Quality Assurance Officer is absent for more than 15 consecutive calendar days, he/she shall designate another full time qualified member to temporarily perform this function. The Technical Director will communicate this designation via email to all employees. If the absence exceeds 65 consecutive calendar days, the accreditation body will be notified in writing.

2.2.3. Analysts are responsible for technical conduct, evaluation and reporting of all analytical tasks. Upon completion of the Demonstration of Capability, the analyst is authorized to perform the analyses, utilize the necessary equipment, evaluate and interpret the results and report the data in accordance with the SOP and QA Manual guidance. A record of this authorization is documented using the Demonstration of Capability form, which is signed by the Technical Director and QAO. The Laboratory Director takes overall responsibility for assuring that approved procedures are documented and followed, that all data are recorded and reviewed and that all deviations from approved procedures are documented. The QA Officer approves QC acceptance criteria and works with analysts, Laboratory Director and Technical Director to bring out-of-control methods back to within established acceptance limits. Only the Lab Director, Assistant Lab Director, QA Officer or Technical Director are authorized to approve the resumption of work after a data recall.

2.2.4. The Quality Assurance Department, under the direction of the Quality Assurance Officer (QAO) shall be responsible for conducting systems audits and inspections for compliance with this manual, SOPs and QAPPs or other project-specific protocols. The QAO is also responsible for maintaining archives and historical files of all QA documents, reviewing QC charts, documenting findings and corrective actions, and reporting findings to management. The QAO must insure complete and effective communications of quality assurance matters among personnel at all levels. By implementing and maintaining the quality program, the QA Department strives to continually improve the quality systems. By design, the QA Officer functions independently from the laboratory operations for which quality assurance is provided. The Quality Assurance Officer shall report directly to the General Manager.

2.2.5. The Laboratory Director shall designate analysts and replace if necessary. The Laboratory Director shall assure that that personnel and other resources are adequate, that personnel have been informed of their responsibilities, that deficiencies are reported to Laboratory Director and that corrective actions are taken and documented. The Lab Director must insure that there is adequate supervision by personnel familiar with procedures, methods and assessments of environmental data. The Quality Assurance Officer and Laboratory Director shall authorize any significant changes to written SOPs in writing.

2.2.6. Management is committed to providing personnel, equipment, training and tools to insure ongoing improvement and compliance with the Quality Assurance Plan described in this manual. Employees with concerns or the inability to adhere to the guidelines provided herein are required to discuss those issues with management immediately to insure a rapid return to compliance. Failure to do so may result in termination of employment.

2.3. Training and Orientation

2.3.1.1. Each new employee receives a four part orientation: human resources, safety, quality assurance and customer service. A record of all aspects of this training are documented and filed.

2.3.1.1.1. The human resources orientation involves matters of personal concern such as benefits, salary, and company policies at the time of employment.

2.3.1.1.2. The safety orientation includes training in safe lab procedures, lab safety policies and review of OSHA's Hazard Communication Program (29 CFR 1910.1200) and the laboratory Chemical Hygiene Plan.

2.3.1.1.3. The Quality Assurance orientation provides the new employee with information on the QA program through a brief introduction to the QA manual and SOPs, acceptable recordkeeping practices, confidentiality, appropriate ethical behavior, and the individual's responsibility.

2.3.1.1.4. The new employee customer service training provides the employee with a basic understanding of the role of the laboratory in fulfilling the customer's requirements within the structure of the regulatory environment. The training of a new employee concentrates on his/her scientific background and work experience to provide the employee with a level of competence so that the individual will be able to function within the defined responsibilities of his/her position as soon as possible.

2.3.2. Included in the employee training folder is a record that the employee understands their responsibility to perform assigned jobs safely and in accordance with our QA Manual and SOPs. All employees have the authority, and responsibility, to "stop work" in any situation which makes them feel undue pressure in performing their responsibilities from any commercial, financial or customer matter.

2.3.3. Training is a process used to assist personnel in their professional development. The training techniques utilized may include:

2.3.3.1. Apprenticeship

2.3.3.2. Lectures

2.3.3.3. Conferences and Seminars

2.3.3.4. Short courses

2.3.3.5. Specialized training by instrument manufacturers

2.3.3.6. Participation in check-sample or proficiency sample programs.

2.3.4. The employee will be trained in their responsibilities by a peer that has already demonstrated proficiency in the method by means of a current acceptable demonstration of capability (DOC). See Figure 2-1. For methods that utilize a work cell, two employees responsible for different parts of a test method, the DOC must be performed and passed as a pair. The DOC is only applicable to the portion of the analysis that the individual performed. Typically the two parts of a test method are separated into extraction and analysis. If either or both of the analysts are changed, the DOC is repeated after an adequate training period. In addition, a trained analyst will review the first initial calibrations performed by the analyst in training prior to release of any data. No data will be released by an analyst in training until the Demonstration of Capability, SOP review, and calibration review documentation have been completed.

2.3.5. The employee is responsible for providing documentation of training and proficiency to the Quality Assurance department. The QA department maintains a training file for each technical employee. The training file for each employee contains a resume, Demonstration of Capability forms for all methods performed either as an individual or part of a workcell, transcripts, record of understanding of the ethics and company philosophy on quality and safety, job description, and any records of on site or offsite training. Annually, the Demonstration of Capability is updated by the adding documentation of continuing proficiency by at least one of the following: acceptable performance of a blind sample; another demonstration of capability; successful analysis of a blind performance sample on a similar test method using the same technology; analysis of at least 4 consecutive lab control samples with acceptable levels of precision and accuracy; or if one of the above cannot be performed, the analysis of authentic samples that have been analyzed by another trained analyst showing statistically indistinguishable results.

2.3.6. On an annual basis each employee receives a performance appraisal. As part of this appraisal the employees skills, development areas, goals and training needs are discussed. Professional development and advancement for the employee, in accordance with the business needs and goals, are also discussed. Any training goals are documented, including whether the training can be performed in house or whether the training must be performed by an outside vendor.

2.4. Data Integrity and Ethics Training

2.4.1. To insure data integrity and ethical behavior in the laboratory a four-part program is implemented.

2.4.2. During the first week of employment, employees are informed about the regulatory nature of the work performed. The training includes an overview of the regulations that impact our work and our role in protecting human health and the environment.

2.4.3. This discussion is understood by employees and documented on letter signed by employees (Figure 2-3). The failure to uphold moral, ethical, and legal responsibilities in the process of our work is justification for immediate termination of employment and could also result in legal action up to and including penalties and prosecution. This document is reviewed with and signed by the employees each year.

2.4.4. In addition to the new employee orientation on ethics, all employees participate in proactive discussions regarding ethics and ethics refresher training once each year. Open dialogue and timely communication of ethical challenges faced by all employees are facilitated in discussions of ethics at staff meetings. All employees are encouraged to bring examples of situations in which an ethical issue does or could exist. This discussion fosters an attitude and visible support to do" the right thing." Some examples discussed include undocumented data manipulations, adjustments of instrument clocks, changes in standard concentrations with no justification, data changes not initialed, and improper chromatographic peak integrations.

2.4.5. The laboratory maintains a standard operating procedure for data integrity. Senior management signs and dates these procedures during the review and approval process.

2.4.6. All employees are responsible for reporting any data integrity or ethical issue immediately. Employees may confidentially speak with the QAO, Technical Director, Lab Director or owner at any time regarding any data integrity or ethical concern. It is the responsibility of the QAO, Technical Director Lab Director or owner to maintain employee confidentiality while addressing data integrity or ethical issues. Records of the reporting of a data integrity or ethical issue are documented on the Corrective Action Form and follow the corrective action process as defined in the QA Manual.

Figure 2-1
Demonstration Capability
Certification Statement

Date:
Laboratory Name: Absolute Resource Associates, LLC
Laboratory Address: 124 Heritage Ave. Portsmouth, NH 03801
Analyst(s) Name(s):

Matrix:
Method Number/SOP # and Revision#:
Parameters:

We the undersigned, CERTIFY that:

1. The analysts identified above, using the cited test method, which is in use at this facility for the analysis of samples under the National Environmental Accreditation Program, have met the Demonstration of Capability.
2. The test method was performed by the analyst identified on this certification.
3. A copy of the test method and the laboratory-specific SOPs are available for all personnel on site.
4. The data associated with the demonstration capability are true, accurate, complete and self-explanatory.
5. All raw data (including a copy of this certification form) necessary to reconstruct and validate these analyses have been retained at the facility, and that the associated information is well organized and available for review by authorized assessors.

Technical Director	Signature	Date
Quality Assurance	Signature	Date

Figure 2-2

ORGANIZATIONAL CHART

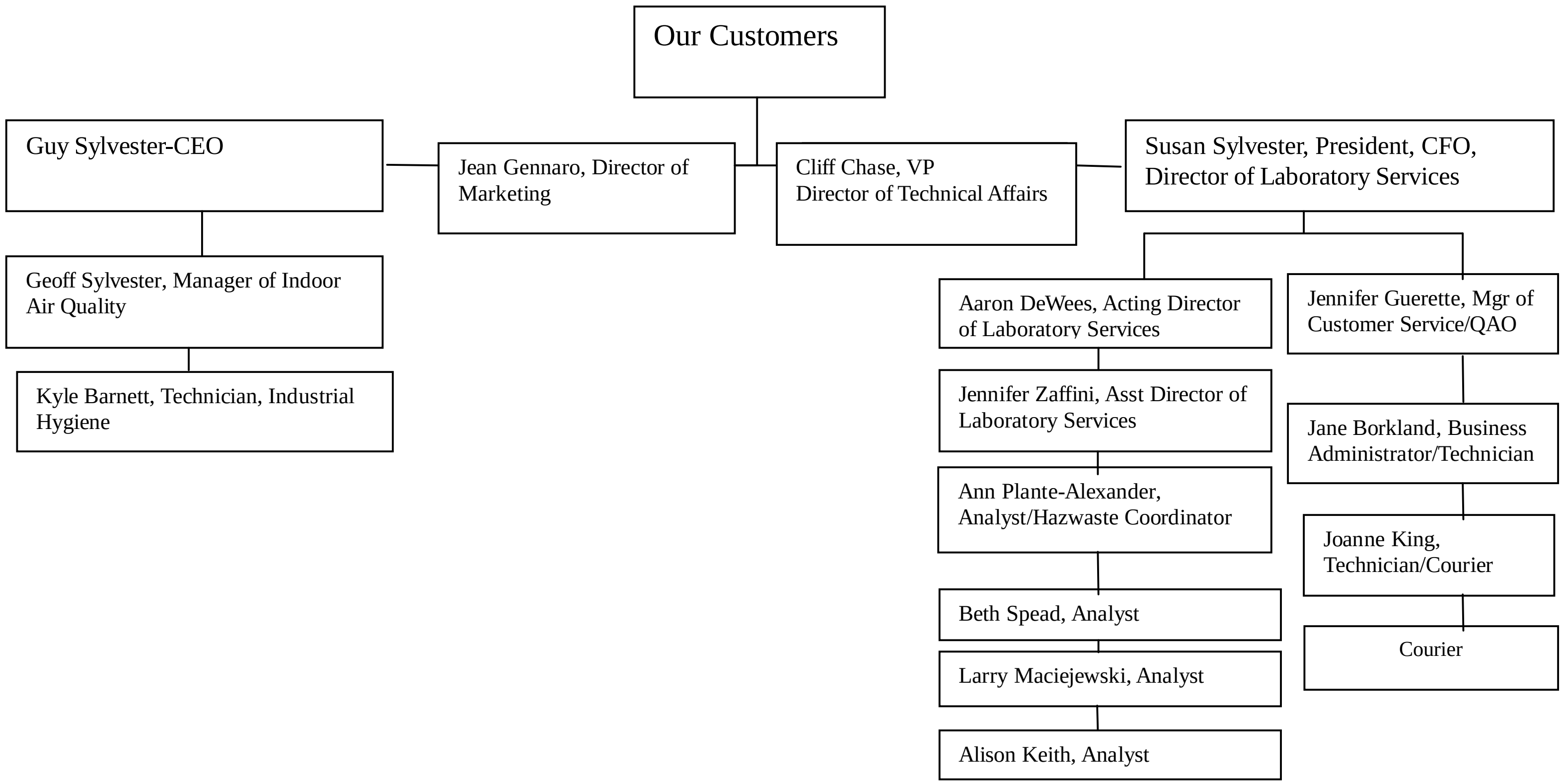

Figure 2-3

Dear ______________________,

Absolute Resource Associates, LLC (ARA) welcomes you to our team! As you begin your employment at ARA it is imperative that you understand and commit to helping us all achieve our mission while adhering to the values we use to guide us in our actions and decision making in all aspects of our business.

Mission and Values Statement

To provide our customers with quality data and technical services by focusing on technical expertise and superior customer service, utilizing environmentally friendly technologies, and providing direct access to technical resources. By providing consistent, reliable support and services, we will demonstrate our commitment to our customers' success.

In the spirit of our mission and vision, we will continue to operate being mindful of our values. We will:

- *Be open, honest and have trust in each other*
- *Be respectful and mindful of family values*
- *Minimize our environmental impact*
- *Work as a team to provide consistent service to our customers*
- *Provide accurate and timely results*
- *Promote professional development*
- *Innovate and be a part of business growth and change*
- *Be there when needed*
- *Stay connected with our customers and understand their needs, they are our business*
- *Know our business: stay current with regulations and technologies*
- *Be fair and strive for the mutual success of customers, employees and company*

The information we provide to our customers, regulators, and other users of our analytical services is a key element in decision making that is ultimately focused on the protection of human health and the environment. To that end, our commitment is that no influence will be permitted to interfere with our moral and ethical responsibility to provide analytical data of known quality.

Your responsibility as an employee of ARA is to uphold our unquestionable commitment in all aspects of your work. In the event that you feel unable to perform your job responsibilities in accordance with this commitment, or you are aware of any situation at ARA in which this may be occurring, you are responsible to communicate the information. If you are not satisfied with the response you are to see the owner(s) of the company directly. Failure to meet this responsibility could result in termination, and even penalties or prosecution in the event of an investigation.

Please sign below to indicate your understanding and acceptance of ARA's mission and values and your responsibility as an employee of ARA. Thank you for joining our team!

Sincerely,
Absolute Resource Associates, LLC

3. OBJECTIVES

3.1. Introduction

3.1.1. We are committed to the philosophy that quality operations result from quality planning, design, and work performance by skilled, committed operational personnel. The company's policy is to perform its varied types of technical work in accordance with standard quality assurance practices such as Good Laboratory Practices. The company has a Quality Assurance Officer responsible for maintenance of standard operating procedures, laboratory audits, performance evaluations, state certifications and quality assurance documentation.

3.1.2. Each laboratory worker is responsible for reviewing standard operating procedures when necessary; following these procedures during routine analyses; recording quality control information required by those procedures in the proper location, and taking appropriate corrective action including suspending analyses when quality control criteria are not met.

3.1.3. Objectives of the quality program are:

3.1.3.1. to provide a quality organization independent of the pressures of project performance with the responsibility and authority for auditing and recommending corrective action;

3.1.3.2. to provide a quality organization with clear paths of communication with management;

3.1.3.3. to perform regularly scheduled audits and thereby document an objective evaluation of quality-related practices;

3.1.3.4. to promptly identify variances and implement corrective actions;

3.1.3.5. to maintain readily identifiable and retrievable records that provide documentary evidence of the quality of activities performed;

3.1.3.6. to provide procedures for implementing project-specific quality plans;

3.1.3.7. to define responsibility and authority for developing and implementing quality plans;

3.1.3.8. to provide quality reference documentation for each project.

3.1.3.9. Quality Assurance objectives for measurement data can be expressed in terms of completeness, representativeness, accuracy, precision, comparability and traceability.

3.2. Completeness

3.2.1. Completeness is a measure of the amount of valid data obtained from a measurement system compared to the amount that was expected. The QA objective for completeness is to maximize the number of valid results. This can be attained by:

3.2.1.1. minimizing sample loss and breakage

3.2.1.2. performing sufficient QC samples to document control

3.2.1.3. documenting all aspects of the analytical system

3.3. Representativeness

3.3.1. Representativeness is the extent to which reported analytical results truly depict the chemistry of the sampled environment. Representativeness is a qualitative objective which is optimized through proper selection of holding times and procedures, through proper sample preservation, and through prompt extraction and analysis.

3.3.2. U.S. EPA guidance is followed for sample preservation and field preservation is checked upon sample receipt in the laboratory.

3.3.3. Sample holding times follow EPA recommendations. In cases where no formal recommendation has been made, the holding time for that analyte in a different matrix or a similar analyte in a similar matrix is applied.

3.4. Accuracy, Precision and Bias

3.4.1. Accuracy and precision data are optimized through the use of analytical procedures that minimize biases through the use of standard procedures, through the meticulous calibration of analytical equipment and by implementing corrective action whenever measured accuracy and precision do not meet pre-established limits.

3.4.2. Laboratory generated QC samples, such as method blanks, Laboratory Control Spike/Spike Duplicate Samples, Four replicate recovery studies are used to assess the accuracy, precision and bias of measurements due to laboratory activities. QC Samples, such as surrogate spikes and matrix spike/matrix spike duplicates are used to monitor the effects of the sample matrix on precision and accuracy. QC Check Samples such as field blanks, field duplicates and trip blanks are used to assess the accuracy and precision of both sampling and laboratory activities. Accuracy and precision goals for the laboratory are based on laboratory historical data, specific method requirements and the requirements of each specific project.

3.4.3.

3.5. Comparability

3.5.1. Comparability is the extent to which comparisons among different measurements of the same quantity or quality will yield valid conclusions. Comparability is a qualitative objective that will be attained by utilizing standard techniques for sample analysis and by reporting analytical data in appropriate units. Comparability between analytical results obtained by the company and those obtained by other researchers will be ensured through the use of EPA, ASTM, and other recognized methods.

3.6. Traceability

3.6.1. Traceability is the extent to which results can be substantiated by documentation. Traceability documentation exists in two forms: that which links final numerical results to authoritative measurement standards, and that which explicitly describes the history of each sample from collection to analysis.

3.7. The fundamental mechanisms that will be employed to achieve these quality goals can be categorized as prevention, assessment and correction, as follows:

3.7.1. PREVENTION of defects through planning and design, documented instructions and procedures, and careful selection and training of skilled, qualified personnel;

3.7.2. Quality ASSESSMENT through a program of regular audits and inspections to supplement continual informal review;

3.7.3. Permanent CORRECTION of conditions adverse to quality through a closed-loop corrective action system.

3.8. This manual has been developed as a tool to achieve these goals.

4. STANDARD PRACTICES

4.1. Laboratory Safety

4.1.1. The laboratory shall be equipped with suitable hoods, protective clothing, eye wear, gloves, and other measures to prevent or minimize staff contact with hazardous substances. Safety equipment includes eyewash stations, showers, spill adsorbents and neutralizers, fire extinguishers, and first aid materials.

4.1.2. As a matter of policy, the company reserves the right to reject hazardous samples. It is the responsibility of the sample receiving personnel to request information from the client about any known hazards.

4.1.3. The Safety Manager or designee prepares and maintains safety-related SOPs, conducts safety and occupational health orientation, training and review sessions as required, and maintains up-to-date familiarity with safety and occupational health issues pertinent to the company.

4.1.4. The Safety Manager prepares and maintains educational programs as required to comply with state and federal "right to know" legislation.

4.1.5. The Safety Manager or her designee shall conduct an orientation session with each new staff member to familiarize him/her with routine and emergency safety procedures and equipment. Generally, the first day of employment shall be devoted to orientation and health and safety concerns. Protective eyewear and a lab coat shall be issued to all laboratory staff. Appropriate use of eye and skin protection shall be discussed as well as the use of safety glasses, face shields, goggles, fume hoods, gloves. The location of eye wash stations, showers, fire extinguishers, and first aid equipment shall be shown to the employee and their use shall be described or demonstrated. Fire and spill notification, emergency procedures, and evacuation procedures shall be reviewed during this session. The orientation includes an introduction to potential chemical hazards, Material Safety Data Sheets (MSDS) and the Hazard Communication Program. The location of the MSDS binders is identified and opportunity to review is provided.

4.1.6. Employees shall be responsible for their own safety. Lab Director, Technical Director and QA Manager may require that certain levels of protective equipment be worn when in their judgment it is appropriate. Failure of an employee to wear required protective equipment will result in immediate disciplinary action.

4.2. Security and Confidentiality

4.2.1. Security shall be maintained within all facilities with the purpose of controlling external influences on samples, analytical processes, and data. This helps assure the completeness, representativeness, accuracy, and precision of analytical results.

4.2.2. All visitors to the facility enter through the front door and are accompanied by an employee while they are in the facility. There are two entrances to the laboratory. The door to the front office area is locked when the front office area is not occupied and after business hours. The back door is locked when the lab area is not occupied and after normal business hours.

4.2.3. To preserve confidentiality (including national security concerns) and, analytical results, methods performed or discussion of any activities about the generation of a project's analytical results are discussed only with the customer or the customer's approved representative. All information related to a customer's samples are kept confidential. Requests to discuss project information with anyone other than the customer must be approved by the customer and documented in the project folder.

4.3. Traceability of Standards, Instrumentation, and Data

4.3.1. Standards

4.3.1.1. Since calibration standards used for method calibration affect all data derived from the method, the importance of quality and traceability is paramount. Acceptable materials are noted in individual SOPs or are approved by the Lab Director prior to purchase.

4.3.1.2. Only materials of certified purity from reputable suppliers are purchased. The record of the orders are maintained in a PO database which references vendors, their part numbers, description, and initials of person who placed the order. Record of reference material received shall be maintained in the appropriate standard notebook.

4.3.1.3. The company strives to purchase only the highest quality materials. To that end, reference materials shall be NIST traceable or EPA certified, whenever possible. Reference standards are handled carefully and only used for the purpose of calibration.

4.3.1.4. If assayed materials are unavailable, the material of highest purity available shall be obtained and assayed in-house before use.

4.3.1.5. The water used in analytical procedures must be purified and free of contaminants that could interfere with tests. The filtration system is maintained by a contractor and verified and documented through method blanks run with each sample batch.

4.3.1.6. All containers shall be identified with the standard/reagent serial reference numbers and dated upon receipt.

4.3.1.7. Bound laboratory notebooks shall be used by analysts and technicians to record receipt of standards and chemicals, and preparation of working standards and reagents from identified reference material. There is a standard/reagent notebook for Metals, Acids, Solvents, Organics, and Inorganics/Microbiology.

4.3.1.8. To ensure traceability information regarding both purchased and prepared standards and reagents must be documented. See section 7.2 for specific information that must be included in notebooks, logs and containers for standards and reagents.

4.3.2. Instruments and Equipment

4.3.2.1. Instrumentation used shall be as prescribed in the SOP for the analytical method and as per manufacturer instructions. Any instrumentation or equipment affecting the quality of environmental testing must be approved by the Lab Director prior to purchasing.

4.3.2.2. All instruments used to collect samples, generate sample results and/or reduce data shall be designated by a unique identifier. This instrument identifier shall appear on the instrument, in the analysts' notebooks, instrument logbooks and/or computer-generated hardcopy for all sample analyses. Instruments are operated only by trained and authorized personnel.

4.3.2.3. Preventive maintenance shall be provided for all instruments and equipment as specified by the manufacturer, instrument manual or as established by the Technical Director or QA Officer. Preventive maintenance shall be conducted in order to assure timely, accurate and reproducible analytical processes in a safe laboratory. A defective or suspect piece of equipment or instrument is labeled "out of service" until repairs are completed. Impact to any data are identified and corrective actions are taken. All maintenance activities shall be recorded in either the instrument run log or a separate logbook unique to the instrument. If it becomes necessary to send an instrument or piece of equipment to another location for maintenance, its functions and calibrations are checked before it is returned to service.

4.3.3. Data. Data Integrity is critical to the quality of the company's work product, which is used to support public health, environmental quality and remediation decisions. Systems are in place to ensure results can be reconstructed and have not been effected by improper actions. Refer to the Data integrity SOP QA-5003 for an extensive discussion of prohibited actions, ethics training and reporting responsibility.

4.3.3.1. All data generated in and/or reported from the laboratory shall include reference to the person(s) who performed the analysis, the date of analysis, the method used, the identification of the instrument and the acceptability of the results in the context of the QC system.

4.3.3.2. All data pertinent to sample preparation shall be recorded by the laboratory staff in bound notebooks with numbered pages and/or in computer spreadsheets. They shall contain the information described in section 9.2.

4.3.3.3. Manual Integration: Computer software systems should be set up to minimize the need for manual modification to the automated output. With some applications and limitations to the software used, manual integrations are sometimes are necessary. Refer to the SOP: QA-5000. For DOD projects manual integrations require justification for the modification to be stated on the raw data. This information is included in the DOD case narrative.

4.3.3.4. Data backup and archiving: All business information and laboratory data used for the generation of laboratory results are maintained on robust file servers and are backed up regularly, with backup media stored off-site. The design of the archiving process allows revisions of documents to be archived and traceable. The archived laboratory data include raw instrument data, calibration data and reduced results.

4.3.3.5. Electronic audit trail: The Laboratory Information Management System (LIMS) includes functionality which logs changes to data and requires user input to document reasons for data changes. The audit log file includes data and time of change, user name, original value, new value and reason for change. Data reduction software maintains automatic log files which track calibration date/time, data files used, integration date/time, manual integration and deletion tracking information.

4.3.3.6. Software Validation: Off-the-shelf software applications (predominantly Microsoft Excel) and a purchased LIMS ("Aspen") are used in the data reduction process. Periodic validation of calculations are performed by means of manual calculation checks. Manual calculation checks are also performed in the event of modifications or introduction of new calculation procedures.

4.3.3.7. Access to data and computer systems: All computer systems require login to access laboratory data. Each user is assigned a unique user account which is password protected. Additionally, the LIMS requires an additional unique login to a password protected user account. Some computers are used remotely, which connect to network resources only via secure VPN connections.

4.3.3.8. All computers and laboratory equipment are maintained in a secure, climate controlled laboratory or office environment. All equipment is maintained in accordance with manufactures' recommendations.

4.3.3.9. All employees are trained in the company's "computer use" policy which makes employees aware of prohibited activities, some of which may make the internal network vulnerable to malicious intrusion.

4.4. Accountability

4.4.1. All areas of the laboratory in which samples are received, stored, processed, or analyzed shall be kept in a condition that minimizes the risk of samples becoming lost or accidentally destroyed, contaminated, degraded, misidentified, improperly handled or otherwise compromised. The following practices shall be followed to assure that data reported represent results on the sample as submitted to the facility.

4.4.2. All employees are responsible for the cleanliness and order of their work areas. The Lab Director shall routinely tour the facilities and take appropriate actions to maintain a clean and orderly working environment. In addition, the safety committee performs monthly inspections and notes housekeeping needs. These shall be brought to the attention of the appropriate personnel who formulate and institute corrective action.

4.4.3. Each sample shall be assigned a unique Laboratory ID number personnel trained to receive samples. Provisions to identify field replicates and additional sample volume shall be incorporated into this procedure as described in Standard Operating Procedure QA-400, Sample Receiving and Identification.

4.4.4. Cross-referencing of Laboratory ID numbers and client's Sample IDs shall be implemented in Sample Management documents as described in Standard Operating Procedure QA-400, Sample Receiving and Identification.

4.4.5. Sample analyses shall be identified by the Laboratory ID number in all logbooks, consisting of bound laboratory notebooks with pre-numbered pages.

4.4.6. Standards shall be stored separately from samples and extracted samples.

4.4.7. Computerized systems for data generation shall be validated prior to implementation and shall contain provisions for password access and additional security measures as required.

4.5. Sample Analysis/Review of Requests and Contracts

4.5.1. All sample analysis requests are documented on a Chain of Custody (CoC). Upon receipt of a request, the laboratory will review the request to insure that the lab has the appropriate personnel, accreditation and equipment. If the laboratory does not have the ability to meet the project requirements, the customer is notified immediately.

4.5.2. If a QAPP or other requirements or contract has been prepared for the project, this must be reviewed prior to receipt of the samples. Any discrepancies or deviations remedied prior to the initiation of the project by the QA Officer and/or the Technical Director. Project specific data reporting requirements, including quantitation limits, are reviewed and discussed with the customer. It is incumbent on the laboratory to inform the customer of any deficiencies, conflicts, lack of accreditation, or inability of the lab to complete the work. Records of this review are maintained in the customer/project folder. If a contract is amended after work has begun, the changes are reviewed to ensure the project requirements can still be met. The changes are communicated to all affected personnel.

4.5.3. Samples shall be analyzed within holding times as specified the SOP, or as prescribed in the associated QAPP.

4.5.4. Samples shall be analyzed following written Standard Operating Procedures (SOPs) which have been approved in writing by management. Substantial changes to established procedures shall be authorized in writing by management via an SOP revision process as described in Standard Operating Procedure QA-0000, Preparation of SOPs.

4.5.5. In the event of departure from SOPs for a specific set of data, a discussion shall be recorded with the raw data and in the final report, as applicable.

4.5.6. When procedures require sub-sampling from a sample container, the sample is well mixed to insure that the aliquot removed is representative of the sample as a whole.

4.6. Customer Communications

4.6.1. We strive to maintain clear and open communications with our customers. This is especially important when beginning work with a new customer or on a new project, and clarifying details, or changes to current projects. Larger projects can require continued communication throughout the work and may be assigned a dedicated project manager. Discussions with customers often include recommendations, guidance and data interpretation. Standard Operating Procedures are available to customers upon request.

4.6.2. When a customer specifies a date when results are needed, any issues that arise which adversely affect the completion date are brought to their attention. Customers are updated with new expected completion dates. The customer is contacted whenever problems occur with samples or analyses or there are deviations from the specified requirements. These communications are recorded (often on the SRCR or as email) and filed in the project's folder.

4.6.3. The satisfaction of our customers is paramount. Customer feedback provides valuable information on what we are doing well and areas for improvement. Customer comments, both verbal and written, are documented and kept on file. Whenever possible, we engage our customers in conversations in an attempt to learn their opinion on the service we provide. A "customer feedback form" is available on the company's website, which is delivered to the QA department via email. Feedback from customers is reviewed by the QA department and shared at meetings and/or by email with the staff. Any information that identifies deficiencies is used to facilitate change, improving the overall quality system and prompt corrective actions. Positive feedback informs personnel of what is working well and its value to our customers. Sharing comments from or customers creates motivation to maintain good quality systems.

4.7. Data Review

4.7.1. Each analysis shall have written procedures for data review which incorporate the quality assurance goals of traceability, accountability, completeness, precision and accuracy.

4.7.2. No final report shall be issued which has not undergone the data review process.

4.8. Documentation

4.8.1. All information related to the quality assurance practices outlined in this manual shall be contained in records, according to the TNI standard (The National Environmental Laboratory Accreditation (NELAC)Institute). This shall include, but not be limited to, standard operating procedures, results of instrument calibrations, analysis of quality control samples, and analysis of samples, sample custody, preparation of standards, corrective action, audits and inspections.

4.8.2. The Quality Assurance Officer shall keep quality-related documents.

4.9. Accreditation Status

4.9.1. The laboratory notifies customers of our current certification status through information posted on our website. The location of our certified parameter list is noted on chain of custody forms. If accreditation is lost for a parameter, the customer is notified when samples are received and arrangements are made for subcontracting the sample to a laboratory with the required accreditation.

4.10. Subcontracting Samples

4.10.1. Occasionally the laboratory is asked to accept samples for a parameter for which we are not certified. Customers can find a list of analyses that are normally sent to an appropriate subcontract laboratory on our website. The customer is directed to our website by a note on our chain of custody.

4.11. Subcontracted Personnel

4.11.1. In the event that contract employees are hired to perform work, they will be supervised in accordance with the QA Manual. Contract employees will perform their requested tasks only after receiving the appropriate training as required for all personnel.

5. MATERIALS AND APPARATUS

5.1. Reagents, Solvents and Gases

5.1.1. Only chemical reagents, solvents, gases, and standards, supplied by reputable chemical suppliers, are used in the laboratory. All chemical reagents used for analyses shall be at least "Analytical Reagent Grade". Individual SOPs or method references may indicate specific reagent requirements.

5.1.2. Materials are dated and logged upon receipt in the laboratory. Contaminants in reagents are apparent through the analysis of blanks. Appropriate filters are used on gas lines to prevent contamination.

5.1.3. All solvents and gases used shall be chosen to assure compliance with specific method and SOP requirements.

5.2. Laboratory Equipment

5.2.1. Refrigerator/Freezer Temperature Logs

5.2.1.1. Refrigerators and freezer temperatures are checked and recorded every day they are in use. (per frequency in SOP800) Temperatures are maintained within the acceptance criteria of the method specified temperature or as required by our accreditation standard. For specified temperatures of 4°C, a temperature ranging from just above the freezing temperature of water to 6°C is acceptable. To ensure temperatures are maintained over weekends and holidays, thermometers capable of measuring minimum and maximum temperatures are employed. These thermometers are reset on Fridays and the minimum and maximum values are recorded on Monday. Corrective action is taken if a refrigerator/freezer exceeded the recommended range. Logs are reviewed by the QA Officer or designee, to verify they are operating properly, within established temperature ranges. Routine maintenance such as defrosting is performed as needed. All information is recorded in data sheets. The QA Department is responsible for ascertaining that checks have been performed and that necessary corrective actions have been instituted.

5.2.2. Glassware

5.2.2.1. All glassware used in the laboratory is maintained in good condition, cleaned, properly stored, and separated according to its specific application. Calibration is verified upon evidence of deterioration. Chipped, cracked, or otherwise defective glassware is either discarded or repaired. The laboratory purchases its analytical glassware from commercial laboratory glassware suppliers such as Ace Glass and Kontes. All volumetric glassware utilized is class "A" certified. When Class A glassware is not available, such as digestion vessels for metals analysis, the vessels are verified by the vendor. This certification is filed in the metal's room filing cabinet.

5.2.3. Glassware Cleaning

5.2.3.1. Laboratory glassware is scrupulously cleaned prior to use. Different cleaning procedures exist for different types of analyses and glassware. The glassware washing protocols can be found in the glassware washing SOP QA802.

5.3. Sample Preservation and Storage

5.3.1. Samples and sample extracts, fractions or leachates are preserved according to the EPA's guidelines, unless otherwise instructed, and stored to minimize sample contamination. To keep samples of differing levels of contamination separate, samples are segregated when high levels of contamination are known to be present. The laboratory relies upon information supplied by the field samplers to document any known hazards. If there are samples that are suspected high level contamination, they are unpacked in a hood and stored in a cooler, separate from all other laboratory samples. Specifically, high level VOC samples, such as petroleum product samples, are stored separately from low level samples.

5.4. Instrumentation

5.4.1. Laboratory instrumentation used shall be as specified in the protocol for the analytical method. Table 5-1 is a listing of major analytical instrumentation present in this laboratory.

5.4.2. Preventive maintenance shall be conducted according to a written schedule for each instrument and the activities documented in a bound instrument maintenance logbook.

TABLE 5-1

ANALYTICAL INSTRUMENTATION

Item	ID #	#	Description	Date Acquired	Condition
GC/MS and GC Systems					
GC/MS	VOA-01	1	HP 5890-II+ with 5791 MS	2000	Used
	PCG-1	1	Data Acquisition PC P-III	2009	Used
	VOA-01 PT	1	Tekmar 3000 P&T	2000	Used
	VOA-01 AS	1	Varian Archon Autosampler	2005	New
GC/FID/PID	VOA-02	1	HP 5890-II+	2000	Used
		1	Tekmar 2000	2000	Used
		1	Tekmar 2016	2000	Used
	PCG-1	1	Data Acquisition PC P-III	2009	Used
	Back up	1	Tekmar 2016 Concentrator	2000	Used
GC/MS	VOA-03	1	HP 6890+ with 5793 MS	2001	New
	VOA-03 PT	1	Tekmar 3100 Concentrator	2001	New
	VOA-03 AS	1	Varian Archon P&T Vial Autosampler	2001	New
	CPQ-1	1	Data Acquisition PC P-III	2001	New
TOC Analyzer	VOA-04	1	OI Analytical Aurora Model 1030	2010	New
GC/ECD/FID	SVOA-01	1	HP 5890-II+	2000	Used
		1	HP 5793 Autosampler	2000	Used
		1	HP 7673A Autosampler Tower	2000	Used
		1	HP 7673A Autosampler Tower	2001	Used
	SVOA-01GCR	1	GC Racer, Zip Scientific	2008	New
	SVOA-01GCC	1	GC Chaser, Zip Scientific	2008	New
GC/MS/DS	SVOA-02	1	HP 5890-II+ with 5972 MS	2000	Used
		1	HP 486DX/66 Computer	2000	Used
		1	HP 5973Autosampler	2000	Used
GC/ECD-Dual	SVOA-03	1	HP5890II+	2002	Used
		1	HP7673A Tower	2002	Used
Metals Instruments					
AA Spectrophotometer	MET-04	1	CETAC QuickTrace M-6100	2009	New

Item	ID #	#	Description	Date Acquired	Condition
ICP	MET-03	1	Thermo Elemental- Iris Intrepid	2002	New
Inorganic Instrumentation					
Electrometer/pH	Inorg-01	1	Beckman I40 (backup pH meter)	2000	Used
Electrometer Probes/ISE	Inorg-02	1	Jenco 6072	2000/ 2005	Used/New
DO Meter	Inorg-03	1	YSI Digital	2000	Used
Conductivity Meter	Inorg-04	1	Orion Model 120	2000	Used
Analytical Balance	Inorg-05	1	Sartorius BA 110S	2000	Used
	Inorg-06	1	American Scientific. Products	2000	Used
	Inorg-12	1	Sartorius H-51	2000	Used
	Inorg-13	1	Sartorius 1402 MP8-1		Used
	Inorg-15	1	A&D Co. EK-300i	2005	New
	Inorg-20	1	Mettler-Toledo AL104	2007	New
UV/VIS Spectrophotometer	Inorg-07	1	Sequoia-Turner Model 390	2000	Used
TCLP Tumbler	Inorg-09	1	12 Position-Env'l Express	2005	Used
Distillation Unit	Inorg-10	1	Kontes 10 Position	2001	New
Chiller Unit	Inorg-11	1	Neslab RTE 101	2001	New
Ion Chromatography	Inorg-14	1	Lachat Quick Chem 8000	2000	Used
		1	Lachat 10-510-00	2000	Used
Turbidity Meter	Inorg-17	1	HF Scientific, DRT-15CE	2006	Used
TKN Block Digester	Inorg-18	1	Lachat Model BD-46	2006	New
Electrometer/pH	Inorg-19	1	Hanna pH 21 meter	2007	New
pH Meter-portable	Inorg-21	1	Eutech Instruments, Oakton	2010	New
Chorine Meter	Inorg-22	1	HACH Pocket Colorimeter II, 58700-00	2011	New
Segmented Flow Analysis	Inorg-23	1	Alpchem by OI Analytical	2011	New
Misc. Instrumentation					
Sample Concentrator	SVOA-04	1	Rapid Vap N2 Labconco	2001	New

Item	ID #	#	Description	Date Acquired	Condition
Sonicator	SVOA-06	1	Misonix Dual Horn Assembly	2002	New
SPE-DEX 4790 Extractor	SVOA-07	3	Horizon technology- three extractors & one controller	2005	New
Microwave –MARS	SVOA-08	1	Microwave Accelerated Reaction System- 907501	2006	New
Laminar Flow Hood	Micro-01	1	CRP C-1003	2005	Used
Micro Incubator-med	Micro-02	1	Fisher 146E	2005	New
Microscope	Micro-03	1	Olympus CX21	2005	New
UV Light	Micro-04	1	Spectroline E-Series	2005	New
Micro Incubator- sm	Micro-05	1	Boekel indust-132000	2006	Used
Quanti-Tray Sealer	Micro-06	1	Idexx Model 2X #89-10894-04	2009	New
Centrifuge	Misc-01	1	IEC Centra CL 12	2000	Used
Flash Point Tester	Misc-02	1	Pensky Martin Closed Cup	2000	Used
Digi-Prep Digestor	Misc-05	1	SCP Science (DigiPrep 3000)	2002	New
Block Digestor	Misc-29	1	CPI-MOD Block 70mL/2 Blocks	2009	New
Soxhlet Extractor	Misc-06	1	Heating unit for soxhlet	2003	Used
Neslab Chiller	Misc-07	1	Neslab	2003	New
Vacuum Air Pump	Misc-08	1	Fisher	2002	New
BOD Incubator	Misc-09	1	Labline	2005	Used
Zero Headspace Extractor	Misc-10	2	Millipore	2000	Used
Laboratory Ovens	Misc-28(V)	1	Quincy Lab Model 30 GC Oven	2007	New
	Misc-30(H)	1	Quincy Mod 30 GC Oven #G3007838	2009	New
	Misc-13(K)	1	Fisher Isotemp	2000	Used
	Misc-14	1	Lindberg	2000	Used
Freezer	Misc-15(A)	1	Login-Ice	2004	New
Freezer	Misc-16(B)	1	VOC Standards	2004	New
Refrigerator	Misc-17(C)	1	General Sample Storage	2000	Used
Refrigerator	Misc-18(E)	1	Inorganic Standards	2000	Used
Freezer	Misc-19(F)	1	SVOA Standards	2000	Used
Refrigerator	Misc-26(O)	1	Sample Stor(TurboAirTMG-48R)	2006	Used
Refrigerator	Misc-31(P)	1	Sample Stor(TurboAirTMG-48R)	2010	Used
Refrigerator	Misc-32(D)	1	GE compact refrigerator	2010	Used
Flammables Cabinet	Misc-22(M)	1	Justrite Mfg, 12 gallon capacity	2000	Used
Flammables Cabinet	Misc-23(JZ)	1	Justrite Mfg, 45 gallon capacity	2005	New

Item	ID #	#	Description	Date Acquired	Condition
Acids Cabinet	Misc-24(S)	1	4 gallon capacity	2000	Used
Acids Cabinet	Misc-25(R)	1	Justrite Mfg, 22 gallon capacity	2005	New
Water Purification System	Misc-27	1	Hydro Service& Supplies Pico-system: UV, RO, Carbon Filter	2006	New
Data Management Equipment & Software					
LIMS		1	Aspen Enterprise LIMS v 7.5	2003	New
Office Productivity Software		15	Microsoft Office	2001-2009	New
Backup System		5	Iomega External Drive USB	2009-2010	New
DAT Backup System		1	Compaq AIT	2003	New
Servers, Desktop & Notebook Computers		24	HP, Compaq, Dell, Iomega, white box	2000-2010	New/Used
NO LONGER IN USE					
OVEN	Misc-12(H)	1	CMS 1200	2000	Disposed12/09
pH Meter-portable	Inorg-16	1	Eutech Instruments, Oakton	2006	Disposed 7/10
AASpectrophotometer	MET-01	1	Unicam 969 Solar/Cold Vapor Hydride apparatus	2000	Disposed 8/09
Refrigerator	Misc-21(P)	1	Sample Storage (True 111356)	2003	Disposed 09/10

6. SAMPLE RECEIPT AND TRACKING

6.1. Introduction

6.1.1. Chain-of-Custody encompasses three major elements: the field sampling, the laboratory analysis and the final data file. This section covers quality assurance related activities from the receipt of samples at the laboratory through the issuance of the report and the long term storage of the data.

6.2. Chain-of-Custody and Sample Receipt

6.2.1. The company uses the National Enforcement Investigations Center (NEIC) of EPA definition of custody of evidence in the following manner:

6.2.1.1. It is in actual possession, or

6.2.1.2. It is in view, after being in physical possession, or

6.2.1.3. It was in possession and then locked or sealed to prevent tampering, or

6.2.1.4. It is in a secure area.

6.2.1.5. Samples may be physical evidence and should be handled according to certain procedural safeguards.

6.2.2. Field personnel or client representatives complete the Chain-of-Custody Forms. Samples are received by the laboratory accompanied by these forms. The Chain-of-Custody (CoC) is the means by which the courts, in some types of legal proceedings, will accept proof of custody of samples from time of receipt to completion of analysis.

6.2.3. The sampler should provide the following information:

6.2.3.1. Client project name

6.2.3.2. Field sample number/identification

6.2.3.3. Date and time sampled

6.2.3.4. Sample type

6.2.3.5. Preservative

6.2.3.6. Analysis requested

6.2.3.7. Sampler Initials

6.2.3.8. Signature of person relinquishing samples

6.2.3.9. Date and time relinquished

6.2.3.10. Sampler remarks

6.2.3.11. Custody Seal Number (if applicable)

6.2.4. The record is filled out completely and legibly. Correction of errors is made by drawing a single line through and initialing and dating the error. The correct information is then recorded with indelible ink. All transfers of samples except to and from commercial couriers must be recorded on the Chain-of-Custody via the "relinquished" and "received by" sections. All information except signatures may be printed.

6.3. Sample Receipt and Log-In

6.3.1. Typically, samples are received by the laboratory during normal business hours (8:00 am to 5:00 pm), Monday through Friday.

6.3.2. Shipments for after hours and weekend deliveries are prearranged with laboratory personnel to ensure that personnel will be available to take custody, sign the CoC, record the date and time of sample receipt and to refrigerate the cooler in the login area.

6.3.3. The company maintains a Sample Receipt Policy which describes the requirements and information necessary for sample acceptance. This policy is posted in the Login area and is also available on our website. Any discrepancies are documented and discussed with the customer.

6.3.4. The Sample Acceptance Policy is as follows:

6.3.4.1. As per the requirements of TNI accreditation, any samples which are received that are missing critical information or have sample integrity discrepancies are rejected, unless authorization is given to proceed. Please make sure the following information is complete when submitted with your samples and that sample integrity is maintained by using the correct sample containers and preservation for the analyses required.

6.3.4.1.1. Sample Identification

6.3.4.1.2. Sample Location

6.3.4.1.3. Date and time of collection

6.3.4.1.4. Sample Collector’s name

6.3.4.1.5. Preservation Type

6.3.4.1.6. Unique ID on the sample labels

6.3.4.1.7. Proper sample containers

6.3.4.1.8. Sufficient sample volume

6.3.4.1.9. Proper sample temperature

6.3.5. Upon sample receipt, the coolers are inspected for the general condition of the Custody Seal, if present. The coolers are then opened and the temperature is measured from a representative sample or “temperature blank” if present, and is recorded on the CoC. Each sample is inspected for damage. The sample containers are removed from the cooler and identities are verified against the Chain-of-Custody. Sample integrity and volume requirements are reviewed in accordance with the Sample Preservation Chart (Table 6-1).

6.3.6. All information regarding sample condition upon receipt is documented on the Sample Receipt Condition Report (SRCR). The report documents:

6.3.6.1. The job number

6.3.6.2. The method of delivery (client, lab courier, etc.)

6.3.6.3. Custody Seals present/intact

6.3.6.4. CoC signed and correct

6.3.6.5. Lab preservation

6.3.6.6. Temperature upon receipt

6.3.6.7. Proper Sample Containers

6.3.6.8. VOC sample integrity

6.3.6.9. Samples within holding time

6.3.6.10. Rush TAT communicated

6.3.6.11. Work Subcontracted if needed

6.3.6.12. Immediate Tests Communicated

6.3.6.13. Personnel who received and inspected the samples

6.3.6.14. Personnel who logged the samples into the LIMS

6.3.6.15. Secondary review of login checklist

6.3.7. The Sample Receipt Condition Report is completed by signing and recording the date and time. If there are any discrepancies, if the methods selected are inappropriate or if there are problems with the samples or documentation, the customer is immediately notified. Communication with the customer is noted on the SRCR in the comments section. If the customer requests that the laboratory proceed with the analysis despite identified issues, the laboratory must document the approval to continue work on the SRCR. The report must indicate the discrepancy when it could affect the sample integrity or data quality. If sampling time is not available, the earliest time of day is assumed (12:01am).

6.3.8. The samples are logged into the LIMS. Each project is assigned a unique job number. A unique suffix is assigned to each sample on the project chain of custody during the receiving process. A complete Lab Sample Number consists of the job number followed by a numerical suffix, serialized to account for the number of samples from the CoC. The appropriate laboratory sample ID is recorded on every bottle received. It may be written in permanent ink on the side of the bottle, or adhered to the bottle with a "weatherproof" type label. Each container in a sample group is uniquely identified by the analysis written on the sample label. Any containers received with the same sample ID and analysis label are distinguished by adding a letter to the Lab Sample number. For example, VOC vials received in duplicate would be labeled 20000-01A and 20000-01B. Samples, sub-samples, extracts and digests are identified in this manner. This ID is retained throughout the life of the sample while in the laboratory.

6.3.9. Once labeled with an ID number, the samples are placed in the appropriate storage location. All volatile organic samples are stored away from other samples, to minimize the potential of contamination from samples which may contain high levels of volatile organic compounds.

6.3.10. The sample information along with requested analyses are logged into the LIMS. All special instructions or customer requirements are included in the test-specific notes. The LIMS is used to generate work lists of all samples in the system.

6.3.11. In the event that internal chain of custody is required, the procedures as defined in the Sample Receipt and Login SOP are followed. This procedure will document the internal custody and use of each container within the laboratory.

6.4. Analysts Work Lists

6.4.1. Each analyst is responsible for his/her own daily work list. Work lists are discussed with the Laboratory Director as necessary. A review of work in process, scheduled due dates, lab capacity, projects and upcoming resource needs is discussed on an ongoing basis.

6.5. Sample Disposal

6.5.1. After completion of sample analysis and submission of the report, unused portions of samples are retained by the laboratory for a minimum of four weeks. After four weeks, samples will be disposed in accordance with local, state and federal law. Samples that are considered hazardous waste and are handled by licensed hazardous waste disposal firms. Please refer to QA5001 Lab Sample Characterization and Disposal for details.

6.6. Subcontracting Analytical Services

6.6.1. Every effort is made to perform all chemical analyses at the laboratory. There are, however, instances where subcontracting of analytical services is necessary. If the customer requires NELAP or any other certification for the work to be performed, the laboratory will ensure that the subcontract laboratory currently maintains the required certification. The report will clearly indicate that the laboratory performing the analysis meets the certification requirements of the customer. Approval from the client must be obtained before samples are subcontracted. Any subcontract laboratory analysis performed which is not accredited by DoD must be approved by the customer and noted in the final report. Subcontract laboratory certification information is maintained and updated regularly.

6.6.2. Typically subcontracted analyses are listed on our website. If subcontracting becomes necessary for analyses that are typically analyzed internally, approval is obtained from the customer. This approval is documented on the SRCR, CoC, quote or bid. Arrangements are then made with an appropriate subcontract laboratory. Arrangements and terms of agreement are made with the appropriate subcontract laboratory personnel (i.e., laboratory manager, customer service contact, or the appropriate laboratory section manager). The specific terms of the subcontract laboratory agreement should include (when applicable):

6.6.2.1. Method (EPA or otherwise) of analysis

6.6.2.2. Number and type of samples expected

6.6.2.3. Project specific QA/QC requirements, detection limits

6.6.2.4. Deliverables required

6.6.2.5. Applicable laboratory certification status

6.6.2.6. Price per analysis

6.6.2.7. Turn around time requirements

6.6.3. Chain-of-Custody forms are generated for samples which require subcontracting to other laboratories. The laboratory personnel repackages the samples for shipment, creates a chain-of-custody form and records the following information:

6.6.3.1. Laboratory Sample Number

6.6.3.2. Sample matrix, date and time of sample collection

6.6.3.3. Requested analysis

6.6.3.4. Special instructions (quick turn around, required detection limits, anything unusual known about the samples or analytical procedure).

6.6.3.5. Signature in "Relinquished By"

6.6.4. All subcontracted sample data reports are sent to the company for review prior to forwarding to the customer. Unless the subcontract laboratory is specified by the customer, Absolute Resource Associate's assumes responsibility for the data supplied by the subcontractor. The subcontract lab's report is forwarded to the customer or the data are included in the company's report, referencing the subcontract lab.

Table 6-1

Preservation, Bottle Type and Holding Time Chart
AQUEOUS

Analysis	Preservation	Glass(G)/Plastic(P)	Size(mL)	Holding Time	Combinations/Notes
Water Samples					
ABN/PAH 8270/625	None	G-Amber	1000	7days	Extra bottles may be sent for QC
Alkalinity	None	P	125	14days	Needs separate container
Ammonia (NH3)	H2SO4 (pH<2)	P	250	28days	COD, Total Phosphorus, TKN
Anions(NO2, NO3,Cl, Br, O-PO4*, SO4)	None	P	60	NO2/NO3-O-PO48hr--Cl, Br,SO4,F-28days	All anions can be performed with one 60mL plastic container.
Note:*Anions O-PO4 (if filtration is required)	None	P	60	Filter within 15 mins	Syringe & Filter included upon Request
Anions NO2+NO3	H2SO4 (pH<2)	P	60	28days	3 drop H2SO4 into 60mL Bottle
BOD	None	P	500	48 hours	pH, Conductivity
COD	H2SO4 (pH<2)	P	60	28 days	NH3, T-Phos, TKN (in 250mL)
Bacteria	Sodium Thiosulfate	P-Sterile Container	100	6 hr- ww, 30hr-dw	ww-waste water, dw-drinking water
Conductivity	None	P	125	28days	BOD, pH
Cyanide	NaOH (pH>12)	P	125	14days	
1,4 Dioxane	None	G	2*40	14days	No headspace, HCl preserved vials are acceptable
DMF	None	G	2*40	14days	
EDB/ DBCP (504.1)	Sodium Thiosulfate	G	2*40	14days	3 mg sodium thiosulfate per vial
EPH	HCl (pH<2)	G-Amber	1000	14days	
Flashpoint	None	G	250 or 4oz		Must be separate container
Gases	HCl (pH<2)	G	2*40	14days	Includes methane, ethane, ethene
Hexavalent Chromium	(NH4)2SO4 Buffer	P	125	28 days	
Metals	HNO3 (pH<2)	P	250	6 months Hg: 28 days	
Odor	None	G-Amber	1L WM	24 hours	
Oil & Grease	HCl (pH<2)	G	1000	28 days	Extra bottles may be sent for QC
Pesticides 608/8081/8082	None	G	1000	7days	Must be pH 5-9 at receipt, Extra bottles may be sent for QC
PCB 608/8081/8082	None	G	1000	7days	Extra bottles may be sent for QC

pH	**None**	**P**	**125**	**15 minutes**	**BOD, Conductivity**
Propylene/Ethylene Glycol	**None**	**G vial**	**1*40**	**14 days**	**No headspace**
Total Phenol	**H2SO4 (pH<2)**	**G-amber**	**250**	**28 days**	
Sulfide	**Zinc Acetate, NaOH (pH>12)**	**P**	**125**	**7 days**	
Surfactant	**None**	**G-amber**	**250**	**48 hours**	
TDS/TSS/TS	**None**	**P**	**250(500 for TSS)**	**7days**	**Must be separate container**
TOC	**H2SO4 (pH<2)**	**G-amber**	**2*40**	**28days**	**No Headspace, Subcontracted**
TKN	**H2SO4 (pH<2)**	**P**	**250**	**28days**	**COD, T-Phos, NH3**
TPH 8100/DRO 8015	**None**	**G**	**1000**	**7days**	
TPH ME DRO	**HCl (pH<2)**	**G**	**1000**	**7days**	
Total Phosphorus	**H2SO4 (pH<2)**	**P**	**125**	**28days**	**TKN, COD, NH3 (in 250mL)**
Turbidity	**None**	**P**	**125**	**48 hours**	
VOC 624/8260/524.2/VPH/8021 / 8015GRO/MEGRO	**HCl (pH<2)**	**G vial**	**2*40**	**14 days**	**No headspace**

SOLIDS

Analysis	**Preservation**	**Glass(G)/Plastic(P)**	**Size**	**Holding Time**	**Combinations/Notes**
Soil Samples					
ABN/PAH 8270/625	**None**	**G-Amber**	**4oz**	**14 days**	**Can be combined in one 4oz amber jar** ***Analyses which can go into clear jars, may also share a 4oz Amber jar with the parameters to the left.**
TPH 8100/DRO 8015	**None**	**G-Amber**	**4oz**	**14 days**	
TPH ME DRO	**None**	**G-Amber**	**4oz**	**14 days**	
Pesticides 8081/8082	**None**	**G-Amber**	**4oz**	**14 days**	
EPH	**None**	**G-Amber**	**4oz**	**14 days**	
TOC	**None**	**G-Clear**	**2oz**	**28 days**	**Subcontract**
Hexavalent Chromium	**None**	**G-Clear**	**4oz**	**30 days**	**Subcontract**
Ignitability	**None**	**G-Clear**	**4oz**	**14 days**	**Must have it's own container**
PCB 8081/8082	**None**	**G-Clear**	**4oz**	**14 days**	**All of these parameters can share one 4oz clear jar** ***If TCLP is required an additional 4oz jar is needed**
Anions(NO2, NO3,Cl, Br, O-PO4, SO4)	**None**	**G-Clear**	**4oz**	**NO2,NO3,O-PO4 7days All other anions 28days**	
COD	**None**	**G-Clear**	**4oz**	**28 days**	
Conductivity	**None**	**G-Clear**	**4oz**	**28 days**	
Cyanide	**None**	**G-Clear**	**4oz**	**14 days**	
Metals	**None**	**G-Clear**	**4oz**	**180 days, Hg 28 days**	
pH	**None**	**G-Clear**	**4oz**	**7 days**	
Sulfide	**None**	**G-Clear**	**4oz**	**7 days**	

TS	**None**	**G-Clear**	**4oz**	**7 days**	***Analyses which require amber jars cannot be taken from clear jars**
TKN	**None**	**G-Clear**	**4oz**	**28 days**	
Ammonia (NH3)	**None**	**G-Clear**	**4oz**	**28 days**	
Total Phosphorus	**None**	**G-Clear**	**4oz**	**28 days**	
VOC VPH	**MeOH (10mL)**	**G-Clear**	**40mL**	**28 days**	**Multiple VOC methods, and GRO can share one MeOH preserved vial**
VOC 8260/8021/8015GRO/MEGRO	**MeOH (10mL)**	**G-Clear**	**40mL**	**14 days**	

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7. CALIBRATION PROCEDURES AND FREQUENCY

7.1. Introduction

7.1.1. All instruments and equipment used in the laboratory must follow a well defined calibration routine. Calibration may be accomplished by laboratory personnel using certified reference materials traceable to NIST or EPA certified materials or by external calibration agencies or equipment manufacturers. Calibration procedures are stopped or not used if the environmental conditions jeopardize the results of the analysis. The discussion presented here is general in nature because the requirements for calibration are equipment or method specific. Details of calibration can be found in Standard Operating Procedures, analytical methods, and equipment manuals.

7.2. Standards and Traceability

7.2.1. Analytical standards are prepared from pure materials or are purchased prepared from reputable vendors. They are used to prepare serial dilutions that are used as calibration and spiking standards. Each laboratory section is responsible for the preparation, storage and disposal of its standards. The preparation information is recorded into section specific Standards Notebooks. The notebooks are where the preparer records all information needed to maintain proper traceability.

7.2.2. Each standard is given an internal identification number, which is unique for each standard, standard lot number and shipment received. The preparation of all stock standards shall be documented in a Standards Notebook. To insure traceability, the following information shall be recorded in the notebook:

7.2.2.1. Manufacturer’s Name

7.2.2.2. Date of Receipt

7.2.2.3. Storage Location

7.2.2.4. Expiration Date

7.2.2.5. Lot/Serial number

7.2.2.6. The original container must also be labeled with the expiration date.

7.2.2.7. Unique identification number assigned

7.2.2.8. Vendor Certificate of Analysis (filed separately in binders)

7.2.3. All standards shall be labeled with the standard serial reference number (small glass ampoules), and with the name, concentration, date of preparation and expiration date of the stock standards. All diluted working standards not consumed during an analytical session shall be labeled fully, including the serial reference number of any stock standard used in its preparation.

7.2.4. All reagents for every parameter are considered to be standards and must follow the same quality control requirements as the standards. All inorganic reagents except those used in metals analysis are documented in the inorganic standards notebook, all organic reagents are documented in the organic standards notebook; all reagents for metals are documented in the metals standards notebook; all acids are documented in the acid log book. All diluted working standards not consumed during an analytical session shall be labeled fully, including the serial reference number of any stock standard used in its preparation. The standard/reagent notebook must also include the following preparation information for all standards and reagents prepared in the laboratory.

- The unique standard/reagent ID number to trace standard or reagent to neat materials
- Date of Preparation
- Either describe the method of preparation (how much of what to what) or refer to the SOP
- Expiration Date
- Initials of person who prepared the standard or reagent

The containers of prepared reagents and standards must contain the following.

- A unique identifier (this is the standard or reagent number you are assigning)
- Expiration Date
- Preparer's Initials
- A link to the information in standard and reagent prep records (this is achieved with the standard or reagent number)
- The date the container was opened.

7.2.5. Prior to the use of standards or reagents they must be checked for degradation or inconsistencies. Changes in color, liquefaction, evaporation, or clumping are indicator of degradation. Also, very poor recoveries from newly prepared quality control spikes or abnormally low instrument response to a specific standard are indications of possible standard degradation. For some standards, degradation is more easily noted. For example, DDT breaks down to form other analytes which can be determined by the same procedure. Degradation of DDT can be observed on a chromatogram by the increased concentrations of DDD and DDE. If degradation is observed before the expiration date, it should be noted in the Standard or Reagent Notebook and the material removed from service.

7.2.6. Standards which are held past manufacturer assigned expiration dates may only be used for qualitative purposes, and are never used for primary calibration. All standards are checked periodically in order to identify any which have expired or degraded.

7.2.7. Prepared solutions, organic solvents, standards or reagents may have the expiration date extended by the analysis of a fresh standard/solution, that has been verified by a second source, in comparison with the expired solution. If the results of the fresh solution and the expired solution meet the method accuracy (ICV) recovery and precision (duplicate) criteria, the expired solution may have the expiration date extended for half of the period originally specified.

7.2.8. Unless otherwise specified in an SOP, the following expiration dates will apply for materials received without an expiration date from the manufacturer. Expiration dates are from date of opening of the container.

7.2.8.1. Solid inorganic chemicals and reagents: 5 years

7.2.8.2. Organic solids: 3 years

7.2.8.3. Concentrated Acids or Bases: 5 years

7.2.8.4. Organic Solvents: 1 year

7.2.8.5. Dilutions and Prepared Standards/Reagents: 1 year

7.2.9. Before any set of standards can be utilized in a calibration curve they must be verified by a secondary means which includes all target compounds of interest:

7.2.9.1. Analysis of an EPA QC Check Sample,

7.2.9.2. Analysis of an independently prepared check standard, or

7.2.9.3. Analysis of purchased standard with a separate lot number and separate source from the calibration curve.

7.3. General Calibration Procedures

7.3.1. Calibration standards for each parameter are chosen to bracket the expected concentrations of those parameters in the sample, and to operate within the dynamic range of the instrument. Results that fall outside of the calibration range require reanalysis at a dilution which produces a result bracketed by the calibration standards. Except where methods allow, any measured concentrations outside the calibration range are reported with qualifiers. All reported analytes and surrogates are included in the initial calibration. Calibration curves are prepared at a minimum of five concentration levels, or as described in the SOP. Either an internal standard or external standard quantitation technique is utilized. Calibration data are stored electronically and are linked to sample data through excel worksheets and other data reduction software.

7.3.2. Calibration standards are prepared from materials of high purity. To establish instrument calibration, working standards are prepared from more concentrated working stock solutions. All organic standards are refrigerated or frozen. Inorganic standards are refrigerated as necessary. Data regarding their preparation is recorded in the appropriate Standards Notebook.

7.3.3. Instrumental responses to calibration standards for each parameter are subjected to an appropriate statistical test of fitness (least squares linear regression, quadratic equation, or relative standard deviation of response factors) or as required by the method or QAPP. The calibration must reflect an acceptable correlation of data points as specified in the referenced methods (e.g. correlation coefficient of at least 0.995 or linearity <15-20% RSD) to be acceptable. In cases where the calibration data are outside of the specified criteria, the analyst must rerun the calibration procedure and changing instrumental conditions as necessary until the criteria are met. Provided the total number of points required in the curve is met, points may be dropped from either end of the curve to meet the acceptance criteria if the decision is justified, reviewed and documented. Removal of low or high points will change the range of the calibration and must be considered when evaluating subsequent results. The calibration is verified by an ICV or per other method requirements as stated in the SOPs.

7.3.4. For analyses which are performed frequently and for which substantial calibration data are available, a complete recalibration is not required each time an analysis is performed providing that the continuing calibration criteria are met. A CCV is analyzed at the beginning and end of each analytical batch, except with internal standard methods and it is only required at the beginning. A CCV is run when the time period for the previous calibration has expired, after a specified number of field samples analyzed, or as a method requires. A continuing calibration verification is used to confirm a calibration is still acceptable. It is not used to quantitate data.

7.3.5. If the method criteria are not met, a second calibration verification can be analyzed. If the second attempt fails to produce acceptable results, corrective actions must be taken. This must be followed by two consecutive acceptable CCVs or a complete recalibration is necessary. All samples associated with a failed CCV will be re-analyzed or qualified if re-analysis is not possible.

7.4. Analytical Balances

7.4.1. A contracted qualified service technician checks the entire analytical range of the balance on an annual basis. The accuracy of weights is then verified by placing them on the newly calibrated balance. If balances are calibrated by an external agency, verification of their weights shall be provided. The calibration of each balance is checked each day of use, with a minimum of two weights which bracket the range of use. Calibration weights are Class S or better and are traceable to the National Institute of Standards and Technology (NIST). Every three years, or anytime the weight variance is outside the acceptance criteria for either balance, the weights are re-certified, and re-calibrated if needed, using NIST traceable weights. All information pertaining to balance and calibration weight maintenance and calibration is found in the balance logbooks and calibration files(both hard copy and electronic).

7.5. Thermometer

7.5.1. A certified, or reference, thermometer is maintained for checking calibration of working thermometers. The reference thermometer is of sufficient range to cover the working temperatures of all thermometers in daily use in the laboratory. Reference thermometers are provided with NIST traceability for initial calibration and are re-certified every three years with equipment directly traceable to NIST.

7.5.2. Working thermometers are verified with the reference thermometer before initial use and once per year. Digital thermometers are checked once per quarter. The thermometers are checked at two temperatures that bracket the target temperature. A correction factor is determined by averaging the results of the two checks. Correction factors above the smallest calibration interval are rounded to the nearest calibration point. Each thermometer is tagged with its number, correction factor, initials, location and date calibrated. Additionally prior to use, laboratory personnel visually inspect working thermometers

7.5.3. Calibration temperatures and acceptance criteria are based upon the working range of the thermometer and the accuracy required. Laboratory thermometer inventory and calibration data are found in the thermometer logbook. This procedure is described in more detail in SOP 800.

7.6. pH/Electrometer

7.6.1. Before use and once after every four hours, the meter is calibrated using pH 4, pH 7 and pH 10 buffer solutions, per the instrument instructions and pH SOP. If the check standard is not within 0.06 units of the true value, the entire analytical unit shall be checked for the source of the problem.

7.7. Spectrophotometer

7.7.1. Prior to use and afterward, the area around the spectrophotometer checked for cleanliness. The lamp is checked to be operational and is changed as necessary. In the event that the response for a calibration curve is inconsistent with previous data and the source of the discrepancy is found to be the spectrophotometer, the unit will be serviced. All records are kept in the instrument logbook.

7.8. Analytical Pipettes

7.8.1. The calibration of volumetric microliter pipettes is verified quarterly. Variable volume pipettes shall be calibrated at the volume to be used or the highest and lowest volume for the range used, e.g. 1000µL and 100µL for a 1000µL pipette. Refer to QA-800 for the procedure and acceptance limits used. If a pipette cannot be calibrated within the required limits, this is noted in the logbook, the pipette is labeled as "out of service" and must be serviced to meet specifications prior to being returned to use.

7.9. Microliter Glass Syringes

7.9.1. The certificate of accuracy must be kept on file with the QA Department.

7.9.2. Upon receipt, the laboratory must verify the accuracy of the syringe by making three measurements and recording the results on the certificate. The accuracy of these measurements must meet the criteria as specified on the certificate.

7.10. Instrumentation Calibration Procedures

7.10.1. The calibration procedures for the instruments used in the laboratory are specified in the specific SOPs. Curve acceptability criteria and calibration verification limits are found in the SOP.

8. ANALYTICAL PROCEDURES

8.1. Introduction

8.1.1. The company analyzes environmental samples from many sources, including surface and groundwater, soil, sediment, tissue, and waste. The methodologies generally employed constitute the most recent guidance from agencies such as EPA, ASTM, USGS, NIOSH and state regulatory agencies. In some situations, the company will develop and validate methodologies which are more applicable to a specific problem or objective. Any non-standard procedures require customer approval prior to use.

8.1.2. Analytical procedures are detailed descriptions of any and all processing, preparation and analysis of samples in the laboratory. In some instances, data format, presentation and delivery are also described. All analytical procedures shall be conducted in strict adherence with written Standard Operating Procedures which have been reviewed and approved by the Laboratory Director and the Quality Assurance Officer. Documents from which SOPs are developed include the references listed in Table 8.1. Additional SOPs may be adapted from other sources or generated in-house as project needs require. Required resources and equipment must be obtained for all methods that are validated and performed. Qualified personnel must perform method development and analysis.

8.2. Analytical Methods

8.2.1. Numerous sources of information are available to offer guidance in analytical methods. Selection of the appropriate method is dependent upon data use and the regulatory requirements of the analysis. Table 8-1 describes the analytical references routinely used. Table 8-2 is a list of methods performed, the associated method reference and the SOP number. The most current SOP revision in use is documented in the laboratory SOP files. SOPs are maintained for analyses and major company functions.

8.3. TNI and DoD Guidelines of Method Validation

8.3.1. Prior to the use of any method in the laboratory the following information must be complete:

8.3.1.1. SOP, including independent calibration verification

8.3.1.2. Demonstration of Capability (DOC)

8.3.1.3. Method Detection Limit Study

8.3.1.4. Successful evaluation of Split Samples or blind samples, when possible

8.3.2. A DOC is required prior to using any test method, any time there is a change in instrumentation, personnel, workcell participants, or test method. One of the following is required.

8.3.2.1. QC sample from outside source, if possible

8.3.2.2. Prepare diluted standards in a clean matrix, at a concentration at or below the midpoint of the calibration curve.

8.3.2.2.1. Prepare and analyze four aliquots of the diluted standard concurrently, or over a period of days.

8.3.2.2.2. Calculate the mean recovery in the appropriate reporting units and compare to the method % recovery acceptance criteria. Calculate the standard deviation and compare to precision acceptance criteria of the method. If acceptance criteria are met, analysis may proceed.

8.3.2.3. If acceptance criteria for a parameter are not met, the performance is unacceptable for that parameter. The source of the problem is identified the process is repeated for all parameters that failed to meet the criteria.

8.3.2.4. After successfully completing the DOC for an analysis, and prior to performing the analysis independently, a copy of the information required above, is given to the QA Officer in electronic or hard copy format. The Demonstration of Capability form is completed and placed in the employee-training file.

8.4. Determining Bias

8.4.1. Precision and bias is evaluated for all methods where the procedure is appropriate. Determination of precision and bias at the Limit of Quantitation is required by some certifications, programs, and specific project objectives. Methods are evaluated by the "four replicate recovery study" procedure. The evaluation is analyte and matrix specific and must be performed initially and any time the method is modified.

8.4.1.1. Prepare diluted standards in a clean matrix, at a concentration at or below the midpoint of the calibration curve or at the Level of Quantitation, as required.

8.4.1.2. Prepare and analyze four aliquots of the diluted standard concurrently, or over a period of days.

8.4.1.3. Calculate the standard deviation of the four recoveries and document the results in a tabular format to be reported to client as requested.

8.5. Detection Limits

8.5.1. Method Detection Limit Determination

8.5.1.1. The detection limit of each method is determined for all applicable methods. If a protocol does not exist to determine the detection limit, the limit of the procedure reflects the instruments limitations and the intended application of the test method. When an analytical procedure does not detect a parameter of interest, it is important to understand what the lower limit of detection is for that particular instrument, method and sample matrix. The laboratory strives to prevent matrix interferences from effecting analytical sensitivity, thereby raising the analytical detection limit. When matrix interferences are suspected, various techniques may be used to reduce or eliminate their effects.

8.5.1.2. Detection Limits are determined for all methods based on individual method specifications and recommendations, instrument limitations, and MDL studies. Method detection limit studies are performed for each method in use, initially, or as specified in the method, or after significant change with the instrument or procedure.

8.5.1.3. Method detection limits may be determined using replicate spiked laboratory water samples. A minimum of seven aliquots of a sample spiked for the purpose are processed through the entire analytical method. The laboratory calculates the detection limit as approximately three times the standard deviation of replicate measurements of the spiked samples. Sample preparation and analysis for the MDL calculation is conducted concurrently or over a period of days. The reader is referred to 40 CFR Part 136, Appendix B for further discussion.

8.5.1.3.1. To determine the concentration of standard to analyze for the study, the method detection limit (MDL) must be estimated. If there is no prior knowledge, use 3x the standard deviation of two recent method blanks. Then, prepare the standard at a concentration that is 2-3 times the estimated MDL for single analyte tests and 1-4 times the estimated MDL for multiple analyte tests. This study must be performed on every instrument that is used for the analysis of samples and reporting of data. Seven aliquots of the standard that are subjected to the entire preparation and analytical process are analyzed and the MDL is calculated. The MDL study information is to include the instrument used, the date of analysis and the analyst. The resulting MDL value determines your detection limit.

8.5.1.3.2. The QA Department reviews all MDL studies to check the correctness of the standard concentration, to be sure that all analyte values are greater than the MDL, and that the analyte values are, at a minimum, less than 10 times the MDL.

8.5.2. Limit of Detection (LOD) Verification

8.5.2.1. The LOD is the level at which a minimum amount of an analyte can be reliably detected by an analytical process. A verification of the LOD is required by some certifications, programs, specific project objectives and for any analytes that are reported between the LOQ and the detection limit. Methods that must meet this requirement are evaluated and documented on an instrument and matrix specific basis, one time per year, or anytime there is a change to the test method or instrument. Applicable DoD methods are verified one time each quarter.

8.5.2.1.1. The LOD verification standard is prepared at a concentration of two to three times the detection limit (as determined by the MDL study) for single analyte tests and one to four times for multiple analyte tests and analyzed in accordance with the SOP. All sample processing steps are followed. The LOD is verified by qualitative identification of the analyte in the QC sample. Method requirements for analyte identification must be met, such as ion presence, ion ratios, and secondary column confirmation. The signal to noise ratio at the LOD must be at least three. For data systems that do not provide a measure of noise, the signal produced by the verification sample must produce a result that is at least three standard deviations greater than the mean method blank concentrations. This spike concentration establishes the LOD. No results below the limit of quantitation may be reported without a valid LOD study.

8.5.2.1.2. If the LOD verification fails, then the laboratory must do one of the following:

1. repeat the detection limit determination study and perform the LOD verification at

a higher concentration

2. perform and pass two consecutive LOD verifications at a higher concentration and set the LOD at this higher concentration.

8.6. Limit of Quantitation-LOQ

8.6.1. The limit of quantitation is a concentration that can be reported with a specific degree of confidence. It is set at or above the lowest standard in the calibration curve. For multi-component targets such as TPH and PCB, the LOQ is set at the level at which the pattern is recognizable. The LOQ must be above the LOD. The limit of quantitation (LOQ), is verified by analyzing a standard containing all the analytes of concern at a concentration 1 to 2 times the expected LOQ, in accordance with the SOP. For the LOQ to be valid, the standard must be recovered within the LCS method acceptance criteria. The LOQ must be documented and verified annually or any time a method is modified. If the LOD is re-evaluated or verified annually then the annual LOQ verification is not required. Any methods for which DoD certification is held the LOQ must be verified quarterly, regardless if an LOD evaluation is performed.

8.7. Reporting Limit

8.7.1. Depending on the use of the data, the project data quality objectives, and customer requests, the reporting limits can vary. Reporting limits are generally established at or above the LOQ, which is at or above the lowest standard in the calibration curve. Any data reported below the LOQ are appropriately qualified. Where exceptions exist due to method specifications, such as metals by ICP, the method SOP clarifies when reporting limits may be at the MDL. In metals analysis, where a calibration point at the reporting limit is not practical, check standards analyzed at the reporting limit are generally expected to be recovered at 80-120%.

TABLE 8-1
ANALYTICAL PROTOCOLS

- "Guidelines Establishing Test Procedures for the Analysis of Pollutants Under the Clean Water Act." Federal Register, 40 CFR Part 136, October 26, 1984.

- "Test Methods for Evaluating Solid Wastes: Physical/Chemical Methods." SW-846. 2nd edition, 1982 (revised 1984), 3rd edition, 1986, Office of Solid Waste and Emergency Response, U.S. EPA.

- "Methods for Chemical Analysis of Water and Wastes", EPA 600/4-79-020, 1979 Revised 1983, U.S. EPA.

- "Standard Methods for the Examination of Water and Wastewater",20th, 19th, 18th editions, 1998, 1995, 1992. APHA-AWWA-WPCF.

- "NIOSH Manual of Analytical Methods", Third Edition, 1984, U.S. Department of Health and Human Services, National Institute for Occupational Safety and Health.

- "Methods for the Determination of Organic Compounds in Finished Drinking Water and Raw Source Water", U.S. EPA, Environmental Monitoring and Support Laboratory - Cincinnati (September 1986).

Table 8-2

Parameter List, Method and SOP Number

Analyte	Method	SOP No.
Alkalinity	SM 2320B	5801
Sulfate	EPA 300.0	5802
Nitrate	EPA 300.0	5802
Nitrite	EPA 300.0	5802
Chloride	EPA 300.0	5802
ortho-Phosphate	EPA 300.0	5802
Fluoride	EPA 300.0	5802
Chemical Oxygen Demand	EPA 410.4	5811
Total Cyanide	SM 4500CN-E, EPA 9014	5814
Cyanide by ISE	SM4500CN-F	5815
Oil and Grease	EPA 1664	5860
Total Phenols	EPA 420.1	5508
Ammonia-N	SM4500NH3F	5822
TKN	D3590-89,02A	5825
Total Phosphorus	EPA 365.3	5827
Total Filterable Residue	SM2540C	5834
Total Suspended Residue	SM2540D	5834
Total Residue	SM2540B,G	5834
Specific Conductance	SM 2510B	5836
pH @ 25	SM 4500H+B	5851
Biochemical Oxygen Demand	SM5210B	5843
Hardness by Calculation	SM2340B	5603
Turbidity	SM2130B	5862
Mercury by Cold Vapor	EPA 245.1, 7470A	5600
Metals by ICP	EPA 200.7, 6010C	5603
Semi-Volatile Organics	EPA 625	5200
Semi-Volatile Organics SW-846	8270D	5515
Ultrasonic extraction	3550C	5520
Microwave extraction	3546	5522
Liquid-Liquid extraction	3510C	5524
EDB	EPA 504.1	5315
Volatile Organics SW-846	8260B	5120
Volatile Organics Wastewater	EPA 624	5101
Volatile Organics Drinking Water	EPA 524.2	5109
Pesticides/PCB's	EPA 608	5302
Pesticides SW-846	8081	5304

Table 8-2 Continued
Parameter List, Method and SOP Number

Analyte	Method	SOP No.
PCB SW-846	8082	5303
Soxhlet extraction	3540C	5305
Coliform, E. coli P/A & MPN	Colilert SM 9223B	1001
Polyaromatic Hydrocarbons (PAH)	EPA 8270	5515
VOC	EPA 8260	5120
Gas Range Organics/ME GRO	EPA 8015/MHETL 4.2.17	5115
Diesel Range Organics	EPA 8015	5501
ME DRO	MHETL4.1.25	5314
Volatile Petroleum Hydrocarbons	MADEP	5130
Extractable Petroleum Hydrocarbons	MADEP	5313

9. DATA REDUCTION, VALIDATION, REVIEW, and FINAL REPORTING

9.1. Introduction

9.1.1. All analytical data generated undergoes a well-defined and well-documented data review process. The data review process is a multi-tier system. A log containing signatures for all individuals who are responsible for signing or initialing any lab record is maintained.

9.2. Analytical Records

9.2.1. Essential information associated with an analysis is recorded in analytical records, such as computer data files, printouts, analytical notebooks and run-logs. This information is recorded in a legible, permanent, un-obscured manner. Errors are corrected by drawing a single line through the incorrect entry and the correct value written nearby. This change is initialed and dated by the individual making the change. Changes other than transcription errors must include explanation the change.

9.2.2. When analytical data are changed in the LIMS, the audit trail functionality of the software records the original value, user name, date/time and requires the user enter a reason for the change.

9.2.3. Any occurrences or conditions that could affect the results of environmental tests are documented and analyses immediately stopped.

9.2.4. Observations, data and calculations are recorded at the time they are made and are traceable to the related task.

9.2.5. Information documented in analytical records at the time of preparation includes:

9.2.5.1. Date and time of preparation

9.2.5.2. Method reference/SOP reference

9.2.5.3. Analyst's initials

9.2.5.4. Preparation weights and/or volumes

9.2.5.5. Relevant QC sample association information

9.2.5.6. The analysis to be performed.

9.2.5.7. Comments or observations made during the procedure

9.2.6. At the time of sample analysis, at minimum, the following information is recorded in the laboratory notebook:

9.2.6.1. Laboratory sample identification number

9.2.6.2. Any dilution of the original sample and/or extract/digest

9.2.6.3. Other relevant sample data as described in the SOP

9.2.6.4. Date and Time of analysis, unless this information is captured by data collection software.

9.2.6.5. Method/SOP used

9.2.6.6. Instrument ID and reference to Instrument conditions

9.2.6.7. Analysis type

9.2.6.8. All manual Calculations, manual integrations and interpretations

9.2.6.9. Analysts initials

9.2.6.10. Sample preparation details

9.2.6.11. Sample analysis

9.2.6.12. Standard/Reagent IDs which reference receipt information

9.2.6.13. Calibration criteria, frequency and acceptance criteria

9.2.6.14. Data and statistical calculations

9.2.6.15. Assessment of data and quality control

9.2.6.16. Documentation of review

9.2.7. At the time of setting up autosampler or other data acquisition sequences, the following data are included:

9.2.7.1. Laboratory sample ID

9.2.7.2. analyst name/initials

9.2.7.3. sample dilution information

9.2.8.

9.2.8.1. Refer to section 4.3.3 of this document for a discussion of electronic data security, verification and backups.

9.2.8.2. Default values used in the calculation of results reside in the “TestGroupLibrary” and “QCReferenceLibrary” of the LIMS. These values are copied to new records in the database which are unique to each sample’s analysis. These records are maintained permanently, allowing for changes to these values to be tracked over time.

9.2.8.3. Method performance results, expected values and acceptance criteria are stored in the LIMS and can be reviewed with associated sample results.

9.3. Data Reduction

9.3.1. When primary analytical data, otherwise known as "raw data", are manually generated, the data are recorded either in bound Logbooks with pre-numbered pages, on preprinted forms or directly entered into computer files. All written entries are made in ink and all entries are initialed and dated by the individual making the entry. It is acceptable to initial and date once for an entire page provided it is clear that it applies to the whole page. Data may not be obscured in any way. This includes over-writing to change an entry, scribbling out or the use of white-out.

9.3.2. The analyst who completes the testing assembles all relevant data with chromatograms and other information essential to data interpretation. The results are reviewed and using Excel, are reduced to a worksheet for importing to the LIMS. Once all of the data are imported and reviewed, the final report may be generated.

9.4. Reporting of Results

9.4.1. The units for reporting results are specified in the SOP and are matrix specific. The reporting units are always in volume and weight units, not unspecified units such as ppm or ppb. Generally, inorganic results are reported in units of mg/L (aqueous) or ug/g (solid) and organic results are reporting in units of ug/L (aqueous) or ug/g (solid). Solid samples are reported on a dry weight basis, unless otherwise specified in the method or when stated as such in the lab report.

9.4.2. Concentrations are reported using two significant figures unless this shows a decimal place less than the reporting limit, in which case one significant figure is reported.

9.4.3. When interpretations of results are required, the basis for the conclusion is noted in the analytical records, and the data are qualified with wording which conveys the opinion. The customer is contacted whenever data are qualified in a manner that may affect the usability of the results.

9.5. Data Qualifiers

9.5.1. Data qualifiers are used to communicate information and explanations to the customer. The following is a list of commonly used qualifiers:

9.5.1.1. U: Analyte not detected above the reporting limit. As specified by the client, U can also be used to signify that the analyte was not detected above the established LOD.

9.5.1.2. J: The analytical result was below the instrument calibration range. The reported concentration is an estimate. As specified by the client, J can also be used to signify that the analyte was detected between the detection limit and the LOQ and is therefore estimated.

9.5.1.3. E: The analytical result was above the instrument calibration range. The reported concentration is an estimate. This qualifier is to be used when sample is unable to be re-analyzed at a dilution.

9.5.1.4. B: A low level of this analyte was also detected in the method blank.

9.5.1.5. * The surrogate showed recovery outside the acceptance limits.

9.5.1.6. # The associated LCS/D showed recoveries outside the acceptance limits.

9.5.2. Many situations may arise requiring the use of data qualifiers. A text document containing “standard notes” is available to all analysts. To keep the qualifiers consistent among analysts, the most appropriate data qualifier is chosen from this document and applied to effected samples. The qualifier is ultimately reviewed for sensibility by the laboratory director during final report review. Any data qualifier used is defined in the report.

9.6. Data Validation and Secondary Review

9.6.1. The data validation and secondary review process encompasses login, initial calibrations, analytical data review and final report review. This process ensures that every area of the laboratory that contributes to the generation of final data and reports is reviewed for accuracy and compliance to customer requests. Documentation of reviews is noted as dated initials or signatures on data summaries, logbooks and reports.

9.7. Login Review

9.7.1. A review of the login process (secondary review) is performed after the samples have gone through the entire login process and the login data are in the computer. The login review checklist is located on the SRCR (Attachment). The fields located on the bottom of the SRCR are checked in the LIMS for correction. Any changes or questions regarding the login are discussed with the person who received and logged in the samples and are recorded on the SRCR. Any analyst performing the secondary review for login must be trained in the login procedure and signed off on the login SOP.

9.8. Initial Calibration Review

9.8.1. To insure accuracy of the initial calibration process, an initial calibration review is performed. The analyst is responsible for reviewing the calibration using the checklist provided.(Attached) The purpose of the initial calibration review is to verify the integrity of the curve, including the TNI requirements of a calibration curve (refer to SOPs for calibration requirements), the ICV, and all reagents and standards involved. The initials of the analyst and the date reviewed directly on the calibration curve indicate the documentation of the calibration curve review by the analyst.

9.8.2. To ensure initial demonstration of capability in calibration review, new analysts must perform one calibration curve that is reviewed by their trainer. In cases where there is no trainer available, the QAO or Laboratory Director can serve as the secondary reviewer. One calibration curve is also reviewed on all new methods. Once the successful review of one calibration has occurred, the analyst takes over responsibility of reviewing their own calibration curves.

9.9. Analytical Data Review

9.9.1. The analyst performs the first step in the data review process. Each analyst reviews his or her work for completeness, accuracy, compliance with the QA Manual, SOP and customer requirements. The review includes checking the following information. The analyst signature on the raw data documents and indicates that these items have been reviewed.

9.9.1.1. Sample information (such as sample identification, dates of sampling, analysis, preparation, matrix)

9.9.1.2. Transcription of data from worksheets to electronic files, when applicable.

9.9.1.3. Method QC criteria met

9.9.1.4. QAPP and QC protocol

9.9.1.5. Raw data, manual integrations are correctly interpreted

9.9.1.6. SOP followed

9.9.1.7. Dilutions noted and accounted for in calculations

9.9.1.8. Unusual items noted such as matrix difficulties, special preparation notes

9.9.1.9. Holding times met

9.9.2. The secondary reviewer performs the next level of analytical data review. This review is done by a peer and includes the items listed in the following checklists for inorganic and organic areas (attachment). Particular attention is paid to checking all manual entries made during the secondary review. Method QC sample results are also reviewed. The secondary reviewer documents completion of this review by initialing and dating the raw data. The secondary reviewer does not have the responsibility of changing the data. Any corrections are done by the analyst whose work is being reviewed. See review summaries (attached) for both inorganic and organic analyses.

9.9.3. The Lab Director or designee performs a complete report level review prior to signing a report. This review follows the checklist attached. (Attachment)

9.9.4. The internal audit may include a review of the reports generated by the QA Officer or designee. Reports generated by the laboratory are reviewed for overall compliance with the QA Manual, SOP, and customer requirements. The checklist used for this review is attached.(Attachment). Ten percent of projects requiring DoD certification are reviewed. Any nonconformance noted is documented on a corrective action report and followed through the corrective action process.

9.10. Data Report

9.10.1. The report to the client at a minimum includes the following sections:

9.10.1.1. Cover page (Brief narrative)

9.10.1.2. The results

9.10.1.3. Chain-of-Custody forms

9.10.2. The cover page briefly describes that the results meet QA Manual, SOP and quality control requirements unless otherwise noted. The CEO, President, Technical Director, Laboratory Director (acting or otherwise) and Quality Assurance Officer are authorized to sign and release reports at the request of, or in the absence of the Laboratory Director. The cover letter includes, at a minimum.

9.10.2.1. Title

9.10.2.2. Unique job number

9.10.2.3. Customer name, address and phone number

9.10.2.4. Company name and address

9.10.2.5. Project name provided by the customer

9.10.2.6. Date of sample receipt by the laboratory

9.10.2.7. Date of reporting of results by the laboratory

9.10.2.8. Name and function of authorized person signing report

9.10.2.9. Authorized signature

9.10.2.10. The total number of pages

9.10.3. The sample results are tabulated. Sample ID, Field ID, and date analyzed are presented along with the results for each parameter, reporting limits and method reference. The CoC is also included. The result pages include:

9.10.3.1. Sample ID

9.10.3.2. Field ID

9.10.3.3. Date Sampled

9.10.3.4. Sample matrix

9.10.3.5. Units

9.10.3.6. Method Reference

9.10.3.7. Analytical Result

9.10.3.8. Reporting limit

9.10.3.9. Analyte name

9.10.3.10. Date Prepared

9.10.3.11. Time prepared (for all DoD projects)

9.10.3.12. Analysis date

9.10.3.13. Analysis time when holding time is < 72 hours (or for all DoD projects)

9.10.3.14. Dilution factor

9.10.3.15. Percent Solids for solid samples

9.10.3.16. Analyst initials

9.10.3.17. Qualifiers or footnotes as applicable (including cleanup procedures for DOD projects)

9.10.4. Some projects have special requirements and may include other components in their reports. In addition to the above noted sections and information, the following also may be included.

9.10.4.1. A Sample Association Table, QC Narrative, and Quality Control Summary can be provided when requested by the customer, and is standard for some protocols and programs, such as MCP and DoD.

9.10.4.1.1. The sample association table relates the Field ID, Sample ID and analyses requested.

9.10.4.1.2. The narrative highlights pertinent information which may include reference to compliance with a standard, quality control issues, deviations from procedures, identification and justification of manual integrations, special requests, special sample prep or handling procedures and discrepancies.

9.10.4.1.3. The quality control summary includes QC sample results, recoveries, RPDs, acceptance limits and batch numbers for associated QC samples.

9.10.4.2. A report which is part of the DoD program includes the following unless it is excluded by the project requirements:

9.10.4.2.1. Table of contents

9.10.4.2.2. sample association table

9.10.4.2.3. reference to any subcontracted data

9.10.4.2.4. case narrative (including identifications/justifications for manual integrations and cleanup procedures)

9.10.4.2.5. quality control summary

9.10.4.2.6. Precision and Bias at the LOQ

9.10.4.2.7. the current LOD and LOQ studies associated with the reported data

9.10.4.2.8. sample management records including: shipping documents, SRCRs, email or telephone conversation documentation associated with the project, and any sampling procedures if the laboratory had involvement in sample collection.

9.10.4.2.9. Any additional information as requested in DoD project scope of work or specified data validation be performed. These components may include: Calibration data, performance standards, MDL studies, raw data, project action levels and other supporting documentation.

9.10.5. The final report is sent to the person listed on the COC listed under "Report to:" It may also be sent to additional people as directed on the COC or as communicated by the customer.. This information is recorded on the SRCR, COC or as standing instructions in the customer's file. The customer may request a paper copy of the report, electronic PDF file, or link to secure online report files is sent to the customer. An electronic copy of the report is kept in a data folder which is filed by Job ID number.

9.11. Reissued Reports

9.11.1. Any changes made to final reports must follow the QC protocol described in the QA Manual and other applicable SOPs. The Job ID remains the same, providing a unique link to the original report. Changes can be made to a report after it has been finalized in two ways.

9.11.1.1. If a small number of changes are needed, where only a few report pages are affected, the individual report pages can be reissued. The changes must be made and documented in the project folder. Each revised page must have a revision date added, to distinguish it from the original. A signed and dated cover page outlines the changes and which report pages are included in the supplement to the original report. The cover letter and attached pages are forwarded to the customer.

9.11.1.2. If the changes impact a larger portion of the report, the entire report should be reissued. All pages that are revised must have a revision date added. The report is reviewed for accuracy. A new cover letter stating that the report is reissued and the reason for the reissue is signed and dated.

Sample Receipt Condition Report

Absolute Resource Associates **Lab ID number: ______________**

Sample Shipped: _______ UPS _______ Fed. Ex _______ Other
Samples Hand Delivered: _______ Client _______ Lab Courier _______ Other

	Yes	No	N/A	Comments
1.Custody Seals Present and intact:	_______	_______	_______	______________________________
2. COC signed:	_______	_______	_______	______________________________

Preservation		**Bottle Size/Type/Quantity**										pH √ (if >5 samples, check 20%)DOD-chck all!
HCl		40mL(G)		250mL(P)		500mL(P)		1000mL(G)		Other		
HNO3		125mL(P)		250mL(P)		500mL(P)		Other		Other		
H2SO4		40mL(G)		60mL(P)		125mL(P)		250mL(P)		500mL(P)		
NaOH		125mL(P)		250mL(P)		Other		Other		Other		
MeOH		20mL(G)		40mL(G)		Other		Other		Other		
(NH4)2SO4		60mL(P)		125mL(P)		250mL(P)		Other				
ZnAc/NaOH		125mL(P)		250mL(P)		Other		Other		Other		
NaS2O3		40mL(G)		120mL(P)		Other						Residual Chlorine: ABN625 ______ Pesticide608______ (Bacteria checked by analyst)
None (W)		60mL(P)		125mL(P)		250mL(P)		500mL(P)		1L(G)		
None (S)		2oz(G)		4oz(G)		8oz(G)		Syringe		Other		

Temperature upon receipt: _______ °C | **Received on Ice: Yes No** | **Sampled <24 ago?____________**

	LoginRvw	Yes	No	N/A	Comments
☺Proper sample containers?		______	______	______	______________________________
☺Enough sample/ correct preservative?		______	______	______	______________________________
☺VOC's Integrity (Waters- no headspace. Solids: Methanol covers solid in jar, no leaks apparent.)		______	______	______	______________________________
☺Samples within holding time:		______	______	______	______________________________
☺Immediate Tests Communicated:	☐	______	______	______	NO3, NO2,O-PO4, pH, BOD,,BacT,Surfactant, Turbidity,Odor
☺Date,Time &ID on bottle match COC?		______	______	______	______________________________
☺Rushes Communicated:	☐	______	______	______	______________________________
☺Work Subcontracted:		______	______	______	______________________________
☺Pesticides (608) pH Check (pH5-9)		______	______	______	______________________________
☺Customer notified of discrepancies	☐	______	______	______	______________________________

Inspected and Received By: ____________________ Date/Time: ____________________

Reviewer's Checklist

☐ Client ID/Project Mngr	☐**TAT**	☐ **Sample ID**	☐**Analyses In Correctly**
☐ Project Name	☐ Rec'd Date/Time	☐ Matrix	-References
☐ QA/QC Required	☐ On ice, temp?	☐ Date/Time Collected	-Wastewater Methods
☐ EDD	☐ **Subbed samples sent (COC in folder)**		☐ Notes from COC in ASPEN

Reviewed By:____________ Date: ____________

Notes: **see back→**

Inorganic Initial Calibration Review Checklist

Reviewed By: ______________
Date: _____________

Calibration Date: _______________

Standards

Standard(s) ID #: ______________________________

____

Expiration Dates OK?: ________ yes ________ no ________ N/A

Correct Concentrations: ________ yes ________ no ________ N/A

Concentration Levels

Lowest Level is the Reporting Limit? ________ Yes ________ no ________ N/A
At least three cal points plus one blank? ________ Yes ________ no ________ N/A

III. Verification

R^2 Value is 0.995 or greater? ________ Yes ________ no ________ N/A
Initial Calibration Verification
Standard has a different Lot # (if same source) or is from a second source?

________ Yes ________ no ________ N/A

Initial Calibration Verification is within ±10%? ________ Yes ________ no
________ N/A

Comments:

Organic Initial Calibration Review Checklist

Reviewed by: ____________
Date: ____________

Calibration Date: ____________
"Method" File Name: ____________

Standards

Concentrations Accurate?	Yes	No	N/A
Expiration Dates OK:	Yes	No	N/A

Concentration Levels

Lowest level at or below Reporting Limit:	Yes	No	N/A
Curve fit acceptable:	Yes	No	N/A
Enough calibration levels	Yes	No	N/A

Initial Calibration Verification

ICV from 2nd source:	Yes	No	N/A
% Recovery acceptable :	Yes	No	N/A

Qualitative

Retention times verify with a known standard	Yes	No	N/A
Retention times stable:	Yes	No	N/A
Mass Spec. Reference spectra match:	Yes	No	N/A

Comments:

<u>Inorganics Data Review Guideline Checklist</u>

INORGANIC SECONDARY REVIEW CHECKLIST

To be reviewed by an individual, other than the analyst, that is trained in performing secondary review. The secondary reviewer must initial the method run log after completion of review.

<u>Items to be checked from the Run Log to the Excel Worksheet</u>

- Dilution Factors
- Initial sample weight/volume
- Final volume
- Correct Lab ID
- Transcription Errors in Results

<u>Items to be checked in the Aspen Worksheet</u>

- Dry weight present and used in calculation
- Significant Figures appropriate
- Date analyzed
- Analyzed within holding time?
- QC page is acceptable or qualified accordingly
- Qualifiers present (Grammatically correct)
- Reason for re-analysis noted (as applicable)

<u>Organics Data Review Guideline Checklist</u>

ORGANICS SECONDARY REVIEW CHECKLIST

To be reviewed by an individual, other than the analyst, that is trained in performing secondary review. The secondary reviewer must initial the raw data after completion of review. The primary analyst is responsible for checking that the dilution info in logbook matches the quant report. The primary analysis must also initial and date the raw data to show acceptance of q-edits, batch QC, IS responses, surrogate recoveries, and dilutions.

Review of Quant sheets (raw data) and Aspen Worksheets

- Dilution factor matches quant report. Results/Quant limits reasonable for dilution
- Field ID is logical
- Entries checked to include: IV, FV, Prep date, Soil weight, MeOH volume, dry wt.
- Surrogate standards passing?
- Quant reports "QT reviewed"?
- Check C-Gram for any large, unlabelled peaks. Noted on report?
- Quant reports initialed and dated by analyst?
- QC page is acceptable or qualified accordingly
- Relevant notes on quant report entered: pH? HC's?
- Any analytes present above the reporting limit are highlighted and in Aspen
- Significant figures appropriate
- VPH: all ranges are manually integrated?
- Values within calibration range? (initial all "CHECK" qualifiers)
- "F+?" flags are checked to confirm analyte and initialed by secondary reviewer
- Sample run within holding time? (check for "Expired?" flag)
- Any Estimated values?
    - Marked as "E"?
    - Define qualifier (E=)
- Reason for re-analysis noted on quant sheet as applicable

Final Report Review Guideline Checklist

Secondary Review Checklist: Final/Admin Review

LAB REPORT CONTENTS

- All sample reports present?
- Batch QC present if it is required? All footnotes correct?
- Reporting limits met?
- Correct Method used?
- Certification OK for applicable analyses?
- Data sensibility: Dup matches a sample, INF/MID/EFF
- Data Reviewed in the Lab- signed by reviewer and analyst?
- Review COC vs Report contents. All analyses present? Subbed data present?
- Does report need narrative?
- Sample discrepancies, problems, questions noted in cover letter and/or Narrative?
- Check SRCR for any notes needed in report
- Necessary customer contacts made and documented.

INVOICING

- Correct “bill to” client and address used?
- PO number included if required?
- Combo pricing used?
- Pricing is correct: check notes in Aspen, Quotes, discounted fee schedules?
- Rush pricing correct (check to make sure Rush was on time)?
- Sampling fee needed?
- Analyses requested on COC match invoice?
- Each analysis priced the same: check math, extensions…

REPORTING

- Is report cover sheet signed, dated and total pages noted?
- Is a Fax requested? Has it been sent and noted on SRCR/Fax cover sheet?
- Is EDD required? Has it been sent and noted on SRCR and dated in “O”?

Laboratory Report Checklist

Report Number: **Date of Review:**

	Yes	No/ Notes
Cover Sheet Information:		
Laboratory name and Address present?		
Authorized Signature present?		
Total number of pages listed on cover sheet? All pages present?		
Statement regarding QA/QC procedures present?		
General Information:		
Sample collection date/time on COC?		
Relinquish signatures/dates/times on COC?		
Name/initials of person collecting samples on COC?		
Temperature upon receipt 4C(+/-2C)or customer contact noted?		
Samples on ice upon receipt?		
Correct preservations noted on SRCR, VOA headspace noted?		
Trip Blank noted and logged in if received?		
Correct sample containers for analysis selected?All intact?		
Anything noted on SRCR: filtration, sep. phase, matrix notes etc?	*	
Sample field identification & RL ID# on reports match COC? (Note:		

check one parameter, unless change to login was made-check SRCR)	Analysis:		Analysis:	
Reported Data:	Yes/N/A	No/ Notes	Yes/N/A	No/ Notes
Is certification for analysis current?				
Method Reference on report page? For extraction?				
Certification statement present for EPH/VPH? Rcpt temp matches COC?				
Units on report page(solids on a dry wt basis)?				
Matrix noted on report page?				
Lab report #, sample ID # and field ID # on report page?				
Analyst noted on report page?				
Dilution factor noted on report page?				
Percent moisture for solid samples noted on report page?				
Reporting quantitation limits adjusted for dry wt and dilution?				
Date of extraction on report page?				
Date of analysis on report page?				
Holding time met?				
Any notes on SRCR/COC(filtration,sample condition,pH) also on report?	*			
Acceptance ranges provided for QC? Batch QC present if required?				
Optional Comprehensive Review-Data-QA/QC:				
Method blank <RL or noted on report?				
Surrogates, every sample, in control or noted on report?				
MS/MSD/Duplicate, 1/20, in control, or discussed?				
LCS, as required, in control, or discussed?				
Calibration criteria (current curve, CCV in control) or discussed?				
Secondary review complete and noted?				
Any findings qualified on report, explained well, data impact clear?				
Target analytes correct? (Trace minimum 1/10 back to raw data)				
Significant figures correct?				
Values w/in calibration range or value from diluted run subbed in?				

10. RECORDS MANAGEMENT

10.1. Introduction

10.1.1. Records are the means by which an organization documents its operations and activities. They are an integral part of the Quality Assurance Program since they provide evidence for program functionality and necessary information for performance evaluation and quality assurance audits.

10.2. Reports:

10.2.1. A paper copy of the report, electronic PDF file, or link to secure online report files is sent to the customer. Mailing and email addresses are verified via the LIMS submitter library, the CoC form or other business documents. An electronic copy of the report is kept in a data folder which is filed by Job ID number.

10.3. Hard Copy Records:

10.3.1. All printed raw data, sample receipt information and CoCs are kept in the project file folder. The laboratory maintains all information necessary for reconstruction of the reported data. The records maintained by the laboratory, for a minimum of 5 years include the following. Data generated in support of MADEP is maintained for 10 years.

10.3.1.1. Standard Operating Procedures

10.3.1.2. Sample Tracking records

10.3.1.3. Chains-of-Custody forms

10.3.1.4. Standards Traceability Records

10.3.1.5. Maintenance Logbooks

10.3.1.6. Data Report/Raw Data Package

10.3.1.7. Calibration Records

10.3.1.8. Log Books

10.3.1.9. Employee Initials Log

10.3.1.10. QA Records: includes audit reports, WP/WS study results, corrective action reports.

10.3.2. All logbooks are assigned a QA number which is recorded in the QA Register. When logbooks become full this is recorded in the QA register, the log is archived and a new unique QA number is assigned to the replacement log. Archived logs are stored in file drawers for a period of time, then placed in storage boxes for long term storage. An archive log is maintained to keep record of the archive box number, contents, date archived, and disposal date.

10.3.3. Records are kept on site or at a secure off-site storage facility. They are protected from fire, theft, loss and deterioration. Access to archived records is recorded in the archive logbook. When a file is removed from archives, the box number, file number, date removed and initials is recorded. The responsible party must also record when the file is returned.

10.3.4. In the event of a transfer of company ownership, the transfer of records will be addressed in the purchase and sales agreement. In the event of a change in business status, customers will be given the option to retrieve documents they own. All documents not retrieved will be destroyed.

10.4. Electronic Records

10.4.1. All electronic records are maintained for a minimum of 5 years from the report's completion date, Massachusetts DEP related work is kept for a minimum of 10 years. Electronic records retained include:

10.4.1.1. A project folder is maintained on a file server containing processed results:

10.4.1.1.1. PDF version of the final report

10.4.1.1.2. CoC forms

10.4.1.1.3. sub sections of reports and QC reports, used to generate the final report

10.4.1.1.4. All files which had been saved to the project folder, which may include:

10.4.1.1.4.1. email correspondence

10.4.1.1.4.2. Correspondence or notes relating to activities for the project

10.4.1.1.4.3. preliminary or draft reports

10.4.1.2. All instrument data are centrally located on a fileserver which includes raw data and calibration files.

10.4.1.2.1. Raw/data acquisition files

10.4.1.2.2. instrument calibration (method) files

10.4.1.2.3. quantitation result files

10.4.1.2.4. mass spec tune files

10.4.1.2.5. data acquisition (method) parameter files

10.4.1.2.6. instrument sequence files

10.4.1.2.7. data acquisition databases, including calibration files.

10.4.1.3. Files used in the process generating LIMS import files:

10.4.1.3.1. to calibrate, calculate and check manual tests results

10.4.1.3.2. summary files used to calculate and build files for importing into LIMS

10.4.1.3.3. LIMS import files

10.4.1.4. LIMS database

10.4.2. In addition to the "live" fileserver copies of these data, data are copied to removable media nightly and rotated to an off-site facility.

10.4.3. Prior to decommissioning obsolete hardware, data on this old media has been copied to the current systems, making maintenance of legacy systems unnecessary.

10.4.4. All sample and customer related data are stored on server systems, therefore individual PCs do not require backups.

10.4.5. Users are required to login using their assigned user names and passwords in order to access data and networked resources. The company uses a Microsoft Windows server environment which requires complex passwords for authentication. The MS SQL Server based LIMS has another username/password requirement, which limits user access to modules necessary to perform tasks required. It is the responsibility of the Lab Director to indicate which security groups are appropriate for each employee's job function. A form is used to communicate and document which employees have read or read/write access to the data. The LIMS administrator uses this to assign proper security groups. The LIMS includes features for sample login, test scheduling, results entry and reporting, with audit trail functionality.

10.4.6. The Information Systems Manager is responsible for operation and maintenance of the LIMS. This includes implementation, upgrades, user training, customizing, data archiving and maintaining database backups.

10.4.7. Data are communicated to customers in many ways. It is important to ensure that results are only given to the customer of record.

10.4.7.1. Due to the risk of miscommunication, giving verbal results is discouraged.

10.4.7.2. Faxed reports are transmitted to either the number provided on the CoC or found in the customer's contact information in the LIMS.

10.4.7.3. Data are also available through secure connection to the company's website. Access is only provided to individuals who have been assigned a unique username and password. The site utilizes SSL to ensure authenticity and provide encryption to prevent unauthorized individuals from accessing data.

11. QUALITY CONTROL

11.1. Introduction

11.1.1. A quality control program is a systematic process that controls the validity of analytical results by measuring the accuracy and precision of each method and matrix, developing expected control limits, using these limits to detect errors or out-of-control events, and requiring corrective action to prevent or minimize the recurrence of these events. Generally, TNI Quality Systems standards or requirements are followed, unless a mandated test method or regulation is more stringent. Projects that require DoD certification must meet the standards outlined in the DoD Quality System Manual. If it is not clear which requirements are more stringent, the standard from the method or regulation is to be followed.

11.1.2. The Lab Director or QA Officer must approve any departures from documented policies, procedures or standard specifications. These departures must be documented.

11.1.3. In the event that results are impacted by failing quality control sample analysis or other data integrity issues, the customer is notified as soon as the information has been reviewed. The customer is informed of the impact to the data and is given the opportunity to decide whether the data are usable or not. If the data are not usable, the data will be recalled and not reported to the customer. If the data are deemed useable, the data are reported with appropriate qualifiers.

11.1.4. If the failing quality control is found to be the result of a systematic problem, analyses will be halted until the issue has been resolved. The analyst is responsible for documenting the investigation and determining that the problem has been corrected and quality control restored.

11.2. Positive and Negative Controls

11.2.1. The results of quality control samples help characterize accuracy and precision of the preparation and analysis process. This section describes the quality control information gathered by each of these analytical measurements. Instructions for preparation of the QC samples or spiking solutions is described in the respective SOP.

11.2.2. Method Blank (Negative Control)

11.2.2.1. Refer to SOPs, QAPP or other project needs for frequency requirements and for analytical run sequence. Generally, a Method Blank is prepared 1/20 samples or 24 hours, whichever is more frequent.

11.2.2.2. A method blank is a volume of laboratory water for water samples, or a clean solid matrix for soil/sediment samples, processed through the entire analytical procedure along with and under the same conditions as the associated field samples. The volume or weight of the blank must be approximately equal to the sample volume or weight processed. Analysis and evaluation of the blank verifies that method interferences caused by contaminants in solvents, reagents, glassware, and other sample processing equipment are known and minimized.

11.2.2.3. Unless otherwise stated in the SOP or project plan, the concentration of all analytes in a method blank must be below the reporting limit for the analyte or at or below 1/10 the concentration found in any of the samples

11.2.2.4. In the event that a customer requires adherence to the "Shell" document, the method blank limits are as follows. The concentration of all analytes in the method blanks shall be acceptable only if:

11.2.2.4.1. below one half of the reporting limit

11.2.2.4.2. less than 5% of the regulatory limit (if known)

11.2.2.4.3. less than 5% of the sample result for the same analyte

11.2.2.5. For applicable methods for projects requiring DoD certification, The blank results must meet the requirements of the method as well as project-specific objectives. The concentration of all analytes in the method blanks shall be acceptable only if:

11.2.2.5.1. below one half of the reporting limit

11.2.2.5.2. less than 10% of the regulatory limit (if known)

11.2.2.5.3. less than 10% of the amount measured in any sample

11.2.2.6. If the blank does not meet these criteria, corrective action is taken to eliminate the source of the contamination. If acceptable to the project, the samples affected will be flagged "B" indicating blank contamination.

11.2.2.7. If any analytes are found above one half of the reporting limit for the majority of analytes or above the reporting limit for analytes known to be common lab contaminants, assess the effect this may have had on samples in the batch.

11.2.2.8. If analyte is only found in the method blank, no further action is necessary. Steps should be taken to find and eliminate the source of the problem.

11.2.2.9. Reanalysis is required if the contaminant is found in the method blank and the samples.

11.2.2.10. Any evidence of continual daily method blank contamination must result in a corrective action to eliminate the source prior to further sample analysis.

11.2.3. <u>Accuracy Measurements (Method Positive Control)</u>

11.2.3.1. Laboratory Control Samples (LCS), consist of aliquots of ideal matrices (water, sand, etc.) spiked with analytes of interest. LCSs provide an estimate of bias based on recovery of the compounds from a clean matrix. They provide evidence that the laboratory is performing the procedure within accepted guidelines. LCS true values are chosen to be within the calibration range. For any methods which DoD certification is held, LCS concentrations must be at or below the midpoint of the calibration curve. They are processed in the same manner as field samples and are analyzed and reported (if required) with their associated samples.

11.2.3.1.1. LCSs for procedures with extensive lists of analytes that may interfere with one another may include a limited number of analytes, but the analytes included must be representative of as many analytes as practical. The minimum number of analytes included in the spike for methods with long analyte lists. Over the course of a 2-year period, all reported analytes must have been included in the LCS at one time.

11.2.3.1.1.1. 1-10 reported analytes, spike all components

11.2.3.1.1.2. 11-20 reported analytes, spike at least 10 or 80%, whichever is greater.

11.2.3.1.1.3. 20 or more reported analytes, spike at least 16 targets

11.2.3.2. In the case of metals analysis, all analytes of interest must be included, when this is practical.

11.2.3.3. Upon request of a project or customer, samples will be spiked with all analytes of interest, not a subset.

11.2.3.4. Laboratory pure water is used to prepare LCSs for me analysis of water. Where available, highly characterized solids, Certified Reference Material (CRM) are used for LCSs for methods for analysis of solids. Where no CRM is available, a clean soil matrix is spiked with analyte. The frequency is as stated in the SOP but are generally prepared one per batch of 20 samples or one per 24 hours, whichever is more frequent.

11.2.3.5. The recoveries of the LCS analytes are calculated as percent recovery and documented. The percent recovery is compared to the acceptance criteria as documented in the SOP. Acceptable recovery validates system and method performance. If an LCS is not acceptable, the entire batch of samples is considered suspect and need to be reanalyzed. If it is not possible to reprocess the associated samples due to volume or other limitations, the data will be flagged appropriately in the report.

11.2.3.6. For methods governed by NELAC, the LCS requirements and acceptance criteria are specified in each SOP. For methods governed by other programs, or where NELAC permits, the following rules may be applied. When several analytes (>10) are reported, a small percentage of sporadic marginal failures (SMF) may be tolerated (i.e. will not necessarily require rejecting the data). If contaminants of concern are identified though customer communications or project specific requirements, marginal exceedances will not be acceptable for those analytes. SMF exceedances must be random.

11.2.3.7. The number of reported analytes dictates the number of allowable SMF QC failures.

11.2.3.7.1. >90 analytes in LCS, 5 analytes allowed in ME of LCS control limit

11.2.3.7.2. 71-90 analytes in LCS, 4 analytes allowed in ME of LCS control limit

11.2.3.7.3. 51-70 analytes in LCS, 3 analytes allowed in ME of LCS control limit

11.2.3.7.4. 31-50 analytes in LCS, 2 analytes allowed in ME of LCS control limit

11.2.3.7.5. 11-30 analytes in LCS, 1 analytes allowed in ME of LCS control limit

11.2.3.7.6. <11 analytes in LCS, no analytes allowed in ME of LCS control limit

11.2.3.8. Acceptance limits for marginal exceedances are as follows:

11.2.3.8.1. ICP Metals: The adjusted control limit for the SMF is 60-140%.

11.2.3.8.2. Pesticides: The adjusted control limit is 30-150%.

11.2.3.8.3. VOC: The adjusted control limits are 60-140%.

11.2.3.8.4. SVOC: The adjusted control limit for water is 15-150%, solids 25-150%.

11.2.3.9. For applicable methods of projects requiring DoD certification refer to the DOD manual for marginal exceedence criteria. The same analyte may not exceed the LCS control limits more than two out of three consecutive LCSs. The last three LCS/D Excel summary sheets are cycled through a file. Each time a new LCS/D summary sheet is added the oldest one is removed and they are evaluated to ensure no compounds were outside the limits in all three LCS/Ds. This occurrence may be indicative of non-random behavior and the source of the problem must be identified and corrective action taken before samples are reanalyzed. The marginal exceedance limit is ± four standard deviations from the mean.

11.2.4. <u>Accuracy Measurements (Sample Specific Positive Control)</u>

11.2.4.1. Matrix Spikes/Matrix Spike Duplicates

11.2.4.1.1. Matrix spikes/Matrix spike duplicates (MS/MSD) are similar to the Laboratory Control Sample except the analytes used for spiking are added to separate aliquots of field samples to measure matrix interference.

11.2.4.1.2. Matrix specific QC samples are an indication of that sample's specific matrix. It is not used to disqualify the usability of the analytical QC batch. The concentration of a matrix spike is at or below the midpoint of the calibration, unless otherwise directed by project-specific requirements.

11.2.4.1.3. The frequency of the analysis of matrix spike QC samples is stated in individual method SOPs. Matrix spikes are always analyzed when requested by the customer or required by project protocol or certification. A matrix spike and matrix spike duplicate are analyzed in each batch containing DoD samples unless excluded by the project requirements.

11.2.4.1.4. If the native sample concentration exceeds the spike concentration by a factor of 4 times or more, the matrix spike recovery acceptance criteria do not apply. For DoD projects, if the native sample concentration of a spiked analyte is known to be greater than five times the LOQ, a sample duplicate may be analyzed in place of a matrix spike duplicate.

11.2.4.1.5. The percent recovery and percent relative difference are calculated and compared to the acceptance criteria specified in method SOPs unless other criteria are specified by a program. For applicable methods for projects requiring DoD certification, the MS/MSDs are evaluated using the LCS acceptance criteria. If the acceptance criteria are not met, effort is made to determine the cause of the failure and the impact of the failure on the sample results is noted in the report for the affected sample.

11.2.4.1.6. If the components to be spiked are not mandated by the test method or program, the following is applied:

11.2.4.1.6.1. The spike should be chosen to represent the chemistry of the components to be reported.

11.2.4.1.6.2. For methods that include 1-10 reported compounds, spike all components.

11.2.4.1.6.3. For methods that include 10-20, spike at least 10 or 80%, whichever is greater.

11.2.4.1.6.4. For methods with more than 20, spike at least 16 components.

11.2.4.2. Surrogates

11.2.4.2.1. Surrogates are compounds that behave similarly to the compounds of interest in a test method, but are not likely found in the environment. They provide data representing the effectiveness of a particular method on a sample specific basis.

11.2.4.2.2. The number of surrogates, limits and type of surrogate to use are normally specified in the test method and are referenced in the SOP. If surrogate limits are not provided in the test method, default limits are established using those from a similar method with published limits or are established statistically using historical data.

11.2.4.2.3. Prior to sample preparation, surrogates are added to samples, standards and other QC samples analyzed by most GC/MS and GC procedures.

11.2.4.2.4. Recoveries are compared to the acceptance criteria found in the SOP. For samples that do not meet the acceptance criteria, depending on the situation, the samples may be reanalyzed, processed through a clean up procedure to remove non-target interference or noted in the analytical report.

11.2.4.2.5. Surrogate failures in a method blank or LCS are indicative of a method performance failure and must be corrected prior to continued analysis or any affected sample reports must be flagged appropriately.

11.2.4.3. Internal Standards

11.2.4.3.1. An Internal standard is an analyte that has the same characteristics as the surrogate, but is added to each sample, just prior to analysis and is used for quantitation. It corrects for bias or change in instrument performance from sample to sample, incorporating variations such as injection volume as well as matrix interferences associated with the analysis step.

11.2.5. Precision Measurements (Sample Specific Control)

11.2.5.1. A Laboratory duplicate is a sample or laboratory control sample that has been homogenized and split into two equal portions before the sample preparation process. It measures sample precision associated with the preparation through analysis. A duplicate sample can be analyzed when the sample is historically known to have a native concentration that would exceed the spike concentration by a factor of 4 times or more.

11.2.5.2. The frequency is as stated in the SOP, or as requested by the customer or required by project protocol or certification.

11.2.5.3. Check the SOP for actual frequency and control limits.

11.2.5.4. The relative percent difference is calculated and compared to the limits stated in the

SOP. If the criteria are not met, the failure is to be investigated and any resulting impacts noted on the report for the sample affected.

11.2.5.5. If the sample result is less than 5 times the reporting limit for the method, the RPD limits are as follows:

11.2.5.5.1. Aqueous Samples: The difference between the two results should be less than or equal to the reporting limit value.

11.2.5.5.2. Solid Samples: The difference between the two results should be less than or equal to two times the reporting limit value.

11.3. Control Limits

11.3.1. For those methods that do not have control limits specified for quality control parameters, the acceptance limits will be statistically determined, control limits set at ±3 standard deviations from the mean recovery. The warning limits are ±2 standard deviations from the mean. The limits can be generated using the first 10-20 data points collected using the method, however the ideal number of points for control limit generation is at least 30. When 30 or more points are gathered the limits are recalculated. These limits are reevaluated annually.

11.4. In-house Control Limits

11.4.1. In house method control limits for LCSs, MSs and Surrogate Standards may be generated to evaluate method performance. These are updated annually or at a frequency prescribed by a specific program or QAPP. The limits are calculated for all analytes on a matrix specific basis. All recovery data are included in the calculations, except where exclusions are based on a scientifically valid, documented reason. A minimum of 30 points are used to generate the limits. Control charts are quality control tools which graphically display the QC data over time. The data required for generation of accuracy and precision control charts is maintained by the laboratory. These charts allow the detection of trends, when applicable. When requested or as needed to evaluate method performance, control charts can be generated using a spreadsheet application for review.

11.4.2. Warning limits express a narrower confidence interval and are used to warn the analyst or supervisor of possible system bias, before an out-of-control event occurs. Control limits express the outer limits of accepted method variability.

11.4.3. Warning Limits

11.4.3.1. The warning limits are set at ±2 standard deviations from the mean or a 95% confidence interval.

11.4.4. Control Limits

11.4.4.1. The control limits are set at ±3 standard deviations from the mean or a 99% confidence interval.

11.5. Measurement Uncertainty

11.5.1. When a project requires reporting of measurement uncertainty, in absence of a project specified procedure, the following approach is used. Uncertainty is expressed as a ± value, reported along with each analytical result. This uncertainty represents a 99% level of confidence that a value is within the range specified.

11.5.2. Methods used can include many analytical steps and procedures, including instrument calibration, sample amount determination, digestion/extraction and analytical measurement, which can be difficult to characterize. Given that Lab Control Samples experience the same sources of uncertainty as samples, a statistical approach, based on LCS performance data is used.

11.5.3. For each analyte/method, a data set of at least 20 prior LCS recovery data points (when available) are used in the following formula:

± value = Reported Value * [Average Recovery(%) ± 3 * σ / Average Recovery(%)]

where: σ = standard deviation of the data set.

11.6. Accuracy Calculations

11.6.1. Note all calculations are done using at least 3 significant figures. Dilution, sample volume and dry weights adjustments are all included in calculated results.

11.6.2. LCS

11.6.2.1. %R = (SR / SA) * 100

11.6.2.2. %R is the percent recovery

11.6.2.3. SR is the measured result for the LCS, in concentration units

11.6.2.4. SA is the concentration of the spike added, in concentration units.

11.6.3. Matrix Spike

11.6.3.1. % R=(SSR-SR)/SA * 100

11.6.3.2. %R is the percent recovery

11.6.3.3. SSR is the concentration of the spiked sample concentration

11.6.3.4. SR is the original measured result for the sample

11.6.3.5. SA is the concentration of the spike added.

11.7. Precision calculations

11.7.1. The comparison of the two values is expressed as relative percent difference (RPD), where relative percent difference is calculated to be an absolute value of three significant figures greater or equal to zero. Note all calculations use a minimum of 3 significant figures. Dilution, sample volume and dry weights adjustments are all included in calculated results.

11.7.2. <u>Sample Duplicates</u>

11.7.2.1. RPD= S-D/((S+D)/2)

11.7.2.2. RPD is the relative percent difference

11.7.2.3. S is the sample concentration

11.7.2.4. D is the duplicate sample concentration

11.7.3. Matrix Spike Duplicates

11.7.3.1. Follow the same calculation as that used for sample duplicates.

12. QUALITY SYSTEM DOCUMENTS

12.1. Document Control

12.1.1. Documents that form the company's quality system are controlled, reviewed and updated when necessary. Control of data are covered in QAM section 9 and control of records in section 10. Quality system documents include SOPs, policies, procedures as well as other hard copy or electronic documentation that impact the quality system. Documents are uniquely identified by the date issued/revised, have numbered pages, notification of total pages/last page and an issuing authority. Documents are assigned to appropriate personnel or made available at locations were applicable functions are performed. Periodic review and revision of quality system documents ensures compliance with procedures and requirements. When changes are made to quality system documents, affected personnel are notified of changes by being given a written copy of the revised document and/or by email or discussions outlining the changes. Whenever practicable, the changes are noted on the document. The current revision can always be identified by checking the "Current/Final" document folders for revision number/revision date of a document. Obsolete documents are removed from use.

12.2. Standard Operating Procedures

12.2.1. Refer to SOP QA-0000, which describes the standard format to be used for all SOPs. SOPs or Controlled Copies of the Method used with any modifications noted are maintained for all accredited analytes and/or test methods.

12.2.2. Standard Operating Procedures (SOPs) are formal, revision-controlled documents that:

12.2.2.1. Define, to our clients and to regulatory agencies, the methods used in the performance of tasks having an effect on the quality of data, findings or conclusions

12.2.2.2. Accurately reflect all phases of current laboratory activities

12.2.2.3. Establish the basis for similar training of personnel and set a standard for assessment

12.2.2.4. Provide standardized instructions for execution and documentation of work, to maximize consistency, uniformity and reliability of products

12.2.2.5. Facilitate coordination among individuals performing separate, but interdependent tasks

12.2.2.6. Are reviewed annually and updated if necessary. The review or revision is documented in individual SOP folders

12.2.3. Responsibilities

12.2.3.1. The Laboratory Director, or designee, is responsible for determining, through consultation with the Quality Assurance Officer, the activities that require SOPs, and for working with the appropriate technical personnel to develop the SOPs.

12.2.3.2. The Quality Assurance Officer is responsible for obtaining technical review and approval of SOPs, for maintaining control of new SOPs and revisions, and for maintaining an up-to-date distribution list for SOPs.

12.2.3.3. Employees are assigned copies of all SOPs that are relevant to their job responsibilities or company-wide procedures. Employees are responsible for performing tasks in accordance with applicable SOPs, except as explicitly directed by the relevant QAPP, contract, or Health and Safety policy. All personnel are also responsible for assisting in designing accurate and practical SOPs and keeping the SOPs up-to-date.

12.2.4. Required SOP Contents

12.2.4.1. Each Standard Operating Procedure shall contain at a minimum, the following information.

12.2.4.2. If a copy of the actual method is used at the SOP, the method is tracked as an SOP and any procedures performed that are different from the method, must be noted on the SOP.

12.2.4.3. The SOP must indicate if the procedure includes any significant modifications from the method. A significant modification would be using other than the prescribed solvents/reagents, detector or extraction/preparation method.

12.2.4.4. Title - The name of the SOP, typically the method name.

12.2.4.5. Page numbers- Pages must be numbered and include the total number of pages.

12.2.4.6. QA number- The internal document control number assigned and tracked by the QA Officer. SOPs are labeled as QA-xxxx.

12.2.4.7. Acceptance - The signature of the originator(s), Quality Assurance Officer, Laboratory Director, author and the analyst who acknowledges receipt of the SOP.

12.2.4.8. Date - date of issue of most recent revision

12.2.4.9. Revision Number and Changes (where practicable) – Identification of the current document in use and a summary of changes made since the previous revision.

12.2.4.10. In addition, in accordance with NELAC regulations, the following items are mandatory components in all SOPs.

12.2.4.10.1. Identification of the test method

12.2.4.10.2. Applicable matrix or matrices

12.2.4.10.3. Detection limit

12.2.4.10.4. Scope and application, including components to be analyzed

12.2.4.10.5. Summary of the test method

12.2.4.10.6. Definitions

12.2.4.10.7. Interferences

12.2.4.10.8. Safety

12.2.4.10.9. Equipment and Supplies

12.2.4.10.10. Reagents and Standards

12.2.4.10.11. Sample collection, preservation, shipment, and storage

12.2.4.10.12. Quality Control

12.2.4.10.13. Calibration and Standardization

12.2.4.10.14. Procedure

12.2.4.10.15. Calculations

12.2.4.10.16. Method Performance

12.2.4.10.17. Pollution Prevention

12.2.4.10.18. Data assessment and acceptance criteria for quality control

12.2.4.10.19. Corrective actions for out-of-control data

12.2.4.10.20. Waste management

12.2.4.10.21. References

12.2.4.10.22. Any tables, diagrams, flowcharts, and validation data

12.2.5. SOP Tracking and Numbering

12.2.5.1. Each SOP is assigned a unique number from the Inventory of SOPs, maintained by the QA Department. The Following is a list of the SOPs currently in use:

Laboratory Quality Assurance Plan	SOP 003	Soxhlet Extraction by EPA3540C	SOP 5305
Sample Receiving and Identification	SOP 400	Dimethylformamide by GC/MS by EPA8270mod	SOP 5310
Bottle Order Preparation	SOP 402	EPH by GC/MS by MADEP 2004-1.1	SOP 5313
Reporting	SOP 500	DRO in Soil and Water by ME 4.1.25	SOP 5314
Administrative Tasks: AP/AR	SOP 501	1,2-Dibromoethane (EDB) by EPA504.1Mod	SOP 5315
Credit and Collections Policy	SOP 502	TPH in Soil & Water by EPA8015Mod	SOP 5501
Hazardous Communication	SOP 600	Total Phenols by Spectrophotometry for liquids	SOP 5508
Chemical Hygiene Plan	SOP 604	PAHs, Base/Neutrals and Acids by EPA8270C	SOP 5515
Contingency Plan	SOP 605	Ultrasonic extraction	SOP 5520
Calibration, Cleaning & Maintenance of Lab Equipment and Glassware	SOP 800	Microwave extraction	SOP 5522
Sample Readiness	SOP 801	Liquid-Liquid extraction	SOP 5524
WetLab Glass Cleaning	SOP 802	Mercury by Cold Vapor Methods EPA245.1 &EPA7470A	SOP 5600
Total Coliform and E. coli in Water	SOP 1001	Metals & Trace Elements in Water, Solids & Waste by ICP by EPA200.7 & EPA6010	SOP 5603
Manual Integration	SOP 5000	Toxicity Characteristic Leaching Procedure (TCLP) by EPA 1311	SOP 5604
Lab & Sample Waste Characterization & Disposal	SOP 5001	Alkalinity by EPA 310.1 or SM2320B	SOP 5801
Hazardous Waste Management	SOP 5002	Anions by Ion Chromatography by EPA300	SOP 5802
Data Integrity	SOP 5003	Organic Acids by IC by QuickChem 21-550-0-1-A	SOP 5803
Field Sampling	SOP 5004	Chemical Oxygen Demand (COD) by EPA410.4	SOP 5811
VOCs in Wastewater by EPA 624	SOP 5101	Hexavalent Chromium	SOP 5813
VOCs in Drinking Water by EPA 524.2	SOP 5109	Cyanide in water & soil by SM4500CN-E	SOP 5814
Gases- Methane, Ethane and Ethylene by GC	SOP 5110	Cyanide by ISE by SM4500CN-F	SOP 5815
GRO in Soil & Water by ME4.2.17	SOP 5115	Ignitability/ Flashpoint by EPA1010	SOP 5821
VOCs in Water and Solid samples by EPA8260B	SOP 5120	Ammonia by SM4500-NH3-D	SOP 5822
Preparation of Solid Samples for VOC analyses	SOP 5125	Total Kjeldahl Nitrogen(TKN) by ASTM D3590-02	SOP 5825
VPH in Solid and Water samples-VPH-04-1.1	SOP 5130	Total Phosphorus by EPA365.3	SOP 5827

TCLP extraction for VOCs	SOP 5140	TS, TSS & TDS by SM2540D, SM2540B,G & SM2540C	SOP 5834
Propylene & Ethylene Glycols	SOP 5150	Specific Conductance by SM2510B & EPA120.1	SOP 5836
VFA 8015	SOP 5155	Sulfide by Spectrophotometry by SM4500-S	SOP 5838
Base/Neutrals and Acids by EPA625	SOP 5200	Surfactant	SOP 5841
Pesticides and PCBs in Wastewater by EPA608	SOP 5302	Biological Oxygen Demand(BOD) by SM5210B	SOP 5843
Polychlorinated Biphenyls in Soil & Water EPA8082	SOP 5303	pH by SM4500 H+B & EPA150.1	SOP 5851
Organo-Chlorine Pesticides in Soil & Water EPA8081B	SOP 5304	Oil and Grease by EPA1664A	SOP 5860
		Turbidity by SM2130B & EPA180.1	SOP 5862

12.2.6. SOP Revisions

12.2.6.1. SOP revisions may be necessitated by regulatory requirement changes, technological advancements or other reasons, but not by the requirements of a single project alone. Contradictions between standard procedures and the requirements of a specific project are resolved in the quality assurance planning for that project and/or are noted in the report for that project.

12.2.6.2. Revisions may be proposed by the Quality Assurance Officer, other management or users. Recommendations for revisions must be sent to the Quality Assurance Officer.

12.2.6.3. An individual must not make revisions only to a personal copy. Written changes may be made, initialed and dated by the QAO. The change must be made to all controlled copies, master copy and the electronic copy, which is saved in the SOP WIP folder as the next SOP revision number. Recommendations for minor revisions will be accumulated by QA and documented in the electronic WIP version of the SOP, until sufficient to warrant a document revision.

12.2.6.4. Revisions are initiated by the preparation of a new electronic draft with the changes incorporated and listed on the cover page.

12.2.6.5. QA Manual revision changes are recorded as notes in a hard copy and/or listed and save electronically. Dated acceptance signatures on the cover page signify approval of the revisions. The QA Officer is authorized to approve minor revisions. Revisions, which effect the technical approach or content, will also require review and approval by the Technical Director. Management and archiving of past revisions is the responsibility of the QAO. Once formally accepted, the new revision replaces the old in the electronic CURRENT FINAL SOP folder. The old revision is marked “OBSOLETE” and moved to the electronic ARCHIVE.

12.2.6.6. The signed hard copy “Master” is kept in the SOP file folder. Old hard copies of signed Masters are noted as being “replaced by the next revision” on the cover page and moved to the back of the folder. Hard copies of the new revision are made, numbered and distributed to controlled copyholders with instructions as to what document(s) it replaces. The old hard copy revision is returned to QA where it is recorded and disposed. Significant content changes to the QA Manual are reviewed with personnel at staff meetings.

12.2.6.7. Employees may request to use the electronic copy in lieu of a paper SOP. A final PDF copy of the SOP is emailed to these individuals and this is noted on the distribution sheet in the SOP file folder.

12.2.6.8. Occasionally, revisions are significant enough to warrant a complete rewrite. In such cases, the changes are not listed on the cover page. Instead "complete rewrite" is entered and the new document must undergo review and approval as for a new SOP. The Quality Assurance Officer shall make the judgment as to whether a complete rewrite is required.

12.2.6.9. Technical revisions and complete rewrites will necessitate training recertification for all personnel involved. The QA Department will distribute required training documentation and instructions with the SOPs.

12.2.7. Distribution

12.2.7.1. The QA Officer distributes SOPs to technical staff and all responsible individuals and maintains a copy of the SOP cover page with the recipient's signature. The signed cover page is required whether the individual has a paper or electronic copy of the SOP. This is filed in the individual SOP folder and signifies that the user has read and understands the new revision. Obsolete copies are returned to the QA Officer, documented as returned and then discarded. The QA Officer maintains a complete set of up-to-date controlled SOPs and distributes them as necessary. Access to originals is obtained through QA personnel.

12.2.8. SOP Archive

12.2.8.1. Management and archiving of past revisions is the responsibility of the QAO. An archive of obsolete hard-copy master versions of SOPs, are maintained by the Quality Assurance Department and are filed in the individual SOP folders. The date the SOP was replaced is noted and initialed on the front cover. Electronic copies of obsolete revisions are maintained in the SOP ARCHIVE folder. The effective dates are clearly indicated on obsolete SOPs.

12.3. Quality System Documents (QSD)

12.3.1. In addition to SOPs, many documents used throughout the business contribute to the overall quality of the system. These charts, tables, policies and other forms facilitate consistency and coordination in activities and provide a standard that is known by all personnel. Quality System Documents also include any test method that is used as written along with notes clarifying any changes or modifications. The system to create and change documents mirrors that of SOPs. The Lab director or QA Officer have the authority to approve changes. The QAO maintains the Quality System Document files.

12.3.2. QSD Contents

12.3.2.1. Each document must include a title, page number (with total number of pages), QA number, issuing authority, date created or revised, and a revision number.

12.3.3. QSD Tracking and Numbering

12.3.3.1. Each QSD is assigned a unique number from the electronic QSD Inventory. Copies of the document are distributed to appropriate personnel and made available at locations were applicable functions are performed. Documents that are not required for daily activities are available electronically. The most current copy of the document is known by checking the revision number/ date and ensuring that this is the revision in the electronic "CURRENT FINAL QSD" folder. Any time a new or revised document is introduced, all affected personnel are notified. Information is outlined by email or though discussions to ensure that changes, content and procedures are understood.

12.3.4. QSD Revisions

12.3.4.1. Revisions may be proposed by the Quality Assurance Officer, Management or users. Recommendations for revisions are reviewed by the Quality Assurance Officer. Since copies of the current revision may be printed as needed, changes to Quality System Documents must be made electronically and finalized as a new revision.

12.3.4.2. Revisions are initiated by the preparation of a new electronic draft with changes incorporated. Management and archiving of past revisions is the responsibility of the QAO. Obsolete versions are moved to the "QSD Archive" folder and the revised document named with the next revision number, is moved to the "Current FINAL QSD" folder.

12.3.5. QSD Distribution

12.3.5.1. Quality System documents that are typically used in hard copy form, are printed and distributed to appropriate personnel and posted at locations. When new updated revisions are distributed, obsolete versions of the document are removed.

13. PERFORMANCE AND INTERNAL AUDITS

13.1. The company's laboratory participates in a variety of inter-laboratory, intra-laboratory and performance checks to provide periodic assessment of the effectiveness of the overall quality control program. This quality control monitoring is ongoing and may include the following procedures and activities to ensure compliance with quality systems:

13.1.1. Each procedure performed includes regular use of reference materials or second source standards to check the performance of the procedure.

13.1.2. Regular participation in proficiency testing studies.

13.1.3. When needed, analytes will be tested by different procedures to assist in troubleshooting a procedure, matrix or instrument problem. For example, ortho-phosphate may be tested by both ion chromatography and colorimetric methods.

13.1.4. Samples that remain after analysis may be used to confirm results, used for comparison in new method development, or used in training.

13.1.5. Routinely, results are reviewed for sensibility. For example, verification that a sample's Total Nitrogen result is greater than its Ammonia result.

13.2. Inter-laboratory Performance Surveys

13.2.1. Performance studies conducted by TNI/DoD approved Proficiency Test Providers constitute the majority of inter-laboratory comparisons.

13.2.2. The company follows the TNI/DoD guidelines for the proficiency testing noted by the laboratory's primary accrediting authority, New Hampshire Department of Environmental Services. Generally, for initial accreditation, the laboratory successfully completes two single blind, single concentration proficiency test samples for each parameter for which certification is being sought.

13.2.3. Generally, for ongoing certification, the laboratory participates in two single blind, single concentration studies for each requested field of proficiency testing. The laboratory must successfully complete the study two out of the three most recent rounds of testing for each field of testing.

13.2.4. In the event of a failure in the proficiency testing studies, the laboratory may participate in a supplemental study in order to maintain the successful participation in two of the most recent three studies. The TNI and/or DoD guidelines regarding the timing of the studies and other requirements are followed.

13.3. Proficiency Testing Studies

13.3.1. The laboratory participates in Water Supply, Water Pollution Study, Solid Matrix and UST studies two times per year, approximately 6 months apart. The laboratory also participates in programs specific to state approved methods.

13.3.2. The fields of testing for which the laboratory generally maintains certification are as follows. The laboratory may choose to request certification for additional parameters throughout the year. Accreditation rules set forth by the TNI and/or DoD accreditation bodies are followed to gain and maintain certification for parameters and groups.

13.3.3. TNI accredited parameters are as follows:

13.3.3.1. Water Supply (Drinking Water)

13.3.3.1.1. Trace Metals

13.3.3.1.2. Inorganics

13.3.3.1.3. Volatile Organic Compounds

13.3.3.1.4. Microbiology

13.3.3.2. Water Pollution (Wastewater)

13.3.3.2.1. Trace Metals

13.3.3.2.2. Inorganics

13.3.3.2.3. Pesticides/ PCBs

13.3.3.2.4. Volatile Organic Compounds

13.3.3.2.5. Semi-volatile Organic Compounds

13.3.3.3. SW-846 Aqueous Matrix-

13.3.3.3.1. Metals

13.3.3.3.2. Cyanide

13.3.3.3.3. Pesticides/ PCBs

13.3.3.3.4. Volatile Organic Compounds

13.3.3.3.5. Semi-volatile Organic Compounds

13.3.3.4. SW-846 Solid Matrix

13.3.3.4.1. Metals

13.3.3.4.2. Cyanide

13.3.3.4.3. Pesticides/ PCBs

13.3.3.4.4. Volatile Organic Compounds

13.3.3.4.5. Semi-volatile Organic Compounds

13.3.3.5. UST

13.3.3.5.1. EPH

13.3.3.5.2. VPH

13.3.3.5.3. GRO

13.3.3.5.4. DRO

13.3.4. DoD accredited parameters are as follows:

13.3.4.1. SW-846 Aqueous Matrix

13.3.4.1.1. Metals

13.3.4.1.2. Pesticides/ PCBs

13.3.4.1.3. Volatile Organic Compounds

13.3.4.1.4. Semi-volatile Organic Compounds

13.3.4.2. SW-846 Solid Matrix

13.3.4.2.1. Metals

13.3.4.2.2. Pesticides/ PCBs

13.3.4.2.3. Volatile Organic Compounds

13.3.4.2.4. Semi-volatile Organic Compounds

13.3.4.3. UST

13.3.4.3.1. EPH

13.3.4.3.2. VPH

13.3.4.3.3. GRO

13.3.4.3.4. DRO

13.3.5. Analysis and Reporting

13.3.5.1. The proficiency samples are logged into the LIMS, handled, prepared and analyzed in the lab in the same manner as routine environmental samples. The PT sample provider's directions for dilution of any concentrated PT samples are followed. These dilutions are witnessed by another analyst. The results are entered into the data base of the test provider and are reviewed for transcription errors. A print out of the entries are kept in the project folder and filed in a drawer designated for PT data.

13.3.5.2. Proficiency test samples are not subcontracted to or knowingly accepted from another laboratory. Results are never compared with other laboratories or discussed with the PT provider before the close of the study.

13.3.6. Evaluation of Performance

13.3.6.1. PT study results are sent to the laboratory and the Primary Accrediting Authority directly from the study provider.

13.3.6.2. The laboratory reviews the results and immediately initiates investigations in the event of any failures. The Lab Director is responsible for overseeing the investigation. Investigations and corrective actions for any failed analytes or analyte groups, are documented using the Corrective Action procedure and completed within two weeks of receipt of results. The QAO is responsible for insuring that the investigation is completed in a timely manner. A copy of the completed corrective action document is submitted to the accrediting authority as soon as practicable.

13.3.6.3. The Primary Accrediting authority also evaluates the laboratory performance after each round of testing. The Authority may grant accreditation after the successful completion of two PT studies for the requested field of proficiency within the most recent three rounds. The analysis dates of successive PT samples must be at least 15 calendar days apart. The Primary Accrediting Authority communicates any changes to certification status to the QAO.

13.3.6.4. An analyte is scored as passing if the result is within the acceptance criteria set forth by the PT provider. The PT is scored as acceptable if the true value falls below the reported quantitation limit and the reported PT result is entered as less than the QL. Some PT samples are scored as "analyte groups". Eighty percent of the analytes must have acceptable results for the group to be scored as passing. A not acceptable result for the same analyte in a group in two out of three consecutive PT studies, will result in a failure for that analyte.

13.3.6.5. If the results for two out of three proficiency tests for the same parameter or group are not acceptable, the requirements for initial acceptance must be met before any samples are reported by the method.

13.3.6.6. In addition to the NELAC required proficiency testing studies, the company also participates in the annual NPDES DMR-QA study. The study is specific to those customers requiring NPDES monitoring. The NPDES permit holder receives results of the study to forward to the DMR-QA coordinator. Corrective actions, where applicable, are communicated with the NPDES permit holder.

13.4. Internal Audits

13.4.1. The Quality Assurance Officer (QAO) plans, organizes and schedules internal audits The audit structure assures that all areas of the lab are included over the course of the year. The person performing the audit shall be approved by the QAO, and be independent of the activity that they are auditing. The purpose of internal audits is to annually review the overall quality assurance system and review the technical performance of all analysts. Internal audits are also conducted to ensure that any corrective actions investigations are being performed. These investigations may be a result of an audit, failed proficiency test sample, or other occurrence described in Section 15 of this manual Documentation of investigations includes any disciplinary action involved, corrective actions taken, all appropriate notifications of clients and a prevention of recurrence. Audits are saved electronically and/or a hard copy filed.

13.4.2. The QAO is responsible for generating a written report, to be shared with all analysts and the Laboratory Director within one week of the audit's completion. The Lab Director is responsible for response to deficiencies or initiation of corrective actions within one week of receiving the report. Customers are notified immediately (within 1 business day) if an internal audit reveals that data have been significantly affected by the deficiency. Communications documenting on-going investigation, resolution and corrective actions taken with the customer are documented in the Job number folder.

13.4.3. The following is an example of the items that may be covered in an internal audit.

13.4.3.1. Temperature Logs of Ovens and Refrigerators (verifying temperatures are being checked and recorded.)

13.4.3.2. Pipettes are calibrated with documentation each quarter

13.4.3.3. Spot check balance calibration to ensure it is done daily

13.4.3.4. Standards: Expired standards are not in use or being maintained for use

13.4.3.5. Laboratory Notebook reviews. Verifying all entries are clear, no evidence of falsification exists, corrections are noted properly and that required elements in the notebook are present.

13.4.3.6. Method Detection Limit (MDL) studies are current: This is a verification there was no change in analysts and current MDL is valid.

13.4.3.7. Spot-check any manual calculations that are performed.

13.4.3.8. Certification Status of all applicable parameters, making sure lists are up-to-date

13.4.3.9. Proficiency testing schedule is being met

13.4.3.10. Maintenance checks on all instruments. To ensure that vendor recommended maintenance procedures are being performed.

13.4.3.11. Deficiencies of most recent audit. To ensure corrective action remedies continue to be followed. This is also a tool to verify new analyst's training.

13.4.3.12. Report review to verify standards traceability from final report to NIST traceable materials.

13.4.3.13. Review of all SOPs to ensure they are up-to-date with current practice.

13.4.3.14. Auditing employee-training files to ensure that all components of the NELAC requirements are included and up-to-date.

13.4.3.15. QA Manual updates completed, if necessary

13.4.3.16. In addition to the above, the QAO may use the NELAC method checklists or other materials to audit each method.

13.5. Management Review

13.5.1. The annual review is completed by April 30 each year. Following the internal audit, the Lab Director and QA Officer, at a minimum, review the following key elements of our overall Quality Program and environmental testing activities to ensure their continued suitability and effectiveness and to introduce necessary changes and improvements. Findings from the management review and resulting actions are recorded and kept on file. The findings and actions must be addressed in an appropriate and agreed upon timeframe and are reviewed to ensure completion.

13.5.2. One critical piece of the management review focuses on data integrity. The investigation looks for any evidence of inappropriate actions or vulnerabilities related to data integrity. Any findings are handled in a confidential manner until a full evaluation has been conducted and all issues clarified. Findings are documented in the same manner as corrective actions.

13.5.3. The following checklist is an example of the items that may be included in the Management Review.

13.5.3.1. Suitability of Policies and Procedures

13.5.3.2. Reports from Managerial and Supervisory Personnel

13.5.3.3. Proficiency Testing Performance

13.5.3.4. Internal and External Audit Findings and Trends

13.5.3.5. Customer Feedback and Trends

13.5.3.6. Complaints

13.5.3.7. QA Manual Updates

13.5.3.8. Effectiveness of Corrective Actions

13.5.3.9. Changes in Work Volume or Mix

13.5.3.10. Training

13.5.3.11. Data Integrity Investigations

14. PREVENTIVE MAINTENANCE

14.1. To minimize downtime and interruption of work, preventive maintenance is routinely performed on analytical equipment. Designated laboratory personnel are trained in routine maintenance procedures for all major instrumentation. When repairs are necessary, trained staff, the instrument manufacturer or other qualified service personnel perform repairs.

14.2. Detailed logbooks documenting preventive maintenance, non-routine maintenance and repairs are maintained for each instrument. The log book contains the following information.

14.2.1. The name of the equipment and instrument ID number.

14.2.2. The manufacturer's name, model and serial number

14.2.3. Date received and place in service

14.2.4. Current location, if appropriate

14.2.5. Condition when received (new, used)

14.2.6. Copy of the manufacturer's instructions or a reference thereto

14.2.7. Details of maintenance performed and planned

14.2.8. History of damage, malfunction, modification or repair.

14.3. The following are brief summaries of maintenance for each major instrument. Refer to SOPs, manufacturers instructions and application notes for detailed information.

14.4. Preventive Maintenance – GC/MS. Regularly performed maintenance may include, but is not limited to the following for GC/MS instrumentation:

14.4.1.1. Removal of 2-3 inches from the injection end of capillary column

14.4.1.2. Injection port liner replacement

14.4.1.3. Replace injection port septum

14.4.1.4. Clean ion source as needed

14.4.1.5. Check vacuum pump oil level

14.4.1.6. Check carrier gas tanks

14.4.1.7. Replace or recondition vent traps

14.4.2. Preventive Maintenance – GC Regularly performed maintenance may include, but is not limited to the following for GC instrumentation:

14.4.2.1. Removal of 2-3 inches from the injection end of capillary column

14.4.2.2. Injection port liner replacement

14.4.2.3. Replace septum

14.4.2.4. Check carrier and support gases

14.4.2.5. Wipe test ECD

14.4.3. Preventive Maintenance – ICP

14.4.3.1. Check liquid argon tank level

14.4.3.2. Change pump tubing

14.4.3.3. Clean nebulizer and spray chamber as needed

14.4.3.4. Replace and realign plasma torch as needed

14.4.3.5. Check cooling system water level

14.4.3.6. Empty waste reservoir when full

14.4.4. Preventive Maintenance - Mercury Analyzer

14.4.4.1. Remove and clean sample cell and connecting tubes

14.4.4.2. Clean sample compartment windows

14.4.4.3. Empty waste reservoir when full

14.4.5. Preventive Maintenance - General Laboratory Areas

14.4.5.1. Clean and calibrate balances annually by service provider

14.4.5.2. Check balance calibration each day of use

14.4.5.3. Calibrate class "S" weights annually

14.4.5.4. Calibrate automatic pipettes quarterly

14.4.5.5. Check for certificate of accuracy for glass micro-liter syringes and lab verification

14.4.5.6. Calibrate thermometers annually

14.4.5.7. Record refrigerator, freezer, and oven temperatures each day in use

14.4.5.8. Clean, check, calibrate to manufacturers specifications all pH, DO, and conductivity meters, and spectrophotometers

14.4.5.9. General housekeeping: keep counter tops, hoods, and floors clean

14.4.6. Preventive Maintenance: Ion Chromatograph

14.4.6.1. inspect and change tubing

14.4.6.2. monitor baseline drift

14.4.6.3. clean column with EDTA solution as needed

14.4.6.4. replace column when baseline drift reappears after column cleaning

14.4.6.5. guard column inversion and cartridge replacement monthly

14.4.6.6. methanol/water changed monthly to lubricate pumps

15. CORRECTIVE ACTION

15.1. Introduction

15.1.1. When errors, deficiencies, unusual occurrences, or out-of control situations exist, the QA program provides systematic procedures, called "Corrective Actions" (CA), to resolve problems, restore proper function and prevent recurrence. Corrective Actions are often shared at staff meetings, in effort to educate and prevent similar situations from occurring.

15.1.2. When the situations impact customers samples, affect the quality of work, or identify systematic problems the actions taken to correct the situation are recorded. Procedures to record corrective actions for common issues, such as QC failures, are outlined in SOPs. Any failure that does not have a documented procedure in our quality control system, requires a written corrective action report (Figure 15-1).

15.1.2.1. When events occur during the course of laboratory analysis, the procedure to respond may be found listed in the method SOP or specified in section 15.4 of this manual. An example of this is an event where QC or sample results are beyond established acceptance limits. This can be due to data that are outside of the accepted bounds for accuracy and/or precision, method blank contamination, or other sample specific criteria. Typically, these events are isolated to a particular sample or project and are not indicative of a systematic error. Following written procedures, these types of events are noted in the laboratory notebooks and/or project record, including a record of actions taken to correct or address the situation. Any time an event may be indicative of a system failure, or a non-isolated problem, a formal write up of the corrective action process is required.

15.1.2.2. Anytime a written procedure does not exist to direct how to correct and document a deficiency, a corrective action report must be written. Employees should report these out-of-control events and participate in the corrective action process with the Technical Director, QA Officer or Laboratory Director. The following provide a few examples of the various situations that require Corrective Action reports:

15.1.2.2.1. Usual occurrences, that may be indicative of a problem with a system

15.1.2.2.2. A Non-isolated error or problem that may also be occurring in other areas of the lab/company or affect other data, computers, etc.

15.1.2.2.3. Deficiencies that could affect data such as: Samples stored at an incorrect temperature or held beyond prescribed holding times, or improper maintenance of records. Events, such as these, which do not readily cause an immediate, obvious effect on data quality, can be more difficult to identify.

15.1.2.2.4. Departures from procedures or documented policies.

15.1.2.2.5. Investigations into an inquiry or questioning of data received from a client or from the results of performance evaluation samples. All data changes are reported on a corrective action report form.

15.1.2.2.6. Complaints that are received from customers- corrective actions must begin immediately (for specific guidance see section 15.3).

15.2. Corrective Action Documentation

15.2.1. It is the responsibility of every employee to report occurrences or events requiring corrective actions when identified. These are recorded on a “Corrective Action Form”. The person reporting the issue records their name and date and a brief description of the event, notifies the QAO and gives the CA report the individual(s) responsible for the CA resolution. The form is saved (using a name containing the date and a brief description of the occurrence) to the “CAs in progress folder” where it remains while the investigation is conducted, corrective actions initiated, preventions identified and signatures obtained. Upon initiation of the corrective action process, the QAO works with the parties involved to assign a reasonable due date. The timeframe for completing the CA process varies depending on the sensitivity of the issue and complexity of the problem. The QA Officer and Lab director ensure that the process is completed, actions taken and preventative measures in place within a reasonable and agreed upon period of time.

15.2.2. During the investigation, it is determined whether there has been any impact to data and define if or how the data can be reported (i.e. with qualifiers). Any time a corrective action results in the quality of data that has been released to a customer being impacted or data significantly changed, the customer is notified and work is recalled or revised. Boxes are checked on the CA form to identify specific types of issues. This helps ensure that appropriate personnel are informed of the problem and/or involved in the corrective action. This system is also used to evaluate corrective action data and identify trends related to:

15.2.2.1. Proficiency Tests (unacceptable results)

15.2.2.2. Customer complaints

15.2.2.3. Recurring problems (previous CAs have been reported on the same issue)

15.2.2.4. Non-isolated issues (could affect other data, people, areas of the lab, computer systems)

15.2.3. Once the investigation is complete, the most effective and appropriate corrective actions are identified and applied to correct the situation. Then actions are determined to prevent the problem from recurring. This pro-active process identifies opportunities for improvement within the quality system. These preventative actions must be developed and implemented to complete the CA process. Preventative actions are monitored by supervisors and audited by QA to ensure their effectiveness.

15.2.4. Both the QA officer and Lab Director must approve the corrective actions and prevention. The QAO is responsible for the maintenance of corrective action records. When the corrective action documentation is complete, the electronic copy is moved to the “completed and filed” folder under the appropriate year. The hard copy is signed by the responsible party as defined on the form, QA officer and Lab Director and initialed by any other personnel who were not directly involved, but need to know about the corrective actions and preventions. It is filed in a folder with the corrective actions from that year and an unsigned copy is kept electronically.

15.2.5. The QA officer tracks CAs in progress, reviews completed corrective actions and determines if a follow-up audit is needed. Audits are typically done to ensure that preventions specified in the

CA are being followed. A copy of the CA form is kept by the QA Officer in an "audit follow up" folder to be scheduled for a future date. The results of the audit are recorded on the copy and attached to the original signed CA.

15.2.6. It is the QA Officer's and Lab Director's responsibilities to notify company management of any issues which they consider exceptional, which often include non-isolated, systematic issues. The QAO must provide an annual summary to the management team.

15.3. Complaints

15.3.1. A customer complaint is any communication from a customer, or other party, internal or external, which expresses dissatisfaction with services provided.

15.3.2. All personnel are responsible and accountable for the communication of and then the resolution of each and any complaint, particularly with respect to laboratory compliance and/or data integrity.

15.3.3. Complaints shall be communicated and documented on a Corrective Action Report form. Internal communication through e-mail may also be used to insure quick communication of the issues to all personnel. A complete and thorough audit shall be conducted to evaluate the validity of the complaint and insure corrective action is in place to prevent a re-occurrence of the situation.

15.3.4. All customer complaints are reviewed in staff meetings and documented in the staff meeting minutes. Any additional follow up notes or necessary corrective actions shall be documented in the corrective action folder.

15.4. General guidance for failures during sample analysis

15.4.1. The analyst generating the data are responsible for checking the results against the established limits. Any deviations are immediately addressed. If data are outside accepted limits, the analyst immediately begins investigation and corrective action. If the situation is not corrected so that an out-of-control condition recurs, or is expected to, the analyst shall notify the appropriate supervisor. Together they are responsible for identifying the source of the problem and initiating corrective action documentation if deemed necessary. Completion of corrective action should be evidenced by the return of data to prescribed acceptable limits.

15.4.2. If an out-of-control event does occur during analysis, for instance a surrogate recovery falls outside the expected range, the analyst must describe in the logbook or raw data, the investigative and corrective actions taken, and the cause of the event. In the event that the investigation reveals the possibility of a systematic error, a corrective action report must be initiated.

15.4.3. The investigative action taken is somewhat dependent on the analysis and the event. However, listed below is a progression of steps which may be taken to find the cause of an out-of-control event:

15.4.3.1. Check calculations to ensure there are no errors

15.4.3.2. Check standard and spiking solutions for degradation or contamination

15.4.3.3. Check instrument performance

15.4.3.4. Make sure all dilutions are accounted for in the calculations

15.4.3.5. Check sample labeling and matrix appearance

15.4.4. If the problem is with the standards or instrument performance, the analyst must recalibrate or retune the instrument before reanalyzing the sample extracts affected. If the out-of-control condition is still not remedied, the samples may require re-extraction and reanalysis or data qualification.

15.4.5. If the failures noted are suspected to or do affect the quality of the data being reported, the deviation is noted on the analytical result page for the affected samples. The qualifying of data are to alert the data end user to the fact that the analysis may not fulfill the data quality objectives (DQOs) for that particular project.

15.5. Specific Corrective Action Guidance

15.5.1. Method Blanks

15.5.1.1. If the method blank is not within the criteria established in the SOP, investigate the source of the contamination.

15.5.1.2. Generally, if target compounds are detected in the method blank above the detection limit the corrective action consists of checking the calculations, reanalyzing the blank, qualifying the associated sample data, and investigating the source of the problem to implement corrective action for the future.

15.5.1.3. When any target compound is detected in a method blank above the action levels in the SOP, but not in associated samples, then no qualifier is applied. Investigate the source of the problem and correct.

15.5.1.4. If the concentration of the analyte in the blank is at or above the reporting limit and is greater than 1/10 of the amount measured in any sample the samples affected must be reprocessed or the analytical data must be qualified.

15.5.1.5. In certain isolated circumstances, depending on the project needs, the reporting limit of the method may be adjusted due to blank contamination. This is described in the report.

15.5.1.6. In the event of a customer or project specific plan regarding blank contamination, the criteria noted in that project specific quality assurance project plan would be followed.

15.5.2. Surrogates

15.5.2.1. The percent recovery of the surrogates is calculated for each sample, blank, and LCS. Corrective action is taken whenever one (or more) surrogate recovery is outside the acceptance criteria. The following corrective actions are taken when required.

15.5.2.1.1. Check calculations to assure there are no errors.

15.5.2.1.2. Check internal standard and surrogate solutions for degradation, contamination, etc., and check instrument performance;

15.5.2.1.3. Reanalyze the sample or extract. If reanalysis of an extract shows similar results, re-extract the sample if sample is available;

15.5.2.1.4. If a method blank surrogate is outside of acceptance criteria, the corrective action procedure must be initiated. Associated results may not be reported without comments discussing the QC failure. Corrective action may include reanalysis, re-extraction or recalibration.

15.5.2.1.5. If the surrogate could not be measured because the sample required a dilution, no corrective action is required. The recovery of the surrogate is recorded with a note indicating surrogate diluted out of range.

15.5.2.1.6. If the surrogate recovery is high, but no analytes are detected in the sample, no corrective action is required.

15.5.2.2. If the LCS is acceptable, the problem may be attributed to a matrix effect. Samples exhibiting a matrix effect will be qualified and discussed in the report narrative.

15.5.2.3. Reanalyze the sample or extract if the steps above fail to reveal a problem. If the reanalysis of the extracts yields surrogate spike recoveries within the stated limits, then the reanalysis data are reported.

15.5.2.4. If reanalysis does not correct the problem, then re-extraction of the sample is performed if additional sample is available. If no additional sample is available, the original analysis data are reported and a qualifying statement written in the report narrative.

15.5.3. Laboratory Control Sample

15.5.3.1. The percent recovery of the Laboratory Control Samples (LCS) is calculated. Corrective action is taken whenever the outside the acceptance criteria. All samples analyzed with an "out of control" LCS are considered suspect.

15.5.3.1.1. Check calculations to assure there are no errors;

15.5.3.1.2. Check internal standard and spiking standard solutions for degradation, contamination, etc., and check instrument performance;

15.5.3.1.3. If no assignable cause can be found to explain the reason for the failure (wrong standard used, dilution incorrect, etc.), then all samples associated with the failed LCS must be re-extracted and re-analyzed.

15.5.3.1.4. If sample is not available for re-extraction and reanalysis, then the data are reported and a qualifying statement included in the report narrative describing any potential impact to the analytical data.

15.5.4. Calibration

15.5.4.1. If the method criteria are not met for initial calibration, then the calibration curve is rejected. No samples are to be processed for failing analytes until a passing calibration is achieved.

15.5.4.2. If a continuing calibration check (CCV) fails high and all samples in the batch are non-detect, the data can be reported and no further action is necessary.

15.5.4.3. If a continuing calibration check (CCV) fails low and the sample data in the batch have exceeded the regulatory limit, the data can be reported and no further action is necessary.

15.5.4.4. Otherwise, the samples affected by the unacceptable calibration are reanalyzed after a new calibration curve is established, evaluated and accepted. If reanalysis is not possible, data are reported with appropriate qualifiers and/or explained in the case narrative.

15.5.4.5. Samples that fall outside the calibration range are diluted until bracketed by the calibration standards and re-run. When re-analysis is not possible, results that fall above the high point in the curve or below the low point are reported with data qualifiers, unless this is not required by the method(as specified in the SOP).

15.5.5. <u>Matrix Spike/Matrix Spike Duplicate</u>

15.5.5.1. The recovery of the matrix spikes and RPD of the duplicates is compared to the acceptance criteria. If the criteria are not met, the following steps are taken.

15.5.5.1.1. Check standard concentrations, spike calculations, sample matrix and instrument performance.

15.5.5.1.2. When practical or if warranted through the investigation, reanalyze the sample to assist in the demonstration of suspected matrix interference.

15.5.5.1.3. Where applicable and as prescribed in SOPs or project plans, perform post digestion spikes, dilution tests, or method of standard additions.

15.5.5.1.4. Review LCS recoveries to insure demonstration of system control.

15.5.5.2. If no error can be found, the affected sample is to be reported with a data flag explaining the deviation from the criteria.

15.5.5.3. An exception to these criteria is allowed for matrix spike samples when the sample concentration exceeds the spike concentration by a factor or 4 or more. These data are inappropriate for evaluation. If a case narrative is provided this is to be noted in the report.

CORRECTIVE ACTION REPORT

Method: ______________________

Date: Reported By: **Response due by**: ____________________

CA issued to: ____

Sample ID Number(s) Involved:______________________________

☐ Proficiency Test ☐ Customer Complaint ☐ Recurring problem ☐ Non-isolated issue

Description of Event:

Discussion of Known or Suspected Cause:

Corrective Action(s) Taken (include date, analyst and action):

____

Prevention:

____

Reviewed by:

Signed/dated	Name	Initials
Analyst	__________	________
	__________	________
Signed/dated	__________	________
Supervisor	__________	________

Signed/dated
Quality Assurance Officer

Follow up audit due after:________________
Completed on:___________ Initials:______

16. QUALITY ASSURANCE REPORTS TO MANAGEMENT

16.1. Quality Assurance Audit Reports

16.1.1. Results of audits performed by the QA officer are detailed in written audit reports. These reports are distributed to the staff for review and appropriate action. These and other QA related reports are distributed as produced and discussed at monthly staff meetings.

16.1.2. Audit reports will include, but not be limited to:

16.1.2.1. Results of internal laboratory review activities

16.1.2.2. Results internal data review activities

16.1.2.3. Results of Proficiency Evaluation studies

16.1.2.4. Results of state certification applications

16.1.2.5. Summary of customer complaints, audit actions, and results

16.1.2.6. Method detection limit study status

16.1.2.7. Corrective Action reports and status

16.2. Management Review

16.2.1. To document management review, the audit report will contain signature section to be signed and dated by the Laboratory Director, Technical Director and QA Officer, acknowledging review of its contents and that any necessary remedial actions are being addressed, as dictated by their position.

16.3. Management Review of the Quality Assurance Program

16.3.1. Review of the appropriateness and adequacy of the Quality Assurance Program is ongoing. At anytime, any employee is encouraged to present recommended changes to the Quality Assurance Officer.

16.3.2. Periodically, management will review the QA Manual and other supporting documents to ensure the program effectively addresses all aspects of the company’s processes.

17. TREATMENT SYSTEM SAMPLING

17.1. Procedures

17.1.1. Based upon specific customer request, laboratory personnel may perform basic treatment system sampling. Sampling procedures follow the EPA guidelines for sampling, Industrial User Inspection and Sampling Manual for POTWs, April 1994. Standard operating procedures exist for field sampling activities.

17.2. Records

17.2.1. The location of sampling, date and time collected and the name of the person collecting the sample is noted on the Chain of Custody form. Environmental conditions are also noted on the form. A diagram of the sampling locations is located in the customer folder.

17.3. Reporting

17.3.1. The final report with the sample results includes a copy of the Chain of Custody which contains the sampling information and a reference to the sampling procedures used.

Table 2
Surface Sediment Results
Squamscott River Outfall, Exeter, NH

Constituent PAH (ug/Kg)	Oct-08 SD-01-A 0-1 ft.	Oct-08 SD-02-A 0-1 ft.	Oct-08 SD-03-A 0-1 ft.	Oct-08 SD-04-A 0-1 ft.	Oct-08 SD-05-A 0-1 ft.	Oct-08 SD-06-A 0-1 ft.	Dec-08 SD-6-A 0-0.5 ft.	Oct-08 SD-07-A 0-1 ft.	Oct-08 SD-08A 0-1 ft.	Oct-08 SD-08B-A 0-1 ft.	Oct-08 SD-09-A 0-1 ft.
Acenaphthene	77,000	16,000	48,000	23,000	14,000	290,000	1,900	14,000	8,200	6,700	21,000
Acenaphthylene	6,400	3,600	5,000	2,200	2,100	35,000	780	2,400	1,100	1,400	2,600
Anthracene	34,000 B	14,000	28,000	12,000	9,000 B	140,000	1,300	8,300	5,200	5,800 B	13,000
Benzo(a)anthracene	17,000	10,000	17,000	7,300	5,900	80,000	2,100	7,200	3,300	4,900	9,400
Benzo(a)pyrene	13,000	8,900	12,000	5,300	4,500	63,000	1,700	7,100	2,600	4,400	6,300
Benzo(b)fluoranthene	3,500	4,600	6,200	1,200	1,100	19,000	1,700	3,000	560	1,000	3,200
Benzo(ghi)perylene	7,200	4,100	6,400	2,900	2,000	28,000	840	2,800	1,300	2,000	4,700
Benzo(k)fluoranthene	18,000	11,000	17,000	6,800 B	5,900 B	71,000	640	7,800	3,300 B	5,000 B	9,000
Chrysene	14,000	8,600	14,000	5,500	4,400	74,000	1,500	5,700	3,200	4,400	7,000
Dibenzo(a,h)anthracene	650	970	1,700	740	220 J	7,500	*215*	650	360 J	470 J	1,000
Fluoranthene	35,000	19,000	33,000	13,000	10,000	140,000	3,400	12,000	6,100	9,100	16,000
Fluorene	32,000	12,000	30,000	11,000	8,800	150,000	1,000	8,500	5,000	4,700	13,000
Indeno(1,2,3-cd)pyrene	5,600	3,200	5,200	2,400	1,700	24,000	760	2,200	1,100	1,600	3,400
2-Methylnaphthalene	87,000	16,000 B	80,000 B	35,000 B	17,000	540,000 B	540	21,000 B	12,000	6,100	7,800 B
Naphthalene	140,000 B	12,000 B	94,000 B	42,000 B	20,000 B	650,000 B	930	28,000 B	10,000	7,900 B	14,000 B
Phenanthrene	100,000 B	38,000 B	83,000 B	34,000 B	26,000 B	390,000 B	3,200	24,000 B	16,000	18,000 B	39,000 B
Pyrene	50,000	24,000	47,000	18,000	14,000	210,000	4,300	17,000	8,300	11,000	22,000
Total PAHs	640,350	205,970	527,500	222,340	146,620	2,911,500	26,805	171,650	87,620	94,470	192,400
Total Organic Carbon (%)	3.86	5	5	3	8	7	2	3	6	6	4
Metals (mg/Kg)											
Arsenic	10	15	14	7	15	13	11	10	14.8	15	12
Cadmium	1	1	0	15	1	1	*0*	0	0.57	1	1
Chromium	128	228	132	61	317	238	75	118	178	274	94
Lead	67	125	83	69	159	151	47	80	93.5	204	109
Grain Size Distribution (%)											
Fines	34.50	83.80	48.10	27.60	88.30	73.20	46.60	44.20	77.40	82.00	72.60
Sand	53.20	16.20	47.20	68.60	11.70	26.60	53.30	53.60	22.30	18.00	26.80
Gravel	12.30	0.00	4.70	3.80	0.00	0.10	0.10	2.20	0.30	0.00	0.50

Table 2 (Cont.)
Surface Sediment Results
Squamscott River Outfall, Exeter, NH

Constituent	Oct-08 SD-10A-A 0-1 ft.	Oct-08 SD-11-A 0-1 ft.	Oct-08 SD-11A-A 0-1 ft.	Oct-08 SD-12 0-1 ft.	Oct-08 SD-12A-A 0-1 ft.	Dec-08 SD-15-A 0-0.5 ft.	Dec-08 SD-16-A 0-0.5 ft.	Dec-08 SD-18-A 0-0.5 ft.	Dec-08 SD-20-A 0-0.5 ft.	Dec-08 SD-21-A 0-0.5 ft.	Dec-08 SD-22-A 0-0.5 ft.
PAH (ug/Kg)											
Acenaphthene	**3,900**	**70,000**	**44,000**	**36,000**	**28,000**	*280*	*280*	*2,500*	7,200	*330*	*295*
Acenaphthylene	**620**	**6,200**	**5,200**	**4,400**	**3,800**	*280*	*280*	*315*	3,000	*330*	*295*
Anthracene	**2,700** B	**34,000**	**23,000** B	**20,000**	**17,000**	*280*	*280*	*1,200*	8,300	*330*	*295*
Benzo(a)anthracene	**2,300**	**18,000**	**13,000**	**12,000**	**11,000**	**650**	**840**	*750*	11,000	**1100**	*295*
Benzo(a)pyrene	**2,400**	**13,000**	**10,000**	**8,200**	**9,500**	**570**	*280*	*315*	8,100	**1000**	*295*
Benzo(b)fluoranthene	**550**	**3,300**	**2,400**	**1,900**	**2,200**	**720**	*280*	*315*	7,700	**1300**	*295*
Benzo(ghi)perylene	**1,100**	**8,200**	**3,700**	**4,600**	**6,400**	*280*	*280*	*315*	2,900	*330*	*295*
Benzo(k)fluoranthene	**2,600** B	**18,000** B	**13,000** B	**11,000** B	**12,000** B	*280*	**690**	*315*	2,600	*330*	*295*
Chrysene	**2,200**	**14,000**	**9,600**	**8,600**	**10,000**	**640**	**970**	*700*	8,500	**1500**	*295*
Dibenzo(a,h)anthracene	**280** J	**940**	**390** J	**1,200**	**1,600**	*280*	*280*	*315*	880	*330*	*295*
Fluoranthene	**4,000**	**34,000**	**24,000**	**21,000**	**19,000**	**970**	**1,200**	*1,500*	19,000	**6700**	**710**
Fluorene	**2,600**	**33,000**	**22,000**	**18,000**	**17,000**	*280*	*280*	*640*	5,500	*330*	*295*
Indeno(1,2,3-cd)pyrene	**900**	**6,600**	**3,200**	**3,800**	**5,100**	*280*	*280*	*315*	3,000	*330*	*295*
2-Methylnaphthalene	**2,500**	**120,000**	**74,000**	**63,000**	**44,000**	*280*	*280*	*315*	*265*	*330*	*295*
Naphthalene	**2,700** B	**160,000**	**84,000** B	**76,000**	**59,000**	*280*	*280*	*315*	2,700	*330*	*295*
Phenanthrene	**8,100** B	**98,000**	**70,000** B	**58,000**	**47,000**	*280*	*280*	*2,000*	27,000	**1500**	*295*
Pyrene	**4,800**	**51,000**	**33,000**	**30,000**	**27,000**	**1,100**	**1,400**	*2,000*	23,000	**2400**	**750**
Total PAHs	**44,250**	**688,240**	**434,490**	**377,700**	**319,600**	**7,730**	**8,460**	**14,125**	140,645	**18,800**	**5,885**
Total Organic Carbon (%)	**4.0**	**8.3**	**7.3**	**6.9**	**5.6**	**2.8**	**2.6**	**3.0**	2.9	**4.9**	**2.1**
Metals (mg/Kg)											
Arsenic	15	12.5	13	14	15	**16**	16	**17**	14	**10**	**13**
Cadmium	2	1	1	1	1	*0.4*	0.35	**1**	1	*0.28*	*0.35*
Chromium	83	250	212	218	159	**92**	130	**250**	86	**71**	**98**
Lead	200	132	171	138	150	**50**	63	**88**	160	**86**	**53**
Grain Size Distribution (%)											
Fines	80.4	74.8	71.6	68.1	87.0	50.6	85.0	88.6	83.8	32.2	86.3
Sand	19.6	25.1	28.4	28.8	13.0	36.4	14.4	10.8	16.2	65.6	13.7
Gravel	0.0	0.1	0.0	3.1	0.0	13.0	0.7	0.6	0.0	2.2	0.0

Table 2 (Cont.)
Surface Sediment Results
Squamscott River Outfall, Exeter, NH

Constituent	Dec-08 SD-23-A 0-0.5 ft.	Dec-08 SD-25-A 0-0.5 ft.	Dec-08 SD-25-A dup. 0-0.5 ft.	Dec-08 SD-26-A 0-0.5 ft.	Dec-08 SD-27-A 0-0.5 ft.	Dec-08 SD-28-A 0-0.5 ft.	Dec-08 SD-29-A 0-0.5 ft.	Dec-08 SD-30-A 0-0.5 ft.	Dec-08 SD-31-A 0-0.5 ft.	Dec-08 SD-32-A 0-0.5 ft.	Dec-08 SD-33-A 0-0.5 ft.
PAH (ug/Kg)											
Acenaphthene	*265*	*295*	*295*	**2000**	**1,800**	*115*	*200*	**360**	*115*	*165*	*165*
Acenaphthylene	*265*	*295*	*295*	**1100**	**1,700**	*115*	*200*	**400**	**850**	**490**	**420**
Anthracene	*265*	*295*	*295*	**2600**	**1,700**	**360**	*200*	**1,200**	**910**	**620**	**390**
Benzo(a)anthracene	**990**	**660**	**740**	**2100**	**4,400**	**1,200**	**1,300**	**2,800**	**3,100**	**2100**	**1300**
Benzo(a)pyrene	**870**	*295*	*295*	**1700**	**3,700**	**950**	**1,100**	**2,100**	**2,500**	**1700**	**1100**
Benzo(b)fluoranthene	**880**	**640**	**700**	**1500**	**3,700**	**1,300**	**1,300**	**2,700**	**2,800**	**2500**	**1700**
Benzo(ghi)perylene	*265*	*295*	*295*	*330*	**1,600**	**400**	**510**	**800**	**1,100**	**670**	**440**
Benzo(k)fluoranthene	*265*	*295*	*295*	*330*	**1,100**	**460**	**750**	**1,200**	**1,100**	**800**	**540**
Chrysene	**800**	*295*	*295*	**2100**	**3,700**	**1,100**	**1,200**	**2,800**	**2,700**	**2200**	**1500**
Dibenzo(a,h)anthracene	*265*	*295*	*295*	*330*	*250*	*115*	*200*	*115*	*115*	*165*	*165*
Fluoranthene	**1,100**	**1,000**	**1,100**	**4200**	**6,700**	**2,300**	**2,500**	**6,100**	**5,500**	**4100**	**2800**
Fluorene	*265*	*295*	*295*	**1800**	**1,400**	*115*	*200*	**630**	*115*	*165*	*165*
Indeno(1,2,3-cd)pyrene	*265*	*295*	*295*	*330*	**1,600**	**420**	**520**	**880**	**1,100**	**750**	**500**
2-Methylnaphthalene	*265*	*295*	*295*	*330*	*250*	*115*	*200*	*115*	*115*	*165*	*165*
Naphthalene	*265*	*295*	*295*	*330*	**960**	*115*	*200*	*115*	*115*	*165*	*165*
Phenanthrene	*265*	*295*	**690**	**6800**	**2,900**	**950**	**1,000**	**4,600**	**2,100**	**1600**	**1100**
Pyrene	**1,500**	**1,200**	**1,400**	**5700**	**7,800**	**2,200**	**2,100**	**4,700**	**4,800**	**3300**	**2200**
Total PAHs	**9,055**	**7,335**	**8,170**	**33,580**	**45,260**	**12,330**	**13,680**	**31,615**	**29,135**	**21,655**	**14,815**
Total Organic Carbon (%)	**2.9**	**3.2**		**3.1**	**3.3**	**1.5**	**0.9**	**0.6**	**0.9**	**1.1**	**0.8**
Metals (mg/Kg)											
Arsenic	**17**	**17**	**19**	**13**	**14**	**5.3**	**5.7**	**3.4**	**6**	**8.6**	**3.7**
Cadmium	*0.4*	**0.72**	0.4	**0.7**	**1**	**0.55**	*0.2*	*0.16*	*0.4*	*0.17*	0.17
Chromium	**150**	**150**	**160**	**180**	**110**	**100**	**40**	**21**	**29**	**27**	**22**
Lead	**63**	**66**	**69**	**65**	**110**	**58**	**36**	**39**	**35**	**490**	**43**
Grain Size Distribution (%)											
Fines	82.2	94.4	0	78.5	73	12.9	22	10.9	14.5	5.3	5.1
Sand	15.9	5.3	0	18.4	27	69.6	68.8	84.2	82.9	94.3	92.4
Gravel	1.9	0.25	0	3.1	0	17.6	9.2	4.9	2.6	0.4	2.5

Table 2 (Cont.)
Surface Sediment Results
Squamscott River Outfall, Exeter, NH

Constituent	Dec-08	Dec-08	Dec-08	Reference Locations	
	SD-34-A	SD-35-A	SD-36-A	SD-13-A	SD-14-A
PAH (ug/Kg)	**0-0.5 ft.**	**0-0.5 ft.**	**0-0.5 ft.**	**0-1 ft.**	**0-1 ft.**
Acenaphthene	**590**	*330*	*165*	68 J	**85**
Acenaphthylene	**800**	*330*	*165*	*290*	**43**
Anthracene	**2400**	*330*	*165*	170 BJ	**140**
Benzo(a)anthracene	**4400**	**1300**	**930**	**520**	**300**
Benzo(a)pyrene	**3500**	*330*	**720**	**550**	**420**
Benzo(b)fluoranthene	**4600**	**1500**	**960**	**310**	**530**
Benzo(ghi)perylene	**1200**	*330*	*165*	**280** J	**220**
Benzo(k)fluoranthene	**1800**	**1000**	*165*	**600** B	**330** B
Chrysene	**4700**	**1200**	**960**	**520**	**280**
Dibenzo(a,h)anthracene	*165*	*330*	*165*	*290*	**49**
Fluoranthene	**9600**	**3000**	**1900**	**890**	**560**
Fluorene	**1000**	*330*	*165*	*290*	**65**
Indeno(1,2,3-cd)pyrene	**1400**	*330*	*165*	**260** J	**180**
2-Methylnaphthalene	*165*	*330*	*165*	*290*	**6** J
Naphthalene	**480**	*330*	*165*	*290*	**19** J
Phenanthrene	**7000**	**1700**	**740**	**510** B	**420**
Pyrene	**7700**	**2400**	**1600**	**880**	**560**
Total PAHs	**51,500**	**15,400**	**9,460**	**7,008**	**4,207**
Total Organic Carbon (%)	**0.81**	4.4	3.1	**2**	**1**
Metals (mg/Kg)	**3.5**	**9.9**	**6.1**	8	4
Arsenic	*0.18*	*0.29*	*0.2*	0	*0*
Cadmium					
Chromium	**22**	**60**	**54**	56	25
Lead	**92**	**76**	**36**	77	15
Grain Size Distribution (%)					
Fines	4.1	33.5	15.9	35.9	24
Sand	86.8	65.3	80.4	51.9	73.7
Gravel	9.1	1.1	3.7	12.2	2.3

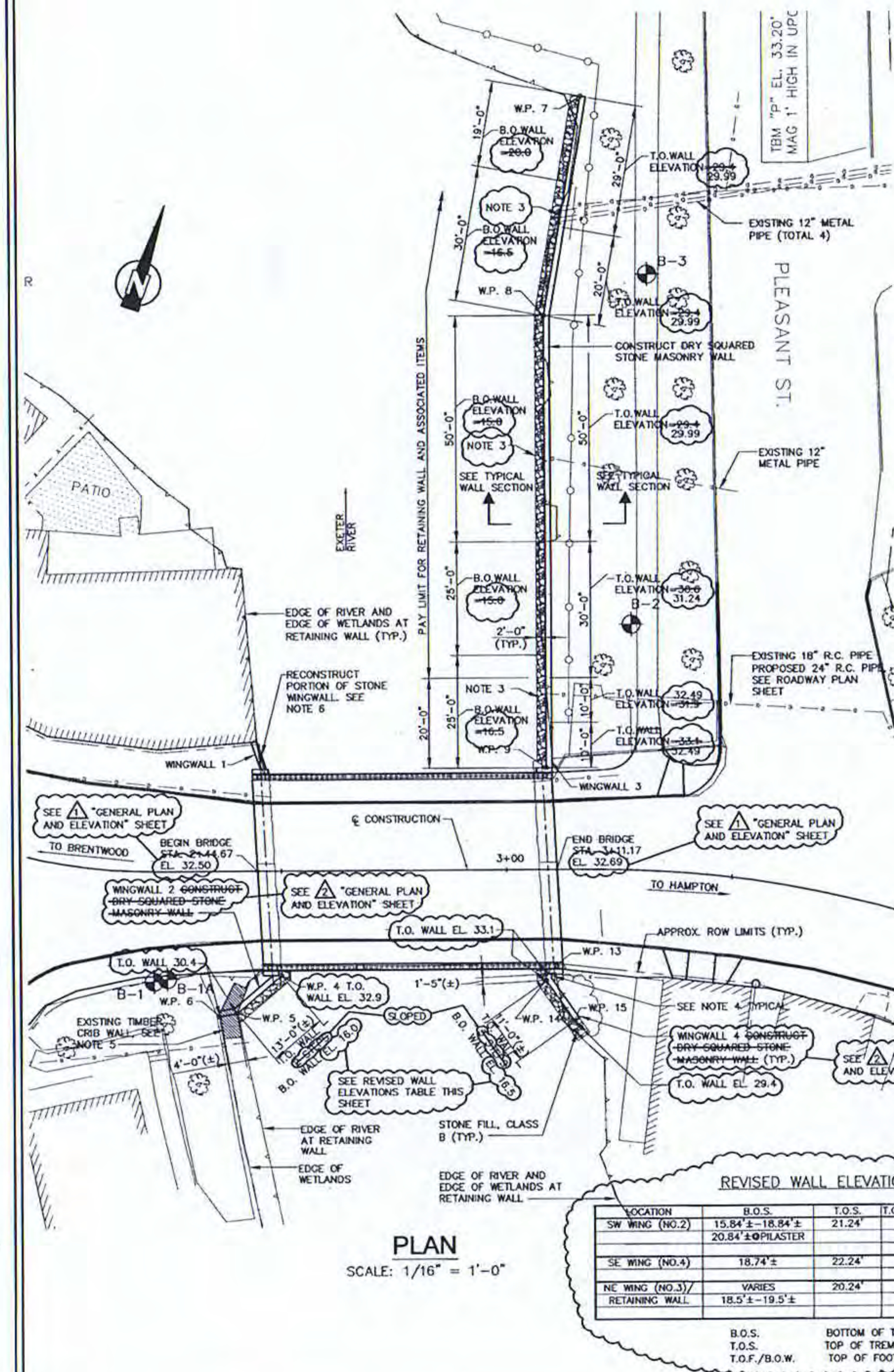
Note: Italics indicate results less than the associated analytical reporting limit

EX-24A
EX-26
EX-24
EX-22
EX-27
EX-25
EX-23
EX-35
EX-31
EX-34
EX-08B
EX-30
EX-33
EX-12A
EX-08A
EX-29
EX-32
EX-15
EX-12
EX-11A
EX-08
EX-11
EX-28
EX-10A
EX-04
EX-07
EX-03
EX-09A
EX-02
EX-6A
EX-06
EX-05
EX-20
EX-01
EX-18
EX-21
EX-16
EX-19
EX-17
EX-36
EX-13
EX-14
* Approximately 400 ft. south east of outfall
Approximate Outfall Location
0 12.5 25 50 75 100
Feet
Legend
October 2008 Samples
December 2008 Samples
April 2009 Samples
N
SEDIMENT SAMPLING LOCATIONS
2008/09
Unitil Corporation
Squamscott River Sediment Investigation
Exeter, NH
SCALE
AS NOTED
DATE
06/09
PROJECT NO.
13046-001
AECOM
FIGURE NO.
2-1

Appendix J

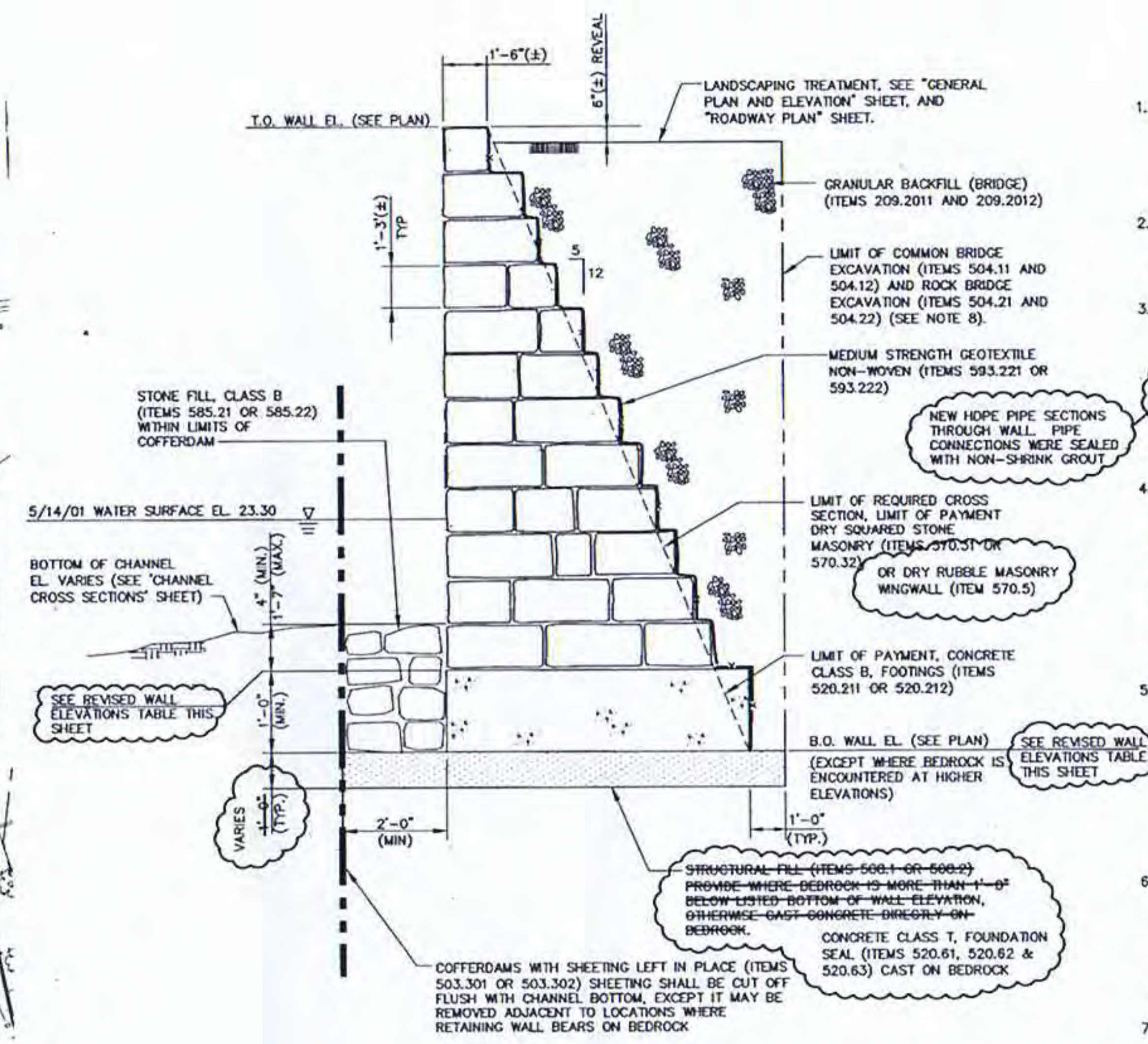
Great Bridge Plan Sheet (NHDOT)

Appendix J



PLAN

SCALE: 1/16" = 1'-0"

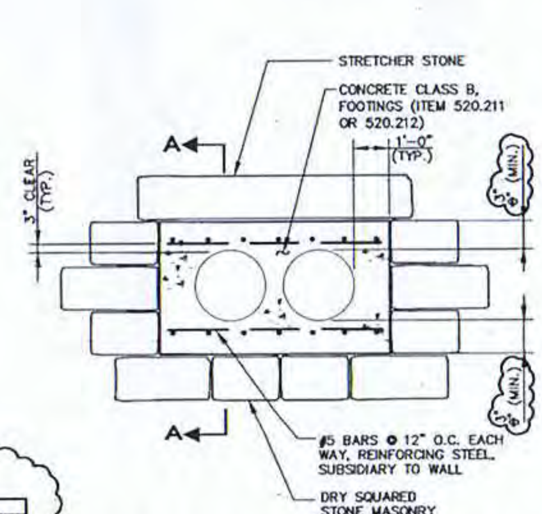


TYPICAL WALL SECTION

SCALE: 3/8" = 1'-0"

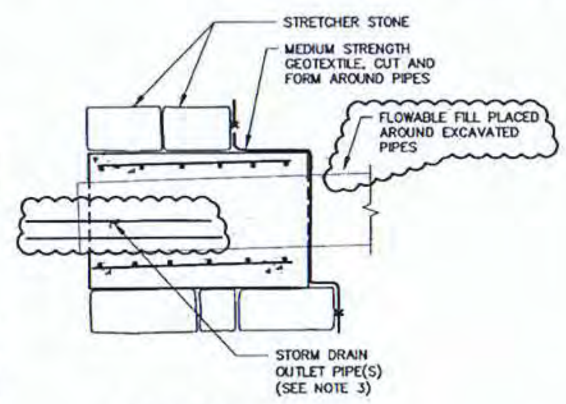
NOTES

1. DRY SQUARED STONE MASONRY (F) (ITEM 570.31) SHALL HAVE A ROCK-FACED FINISH, AND BE CONSTRUCTED IN A RANGED PATTERN. THE STONE SHALL HAVE THE FOLLOWING GEOMETRY.
   - HEIGHT 1'-3" (± 1")
   - WIDTH NOT LESS THAN 1'-6"
   - LENGTH NOT LESS THAN 2'-0"
2. CONTRACTOR TO INSTALL COFFERDAM AS CLOSE AS POSSIBLE TO EDGE OF RIVER AT RETAINING WALL, (MIN 2'-0") AWAY FROM THE WALL SEE PLAN. THE SHEETS SHALL NOT BE REMOVED UNTIL THE WALL ELEVATION IS 3'-0" ABOVE THE WATER LEVEL.
3. THE STORM DRAIN OUTLET PIPES (THREE LOCATIONS TOTAL) AND DRY HYDRANT THAT PENETRATE THE RETAINING WALL ALONG THE PARK SHALL BE ENCASED IN CONCRETE AS SHOWN ON THE PIPE PENETRATION DETAIL. ~~STONE STRETCHERS SHALL SPAN OVER THE CONCRETE ENCASEMENT.~~ THE OUTLET SECTION OF THE METAL PIPES (TWO LOCATIONS) SHALL BE REMOVED AND REPLACED AND CONNECTED TO THE EXISTING PIPES AT THE EDGE OF THE DISTURBED AREA IN A METHOD APPROVED BY THE ENGINEER. ~~REMOVAL AND REPLACEMENT OF THE METAL PIPES IS SUBSIDIARY TO THE RETAINING WALL.~~ THE R.C. PIPE (ONE LOCATION) SHALL BE REMOVED AND REPLACED AS SHOWN ON THE ROADWAY PLAN SHEET.
4. INTERSECTION OF THE NEW STONE WINGWALLS WITH THE EXISTING ABUTMENTS:
   a. THE CONTRACTOR SHALL NOTIFY THE ENGINEER PRIOR TO EXCAVATING NEAR THE ABUTMENT AND UNDER NO CIRCUMSTANCE SHALL EXCAVATE BELOW THE BASE OF THE STONE ABUTMENT WITHIN NEITHER A 5-FOOT DISTANCE NOR A 1:1 SLOPE.
   b. THE TOP OF THE STONE WINGWALL SHALL MATCH THE TOP OF THE CONCRETE ENDWALL.
   c. THE CONCRETE ENDWALLS SHALL BE FORMED AND CAST PRIOR TO PLACING THE ADJACENT STONE FOR THE WINGWALLS.
   d. THE NEW STONES INTERSECTING THE EXISTING ABUTMENT SHALL BE NEATLY CUT AND PLACED AS APPROVED BY THE ENGINEER.
5. A PORTION OF THE EXISTING TIMBER CRIB WALL AND BASE STONES SHALL BE REMOVED IN ORDER TO CONSTRUCT WINGWALL 2. THE CONTRACTOR SHALL CONSTRUCT A NEW WALL EXTENDING FROM THE TEMPORARY END OF THE CRIB WALL TO THE FACE OF THE NEW WINGWALL. THE CONTRACTOR SHALL PROPOSE, AND RECEIVE APPROVAL FROM THE TOWN AND THE ENGINEER, A DETAIL (SUBSIDIARY TO 568.1) OF THE NEW EXTENSION WALL PRIOR TO CONSTRUCTION OF SUCH. THE CONTRACTOR SHALL SECURE AND PROTECT THE TEMPORARY END OF THE CRIB WALL UNTIL CONSTRUCTION HAS BEEN COMPLETED. REMOVAL OF THE EXISTING CRIB WALL AND BASE STONES IS INCLUDED UNDER ITEM 502. CONSTRUCTION OF THE EXTENSION WALL SHALL BE INCLUDED UNDER "EXTENSION OF TIMBER CRIB WALL" (ITEM 568.1)
6. PORTIONS OF STONE MASONRY AT WINGWALL 1 SHALL BE RECONSTRUCTED WITH MORTARED STONES AND THE REMAINDER OF THE WALL FACE SHALL BE POINTED (ALL ASSOCIATED REMOVAL AND RECONSTRUCTION COSTS SHALL BE INCLUDED UNDER RECONSTRUCTING STONE WINGWALL (ITEM 572.202)). THE PORTION OF WALL TO BE RECONSTRUCTED SHALL BE KEPT TO A MINIMUM AS NECESSARY TO PLACE THE BRIDGE SEAT AND ABUTMENT ENDWALL, AND CORRECT ANY DISTURBANCE CAUSED BY UTILITY RELOCATION. ALL WORK SHALL BE IN ACCORDANCE WITH SECTION 570.
7. FOR ADDITIONAL INFORMATION SEE "GENERAL PLAN AND ELEVATION" SHEET, "ABUTMENT DETAILS" SHEETS, "ROADWAY PLAN" SHEET, AND "WETLANDS PERMIT PLAN" SHEET.
8. REMOVAL OF THE EXISTING WINGWALLS AND RETAINING WALL SHALL BE INCLUDED IN ITEMS 502 AND 502.1 RESPECTIVELY.



PIPE PENETRATION DETAIL

SCALE: 3/8" = 1'-0"



SECTION A-A

SCALE: 3/8" = 1'-0"

WORKING POINT TABLE

POINT	NORTHING	EASTING
W.P. 4	176056.22	1177607.06
W.P. 5	176045.07	1177600.38
W.P. 6	176043.13	1177596.88
W.P. 7	176261.74	1177607.56
W.P. 8	176213.35	1177615.27
W.P. 9	176118.83	1177647.92
W.P. 13	176075.38	1177662.52
W.P. 14	176074.09	1177663.05
W.P. 15	176067.63	1177671.96

NOTE: NORTHING AND EASTING OF WORKING POINTS 4, 13 AND 14 ARE APPROXIMATE, TRUE LOCATION SHALL MATCH EXISTING ABUTMENT CORNER STONES, AS APPROVED BY THE ENGINEER.

REVISED WALL ELEVATIONS

LOCATION	B.O.S.	T.O.S.	T.O.F./B.O.W.	REMARKS
SW WING (NO.2)	15.84'±–18.84'± 20.84'±@PILASTER	21.24'	23.24'	NOT ON BEDROCK BOT OF 5x5 KEY 16.44'±–17.64'±
SE WING (NO.4)	18.74'±	22.24'	23.24'	DOWELED INTO BEDROCK
NE WING (NO.3)/ RETAINING WALL	VARIES 18.5'±–19.5'±	20.24'	21.24'	T.O.S. AND T.O.F. = ENTIRE LENGTH OF WALL

B.O.S. BOTTOM OF TREMIE SEAL
T.O.S. TOP OF TREMIE SEAL
T.O.F./B.O.W. TOP OF FOOTING

STATE OF NEW HAMPSHIRE
DEPARTMENT OF TRANSPORTATION • BUREAU OF BRIDGE DESIGN

TOWN: EXETER — BRIDGE NO. 103/073 — STATE PROJECT 12676
LOCATION: GREAT BRIDGE OVER THE EXETER RIVER

WINGWALL AND RETAINING WALL DETAILS

	BY	DATE		BY	DATE
DESIGNED	MAC	12/01	CHECKED	WRB	12/01
DRAWN	MAC	12/01	CHECKED	WRB	12/01
QUANTITIES			CHECKED		

REVISIONS AFTER PROPOSAL
ISSUE DATE
REV. DATE
FEDERAL PROJECT NO.
SHEET NO. 8 — TOTAL SHEETS 38
BRIDGE SHEET OF
FILE NUMBER

SEA Consultants Inc. Science/Engineering/Architecture — CAMBRIDGE, Ma. CONCORD, N.H. ROCKY HILL, Ct.
SHEET SCALE
SEA Project No. 2000597.01A
File: 597WALL.dwg

Appendix K

Exeter River Water Quality Report Card

Welcome to New Hampshire's Watershed Report Cards built from the 2010, 305(b)/303(d)

Each Watershed Report Card covers a single 12 digit Hydrologic Unit Code (HUC12), on average a 34 square mile area. Each Watershed Report Card has three components;

1. REPORT CARD - A one page card that summarizes the overall use support for Aquatic Life, Primary Contact (i.e. Swimming), and Secondary Contact (i.e. Boating) Designated Uses on every Assessment Unit ID (AUID) within the HUC12.
2. HUC 12 MAP - A map of the watershed with abbreviated labels for each AUID within the HUC12. **New for 2010, all AUIDs have been rebuilt on 1:24,000 hydrography and the maps have been built on an 11"x17" format.**
3. ASSESSMENT DETAILS - Anywhere from one to forty pages with the detailed assessment information for each and every AUID in the Report Card and Map.

How are the Surface Water Quality Assessment determinations made?

All readily available data with reliable Quality Assurance/Quality Control is used in the biennial surface water quality assessments. For a full understanding of how the Surface Water Quality Standards (Env-Wq 1700) are translated into surface water quality assessments we urge the reader to review the 2010 Consolidated Assessment and Listing Methodology (CALM) at http://des.nh.gov/organization/divisions/water/wmb/swqa/2010/documents/2010calm.pdf.

Where can I find more advanced mapping resources?

GIS shapefiles and google earth KML map files are accessible from http://des.nh.gov/organization/divisions/water/wmb/swqa/2010/index.htm.

How are assessments coded in the report card?

Assessment outcomes are displayed on a color scale as well as an alpha numeric scale that provides additional distinctions for the designated use and parameter level assessments as outlined in the table below.

		Severe Not Supporting, Severe	**Poor** Not Supporting, Marginal	**Likely Bad** Insufficient Information – Potentially Not Supporting	**No Data** No Data	**Likely Good** Insufficient Information – Potentially Full Supporting	**Marginal** Full Support, Marginal	**Good** Full Support, Good
CATEGORY	**Description**							
*Category 2	Meets standards						2-M or 2-OBS	2-G
Category 3	Insufficient Information			3-PNS	3-ND	3-PAS		
Category 4	Does not Meet Standards;							
4A	TMDL^ Completed	4A-P	4A-M or 4A-T					
4B	Other enforceable measure will correct the issue.	4B-P	4B-M or 4B-T					
4C	Non-pollutant (i.e. exotic weeds)	4C-P	4C-M					
Category 5	TMDL^ Needed	5-P	5-M or 5-T					

* "Category 1" only exists at the Assessment Unit Level.
^ TMDL stands for Total Maximum Daily Load studies (http://des.nh.gov/organization/divisions/water/wmb/tmdl/index.htm)

WATERSHED 305(b) ASSESSMENT SUMMARY REPORT:

HUC 12 010600030805

HUC 12 NAME GREAT BROOK-EXETER RIVER

(Locator map on next page only applies to this HUC12)

Assessment Cycle 2010

Good	Full Support Good
Marginal	Full Support Marginal
Likely Good	Insufficient Information – Potentially Full Support
No Data	No Data
Likely Bad	Insufficient Information – Potentially Not Support
Poor	Not Support Marginal
Severe	Not Support Severe

ASSESSMENT UNIT ID	MAP LABEL	ASSESSMENT UNIT NAME	AQUATIC LIFE	SWIMMING	BOATING	FISH CONSUMP.
NHEST600030806-01	E*0806-01	SQUAMSCOTT RIVER	5-P	5-P	5-P	5-M
NHIMP600030805-02	I*02	BRICKYARD BROOK - BLUNT POND	3-ND	3-ND	3-ND	4A-M
NHIMP600030805-03	I*03	PHILBRICK POND - BRANCH GREAT BROOK	3-ND	3-ND	3-ND	4A-M
NHIMP600030805-04	I*05-04	EXETER RIVER	5-P	5-P	5-M	4A-M
NHIMP600030805-05	I*05	EAST KINGSTON GOLF COURSE POND	3-ND	3-ND	3-ND	4A-M
NHLAK600030805-01	L*01	PICKPOCKET POND	3-PNS	3-ND	3-ND	4A-M
NHLAK600030805-02	L*02	UNNAMED POND	3-ND	3-ND	3-ND	4A-M
NHLAK600030805-03	L*03	UNNAMED POND	3-ND	3-ND	3-ND	4A-M
NHLAK600030805-04	L*04	UNNAMED POND	3-ND	3-ND	3-ND	4A-M
NHRIV600030805-01	R*01	EXETER RIVER	3-PNS	3-ND	3-ND	4A-M
NHRIV600030805-02	R*02	EXETER RIVER	5-P	5-P	3-ND	4A-M
NHRIV600030805-03	R*03	BRICKYARD BROOK	3-ND	3-ND	3-ND	4A-M
NHRIV600030805-04	R*04	GREAT BROOK - BRICKYARD BROOK - HOBBS BROOK - YORK BROOK	5-P	5-P	3-ND	4A-M
NHRIV600030805-05	R*05	MILL BROOK - UNNAMED BROOK	3-ND	3-ND	3-ND	4A-M
NHRIV600030805-06	R*06	MILL BROOK - UNNAMED BROOK	3-ND	3-ND	3-ND	4A-M
NHRIV600030805-07	R*07	GREAT BROOK - UNNAMED BROOK	3-ND	3-ND	3-ND	4A-M
NHRIV600030805-08	R*08	UNNAMED BROOK	3-ND	3-ND	3-ND	4A-M
NHRIV600030805-09	R*09	EXETER RIVER	5-P	3-ND	3-ND	4A-M
NHRIV600030805-10	R*10	UNNAMED BROOK	3-ND	3-ND	3-ND	4A-M
NHRIV600030805-11	R*11	UNNAMED BROOK	3-ND	3-ND	3-ND	4A-M
NHRIV600030805-12	R*12	UNNAMED BROOK	3-ND	3-ND	3-ND	4A-M
NHRIV600030805-13	R*13	UNNAMED BROOK	3-ND	3-ND	3-ND	4A-M
NHRIV600030805-14	R*14	UNNAMED BROOK	3-ND	3-ND	3-ND	4A-M
NHRIV600030805-15	R*15	PERKINS BROOK - UNNAMED BROOK	3-ND	3-ND	3-ND	4A-M
NHRIV600030805-16	R*16	UNNAMED BROOK	3-ND	3-ND	3-ND	4A-M
NHRIV600030805-17	R*17	UNNAMED BROOK	3-ND	3-ND	3-ND	4A-M
NHRIV600030805-18	R*18	UNNAMED BROOK	3-ND	3-ND	3-ND	4A-M
NHRIV600030805-19	R*19	UNNAMED BROOK	3-ND	3-ND	3-ND	4A-M

WATERSHED 305(b) ASSESSMENT SUMMARY REPORT:

HUC 12 010600030805

HUC 12 NAME GREAT BROOK-EXETER RIVER

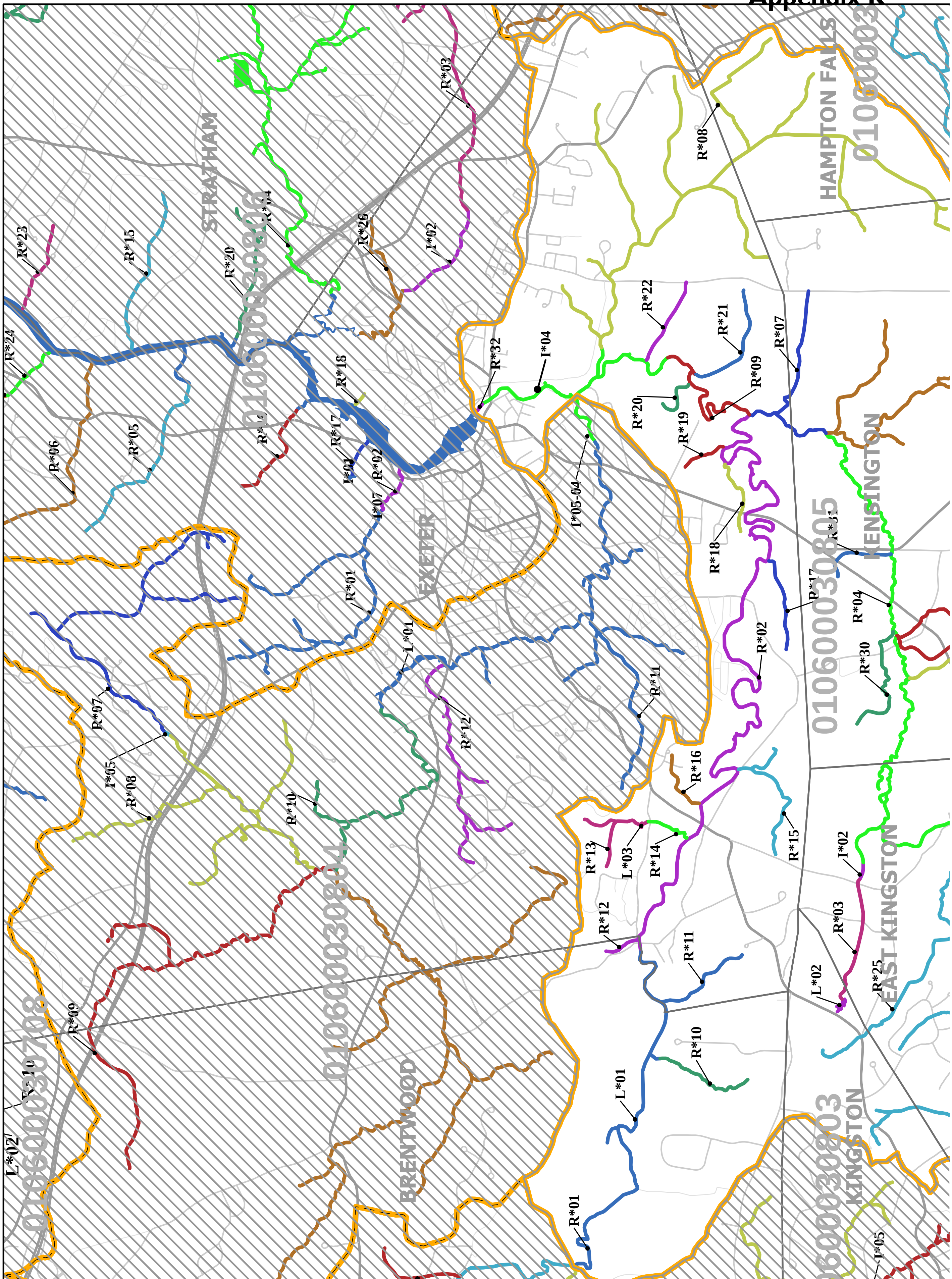
(Locator map on next page only applies to this HUC12)

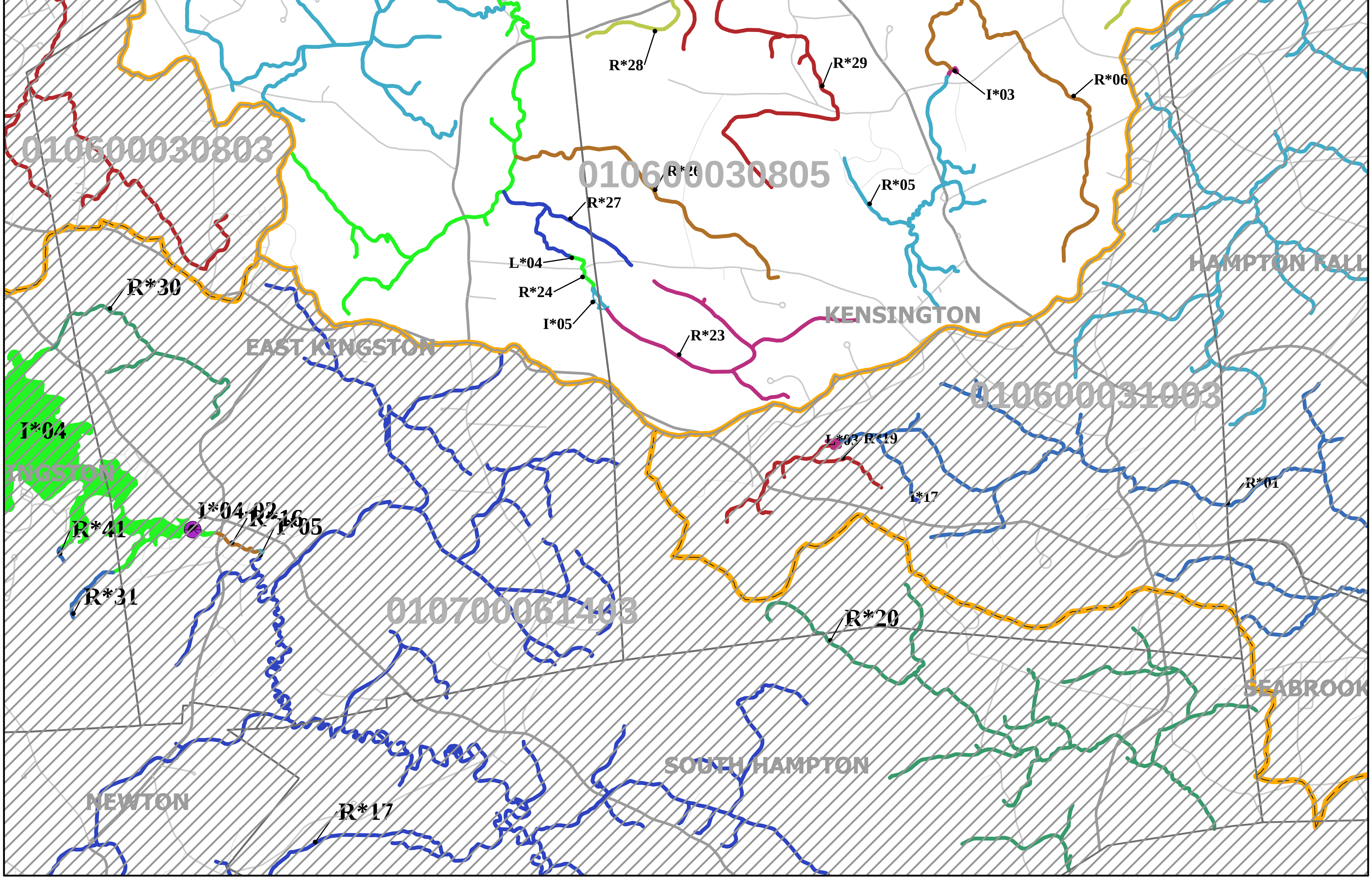
Assessment Cycle 2010

Good	Full Support Good
Marginal	Full Support Marginal
Likely Good	Insufficient Information – Potentially Full Support
No Data	No Data
Likely Bad	Insufficient Information – Potentially Not Support
Poor	Not Support Marginal
Severe	Not Support Severe

ASSESSMENT UNIT ID	MAP LABEL	ASSESSMENT UNIT NAME	AQUATIC LIFE	SWIMMING	BOATING	FISH CONSUMP.
NHRIV600030805-20	R*20	UNNAMED BROOK	3-ND	3-ND	3-ND	4A-M
NHRIV600030805-21	R*21	UNNAMED BROOK	3-ND	3-ND	3-ND	4A-M
NHRIV600030805-22	R*22	UNNAMED BROOK	3-ND	3-ND	3-ND	4A-M
NHRIV600030805-23	R*23	UNNAMED BROOK	3-ND	3-ND	3-ND	4A-M
NHRIV600030805-24	R*24	UNNAMED BROOK	3-ND	3-ND	3-ND	4A-M
NHRIV600030805-25	R*25	UNNAMED BROOK - YORK BROOK	3-ND	3-ND	3-ND	4A-M
NHRIV600030805-26	R*26	UNNAMED BROOK	3-ND	3-ND	3-ND	4A-M
NHRIV600030805-27	R*27	UNNAMED BROOK	3-ND	3-ND	3-ND	4A-M
NHRIV600030805-28	R*28	SPRING BROOK	3-ND	3-ND	3-ND	4A-M
NHRIV600030805-29	R*29	HOBBS BROOK - UNNAMED BROOK	3-ND	3-ND	3-ND	4A-M
NHRIV600030805-30	R*30	UNNAMED BROOK	3-ND	3-ND	3-ND	4A-M
NHRIV600030805-31	R*31	UNNAMED BROOK	3-ND	3-ND	3-ND	4A-M
NHRIV600030805-32	R*32	SQUAMSCOTT RIVER	3-ND	3-ND	3-ND	4A-M

AUIDs for HUC12: 010600030805 - Great Brook-Exeter River





Town Boundaries
HUC12 Boundaries

Assessment Unit Coloring
AUs Ending with:

0 =
1 =
2 =
3 =
4 =
5 =
6 =
7 =
8 =
9 =

Roads
Interstate
State
Local
Private and Class 6

Scale:1:42,932

0 0.4 0.8 1.2 1.6 Miles

Abbrv. Label — HUC 12
L* 03 — 010 700060201
AUID = NH LAK700060201 - 03

Assessment Unit IDs are derived from the HUC12 they reside within. The labels have been shortened on this map for presentation purposes.
Example: the Label "L*03" in HUC12 = 010700060201 represents AUID = "NHLAK700060201-03"
In rare cases where an AUID extends beyond the boundary of a single HUC12, additional portions of the end of the HUC 12 number have also been replaced.

H:\Water Quality\305(B)-303(D) PROGRAM\2010\AUIDs\HUC12Maps

Assessment Unit ID	NHEST600030806-01	Size	0.4777 SQUARE MILES
Assessment Unit Name	SQUAMSCOTT RIVER	Beach	N
Primary Town	STRATHAM	Assessment Unit Category*~	5-P

2010, 305(b)/303(d) - All Reviewed Parameters by Assessment Unit

Designated Use Description	*Desig. Use Category	Desig. Use Threat	Parameter Name	Parameter Threatened (Y/N)	Parameter Category*	TMDL Schedule	Expected To Attain Date	Source Name (Impairments only)
Aquatic Life	5-P		.ALPHA.-ENDOSULFAN(ENDOSULFAN 1)	N	2-G			
			.BETA.-ENDOSULFAN (ENDOSULFAN 2)	N	2-G			
			2-METHYLNAPHTHALENE	N	2-G			
			ACENAPHTHENE	N	5-M	2023		Source Unknown
			ACENAPHTHYLENE	N	5-M	2023		Source Unknown
			ALUMINUM	N	5-M	2023		Source Unknown
			AMMONIA (UN-IONIZED)	N	2-G			
			ANTHRACENE	N	5-M	2023		Source Unknown
			ANTIMONY	N	2-G			
			ARSENIC	N	5-M	2023		Source Unknown
			BENZO(A)PYRENE (PAHS)	N	5-M	2023		Source Unknown
			BENZO[A]ANTHRACENE	N	5-M	2023		Source Unknown
			BENZO[B]FLUORANTHENE	N	2-G			
			BENZO[G,H,I]PERYLENE	N	2-G			
			BENZO[K]FLUORANTHENE	N	2-G			
			BIPHENYL	N	2-G			
			CADMIUM	N	5-M	2023		Source Unknown
			CHRYSENE (C1-C4)	N	5-M	2023		Source Unknown
			CIS-CHLORDANE		2-G			
			COPPER	N	5-M	2023		Source Unknown
			Chlorophyll-a	N	5-P	2021		Source Unknown
			DDD	N	2-G			
			DDE	N	2-G			
			DDT	N	2-G			
			DIBENZ[A,H]ANTHRACENE	N	5-M	2023		Source Unknown
			DIELDRIN	N	2-G			
			DISSOLVED OXYGEN SATURATION	N	2-M			
			ENDOSULFAN SULFATE	N	2-G			

Severe	Poor	Likely Bad	No Data	Likely Good	Marginal	Good
Not Supporting, Severe	Not Supporting, Marginal	Insufficient Information – Potentially Not Supporting	No Data	Insufficient Information – Potentially Full Supporting	Full Support, Marginal	Full Support, Good

*DES Categories; 2-G = Supports Parameter well above criteria, 2-M = Supports Parameter marginally above criteria, 2-OBS = Exceeds WQ criteria but natural therefore not a WQ exceedence, 3-ND = Insufficient Information/No data, 3-PAS= Insufficient Information/Potentially Attaining Standard, 3-PNS= Insufficient Information/Potentially Not Attaining Standard, (4A=Impaired/TMDL Completed, 4B=Impaired/Other Measure will rectify Impairment, 4C=Impaired/Non-Pollutant, 5=Impaired/TMDL needed) M=Marginal Impairment, P=Severe Impairment, T=Threatened (http://des.nh.gov/organization/divisions/water/wmb/swqa/index.htm)

Assessment Unit ID	NHEST600030806-01	Size	0.4777 SQUARE MILES
Assessment Unit Name	SQUAMSCOTT RIVER	Beach	N
Primary Town	STRATHAM	Assessment Unit Category*~	5-P

2010, 305(b)/303(d) - All Reviewed Parameters by Assessment Unit

Designated Use Description	*Desig. Use Category	Desig. Use Threat	Parameter Name	Parameter Threatened (Y/N)	Parameter Category*	TMDL Schedule	Expected To Attain Date	Source Name (Impairments only)
Aquatic Life	5-P		ENDRIN	N	2-G			
			Estuarine Bioassessments	N	5-P	2021		Source Unknown
			FLUORANTHENE	N	5-M	2023		Source Unknown
			FLUORENE	N	5-M	2023		Source Unknown
			HEXACHLOROBENZENE	N	2-G			
			INDENO[1,2,3-CD]PYRENE	N	2-G			
			IRON	N	2-G			
			LEAD	N	5-M	2023		Source Unknown
			LINDANE	N	2-G			
			Light Attenuation Coefficient	N	5-P	2021		Source Unknown
			MERCURY	N	5-M	2023		Source Unknown
			NAPHTHALENE	N	2-G			
			NICKEL	N	5-M	2023		Source Unknown
			Nitrogen (Total)	N	5-P	2021		Source Unknown
			Oxygen, Dissolved	N	5-P	2019		Source Unknown
			PHENANTHRENE	N	5-M	2023		Source Unknown
			POLYCHLORINATED BIPHENYLS	N	2-G			
			PYRENE	N	5-M	2023		Source Unknown
			SILVER	N	2-G			
			TOXAPHENE	N	2-G			
			TRANS-NONACHLOR		5-M	2023		Source Unknown
			ZINC	N	5-M	2023		Source Unknown
			pH	N	5-P	2021		Source Unknown
Drinking Water After Adequate Treatment	2-G		COPPER	N	3-PAS			
			ESCHERICHIA COLI	N	3-PNS			
			FECAL COLIFORM	N	3-PNS			
			NICKEL	N	3-PAS			
			ZINC	N	3-PAS			

Severe	Poor	Likely Bad	No Data	Likely Good	Marginal	Good
Not Supporting, Severe	Not Supporting, Marginal	Insufficient Information – Potentially Not Supporting	No Data	Insufficient Information – Potentially Full Supporting	Full Support, Marginal	Full Support, Good

*DES Categories; 2-G = Supports Parameter well above criteria, 2-M = Supports Parameter marginally above criteria, 2-OBS = Exceeds WQ criteria but natural therefore not a WQ exceedence, 3-ND = Insufficient Information/No data, 3-PAS= Insufficient Information/Potentially Attaining Standard, 3-PNS= Insufficient Information/Potentially Not Attaining Standard, (4A=Impaired/TMDL Completed, 4B=Impaired/Other Measure will rectify Impairment, 4C=Impaired/Non-Pollutant, 5=Impaired/TMDL needed) M=Marginal Impairment, P=Severe Impairment, T=Threatened (http://des.nh.gov/organization/divisions/water/wmb/swqa/index.htm)

2010, 305(b)/303(d) - All Reviewed Parameters by Assessment Unit

Assessment Unit ID NHEST600030806-01
Assessment Unit Name SQUAMSCOTT RIVER
Primary Town STRATHAM

Size 0.4777 SQUARE MILES
Beach N
Assessment Unit Category*~ 5-P

Designated Use Description	*Desig. Use Category	Desig. Use Threat	Parameter Name	Parameter Threatened (Y/N)	Parameter Category*	TMDL Schedule	Expected To Attain Date	Source Name (Impairments only)
Fish Consumption	5-M		COPPER	N	3-PAS			
			Mercury	N	5-M	2017		Source Unknown Atmospheric Deposition - Toxics
			NICKEL	N	3-PAS			
			Polychlorinated biphenyls	N	5-M	2017		Source Unknown
			ZINC	N	3-PAS			
Primary Contact Recreation	5-P		Chlorophyll-a	N	5-P	2012		Source Unknown
			Enterococcus	N	5-P	2010		Animal Feeding Operations (NPS) Wet Weather Discharges (Point Source and Combination of Stormwater, SSO or CSO) Combined Sewer Overflows Source Unknown
			Nitrogen (Total)	N	5-P	2021		Source Unknown
Secondary Contact Recreation	5-P		Enterococcus	N	5-P	2010		Combined Sewer Overflows
Shellfishing	5-M		COPPER	N	3-PAS			
			Dioxin (including 2,3,7,8-TCDD)	N	5-M	2017		Source Unknown
			Fecal Coliform	N	3-PNS			
			Mercury	N	5-M	2017		Source Unknown Atmospheric Deposition - Toxics
			NICKEL	N	3-PAS			
			Polychlorinated biphenyls	N	5-M	2017		Source Unknown
			ZINC	N	3-PAS			
Wildlife	3-ND							

Severe	Poor	Likely Bad	No Data	Likely Good	Marginal	Good
Not Supporting, Severe	Not Supporting, Marginal	Insufficient Information – Potentially Not Supporting	No Data	Insufficient Information – Potentially Full Supporting	Full Support, Marginal	Full Support, Good

*DES Categories; 2-G = Supports Parameter well above criteria, 2-M = Supports Parameter marginally above criteria, 2-OBS = Exceeds WQ criteria but natural therefore not a WQ exceedence, 3-ND = Insufficient Information/No data, 3-PAS= Insufficient Information/Potentially Attaining Standard, 3-PNS= Insufficient Information/Potentially Not Attaining Standard, (4A=Impaired/TMDL Completed, 4B=Impaired/Other Measure will rectify Impairment, 4C=Impaired/Non-Pollutant, 5=Impaired/TMDL needed) M=Marginal Impairment, P=Severe Impairment, T=Threatened (http://des.nh.gov/organization/divisions/water/wmb/swqa/index.htm)

Assessment Unit ID NHIMP600030805-04
Assessment Unit Name EXETER RIVER
Primary Town EXETER

Size 36.0000 ACRES
Beach N
Assessment Unit Category*~ 5-P

2010, 305(b)/303(d) - All Reviewed Parameters by Assessment Unit

Designated Use Description	*Desig. Use Category	Desig. Use Threat	Parameter Name	Parameter Threatened (Y/N)	Parameter Category*	TMDL Schedule	Expected To Attain Date	Source Name (Impairments only)
Aquatic Life	5-P		AMMONIA (UN-IONIZED)	N	2-G			
			CHLORIDE	N	3-PAS			
			Chlorophyll-a		3-ND			
			Dissolved oxygen saturation	N	5-M	2021		Source Unknown
			Oxygen, Dissolved	N	5-P	2019		Source Unknown
			pH	N	5-M	2019		Atmospheric Deposition - Acidity
Drinking Water After Adequate Treatment	2-G		ESCHERICHIA COLI	N	3-PNS			
Fish Consumption	4A-M		Mercury	N	4A-M	2017		Atmospheric Deposition - Toxics
Primary Contact Recreation	5-P		Chlorophyll-a	N	5-M	2019		Source Unknown
			Escherichia coli	N	5-P	2010		Source Unknown
								Illicit Connections/Hook-ups to Storm Sewers
Secondary Contact Recreation	5-M		Escherichia coli	N	5-M	2010		Source Unknown
Wildlife	3-ND							

Severe	Poor	Likely Bad	No Data	Likely Good	Marginal	Good
Not Supporting, Severe	Not Supporting, Marginal	Insufficient Information – Potentially Not Supporting	No Data	Insufficient Information – Potentially Full Supporting	Full Support, Marginal	Full Support, Good

*DES Categories; 2-G = Supports Parameter well above criteria, 2-M = Supports Parameter marginally above criteria, 2-OBS = Exceeds WQ criteria but natural therefore not a WQ exceedence, 3-ND = Insufficient Information/No data, 3-PAS= Insufficient Information/Potentially Attaining Standard, 3-PNS= Insufficient Information/Potentially Not Attaining Standard, (4A=Impaired/TMDL Completed, 4B=Impaired/Other Measure will rectify Impairment, 4C=Impaired/Non-Pollutant, 5=Impaired/TMDL needed) M=Marginal Impairment, P=Severe Impairment, T=Threatened (http://des.nh.gov/organization/divisions/water/wmb/swqa/index.htm)

2010, 305(b)/303(d) - All Reviewed Parameters by Assessment Unit

Assessment Unit ID NHRIV600030805-02
Assessment Unit Name EXETER RIVER
Primary Town EXETER

Size 5.2950 MILES
Beach N
Assessment Unit Category*~ 5-P

Designated Use Description	*Desig. Use Category	Desig. Use Threat	Parameter Name	Parameter Threatened (Y/N)	Parameter Category*	TMDL Schedule	Expected To Attain Date	Source Name (Impairments only)
Aquatic Life	5-P		Benthic-Macroinvertebrate Bioassessments (Streams)		3-ND			
			CHLORIDE	N	3-PAS			
			Dissolved oxygen saturation	N	5-P	2016		Source Unknown
			Fishes Bioassessments (Streams)		3-ND			
			Other flow regime alterations		3-PNS			
			Oxygen, Dissolved	N	5-P	2019		Source Unknown
			pH	N	5-M	2019		Source Unknown
Drinking Water After Adequate Treatment	2-G							
Fish Consumption	4A-M		Mercury	N	4A-M	2017		Atmospheric Deposition - Toxics
Primary Contact Recreation	5-P		Escherichia coli	N	5-P	2010		Source Unknown
Secondary Contact Recreation	3-ND		Escherichia coli		3-ND			
Wildlife	3-ND							

Severe	Poor	Likely Bad	No Data	Likely Good	Marginal	Good
Not Supporting, Severe	Not Supporting, Marginal	Insufficient Information – Potentially Not Supporting	No Data	Insufficient Information – Potentially Full Supporting	Full Support, Marginal	Full Support, Good

*DES Categories; 2-G = Supports Parameter well above criteria, 2-M = Supports Parameter marginally above criteria, 2-OBS = Exceeds WQ criteria but natural therefore not a WQ exceedence, 3-ND = Insufficient Information/No data, 3-PAS= Insufficient Information/Potentially Attaining Standard, 3-PNS= Insufficient Information/Potentially Not Attaining Standard, (4A=Impaired/TMDL Completed, 4B=Impaired/Other Measure will rectify Impairment, 4C=Impaired/Non-Pollutant, 5=Impaired/TMDL needed) M=Marginal Impairment, P=Severe Impairment, T=Threatened (http://des.nh.gov/organization/divisions/water/wmb/swqa/index.htm)

2010, 305(b)/303(d) - All Reviewed Parameters by Assessment Unit

Assessment Unit ID NHRIV600030805-09
Assessment Unit Name EXETER RIVER
Primary Town EXETER

Size 0.9760 MILES
Beach N
Assessment Unit Category*~ 5-P

Designated Use Description	*Desig. Use Category	Desig. Use Threat	Parameter Name	Parameter Threatened (Y/N)	Parameter Category*	TMDL Schedule	Expected To Attain Date	Source Name (Impairments only)
Aquatic Life	5-P		Dissolved oxygen saturation	N	5-M	2021		Source Unknown
			Oxygen, Dissolved	N	5-P	2021		Source Unknown
			PH	N	3-PAS			
Drinking Water After Adequate Treatment	2-G							
Fish Consumption	4A-M		Mercury	N	4A-M	2017		Atmospheric Deposition - Toxics
Primary Contact Recreation	3-ND		Escherichia coli		3-ND			
Secondary Contact Recreation	3-ND		Escherichia coli		3-ND			
Wildlife	3-ND							

Severe	Poor	Likely Bad	No Data	Likely Good	Marginal	Good
Not Supporting, Severe	Not Supporting, Marginal	Insufficient Information – Potentially Not Supporting	No Data	Insufficient Information – Potentially Full Supporting	Full Support, Marginal	Full Support, Good

*DES Categories; 2-G = Supports Parameter well above criteria, 2-M = Supports Parameter marginally above criteria, 2-OBS = Exceeds WQ criteria but natural therefore not a WQ exceedence, 3-ND = Insufficient Information/No data, 3-PAS= Insufficient Information/Potentially Attaining Standard, 3-PNS= Insufficient Information/Potentially Not Attaining Standard, (4A=Impaired/TMDL Completed, 4B=Impaired/Other Measure will rectify Impairment, 4C=Impaired/Non-Pollutant, 5=Impaired/TMDL needed) M=Marginal Impairment, P=Severe Impairment, T=Threatened (http://des.nh.gov/organization/divisions/water/wmb/swqa/index.htm)

Assessment Unit ID	NHRIV600030805-32	Size	0.0550 MILES
Assessment Unit Name	SQUAMSCOTT RIVER	Beach	N
Primary Town	EXETER	Assessment Unit Category*~	3-ND

2010, 305(b)/303(d) - All Reviewed Parameters by Assessment Unit

Designated Use Description	*Desig. Use Category	Desig. Use Threat	Parameter Name	Parameter Threatened (Y/N)	Parameter Category*	TMDL Schedule	Expected To Attain Date	Source Name (Impairments only)
Aquatic Life	3-ND		Dissolved oxygen saturation		3-ND			
			Oxygen, Dissolved		3-ND			
			pH		3-ND			
Drinking Water After Adequate Treatment	2-G							
Fish Consumption	4A-M		Mercury	N	4A-M			Atmospheric Deposition - Toxics
Primary Contact Recreation	3-ND		Escherichia coli		3-ND			
Secondary Contact Recreation	3-ND		Escherichia coli		3-ND			
Wildlife	3-ND							

Severe	Poor	Likely Bad	No Data	Likely Good	Marginal	Good
Not Supporting, Severe	Not Supporting, Marginal	Insufficient Information – Potentially Not Supporting	No Data	Insufficient Information – Potentially Full Supporting	Full Support, Marginal	Full Support, Good

*DES Categories; 2-G = Supports Parameter well above criteria, 2-M = Supports Parameter marginally above criteria, 2-OBS = Exceeds WQ criteria but natural therefore not a WQ exceedence, 3-ND = Insufficient Information/No data, 3-PAS= Insufficient Information/Potentially Attaining Standard, 3-PNS= Insufficient Information/Potentially Not Attaining Standard, (4A=Impaired/TMDL Completed, 4B=Impaired/Other Measure will rectify Impairment, 4C=Impaired/Non-Pollutant, 5=Impaired/TMDL needed) M=Marginal Impairment, P=Severe Impairment, T=Threatened (http://des.nh.gov/organization/divisions/water/wmb/swqa/index.htm)

Appendix L

Cultural Resources Reports

INDIVIDUAL INVENTORY FORM

NHDHR INVENTORY #

35. Photo #1 Direction: W
36. Date 2011
37. Reference #: EXE0043 01

Name, Location, Ownership

1. Historic name Great Dam
2. District or area Exeter Waterfront Commercial H.D.
3. Street and number Exeter River, 200 ft. downstream of High St. Bridge (Great Bridge)
4. City or town Exeter
5. County Rockingham
6. Current owner Town Exeter/NH Fish & Game

Function or Use

7. Current use(s) Dam and fish passage
8. Historic use(s) Dam

Architectural Information

9. Style N/A
10. Architect/builder N/A
11. Source N/A
12. Construction date 1914
13. Source NH DES inspection report (2000)
14. Alterations, with dates c. 1938, 1968, post-2000
15. Moved? no ☒ yes ☐ date:

Exterior Features

16. Foundation N/A
17. Cladding N/A
18. Roof material N/A
19. Chimney material N/A
20. Type of roof N/A
21. Chimney location N/A
22. Number of stories N/A
23. Entry location N/A
24. Windows N/A
    Replacement? no ☐ yes ☐ date: N/A

Site Features

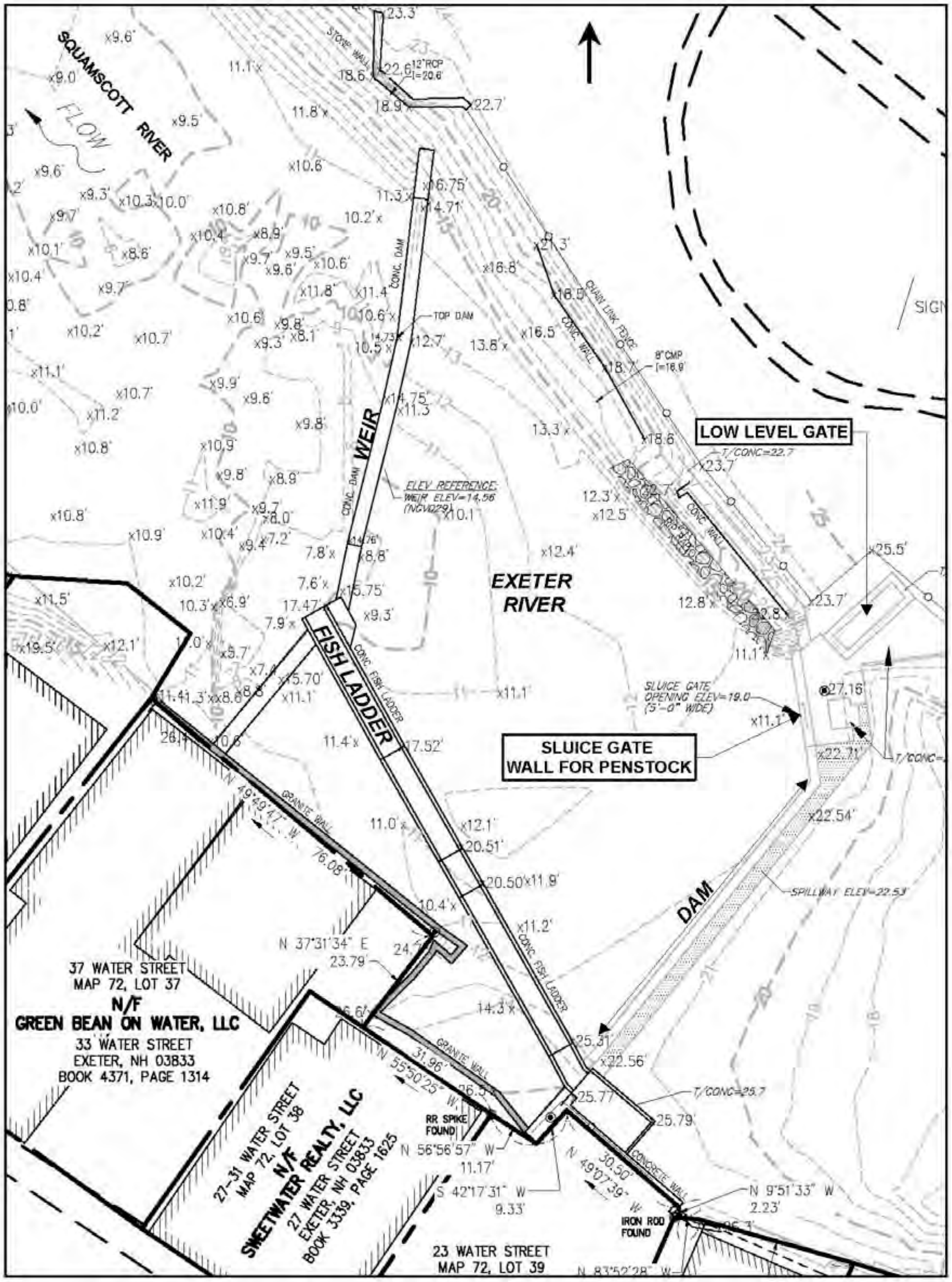
25. Setting Downtown business district
26. Outbuildings N/A
27. Landscape features N/A
28. Acreage N/A
29. Tax map/parcel # N/A
30. UTM reference 4760568N, 341453E
31. USGS quadrangle and scale Exeter, 24,000

Form prepared by

32. Name Rita Walsh and Nicole Benjamin-Ma
33. Organization Vanasse Hangen Brustlin, Inc.
34. Date of survey November 2011

39. LOCATION MAP:

40. PROPERTY MAP:



41. Historical Background and Role in the Town or City's Development:

Summary

The Exeter River's Great Dam (#082.01 in NH DES system), located in the heart of Exeter's central business district, has served an important role in the town's industrial history for almost 100 years. Its location just upstream of the Great Falls has been the site of a dam since the 1640s[1], which provided the source of water power for numerous mills that lined the banks of the Exeter River until 1828. In that year, the Exeter Manufacturing Company and Exeter Mill and Water Power Company purchased the existing dam and water rights and agreed to build a new dam within nine months. The specific completion date for this dam and what type of dam it was is unknown.

The dam from the late 1820s served the Exeter Manufacturing Company, presumably until its replacement in 1914 with the existing concrete gravity dam. No information was found to prove that the 1820s dam was not replaced or modified earlier, although it appeared that the company was preparing to build a new dam by 1896. No plans were found of the 1914 concrete gravity dam and the reason for the dam's replacement in 1914 is unknown.

Modifications were made to the 1914 dam in 1938 and 1968. The nature of the repairs in 1938 is unknown. In the latter year, a concrete fish passage and concrete weir were added by the New Hampshire Fish and Game Department to facilitate fish passage in the river. In October 1981, the dam and its associated water rights were sold to the Town of Exeter by the Miliken Manufacturing Company, which had taken over the operation of the Exeter Manufacturing Company complex in 1966. The last owner and occupant of the mill complex was the Nike Company, which purchased the mill in 1981, but only operated for two years until it closed in 1983. After standing vacant for a few years, the industrial complex was rehabilitated for housing by the Arbor Development Company in the late 1980s, after their purchase in 1986. Only the underground penstock beneath the area that is now Founders' Park on the east bank of the Exeter River is still part of the former industrial complex. The penstock is currently used for cooling water and fire suppression purposes for the condominiums.

Dams and Early Mill Activity at the Great Falls

When the current Great Dam was built in 1914, it had been preceded by over 275 years of water power and mill activities in the immediate area of the Great Falls, from which the dam took its name. The first two centuries of development in the vicinity of Great Falls revolved mostly around family-run mills and some small commercial enterprises along Water Street, on the west bank of the Exeter River, and on the east bank as well. During the 1630s, Reverend John Wheelwright moved from Newburyport, Massachusetts, with his small congregation, seeking more religious freedom than allowed by the Massachusetts Bay Colony. The first settlement was by Great Falls, which allowed residents to take advantage of the water power provided by the falls, the availability of abundant lumber, and the navigability of the Exeter and Squamscott Rivers for transport.

The earliest mill in Exeter was downstream of the Great Dam at the Lower Falls where the String Bridge crosses the Exeter River at Kimball's Island; Thomas Wilson was granted the right to Kimball's Island where he established his grist mill in 1640, two years after the town of Exeter was founded. The earliest mills at the Upper Falls were established soon thereafter in the 1640s by members of the town's prominent Gilman family. Edward Gilman built two saw mills, one on each side of the river. Other members of the Wilson and Gilman families also established mills in the Great Falls vicinity of downtown Exeter, including Humphrey Wilson's saw mill on the east side of the river, and John Gilman's grist mill constructed on the small island at the Lower Falls, now in the center of String Bridge; Bell 1888, 331-332). Several types of mills utilized the falls during the 18th century: the 1802 Plan of Exeter indicates a grist mill, a saw mill, an oil mill, a fulling mill, and two unspecified mills along the banks of the river at Great Falls (Merrill 1802). This map shows a dam in the location of the current Great Dam and two dams with a rounded profile on either side of Kimball's Island, although this map does not show the island itself (it is only referred to as "ledge" and it does not show any buildings on the ledge). Other industries near the river included a nail factory in Hemlock Square, near the east bank of the river near High Street and a starch factory, built 1824, which provided starch to textile factories in Lowell, Massachusetts, at the foot of Great Bridge (High Street) and Franklin Street (Perry 1913, 18-19).

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1 A dam is assumed to have been built by Edward Gilman near or at this location for his mills built in the late 1640s.

Construction of New Dam and Establishment of the Exeter Manufacturing Company

In 1827, seven local men formed two companies that would come to dominate Exeter's central area and have an enormous effect on the town's economy. The original proprietors of both the Exeter Manufacturing Company and the Exeter Mill and Water Power Company were Nathaniel Gilman, John Taylor Gilman, Bradbury Cilley, Steven Hanson, John Rogers, Nathaniel Gilman, III, and Paine Wingate (Textile Age, January 1942, p. 28). The men were the owners of existing Exeter River mill sites at both the Upper and Lower Falls (Griset, n.d.). In an indenture dated February 12, 1828 the company agreed "to build within nine months from the date hereof a good & sufficient new & permanent dam at or near the place where the present upper dam now is & which shall raise the water in said river to the same elevation & height as it is raised by the present dam" (Deed 253/142). The type of dam built and when it was actually constructed within the nine-month period is unknown. An 1831 survey of the Exeter River shows a dam labeled as the Exeter Upper Falls Dam at the current Great Dam site that has an elevation of 18.97 feet and head of the same height (Griset, n.d.). The new company, which was engaged in cotton textile manufacturing, began production in 1830 with two large water wheels and 5,000 spindles (Griset, n.d.).

Beginning in 1844, a series of deeds regarding flowage rights between the Exeter Manufacturing Company and owners of property adjacent to the Exeter and Little Rivers acknowledge previous damage to these lands by flooding, provide damage settlements, and place a restriction on the company to not raise the dams or cause additional damages (Griset, n.d.).

On July 13, 1861, the Exeter Mill and Water Power Company transferred its remaining rights by deed to the Exeter Manufacturing Company in accordance with an act of the legislature dated June 21, 1861. The transfer's intent was to combine all of the mill, water and flowage rights to a single company and to dissolve the other (Griset, n.d.). A history of the company in the textile trade magazine, *Textile Age*, states that the Exeter Manufacturing Company purchased sole rights to the river in 1861 "after the other industries along the river had passed out of existence" (Textile Age, 1942, 28).

The company expanded their operations along the river in 1867 through the purchase of the Hunnewell Privilege (the former site of the Rockingham Factory Dam, on the south side of Route 111) and after a fire, built a new structure in 1876 at their Exeter property on the east bank of the Exeter River/Squamscott River. By this time, there were four large water wheels, which were at times powered by auxiliary steam power due to the "lowering of the river in the summer months". (Griset, n.d.) Two other fires, in 1887 and 1893 caused the company to rebuild again and to expand their operations in Exeter (Exeter Historical Society, MSS 72, Folder 5).

The Exeter Manufacturing Company continued to be a major influence in the town throughout the 19th century and into the 20th century and was one of the three largest industrial firms in New Hampshire (Chase, NR nomination 1984). In 1876 steam power was added to the mill, allowing the factory to continue production year-round, even through the dry season when water levels became low (Exeter Historical Society, MSS72 file). The company also purchased the Pittsfield Mills in 1895, using the Pittsfield location to manufacture materials for bleaching, dyeing and finishing at the Exeter mill (*Textile Age* 1942, 31).

The Kent family became involved with the Exeter Manufacturing Company mill in the late 19th century, beginning a century-long family legacy as managers of the mill. Hervey Kent became manager of the mill in 1862, and helped the company recover from two disastrous mill fires in 1887 and 1893. Hervey Kent's son George Kent ran the mill until his death in 1905, after which George Kent's wife Adelaide appointed agents to manage the mill until her sons were old enough to take over the responsibility during the late 1910s. As the mill was one of the town's primary economic stalwarts, the Kent family reportedly held great sway over the bank, newspaper, and town government (Carman 1987, 22).

In 1896, the Exeter Manufacturing Company transferred a small parcel of land on the west bank of the river on Water Street to the Town of Exeter (411-217, May 25, 1896) which allowed it to reconstruct and move the location of the existing dam. The lot was referred to as a portion of the "sawmill lot" abutting the Town's "engine lot". The consideration stated in the deed was a requirement for the Town to build a stone and concrete wall along the river bank and required that the northerly 25-foot length of the wall be 4 feet thick. The Exeter Manufacturing Company retained the right to construct any new dam abutments against this 25-foot section. (Griset, n.d.) Whether the company actually commenced construction of a new dam at this time is not documented.

In 1914 the company built the present dam, (Levergood, NH Department of Environmental Services, 2000). It is unknown if the dam that was replaced in Exeter was the one that the Exeter Manufacturing Company pledged to build within nine months of February 1828, a more recent dam from the 1890s, or if there had been earlier replacements in the 19th century. The company acquired the similar concrete gravity dam at the Pickpocket Falls in 1919 (and reconstructed it in 1920) from the Portsmouth Savings Bank, which resulted in the company's entire control over the Exeter River from the Squamscott River to the Brentwood Town line (Griset, n.d.

The Exeter Manufacturing Company continued to be the town's leading industry in the early 20th century, long after the other large manufacturing companies in Exeter went out of business, which helped to maintain the prominence of the downtown area around Great Falls as a commercial, municipal, industrial and residential center. By shifting focus away from producing cotton textiles, the Exeter Manufacturing Company managed to avoid the same fate. The extensive bleachery operations at the mill kept it in demand between the two world wars, and the company began selling products overseas (Carman 1987, 52).

In 1934 a spin-off company called the Exeter Handkerchief Factory was established in west Exeter on Lincoln Street, which used remnants from the mill along Great Falls to produce handkerchiefs, gas mask bags (during World War II), and later tablecloths and curtains. During World War II, the Exeter Manufacturing Company shifted to the production of industrial fabric for the military and government. After the war, the company found that it could no longer price its cotton products competitively against materials produced in the southern United States, and in the 1950s switched its production from cotton to synthetic fabrics (Tardiff 1986, 25). Rather than produce the materials in-house, the company used fabric that was manufactured elsewhere, and bleached and finished the products in their facilities (Tardiff 7/9/1980). The company produced faux leather for automobile interiors, vinyl-coated screens for General Electric, and materials for Johnson & Johnson and Westinghouse.

Regulation and oversight of dams in New Hampshire became a state function in September of 1935. The original agency charged with these functions was the Public Service Commission; the New Hampshire Dam Safety Bureau within the Department of Environmental Services now carries out these roles (Griset, n.d.). Reports from 1935 and 1938 noted the Great Dam was used a power source at that time (Griset, n.d.). By 1949, the company had changed their power sources, in addition to their products and manufacturing methods; by the mid-20th century, it relied on coal and oil for its power sources, with the water wheels supplementary to the steam engine, and together they were connected to all of the looms (Carman, 1988 36). A September 26, 1949(7) report noted that the 12-inch automatic flashboards on the dam had been removed and that according to "local people" that power from the dam was not in present use (Griset, n.d.) .

In 1952, the company boasted $18 million in sales and 450 employees in the mill (Tardiff 7/9/1980). Despite the strength of the Exeter Manufacturing Company, however, by the 1960s manager Hervey Kent, Jr. was unable to appoint a successor and sold the company and mill property to Miliken Manufacturing Company in 1966. When the Exeter Manufacturing Company was sold to the Miliken Manufacturing Company in 1966, it marked a major change in the industrial development of the town. In addition to the symbolic loss of an industrial name and family that had dominated the town for more than 100 years, the new factory employed many more automated processes (Exeter Historical Society, MSS72 file). Although the Miliken Manufacturing Company specialized in similar industrial products as its predecessor, the factory required fewer workers and was no longer such a dominant employer in the town.

The Great Dam also experienced changes at this time. In an agreement dated September 9, 1968, the Miliken Company (referred to as Miliken Industrials, Inc.) granted permission to the New Hampshire Fish and Game Department to construct, maintain, and have exclusive control of a fish ladder at the Exeter Great Dam. Constructed to allow diadromous fish passage to native spawning areas upstream, the structure resulted in physical and operational modifications to the dam complex, which included removal of a section of the spillway on the west side, installation of a new retaining wall and extension of the height of the dam to that of the low-level gate and penstock housing (Griset to Patterson, NH Fish and Game, October 26, 2005 letter).

Shortly after purchasing the factory, the Miliken Manufacturing Company constructed a holding pond and waste treatment plant adjacent to their facility where Founder's Park is now located (Carman 1987, 55). As a row of houses had occupied the current area of Founder's Park as late as the 1950s (Exeter Historical Society, MSS12 file), it is possible that these houses were removed in order to accommodate the additions to the Miliken facility. In 1981, the Miliken Manufacturing Company sold the factory to the Nike Company, and donated the water flowage rights and the Great Dam and upstream Pickpocket Dam along the Exeter River to the Town, along with the area of the Squamscott River along Great Falls (Tardiff 1986, 61). The Miliken Company retained the use of the penstock, however. Nike, the new factory occupant, manufactured simulated suede in Exeter for two years before closing the factory permanently (Carman 1987, 55) in 1983, ending the factory's nearly 160-year production history. During the late 1980s, the former factory buildings were converted into a mixed-use residential and commercial complex, with a small number of new buildings added. The penstock still remains in use for this development, supplying cooling water to four of the complex's buildings (Weston & Sampson, 2009, 3-33).

The Great Dam currently serves as an impoundment dam for the Town's water supply, a role it has had since 1981 when the Town acquired the water rights from the Miliken Company. The current dam removal feasibility study that required the preparation of this individual inventory form and a corresponding project area form is the result of the numerous orders of deficiency regarding the dam's condition and, especially, its inability to withstand a 50-year flood, and the concern for the Town's water supply in which the dam plays an important role.

42. Applicable NHDHR Historic Contexts:

18. Locally capitalized textile mills in NH, 1720-1920
90. Water supply, distribution and treatment in New Hampshire, 1850-present
130. Commerce, industry and trade in New Hampshire village and town centers, 1630-present

43. Architectural Description and Comparative Evaluation:

The Great Dam is located in the Exeter River near the Great Falls in the downtown area of Exeter. It is located between the High Street Bridge (known as the Great Bridge) and the String Bridge. The dam is just upstream of the line between the Exeter River and the tidal Squamscott River. Close to the dam, the east bank of the Exeter River contains Founders' Park, a narrow grass-covered slope with sidewalks that was the site of mill tenement housing and former mill sites in the 19th and 20th centuries. The west bank contains a dense cluster of mostly 19th and early 20th century commercial buildings that front on the south end of Water Street, their rear elevations are close to the river's edge, which is lined with granite retaining walls. The natural falls caused by the large ledge outcrops that fully extend between the Exeter River's west and east banks are a prominent feature in the dam's setting. The hydraulic control of these outcrops, which have a peak elevation of 15 feet, would create a smaller, natural impoundment upstream of the dam, should the dam be removed (Weston & Sampson, 2010, 3-25).

The Great Dam (Dam 82.01 in Department of Environmental Services files) is a run of the river dam that consists of five major elements – the ca. 1914 concrete gravity retaining wall dam structure, the ca. 1968 concrete fish passage, the concrete penstock and its wood baffle wall, the concrete low-level gate, and ca. 1968 concrete weir downstream of the dam and fish passage. The major spillway runs across the Exeter River in a northeast-southwest direction and is located 200 feet downstream of the High Street Bridge, known locally as the Great Bridge. The dam turns approximately 45 degrees to the northeast at the north end and frames into a concrete penstock structure and concrete sluice-gate structure containing the low-level gate. The low level gate is used to discharge water from the impoundment area to downstream of the dam. The concrete fish passage (also referred to as a fish ladder or aqueduct) is located on the west side of the river and its upstream end is located on the southwest end of the dam (Wright-Pierce, 2007, p. 3-1). The upstream impoundment created by the dam varies with the flow in the Exeter River; in 2000 the pond was estimated to be 36 acres in size (Levergood, 2000).

The dam, built on bedrock, has a maximum height of 15 feet, with an overall length of 140 feet. The upstream spillway face of the dam has a parabolic surface and the downstream face is a flat vertical surface. The concrete ogee spillway is 78 feet long[2], with a 4-foot freeboard (permanent 1-foot concrete weir) at the spillway lip. The low-level outlet, or gate, on the east bank of the river is 4.5-foot wide by 5-foot high. The penstock, also on the east bank, is 14-foot wide by 7-foot high and is now inoperable (Levergood, 2000). The underground section of the penstock extends approximately 200 yards from the east bank of the river to the former Exeter Manufacturing Company complex.

There is an 18-inch wide by 15-inch deep concrete cap above the dam spillway. It is believe that the cap was installed in the late 1960s to replace flash pins and flash boards. It appears that when the cap was installed, the portion of the dam

2 A report from 1981 (Goodspeed and Mellin) notes the spillway length is 111 feet, rather than 78 feet.

directly adjacent to the penstock gate structure was covered with the same thickness of concrete (Wright-Pierce/Woodlot, 2007, 3-1).

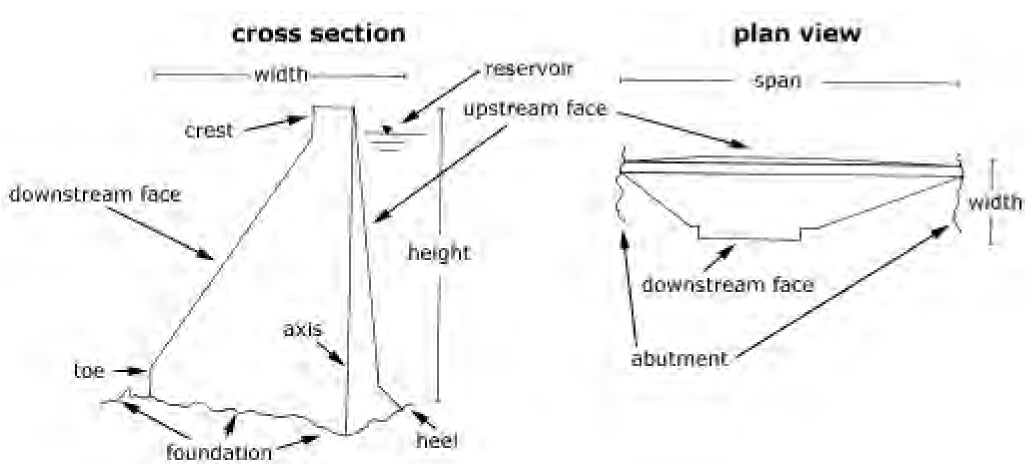
The dam gates consist of a spill gate and two control gates leading to the 14-foot wide by 7-foot high penstock. The wooden control gates are operated on a wheel and gear mechanism located 5 feet above the spillway crest. The gates are protected by an iron trash rack; a single tank is located directly behind the gates to the penstock. Redevelopment of the mill complex in the late 1980s destroyed the tail race constructed for the original turbines.

A small section of the dam extends to the south of the fish ladder on the west side of the river. The dam here is capped by a 3-foot wide by 5 feet deep concrete wall. The downstream spillway side is in poor condition, with severely exposed concrete aggregate (Wright-Pierce/Woodlot, 2007, 3-2).

The dam was extensively modified since its original construction; some of the alterations have impacted the dam's discharge capacity. These alterations include construction of the fish passage facility, which decreased the spillway length; construction of a 1-foot high concrete cap on top of the spillway crest, and de-activation of the 7-foot by 14-foot penstock (Wright-Pierce/Woodlot, 2007, 2-2). Reportedly, the dam was also modified in 1938, but no information was found that specified the alterations (Goodspeed 1981, 4).

Concrete Gravity Dams

Gravity dams are the oldest type of dam, although dams of this type constructed from concrete date to the late 19th century. The dam is characterized as a straight dam of masonry or concrete which resist the applied water load by means of its weight. A cross section and plan view of a typical gravity dam is presented below:



(from http://simscience.org/cracks/advanced/grav_anat1.html)

The first triangular gravity dams were built in Mexico in 1765 and 1800, followed by French engineer J. Augustin Tortene de Sazilly's studies that showed that a gravity dam in the shape of a triangle with a vertical upstream face was the most advantageous. The first use of concrete in a gravity dam was seen in New York State at the Boyds Corner gravity dam, built in 1872. Improvements in the strength of the concrete by controlling the water content were carried on in the late 19th century and early 20th century. Undoubtedly the most well-known example is the Hoover Dam, a curved concrete gravity dam that was constructed between 1931 and 1936 (http://simscience.org/cracks/advanced/grav_hist1.html).

44. National or State Register Criteria Statement of Significance:

The Exeter Great River Dam is considered a contributing resource to the Exeter Waterfront Commercial Historic District, which was originally listed in the National Register of Historic Places in 1980, with a boundary increase that added the former Exeter Manufacturing Company property in 1986.

The district was recognized for its association with important events associated with Exeter's early industrial and commercial growth, with an emphasis on the 18th century through the early 20th century period and its intact and sophisticated array of mostly 18th and 19th century residential, institutional, commercial, and industrial architecture. The original district nomination recognized the district's significance in Architecture, Commerce, Military, Transportation, Industry, and Invention. Industry and architecture were noted as the areas of significance in the second nomination, which recognized the importance of the Exeter Manufacturing Company buildings to the district's significance and architectural character. Neither nomination noted the specific National Register criteria which the district met, but based on the areas of significance, it can be assumed that both Criterion A (association with significant events and Criterion C (represents a significant and distinguishable entity whose components may lack individual distinction). In neither nomination was the dam noted as a contributing resource, it was only mentioned as the dam at Great Falls over which the Exeter River falls; its association with the Exeter Manufacturing Company, which built the dam in 1914, was not mentioned. In fact, in the original 1979-1980 nomination, the industrial buildings of the company were not included; but they were the subject of the boundary expansion, however, in 1986.

The dam and its outlet structures, which date to 1914 with some modifications, are recommended as contributing resources to the existing Exeter Waterfront Commercial Historic District, because the structures meet Criterion A for their role in the Exeter Manufacturing Company's continuing prominence in the town and in the state in the early to mid-20th century. The 44-year old fish passage structure and concrete weir are well outside of the district's official period of significance, which is 1700-1949 and are not recommended as contributing resources to the district. . The dam and its outlet structures are not recommended individually eligible for the National Register as the structures are a typical example of an early 20th century concrete gravity dam and are not distinguished in its engineering design, materials, or operation. As properties less than 50 years of age, the fish passage and concrete weir need to display exceptional significance to be considered individually eligible for the National Register, The fish passage and concrete weir are not recommended individually eligible for the National Register, as their design is very typical for the period and do not represent any innovations in engineering design, materials, or operation.

45. Period of Significance:

The period of significance for the Exeter Waterfront Commercial District is 1700-1949. The 1914 dam and outlet structures fall within this period of significance, but the fish ladder and concrete weir do not.

46. Statement of Integrity:
Although the dam and its outlet structures and the fish passage and concrete weir have received some alterations, their integrity is relatively intact as they all still convey their original purpose and general appearance.

47. Boundary Discussion:

The Great Dam is within the existing National Register-listed Exeter Waterfront Commercial Historic District and the local district, the Downtown Historic District. The boundaries of both districts are shown on the project area form figure. No further boundary discussion is needed.

48. Bibliography and/or References:

Anonymous, Timeline of Exeter Manufacturing Company – 1830-1966, Exeter Historical Society, MSS 72, folder 2

Aten, Carol Walker.
Postcards from Exeter (Portsmouth, NH: Arcadia Publishing, 2003).
Images of America: Exeter (Dover, NH: Arcadia Publishing, 1996).

Bell, Charles Henry. *History of the Town of Exeter, New Hampshire* (Boston: J.E. Farwell & Co., 1888).

Bennett, Lance and Jack Beard, Strafford Rockingham Regional Council, National Register nomination, Exeter Waterfront Commercial Historic District, 1980

Carman, Rebecca W. *Reflections: Exeter Mill* (Boston: Arbor Development Company, Inc., 1988).

Chase, David, National Register nomination, boundary extension, Exeter Waterfront Commercial Historic District, 1984

Exeter Historical Society
MSS72 file – Exeter Manufacturing Company

Goodspeed, Charles H, Associate Professor, University of New Hampshire, and Douglas Mellin, Exeter Town Planner, Exeter Hydropower and DHC Study, July 1981.

Griset, Brian to Cherie Patterson, NH Fish and Game, October 26, 2005 letter. Letter within NH DES Dam file for Exeter Great Dam.

Griset, Brian, "Mendez Trust-Kingston Road Property: Investigative Analysis of Impacting Factors Adversely Effecting (sic) Market Valuation and Use." No date, Griset & Sons Environmental and Boundary Consultants, report within NH DES Dam file for Exeter Great Dam.
Levergood, Grace, P.E., Dam Safety Engineer, Department of Environmental Services, Inspection Report, Dam #082.01, 2000

NH Department of Environmental Services, Dam file, Great Dam, Exeter River, #082.01

Tardiff, Olive

The Exeter-Squamscott: River of Many Uses (Rye, NH: CGC, 1986).
"A factory and its people, Part I," *Exeter News-Letter*, June 4, 1980.
"A factory and its people, Part II," *Exeter News-Letter*, July 9, 1980.

Textile Age, "Exeter Manufacturing Co.," Vol. 6, No. 1, January 1942.

Weston and Sampson, *Town of Exeter, NH, Water Supply Alternatives Study – Final Report*, January 2010

Wright-Pierce, and Woodlot Alternatives Inc., *Exeter River Study, Phase I Final Report*, March 2007

http://simscience.org/cracks/advanced/grav_hist1.html, accessed February 17, 2012

Maps

1802 Phineas Merrill, "A Plan of the Compact Part of the Town of Exeter." Exeter Historical Society archives.

1845 Joseph Dow, "Plan of Exeter Village, New Hampshire." Exeter Historical Society Archives.

1874 "Map of Exeter, New Hampshire." (Philadelphia: Sanford & Everts). Exeter Historical Society archives.

1876 Rockingham County Land Plan 0060. http:// http://nhdeeds.com/rockingham/RoHome.html, accessed February 2012.

1884 "Exeter, New Hampshire," birds-eye view (Brockton, MA: Norris & Wellge). Exeter Historical Society archives.

1886 "Exeter Water Works," Exeter Historical Society archives.

1892 "Exeter," Atlas of the State of New Hampshire (Boston: D.H. Hurd & Co.). Exeter Historical Society archives.

1896 "Exeter, New Hampshire," birds-eye view (Boston: A.W. Moore Co., Lith.). Exeter Historical Society archives.

Sanborn Fire and Insurance Company, "Exeter, NH." 1885, 1892, 1898, 1904, 1913, 1924, 1943 (updated from 1924). http://sanborn.umi.com, accessed January 2012.

Surveyor's Evaluation:

NR listed:	individual	_____	NR eligible:		NR Criteria:	A	__X__
	within district	__X__	individual	____		B	_____
			within district	_X__		C	___
Integrity:	yes	__X__	not eligible	_____		D	_____
	no	_____	more info needed	_____		E	_____

Date photos taken: 2011

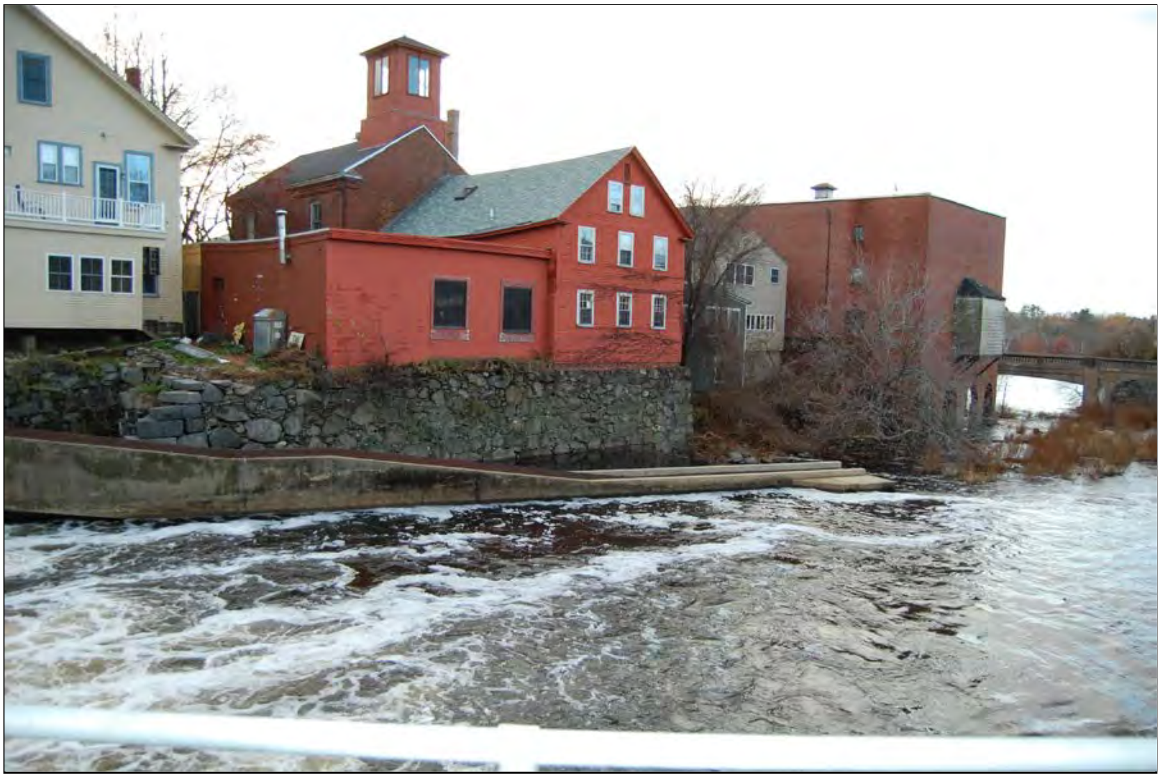


Photo # 2 Description: Ca. 1968 Fish Passage structure at west bank of Exeter River
Roll and Frame # OR Digital file name: EXE0043_02 Direction: NW

Photo # 3 Description: Fish passage (left) and penstock baffle wall (right) and low-level gate (center)
Roll and Frame # OR Digital file name: EXE0043_03 Direction: NW

Date photos taken: 2011

Photo # __4___ Description: Low-level gate (center) and penstock baffle wall (right)
Roll and Frame # OR Digital file name: EXE0043_04 Direction: NW

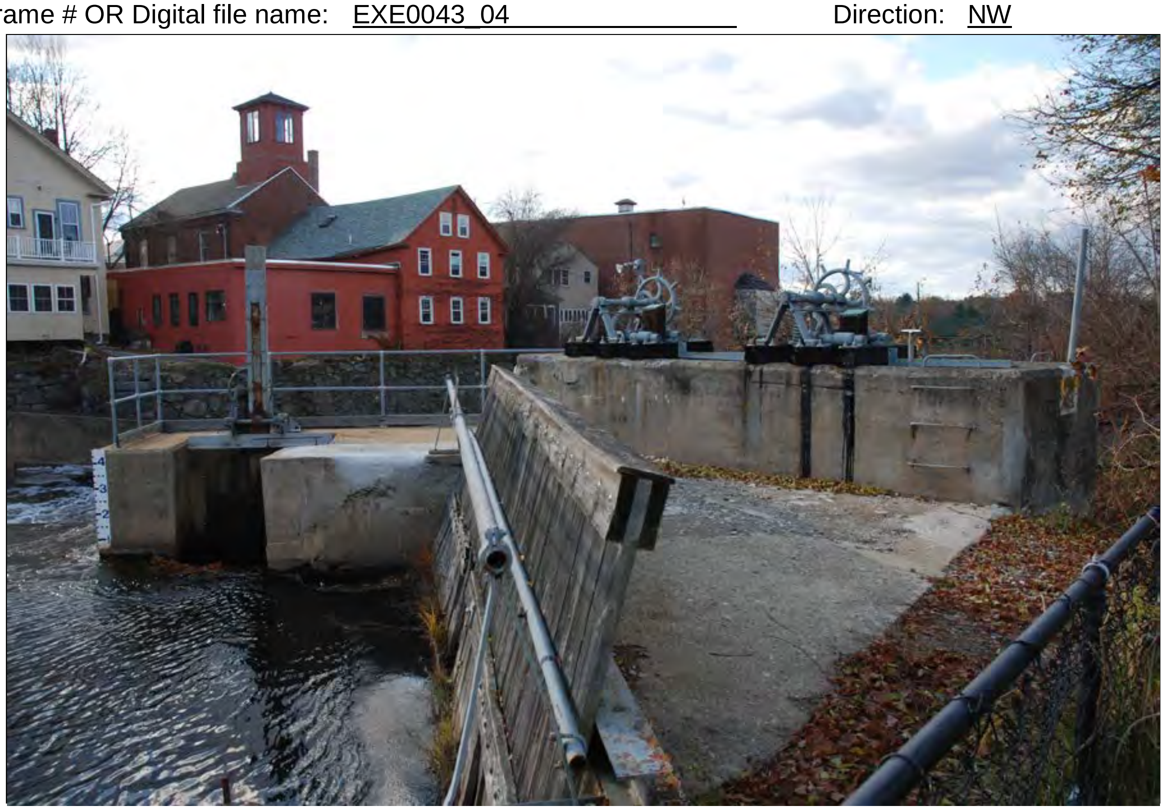


Photo # __5___ Description: Low-level gate (center) and penstock baffle wall
Roll and Frame # OR Digital file name: _EXE0043_05 Direction: NW

Date photos taken: 2011

Photo # __6___ Description: View of Founders' Park and library on east bank of Exeter River, near penstock
Roll and Frame # OR Digital file name: EXE0043_06 Direction: N

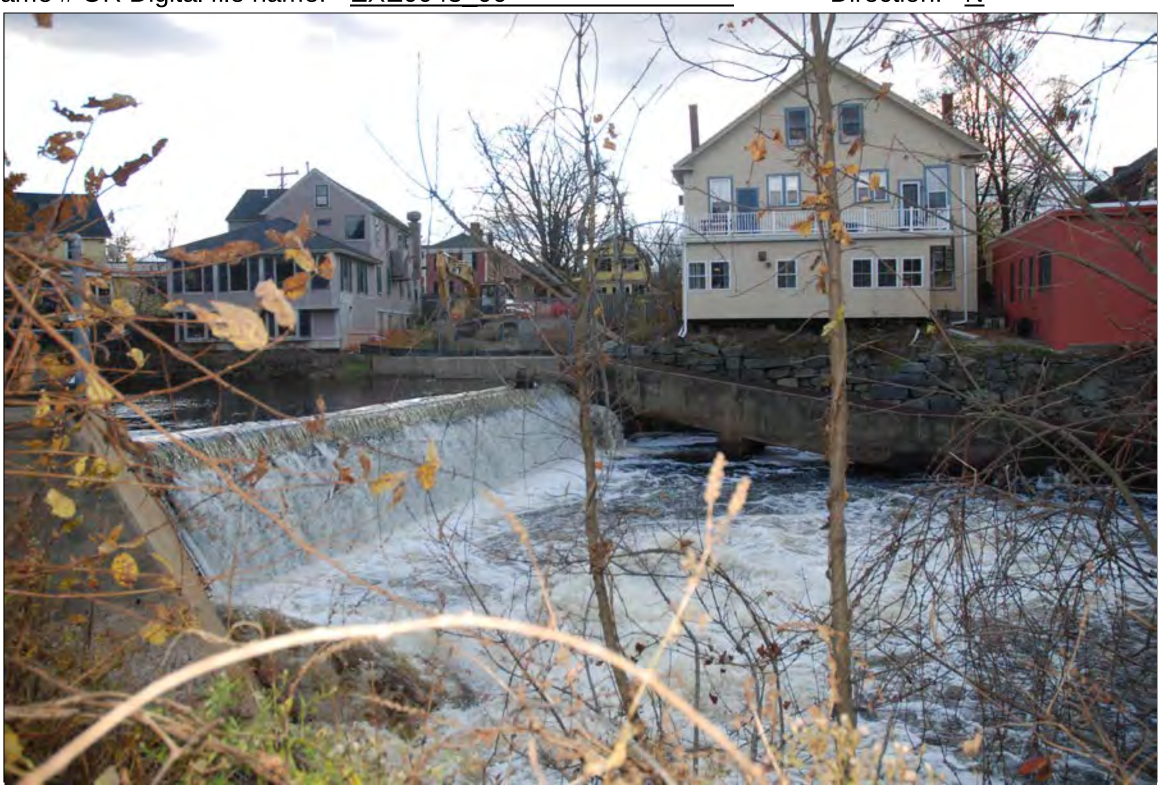


Photo # _7___ Description: View of dam and fish passage from east bank of Exeter River
Roll and Frame # OR Digital file name: EXE0043_07 Direction: W

Date photos taken: 2011

Photo # 8 Description: View of concrete weir at upstream end of spillway
Roll and Frame # OR Digital file name: EXE0043_08 Direction: NW

PHOTO LOG:

1. EXE0043_01 View of dam from East Bank of Exeter River, facing W
2. EXE0043_02 View of ca. 1968 fish passage structure at west bank of Exeter River, facing NW
3. EXE0043_03 View of fish passage (left) and penstock baffle wall (right) and low-level gate (center), facing NW
4. EXE0043_04 View of low-level gate (center) and penstock baffle wall (right), facing NW
5. EXE0043_05 View of low-level gate (center and penstock baffle wall, facing NW
6. EXE0043_06 View of Founders' Park and library on east bank of Exeter River, near penstock, facing N
7. EXE0043_07 View of dam and fish passage from east bank of Exeter River, facing W
8. EXE0043_08 View of concrete weir at upstream end of spillway, facing NW

I, the undersigned, confirm that the photos in this inventory form have not been digitally manipulated and that they conform to the standards set forth in the NHDHR Photo Policy. These photos were printed at the following commercial printer OR were printed using the following printer, ink, and paper: HP Photosmart 8050 Printer, HP Vivera 98 Ink, Hewlett Packard Premium Plus Photo Paper. The negatives or digital files are housed at/with: __VHB__________________________.

SIGNED: Rita Walsh 4/16/12

2009 and 20111 Drawdown Photos

The following images were taken in 2009 and 2011 by Brian Goetz of Weston & Sampson during drawdown episodes. These images are included, as they more clearly show the structures. The photographs' resolutions do not conform to the NHDHR digital photo size requirements, so were not included in the current photos section.

View of dam from High Street Bridge, facing N. Dam is shown in center, with penstock baffle (wood) wall and low-level gate on right hand side of photograph.

View of dam, fish passage (top center), portion of penstock baffle wall (far right), and low-level gate (center). Facing W.

View of dam (on left), low-level gate, and penstock baffle wall, facing NE from Founders' Park

View of ledge outcrops in area just upstream of dam (dam is on far right), facing W

Detailed view of penstock baffle wall, facing SE

View of ledge outcrops just upstream of dam, facing S towards High Street bridge

View of fish passage on left and concrete weir in center, facing N

View of dam parabolic side (downstream) and fish passage, facing W

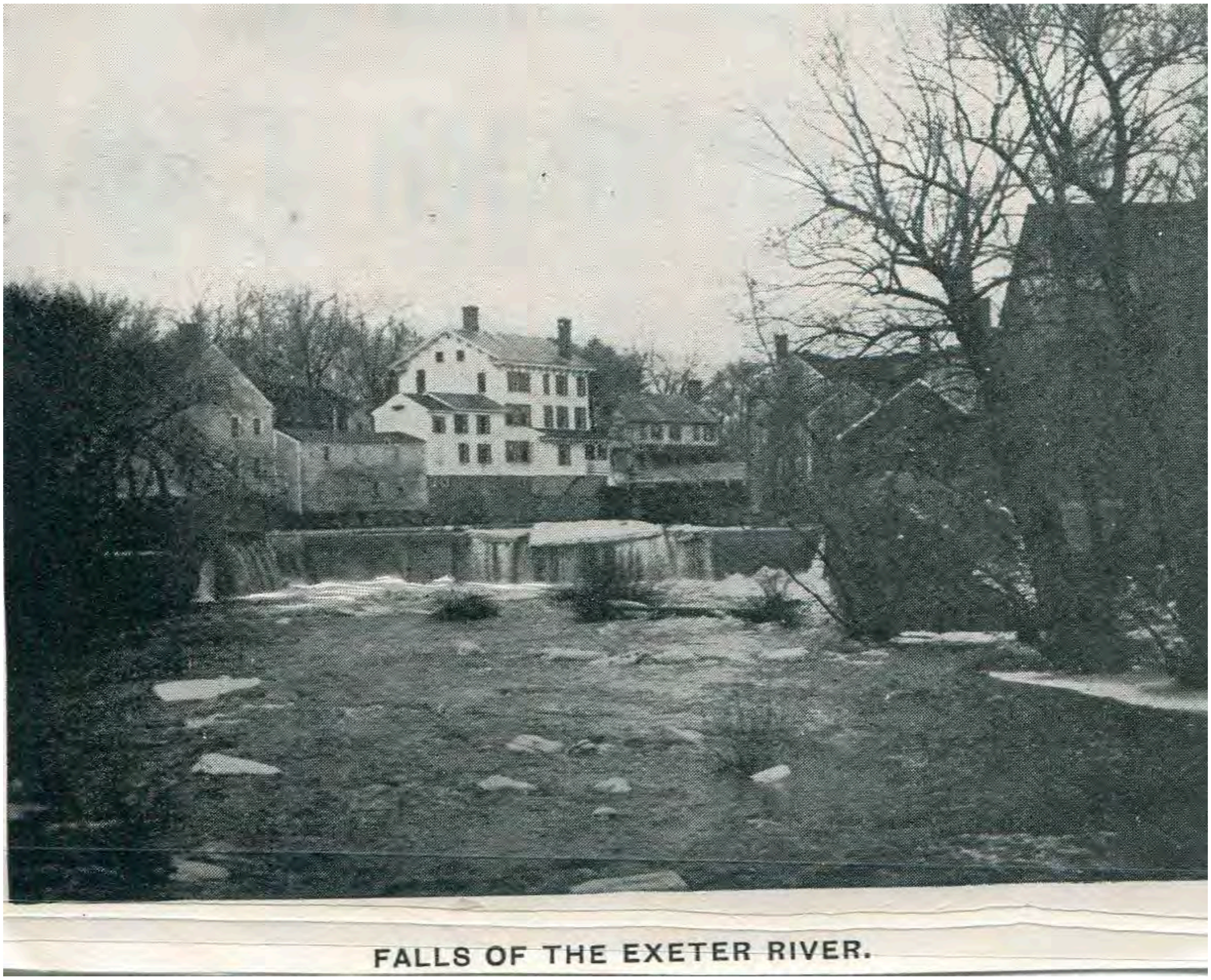
View of low-level gate (left), dam (center), and fish passage (right), facing S

View downstream of fish passage (on left), concrete weir (center) and outcrops on east bank of Exeter River, facing NE

View of ledge outcrops under east of String Bridge (downstream of the dam), facing W

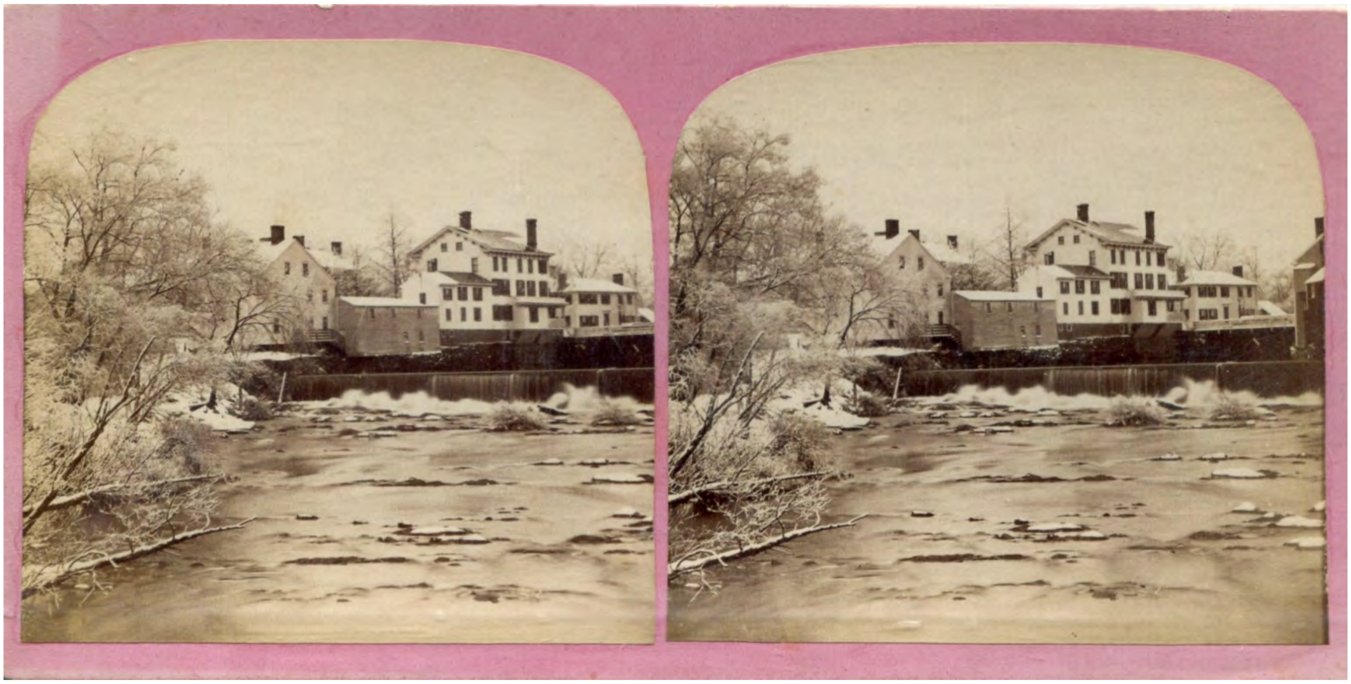
Photograph of Great Falls area facing north, ca. 1857. String Bridge and Kimball's Island on right; Great Falls and Great Dam site just out of frame on right. Carol Walker Aten refers to this as the earliest known photograph of Exeter, an ambrotype copy of a daguerreotype (Aten 1896, 9). Exeter Historical Society, MSS10 Box3_1996.26.2 Dennis Waters collection.

Photograph of Great Dam site facing southeast, 1896. Great Bridge in background. Exeter Historical Society, photographer Lizzie G. Rollins, presented by Dana W. Baker June 1928.



Photograph of Great Dam facing southeast, likely pre-1915 (Ioka Theater on Water Street not visible, constructed 1915). Great Bridge in background. Exeter Historical Society, MSS12 file.

Photograph of Great Dam facing southeast, post-1915 (Ioka Theater visible on extreme right, constructed 1915). Great Bridge in background. Exeter Historical Society, MSS12_1990.35.2.



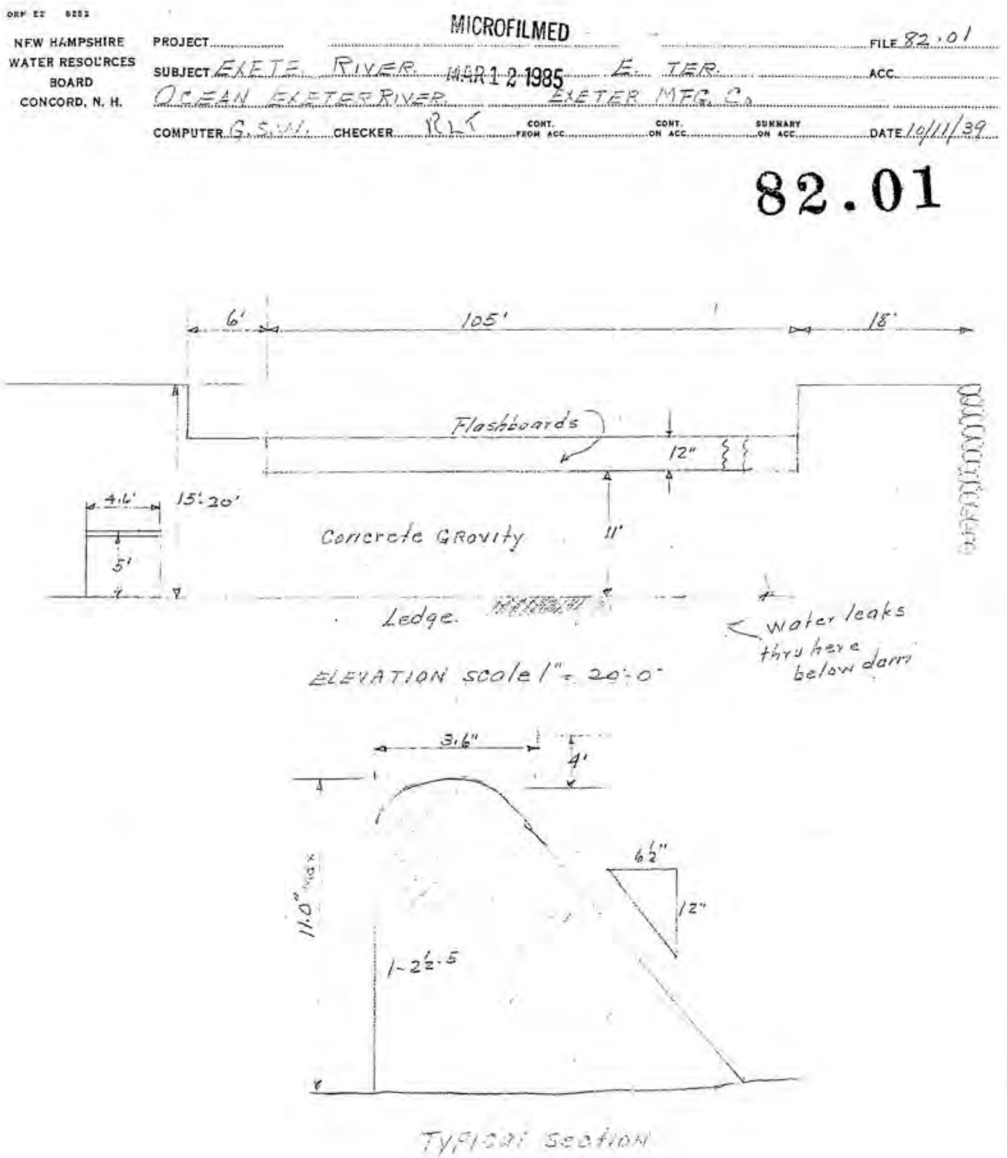
Photograph of Great Dam facing east, photographer William N. Hobbs, no date. Exeter Historical Society, Water Street_MSS12_81.11.8a.

Photograph of Great Dam facing east, post-1915 (Ioka Theater just visible on extreme right, constructed 1915). Great Bridge in background. Exeter Historical Society, MSS12_1995.109.5.

Photograph of String Bridge and Kimball's Island facing southeast, Great Dam visible in background through bridge, post-1915 (Ioka Theater just visible on extreme right, constructed 1915). Exeter Historical Society, MSS12_1998.89.24.

Photograph of Great Dam facing northwest, taken from Great Bridge, J.S. Mitchell photographer, no date. String Bridge and Kimball's Island in background. Exeter Historical Society, MSS12.

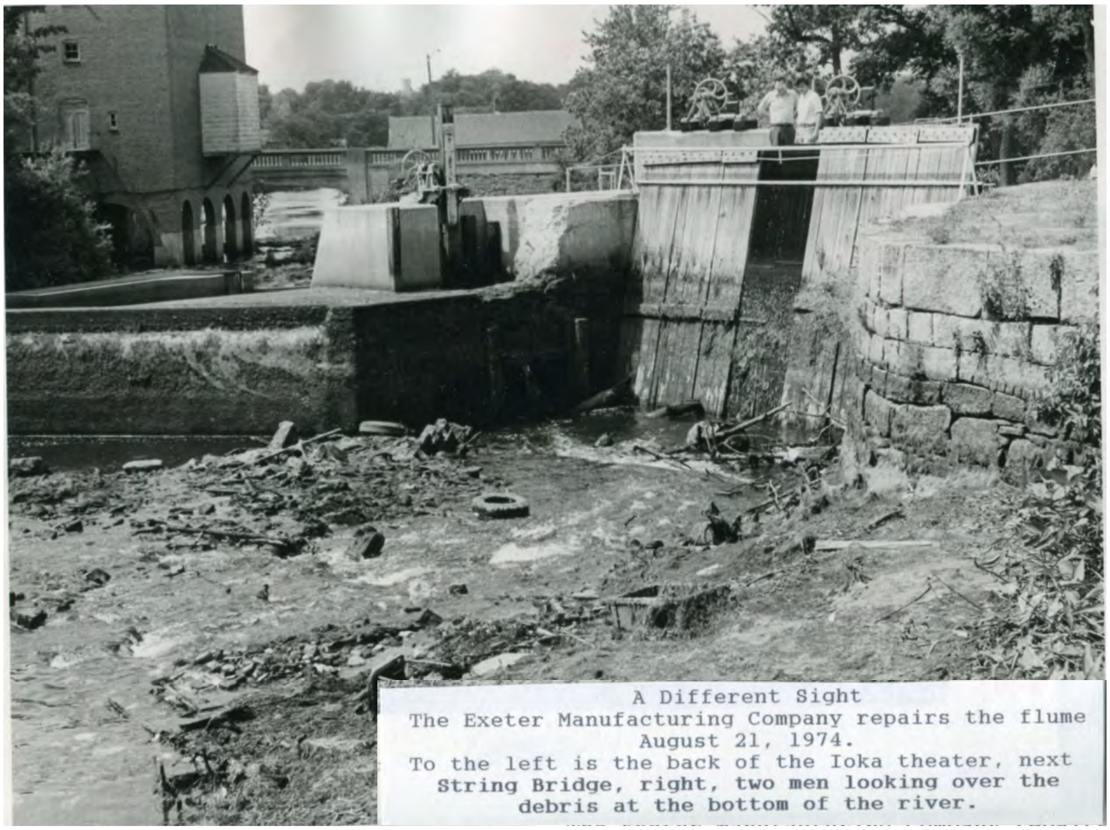
Photograph of Great Dam facing southeast, 1938. Great Bridge in background, Ioka Theater on right. Exeter Historical Society, MSS12_85.48.4.



Typical section and elevation of Great Dam, Dam Inspection Sheet, 1939 (from NHDES Dam File, #082.01.

Aerial photograph of Great Falls area and downtown Exeter, 1950s, Ben Swiezynski photographer. View is facing west. Great Dam is in the center of the photograph, between String Bridge and Great Bridge. High Street extends out of frame on the bottom of the photograph. Exeter Manufacturing Company mill is on the right along the river. Exeter Historical Society, Water Street_MSS12_1996.77.275.

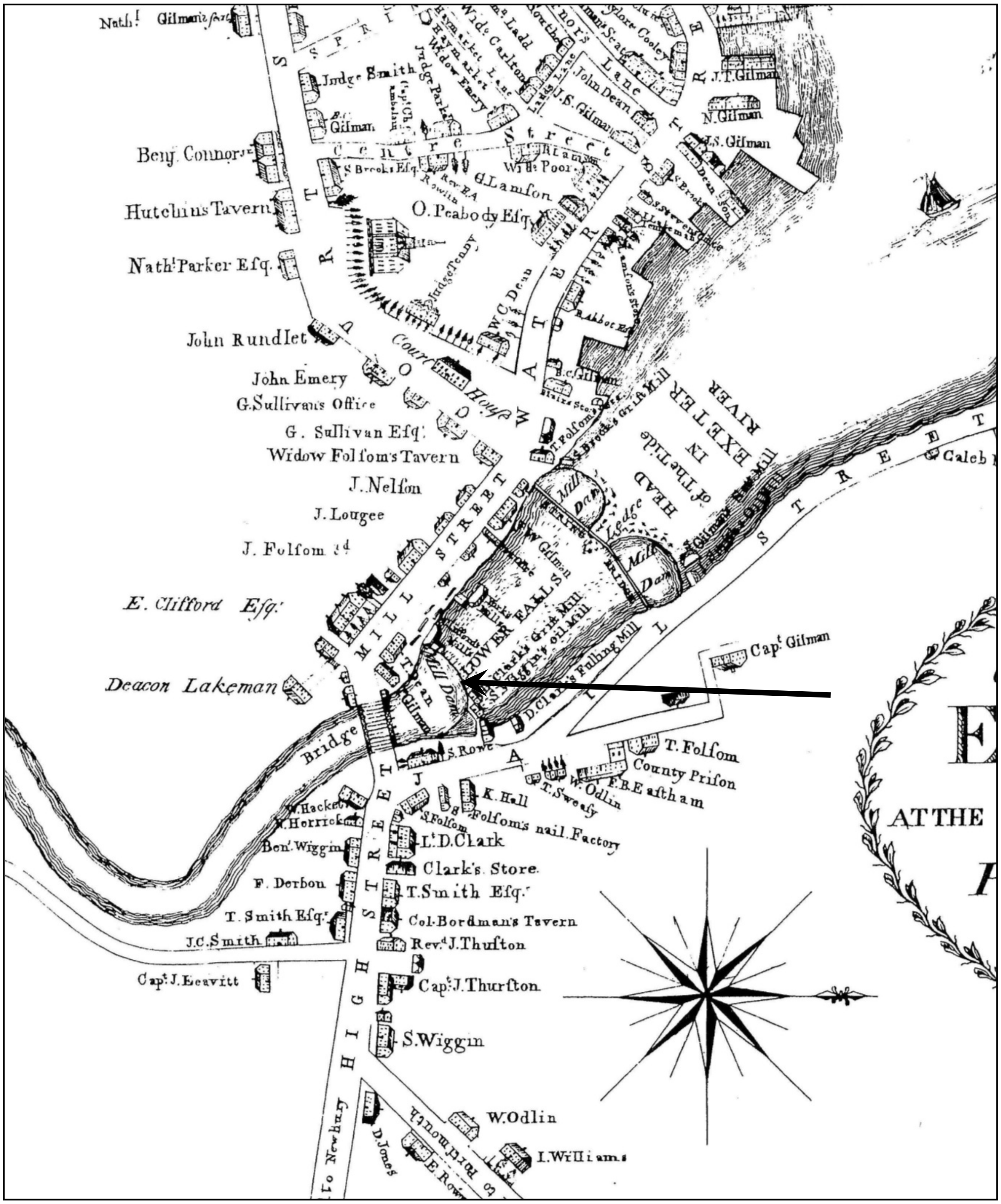
Photograph of Great Dam facing east, 1972, Pleasant Street in background. Exeter Historical Society, MSS12_1998.91.99.



Photograph of Great Dam facing northwest, 1974, with Exeter Historical Society caption. Exeter Historical Society, MSS12_1996.77.177.

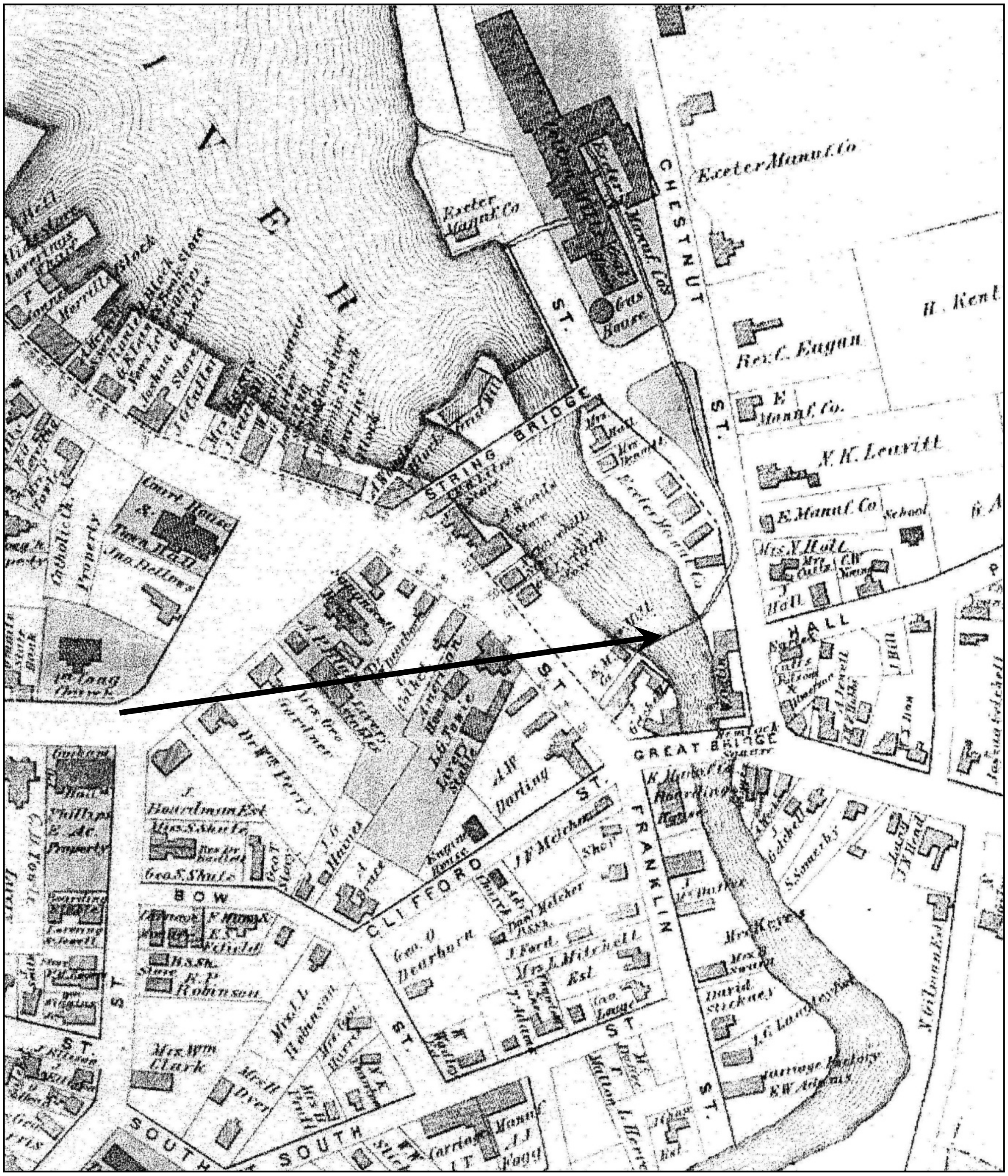
Photograph of Great Dam facing east, 1984, Pleasant Street in background. Exeter Historical Society, MSS12_86.63.2.

Photograph of 1893 Exeter Manufacturing Company Mill fire, 1893. Exeter Historical Society, MSS72.

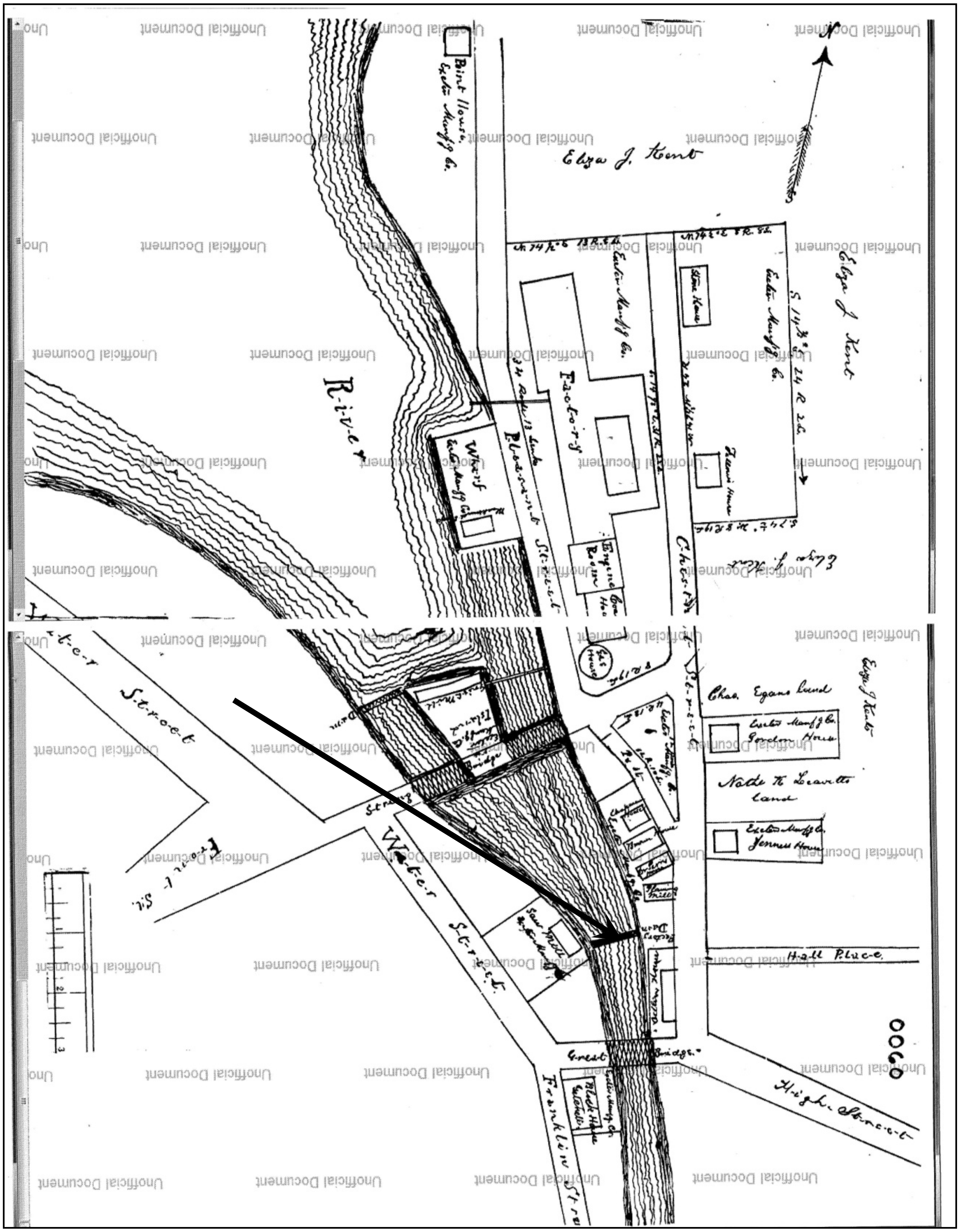


Phineas Merrill, “A Plan of the Compact Part of the Town of Exeter,” 1802. Exeter Historical Society archives. Location of Great Dam indicated by arrow.

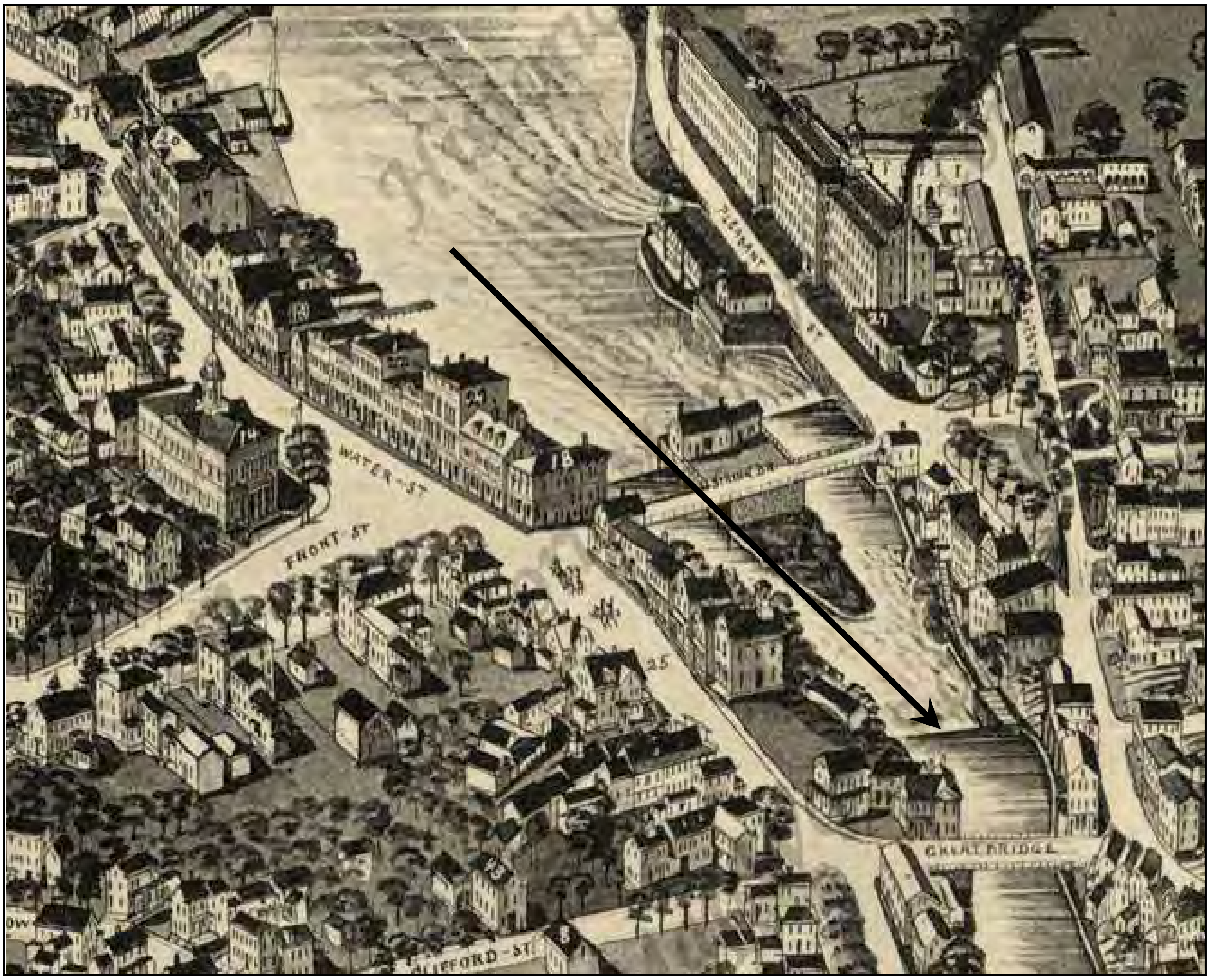
Joseph Dow, "Plan of Exeter Village, New Hampshire," 1845. Exeter Historical Society Archives.
Location of Great Dam indicated by arrow.



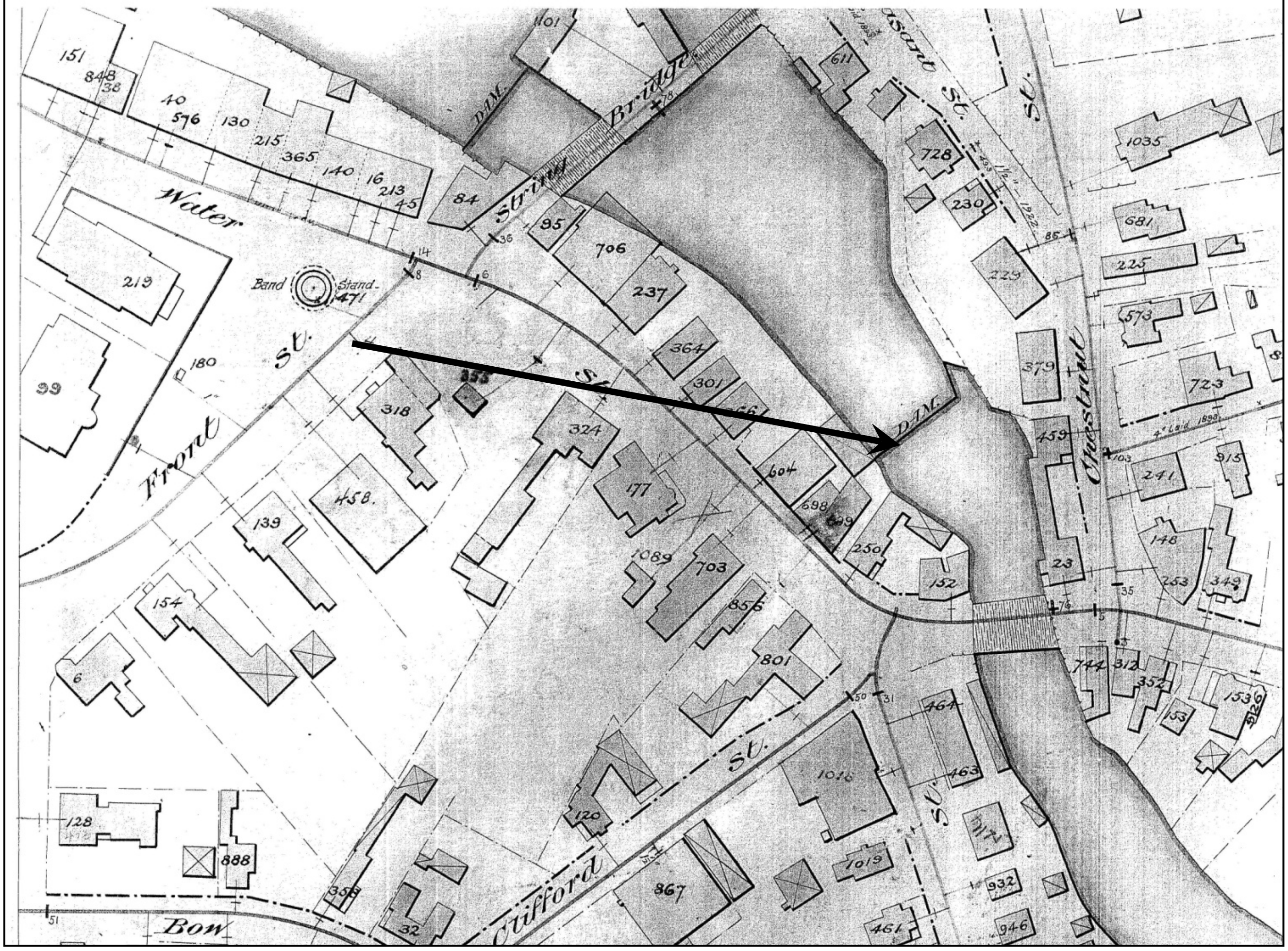
Sanford & Everts, "Map of Exeter, New Hampshire," 1874. Exeter Historical Society archives. Location of Great Dam indicated by arrow.



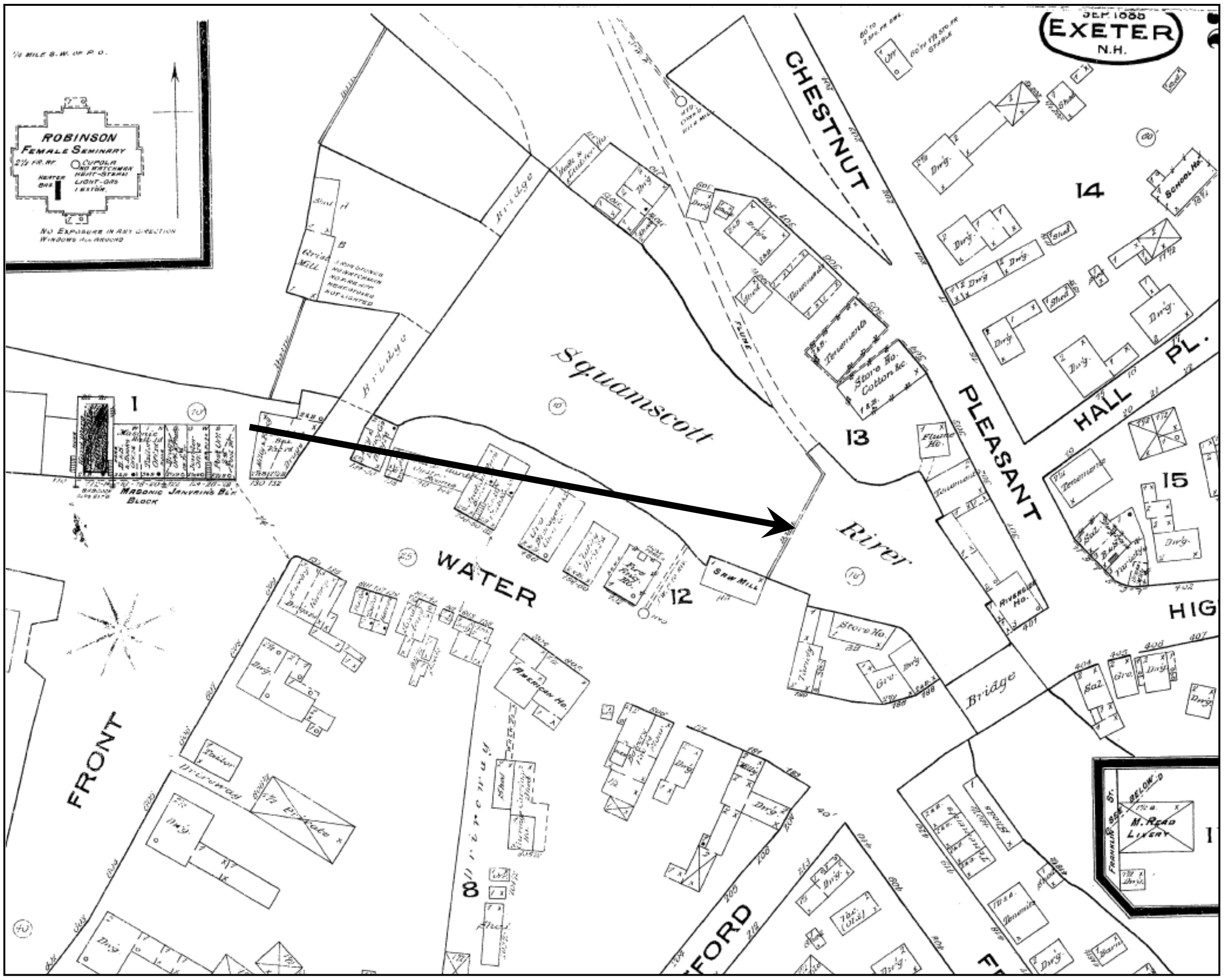
Rockingham County Land Plan 0060, 1876. http:// http://nhdeeds.com/rockingham/RoHome.html, accessed February 2012. Location of Great Dam indicated by arrow.



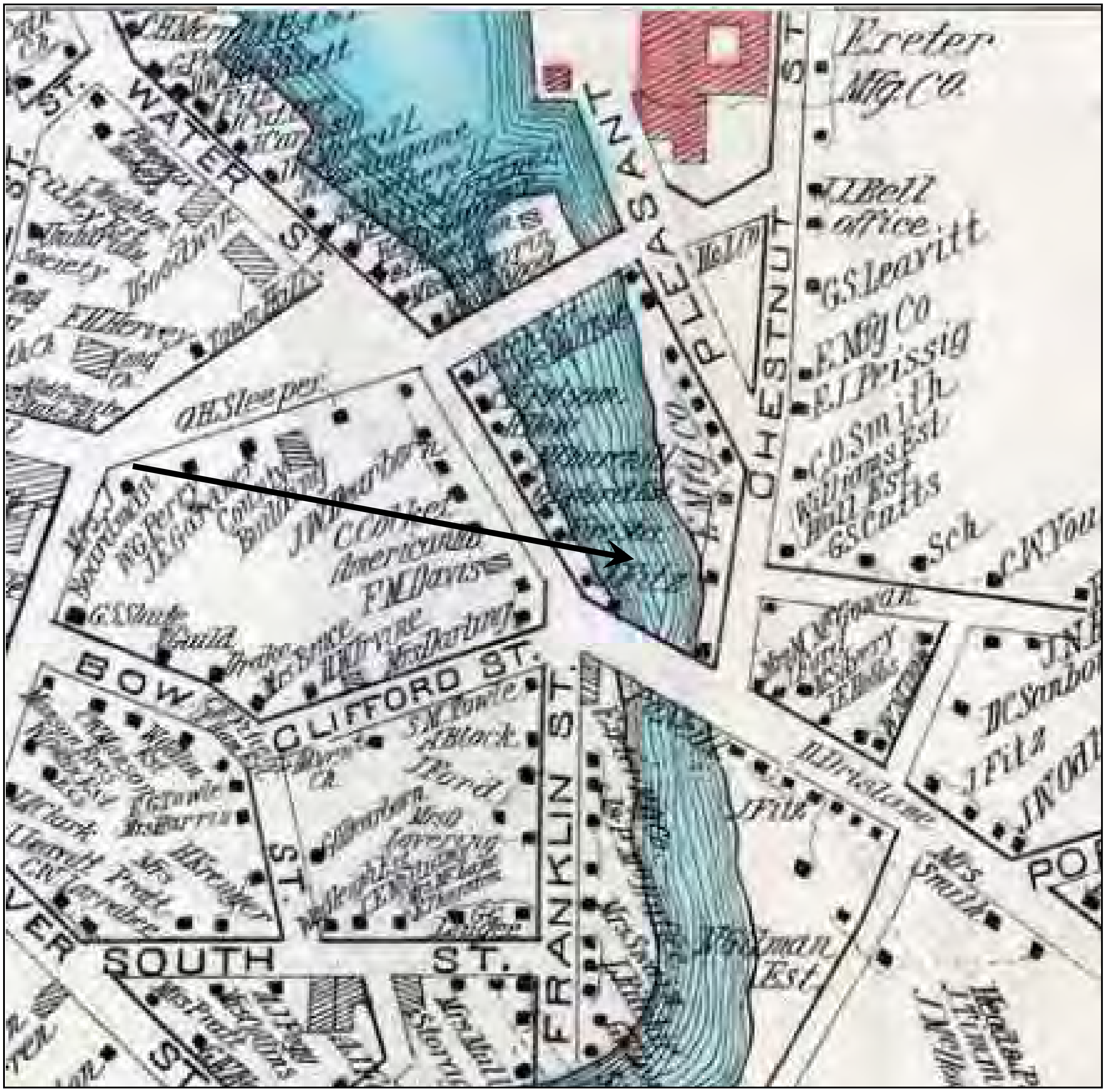
Norris & Wellge, “Exeter, New Hampshire,” birds-eye view, 1884. Exeter Historical Society archives. Location of Great Dam indicated by arrow.



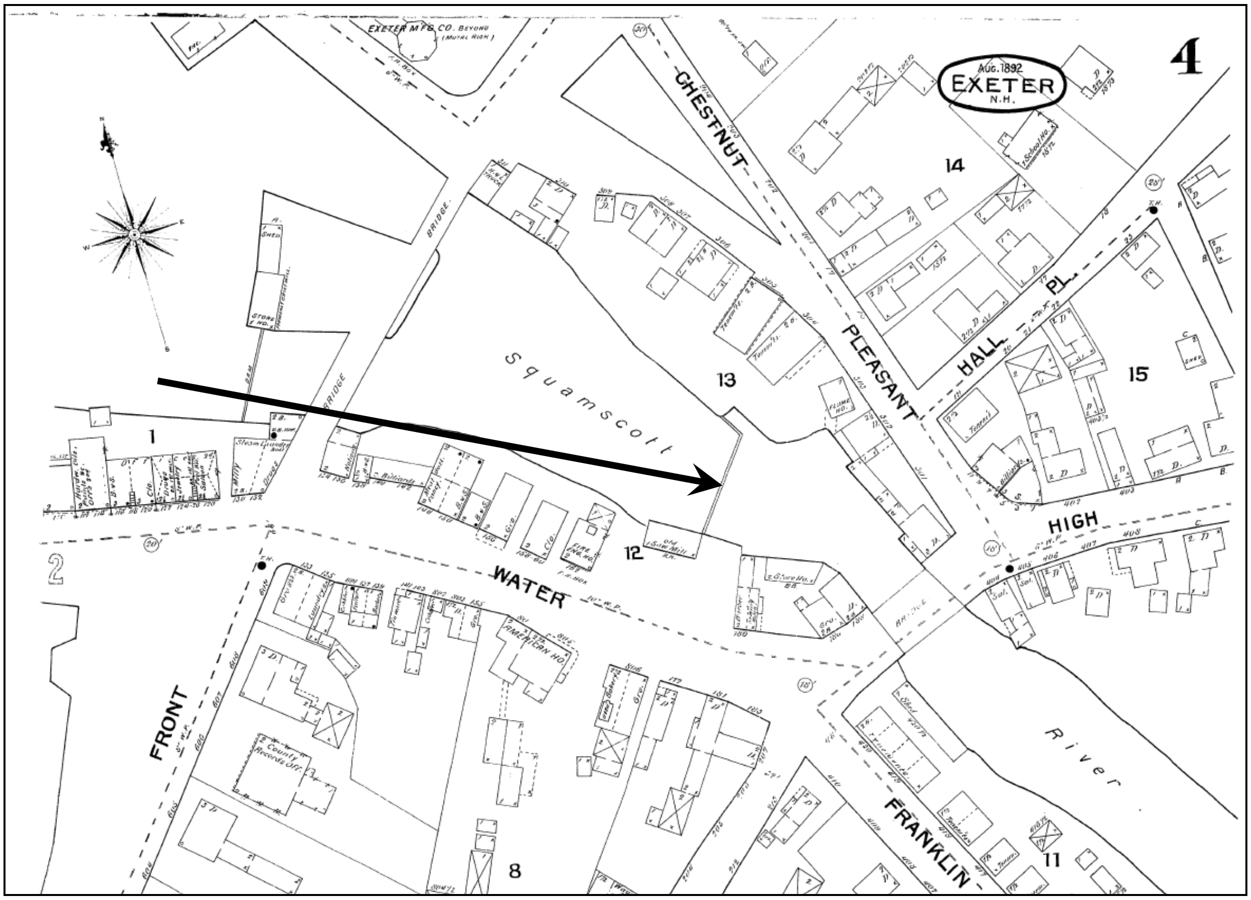
"Exeter Water Works," 1886. Exeter Historical Society archives. Location of Great Dam indicated by arrow.



Sanborn Fire and Insurance Company, Sheet 2, "Exeter, NH," 1885. http://sanborn.umi.com, accessed January 2012. Location of Great Dam indicated by arrow.

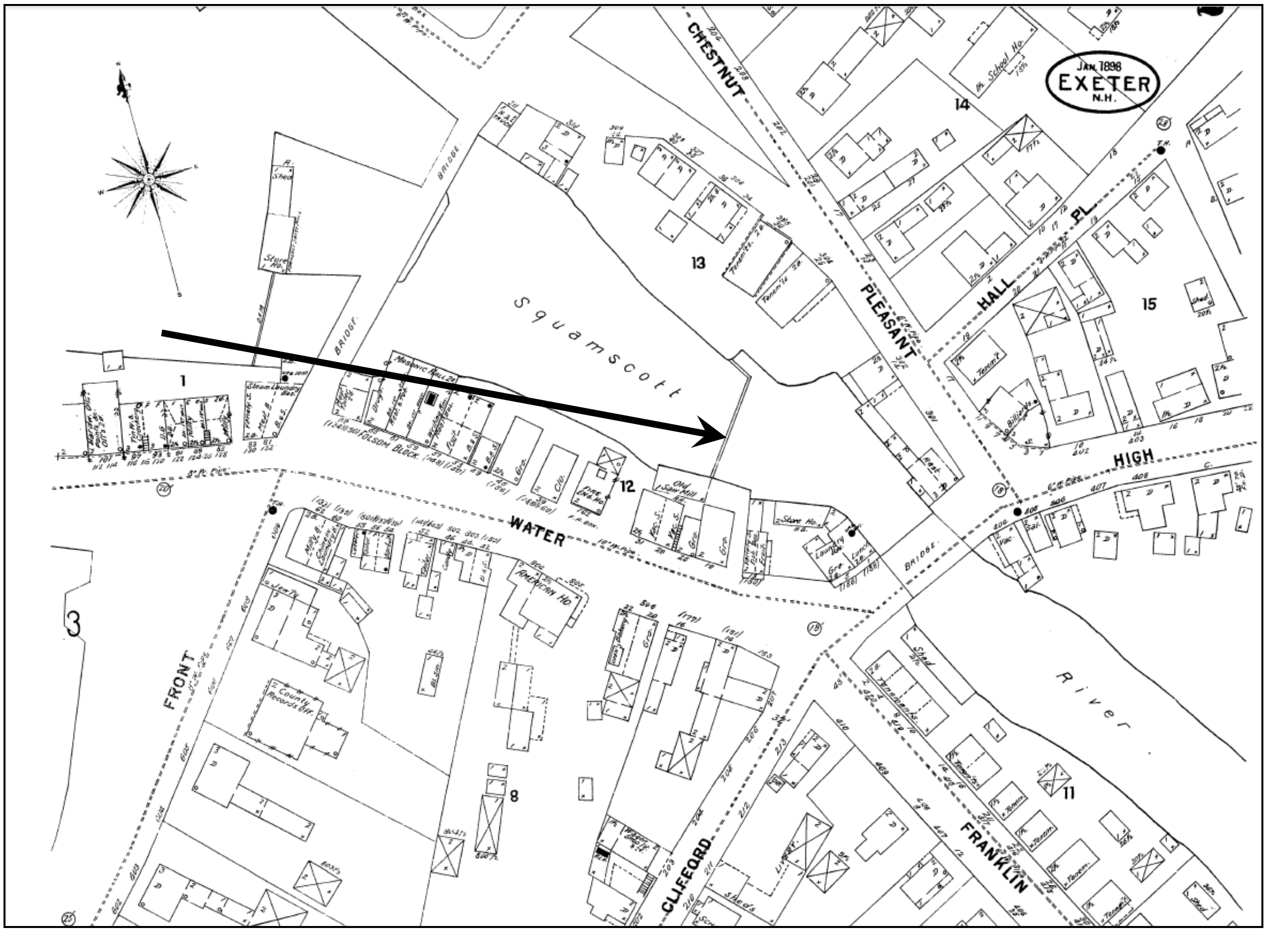


D.H. Hurd & Co., "Exeter," Atlas of the State of New Hampshire, 1892. Exeter Historical Society archives. Great Dam not shown; area of dam indicated by arrow.

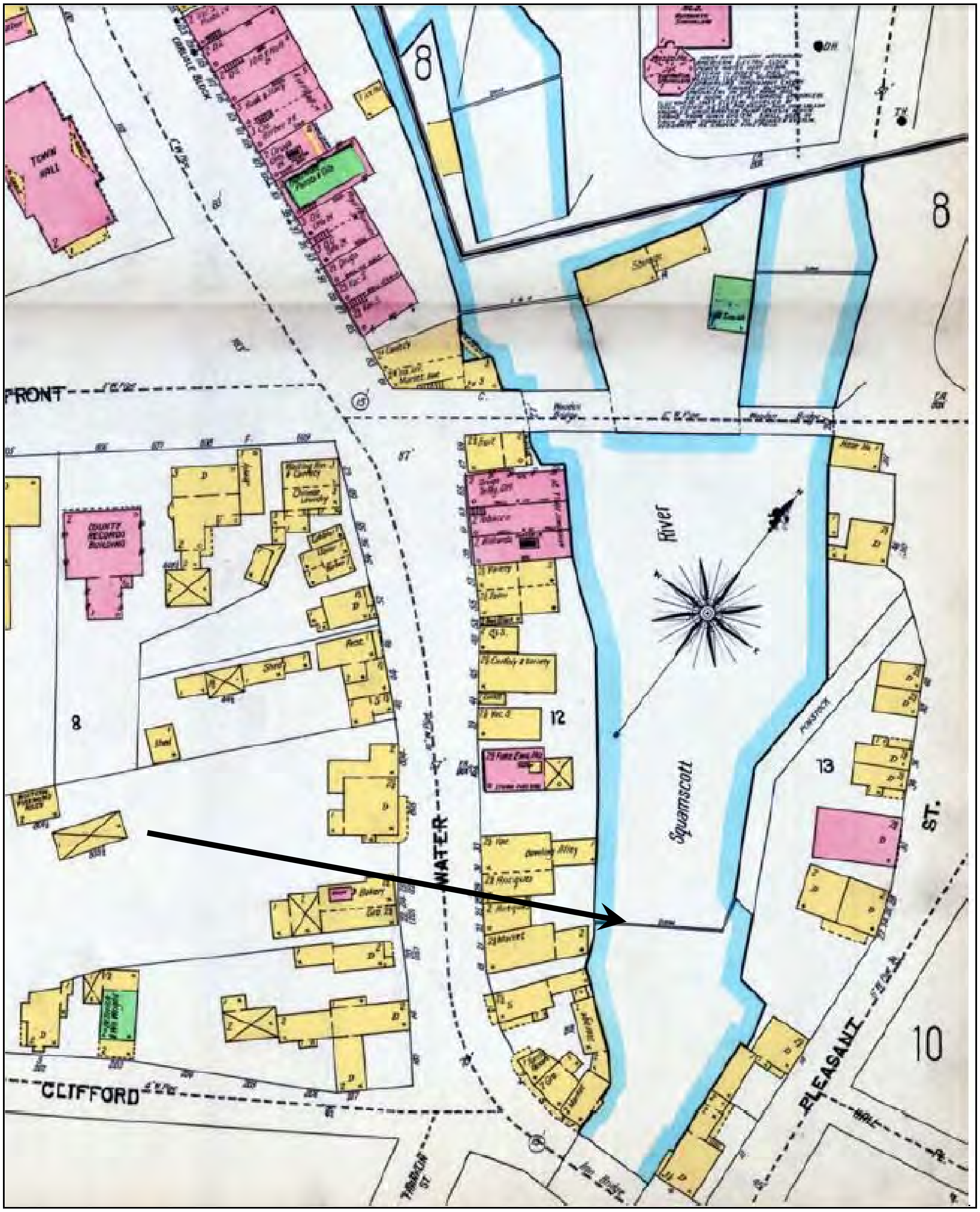


Sanborn Fire and Insurance Company, Sheet 4, “Exeter, NH,” 1892. http://sanborn.umi.com, accessed January 2012. Location of Great Dam indicated by arrow.

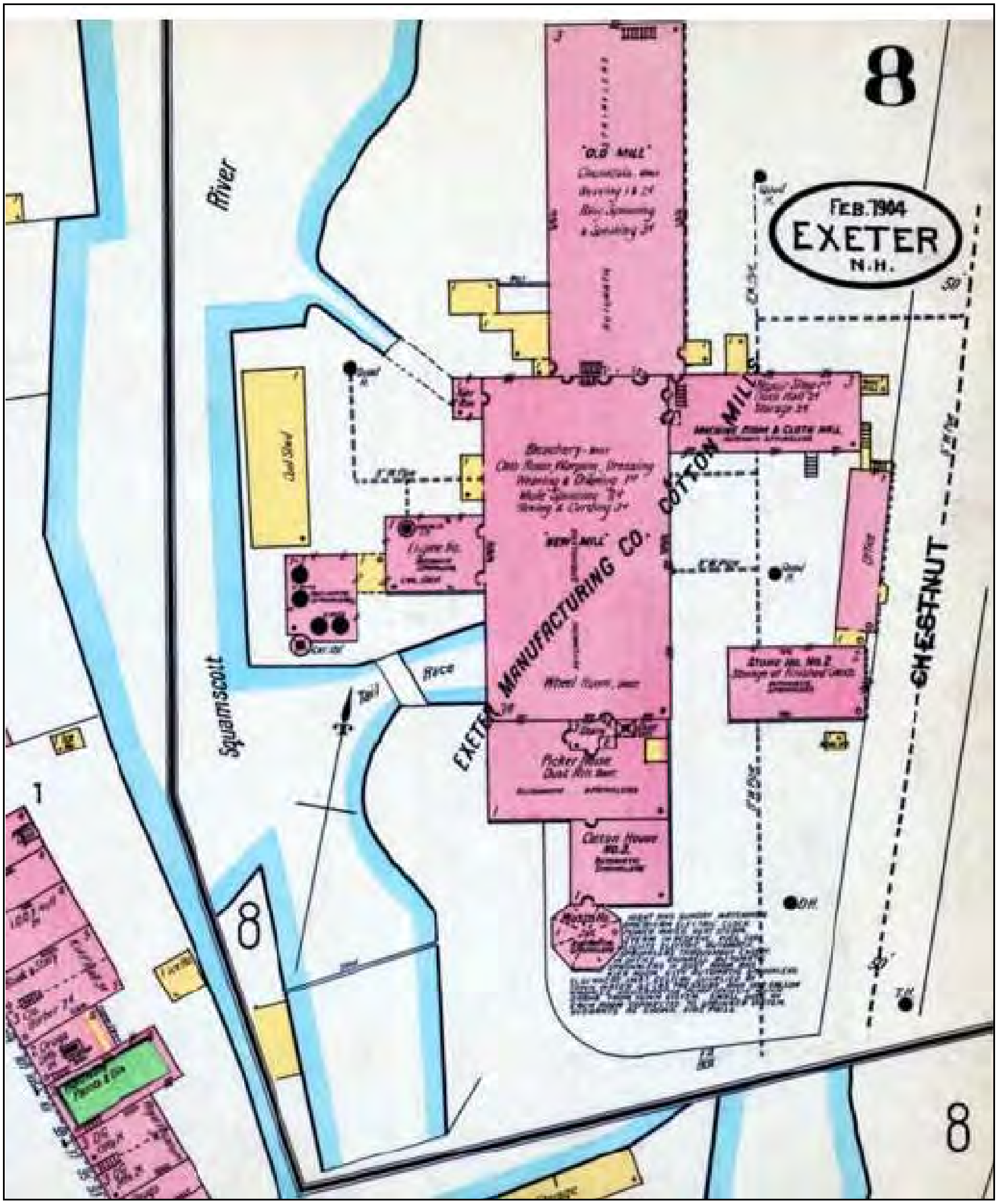
A.W. Moore Co., Lith., "Exeter, New Hampshire," birds-eye view, 1896. Exeter Historical Society archives.
Location of Great Dam indicated by arrow.



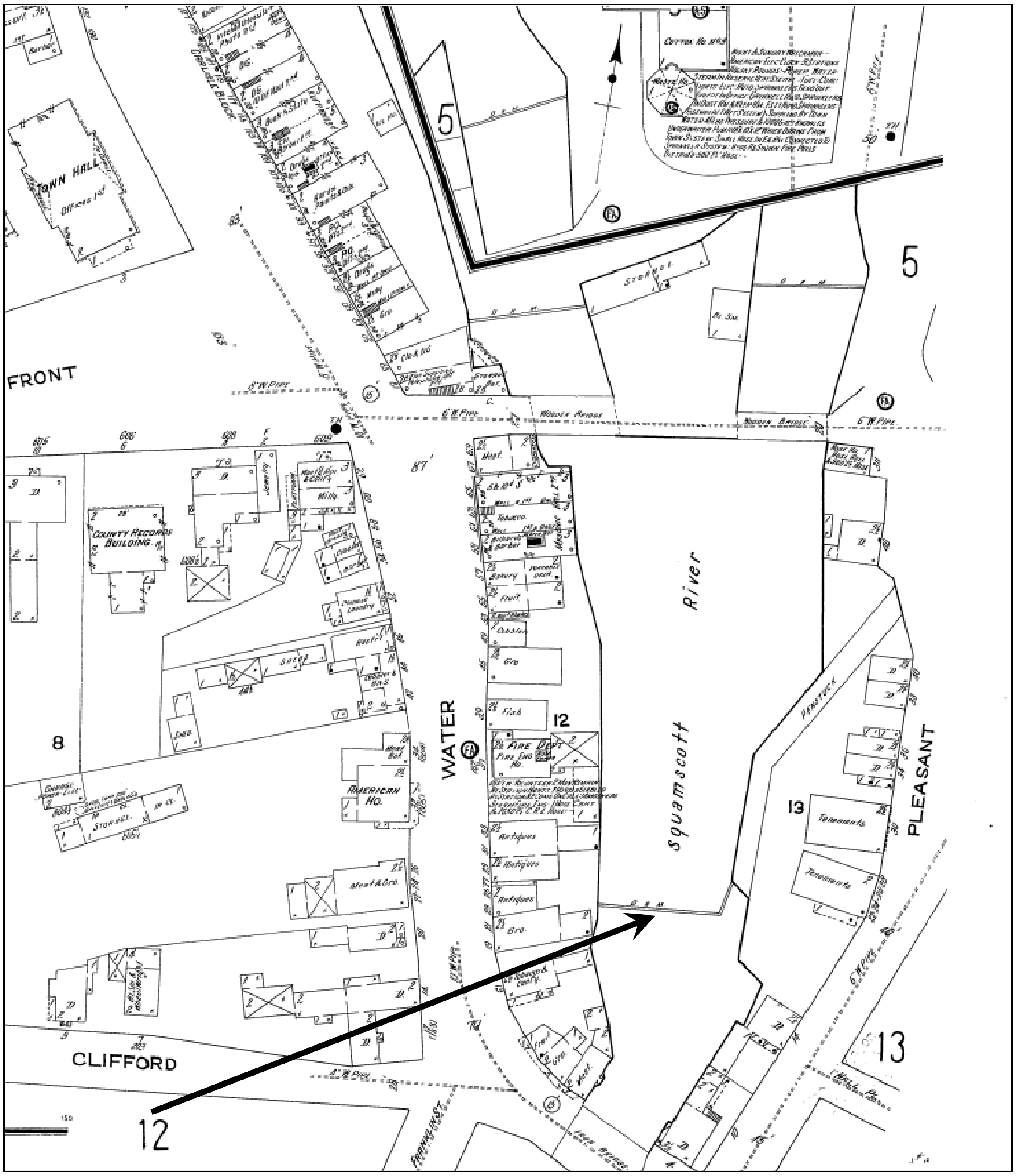
Sanborn Fire and Insurance Company, Sheet 2, "Exeter, NH," 1898. http://sanborn.umi.com, accessed January 2012. Location of Great Dam indicated by arrow.



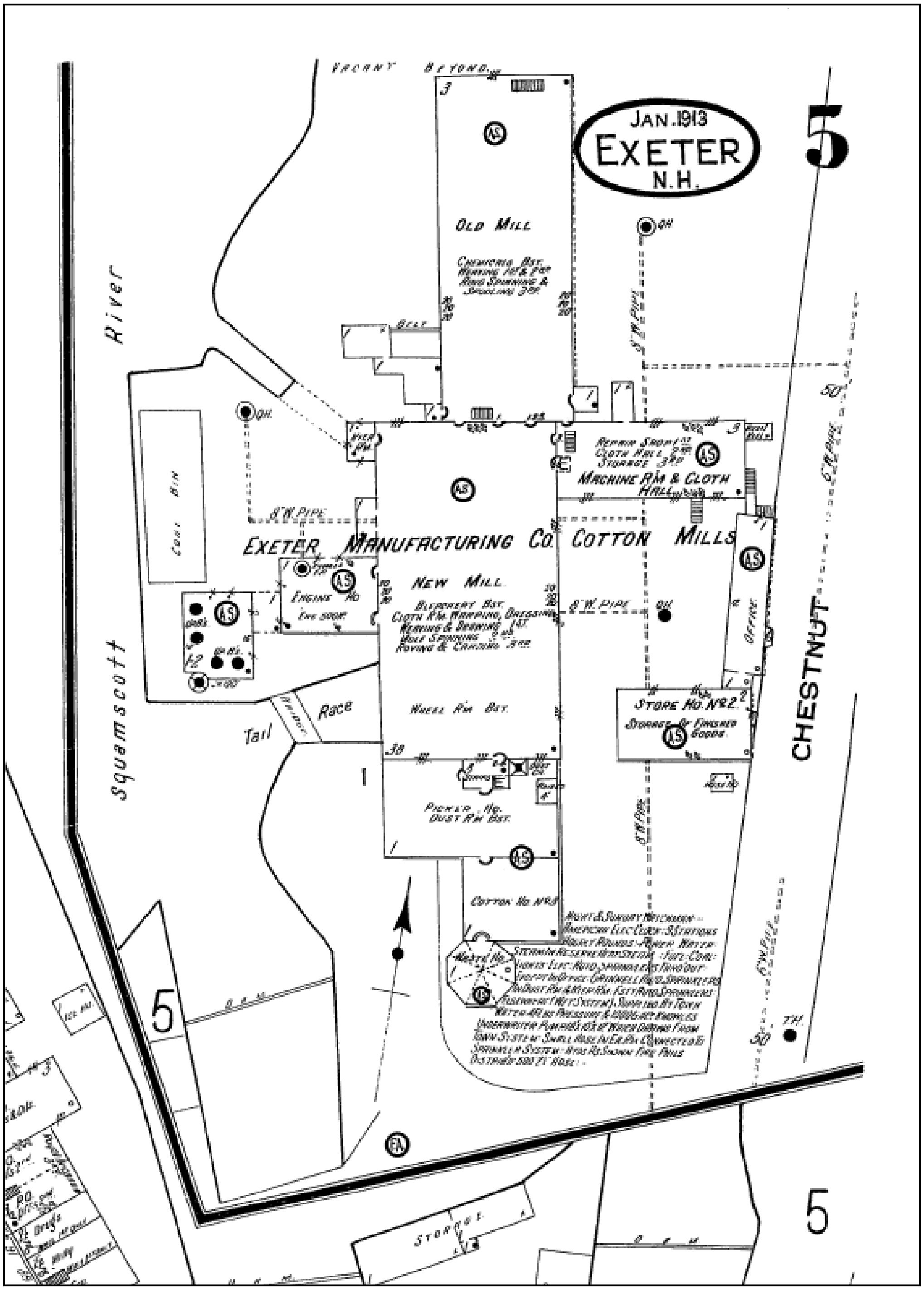
Sanborn Fire and Insurance Company, Sheet 8, "Exeter, NH," 1904. http://sanborn.umi.com, accessed January 2012. Location of Great Dam indicated by arrow.



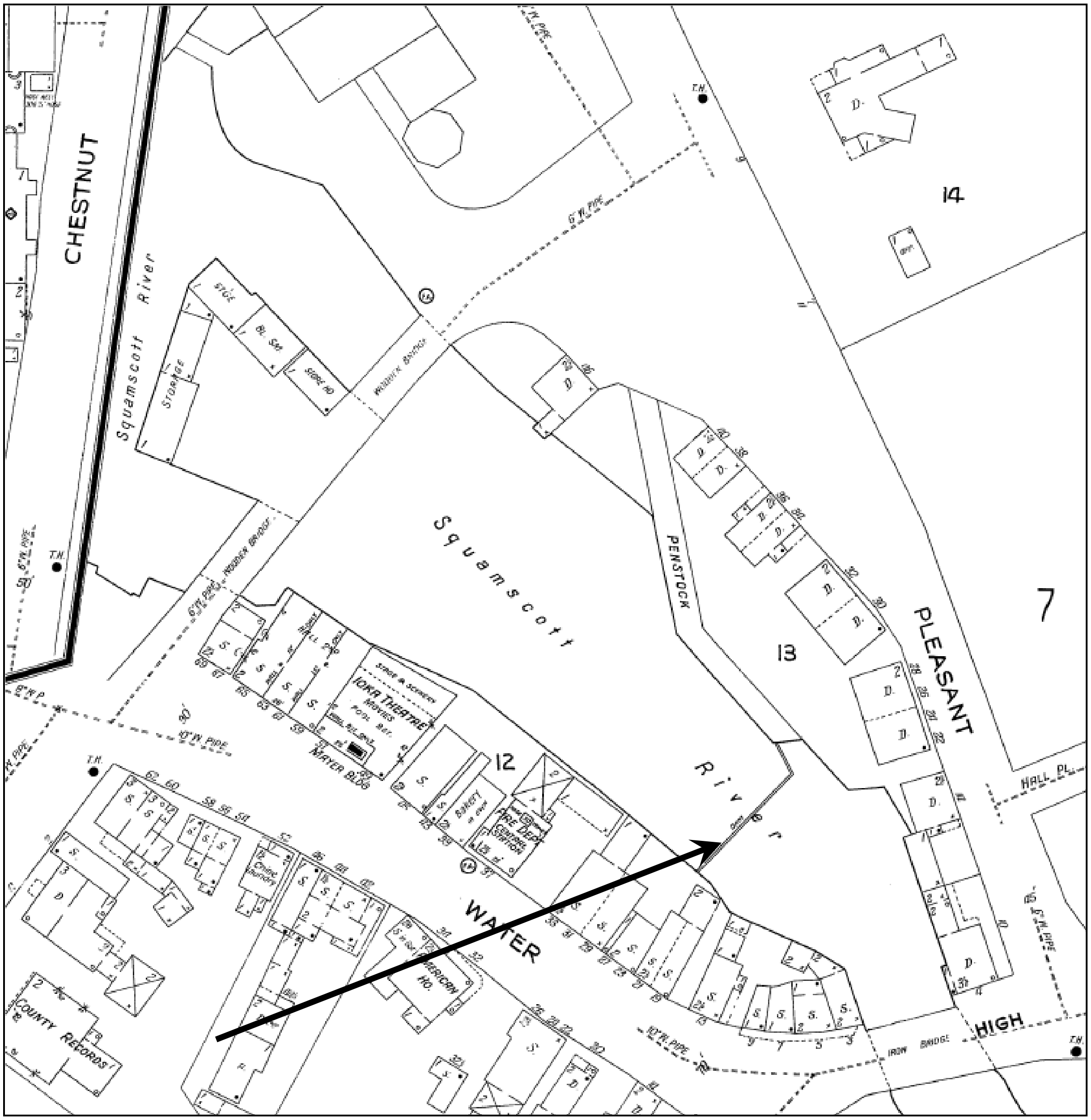
Sanborn Fire and Insurance Company, Sheet 8, "Exeter, NH," 1904. http://sanborn.umi.com, accessed January 2012.



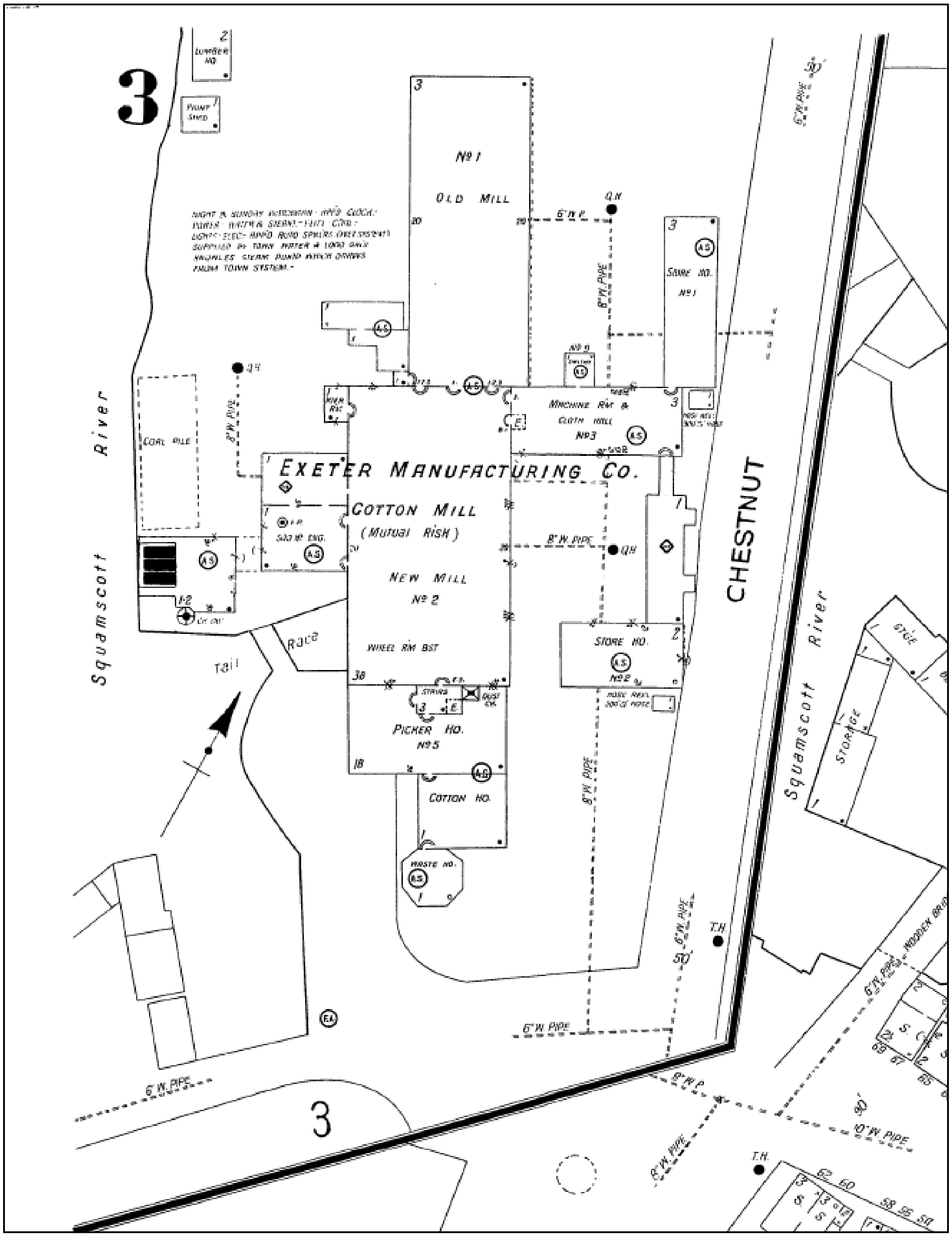
Sanborn Fire and Insurance Company, Sheet 5, "Exeter, NH," 1913. http://sanborn.umi.com, accessed January 2012. Location of Great Dam indicated by arrow.



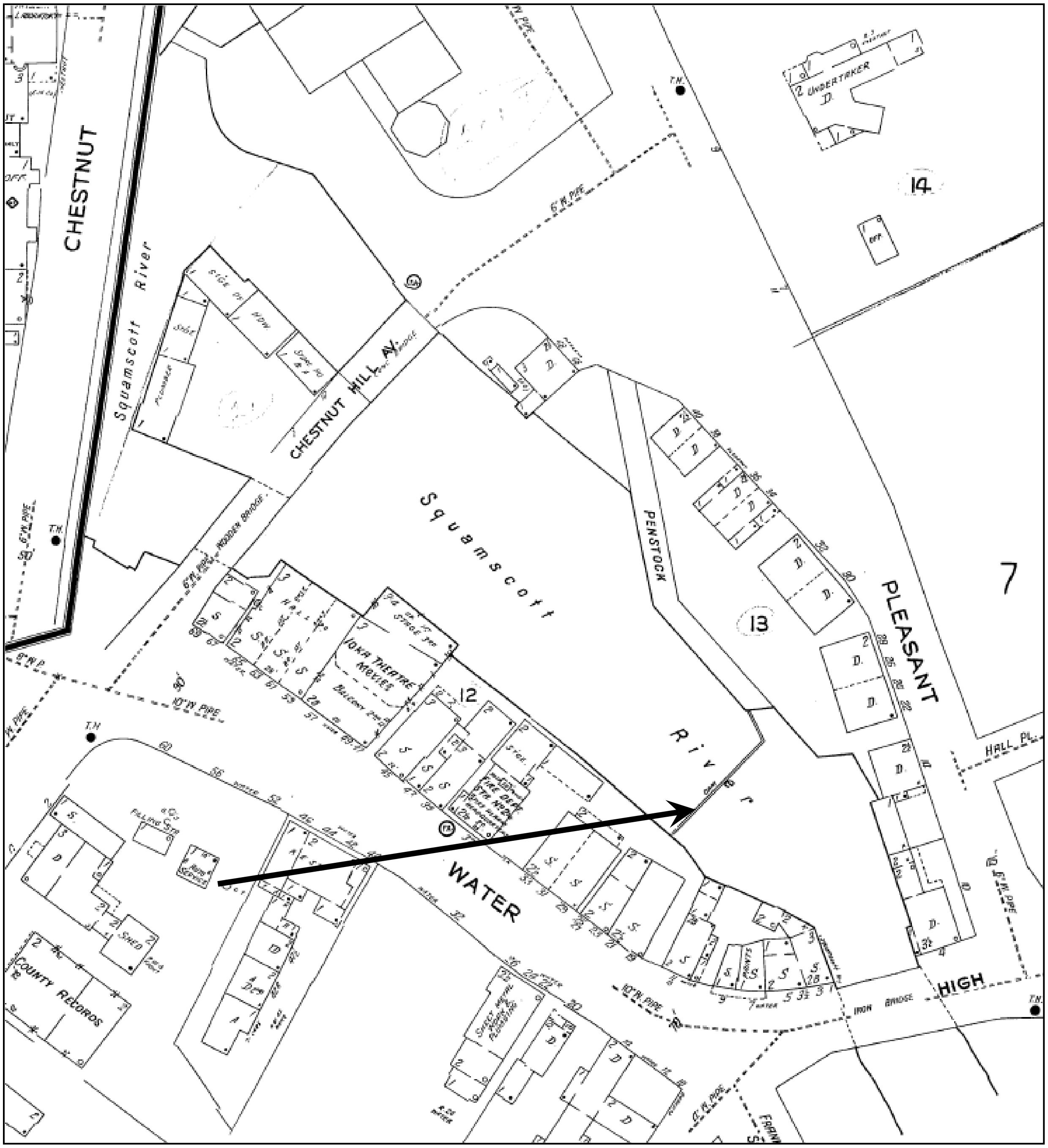
Sanborn Fire and Insurance Company, Sheet 5, “Exeter, NH,” 1913.
http://sanborn.umi.com, accessed January 2012.



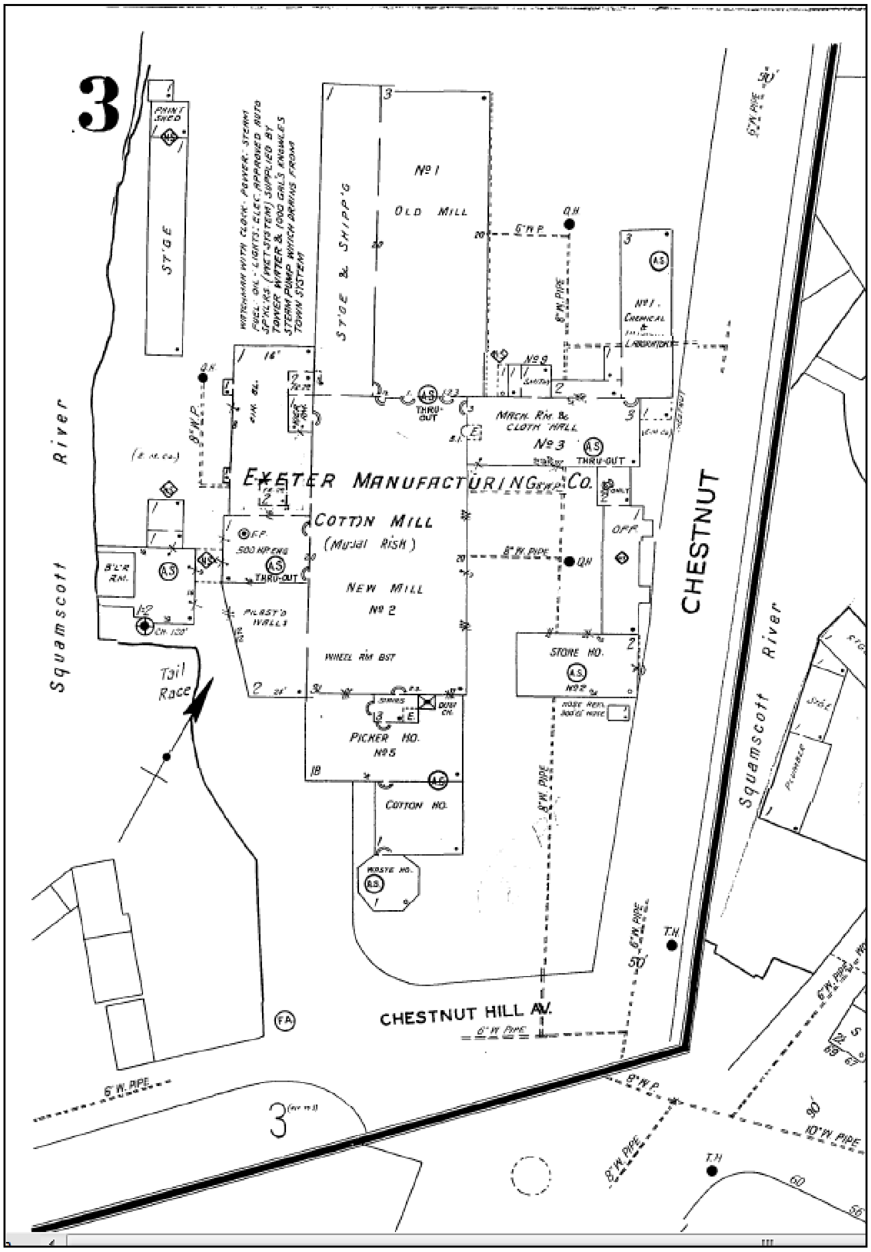
Sanborn Fire and Insurance Company, Sheet 3, "Exeter, NH," 1924. http://sanborn.umi.com, accessed January 2012. Location of Great Dam indicated by arrow.



Sanborn Fire and Insurance Company, Sheet 3, "Exeter, NH," 1924. http://sanborn.umi.com, accessed January 2012.



Sanborn Fire and Insurance Company, Sheet 3, "Exeter, NH," 1943 (updated from 1924). http://sanborn.umi.com, accessed January 2012. Location of Great Dam indicated by arrow.



Sanborn Fire and Insurance Company, Sheet 3, "Exeter, NH," 1943 (updated from 1924). http://sanborn.umi.com, accessed January 2012.

Path: \\nhbedata\projects\52151.00\GIS\Project\PhotoLocations_Final.mxd Date: 2/24/2012

Legend

Photograph Location & Direction

0 60 120 Feet

Vanasse Hangen Brustlin, Inc.

Photograph Locations

Exeter Great Dam Removal
Feasibility & Impact Analysis

Exeter, NH

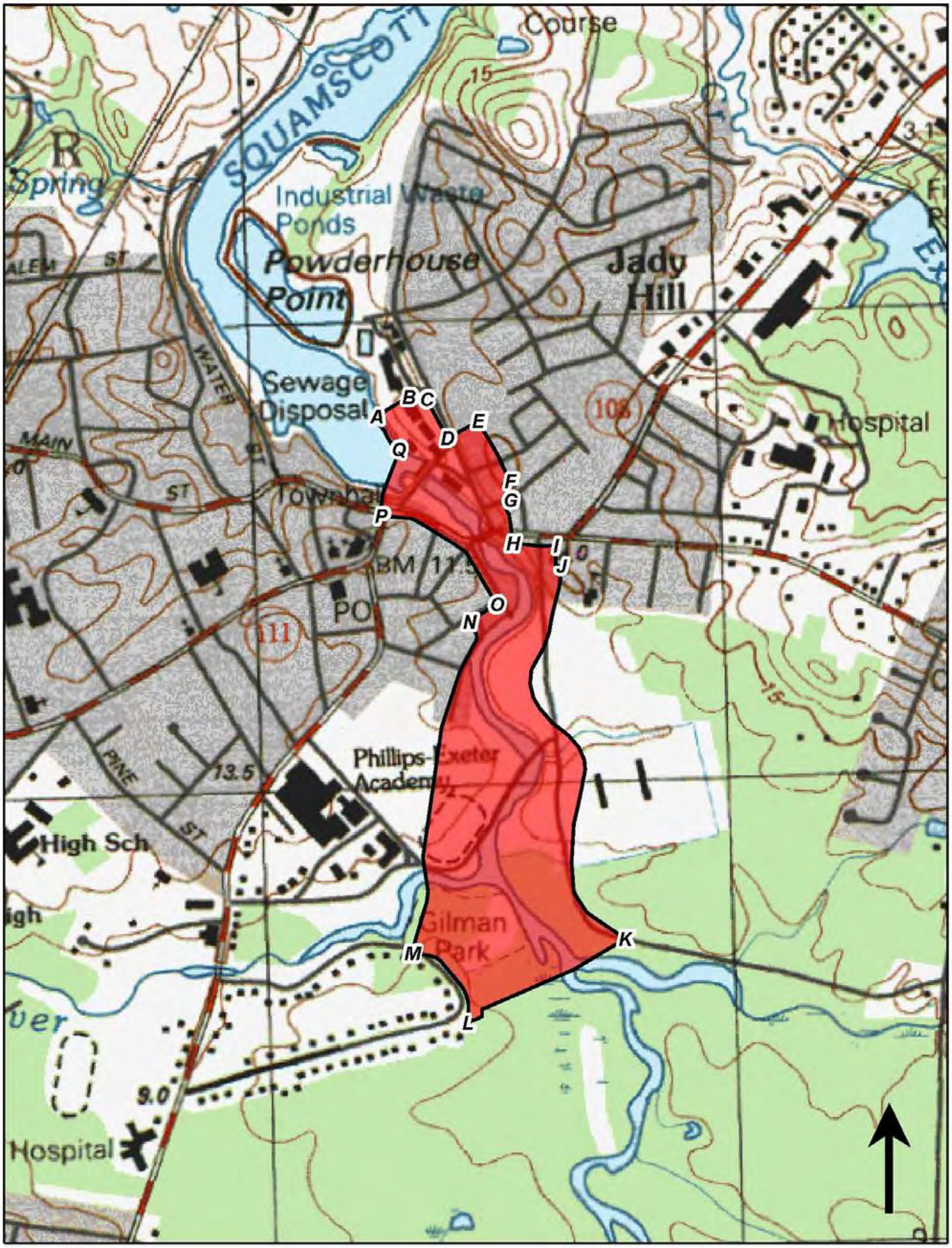
1. Type of Area Form
   Town-wide: ☐
   Historic District: ☐
   Project Area: ☒
2. Name of area: Exeter Great Dam Area
3. Location: Roughly bounded by the areas and streets bordering the Exeter River, bounded on the north by the high tide mark between the Exeter River and Squamscott River and Gilman Park to the south
4. City or Town: Exeter
5. County: Rockingham
6. USGS quadrangle name(s): Exeter
7. USGS scale: 24,000
8. UTM reference: See page 2
9. Inventory numbers in this area:
   EXE 0019 (164 Water Street) - adjacent
   EXE 0020 (154 Water Street) - adjacent
   EXE 0021 (156 Water Street) - adjacent
   String Bridge (inventoried, no # assigned)
   EXE 0043 (Great Dam)
10. Setting: .75 linear mile along both sides of the Exeter River in Exeter's village center, characterized by densely developed groups of mostly 19th and 20th commercial, residential and institutional properties
11. Acreage: 77 acres
12. Preparers: Rita Walsh, Nicole Benjamin-Ma
13. Organization: Vanasse Hangen Brustlin, Inc.
14. Date(s) of field survey: November 2011

15. Location Map See page 3

8. UTM references (continued)

UTM Point	Longitude	Latitude
A	341274.616839361	4760803.13521025
B	341344.349542673	4760842.73491213
C	341381.574444441	4760836.32611183
D	341424.252846468	4760752.28260783
E	341491.65364967	4760785.89300943
F	341555.916952722	4760654.49450319
G	341554.966452677	4760615.09490132
H	341556.92645277	4760521.91779689
I	341649.485457166	4760514.06439652
J	341659.701657652	4760470.49669445
K	341771.314362952	4759667.88645633
L	341428.871246688	4759499.56254833
M	341312.519441161	4759651.56945555
N	341458.662448103	4760356.86728905
O	341518.243350932	4760392.48069075
P	341276.872339468	4760589.12350009
Q	341318.569241448	4760731.15660683

15. Location Map



16. Sketch Map

See attached figures, which are all 30” x 30” in size and folded.

Figure 1. Overview of Project Area Boundaries and Location of Inventoried and Listed Historic Properties

Figure 2. Northern Half of Project Area, with Photo Locations

Figure 3. Southern Half of Project Area, with Photo Locations

17. Methods and Purpose

This project area form was prepared as part of the Exeter Great Dam Removal Feasibility Study, which is examining the specific possible impacts of the dam's removal. The project area, where impacts are anticipated to occur, is the high tide mark of the Squamscott River at String Bridge, south (or upstream) to the area of Gilman Park along the Exeter River. The properties adjacent to both the Squamscott and the Exeter Rivers, which may be visually affected, are also included in the project area. A decision regarding the dam's removal will be made by the Town of Exeter after the feasibility and impact studies have been completed. A separate individual inventory form has been prepared for the Great Dam (EXE0043).

Information for this form was compiled from a variety of sources. The holdings at the Exeter Historical Society served as the primary source of information, including photographs, maps, histories, town records, books, and a number of subject files. Barbara Rimkunas, the curator of the historical society, provided a great deal of research on the background of the residents of the area identified locally as "Franklin Street," located south of the central business district on the west side of the Exeter River. A site file search was conducted at the New Hampshire Division of Historical Resources in September 2011, in order to identify previously recorded resources in the area as well as properties and districts listed in the National Register. The New Hampshire Department of Environmental Services' Dam Safety Bureau has a large file of documents relating to the history and condition of the dam, which were extensively used. The Exeter Public Library provided a large collection of town directories and local histories. Online resources, such as the Town of Exeter's website and indexed historical records available via Google Books, were also utilized as references.

Fieldwork consisted of a pedestrian review of every street in the project area, including the identification of any previously unidentified districts or areas that could be considered potentially eligible for the National Register. Photographs consisted of both individual buildings and streetscapes in order to capture all buildings and structures within the project area. The extent of the field survey was defined by the understanding that the primary impact of the project would be the removal of the existing dam, fish ladder and concrete weir, which are all within both a local and National Register district. The removal of the dam may also lower the level of the Exeter River upstream, possibly by up to five feet, with the impacts possibly extending south to Gilman Park. There are no impacts anticipated at the head of the tidal Squamscott River, at Kimball's Island and String Bridge.

18. Geographical Context

The Town of Exeter is located in Rockingham County, in the southeast corner of New Hampshire. Exeter is bordered on the west by the Town of Brentwood; on the south by the towns of Kingston, Kensington, Hampton Falls and Hampton; on the east by the Town of Stratham; and on the north by the Town of Newfields. The town is located approximately eight miles inland from the Atlantic Ocean, and four miles south of Great Bay, which borders the Town of Newington, the City of Dover, and the City of Portsmouth before meeting the ocean.

The project area is located in downtown Exeter at the confluence of the Squamscott and Exeter Rivers and extends south to Gilman Park. The flat topography of the area, along with abundant local timber and the opportunities afforded by the rivers, attracted settlers from the nearby Massachusetts Bay Colony. Their first settlement in Exeter was located in the project area at the Great Falls.

The major geographical features in the project area are the Squamscott and Exeter Rivers, which meet at the project area at Great Falls. Exeter River, which begins approximately 40 miles west in the Town of Chester, generally follows the town's south boundary starting at Pickpocket Falls, before bending north (downstream) toward downtown Exeter, where it flows into the Squamscott River. The head of the tidal Squamscott River is in downtown Exeter at Kimball's Island, and flows into the town of Newfields before entering the Great Bay.

19. Historical Background

Summary

Throughout Exeter's nearly 400-year history, the area around the Great Falls (also referred to as "Squamscott Falls" in town histories) has served as the town's municipal and commercial town center. Great Falls has also served as the town's industrial center for much of its history. The earliest Euro-American settlement in the town was adjacent to the falls, which became the site of the town's first mills. In 1828-1830 the Exeter Manufacturing Company constructed a large mill on the east side of the falls, gradually taking over the various smaller mills along Great Falls as well as a 40-mile-stretch of the Exeter River. The mill dominated Exeter's employment base for decades, and the steady availability of jobs attracted immigrants who settled nearby throughout the 19th and early 20th centuries. In 1842, the establishment of the Boston & Main Railroad, more than ½ mile west of the town center at Great Falls, drew focus away from the Exeter Manufacturing Company mill as the industrial heart of the town, adding a new industrial center along the railroad. By the 1930s, most of the other factories had closed down, once again leaving the Exeter Manufacturing Company mill near Great Falls as the primary industrial enterprise in the town. Shifts in production sustained the Exeter Manufacturing Company throughout much of the 20th century, but by the 1960s the mill was facing stiff competition from factories located in southern states. In addition, the increased use of private automobiles allowed residents to live in Exeter but work in the Boston or Portsmouth areas. After the Exeter Manufacturing Company mill was sold in 1966, the new owners of the factory continued production for another two decades, after which time the Great Falls area's prominence as the industrial heart of the town ended. However, the area's role as the commercial and municipal center of Exeter has continued unabated to the present.

Early Settlement of Great Falls Area (1630s – 1827)

The first two centuries of development in the vicinity of Great Falls revolved mostly around family-run mills and some small commercial enterprises along Water Street, on the west bank of the Exeter River, and on the east bank as well. During the 1630s, Reverend John Wheelwright moved from Newburyport, Massachusetts, with his small congregation, seeking more religious freedom than allowed by the Massachusetts Bay Colony. The first settlement was by Great Falls, which allowed residents to take advantage of the water power provided by the falls, the availability of abundant lumber, and the navigability of the Exeter and Squamscott Rivers for transport. The first mill established in Exeter was Thomas Wilson's grist mill at Great Falls, which was constructed in 1638 (Monroe 1998, 2). Edward

Gilman built two saw mills soon after, one on each side of the river. Other members of the Wilson and Gilman families also established mills in the Great Falls vicinity of downtown Exeter, including Humphrey Wilson's saw mill on the east side of the river, and John Gilman's grist mill constructed on the small island at the lower falls (now in the center of String Bridge; Bell 1888, 331-332). Several types of mills utilized the falls during the 18th century: the 1802 Plan of Exeter indicates a grist mill, a saw mill, an oil mill, a fulling mill, and two unspecified mills along the banks of the river at Great Falls (Merrill 1802). A nail factory was located in Hemlock Square, near the east bank of the river near High Street. A starch factory, which provided starch to textile factories in Lowell, Massachusetts, was constructed at the foot of Great Bridge and Franklin Street (Perry 1913, 18-19). In 1822, the tenement building now known as the "Long Block" was constructed by Nathaniel Gilman on the site of the former starch factory (Historic Exeter Associates 1994; Perry 1913, 19; N. Merrill n.d.), testifying to the growing population of mill workers in the Great Falls area by the end of the first quarter of the 19th century.

Transportation and its associated infrastructure within the new settlement were also concentrated in the Great Falls area of downtown Exeter. The predecessors to the two bridges serving the area, Great Bridge and String Bridge, were first constructed during the 17th century around the same time as the mills. The predecessor of Great Bridge was likely the first bridge constructed in what is now downtown Exeter, during the mid-17th century (Bell 1888, 124-125). Originally, the bridge was constructed to handle pedestrians and horseback riders, but when the bridge became part of the "county way" ca. 1675 (Water Street and High Street), the bridge was widened to accommodate carriages. By 1693, the bridge was referred to as the "Great Bridge," indicating the presence of a second smaller bridge nearby (Bell 1888, 125). The String Bridge was for pedestrians only, with a rough design consisting of wood planks laid across the river and rope used for handrails. The two parts of the String Bridge – one part extending from the west riverbank to the island, and the second part extending from the island to the east bank - were likely constructed separately to serve different mills established on the island. The east portion was constructed to allow residents to carry materials to Thomas Wilson's grist mill. Capt. John Gilman established a second grist mill on the west side of the island soon after, and in 1709, the town ceded water and property rights associated with the Gilman grist mill, along with "the privilege for a bridge to go on the island" (Bell 1888, 125). String Bridge was not upgraded for carriages until the 19th century.

The first two highways in Exeter likely correspond to the current Front Street and Water Street (Bennett and Beard 1980, 7-1). The 1802 Plan of Exeter shows a number of residences along Water Street and Mill Street (now lower Water Street; Merrill 1802). Several of the owners associated with these houses – Clifford, Fulsom, Gilman – are also associated with the mills along the riverbanks at Great Falls, including the Gilman Garrison and House (NR #76000131) , located on the west side of Water Street, which also served as an inn around 1720 (Chapin, 1974, continuation sheet 5). The 1802 Plan of Exeter shows that settlement in the town center mostly occurred on the west side of the river, extending north along Water Street to a number of shipyards, and west along Front Street to the Exeter Academy (established 1781). While the few buildings on the east side of the river were generally limited to mill buildings, a number of residences extended east along High Street and north along Jail Street (now Pleasant Street), named for the county prison located near the intersection of High Street (Merrill 1802).

By the early 19th century, Water Street was also used for commercial purposes, due to its close proximity to the mills, dwellings, churches, and town buildings clustered in the Great Falls area of downtown Exeter. The 1802 Plan of Exeter shows a series of stores along Water Street, and a building used as a wool factory was adapted for use as a machine shop during the early 19th century (Perry 1913, 25). A compilation of New Hampshire cabinetmakers between 1790 and 1850 shows approximately ten furniture makers in Exeter (Giffen 1968, 78). It is likely that several of these were active in the town center, primarily along the densely settled Water Street and Front Street. Shipbuilding joined lumber production as a primary industry in the Great Falls vicinity and north along the Squamscott River, prompting several of the commercial and industrial structures on Water Street to be constructed with basements and sub-basements along the waterfront in order to allow goods to be loaded directly to and from the wharves (Bennett and Beard 1980, 8-6).

Rise of the Exeter Manufacturing Company at Great Falls (1827 – World War I)

The establishment of the Exeter Manufacturing Company and its mill along the west side of Great Falls marked a major turning point for the town, forming a major influence in Exeter's economic and social development as the town shifted from the export of lumber to large-scale manufacturing. The Exeter Manufacturing Company was incorporated by several of the town's business leaders on June 26, 1827. The Exeter Mill and Water Power Company was formed at the same time, with the purpose of securing water rights to guarantee a water supply for the proposed larger mill. In February 1828, the Exeter Manufacturing Company agreed to "build within nine months a good & sufficient new & permanent dam at or near the place where the present upper dam is and which shall raise the water in said river to the same elevation and height as it is raised by the present dam" (Deed 253/142).

In 1828, construction began on the mill building, a three-story structure housing four water wheels and 5,000 spindles imported from England, along with additional machinery built in shops along Water Street (Tardiff 6/4/1980). When the mill opened in 1830, it was capable of producing more than a million yards of textile sheeting per year, at approximately ¼ of the price of similar handwoven material (Tardiff 6/4/1980). The company utilized a number of buildings along the river in the vicinity of Great Falls throughout the 19th century, including the "Long Block" built for Nathaniel Gilman's mill workers. In order to secure a sufficient water supply, the Exeter Mill and Water Power Company purchased the existing mills at the upper falls at Great Falls, including a grist mill, saw mill, dye house, oil mill, and woolens factory, and reconstructed the upper falls dam at Great Falls in 1828-1829 (Book 253, page 142). The company worked its way inland along the Exeter River, purchasing mills and water rights along the waterway until it owned all of the water rights along the river between Pittsfield, NH and Exeter (Tardiff 6/4/1980). In 1831, the Exeter Manufacturing Company hired a surveyor to evaluate the entire river and make recommendations to increase the water flow for the company's use. The surveyor's suggestions of creating a reservoir, straightening the river, and raising the dam at Great Falls were not carried out (Tardiff 1986, 24-25).

Although the Exeter Manufacturing Company was the earliest and often the most influential manufacturer in Exeter during the 19th century, it was not the only large industrial enterprise in the town. By the mid-19th century, the silting of the Squamscott River made the waterway too shallow for most ships to travel upon (Monroe 1998, 3), causing the decline of Exeter's shipbuilding industry. Attention turned to manufacturing, especially along the Boston & Maine Railroad in west Exeter approximately 0.6 miles from the town center, which was constructed in 1842. The 1896 Moore birds-eye view of Exeter shows that by the end of the century, the cluster of factories along the railroad included the Exeter Machine Company, Exeter Brass Works, the Gale Brothers Shoe Factory, the Cogswell Boot and Shoe Company, and a large-scale grist mill. The Exeter Manufacturing Company, however, continued to anchor the manufacturing center in the Great Falls vicinity of downtown Exeter.

The Exeter Manufacturing Company continued to be a major influence in the town throughout the 19th century and into the 20th century and was one of the three largest industrial firms in New Hampshire (NR nomination 1984). In 1876 steam power was added to the mill, allowing the factory to continue production year-round, even through the dry season when water levels became low (Exeter Historical Society, MSS72 file). The company also purchased the Pittsfield Mills in 1895, using the Pittsfield location to manufacture materials for bleaching, dyeing and finishing at the Exeter mill (Textile Age 1942, 31). In 1914 the company built the present dam, (Department of Environmental Services, 7/12/2000); it is unknown if the dam that was replaced was the one that the Exeter Manufacturing Company pledged to build within nine months of February 1828 or if there had been earlier replacements later in the 19th century. The Kent family became involved with the Exeter Manufacturing Company mill in the late 19th century, beginning a century-long family legacy as managers of the mill. Hervey Kent became manager of the mill in 1862, and helped the company recover from two disastrous mill fires in 1887 and 1893. Hervey Kent's son George Kent ran the mill until his death in 1905, after which George Kent's wife Adelaide appointed agents to manage the mill until her sons were old enough to take over the responsibility during the late 1910s. As the mill was one of the town's primary economic stalwarts, the Kent family reportedly held great sway over the bank, newspaper, and town government (Carman 1987, 22).

The availability of jobs at the mill encouraged a number of immigrants to settle in Exeter, including in the area surrounding Great Falls. In its earliest years, the Exeter Manufacturing Company required females employed at the mill to live within a five-minute walk of the mill, so development of housing for mill workers in the area was not merely a convenience (N. Merrill n.d.). Some of the earliest immigrants to arrive were from Ireland, but during the mid-19th century people moved to Exeter from Poland, Lithuania, and Italy to take advantage of the steady work. German and French Canadians also started moving to the town during the late 19th century, when additional industries were established in Exeter (N. Merrill, 12/15/76). Although it is not clear whether the Exeter Manufacturing Company constructed extensive numbers of houses for its workers, a variety of housing for immigrant workers was constructed in the vicinity of the mill and Great Falls (N. Merrill, n.d.). Tenement housing along the river rented for five dollars per month during the late 19th century, while double-family homes nearby rented for a slightly higher rate (Tardiff 1986, 25). Later immigrants were able to establish businesses outside of the factories – Italians Domenico Poggio and Luigi Gaiero were fruit merchants, with three markets in the commercial district along Water Street during the early 20th century (N. Merrill, 12/22/1976). As immigrant populations grew, so did the opportunity for community-based cultural organizations. The Polish population was served by two major aid societies, the Brotherly Aid Society of the Blessed Virgin Mary (established 1903), and the companion Polish Ladies' Society of Our Lady of Perpetual Help (established 1909). These organizations served as the social center for the Polish community, and helped newly-arrived immigrants get established. Later during the 1920s, the Polish American Citizens Club was established to help immigrants become United States citizens.

In addition to supporting mill workers and their families, the downtown area around Great Falls also hosted smaller industries such as carriage-making and carpentry. Several of the businessmen who became prominent carriage makers in the Great Falls vicinity moved to Exeter in the 1830s -1850s, attesting to the growth of the around Great Falls and along the Exeter River. Much of the area southwest of Franklin Street near the Exeter River was laid out and settled in the decades immediately following the construction of the Exeter Manufacturing Company mill in 1828 and the growth of the carriage industry.

The first carriage shops in the area were established along Franklin Street, where Daniel Melcher, Lewis Mitchell, and Orin Head had carriage shops by the mid-19th century. Several of the carriages were sold within New England in Maine and New Hampshire, with carriages often traveling out for sale in “caravans” of four or six strung together (Exeter Historical Society, SC399 file). By the late 19th century, the area southwest of Franklin Street also hosted a number of carriage manufacturing and painting shops; the 1872 town directory lists more than 40 people in Exeter employed in carriage shops (Exeter Historical Society, SC399 file). When Orin Head’s carriage shop was established on South Street in the early 1840s, the Town selectmen took the opportunity to call for road improvements along both South Street and South River Street (Swazey, 1/2/1914). The Brown and Warren families also ran carpentry shops in the vicinity of Great Falls: Sebastian and Isaiah Brown conducted their building and housing business from a shop along Pleasant Street near the river during the mid-19th century, while Charles Warren and John Brown established their carpentry business on South River Street in 1858 (*Exeter News-Letter*, 1896). Warren and Brown were the builders of a number of prominent structures in Exeter, including the Town Hall, Episcopal Church, Baptist Church, public library, court house, and the gymnasium at the Exeter Academy (*Exeter News-Letter* 2/18/1898). Deacon Josiah Batcheler had a carpentry shop on Water Street during the mid-19th century (*Exeter News-Letter* 8/7/1870).

The commercial area along Water Street near Great Falls continued to develop during the 19th century due to a number of factors, including the population growth caused by the opening of the Exeter Manufacturing Company mill. There were several large fires along the upper block of Water Street during the 1860s and 1870, which destroyed most of the existing wood frame residences and buildings. A number of masonry commercial blocks were constructed during the rebuilding effort, reflecting the growing mercantile nature of downtown Exeter and the vicinity of Great Falls, while the lower block along Franklin Street retained many of its wood frame residences and shops. The Norris and Wellge 1884 birds-eye view of Exeter shows a number of businesses along Water Street, including the Exeter Coal Company office and wharf, the Granite State Savings Bank, Exeter Gazette, and the post office. The Exeter Manufacturing Company experienced two fires in the 1887 and 1893, which caused several transformations in its appearance and operation, especially the largest brick mill building in the complex that dates to 1894. The company appeared to also be planning dam improvements in the late 1890s, although whether they actually carried these out is not documented. Transportation was facilitated in the late 19th century when the Exeter-Hampton Line for streetcars opened in 1897, traveling from the Exeter railroad station, along Front Street into downtown Exeter, across Great Bridge, and along High Street out to the town of Hampton.

The 1896 Moore birds-eye view of Exeter shows grocery and dry goods shops along Water Street, along with a pharmacy and offices. Sanborn Fire and Insurance maps for 1892, 1898, 1904, and 1913 reveal that nearly the entire east side of Water Street along the river was lined with businesses, including tailors, hardware shops, book shops, grocers, tobacco shops, antique dealers, and billiards halls among other services. On the east side of the river, some storefronts surrounded Hemlock Square at the intersection of Pleasant Street and High Street, but the stretch of Pleasant Street along the water was dominated by single-family houses. The 1904 Sanborn map shows that the bridges and dams along Great Falls were still prominent features. Great Bridge is noted as iron, and the two portions of String Bridge are noted as wood, with the old mill building on Kimball’s Island being used for storage next to a blacksmith shop. A dam was located at or near the current location of the Great Dam on all of the 19th and 20th century maps; two smaller dams were located on both sides of Kimball’s Island on most of the maps; although the east side dam is shown sporadically. South of the commercial center, Gilman Park was established in 1891 along the Exeter River, on 10 acres of land donated by Daniel Gilman. Town residents had approached Gilman about the gift of land after learning that a large wooded parcel of his land was going to be used for timber, and Gilman agreed to donate a portion of the land to the town (Aten 2003, 11). The park became popular for picnics, and displayed three Civil War canons along the river (two are extant; Tardiff 1986, 55).

In 1914, the Exeter Manufacturing Company replaced their major dam at the Great Falls with the current concrete gravity dam. Whether this dam replaced the one they originally built in the 1820s, or one that might have succeeded that one later in the 19th century is unknown.

Post-World War I Industrial Decline of Exeter (1918-1966)

The Exeter Manufacturing Company managed to stay afloat long after the other large manufacturing companies in Exeter went out of business, which helped to maintain the prominence of the downtown area around Great Falls as a commercial, municipal, industrial and residential center. Most of the factories established along the railroad in Exeter did not last much past World War I. Gale Brothers Shoe Company, which had become quite prominent in the early 20th century and employed a number of immigrants, was sold in the 1920s and its factory eventually closed (Rimkunas 5/29/2009). By shifting focus away from producing cotton textiles, the Exeter Manufacturing Company managed to avoid the same fate. The extensive bleachery operations at the mill kept it in demand between the two world wars, and the company began selling products overseas (Carman 1987, 52).

In 1934 a spin-off company called the Exeter Handkerchief Factory was established in west Exeter on Lincoln Street, which used remnants from the mill along Great Falls to produce handkerchiefs, gas mask bags (during World War II), and later tablecloths and curtains. During World War II, the Exeter Manufacturing Company shifted to the production of industrial fabric for the military and government. After the war, the company found that it could no longer price its cotton products competitively against materials produced in the southern United States, and in the 1950s switched its production from cotton to synthetic fabrics (Tardiff 1986, 25). Rather than produce the materials in-house, the company used fabric that was manufactured elsewhere, and bleached and finished the products in their facilities (Tardiff 7/9/1980). The company produced faux leather for automobile interiors, vinyl-coated screens for General Electric, and materials for Johnson & Johnson and Westinghouse. In 1952, the company boasted $18 million in sales and 450 employees in the mill (Tardiff 7/9/1980). Despite the strength of the Exeter Manufacturing Company, by the 1960s manager Hervey Kent, Jr. was unable to appoint a successor and sold the company and mill to Miliken Manufacturing Company in 1966.

The area around Great Falls in downtown Exeter remained the heart of the town, supported by the continued prominence of the nearby Exeter Manufacturing Company mill. The 1924 and 1943 Sanborn maps show that Water Street continued to be lined with stores along the east side, as well as a theater, fire station, and a bakery. Franklin Street was populated mostly by single and multi-family dwellings. Pleasant Street, on the east side of the river, was still lined with single-family residences. Great Bridge and String Bridge were replaced with rigid frame concrete structures during this time period. Great Bridge, formerly an iron structure, was replaced in 1934 (Aten 2003, 12). The two portions of String Bridge, leading to Kimball's Island from the east and west river banks, were replaced in 1935. Outside of downtown Exeter, the town was beginning to shift more dramatically from farmland to suburban settlement (Monroe 1998, 6). The increased use of the automobile after World War II allowed people to live in Exeter but work within the metropolitan Boston area. As demand for housing increased, former farmland on the outskirts of the central area of Exeter was subdivided for the construction of new residential areas.

The Vicinity of Great Falls During the Late 20th Century to the Early 21st Century (1966-present)

When the Exeter Manufacturing Company was sold to the Miliken Manufacturing Company in 1966, it marked a major change in the industrial development of the town. In addition to the symbolic loss of an industrial name and family that had dominated the town for more than 100 years, the new factory included many more automated processes (Exeter Historical Society, MSS72 file). Although the Miliken Manufacturing Company specialized in similar industrial products as its predecessor, the factory required fewer workers and was no longer such a dominant employer in the town. Shortly after purchasing the factory, the Miliken Manufacturing Company constructed a holding pond and waste treatment plant adjacent to their facility where Founder's Park is now located (Carman 1987, 55). As a row of houses had occupied the current area of Founder's Park as late as the 1950s (Exeter Historical Society, MSS12 file), it is possible that these houses were removed in order to accommodate the additions to the Miliken facility. In 1981, the Miliken Manufacturing Company sold the factory to the Nike Company, and donated the water flowage rights and the Great Dam and upstream Pickpocket Dam along the Exeter River to the town, along with the area of the Squamscott River along Great Falls (Tardiff 1986, 61). Nike manufactured simulated suede in Exeter for two years before closing the factory permanently (Carman 1987, 55) in 1983, ending the factory's nearly 160-year production history. During the late 1980s, the former factory buildings were converted into a mixed-use residential and commercial complex, with a small number of new buildings added.

By the early 21st century, downtown Exeter and the area of Great Falls had long been established as the town's municipal and commercial center. Despite the decreased prominence of the former Exeter Manufacturing Company factory and its eventual shift in use, the vicinity of Great Falls has continued to serve as the center of activity in the town. The town offices were moved in 1966 from the Town Hall along Court Street to the intersection of Water Street and Front Street, when the Town purchased the former Rockingham County Probate and Deeds building. In addition, several of the former dwellings along Franklin Street have been converted for commercial use, supported by the close proximity of the Exeter Academy, a major institutional entity in the town. The New Hampshire Fish and Game Department added a fish ladder and concrete weir on the west side of the Great Dam in 1968 as part of a fish passage and spawning restoration initiative. In the 1980s, the Town constructed a new public library and park along the east side of the riverfront, on land donated by the Miliken Manufacturing Company, where previously tenements and earlier mills had stood before the Miliken Company built a holding pond and wastewater treatment facility here in the 1970s. The park was named Founder's Park in honor of the 350th anniversary of the settlement of the town.

20. Applicable NHDHR Historic Context(s)

18. Locally capitalized textile mills in NH, 1720-1920
46. Carriage and wagon manufacture, 1820-1900
90. Water supply, distribution and treatment in New Hampshire, 1850-present

130. Commerce, industry and trade in New Hampshire village and town centers, 1630-present

21. Architectural Description and Comparative Evaluation

<u>Summary</u>

The photographs of buildings and areas within the project area are generally arranged from northwest to southeast and their locations are indicated on Figure 1. The National Register nomination for the Exeter Waterfront Commercial District, in which the northern sections of the project area are included, divides the immediate area around the Exeter Great Dam as the Lower Block, the Upper Block, and the Residential Area. The Lower Block lies west of the intersection of Water and Front Street, on the west side of the Exeter River. This area contains the impressive brick commercial buildings from the late 19th and early 20th centuries. The Upper Block, east of the Water and Front Street intersection and the northern tip of Franklin Street, is mostly composed of smaller scale wood frame gable front buildings which have been converted to commercial use; this area escaped the late 19th fire that destroyed most of the Lower Block, so retains its smaller scale and mid-to-late 19th century buildings. The Residential Area, which includes west end of High Street, and Pleasant and Chestnut Streets, is characterized by mostly early 19th century residences, mainly from the Federal period, although there are several Georgian style houses as well.

The project area is focused on Exeter's earliest area of settlement at the Great Falls on the Exeter River, which provided water power for industrial enterprises soon after the town was established. The ledge outcroppings in the river which produced the falls and formed the base of the dams which have been located here since the 1640s and that of Kimball's Island downstream of the falls are prominent features in the project area. Granite retaining walls line both sides of the river downstream of the High Street bridge, with more sporadic instances of retaining walls upstream within the river's impoundment area. On the west side of the Exeter River within the project area, the land is mainly level; the topography east of the river, especially along Pleasant Street is much higher, with a relatively gentle incline down to the river from these streets. As a result, the early 19th century houses on these streets, within the Residential Area described above, have a more imposing appearance and elevated front view of the river and Great Dam. The 1987 brick public library and open space to the south, known as Founders' Park, established in 1988, provide a more tranquil and open setting for the Pleasant Street houses; the area was previously filled with tenement houses and, even earlier, mills. The buildings on the west side of the river, along Water Street and Franklin Streets, in contrast, face away from the river with their rear elevations closest to the river. Two low-scale concrete bridges – the ca. 1985 High Street (or Great Bridge) and the ca. 1935 String Bridge – cross the river on both the upstream and downstream sides of the Great Dam.

The north end of the project area, which includes both the Lower and Upper Blocks defined above, where these bridges are located, is characterized by a dense arrangement of masonry commercial blocks and wood frame former residences, now used commercially, on Water Street. The houses, still serving as residences, fronting on Pleasant Street on the east bank are generally larger and less densely spaced. Just to the south, at the intersection of Pleasant and High Streets, a tight cluster of early 19th century brick and wood frame buildings characterize Hemlock Square. To the southeast along High Street, a series of wood frame, mostly early 19th century houses densely line the street, most with shallow setbacks from the street.

Franklin Street, which begins south of the intersection of Water and High Street, on the west side of the river, holds a number of early to mid-19th century double and single side gable houses. Two automotive-related buildings at the north end of the street are the 20th century successors to the former carriage factory activities that dominated this area in the mid-19th century. South of the Franklin Street area, on both sides of the Exeter River, the land is undeveloped, dominated by the expansive athletic fields of the Philips Exeter Academy. An early 20th century concrete arch bridge connects the fields to the north, while a simple metal footbridge, likely from the late 20th century, leads from Gilman Street on the west bank to Gilman Park, the southern boundary of the project area.

Trees and vegetation within the project area are relatively sparse in the northern end, except for along the east bank in the vicinity of Founders' Park and on Kimball's Island at String Bridge. South of the High Street bridge, trees line the west bank of the river behind Franklin Street. Further south, larger clusters of trees line both banks of the river, which curves several times before branching into the Little River on the west at Gilman Park.

The condition of buildings and structures in the project range from excellent to poor; a direct correlation can be observed regarding the condition of the buildings within the three local historic districts that converge on the north end of the project area and those seen in the Franklin Street area to the south.

<u>Early Settlement of Great Falls Area (1630s – 1827)</u>

As the site of the town's earliest settlement, the project area and areas adjacent to it, are distinguished by the collection of 18th century and early 19th century Georgian and Federal style buildings. The town's oldest extant building, the Gilman Garrison at (**12 Water Street, Photo #14)** dates to ca. 1709 and was a refuge from Indian attacks and as an early inn, while also serving as a residence. The house has been a museum since its acquisition by the Society for the Preservation of New England Antiquities (now Historic New England) in 1966.

An early mill building on Kimball's Island **(Chestnut Hill Street, String Bridge, Photo #24)** has an ascribed date of 1710. The building is just east of the lower falls, where a grist mill first operated in 1638, followed by sawmills at the upper falls (location of the Great Dam) in the late 1640s (Garvin et al, 1994). Its low side gable profile fronting on String Bridge differs markedly from its downstream (north) side, which is two stories in height with a high raised brick foundation. The building is joined by a newer structure to the east from 1978, whose design reflects the earlier modest side gable structure.

On the east side of the project area, two houses at 13-15 High Street (c. 1786) and 17 High Street (1765) are representative of the handsome side gable Georgian houses in the area, but otherwise the majority of the buildings within the project area that predate the establishment of the Exeter Manufacturing Company are early residential examples of the Federal style. The most imposing is the 1816 Simeon Folsom House, 8 High Street, at the intersection with Pleasant Street **(Photo #41, 42, 43).** The building is distinguished by its prominent curved façade at a major intersection, brick construction, and delicate and detailed wood cornice. The simple wood frame house to the east, also estimated at 1816, represents another early Federal style building, with a side gable form and steeply pitched roof with twin inset chimneys; the building, like many others in the area, has received later 19th century additions in the form of bay windows and porches **(10 High Street, Photo # 42)**. The ca. 1820 five-bay house at 23 Pleasant Street **(Photo #34, 35, 37, 39)** represents an early Federal house, albeit with Italianate bays and door hood, that also preceded the mill buildings that would soon be built nearby to the north. Another prominent example of Federal architecture in the area is the Long House at 4-10 Franklin Street, built in 1826 on the site of an earlier starch factory **(Photo #50, 51, 53, 54).** The building's name is derived from its 12-bay façade and it exhibits classic Federal elements in its slender elongated pilasters at the entrances and12/6 sash. Built on the eve of the Exeter Manufacturing Company's establishment, the building was owned and used for many years by the company as mill workers' housing.

<u>Rise of the Exeter Manufacturing Company at Great Falls (1827 – World War I)</u>

The Exeter Manufacturing Company's dominance from its establishment to the early decades of the 20th century greatly impacted the appearance of the project area during this period. The company and other developers built or moved structures that accommodated workers housing near the mill and other factories in Exeter's center. Other important factors, though, were the Boston & Maine Railroad's location west of the river and central commercial district, which drew factories and their workers; fires in the Water Street business area and in the Exeter Manufacturing Company complex; and the decline of the carriage manufacturing industry in the Franklin Street area.

The project area was the site of most early construction efforts soon after the Exeter Manufacturing Company, including the company's earliest buildings to the north of the Exeter Great Dam on the east side of the river. Although their earliest buildings are no longer extant, due to two large fires in the late 19th century, the distinctive main brick mill building with a Federal style cupola survived until 1893. Only one antebellum building, formerly known as Building #3 remains and is a simple Greek Revival building that dates to 1840.

Numerous houses were built near the mill soon after its establishment, both to comply with the company's requirement that workers live within a five-minute walk and to manage the influx of people arriving in the town. The area still retains many examples of substantial Federal and Greek Revival wood frame houses, which are both side and front gable examples with simple door and window trim and massive multiple chimneys. An example of early mill worker housing dates to ca. 1826-1827 and has its two-bay gable end oriented to Pleasant Street and contains two center entrances on the long south-east elevation **(25-27-29 Pleasant Street, Photo #35).** Nearby, a five-bay Greek Revival multi-family building features a pedimented front gable and central entrance with simple frame **(15-17 Pleasant Street, Photo #38)**.

The Franklin Street area on the west side of the Exeter River, south of the Water Street business district, has a number of houses, mostly multi-family, that date to the mid-19th century. By 1845, both sides of Franklin Street, which backs on to the west side of the Exeter River, were lined with both side and front gable houses. Examples of early houses on the street, which are estimated to date to the 1820s-1830s, include several with a Federal style form, some of which have their end gables fronting the street **(26 Franklin Street, Photo #55; 29 and 27 Franklin Street, Photo #61; and 47 Franklin Street, Photo #64).** The ca. 1840 house at **30 Franklin Street (Photo #55)** represents an example of Greek Revival with its wide gable front and wide frieze and corner boards.

Further south, River Street also parallels the Exeter River; its modest wood frame residences are relatively similar to those on Franklin Street, although they appear to date from at least 10 years later, beginning in the late 1840s. Likely two of the earliest houses on the street are **20 and 22 River Street (Photo #67)**, which both have a side gable form, simple detailing, and brick foundations.

Water Street displays several examples of Greek Revival front gable buildings, including the ca. 1840 three -bay building with on the east side of Water Street at the String Bridge; the building has wide wood corner boards and unadorned window trim framing the 6/6 sash; its multi-paned storefront windows are presumed to either be original or date to later in the 19th century **(69 Water Street, Photo #11).** Another prominent Greek Revival building is the rambling wood frame building at the High Street Bridge at **1-9 Water Street (Photo #12, 21, 22, 49).** The building, like so many others is sided with clapboard and has simple trim around the windows and doors.

Prior to the beginning of the Civil War, the business area along Water Street was mostly lined with wood frame side and front gable buildings, many of which still exist at the lower (south) end of Water Street. These buildings escaped the fires in the 1860s and 1870s which claimed the northern portions of the street. Although a material sparingly used earlier in the century, brick was much more commonly used by the late 19th century, presumably due to the recent fires. Not surprisingly perhaps, a brick fire house that dates to 1873 is present in one of the commercial blocks, its modest vernacular design is offset by its more ornamented and prominent hip-roofed fire tower **(27-37 Water Street, Photo #16-18)**. The east side of Water Street north of the String Bridge features a row of brick two and three-story buildings, most with Italianate detailing such as brick corbelling, decorated wood hoodmolds, and heavy cornices **(93-97 Water Street, 99-101 Water Street, and 109-113 Water Street, Photo #9).**South of the String Bridge intersection, the east side of Water Street contains two large brick buildings – the Richardsonian Romanesque Folsom Building, **59-65 Water Street** from 1896, which represents one of the few high style buildings in the project area, and the 1915 Mayer Building, which is Colonial Revival in style – which dominate a block filled otherwise with front gable wood frame buildings **(55 Water Street, Photo #11)**. Otherwise, late 19th century/early 20th century buildings within the project area are rare.

Before and after the late 19th century fires, the Exeter Manufacturing Company had added several buildings, including one from 1875-1875, an Italianate brick structure with corbelling and narrow segmental arched windows, at the north end of the complex (Photo #1), the 1894 main brick factory building that features pier and spandrel construction and wide round arched windows (Photo #1, 30); and the ca. 1891 brick power plant at the southwest corner of the complex **(Photo #28, 30)**, a two-story structure with the complex's iconic brick smokestack. Two other brick buildings were added in 1916 and 1918; a pier and spandrel structure at the northeast corner of the complex and an office structure, respectively, which front on Chestnut Street. Just before World War I, the company also rebuilt its main dam structure at the Great Falls. Completed ca. 1911, it appears the dam was rebuilt to replace an earlier aging structure, but whether this earlier structure dated to ca. 1828 or was a later 19th century replacement is unknown. The gravity dam and its outlet structures were constructed of concrete, a material used for dams beginning in the late 19th century **(Photo #17, 18, 19, 20, 39, 40).**

Exeter's densely developed central area received its first official public park in 1891, a gift of Daniel Gilman. Gilman Park at the southern end of the project area, and less than a mile from the High Street Bridge, now contains several recreational facilities, including baseball/softball fields and a basketball court. A constant feature of the park since 1897 are the cannons near the river's edge that came from the United States Naval Department **(Photo #87).**

Few buildings within the project area date from after 1900, as early 20th century development in the town was taking place outside of the historic village core. Buildings catering to automobile use are rare and only seen on Franklin Street within the project area. The earliest one dates to ca. 1915; the one-story ornamental concrete block structure that likely originally served as a automobile repair facility features a stepped front parapet **(1 Franklin Street, Photo #60)**. A small number of new commercial buildings were added to the Water Street business area during this period, including the 1915 Colonial Revival Mayer Building at **55 Water Street (Photo #11)**, which also hosts the Ioka Theatre.

<u>Post World War I Industrial Decline of Exeter (1918-1966)</u>

New construction in the project area and in nearby areas was infrequent after World War I, largely due to the decline of industry in the area, in tandem with the early 20th century trend of development in outlying areas from the historic center. One important trend in new construction within the project area during this period was the construction or replacement of earlier bridges with modern infrastructure.

Assumed to date to the 1920s, if not somewhat earlier, is the concrete arch bridge owned by the Phillips Exeter Academy that links their athletic fields on both sides of the Exeter River south of the Great Bridge. It is a single-span arch bridge, topped with a closed railing with concrete panels **(Photo #85, 86)**. A near contemporary is the 1935 String Bridge (NH bridge no. 102/074 and 103/074), actually composed of two separate bridges that connect Kimball's Island with both sides of the Exeter River. The existing concrete rigid frame bridges replaced bridge with closed wood railings; this earlier bridges succeeded older structure that featured wood trusses **(Photo #4, 27, 30, 31)**. Another infrastructure change in the project area was the addition of a concrete fish passage and weir by the New Hampshire Fish and Game Department in 1969. The fish passage, on the west side of the river, is a square-sided chute supported by square concrete piers; the concrete weir is composed of concrete piers that are aligned in a straight line across the river upstream of the dam.

A small number of buildings from the mid-20th century in the project area date from this period. A ca. 1940-1950, one-story plain concrete block structure, which originally and still provides automobile repair services, across the street from the earlier automobile-related facility on Franklin Street appears to have been updated in the 1970s with shed roofs on the front **(20-22 Franklin Street, Photo #55).** Two small 1955 brick structures were also added to the Exeter Manufacturing Company complex, one on the roof of the 1870s section at the north end of the complex and one added to the early 20th century office building.

<u>The Vicinity of Great Falls During the Late 20th Century to the Early 21st Century (1966-present)</u>

Exeter's central area was the subject of several revitalization and historic preservation efforts in the later decades of the 20th century, with an eye to retention and rehabilitation of its character-defining buildings and structures. In the 1980s, the Town studied the utilization of the rear elevations and vacant areas behind the 19th and early 20th buildings on the east side of Water Street in an effort to restore a pedestrian and visual historic connection to the rivers.

The old mill structure on Kimball's Island was rehabilitated and a 1978 Georgian structure was built to the east to be sympathetic to the earlier structure **(Photo #23, 25, 29)**. The east side of the Exeter River was improved by the construction of a multi-story brick library structure in 1987 at the east end of String Bridge **(4 Chestnut Street, Photo #32, 33)**, which clearly took its design cues from its contemporaries designed around the same time at the former Exeter Manufacturing Company, seen in their 2- and 3-story height, prominent angular roofs, narrow grouped windows, brick exteriors and wide white trim. These latter buildings at the Exeter Manufacturing Company were built in the late 1980s as well for a conversion of the vacant mill buildings for residential use **(Photo #1, 6, 30),** These improvements on the east side of the Exeter River were enhanced in 1988 by the construction to the south in 1988 of a small riverside park that was named Founders' Park, to acknowledge the town's 350th anniversary **(Between Pleasant Street and the Exeter River, north of High Street, Photo #33, 35, 36, 39).**

The tradition of sensitive new construction in Exeter's center continued in 2003, with the sympathetic replacement of the 1934 concrete High Street Bridge with a similar design in concrete with open railing **(High Street, between Pleasant Street and Water Street, Photo # 41, 44, 49).** Recognition of the earlier bridge is also presented in a plaque affixed to the new bridge.

22. Statement of Significance

Previously Listed and Inventoried Properties

Within or adjacent to the project area are two National Register historic districts – the Exeter Waterfront Commercial Historic District and the Front Street Historic District. The first named district encompasses the Great Dam and the properties bordering the Exeter and Squamscott River. Both of these areas are also designated as local historic districts; the boundary of the Downtown Historic District is the same as the National Register boundary of the Exeter Waterfront Commercial district, but excludes the Exeter Manufacturing Company property on the east side of the Exeter River, while the Front Street local historic district has identical boundaries to the National Register district of the same name. A third local historic district – the High Street Historic District – has its western boundary at the intersection of High and Portsmouth Streets, which is adjacent to the boundaries of the Exeter Waterfront Commercial district. The properties in the High Street local historic district will not be affected by the proposed project as they are too far away visually from the Exeter River.

Individually listed National Register properties adjacent or relatively close to the project area are the Gilman Garrison at 12 Water Street; the Gilman-Ladd House at 164 Water Street (also a National Historic Landmark); Dudley House, 14 Front Street; the First Church/Congregational Church, 21 Front Street; and the Samuel Tenney House at 65 High Street.

Individually inventoried properties are 154 and 156 Water Street, associated with the Exeter News-Leader, which were both determined eligible for the National Register as contributing resources to the Front Street Historic District. The Folsom Tavern at 164 Water Street was also determined eligible as a contributing resource to the same district, and individually eligible for the NH State Register of Historic

Places. The ca. 1935 String Bridge, which crosses the Exeter River at Kimball's Island (Chestnut Hill Avenue) and serves as the connection between Front Street on the west side of the river to Pleasant Street on the east, was documented in the Historic Bridge Inventory, coordinated by the FHWA-NH, NHDOT, and NHDHR, 1999, but no formal National Register eligibility recommendations were made. There has been no Town-wide Area form or other project area forms prepared for Exeter that relate to the project area.

Two properties adjacent to and within, respectively, the project area - Historic New England's Gilman Garrison at 12 Water Street and the Simeon Folsom House and Stores at 8-and 7-11 High Street near Pleasant Street – have been recorded in the Historic American Building Survey.

Significant Contexts, Architectural Patterns, and Property Types

The most significant historic contexts within the project area are associated with Exeter's industrial and commercial development and the concomitant residential and institutional development, which have already been discussed and recognized in the Exeter Waterfront Commercial Historic District and Front Street Historic District National Register nominations. The three local historic districts in Exeter, with their boundaries dovetailed together, represent a comprehensive and intact display of the town's early and continued development from the 18th through the mid-20th century.

The architectural patterns of development within the project area follow the steady succession of 18th through early 20th century styles, with a small number of Georgian houses and a greater number of Federal houses and commercial buildings, which reflect the immediate impact of the establishment of the Exeter Manufacturing Company in 1827. Examples of Greek Revival buildings are prevalent throughout the project area in both residences and commercial buildings, which also illustrates the continued growth within the project area. In general, the examples of these late 18th and early 19th styles are quite modest and only exhibit some of the hallmarks of these styles, seen in their forms, window and door trim, and some details. Examples of Italianate architecture are mostly seen in the commercial block on the east side of Water Street north of the intersection with the String Bridge, the successors to earlier wood-frame buildings lost to fires in the 1860s and 1870s in the area. Italianate details, including bay windows and hoodmolds, can be seen on some older houses within the project area.

Late 19th century architectural styles are the least represented within the project area, those that were built were replacements of buildings lost to fire, as was the case for the Exeter Manufacturing Company's industrial complex. Within the project area, only one example of Romanesque Revival style is present. Similarly, early 20th century architecture is not common as development in Exeter during this time period was taking place further outside of the town's historic core.

Recommendations for Future Survey Work

The area directly impacted by the possible removal of the Great Dam has already been listed in the National Register and is also within a local historic district. The only area potentially impacted by dam removal that has not been studied is upstream (south) of the Great Dam along the west side of the Exeter River. This area, known locally as the Franklin Street area, includes both sides of Franklin Street, Clifford Street, Bow Street, South Street, River Street, River Street Extension, Brown's Lane and Court

Street (see Figure 1, area recommended for further survey). It is a compact area of mostly mid-to late 19th century single and double wood-frame residences that housed immigrant laborers since the area was initially developed in the 1830s and 1840s. The area is also distinguished by the presence of a brick industrial building on South Street at River Street, which served a number of enterprises **(Photo #95)**, and the brick Robinson house at 10 Bow Street **(Photo #92).** The area was a center of Exeter's carriage manufacturing industry, which thrived in the mid-to late 19th century, but no buildings are understood at this time to remain except for the brick industrial building on South Street.

Further research may identify additional buildings associated with Exeter's industrial past in the neighborhood. Always the home to many of Exeter's working class residents, the area retains many of its earliest houses and its less dense pattern of development. The areas has received alterations in the form of replacement siding, window and door replacements, and removal of porches, but still presents an understanding of the area's 19th century appearance. Earlier maps show that many of the houses had outbuildings which no longer stand today. The National Register eligibility of the area should be evaluated as the area represents a neighborhood that was devoted to Exeter's working class residents, many of whom undoubtedly found employment at the Exeter Manufacturing Company and the local carriage shops.

23. Periods(s) of Significance

N/A

24. Statement of Integrity

The project area possesses a high level of integrity at both the district and individual building level. Improvements to the business district that were implemented in the late 1970s and the 1980s, and in more recent years, have resulted in many rehabilitated commercial buildings and a revitalized waterfront area. The new Exeter Public Library building and the new Founders Park on the east side of the Exeter River, which date to the 1987 and 1988, respectively, were built on the site of 19th century workers' housing owned by the Exeter Manufacturing Company. The commanding presence of the brick mill buildings north of the library and park and its attendant Great Dam are important reminders of Exeter's leading industry in the town's center for nearly 150 years.

25. Boundary Justification

N/A

26. Boundary Description

N/A

27. Bibliography and/or References

Aten, Carol Walker.

Postcards from Exeter (Portsmouth, NH: Arcadia Publishing, 2003).

Images of America: Exeter (Dover, NH: Arcadia Publishing, 1996).

Bell, Charles Henry. History of the Town of Exeter, New Hampshire (Boston: J.E. Farwell & Co., 1888).

Bennett, Lance and Jack Beard. "Exeter Waterfront Commercial Historic District," National Register of Historic Place nomination form, 1980.

Carman, Rebecca W. Reflections: Exeter Mill (Boston: Arbor Development Company, Inc., 1988).

Chapin, Barbara, Society for the Preservation of New England Antiquities (now Historic New England). "Gilman 'Garrison' House, 12 Water Street," National Register of Historic Places nomination form, 1974.

Exeter Gazette, "Exeter's Loss! Exeter manufacturing Company's Mill Burned," March 17, 1893.

Exeter Historical Society
- SC225 file – Gale Shoe Brothers
- SC308 file – Head family
- SC348 file – Builders
- SC399 file – Carriage makers
- SC423 file – Francis Ham
- SC477 file – Towle family
- MSS72 file – Exeter Manufacturing Company
- SC129 file – Jewell family
- MSS93, Folder 42 – Moving Houses Talk, Nancy Merrill
- MSS2 file – Transcript of the First Records of the Town of Exeter, NH
- MSS93, Folder 30 – 14 Bow Street
- Merrill Notebook file

Exeter News-Letter
_____ December 11, 1891, "Exeter's New Shoe Factory, From a Photograph by Morse."
_____ May 3, 1907, "Joseph Newell Head."
_____ February 3, 1893, "Orin Head."
_____ April 18, 1940, "Honoré Willsie Morrow."
_____1896, "Sebastian Augustus Brown."
_____ February 18, 1898, "John Hillard Brown."
_____ February 19, 1897, "Josiah Batchelder"
_____ January 30, 1903, "Charles E. Warren."
_____ September 2, 1887, "Nathaniel Marston Jewell."
_____ February 16, 1917, "Lieut. Andrew J. Fogg."
_____ April 6, 1868, "Local."
_____ January 11, 1884, "Sudden Death – Francis Ham."
_____ January 6, 1888, "Toboggan Time."
_____ March 17, 1893, "Disastrous Fire."
_____1884, "Asa Jewell."

Garvin, James L. et al. "Walking Tour of Exeter, New Hampshire," (Exeter, NH: Historic Exeter Associates, 1994).

Giffen, Jane C. “New Hampshire cabinetmakers and allied craftsmen, 1790-1850,” *Antiques*, July 1968.

Griset, Brian, “Mendez Trust-Kingston Road Property: Investigative Analysis of Impacting Factors Adversely Effecting (sic) Market Valuation and Use.” No date, Griset & Sons Environmental and Boundary Consultants, report within NH DES Dam file for Exeter Great Dam.

Merrill, Nancy C.
“1884: A New Industry Comes to the Town,” *Exeter News-Letter*, October 20, 1976
n.d., “History of Franklin, Court Sts.,” *Exeter News-Letter*.
n.d., “Town Grows Out Court Street,” *Exeter News-Letter*.
n.d., “Town Grows Between Court, Front Sts.,” *Exeter News-Letter*.
n.d., “Carriage Making, Taverns,” *Exeter News-Letter*.
n.d., “Exeter In Perspective,” *Exeter News-Letter*.
“The History of 14 Bow Street,” prepared in 1981 for Muriel Simmons, Realtor.
“Ethnic Heritage: Populating a Community, Part II,” *Exeter News-Letter*, December 15, 1976.
“Ethnic Heritage: Populating a Community, Part III,” *Exeter News-Letter,* December 22, 1976.

Perry, William Gilman. Exeter in 1830, ed. Nancy C. Merrill (Hampton, NH: Peter E. Randall, 1972).

Rinkunas, Barbara. “Gale Brothers Show town’s big employer,” *Exeter News-Letter*, May 29, 2009.

Schute, Henry A. “Horses and Other Things,” *Exeter News-Letter*, January 15, 1932.

Tardiff, Olive
The Exeter-Squamscott: River of Many Uses (Rye, NH: CGC, 1986).
“A factory and its people, Part I,” *Exeter News-Letter*, June 4, 1980.
“A factory and its people, Part II,” *Exeter News-Letter*, July 9, 1980.

Textile Age, “Exeter Manufacturing Co.,” Vol. 6, No. 1, January 1942.

Maps

1802 Phineas Merrill, “A Plan of the Compact Part of the Town of Exeter.” Exeter Historical Society archives.

1845 Joseph Dow, “Plan of Exeter Village, New Hampshire.” Exeter Historical Society Archives.

1874 “Map of Exeter, New Hampshire.” (Philadelphia: Sanford & Everts). Exeter Historical Society archives.

1884 “Exeter, New Hampshire,” birds-eye view (Brockton, MA: Norris & Wellge). Exeter Historical Society archives.

1892 “Exeter,” Atlas of the State of New Hampshire (Boston: D.H. Hurd & Co.). Exeter Historical Society archives.

1896 "Exeter, New Hampshire," birds-eye view (Boston: A.W. Moore Co., Lith.). Exeter Historical Society archives.

Sanborn Fire and Insurance Company, "Exeter, NH." 1885, 1892, 1898, 1904, 1913, 1924, 1943 (updated from 1924). http://sanborn.umi.com, accessed January 2012.

28. Surveyor's Evaluation – N/A for a Project Area Form

NR listed:	district	☐	NR eligible:		NR Criteria:	A	☐
	individuals		district	☐		B	☐
	within district	☐	not eligible	☐		C	☐
Integrity:	yes	☐				D	☐
	no	☐	more info needed	☐		E	☐

If this Area Form is for a Historic District: # of contributing resources: ______
# of noncontributing resources: ______

I, the undersigned, confirm that the photos in this inventory form have not been digitally manipulated and that they conform to the standards set forth in the NHDHR Photo Policy. These photos were printed at the following commercial printer OR were printed using the following printer, ink, and paper: _HP Photosmart 8050 Printer, HP Vivera 98 Ink, Hewlett Packard Premium Plus Photo Paper. The negatives or digital files are housed at/with: __VHB______________________________.

Photo 1 description: Exeter Manufacturing Company, from east from west bank

Roll: _____ Frame: _____ Direction: E Date taken: 11-2011 Negative stored: ______

Photo 2 description: Rear of Water Street buildings and Squamscott River

Roll: _____ Frame: _____ Direction: SW Date taken: 11-2011 Negative stored: ______

Photo 3 description: North side of Kimball Island and buildings on both sides of Squamscott River

Roll: _____ Frame: _____ Direction: S Date taken: 11-2011 Negative stored: _____

Photo 4 description: North side of Kimball Island buildings, facing south

Roll: _____ Frame: _____ Direction: S Date taken: 11-2011 Negative stored: _____

Photo 5 description: East side of Water Street buildings, north of String Bridge

Roll: _____ Frame: _____ Direction: SW Date taken: 11-2011 Negative stored: ______

Photo 6 description: Exeter Manufacturing Company and Kimball Island buildings

Roll: _____ Frame: _____ Direction: SE Date taken: 11-2011 Negative stored: ______

Photo 7 description: Water Street, facing south from Swasey Parkway

Roll: _____ Frame: _____ Direction: S Date taken: 11-2011 Negative stored: _____

Photo 8 description: Water Street, facing south from Swasey Parkway

Roll: _____ Frame: _____ Direction: S Date taken: 11-2011 Negative stored: _____

Photo 9 description: Water Street, east side, north of String Bridge

Roll: _____ Frame: _____ Direction: NE Date taken: 11-2011 Negative stored: _____

Photo 10 description: Water Street at String Bridge, east side

Roll: _____ Frame: _____ Direction: E Date taken: 11-2011 Negative stored: _____

Photo 11 description: Water Street, south of String Bridge

Roll: _____ Frame: _____ Direction: SW Date taken: 11-2011 Negative stored: ______

Photo 12 description: Loaf and Ladle Building, northeast corner Water Street and High Street, 1-9 High Street

Roll: _____ Frame: _____ Direction: NE Date taken: 11-2011 Negative stored: ______

Photo 13 description: Water Street and High Street, facing north towards Water Street

Roll: _____ Frame: _____ Direction: N Date taken: 11-2011 Negative stored: _____

Photo 14 description: 9 Water Street, and Water Street, facing northwest from intersection with High Street

Roll: _____ Frame: _____ Direction: NW Date taken: 11-2011 Negative stored: _____

Photo 15 description: Exeter Great Dam and falls, facing north from String Bridge
Roll: _____ Frame: _____ Direction: N Date taken: 11-2011 Negative stored: _____

Photo 16 description: Fish ladder (on extreme left) and concrete weir, rear of Water Street buildings, from Founders Park
Roll: _____ Frame: _____ Direction: W Date taken: 11-2011 Negative stored: _____

Photo 17 description: Rear of Water Street buildings, facing west from Pleasant Street

Roll: _____ Frame: _____ Direction: W Date taken: 11-2011 Negative stored: ______

Photo 18 description: Great Dam, fish ladder, and concrete weir, rear of Water Street buildings, from Founders Park

Roll: _____ Frame: _____ Direction: W Date taken: ________ Negative stored: ______

Photo 19 description: Great Dam and fish ladder, rear of Water Street buildings, from Founders Park

Roll: ____ Frame: ____ Direction: W Date taken: 11-2011 Negative stored: ____

Photo 20 description: Rear of Water Street buildings and Great Dam and portion of fish ladder, from Founders Park

Roll: ____ Frame: ____ Direction: W Date taken: 11-2011 Negative stored: ____

Photo 21 description: High Street Bridge, Loaf and Ladle Building,1-9 Water Street and 11 Water Street on right
Roll: _____ Frame: _____ Direction: NW Date taken: 11-2011 Negative stored: ______

Photo 22 description: High Street Bridge and Loaf and Ladle building, 1-9 Water Street+ from Founders Park
Roll: _____ Frame: _____ Direction: NW Date taken: 11-2011 Negative stored: ______

Photo 23 description: West building on Kimball's Island

Roll: _____ Frame: _____ Direction: NE Date taken: 11-2011 Negative stored: ______

Photo 24 description: West building on Kimball Island's and rear of Water Street buildings from String Bridge

Roll: _____ Frame: _____ Direction: NW Date taken: 11-2011 Negative stored: ______

Photo 25 description: East buildings on Kimball's Island, from west end of Kimball Island

Roll: _____ Frame: _____ Direction: E Date taken: 11-2011 Negative stored: ______

Photo 26 description: View west from east end of Kimball's Island

Roll: _____ Frame: _____ Direction: W Date taken: 11-2011 Negative stored: ______

Photo 27 description: East end of String Bridge and Kimball's Island west building

Roll: _____ Frame: _____ Direction: SW Date taken: 11-2011 Negative stored: ______

Photo 28 description: East side of Exeter River, north of String Bridge, Exeter Mfg. Co. complex on right

Roll: _____ Frame: _____ Direction: N Date taken: 11-2011 Negative stored: ______

Photo 29 description: East side of Kimball's Island and east building from String Bridge, east side of Exeter River

Roll: _____ Frame: _____ Direction: NW Date taken: 11-2011 Negative stored: ______

Photo 30 description: Former Exeter Manufacturing Company buildings from String Bridge

Roll: _____ Frame: _____ Direction: NR Date taken: 11-2011 Negative stored: ______

Photo 31 description: String Bridge towards Chestnut Street (new housing in former Exeter Mfg. Co. complex on left

Roll: ____ Frame: ____ Direction: E Date taken: 11-2011 Negative stored: ____

Photo 32 description: Exeter Public Library, 4 Chestnut Street, from String Bridge

Roll: ____ Frame: ____ Direction: E Date taken: 11-2011 Negative stored: ____

Photo 33 description: Founders Park and Library on east side of Exeter River, from south end of park

Roll: _____ Frame: _____ Direction: N Date taken: 11-2011 Negative stored: ______

Photo 34 description: East side of Pleasant Street at Hall Place, from Founders Park

Roll: _____ Frame: _____ Direction: NE Date taken: 11-2011 Negative stored: ______

Photo 35 description: East side of Pleasant Street north of High Street, from Founders Park

Roll: _____ Frame: _____ Direction: NE Date taken: 11-2011 Negative stored: ______

Photo 36 description: Founders Park, facing north from near High Street and Pleasant Street

Roll: _____ Frame: _____ Direction: NE Date taken: 11-2011 Negative stored: ______

Photo 37 description: East side of Pleasant Street, 23 Pleasant (on left) and 2 Hall Place, from Founders Park

Roll: _____ Frame: _____ Direction: E Date taken: 11-2011 Negative stored: ______

Photo 38 description: East side of Pleasant Street, 15-17 and 7-11, 9 High Street, High Street Bridge, from Founder's Park

Roll: _____ Frame: _____ Direction: SE Date taken: 11-2011 Negative stored: ______

Photo 39 description: Exeter River, Library, Founders Park and east side of Pleasant Street, from High St. Bridge

Roll: ____ Frame: ____ Direction: N Date taken: 11-2011 Negative stored: ____

Photo 40 description: Exeter River, Great Dam, Library and Founders Park. from High Street Bridge

Roll: ____ Frame: ____ Direction: N Date taken: 11-2011 Negative stored: ____

Photo 41 description: View east of Pleasant and High Street intersection, from High Street Bridge

Roll: ____ Frame: ____ Direction: E Date taken: 11-2011 Negative stored: ____

Photo 42 description: 8 and 10 High Street, facing north

Roll: ____ Frame: ____ Direction: N Date taken: 11-2011 Negative stored: ____

Photo 43 description: 8 and 10 High Street, towards Pleasant Street and Exeter River

Roll: _____ Frame: _____ Direction: NW Date taken: 11-2011 Negative stored: ______

Photo 44 description: High Street Bridge, from intersection with Water and Franklin Streets

Roll: _____ Frame: _____ Direction: E Date taken: 11-2011 Negative stored: ______

Photo 45 description: 11 and 5 High Street, west of High Street Bridge

Roll: _____ Frame: _____ Direction: W Date taken: 11-2011 Negative stored: ______

Photo 46 description: 11 High Street, facing west

Roll: _____ Frame: _____ Direction: W Date taken: 11-2011 Negative stored: ______

Photo 47 description: High Street, on the right – 16, 20-22 and partial view of 24-26, and on the left – 25 High Street

Roll: _____ Frame: _____ Direction: W Date taken: 11-2011 Negative stored: ______

Photo 48 description: West side of 5 High Street and Exeter River Impoundment

Roll: _____ Frame: _____ Direction: SE Date taken: 11-2011 Negative stored: ______

Photo 49 description: High Street Bridge, facing towards intersection with Water Street on right and Franklin Street on left

Roll: _____ Frame: _____ Direction: W Date taken: 11-2011 Negative stored: ______

Photo 50 description: Intersection of High, Water and Franklin streets, facing towards High Street Bridge

Roll: _____ Frame: _____ Direction: E Date taken: 11-2011 Negative stored: ______

Photo 51 description: Rear of buildings on east side of Franklin Street, south of High Street

Roll: _____ Frame: _____ Direction: SW Date taken: 11-2011 Negative stored: ______

Photo 52 description: East, rear sides of buildings on east side of Franklin Street, south of High Street

Roll: _____ Frame: _____ Direction: SW Date taken: 11-2011 Negative stored: ______

Photo 53 description: Franklin, High and Clifford Street intersection, 4-10 Franklin Street in foreground

Roll: _____ Frame: _____ Direction: SE Date taken: 11-2011 Negative stored: ______

Photo 54 description: East side of Franklin Street, just south of High and Water streets, 4-10 Franklin Street on right

Roll: _____ Frame: _____ Direction: NE Date taken: 11-2011 Negative stored: ______

Photo 55 description: 26 and 30 Franklin Street

Roll: _____ Frame: _____ Direction: NE Date taken: 11-2011 Negative stored: ______

Photo 56 description: East side of Franklin Street, 32-36 Franklin Street on right, foreground

Roll: _____ Frame: _____ Direction: NE Date taken: 11-2011 Negative stored: ______

Photo 57 description: Franklin Street, east side, 46 and 48 Franklin in right foreground

Roll: _____ Frame: _____ Direction: NE Date taken: 11-2011 Negative stored: ______

Photo 58 description: Franklin Street, from in front of 47 Franklin Street

Roll: _____ Frame: _____ Direction: N Date taken: 11-2011 Negative stored: ______

Photo 59 description: Photo # not used

Roll: _____ Frame: _____ Direction: _____ Date taken: _______ Negative stored: ______

Photo 60 description: 15-17 Franklin Street, with 1 Franklin Street to far right,

Roll: _____ Frame: _____ Direction: NW Date taken: 11-2011 Negative stored: ______

Photo 61 description: 29 Franklin Street, west side of Franklin Street at South Street

Roll: _____ Frame: _____ Direction: NW Date taken: 11-2011 Negative stored: ______

Photo 62 description: 47, 43-45 and portion of 2 South Street (left to right)t

Roll: _____ Frame: _____ Direction: S Date taken: 11-2011 Negative stored: ______

Photo 63 description: Franklin Street, west side, 47 Franklin and 43-45 Franklin Street on left
Roll: ____ Frame: ____ Direction: N Date taken: 11-2011 Negative stored: ____

Photo 64 description: 47 Franklin Street
Roll: ____ Frame: ____ Direction: SW Date taken: 11-2011 Negative stored: ____

Photo 65 description: 12 River Street

Roll: ______ Frame: ______ Direction: SE Date taken: 11-2011 Negative stored: ______

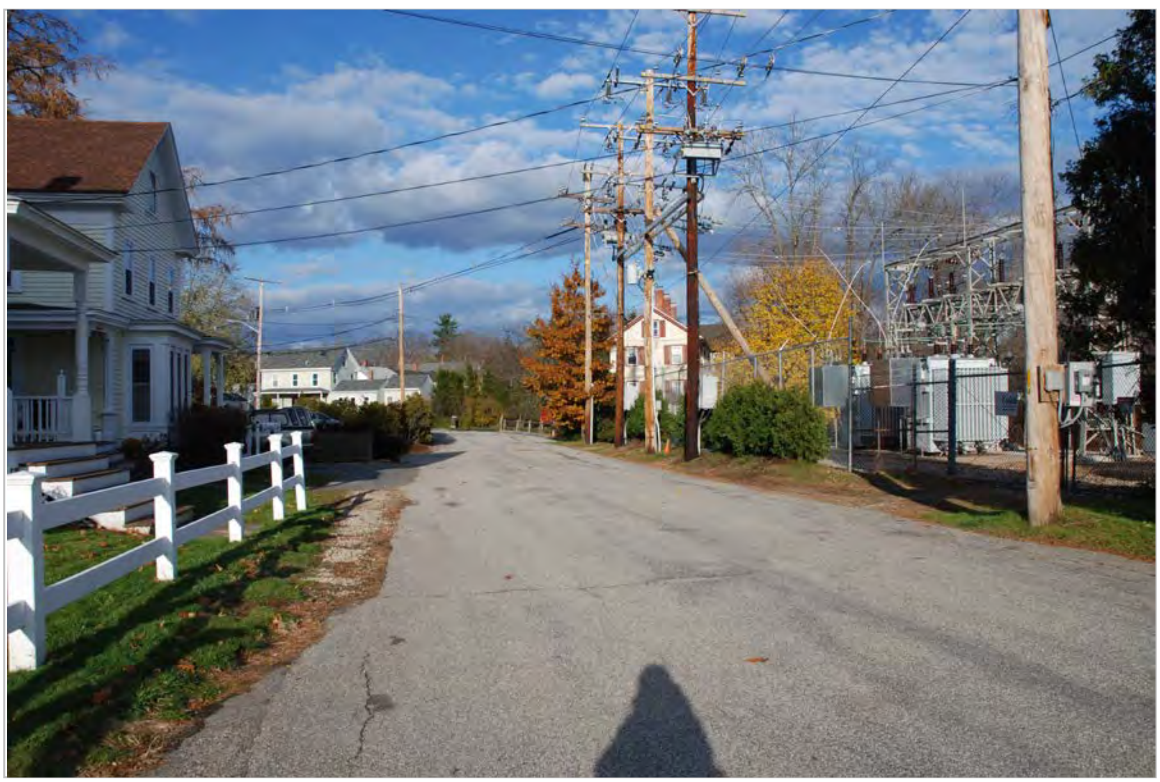


Photo 66 description: River Street, facing northeast from in front of 19 River Street

Roll: ______ Frame: ______ Direction: NE Date taken: 11-2011 Negative stored: ______

Photo 67 description: 20 and 22 River Street

Roll: _____ Frame: _____ Direction: E Date taken: 11-2011 Negative stored: ______

Photo 68 description: River Street, facing northeast, 26 River Street on right

Roll: _____ Frame: _____ Direction: NE Date taken: 11-2011 Negative stored: ______

Photo 69 description: East side of River Street, 28, 34 and 36 River Street from left to right

Roll: _____ Frame: _____ Direction: NE Date taken: 11-2011 Negative stored: ______

Photo 70 description: Southern end of River Street, 25-27 and 31 River Street on left and 36 River Street on right

Roll: _____ Frame: _____ Direction: NW Date taken: 11-2011 Negative stored: ______

Photo 71 description: 44 River Street, facing southeast

Roll: _____ Frame: _____ Direction: SE Date taken: 11-2011 Negative stored: ______

Photo 72 description: View of Philips Exeter Academy ballfields, from 44 River Street

Roll: _____ Frame: _____ Direction: SE Date taken: 11-2011 Negative stored: ______

Photo 73 description: 19 River Street from intersection with River Street Extension

Roll: _____ Frame: _____ Direction: E Date taken: 11-2011 Negative stored: ______

Photo 74 description: 25-27 and 31 River Street, facing southwest

Roll: _____ Frame: _____ Direction: SW Date taken: 11-2011 Negative stored: ______

Photo 75 description: View of High Street Bridge, facing north from Exeter River

Roll: _____ Frame: _____ Direction: N Date taken: 11-2011 Negative stored: ______

Photo 76 description: View north, east of High Street Bridge, 5 and 11 High Street in center from Exeter River

Roll: _____ Frame: _____ Direction: N Date taken: 11-2011 Negative stored: ______

Photo 77 description: View of rear of 17 High Street from Exeter River

Roll: _____ Frame: _____ Direction: E Date taken: 11-2011 Negative stored: ______

Photo 78 description: Exeter River Impoundment from High Street Bridge

Roll: _____ Frame: _____ Direction: S Date taken: 11-2011 Negative stored: ______

Photo 79 description: View of Franklin Street rear yards, 32-36, 30, 26-28 and 20 Franklin Street from Exeter River

Roll: _____ Frame: _____ Direction: NW Date taken: 11-2011 Negative stored: _____

Photo 80 description: View of Exeter River and east bank from 12 River Street parcel

Roll: _____ Frame: _____ Direction: SE Date taken: 11-2011 Negative stored: _____

Photo 81 description: Exeter River and PEA property on east side, from rear of 43 Franklin Street parcel
Roll: ____ Frame: ____ Direction: E Date taken: 11-2011 Negative stored: ____

Photo 82 description: View of 12 River Street on left and 47 Franklin Street on right from Exeter River
Roll: ____ Frame: ____ Direction: NW Date taken: 11-2011 Negative stored: ____

Photo 83 description: View of electric transformer station on River Street from Exeter River

Roll: _____ Frame: _____ Direction: W Date taken: 11-2011 Negative stored: _____

Photo 84 description: View of rear of east side of River Street parcels from Exeter River

Roll: _____ Frame: _____ Direction: NW Date taken: 11-2011 Negative stored: _____

Photo 85 description: View of Phillips Exeter Academy footbridge, facing north from Exeter River

Roll: _____ Frame: _____ Direction: N Date taken: 11-2011 Negative stored: ______

Photo 86 description: View of area south of PEA concrete footbridge on Exeter River

Roll: _____ Frame: _____ Direction: N Date taken: 11-2011 Negative stored: ______

Photo 87 description: View of Gilman Park, facing southeast from Exeter River

Roll: ____ Frame: ____ Direction: SE Date taken: 11-2011 Negative stored: ____

Photo 88 description: Outside of project area, 2 and 4-6 South Street, from Franklin Street

Roll: ____ Frame: ____ Direction: SW Date taken: 11-2011 Negative stored: ____

Photo 89 description: Outside of project area, north side of South Street, 9 South Street

Roll: _____ Frame: _____ Direction: NE Date taken: 11-2011 Negative stored: ______

Photo 90 description: Outside of project area, 11 and 9 South Street

Roll: _____ Frame: _____ Direction: N Date taken: 11-2011 Negative stored: ______

Photo 91 description: Outside of project area, south side of South Street, 2, 4, 6 and 10 South Street

Roll: _____ Frame: _____ Direction: SE Date taken: 11-2011 Negative stored: ______

Photo 92 description: Outside of project area, 10 Bow Street, from intersection of Bow and Clifford Streets

Roll: _____ Frame: _____ Direction: NW Date taken: 11-2011 Negative stored: ______

Photo 93 description: Outside of project area, 14 Bpw Street

Roll: ____ Frame: ____ Direction: NE Date taken: 11-2011 Negative stored: ____

Photo 94 description: Outside of project area, 19 and 21 Bow Street

Roll: ____ Frame: ____ Direction: SE Date taken: 11-2011 Negative stored: ____

Photo 95 description: Outside of project area, South Street at Bow street, 12-24 South St. and 3-7 River Street on right

Roll: ______ Frame: ______ Direction: SE Date taken: 11-2011 Negative stored: ______

Photo 96 description: Outside of project area, north side of South Street, east of Bow Street, 17 South Street in foreground

Roll: ______ Frame: ______ Direction: NE Date taken: 11-2011 Negative stored: ______

Photo 97 description: Outside of project area, 41 South Street on right, from River Street Extension

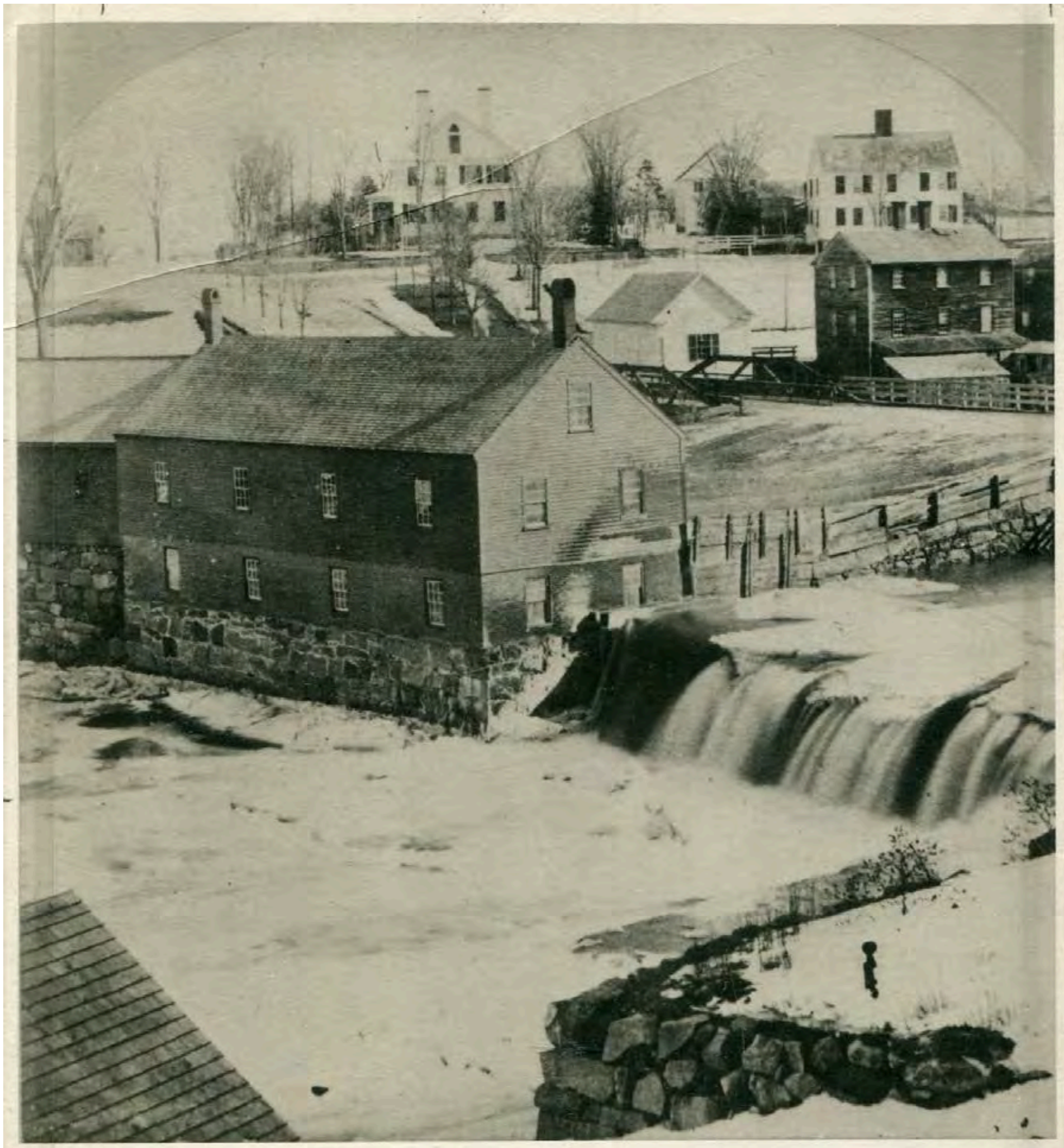
Roll: _____ Frame: _____ Direction: W Date taken: 11-2011 Negative stored: ______

Photo 98 description: Outside of project area, 8 River Street Extension

Roll: _____ Frame: _____ Direction: NE Date taken: 11-2011 Negative stored: ______

Historic Photographs (note: photographs are arranged chronologically as much as possible)

Photograph of Great Falls area facing north, ca. 1857. String Bridge and Kimball's Island on right; Great Falls and earlier dam on site of Great Dam just out of frame on right. Carol Walker Aten refers to this as the earliest known photograph of Exeter, an ambrotype copy of a daguerreotype (Aten 1896, 9). Exeter Historical Society, MSS10 Box3_1996.26.2 Dennis Waters collection.



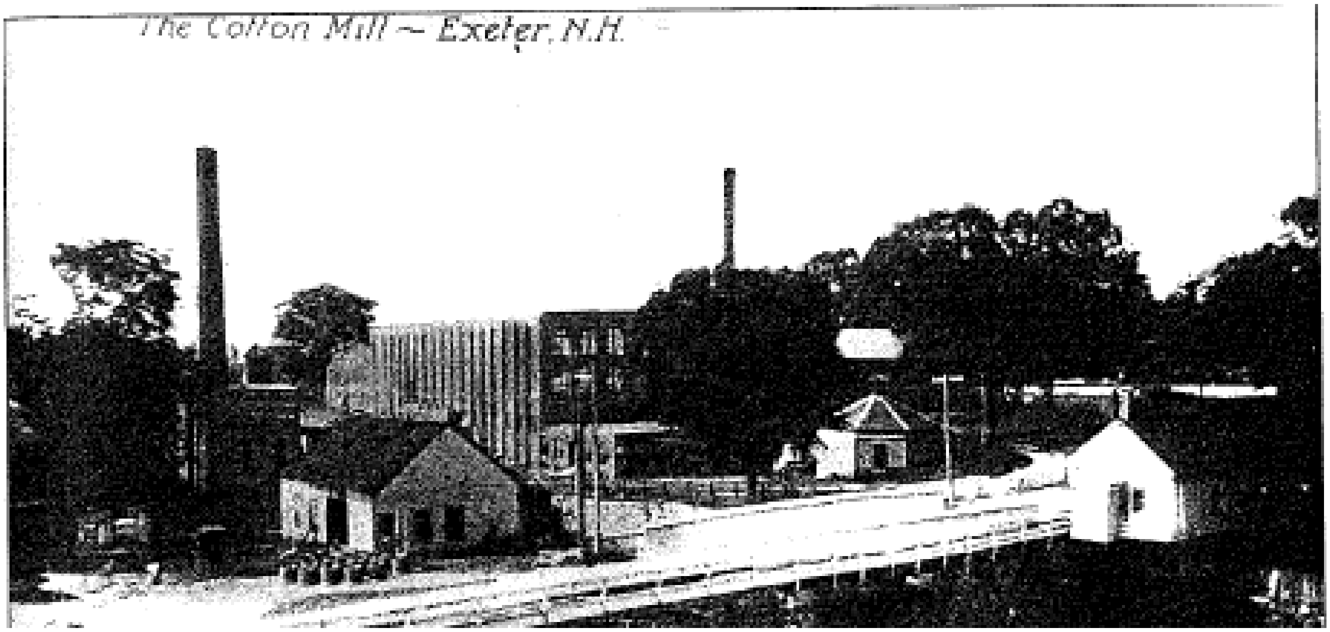
Stereograph view of String Bridge and Kimball's Island facing southwest. Aten (1996) identifies the view as taken by Exeter photographer William N. Hobbs in the 1860s. Exeter Historical Society, MSS12.

Photograph of earlier dam on site of Great Dam facing southeast, 1896. Great Bridge in background. Exeter Historical Society, photographer Lizzie G. Rollins, presented by Dana W. Baker June 1928.

Photograph of String Bridge facing north, Exeter Manufacturing Company mill in background. J.S. Mitchell, identified by Aten (2003) as 1882-1884. Exeter Historical Society, MSS91.

Photograph of earlier dam on site of Great Dam and the Exeter River facing southeast, 1902. Exeter Historical Society, MSS12_83.23.33. Compare with photograph above taken in 1896.

Photograph of Great Bridge facing east toward Hemlock Square, ca. 1900. Note electric railway car crossing bridge. Aten 1996.



Photograph of String Bridge facing north, with Exeter Manufacturing Company mill in background, ca. 1910. Aten, 2003.

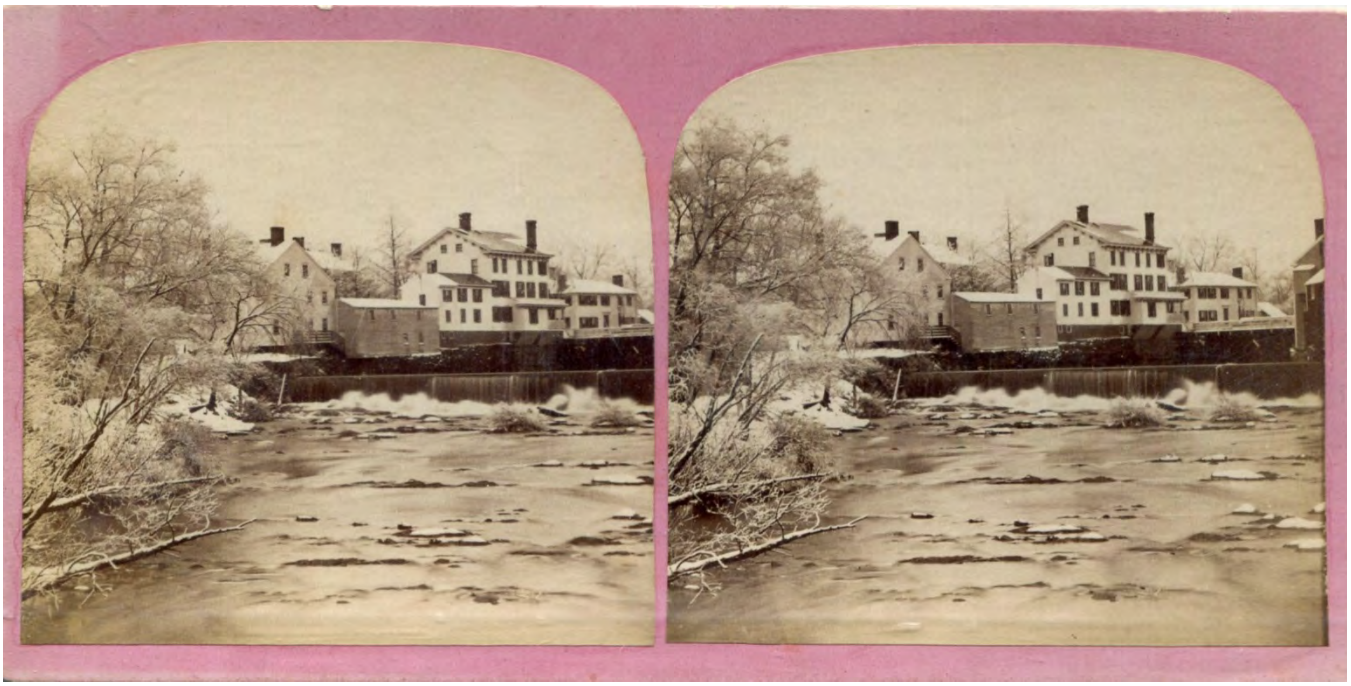
Postcard of Gilman Park, 1910. Exeter Historical Society, MSS91_1910_89.21.

Photograph of Exeter River at Gilman Park, 1910. Aten, 2003.

Photograph of Great Dam facing southeast, post-1915 (Ioka Theater visible on extreme right, constructed 1915). Great Bridge in background. Exeter Historical Society, MSS12_1990.35.2.

Photograph of Great Bridge facing south, pre-1935 (concrete bridge constructed 1935). Exeter Historical Society, MSS12_1995.45.3.

Photograph of parade crossing over Great Bridge, 1923. Aten 1996.



Photograph of earlier dam on site of Great Dam facing east, photographer William N. Hobbs, no date (but likely 19th century). Exeter Historical Society, Water Street_MSS12_81.11.8a.

Photograph of Great Dam facing east, post-1915 (Ioka Theater just visible on extreme right, constructed 1915). Great Bridge in background. Exeter Historical Society, MSS12_1995.109.5.

Photograph of Great Dam facing northwest, taken from Great Bridge, J.S. Mitchell photographer, no date. String Bridge and Kimball's Island in background. Exeter Historical Society, MSS12.

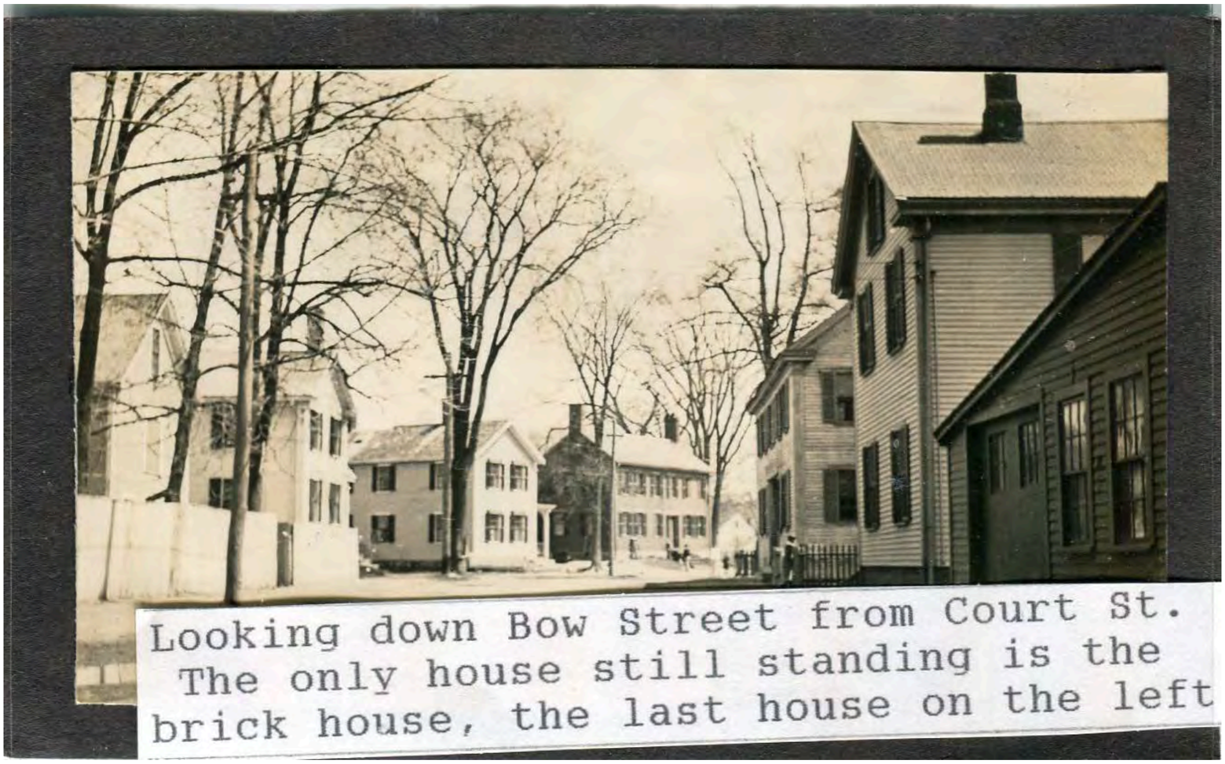
Photograph of Exeter River along Franklin Street, facing south from area of Great Bridge, 1920s. Long Block on right, note wood frame houses left of the Long Block, currently occupied by automobile service shops. Exeter Historical Society, MSS911999.08.06.

Photograph of Exeter River along Franklin Street, facing west. Long Block in center, note wood frame houses left of the Long Block, currently occupied by automobile service shops. Exeter Historical Society, MSS91_1999.08.09.

Photograph of 27 Franklin Street, 1920s or 1930s. Exeter Historical Society, MSS91_1999.08.11.

Photograph of 47 Franklin Street, Major John Chase House, 1930s.
Exeter Historical Society, MSS91_1999.08.08.

Photograph of corner of Franklin Street and South Street, undated. Exeter Historical Society, MSS91_1999.08.10.

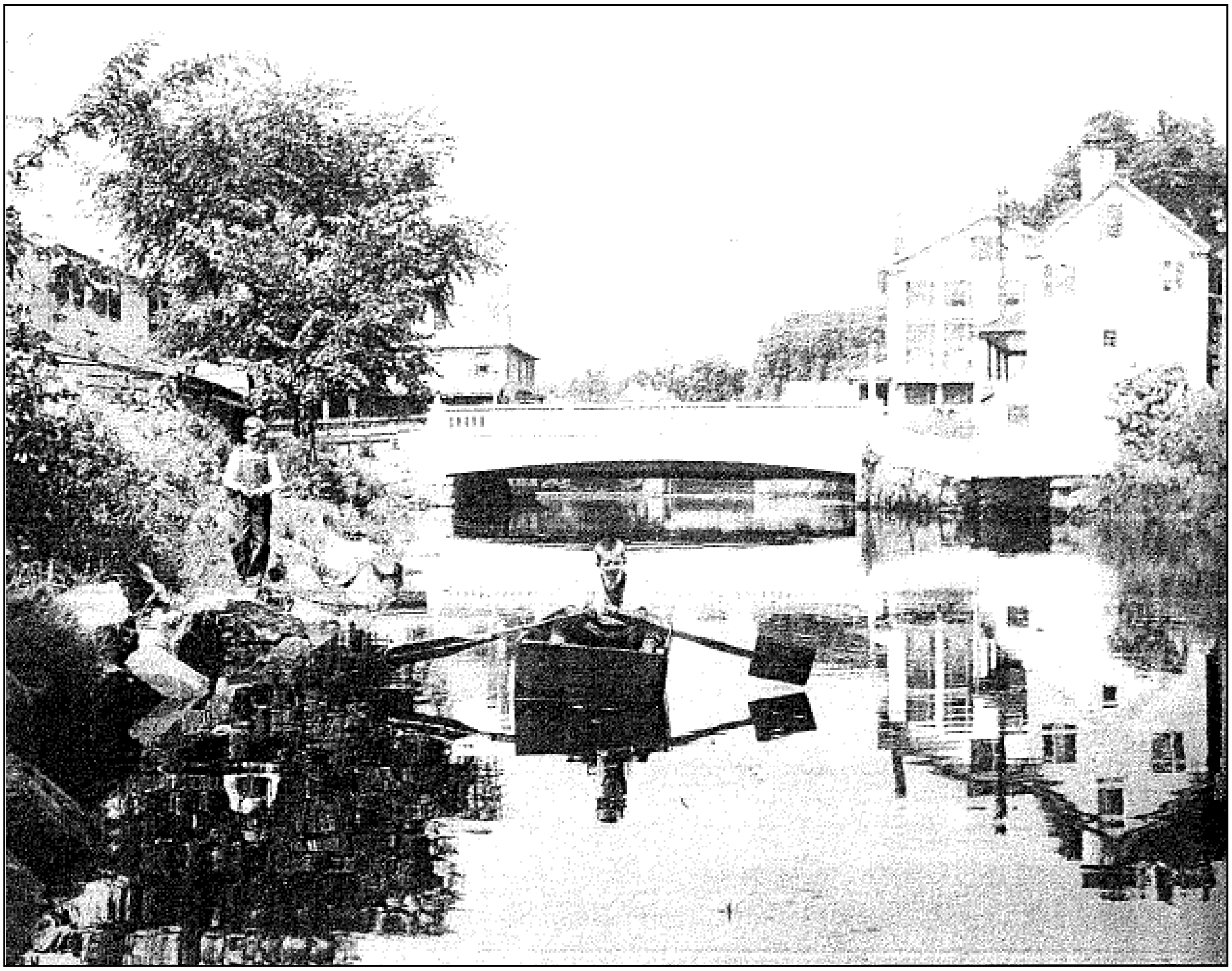


Photograph of corner of Bow Street and Court Street, undated (Historical Society label on bottom). Exeter Historical Society, MSS91_1999.08.03.

Photograph of Squamscott River facing west, Exeter Manufacturing Company mill on left, String Bridge and Kimball's Island in center, post-1935 (concrete String Bridge visible, constructed 1935). Exeter Historical Society, MSS12_1990.35.1.

Photograph of String Bridge and Kimball's Island facing southeast, Great Dam visible in background through bridge, post-1935 (concrete bridge constructed 1935). Exeter Historical Society, MSS12_1998.89.24.

Photograph of String Bridge facing east, pre-1935 (concrete bridge constructed 1935). Exeter Historical Society, MSS91_89.21.77.

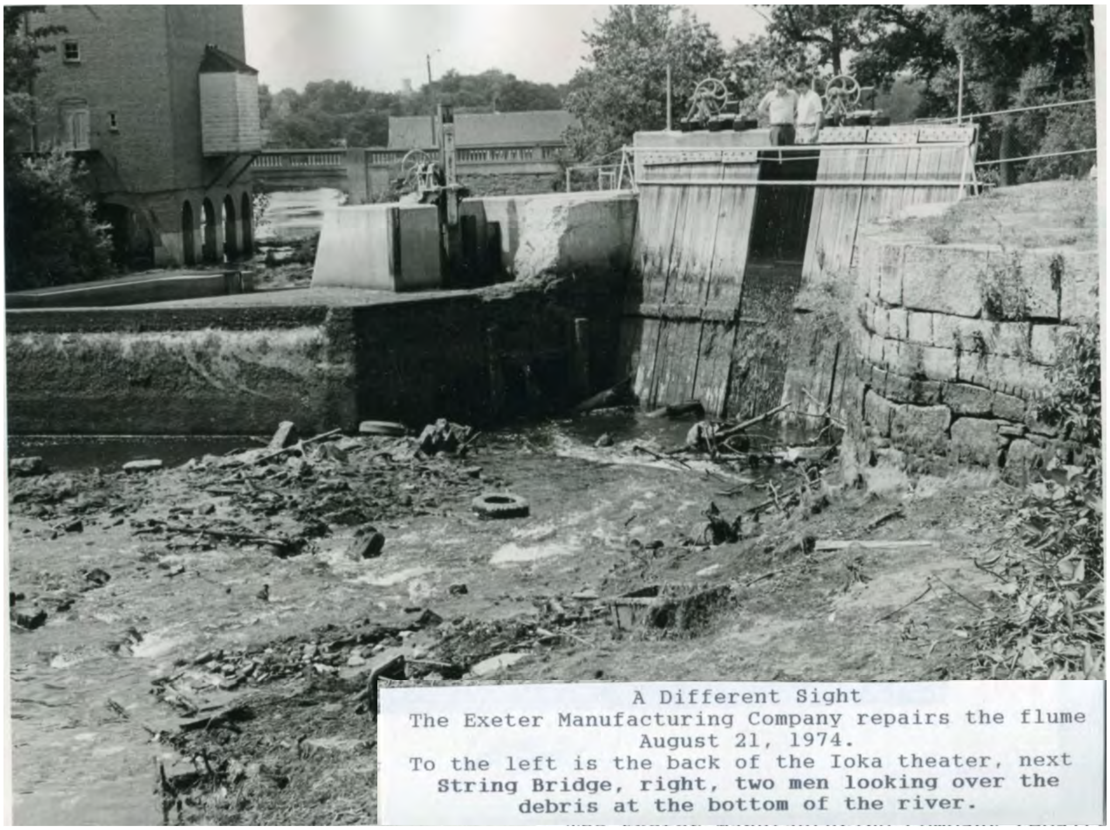


Photograph of Great Falls area looking southeast from dam to Great Bridge, ca. 1930s. Water Street and Franklin Street on right, Pleasant Street on left. Aten, 1996.

Photograph of Exeter River along Franklin Street, facing west, c1930s Exeter Historical Society, MSS91_1999.08.07.

Aerial photograph of Great Falls area and downtown Exeter, 1950s, Ben Swiezynski photographer. View is facing west. Great Dam is in the center of the photograph, between String Bridge and Great Bridge. High Street extends out of frame on the bottom of the photograph. Exeter Manufacturing Company mill is on the right along the river. Exeter Historical Society, Water Street_MSS12_1996.77.275.

Photograph of Great Dam facing east, 1972, Pleasant Street in background. Exeter Historical Society, MSS12_1998.91.99.

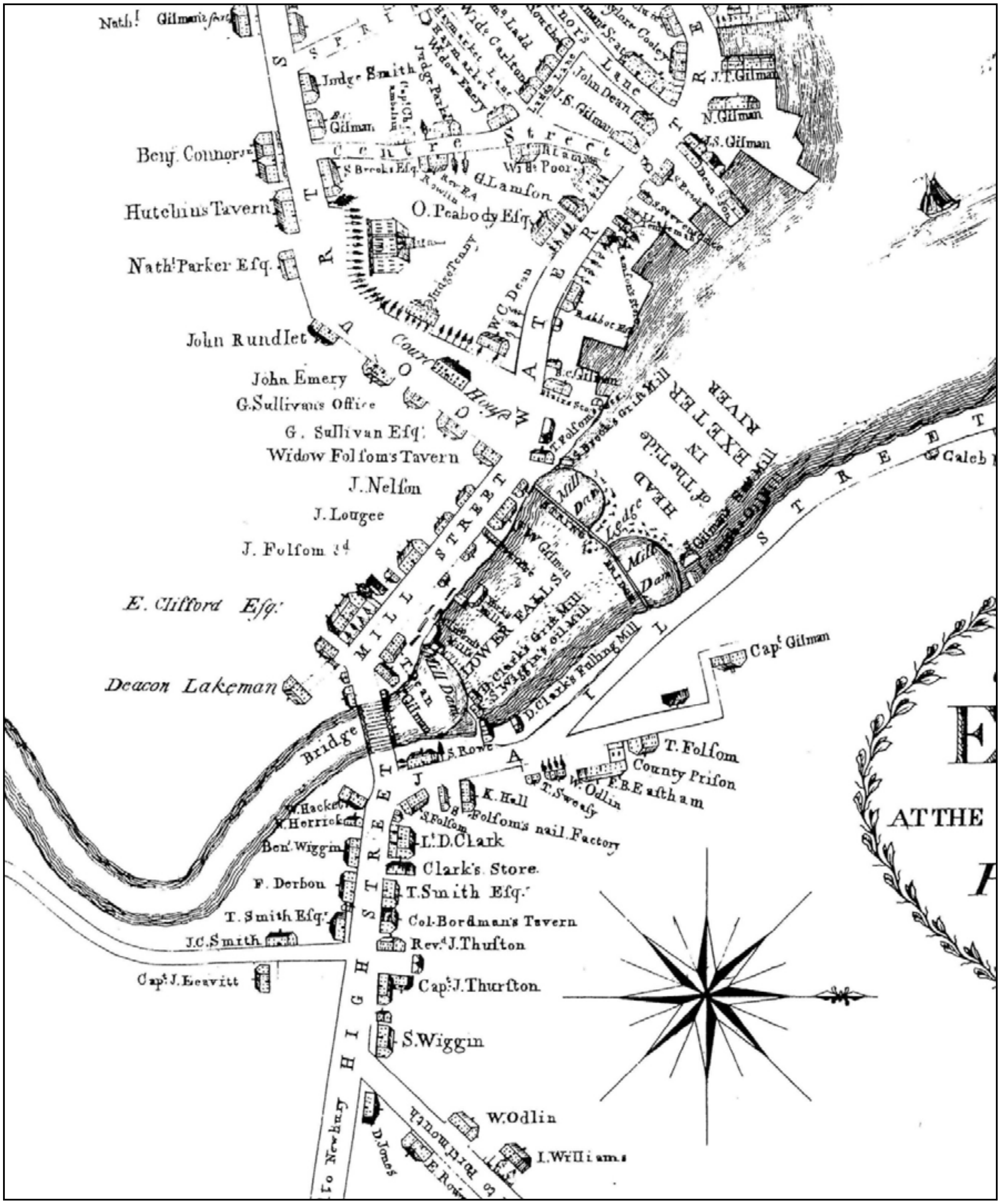


Photograph of Great Dam facing northwest, 1974, with Exeter Historical Society caption. Exeter Historical Society, MSS12_1996.77.177.

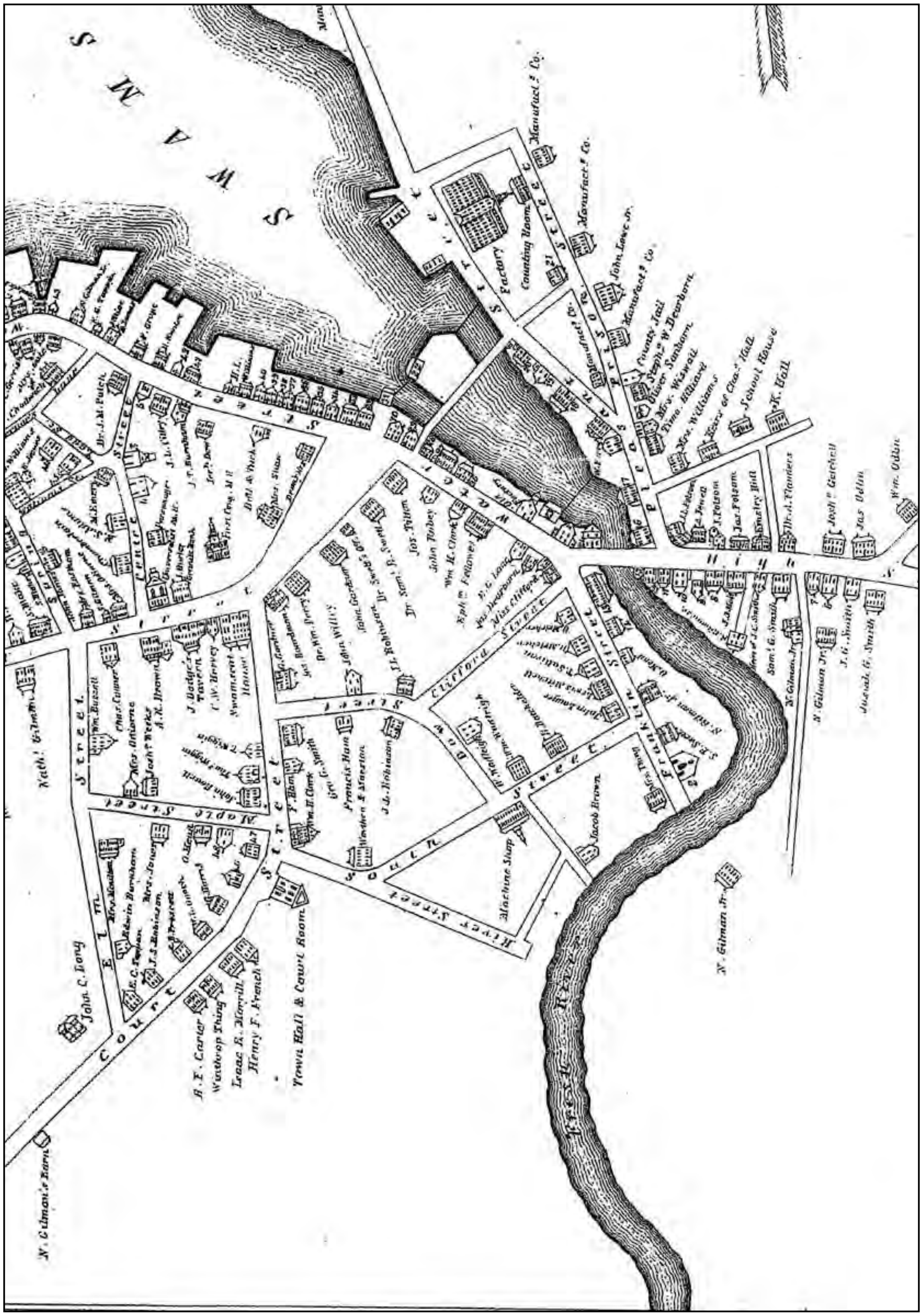
Photograph of Great Dam facing east, 1984, Pleasant Street in background. Exeter Historical Society, MSS12_86.63.2.

Aerial photograph of Great Falls area facing northeast, 1988. Exeter Historical Society, MSS12_83.23.

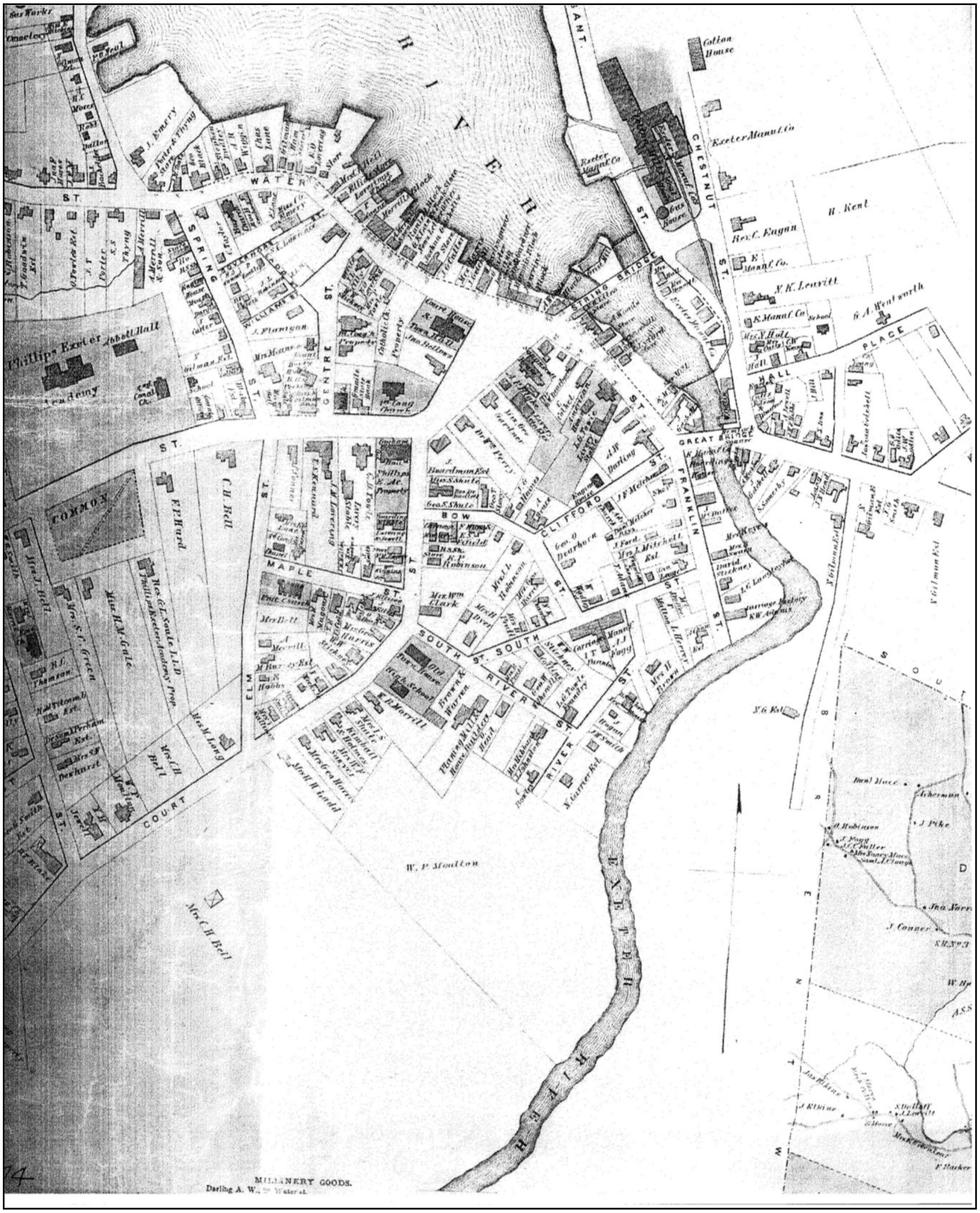
Historic Maps (arranged chronologically)



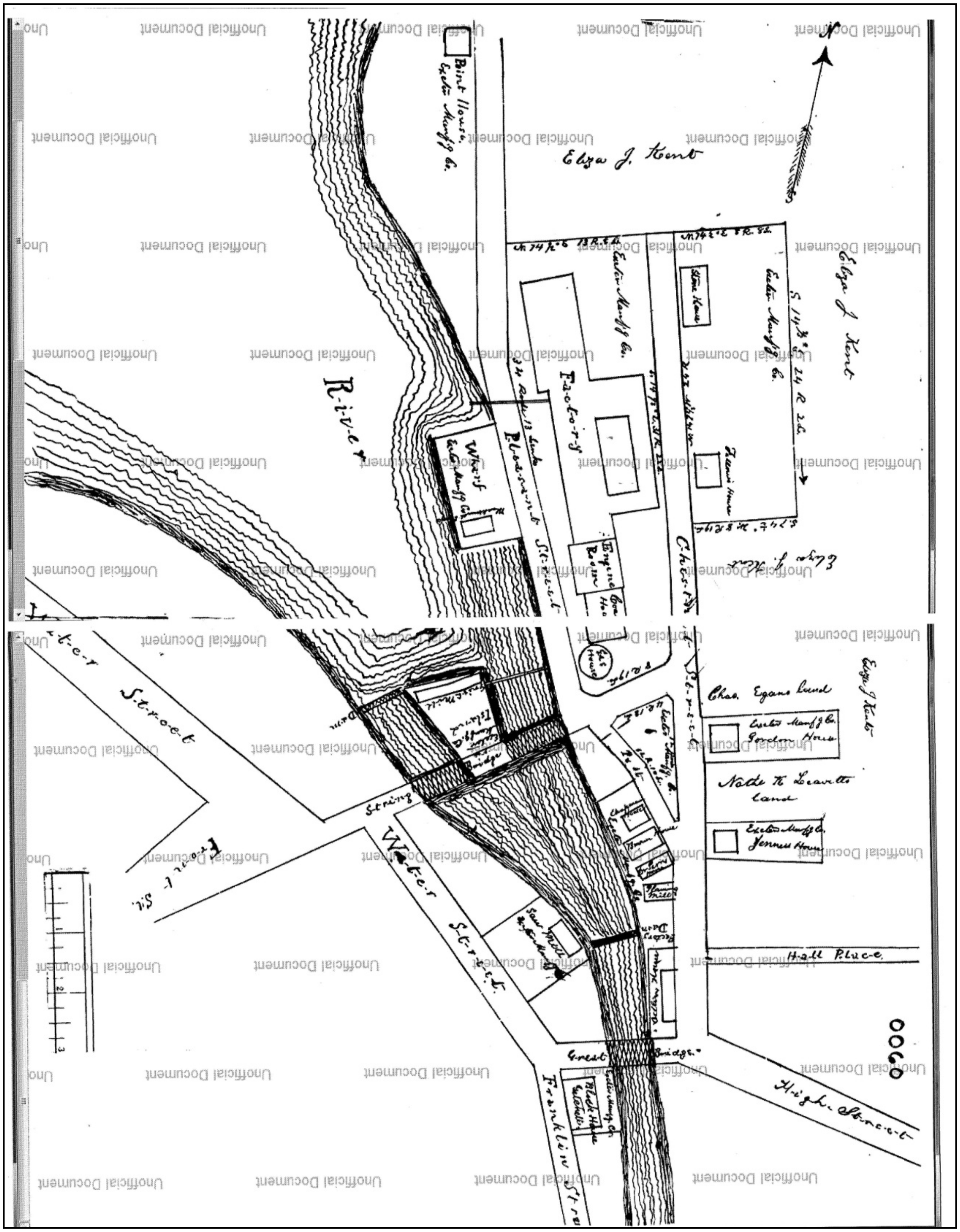
Phineas Merrill, "A Plan of the Compact Part of the Town of Exeter," 1802. Exeter Historical Society archives.



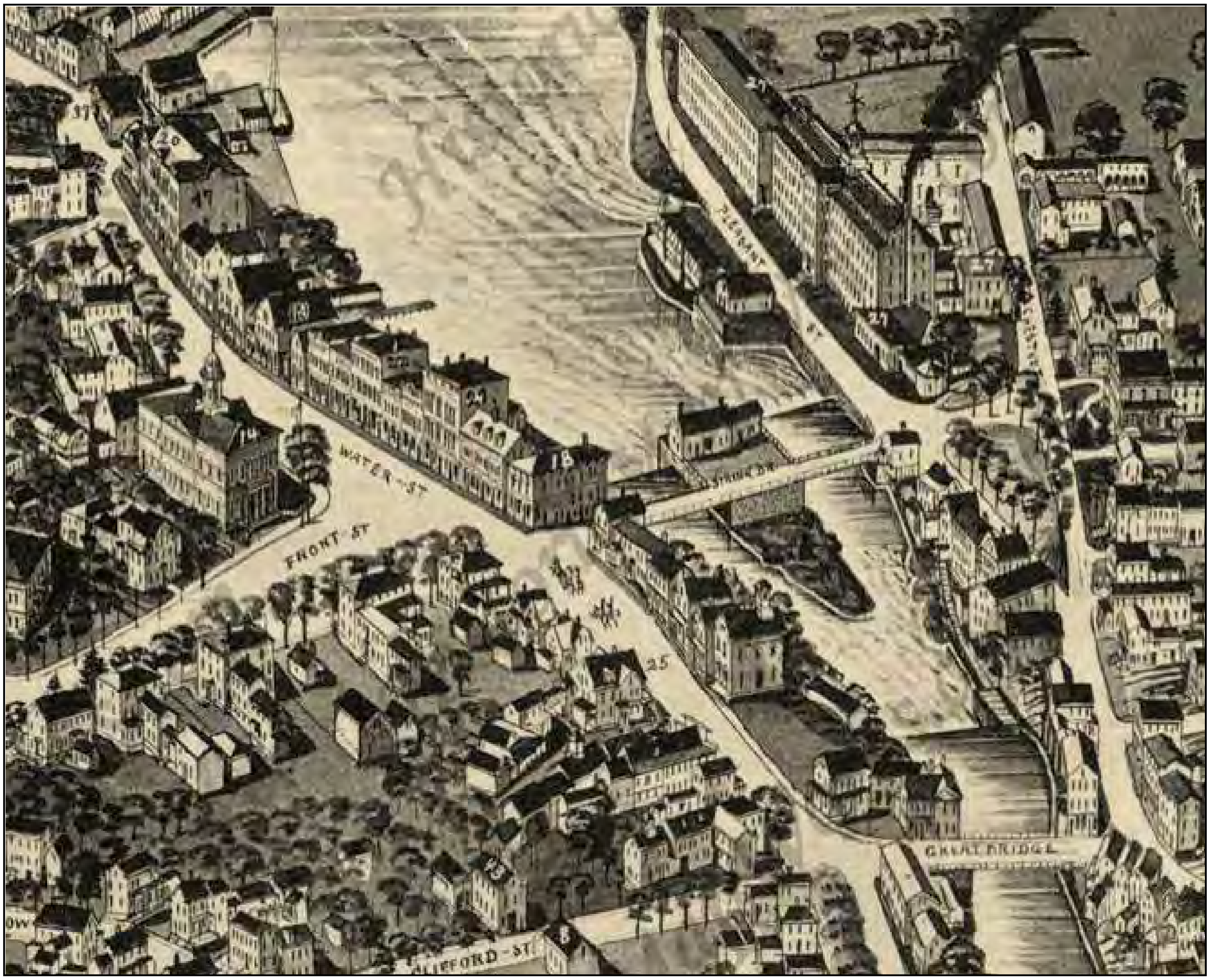
Joseph Dow, "Plan of Exeter Village, New Hampshire," 1845, north at top. Note Exeter River identified as "Fresh River." Exeter Historical Society Archives.



Sanford & Everts, "Map of Exeter, New Hampshire," 1874. Exeter Historical Society archives.

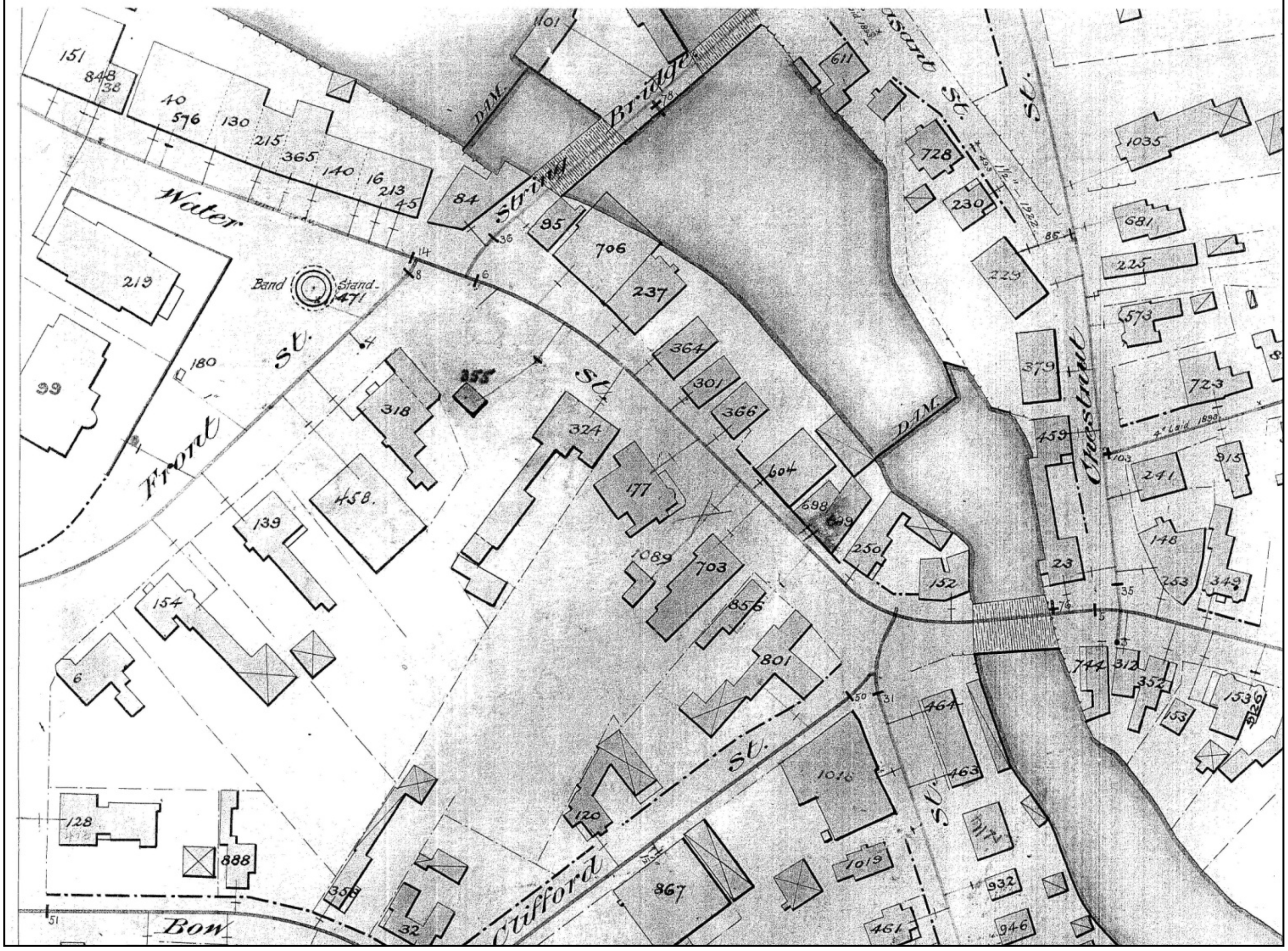


Rockingham County Land Plan 0060, 1876. http:// http://nhdeeds.com/rockingham/RoHome.html, accessed February 2012.

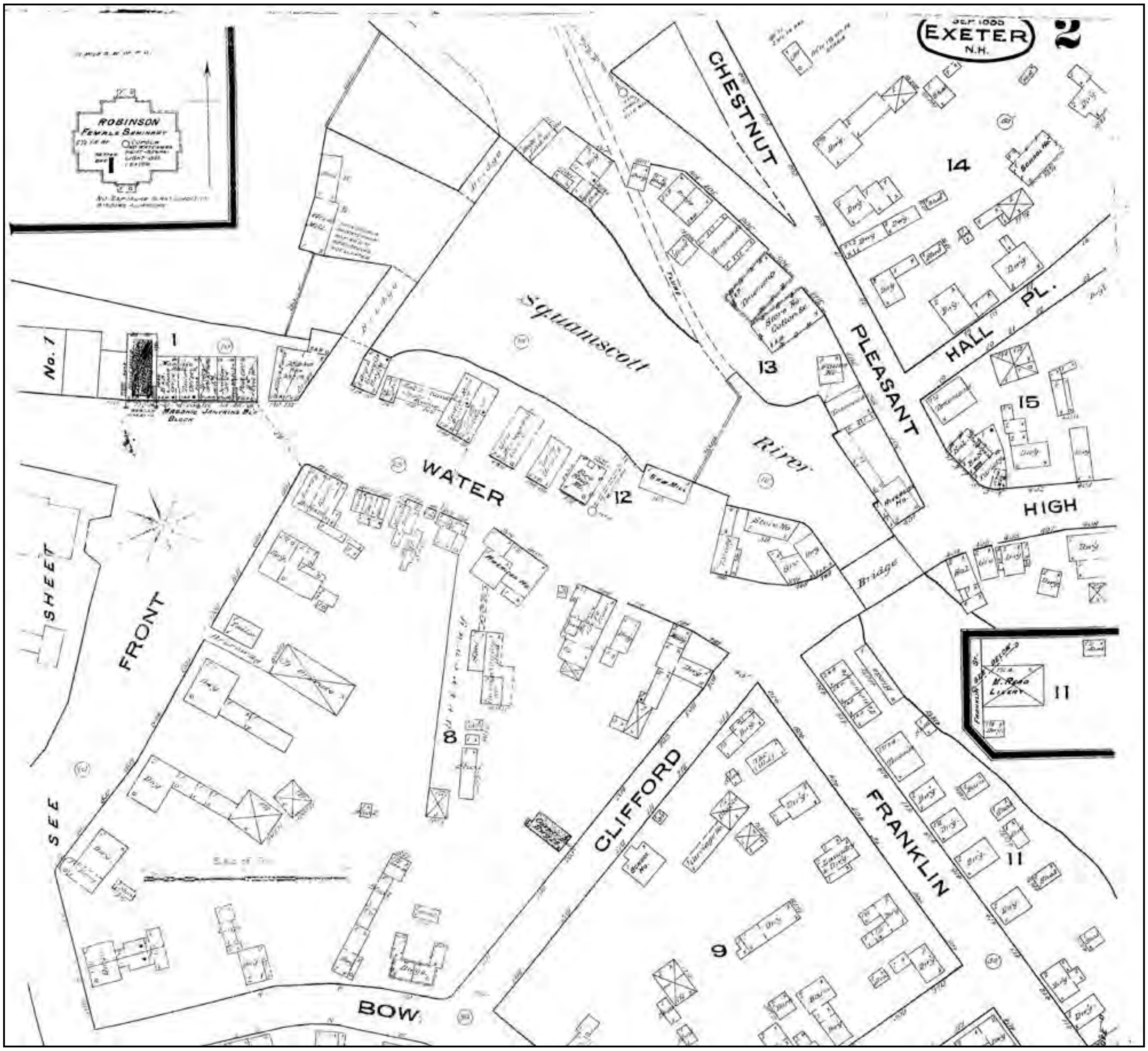


Norris & Wellge, "Exeter, New Hampshire," birds-eye view, 1884, north view at Great Bridge and String Bridge.
http://www.historicmapworks.com, accessed January 2012.

Norris & Wellge, “Exeter, New Hampshire,” birds-eye view, 1884, south view at Franklin Street and South Street. http://www.historicmapworks.com, accessed January 2012.

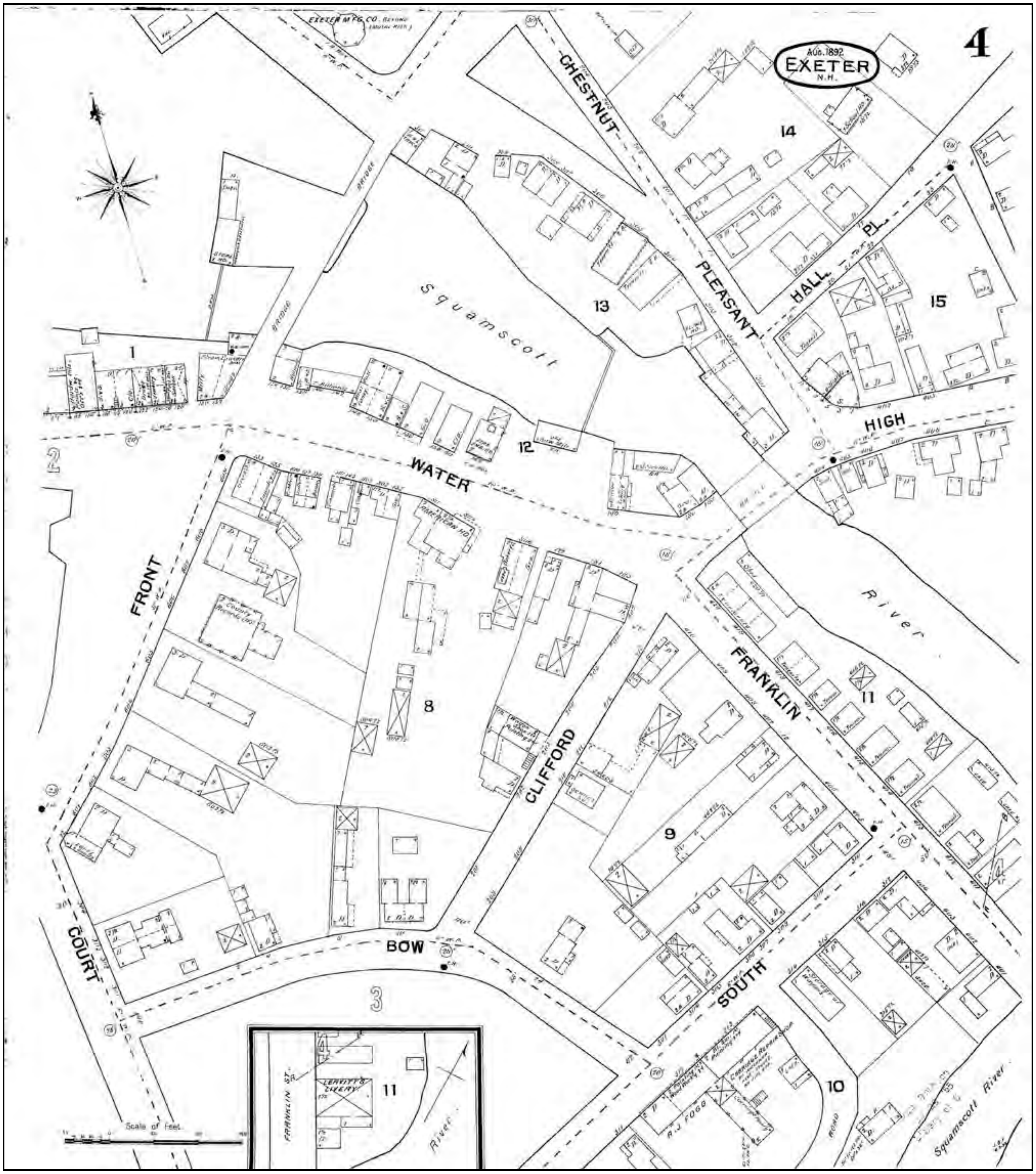


"Exeter Water Works," 1886. Exeter Historical Society archives.



Sanborn Fire and Insurance Company, Sheet 2, "Exeter, NH," 1885. http://sanborn.umi.com, accessed January 2012.

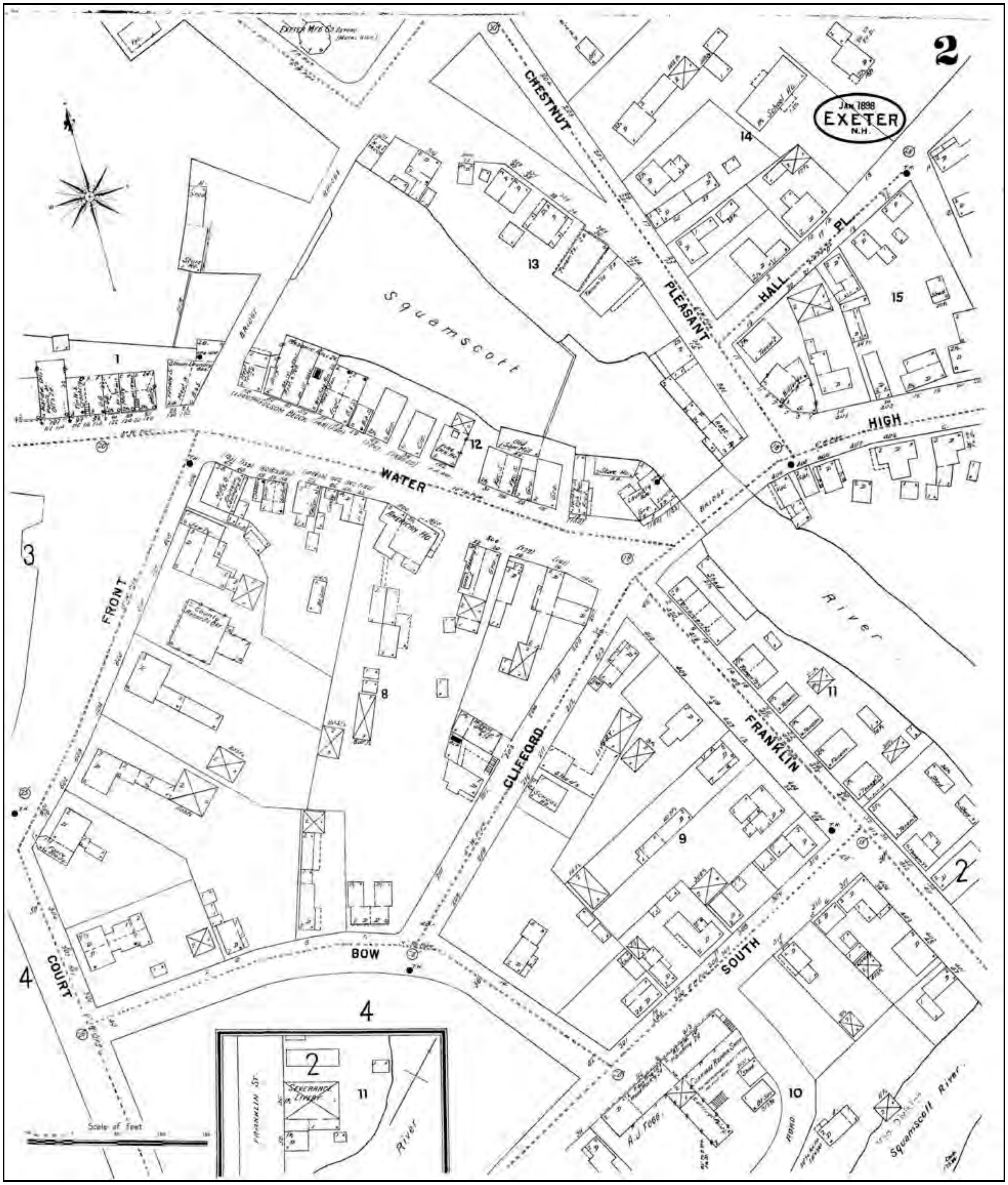
D.H. Hurd & Co., "Exeter," Atlas of the State of New Hampshire, 1892. Exeter Historical Society archives.



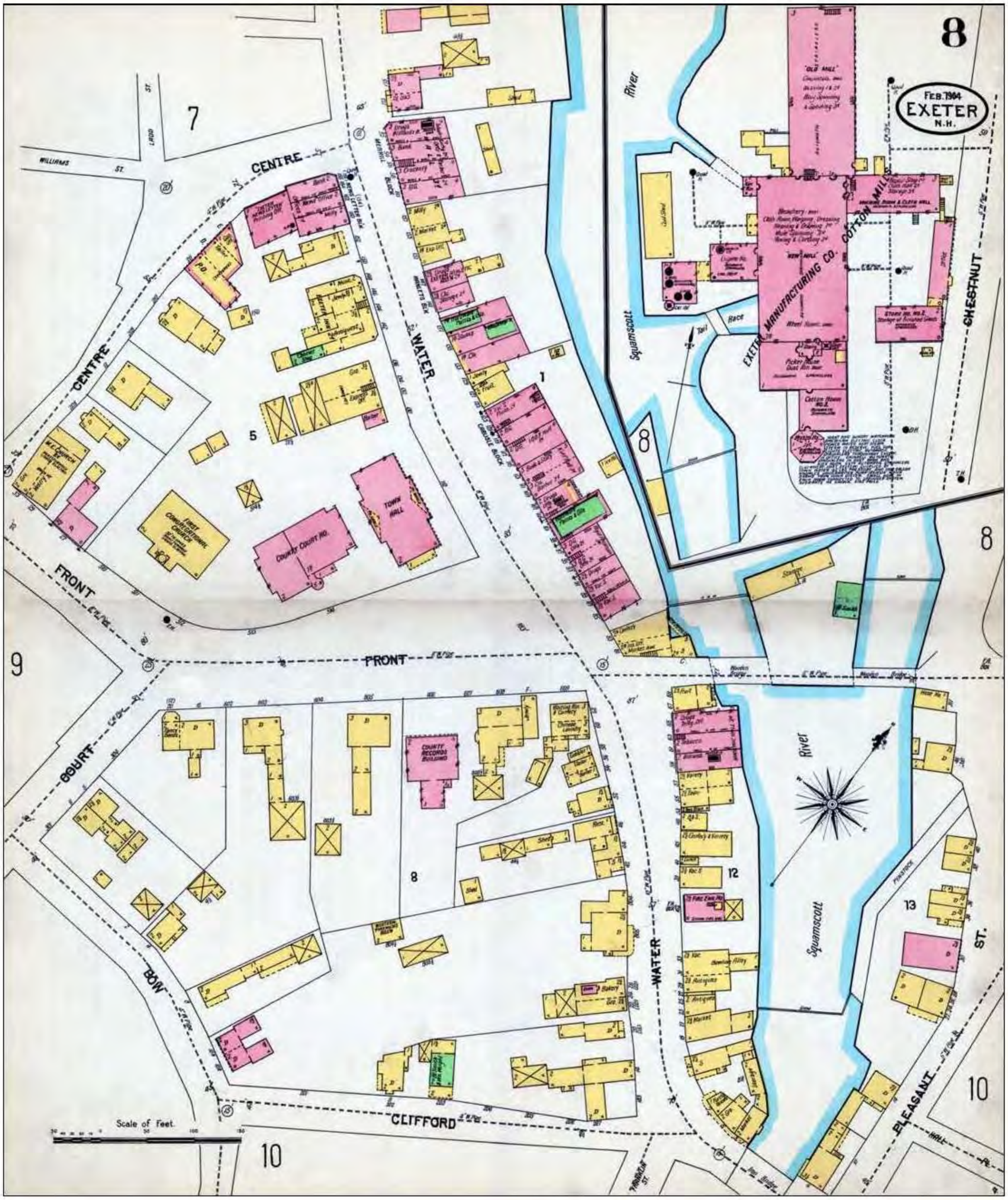
Sanborn Fire and Insurance Company, Sheet 4, "Exeter, NH," 1892. http://sanborn.umi.com, accessed January 2012.

A.W. Moore Co., Lith., "Exeter, New Hampshire," birds-eye view, 1896, north view at Great Bridge and String Bridge. http://www.historicmapworks.com, accessed January 2012.

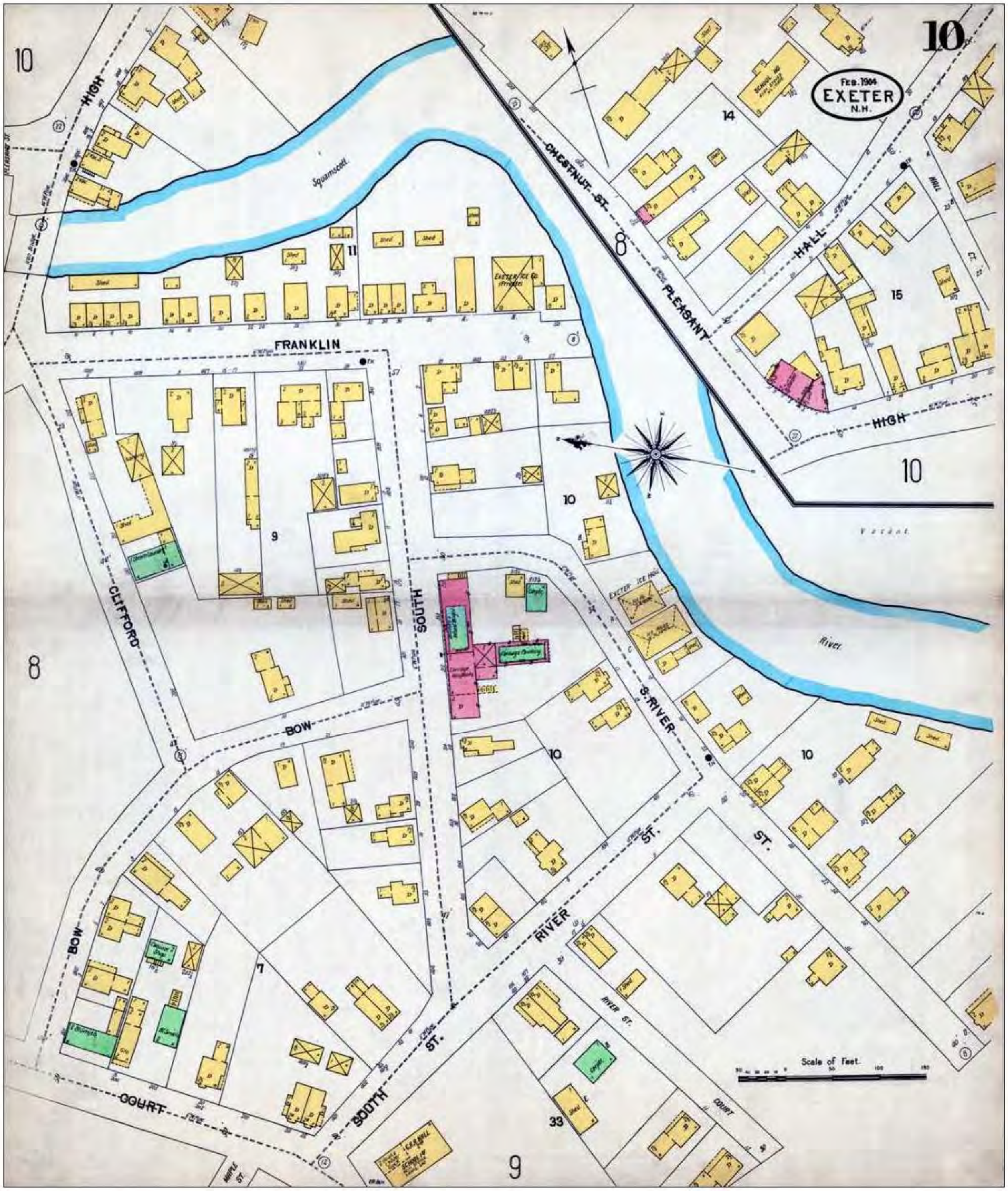
A.W. Moore Co., Lith., “Exeter, New Hampshire,” birds-eye view, 1896, south view at Franklin Street and South Street. http://www.historicmapworks.com, accessed January 2012.



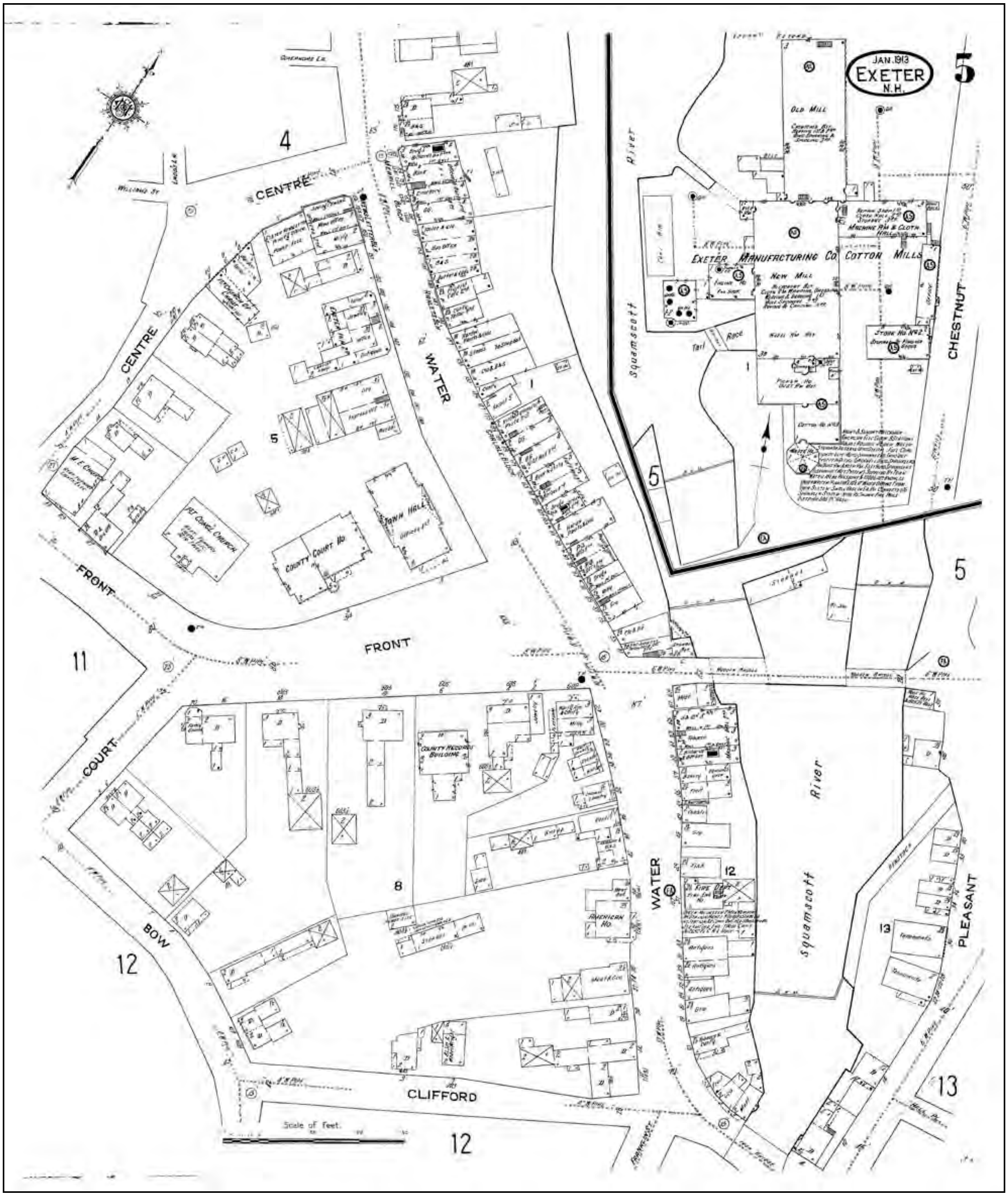
Sanborn Fire and Insurance Company, Sheet 2, "Exeter, NH," 1898. http://sanborn.umi.com, accessed January 2012.



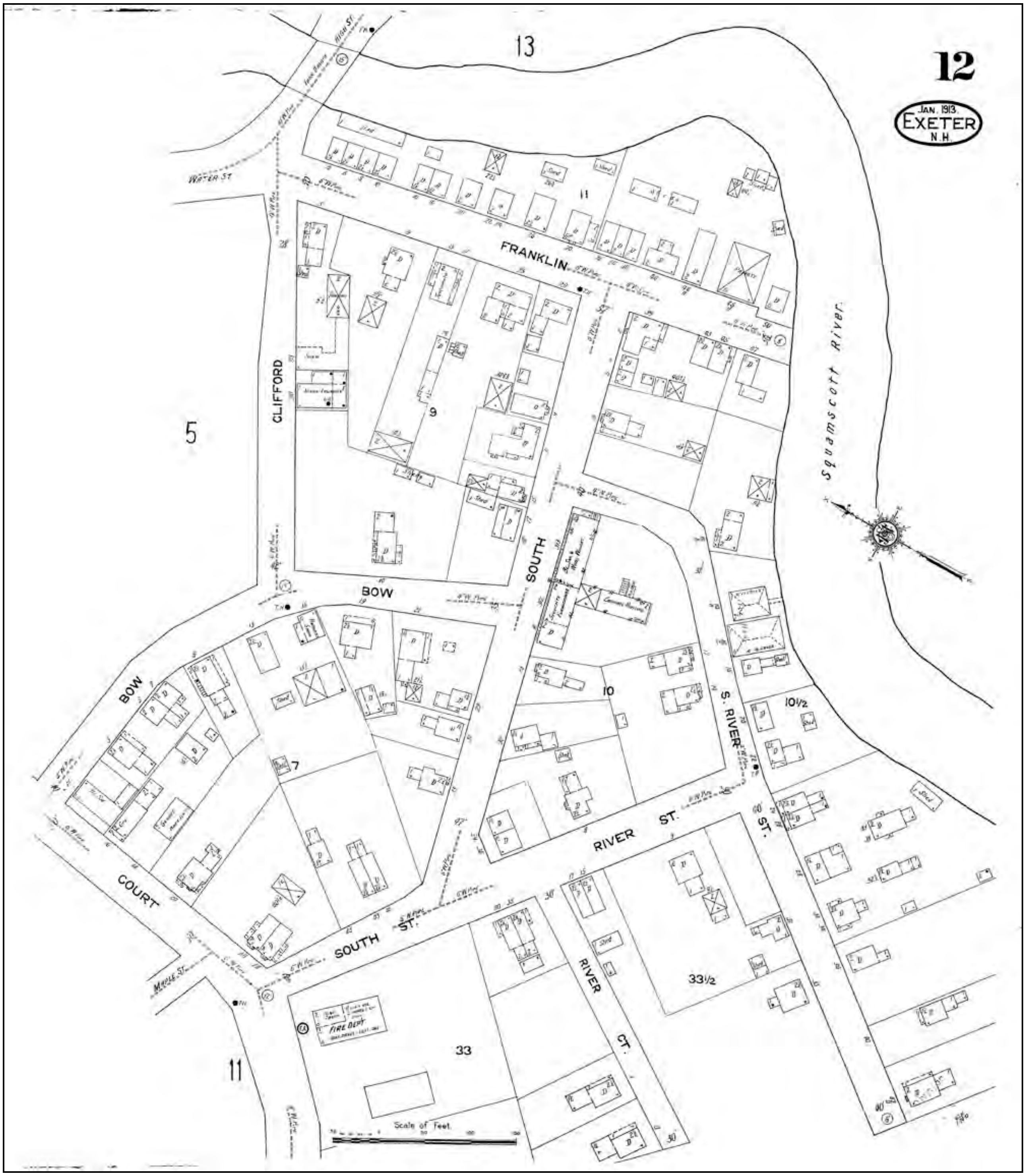
Sanborn Fire and Insurance Company, Sheet 8, "Exeter, NH," 1904. http://sanborn.umi.com, accessed January 2012.



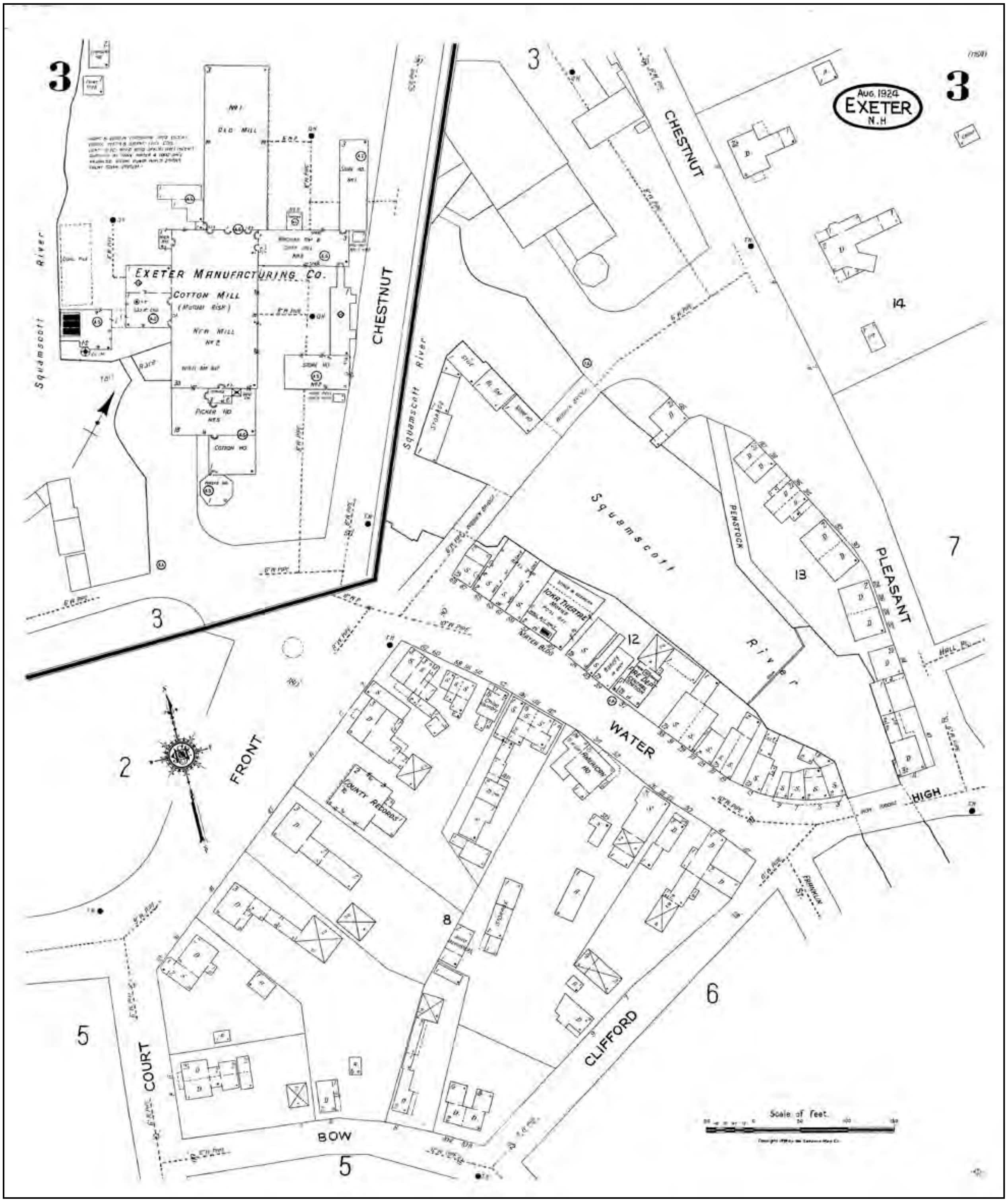
Sanborn Fire and Insurance Company, Sheet 10, "Exeter, NH," 1904. http://sanborn.umi.com, accessed January 2012.



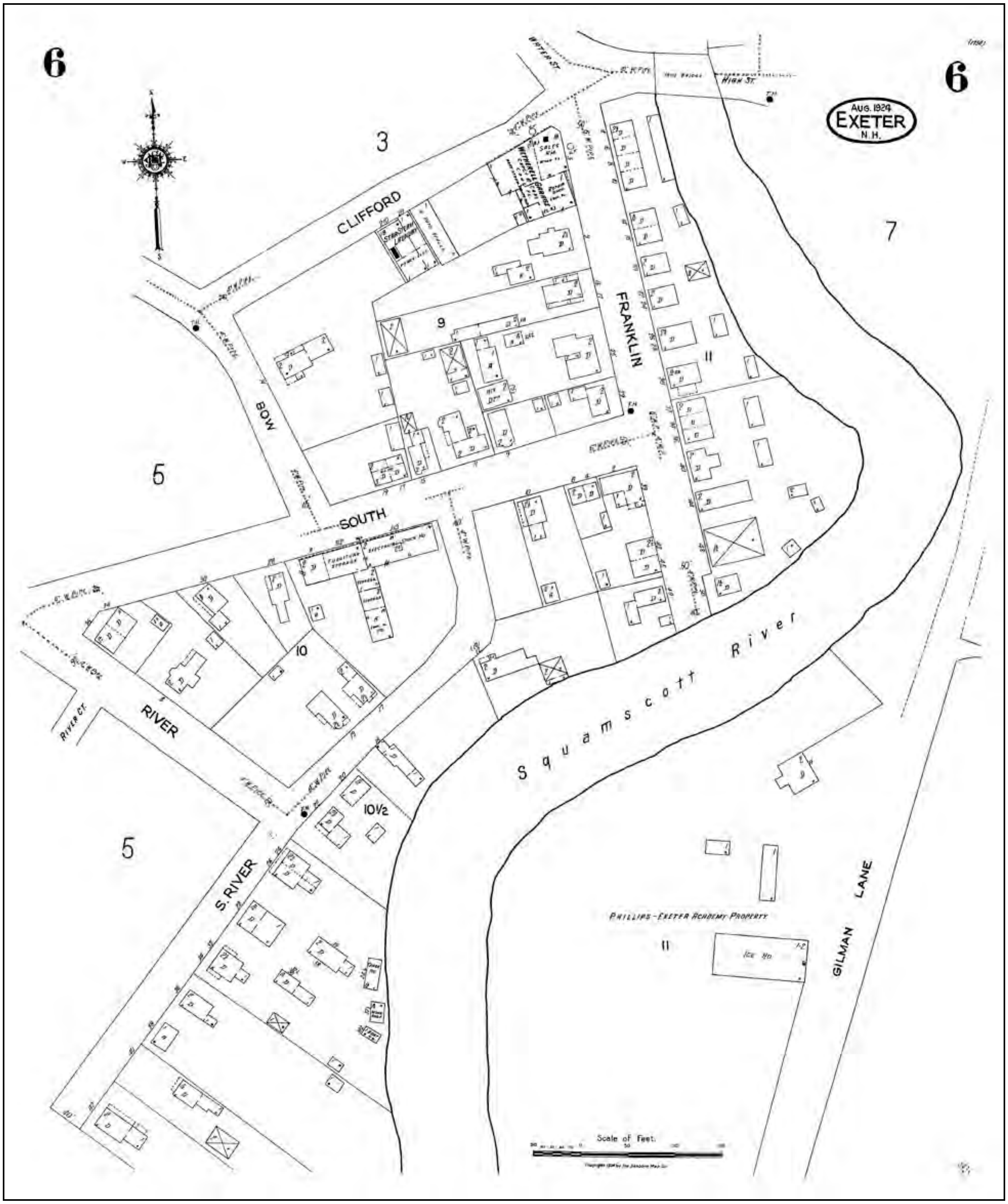
Sanborn Fire and Insurance Company, Sheet 5, "Exeter, NH," 1913. http://sanborn.umi.com, accessed January 2012.



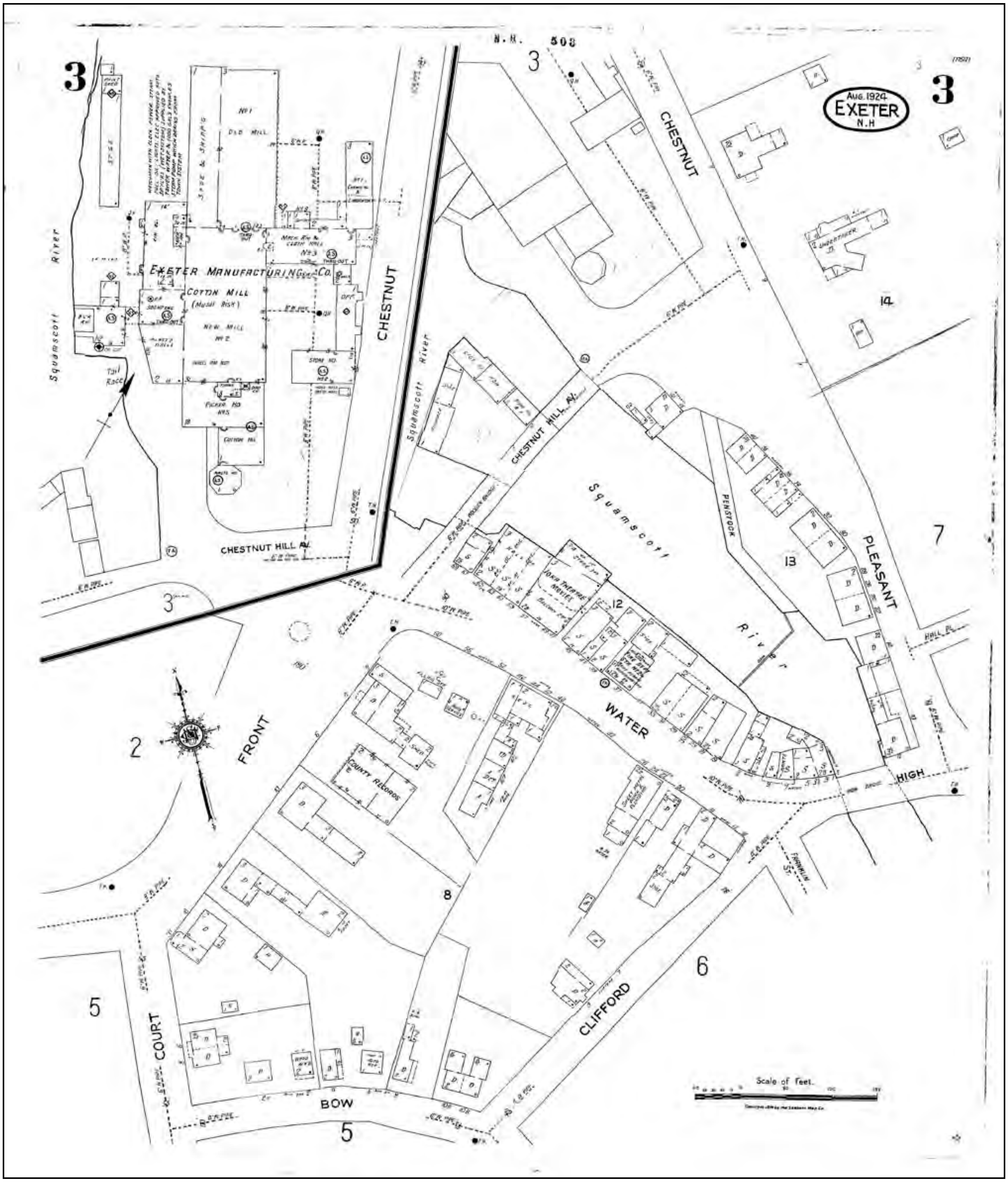
Sanborn Fire and Insurance Company, Sheet 12, "Exeter, NH," 1913. http://sanborn.umi.com, accessed January 2012.



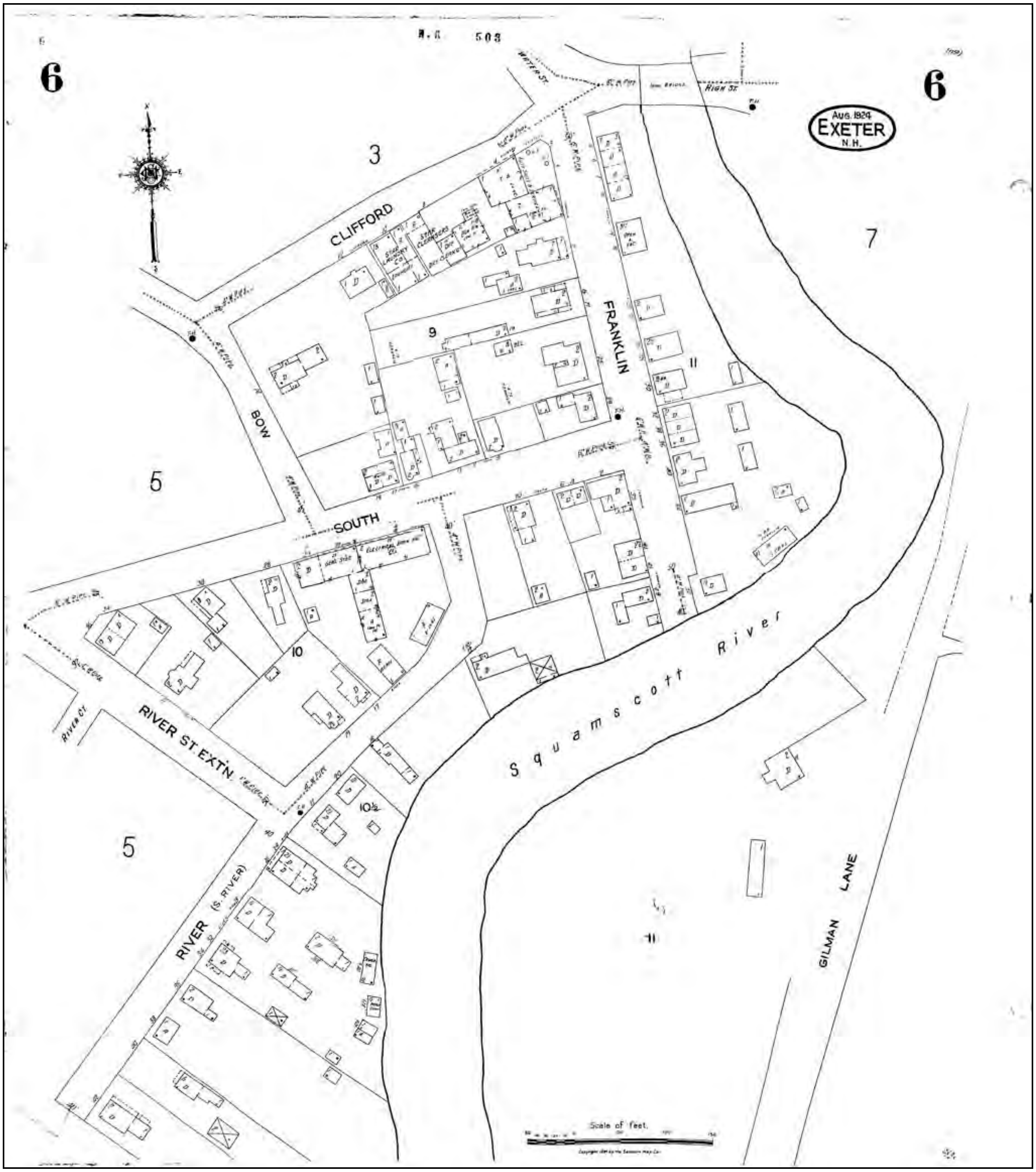
Sanborn Fire and Insurance Company, Sheet 3, "Exeter, NH," 1924. http://sanborn.umi.com, accessed January 2012.



Sanborn Fire and Insurance Company, Sheet 6, "Exeter, NH," 1924. http://sanborn.umi.com, accessed January 2012.



Sanborn Fire and Insurance Company, Sheet 3, "Exeter, NH," 1943 (updated from 1924). http://sanborn.umi.com, accessed January 2012.



Sanborn Fire and Insurance Company, Sheet 6, "Exeter, NH," 1943 (updated from 1924). http://sanborn.umi.com, accessed January 2012.

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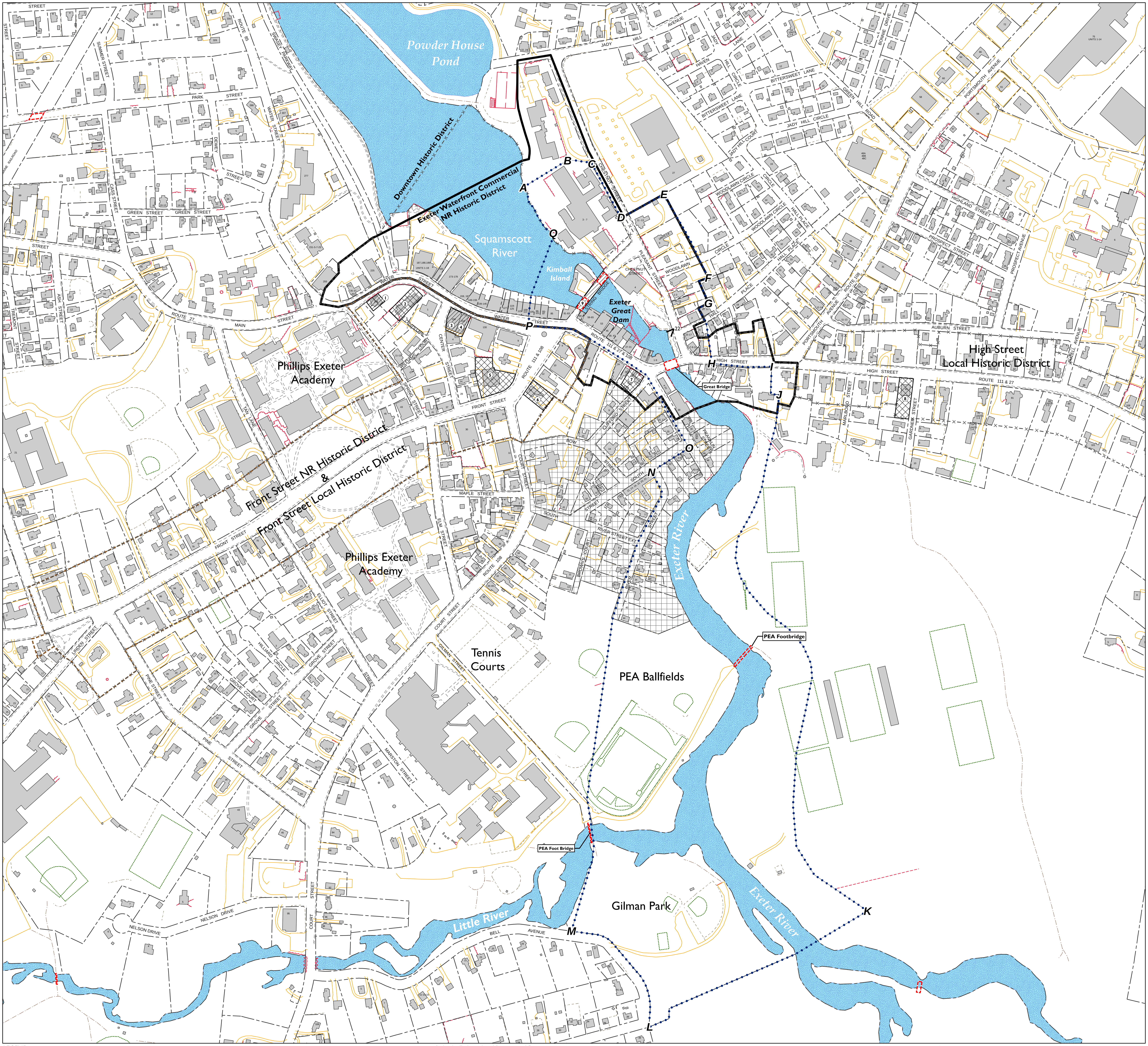

LEGEND

Area Form Boundary

Area Recommended for Further Survey

National Register Historic Districts:

Front Street

Waterfront Commercial

Individual Property

NR Listed Property

Inventoried Property

Local Historic Districts

Downtown Historic, Front Street, High Street

Existing Bridge

Building Footprint

Assessor's Tax Parcels

Surface Water

Exeter Base Plan

Parking Lot/Drive

Fence

Green Space

Recreation

Wall/Retaining Wall

Trail

Sidewalk/Walkway

Individually Listed and Inventoried Properties

1. Folsom Tavern - 164 Water Street
2. Gilman-Ladd House (NHL) - Governors Lane & Water Street
3. Previously Inventoried Property - 156 Water Street
4. Previously Inventoried Property - 154 Water Street
5. The Congregational Church - 21 Front Street
6. Dudley House - 14 Front Street
7. Gilman-Garrison House - 12 Water Street
8. Samuel Tenney House - 65 High Street
9. String Bridge - Inventoried 1982

0 200 400 Feet

Vanasse Hangen Brustlin, Inc.

Figure 1 Overview of Project Area Boundaries and Location of Inventoried and Listed Historic Properties
Exeter River Great Dam Removal
Feasibility & Impact Analysis

Exeter, New Hampshire

March 30, 2012

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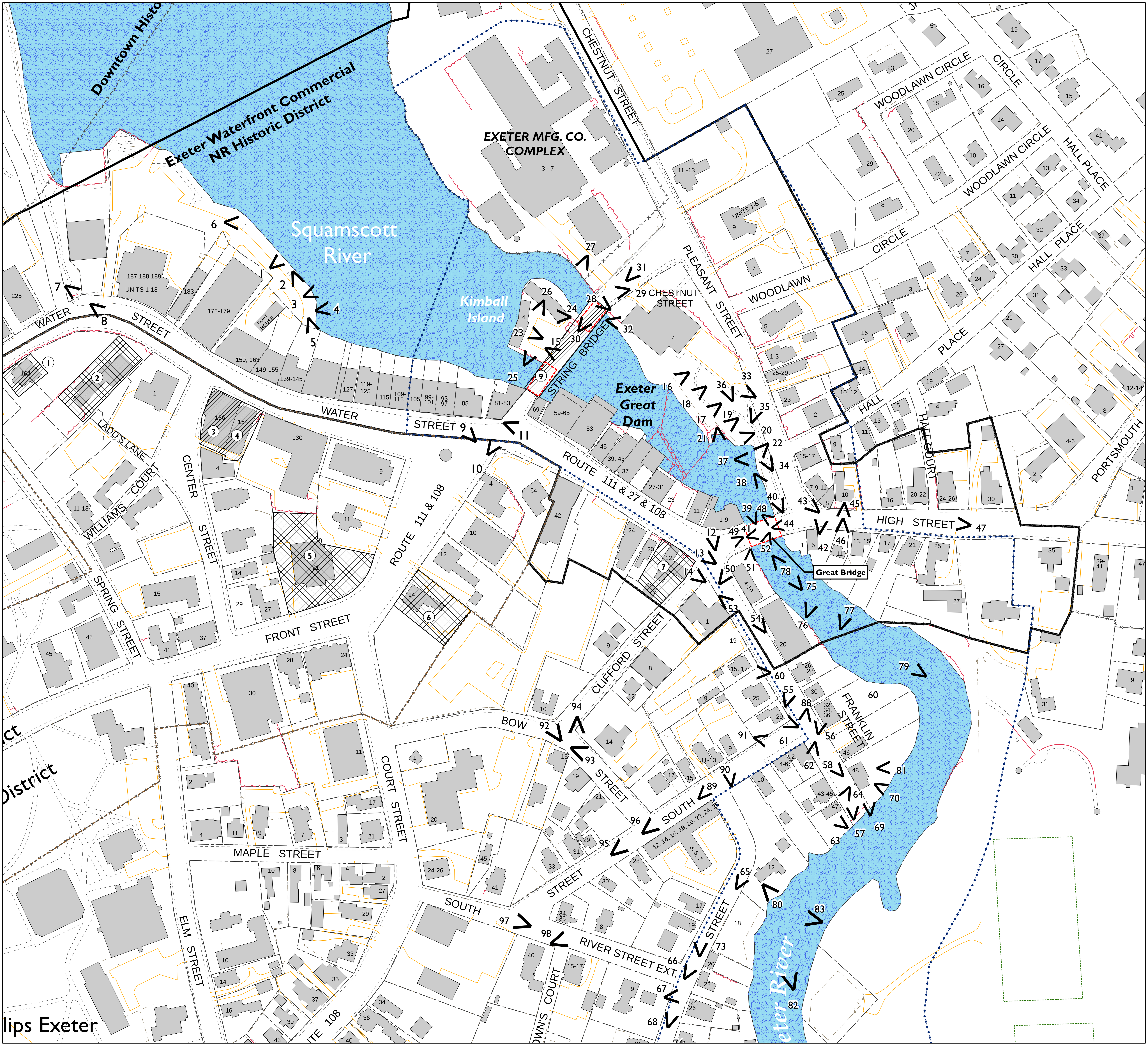

LEGEND

- Photograph Location & Direction
- Area Form Boundary

National Register Historic Districts:
- Front Street
- Waterfront Commercial

Individual Property
- NR Listed Property
- Inventoried Property

Local Historic Districts
- Downtown Historic, Front Street, High Street
- Existing Bridge
- Building Footprint
- Assessor's Tax Parcels
- Surface Water

Exeter Base Plan
- Parking Lot/Drive
- Fence
- Green Space
- Recreation
- Wall/Retaining Wall
- Trail
- Sidewalk/Walkway

Individually Listed and Inventoried Properties
1. Folsom Tavern - 164 Water Street
2. Gilman-Ladd House (NHL) - Governors Lane & Water Street
3. Previously Inventoried Property - 156 Water Street
4. Previously Inventoried Property - 154 Water Street
5. The Congregational Church - 21 Front Street
6. Dudley House - 14 Front Street
7. Gilman-Garrison House - 12 Water Street
8. Samuel Tenney House - 65 High Street
9. String Bridge - Inventoried 1982

0 80 160 Feet

VHB Vanasse Hangen Brustlin, Inc.

Figure 2 Northern Half of Project Area, With Photograph Locations
Exeter River Great Dam Removal Feasibility & Impact Analysis

Exeter, New Hampshire

March 30, 2012

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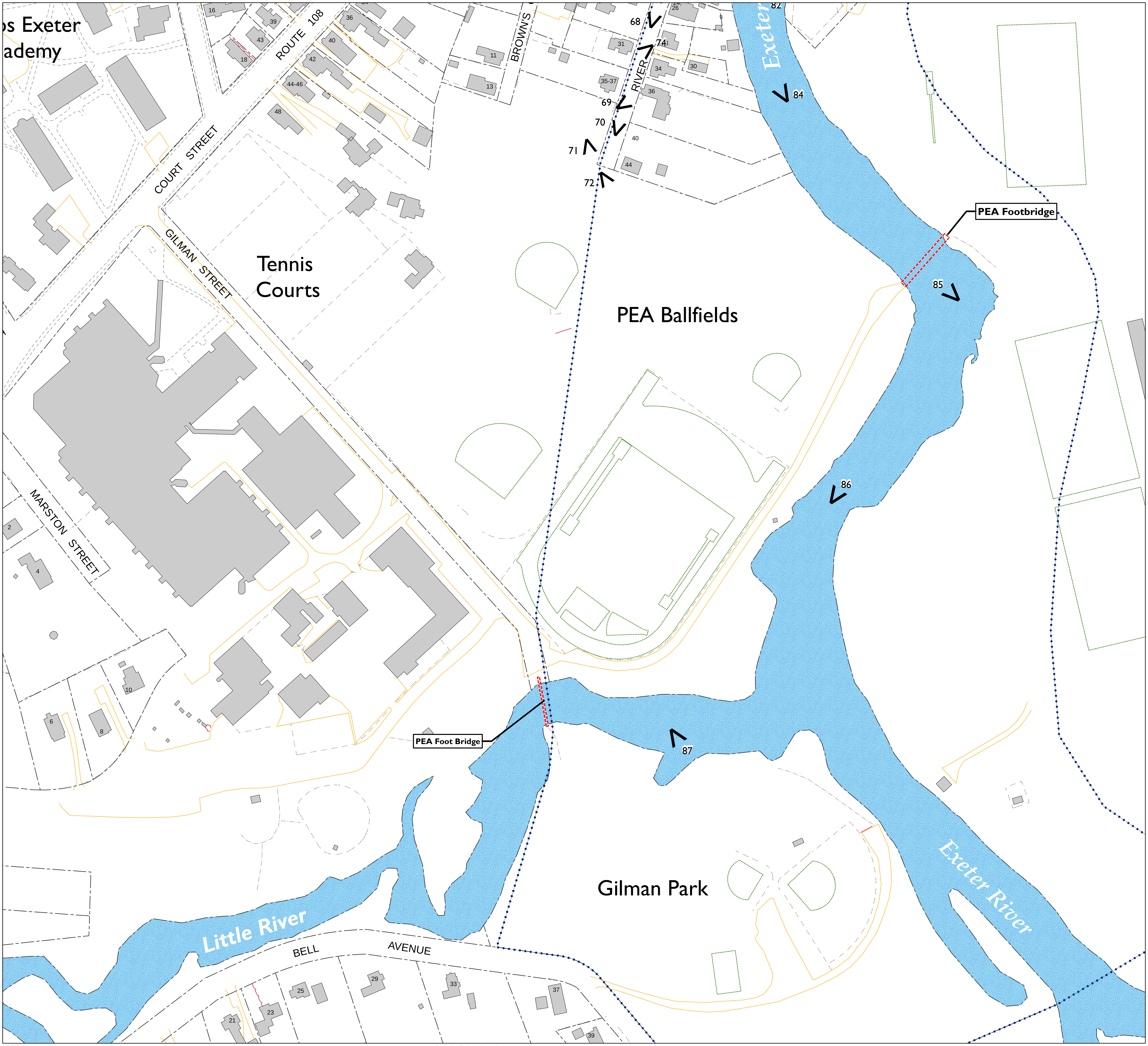

LEGEND

Photograph Location & Direction

Area Form Boundary

National Register Historic Districts:

Front Street

Waterfront Commercial

Individual Property

NR Listed Property

Inventoried Property

Local Historic Districts

Downtown Historic, Front Street, High Street

Existing Bridge

Building Footprint

Assessor's Tax Parcels

Surface Water

Exeter Base Plan

Parking Lot/Drive

Fence

Green Space

Recreation

Wall/Retaining Wall

Trail

Sidewalk/Walkway

Individually Listed and Inventoried Properties

1. Folsom Tavern - 164 Water Street
2. Gilman-Ladd House (NHL) - Governors Lane & Water Street
3. Previously Inventoried Property - 156 Water Street
4. Previously Inventoried Property - 154 Water Street
5. The Congregational Church - 21 Front Street
6. Dudley House - 14 Front Street
7. Gilman-Garrison House - 12 Water Street
8. Samuel Tenney House - 65 High Street
9. String Bridge - Inventoried 1982

0 80 160 Feet

Vanasse Hangen Brustlin, Inc.

Figure 3 Southern Half of Project Area, With Photograph Locations
Exeter River Great Dam Removal Feasibility & Impact Analysis

Exeter, New Hampshire

March 30, 2012

Appendix M

NH Natural Heritage Bureau

northern hardwoods (sometimes a few softwoods). It may occur in complex mosaics with other river terrace communities. Sugar maple and yellow birch are usually important canopy species, with variable mixes of other hardwoods, including white ash, *Acer rubrum* (red maple), *Prunus serotina* (black cherry), and *Betula* spp. (birches). Understory plants that appear to distinguish this variant from more infertile or drier terraces include *Corylus cornuta* (beaked hazelnut), alternate-leaved dogwood, *Lonicera canadensis* (American honeysuckle), Jack-in-the-pulpit, sessile-leaved bellwort, zig-zag goldenrod, red wakerobin, *Gymnocarpium dryopteris* (northern oak fern), and greater bladder sedge. Potential rare species include *Pyrola asarifolia* (pink shinleaf)*, primarily known from the White Mountain region and northward on alluvial soils such as abandoned overflow channels.

CLASSIFICATION CONFIDENCE: 1

DISTRIBUTION: This community is most common in regions with intermediate or base-rich rocks that yield subacid to circumneutral soils, particularly the Connecticut River, Vermont Upland, north and west sides of White Mountain, Mahoosuc-Rangeley Lakes, and Connecticut Lakes subsections.

The **typic variant** is found on till soils in most subsections of the state from about 500–1,600 ft. elevation. Good examples are at Langdon Brook North (Chatham) and parts of Mountain Pond RNA (Chatham). The **high-elevation/near-boreal variant** occurs primarily on till in the Vermont Upland, White Mountain, Mahoosuc-Rangeley Lakes, and Connecticut Lakes subsections from 1,600–2,000 ft. elevation, but may occur locally to the south. Good examples occur on Sugarloaf Mtn. and Black Mtn. (Haverhill). The **terrace flat variant** is documented from valley bottom landscapes of the White Mountain subsection (800–1,200 ft. elevation) but probably occurs elsewhere. Good examples are Peabody River (Gorham), Zealand River (Twin Mountain), Swift River (Albany), and Wild River (Beans Purchase).

SOURCES: NHB field surveys; Fincher 1991; Sperduto and Engstrom 1995.

• Semi-rich oak - sugar maple forest (S2S3)

GENERAL DESCRIPTION: This community occurs at low elevations in central and southern New Hampshire, mostly below 1,500 ft. It forms on sites that are somewhat drier than ***semi-rich mesic sugar maple forests***, and can contain significant amounts of Appalachian species such as *Carya* spp. (hickories), *Ostrya virginiana* (ironwood), *Fraxinus americana* (white ash), and other southern or drier site species. Oaks, sugar maple, and white ash dominate with a moderate to well developed woody understory and a scattered to moderately abundant herb layer. It is distinguished from more nutrient-poor forest types by having species indicative of weakly enriched conditions, and from ***rich mesic forests*** by the absence of strong enrichment indicators (see below). It also lacks many of the rare and uncommon species diagnostic of rich rocky wood communities such as *Carex platyphylla* (broad-leaved sedge), *C. retroflexa* (reflexed sedge)*, *Micranthes virginiensis* (early small-flowered-saxifrage), *Ranunculus fascicularis* (early crowfoot)*, *Symphyotrichum patens* (late purple American-aster)*, certain *Boechera* spp. (rockcresses), *Aureolaria virginica* (downy false foxglove)*, *Lespedeza virginica* (slender bush-clover)*, *Pycnanthemum incanum* (hoary mountain-mint)*, *Paronychia canadensis* (smooth forked whitlow-wort)*, *Thalictrum thalictroides* (anemone meadow-rue)*, *Asclepias quadrifolia* (four-leaved milkweed)*, *Asplenium platyneuron* (ebony spleenwort), and *Woodsia obtusa* (blunt-lobed cliff fern)*.

Soils are well to moderately well drained fine sandy loams, loams, or silt loams with a very shallow hemic O horizon (1–2 cm+), shallow very dark gray to brown A horizons (2–10 cm), and brown to yellowish brown upper B horizons. Moisture availability ranges from dry-mesic to mesic and may be at least seasonally drier than most ***rich mesic forests***. Bedrock includes types that are mafic or have intermediate base cation content such as diorites and gabbros, and the Elliot, Berwick and Kittery Formations. Some sites have silty soils associated with riverine or marine deposits. Settings range from flat to moderately sloped terrain or colluvial positions at slope bases.

CHARACTERISTIC VEGETATION: This community is characterized by a moderately diverse tree canopy dominated by a combination of *Acer saccharum* (sugar maple), *Quercus rubra* (red oak), and white ash. *Pinus strobus* (white pine) is frequent. *Tilia americana* (basswood), *Betula lenta* (black birch), and *Prunus serotina* (black cherry) occur in some examples, and are occasionally abundant. *Tsuga canadensis* (hemlock) and *Fagus grandifolia* (American beech) are occasional to infrequent and <5–15% each when present. Ironwood is often abundant or dominant in the understory, and *Carpinus caroliniana* ssp. *virginiana* (American hornbeam) is occasionally abundant. Among these trees, those usually indicative of at least somewhat enriched conditions are sugar maple, ash, basswood, ironwood, and American hornbeam.

Tall shrubs include an abundance of *Viburnum acerifolium* (maple-leaved viburnum) and lesser amounts and constancy of *Hamamelis virginiana* (American witch-hazel), *Viburnum dentatum* var. *lucidum* (smooth arrowwood), *Corylus cornuta* (beaked hazelnut), and in disturbed examples, *Berberis* spp. (barberries).

Any combination of three or more of the following semi-rich differential species will distinguish this community from more acidic forests: *Toxicodendron radicans* (poison-ivy), *Anemone americana* (blunt-lobed hepatica), *Polygonatum pubescens* (hairy Solomon's-seal), *Actaea rubra* (red baneberry), *Hylodesmum glutinosum* (pointed-leaved tick-trefoil), *Viola rotundifolia* (round-leaved violet), *Tiarella cordifolia* (foam-flower), *Polystichum acrostichoides* (Christmas fern), *Phegopteris hexagonoptera* (broad beech fern), and wide-leaved sedges (*Carex blanda*, *C. laxiflora*, and *C. laxiculmis*). Most sites have only a few of these differential species. The following species may be found in more mesic microhabitats: *Onoclea sensibilis* (sensitive fern), *Osmunda claytoniana* (interrupted fern), *Arisaema triphyllum* (Jack-in-the-pulpit), *Circaea alpina* (small enchanter's-nightshade), *Viola* spp. (violets), and *Geum canadense* (white avens).

Species often present that are not restricted to enriched conditions include *Mitchella repens* (partridge-berry; often abundant), *Lysimachia borealis* (starflower), *Uvularia sessilifolia* (sessile-leaved bellwort), *Solidago caesia* (axillary goldenrod), *Maianthemum canadense* (Canada-mayflower), *Aralia nudicaulis* (wild sarsaparilla), *Monotropa uniflora* (one-flowered Indian-pipe), *Dryopteris carthusiana* (spinulose wood fern), and *Athyrium angustum* (lady fern).

Various other species of northern hardwood and transition hardwood forests tend to be absent. The broader range of enriched site species noted for ***rich mesic forests*** are lacking, though all of the above mentioned species may also occur in that community. Iindicators of strong enrichment that are notably absent include *Caulophyllum thalictroides* (blue cohosh), *Asarum canadense* (Canada wild ginger), *Adiantum pedatum* (northern maidenhair fern), and *Dryopteris goldiana* (Goldie's wood fern).

VARIANTS: Two variants are described.

1. **Typic variant**: As described above.
2. **Appalachian variant**: This variant can contain any of the species found in the typic variant, but also includes a significant component of Appalachian species in the tree canopy, particularly *Carya ovata* (shagbark hickory). Other diagnostic species include *Quercus velutina* (black oak), *Q. alba* (white oak), and *Benthamidia florida* (flowering dogwood).

CLASSIFICATION CONFIDENCE: 2

DISTRIBUTION: The typic variant occurs through central and southern New Hampshire. The Appalachian variant can be found on low elevation till and marine sediment soils in the Coastal Lowland, Coastal Plain, Connecticut River, and southern portion of the NH Upland subsections. Elevations of known examples are less than 500 ft., and the community probably does not occur above 800 ft. Good examples occur in the Crommet Creek vicinity (Durham), south shore of Great Bay (Greenland), and Pawtuckaway State Park (Nottingham).

SOURCES: NHB field surveys.

related to the somewhat enriched soils of this type. *Prunus serotina* (black cherry) is present in some higher terrace examples, and *Ulmus americana* (American elm) occasionally grows in the sub-canopy, along with occasional northern hardwood species, including *Betula alleghaniensis* (yellow birch). *Toxicodendron radicans* (poison-ivy) is a common vine, while *Brachyelytrum aristosum* (northern short husk grass) and *Carex intumescens* (greater bladder sedge) are common graminoids.

Onoclea sensibilis (sensitive fern) and *Matteuccia struthiopteris* ssp. *pensylvanica* (ostrich fern), diagnostic ferns of the two silver maple floodplain forest types, occur together with herbs more commonly found in upland northern forests. These herbs include *Uvularia sessilifolia* (sessile-leaved bellwort), *Maianthemum canadense* (Canada-mayflower), *M. racemosum* (feathery false Solomon's-seal), and *Eurybia divaricata* (white wood aster). Rich woods indicator herbs such as *Arisaema triphyllum* (Jack-in-the-pulpit) and *Caulophyllum thalictroides* (blue cohosh) are occasional, most often occurring in examples dominated by sugar maple (as opposed to silver maple).

CLASSIFICATION CONFIDENCE: 1

DISTRIBUTION: Found along mostly central and northern rivers with high energy and flashy flood regimes. The back-terrace variant is found as far south as Concord, along the Merrimack River, but it is primarily found in the Saco and Androscoggin River drainages. Good examples are found at the Campton WMA island and at various sites along the Saco River (Bartlett, North Conway).

SOURCES: Bechtel and Sperduto 1998; Sperduto and Crowley 2002b.

FLOODPLAIN FORESTS OF MINOR RIVERS

Significant stretches of floodplain forest occur on third-order and some fourth-order rivers in New Hampshire. These communities, frequently dominated by *Acer rubrum* (red maple) and other tree species, have statewide significance and form an integral part of wetland corridors of smaller rivers.

Red maple is generally a common component in the tree canopy of all the floodplain forests of minor rivers. The range of natural communities that may be present on a given floodplain is most likely a result of relative height above the river, distance from the river, and the length of time since the river last flooded or altered its course away from its former channel. Floodplain habitats that may form a mosaic with red maple dominated or co-dominated forested floodplains include oxbow marshes and ponds, riverside meadows and emergent marshes, sand and gravel barrens, vernal pools, shrub thickets, and other forested floodplain community types. These floodplains are hydrologically similar to those with silver maple dominated floodplain forests in that both are profoundly influenced by spring floods. However, red maple dominated or co-dominated floodplain forests and associated floodplain communities along minor rivers and large streams probably differ hydrologically from their silver maple counterparts along major rivers by (1) reduced flood intensity, (2) typically shorter flooding periods, and (3) flooding that may occur earlier in the year. Minor river types often have a denser shrub layer than found in silver and sugar maple floodplain forests.

• Swamp white oak floodplain forest (S1)

GENERAL DESCRIPTION: Floodplain forests dominated or co-dominated by *Quercus bicolor* (swamp white oak) are state and regionally rare. In New Hampshire, they are restricted to within 30 miles of the coast. All occur at less than 150 ft. elevation and are associated with heavy (silty) soils of marine or recent floodplain origin. Diagnostic species include swamp white oak, *Fraxinus pennsylvanica* (green ash), and others indicative of moist, fertile conditions. *Betula nigra* (river birch)*, a rare tree in New Hampshire, is codominant with swamp white oak in several examples of this community along tributaries of the lower Merrimack River.

Floodplains along three river systems with this natural community ranged from ca. 1–6 ft. above the main river channel. The lower floodplain is somewhat poorly drained silt loam or fine sandy silt loam with a thin organic horizon (0–0.8 in.). Medium to high floodplain forests are somewhat poorly to moderately well drained with a similar soil profile. Average soil pH is 5.4.

This community type is most similar to low floodplain variant examples of the ***red maple floodplain forest*** community.

CHARACTERISTIC VEGETATION: Both higher and lower floodplains are dominated by a mix of swamp white oak and *Acer rubrum* (red maple), with an understory of *Carpinus caroliniana* ssp. *virginiana* (American hornbeam), abundant *Onoclea sensibilis* (sensitive fern), and variable amounts of *Viburnum dentatum* var. *lucidum* (smooth arrowwood), *V. lentago* (nannyberry), *Ilex verticillata* (common winterberry), *Toxicodendron radicans* (poison-ivy), *Smilax herbacea* (carrion-flower), *Carex crinita* (fringed sedge), *Cinna arundinacea* (sweet wood-reed), and *Thelypteris palustris* var. *pubescens* (marsh fern). *Fraxinus americana* (white ash) is occasional. *Carex laxiculmis* (spreading sedge), an uncommon sedge restricted to silty soils in southern New Hampshire, is also found in this community. There is little or no moss cover.

VARIANTS: Three variants are described. While two are based on floristic differences associated with elevation above the river channel, a continuum of species compositional change is evident across the elevation gradient at most sites. A third variant is based on the abundance of river birch*.

1. **High variant**: This variant occurs on medium to high elevation floodplains. The herb layer is moderately dense (40–60%) and the shrub layer is moderately to very dense (30–80%). Tree seedling and sapling regeneration in the shrub layer is sparse. There is a greater abundance of upland tree, shrub, and herb species compared to the low floodplain variant. These include *Carya ovata* (shagbark hickory), *Pinus strobus* (white pine), *Quercus rubra* (red oak), *Prunus serotina* (black cherry), *Ostrya virginiana* (ironwood), *Fagus grandifolia* (American beech), *Vaccinium angustifolium* (lowbush blueberry), *Maianthemum canadense* (Canada-mayflower), *Uvularia sessilifolia* (sessile-leaved bellwort), and *Parathelypteris noveboracensis* (New York fern). Among floodplain forests in New Hampshire, shagbark hickory is most frequent in this variant.
2. **Low variant**: The lower floodplain has a moderately dense to dense (40–90%) herbaceous layer, a sparse to moderately dense shrub layer (6–40%), and a light to moderately dense seedling/sapling layer. *Fraxinus pennsylvanica* (green ash) is common to abundant, and diagnostic to this community variant among non-silver maple floodplain forest communities. Other species indicative of the low variant include *Ulmus americana* (American elm), *Swida amomum* (silky dogwood), *Iris versicolor* (blue iris), *Lysimachia terrestris* (swamp yellow-loosestrife), and *Carex stricta* var. *strictior* (small tussock sedge).
3. **River birch variant**: All of the species indicative of the low variant of ***swamp white oak floodplain forest*** may occur in this variant. Red maple, swamp white oak, *Tilia americana* (basswood), white ash, and American elm are all common along with abundant river birch*. *Cardamine bulbosa* (bulbous bitter-cress)* and *Allium canadense* (meadow garlic)* are additional rare plants found in this type.

CLASSIFICATION CONFIDENCE: 2

DISTRIBUTION: Restricted to within 30 miles of the coast in the Great Bay watershed and tributaries of the lower Merrimack River. The river birch variant is restricted to the Beaver Brook and Spicket River systems, where good examples exist. The Exeter, Lamprey, and Powwow Rivers all contain good examples of the low and high floodplain variants.

SOURCES: NHB field surveys; Nichols et al. 2000; Sperduto and Crowley 2002b.

(ca. 15–20 cm down). In wetter portions, deeper mucky silt loams form at the surface. This community is found on Monarda (Cabot) and Peacham soil series in Coos County.

CHARACTERISTIC VEGETATION: Component tree species include sugar maple, yellow birch, and balsam fir. Other trees include *Picea glauca* (white spruce), and *Betula cordifolia* (heart-leaved paper birch). *Fraxinus nigra* (black ash) may be present, but is generally restricted to drainages and other wetter portions of the forest.

A well developed herb layer is dominated by *Glyceria melicaria* (northeastern mannagrass), *Impatiens capensis* (spotted touch-me-not), *Tiarella cordifolia* (foam-flower), *Symphyotrichum puniceum* (purple-stemmed American-aster), *Chamerion angustifolium* ssp. *circumvagum* (narrow-leaved fireweed), *Rubus pubescens* (dwarf raspberry), and *Athyrium angustum* (lady fern). Other herbs include *Epilobium ciliatum* (fringed willow-herb), *Galium triflorum* (fragrant bedstraw), *Thalictrum pubescens* (tall meadow-rue), *Clintonia borealis* (yellow bluebead-lily), *Actaea rubra* (red baneberry), *A. pachypoda* (white baneberry), *Chelone glabra* (white turtlehead), *Solidago flexicaulis* (zig-zag goldenrod), *Ageratina altissima* (white snakeroot), *Eutrochium maculatum* (spotted Joe-Pye weed), *Euthamia graminifolia* (common grass-leaved-goldenrod), *Carex gynandra* (nodding sedge), *Calamagrostis canadensis* (bluejoint), *Phegopteris connectilis* (long beech fern), *Dryopteris intermedia* (evergreen wood fern), *D. campyloptera* (mountain wood fern), *Polystichum braunii* (Braun's holly fern), and *Onoclea sensibilis* (sensitive fern).

Shrubs include *Rubus idaeus* ssp. *strigosus* (strigose red raspberry), *Sambucus racemosa* (red elderberry), *Viburnum lantanoides* (hobblebush), *Acer pensylvanicum* (striped maple), and *Alnus incana* ssp. *rugosa* (speckled alder). Rare or uncommon plants found in this community include *Cypripedium parviflorum* var. *pubescens* (large yellow lady's-slipper)*, *Galium kamtschaticum* (boreal bedstraw), and *Milium effusum* ssp. *cisatlanticum* (millet grass).

CLASSIFICATION CONFIDENCE: 2

DISTRIBUTION: This community is largely restricted to the White Mountains and the North Country. Good examples occur in the Connecticut Lakes Headwaters Natural Area (Pittsburg) and along the lower portion of the Falling Waters Trail in Franconia Notch (Lincoln).

SOURCES: NHB field surveys.

OTHER FORESTS WITH A SEASONALLY HIGH WATER TABLE

Forests that are influenced by a seasonally high water table are transitional between hydric forested wetlands and uplands. Typically they have somewhat poorly drained soils, but can range from poorly drained to moderately well drained. These are "low" or wet forests that are temporarily flooded (e.g., along drainages), seasonally saturated (e.g., along the upland transition of various wetlands), or otherwise maintain a seasonally high water table (such as on silt soils in coastal or northern New Hampshire).

• Hemlock - cinnamon fern forest (S4)

GENERAL DESCRIPTION: This community has a seasonally-high water table, and as such is a transitional community type exhibiting some characteristics of both upland forests and forested swamps. It occurs in imperfectly to somewhat poorly drained areas along stream drainages, high floodplains, inactive river terraces, and other upland-wetland ecotones, and is characterized by *Tsuga canadensis* (hemlock), *Acer rubrum* (red maple), and a mixture of other wetland and upland plant species. Examples may occur along a narrow transition zone between uplands and wetlands or may be broader in extent and cover several acres. Although some sub-surface seepage may influence certain examples, this community is distinct from seepage forest and forest seep communities, which tend to have relatively constant surface or near-surface seepage influence and more seepage or minerotrophic plant indicators.

Soils are nutrient-poor. They vary from loamy sands to sandy loam till and river/kame terrace soils with a shallow water table (within 1 ft. of soil surface for portion of growing season). Mottles are evident within 1 ft. of the soil surface in some examples, while others have deep A horizons (tending to obscure mottles) over moist to wet sediments. Soils series include Au Gres, among other types.

CHARACTERISTIC VEGETATION: Hemlock and red maple dominate in the overstory. Canopy associates may include *Pinus strobus* (white pine), *Betula alleghaniensis* (yellow birch), and less frequently *Quercus bicolor* (swamp white oak), *Q. rubra* (red oak), *Betula lenta* (black birch), *Ulmus americana* (American elm), and *Prunus serotina* (black cherry). *Fraxinus americana* (white ash) may also be prominent in the tree canopy in some upland-wetland ecotones. Other woody species can include *Fagus grandifolia* (American beech), *Picea rubens* (red spruce), *Abies balsamea* (balsam fir), *Acer pensylvanicum* (striped maple), *Vaccinium corymbosum* (highbush blueberry), *Viburnum nudum* var. *cassinoides* (withe-rod), *V. lantanoides* (hobblebush), *Sambucus nigra* ssp. *canadensis* (common elderberry), *Rosa palustris* (swamp rose), *Kalmia angustifolia* (sheep laurel), and *Rubus occidentalis* (black raspberry).

Although the overstory association can approximate certain upland forests, more mesic to wet conditions are indicated by the presence of *Osmundastrum cinnamomeum* (cinnamon fern), *Osmunda claytoniana* (interrupted fern), *Thelypteris palustris* var. *pubescens* (marsh fern), *Arisaema triphyllum* (Jack-in-the-pulpit), *Lonicera canadensis* (American honeysuckle), *Lindera benzoin* (northern spicebush), and various mosses. Other herbs may include *Parathelypteris noveboracensis* (New York fern), *Dryopteris intermedia* (evergreen wood fern), *Aralia nudicaulis* (wild sarsaparilla), *Oclemena acuminata* (sharp-toothed nodding-aster), *Mitchella repens* (partridge-berry), *Oxalis montana* (northern wood sorrel), and *Clintonia borealis* (yellow bluebead-lily).

CLASSIFICATION CONFIDENCE: 2

DISTRIBUTION: Occurs throughout most of New Hampshire primarily south of and including the White Mountains on valley bottoms and drainages of upland till and river/kame terrace soils. Good examples can be found east of swamp north of Birch Hill (Albany), along Allard Brook (Albany), east of White Ledge (Albany), and along Johnson Creek (Durham).

SOURCES: NHB field surveys; Nichols and Sperduto 1997.

• Red maple - elm - lady fern silt forest (S1S2)

GENERAL DESCRIPTION: This forest type is intermediate between upland and wetland communities. It has a seasonally high water table and silt soils with a high water holding capacity and intermediate nutrient status. The vegetation consists of a moderately diverse combination of upland, moist-site forest species, and facultative wetland species. The woody and herbaceous understories are sparse to moderately well developed. Unlike most swamps, there is very little or no organic soil horizon or hummock-hollow microtopography development.

Soils are somewhat poorly drained silt loams with a seasonally high water table, high moisture holding capacity due to the silt content, and moderate base cation status judging from species composition and silty soils. Soil types include some Buxton and Scitico silt loams (of marine origin), among other soils. There is typically no or a very shallow O horizon (<2 cm), very dark gray-black silt loam A horizon, and olive gray silt loam B horizon with redoxymorphic features (mottles) found near the transition to the B horizon.

This community is similar in some respects to somewhat poorly drained floodplains forests and seepage forests, but it is not flooded and does not have mucky organic horizons. It is also similar to the ***hemlock - cinnamon fern forest*** and ***red maple - red oak - cinnamon fern forest*** in terms of drainage class.

CHARACTERISTIC VEGETATION: The dominant tree species is *Acer rubrum* (red maple), accompanied by a diverse but variable assemblage of other trees. *Ulmus americana* (American elm) is usually present in low

MARSHES, SHRUB THICKETS, AND AQUATIC BEDS

The following communities occur in low-energy settings along streams and rivers, open-basins (those with outlets), closed-basins (no outlets) with broadly fluctuating water levels, and on shady, wave-exposed lake and pond shores. These settings contrast with both higher-energy riparian environments and stagnant basins that accumulate peat (covered elsewhere in the Open Wetlands and Riparian Communities section).

OPEN-BASINS AND STREAMSIDES

These drainage marsh communities occur on fine mineral to organic substrates (sand, muck, or shallow muck over sand or silt) along streams or open basins (i.e., those that have an outlet). Communities are mostly seasonally to semi-permanently flooded; aquatic beds are an exception, being permanently flooded or only intermittently exposed. Marshes and aquatic bed communities found along rivers and major streams typically occur in lower energy sections of the riparian corridor and are similar to those in streamside and open-basin settings. As such, they are treated in this section of the classification.

Meadow marshes

This is a broad category of communities characterized by permanently saturated to seasonally flooded mineral, muck, or shallow fibrous peat soils, and dominated by grasses and sedges (graminoids) or mixes of graminoids, herbs, and medium-height shrubs between 0.5–1.5 m tall. These marshes are usually flooded by one to several feet of water during spring snowmelt but have considerably lower water levels by mid to late summer. Rhizomatous, clonal species are common in marshes, and what species dominates at a site is strongly influenced by both hydrologic regime and seed or other propagule availability. A very high diversity of species has been documented from marshes in general. Species richness for a 400 square meter area typically exceeds 30 (-40+) species, even when one or a few species accounts for over 50% of the cover (NHB field surveys).

Typical meadow marsh plants include *Calamagrostis canadensis* (bluejoint), *Glyceria canadensis* (rattlesnake mannagrass), *Leersia virginica* and *L. oryzoides* (cut grasses), *Phalaris arundinacea* (reed canary grass), *Dulichium arundinaceum* (three-way sedge), *Carex stricta* (tussock sedge), *C. lacustris* (lake sedge), *Scirpus cyperinus* (woolly bulrush), *Juncus canadensis* (Canada rush), *Eutrochium dubium* (coastal plain Joe-Pye weed), *E. maculatum* (spotted Joe-Pye weed), *Iris versicolor* (blue iris), and *Thalictrum pubescens* (tall meadow-rue). Meadow marshes may be successional to scrub-shrub swamps and ultimately forested swamps over the course of decades. Conversely, they may revert to either deeper water marshes or aquatic beds following submergence caused by damming of the drainage.

The federally endangered *Scirpus ancistrochaetus* (northeastern bulrush)* occurs in some meadow marshes (as well as emergent marshes). Other potential rare species of meadow marshes include *Mikania scandens* (climbing hempvine)*, *Lysimachia thyrsiflora* (tufted yellow-loosestrife)*, *Iris prismatica* (slender blue iris)*, *Carex trichocarpa* (hairy-fruited sedge)*, *Bidens laevis* (smooth beggar-ticks)*, and *B. discoidea* (small beggar-ticks).

In many cases, meadow marshes are mixed in composition or are transitional to shrub thickets. In other circumstances, one or two species clearly dominate. Numerous associations or dominance types can occur, which may deserve distinction as natural community types with expanded sampling and research.

• Tall graminoid meadow marsh (S4)

GENERAL DESCRIPTION: This meadow marsh community is dominated by tall "matrix" forming graminoids. Dominant species are maintained vegetatively through the development of dense tussocks or by lateral spread (clonal or spreading from loose tussocks).

CHARACTERISTIC VEGETATION: Typical marsh plants here include *Calamagrostis canadensis* (bluejoint), *Glyceria canadensis* (rattlesnake mannagrass), *Leersia virginica* and *L. oryzoides* (cut grasses), *Phalaris arundinacea* (reed canary grass), *Dulichium arundinaceum* (three-way sedge), *Carex stricta* (tussock sedge), *C. lacustris* (lake sedge), *Scirpus cyperinus* (woolly bulrush), *Juncus canadensis* (Canada rush), *Eutrochium dubium* (coastal plain Joe-Pye weed), *E. maculatum* (spotted Joe-Pye weed), *Iris versicolor* (blue iris), and *Thalictrum pubescens* (tall meadow-rue).

A broad diversity of other herbs is often present, but much of the cover and biomass is contributed by only a few species.

VARIANTS: Four variants are described.

1. **Bluejoint variant**: This common variant is dominated by bluejoint. They are often inundated for shorter periods or do not sustain water as close to the surface for as long compared to other meadow marshes.
2. **Tussock sedge variant**: This variant is dominated by tussock sedge.
3. **Bulrush variant**: These marshes are dominated by bulrushes, most commonly woolly bulrush.
4. **Reed canary grass variant**: Reed canary grass is dominant in this variant.

CLASSIFICATION CONFIDENCE: 2

DISTRIBUTION: This community is found throughout the state. Good examples can be found at Pawtuckaway State Park (Nottingham).

SOURCES: NHB field surveys.

• Mixed tall graminoid - scrub-shrub marsh (S4S5)

GENERAL DESCRIPTION: This community is a common meadow marsh scrub-shrub type occurring along stream drainageways and open basins. It is similar to ***tall graminoid meadow marsh*** but has a substantial component of medium- and tall-height shrubs (up to 60% cover overall). Many examples are successional between marsh and shrub thicket or swamp. The substrate consists of a thin, well-decomposed organic layer over fine mineral soils or fine mineral soils with a high organic content.

CHARACTERISTIC VEGETATION: Species include a mixture of tall graminoids such as *Calamagrostis canadensis* (bluejoint) and *Carex stricta* (tussock sedge), other tall grasses and sedges, *Osmundastrum cinnamomeum* (cinnamon fern), *Osmunda regalis* var. *spectabilis* (royal fern), and medium-height shrubs *Spiraea alba* var. *latifolia* (meadowsweet), and *Myrica gale* (sweet gale). Tall shrubs include *Vaccinium corymbosum* (highbush blueberry), *Lyonia ligustrina* (maleberry), *Ilex verticillata* (common winterberry), *Alnus incana* ssp. *rugosa* (speckled alder), *Viburnum nudum* var. *cassinoides* (withe-rod), and *Salix* spp. (willows). *Sphagnum* moss is infrequent. This community is transitional to streamside poor fens that have a greater abundance of *Sphagnum* moss, *Chamaedaphne calyculata* (leatherleaf), sweet gale, and “peatland” sedges such as *Carex utriculata* (swollen-beaked sedge) and *C. lasiocarpa* (wire sedge).

CLASSIFICATION CONFIDENCE: 2

DISTRIBUTION: Occurs throughout the state. Good examples can be found at Pawtuckaway State Park (Nottingham).

SOURCES: NHB field surveys.

Appendix N

NH Wildlife Action Plan

New Hampshire

Wildlife Action Plan

Submitted October 1, 2005

NEW HAMPSHIRE FISH AND GAME DEPARTMENT

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HABITAT PROFILE

Appalachian Oak Pine Forest

Associated Species: Timber rattlesnake, eastern hognose snake, whip-poor will, veery, eastern pipistrelle, eastern red bat, northern myotis, silver haired bat, bobcat, black bear

Global Rank: Not ranked
State Rank: Not ranked
Author: Carol R. Foss, Audubon Society of New Hampshire

Element 1: Distribution and Habitat

1.1 Habitat description

Appalachian oak pine forest systems are found mostly below 900 ft elevation in southern New Hampshire south of and at lower elevations than the hemlock-hardwood-pine forest system. The southern-most portions of the state are associated with the warmer and drier climatic conditions and apparently more fire-influenced landscapes that prevail south of New Hampshire in lower New England. Substrates in these forests include nutrient-poor, dry to mesic sandy glacial tills, and some large areas of sand plain or shallow-to-bedrock tills, particularly in the seacoast and lower Merrimack and Connecticut River valleys. Sand plains in these areas that have a frequent fire history correspond to pitch pine sand plain; those with a less frequent fire regime (i.e., more than 50 to 100 years) are classified as oak pine forest or sometimes hemlock hardwood pine forest systems depending on the composition of trees. More isolated patches of oak pine forest systems are found to the north in central New Hampshire associated with dry rocky ridges or sand plains with a historic fire regime.

1.2 Justification

Appalachian oak pine forest currently has a limited distribution in New Hampshire, covering less than 10% of the state's land area. Available data indicate that only 7.3% of the state's potential Appalachian oak pine forest is on permanently protected lands. This forest type supports 104 vertebrate species in New Hampshire, including 8 amphibians, 12 reptiles, 67 birds, and 17 mammals. Threatened and endangered wildlife species occurring in this forest type include osprey, Cooper's hawk, timber rattlesnake, and eastern hognose snake. In New Hampshire, intense development has dramatically reduced the area of this forest type influenced by natural disturbance regimes, resulting in a preponderance of the forest currently in older age classes. A full range of age classes well distributed on the landscape is important to support the diversity of wildlife species that depend on this forest type.

1.3 Protection and Regulatory Status

Most of New Hampshire's Appalachian oak pine forest occurs on small, privately owned parcels. Less than 15% of this forest type occurs on conservation lands. Forestry on state lands is covered by RSAs 216, 217, and 218. RSA 227 stipulates requirements for residual basal area in riparian areas. The manuals "Best Management Practices for Erosion Control on Timber Harvesting Operations in New Hampshire" (Cullen 1996) and "Good Forestry in the Granite State" (FSSWT 1996) provide recommended management practices for sustainable forestry in New Hampshire.

1.4 Distribution

Appalachian oak pine forest occurs primarily in southern New Hampshire, with more than 40%

by area in Rockingham County and approximately 20%, 15%, and 10% in Hillsborough Strafford, and Cheshire counties, respectively.

1.5 Town Distribution Map

See attached.

1.6 Habitat Map

To develop a map of Appalachian oak pine forest in New Hampshire, a model was developed for each ecoregion subsection of the state based on the 2001 New Hampshire Land Cover Assessment, elevation, landform, and soils. The model was developed by experts from The Nature Conservancy (TNC), the New Hampshire Natural Heritage Bureau (NHNHB), and New Hampshire Fish and Game (NHFG).

First, relevant forested 2001 New Hampshire Land Cover Assessment grid values were combined with elevation ranges from sea level to 900' (CSRC 2001, USGS 2003). Ecological Land Units, created by The Nature Conservancy's Conservation Science Support, were then added to capture additional areas likely to have geo-physical conditions favorable to Appalachian oak pine, or remove areas likely to have geo-physical conditions unfavorable to Appalachian oak pine (TNC 2003). Specifically, north-facing side slopes and north-facing coves were removed from some land cover/elevation classes, and some land cover/elevation classes were restricted to only south-facing sideslopes and south-facing coves.

During previous fieldwork, NHNHB mapped exemplary Dry Appalachian oak-hickory forest, Mesic Appalachian oak-hickory forest, Appalachian oak-mountain laurel forest, and Semi-rich Appalachian oak-sugar maple forest systems in the state. These areas were added to ensure that known Appalachian oak pine locations were captured (NHNHB 2005). These data do not capture all existing locations of these communities, only those that have been mapped by NHNHB.

To further refine the model, soil types associated with Appalachian oak pine were identified by Natural Resource Conservation Service scientists and selected from digitized county soil data, where available (e.g., Merrimack county soils have not been digitized) (NRCS 2002, Homer 2005). The soils were selected, and then clipped to only include forested areas based on the New Hampshire Landcover Assessment, and added to the existing model information. The same was done for hemlock-hardwood-pine, and then Appalachian oak pine was used to erase areas from hemlock-hardwood-pine where there was overlap, so that Appalachian oak pine takes precedence over hemlock-hardwood-pine. NHFG then applied a filter to determine the majority forest type between neighboring polygons in the TNC model, and smoothed the boundaries to generalize the transition between matrix forest types. This process is expected to somewhat over-predict current locations of Appalachian oak pine, but it captures better broad distribution patterns of the type.

Model results were reviewed by experts from TNC, NHFG, and NHNHB, who agreed that the broad patterns depicted by the model align with reasonable expectations. No ground truthing was conducted.

1.7 Sources of Information

The Appalachian oak pine map was developed based on expert input from scientists from the NHNHB, NHFG, and the New Hampshire Chapter of The Nature Conservancy. The results were reviewed by additional scientists from NHFG and the Audubon Society of New Hampshire. A variety of GIS data was used to generate the map including elevation data from the United States Geological Survey, landform data from The Nature Conservancy's eastern regional office, landcover data from the New Hampshire Landcover Assessment, and soils data from the Natural Resource Conservation Service, among others.

1.8 Extent and Quality of Data

The Appalachian oak pine habitat map is a depiction of broad landscape patterns with limited fine-scale accuracy. Additional refinements will likely be necessary based on ground truthing of the existing map. The Natural Resource Conservation Service provided a table of soil series that were believed to be strongly correlated with Appalachian oak pine and other forest types (Homer 2005). Soil series were provided by ecoregional subsection and elevation ranges. There was considerable overlap between series outlined for Appalachian oak pine and other forest types, especially hemlock-hardwood-pine. The transition between Appalachian oak pine and hemlock-hardwood-pine was especially difficult to delineate, as disturbance is a driving factor in the distribution of Appalachian oak pine. The soil series considered to be most strongly correlated with Appalachian oak pine that did not overlap with hemlock-hardwood-pine were used in mapping Appalachian oak pine. Additional review of soils data, as well as land use history and paleoecology information, are necessary for future iterations.

1.9 Distribution Research

Additional fieldwork is needed to evaluate correlations between soil series and forest type as outlined in Homer (2005). County soil surveys outline soils suitable for forestry from an economic perspective. However, little has been done to evaluate soils from an ecological perspective (e.g., if left unmanaged, an area with a particular soil would eventually succeed to Appalachian oak pine forest).
Fieldwork is also needed to ground truth the Appalachian oak pine map.
Research is needed to identify human-created disturbance regimes that can maintain and regenerate Appalachian oak pine forest.

Element 2: Species/Habitat Condition

2.1 Scale

County

2.2 Relative Health of Populations

An approximately 5% decrease in forest area occurred between 1992 and 1993 and 2001 in the 4-county area where approximately 90% of New Hampshire's potential Appalachian oak pine forest occurs. An additional approximately 5% decrease is projected to occur between 2001 and 2025 (calculated from data in SPNHF 2005).

2.4 Relative Quality of Habitat Patches

Analysis pending

2.5 Habitat Patch Protection Status

Approximately 10% of potential Appalachian oak pine forest in the 4-county area where approximately 90% of this forest type occurs is in conservation ownership (calculated from TNC data). Approximately 14% of this type occurs on lands with some form of conservation protection (calculated from NHFG data).

2.6 Habitat Management Status

Approximately 25% of the 4-county area in which approximately 90% of potential Appalachian oak pine forest area occurs is in certified Tree Farms (calculated from TNC data and data in Thorne and Sundquist 2001).

2.7 Sources of Information

See 1.7

2.8 Extent and Quality of Data

See 1.8 regarding extent and quality of data associated with the TNC matrix forest map. Tree farm data from Thorne and Sundquist 2001 are based on a New Hampshire Tree Farm program database issued in August 2000. Data regarding changes in forest area from SPNHF 2005 include information from the New Hampshire Land Cover Assessment, 2001 and results of predictive modeling.

2.9 Condition Assessment Research

- Research is needed to determine the extent of this forest type that occurs in large unfragmented blocks.
- Research is needed to determine the age class distribution of this forest type on the landscape.

Element 3: Species and Habitat Threat Assessment

3.1.1 Transportation Infrastructure

(A) Exposure Pathway
Transportation infrastructure fragments forest blocks, creating edge effects from light penetration and exposure to wind and pollutants such as road salt and hydrocarbons. Transportation infrastructure and its use by vehicles also create dispersal barriers, edge effects, and increased mortality for matrix forest wildlife (Forman et al. 2003).

(B) Direct Evidence
Large carnivores may be unable to maintain sustainable populations in landscapes with road densities exceeding 1 mi/ mi^2 (Forman and Alexander 1998). Roads affect forest and habitat conditions well beyond the actual edge of the forest (Ranney et al. 1981). Roads can negatively affect landscape permeability for black bears, bobcats, and lynx (Forman et al. 2003).

3.1.2. Development (Habitat Loss and Conversion)

(A) Exposure Pathway
Development reduces matrix forest habitat by converting natural forest to landscaped lawns and impermeable surfaces (e.g., buildings, roads). Development also contributes to forest fragmentation by directly reducing habitat, increasing traffic on existing roads, and requiring construction of new transportation infrastructure.

(B) Direct Evidence
A study of 10 New Hampshire communities found that their populations increased by an average of 70.9% (range 9.7 to 189.7%) between 1974 and 1992, while developed land increased by an average of 137.2%. In the community with 9.7% population growth, developed land increased by 15.9% (New Hampshire Office of State Planning (NHOSP) 2000).

3.1.3. Development (Land Use Planning)

(A) Exposure Pathway
In New Hampshire, land use decisions are made at the municipal scale by volunteer planning boards with little or no training in natural resource issues. In cities and some of the larger towns, professional planning staff evaluate proposed developments and provide input to the planning board, but this is the exception rather than the rule. Most professional planners lack training in ecology or natural resources. Decisions are typically based on engineering and aesthetic considerations, with no recognition of direct or cumulative impacts on the underlying ecological functions of the affected lands or on impacts to wildlife habitat.

(B) Direct Evidence
A Growth Management Advisory Committee convened by the New HOSP in 1999 concluded that:

- Impacts of growth and development are cumulative over decades
- Development in New Hampshire has occurred incrementally, resulting in fragmentation and loss of important and environmentally sensitive areas, including forestlands and wildlife habitat
- Communities seldom evaluate the potential impacts of their zoning ordinance or land use regulations (NHOSP 2000)

3.1.5 Altered Natural Disturbance (Succession)

(A) Exposure Pathway
Extinction of the passenger pigeon, fire suppression, development, and accompanying land-use policies have essentially eliminated the major historical natural disturbances for this forest type. Parcelization and extensive residential development now preclude forest management in much of New Hampshire's Appalachian oak pine forest. Habitat for wildlife species requiring early successional stages of this forest type has been substantially reduced.

(B) Direct Evidence
Forest inventory data for New Hampshire show major deficits in the 2-inch diameter class for hickory and the 4-inch diameter class for white oaks (Miles 2005).

3.2 Sources of Information

Threat information was derived from a work session with forestry professionals and stakeholders, available data, published literature, and personal experience.

3.3 Extent and Quality of Data

Threats to Appalachian oak pine forest resulting directly or indirectly from land conversion and development are well documented.

3.4 Threat Assessment Research

The major threats are adequately documented. Research should be directed to condition assessment and conservation actions.

Element 4: Conservation Actions

4.1.1 Incorporate Habitat Conservation into Local Land Use Planning

See Strategies: Local Regulation and Policy

4.1.2 Advise Conservation Commissions and Open Space Committees

See Strategies: Local Regulation and Policy, Education and Outreach

4.1.3 Promote Role of the Regional Planning Commissions in Landscape-Scale Conservation

See Strategies: Local Regulation and Policy

4.1.4 Protect unfragmented blocks and other key wildlife habitats

See Strategies: Land Protection

4.1.5 Develop a comprehensive land protection support program

See Strategies: Land Protection

4.1.6 Advocate adoption of sustainable forestry

See Strategies: Education and Outreach

4.2 Conservation Action Research

Research is needed to provide a sound scientific basis for new tools to help municipalities maintain large forest blocks and significant wildlife habitat in the face of development. Such research could include:

- Road noise effects on forest bird distribution and breeding status
- Behavior and land use of mesocarnivores in relation to development and road densities
- Bear use of mast stands relative to proximity of development
- Effects of residential lot sizes on habitat suitability and landscape permeability for selected wildlife species

Element 5. References

5.1 Literature

Forman, R.T.T., D. Sperling, J.A. Bissonette, A.P.Clevenger, C.D. Cutshall, V.H. Dale, L. Fahrig, R. France, C.R. Goldman, K. Heanue, J.A. Jones, F. S. Swanson, T. Turrentine, T.C. Winter. 2003. Road Ecology. Island Press, Washington.

Forman, R.T.T. and L.E. Alexander. 1998. Roads and their major ecological effects. Annual Review of Ecology and Systematics 29:207-231.

Homer, J. 2005. Soil types corresponding to the NH Natural Heritage Bureau forest systems classification. U.S. Department of Agriculture, Natural Resource Conservation Service, Lancaster, NH, U.S.A., Unpublished Report to New Hampshire Fish and Game Department.

Keys, J.E. and C.A. Carpenter. 1995. Ecological units of the eastern United States: first approximation. U.S. Department of Agriculture, Forest Service.

NHOSP. 2000. Managing Growth in New Hampshire: Changes & Challenges. New Hampshire Office of State Planning in conjunction with The Growth Management Advisory Committee, Concord, New Hampshire,

Ranney, J.W., M.C. Bruner, and J.B. Levenson. 1981. The importance of edge in the structure and dynamics of forest islands. Pp.67-92 in R.L. Burgess and D.M. Sharpe, eds. Forest Island Dynamics in Man-Dominated Landscapes. Springer-Verlag, New York.

Thorne, S. and D. Sundquist. 2001. New Hampshire's Vanishing Forests: Conversion, Fragmentation and Parcelization of Forests in the Granite State. Report of the New Hampshire Forest Land Base Study. Society for the Protection of New Hampshire Forests, Concord.

5.2 Data sources

Complex Systems Research Center. 2001. New Hampshire land cover assessment – 2001. 30m raster data. Available from GRANIT, University of New Hampshire.

Homer, J. 2005. Soil types corresponding to the NH Natural Heritage Bureau forest systems classification. U.S. Department of Agriculture, Natural Resource Conservation Service, Lancaster, NH, U.S.A., Unpublished Report to New Hampshire Fish and Game Department.

Miles, P.D. May 11, 2005. Forest inventory mapmaker web-application version 1.7, St. Paul, MN: U.S.

Departmetn of Agriculture, Forest Service, North Central Research Station [www.ncrs2.fs.fed.us/4801/fiab/index.htm]

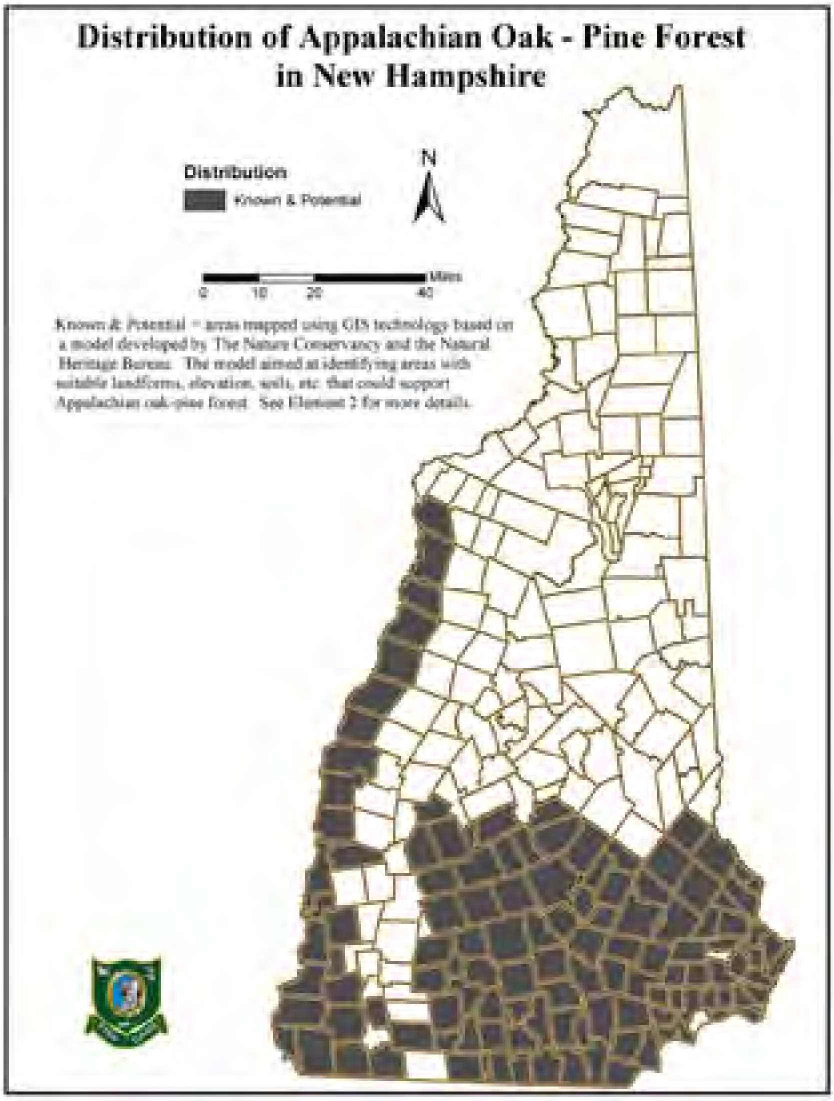
Natural Resources Conservation Service. Date varies, in progress with last revision in 2002. Soil Units of Rockingham, Sullivan, Cheshire, and Strafford Counties. Automated by and available from GRANIT, University of New Hampshire.

New Hampshire Natural Heritage Bureau. January 2005. Exemplary Natural Community Data. Scale varies, vector data. Available with permission from the NH Natural Heritage Bureau.

Sperduto, D, and M. Zankel. 2005. Distribution of matrix forest systems in New Hampshire by subsection, elevation, slope, and aspect. NH Department of Resources and Economic Development, Division of Forests and Lands, Natural Heritage Bureau, and The Nature Conservancy, Concord, NH, U.S.A. Unpublished Report to New Hampshire Fish and Game Department.

The Nature Conservancy, Conservation Science Support. 2003. Ecological Land Units. 30m raster data. Available from TNC, Eastern Resource Office, Boston, MA.

United States Geological Survey. Date varies, complete by 2003. National Elevation Dataset. 30m raster data. Projected by Complex Systems Research Center in January 2005, available from GRANIT, University of New Hampshire.


Distribution of Appalachian Oak - Pine Forest
in New Hampshire
Distribution
Known & Potential
N
Miles
0 10 20 40
Known & Potential = areas mapped using GIS technology based on a model developed by The Nature Conservancy and the Natural Heritage Bureau. The model aimed at identifying areas with suitable landforms, elevation, soils, etc. that could support Appalachian oak-pine forest. See Element 2 for more details.

SPECIES PROFILE

Common Moorhen

Gallinula chloropus

Federal Listing: Not listed
State Listing: Not listed
Global Rank: G5
State Rank: S2
Author: Kim A. Tuttle, NHFG

Element 1: Distribution and Habitat

1.1 Habitat Description

The common moorhen is a member of the secretive rail family (Rallidae). In the northern United States, moorhens require permanently flooded freshwater or brackish shallow ponds or deep marshes. Common moorhens frequent cattail (*Typha* spp.) marshes; they prefer robust, emergent, tall grass-like vegetation interspersed with pools and channels containing leafy plants (Bannor and Kiviat 2002). Moorhens eat leaves and stems of aquatic plants, as well as smaller amounts of grasses, herbs, seeds and berries, and some animals such as snails, insects, and worms (DeGraaf and Yamasaki 2001). Young moorhens will often eat dragonfly and mayfly nymphs (Hebert and Elkins 1994).

Moorhens may use altered, artificial, agricultural, or urban wetland habitats, including small ponds and sewage lagoons, and they commonly forage on lawns, fields, and golf courses near water (Bannor and Kiviat 2002). Nests are usually found in emergent vegetation, occasionally in shrubs such as willow (*Salix* spp.) or alder (*Alnus* spp). Water depth surrounding nests is usually 0.3 to 0.91m (1 to 3 ft deep). Nests are well concealed by overhanging wetland vegetation (DeGraaf and Yamasaki 2001).

1.2 Justification

Regional declines in moorhen populations have been attributed to loss or degradation of emergent wetland habitats. The common moorhen appears to have extended its range northward in the last century (Bannor and Kiviat 2002) but is thought to be less abundant than in the early 1900s due to the filling of wetlands (Degraaf and Yamasaki 2001).

Invasive, non-native plant species threaten cattail-dominated wetlands and increase the number of subsidized predators such as raccoons (*Procyon lotor*). These threats may be highest in southern New Hampshire, where development is most severe. For example, replacement of cattail by purple loosestrife (*Lythrum salicaria*) may have contributed to a decline in moorhens at Montezuma National Wildlife Refuge, New York (Sibley 1988 in Bannor and Kiviat 2002). The introduction of predatory game fish, such as the largemouth bass (*Micropterus salmoides*), to New Hampshire may further limit range expansion of the common moorhen. Bell and Cordes (1977, in Bannor and Kiviat 2002) collected 5 largemouth bass in Louisiana containing moorhen chicks.

1.3 Protection and Regulatory Status

- Migratory Bird Treaty Act (1918)
- See Marsh and Shrub Wetlands habitat profile for regulations regarding wetland impacts.

1.4 Population and Habitat Distribution

The North American breeding range extends from southern Maine to Florida, from the west to southern Minnesota and eastern Texas, and from California to southern New Mexico and south along both Mexican coasts. Wintering populations migrate to the southeastern and southwestern United States, with the largest concentrations in Florida (Hebert and Elkins 1994, Bannor and Kiviat 2002).

In New England, the common moorhen is a rare to uncommon local breeder and migrant (DeGraaf and Yamasaki 2001). It is listed as a Species of Special Concern in Massachusetts (Massachusetts Division of Fisheries and Wildlife 2003) and Endangered in Connecticut (Connecticut Department of Environmental Protection 2004). The breeding population of Massachusetts is estimated between 11 and 20 pairs (Massachusetts Division of Fisheries and Wildlife 2005). Common moorhens have always been thought to be rare and local in Vermont (Environmental Protection Agency 2005).

Common moorhens are rare in New Hampshire and are near the northern edge of the breeding range. The first confirmed nesting occurred in July 1960, with 2 adults and at least 6 young observed on a small pond in Portsmouth, which is no longer considered suitable (Hebert and Elkins 1994). There are New Hampshire breeding records for the towns of Concord, Barrington, Rochester, and Nottingham, as well as a 1998 sighting of an immature moorhen at the Exeter Wastewater Treatment plant. Multiple moorhens have been seen in Rye, Exeter and Orford, whereas single observations in the northern towns of Haverhill, Jefferson, Errol, and Dummer need further documentation to confirm breeding. Single observations have also been recorded in marshes in Hampton Falls, Durham, Newington, Marlow, Hebron, and Holderness (New Hampshire Wildlife Sightings Database 2005, Hebert and Elkins 1994).

1.5 Town Distribution Map

1.6 Habitat Map

See habitat map for Marsh and Shrub Wetlands.

1.7 Sources of Information

NatureServe (2005) was used for status and ranking information. New Hampshire Wildlife Sighting (2005), New Hampshire Heritage Bureau databases (2005), and Hebert and Elkins (1994) were the primary sources of locality records. Habitat and life history information was taken from published literature, including Foss (1994).

1.8 Extent and Quality of Data

The distribution of common moorhen breeding locations in New Hampshire appears to be limited to a few suitable cattail marshes or wastewater treatment facilities in the southeast part of the state. Recent distribution data are largely the result of records submitted to the New Hampshire Wildlife Sightings web page from New Hampshire Bird Records collected and reviewed by NHA. Although common moorhen records are few in the state, submitted reports are carefully reviewed before they are accepted, resulting in high-quality records.

1.9 Distribution Research

Systematic surveys are needed to provide more information regarding distribution, condition, and habitat requirements of the species. NHA volunteers should be recruited to identify common moorhen breeding locations. They should begin around the third week of May, and should concentrate particularly on those areas where breeding is suspected but not confirmed (e.g., Pontook Reservoir in Dummer, Reed Marsh in Orford, and Eel Pond in Rye). Common moorhen, and other uncommon, elusive wetland birds such as the Virginia rail (*Rallus limicola*) and Sora (*Porzana Carolina*) should be incorporated into habitat inventories and management and restoration efforts.

Element 3: Species Threat Assessment

Wetland loss and degradation, including shoreline modification and alteration of vegetated edges, are the greatest threats to common moorhen. See threats in Marsh and Shrub Wetland habitat profile.

Element 4: Conservation Actions

Maintaining natural, tall, grass-like emergent vegetation, especially cattail, at the borders of ponds and wetlands. See Marsh and Shrub Wetland habitat type for relevant conservation strategies.

Element 5: References

5.1 Literature

Bannor, B.K., and E. Kiviat. 2002. Common moorhen (*Gallinula chloropus). In* The birds of North America, no. 685, A. Poole and F. Gill, editors. The Birds of North America, Inc., Philadelphia, Pennsylvania, USA.

DeGraaf, R.M. and M. Yamasaki. 2001. New England wildlife: habitat, natural history, and distribution. University Press of New England, Hanover, New Hampshire, USA.

Connecticut Department of Environmental Protection Natural Diversity Database webpage 2004. Connecticut Department of Environmental Protection. Hartford, Connecticut. Available http://dep.state.ct.us/burnatr/wildlife/factshts/cmoorhen.htm. (Accessed 18 February 2005).

Environmental Protection Agency, Region 1 webpage 2005. Species profile: Common Moorhen. Environmental Protection Agency. Washington, D.C. Available http://epa.gov/region1/ge/thesite/restofriver/reports/final_era/B%20-%20Focus%20Species%20Profiles/EcoRiskProfile_common_moorhen.pdf (Accessed 1 March 2005).

Hebert, V.L. and K.C. Elkins. 1994. Common moorhen. Pages 76-77 *in* Atlas of breeding birds in New Hampshire, C.S. Foss, editor. Arcadia, Dover, New Hampshire, USA.

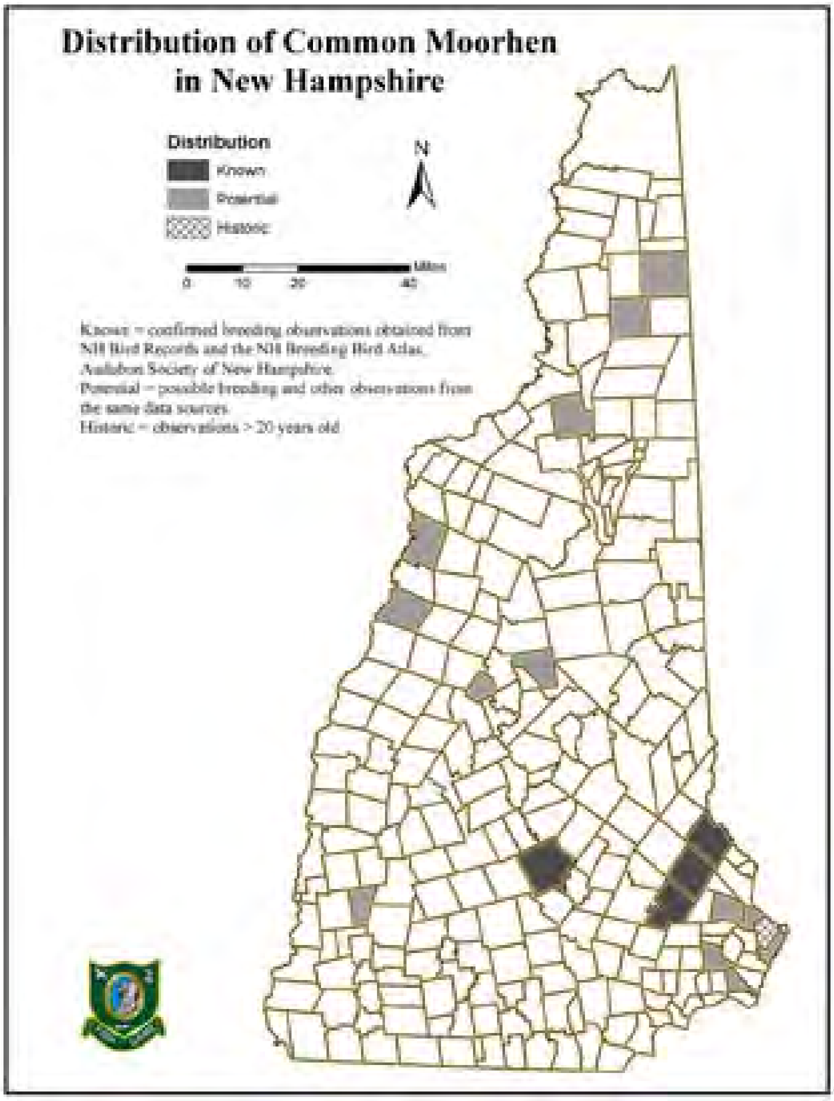
Massachusetts Natural Heritage Program webpage 2005. Massachusetts Rare and Endangered Wildlife. Division of Fisheries and Wildlife, Westborough, Massachusetts. Available http://www.mass.gov/dfwele/dfw/nhesp/nhfacts/galchl.pdf. (Accessed 18 February 2005).

NatureServe. 2005. NatureServe Explorer: An online encyclopedia of life [web application]. Version 4.2. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer. (Accessed: 15 February 2005).

5.2 Data Sources:

New Hampshire Natural Heritage Bureau. 2005. Database of Rare Species and Exemplary Natural Community Occurrences in New Hampshire. Department of Resources and Economic Development, Division of Forests and Lands. Concord, New Hampshire, USA.

Wildlife Sightings database. Maintained by the University of New Hampshire Complex Systems, Durham, New Hampshire, USA. (Accessed Feb. 15, 2005)


Distribution of Common Moorhen
in New Hampshire
Distribution
Known
Potential
Historic
N
Miles
0
10
20
40
Known = confirmed breeding observations obtained from NH Bird Records and the NH Breeding Bird Atlas, Audubon Society of New Hampshire.
Potential = possible breeding and other observations from the same data sources.
Historic = observations > 20 years old

HABITAT PROFILE

Floodplain Forests

Associated Species: Jefferson Salamander, northern leopard frog, Wood Turtle, Red Shouldered Hawk, Cerulean Warbler, Eastern Red Bat, Silver Haired Bat

Federal Listing: Not listed
State Listing: Not listed
Global Rank: Not ranked
State Rank: Alder alluvial shrubland (S3), Alder – dogwood – arrowwood alluvial thicket (S4), Alluvial mixed shrub thicket (S4), Aquatic bed (S4S5), Balsam fir floodplain/silt plain (S2), Basswood – white ash – black maple floodplain forest (S1), Blue-joint – goldenrod – virgin's bower riverbank/floodplain (S3S4), Herbaceous riverbank/floodplain (S2S4), Herbaceous/wooded riverbank/floodplain (S4), Meadowsweet alluvial thicket (S3?), Oxbow buttonbush swamp (S3), Oxbow marsh (S3), Red maple floodplain forest (S2S3), Riverbank/floodplain fern glade (SU), Silver maple – false nettle – sensitive fern floodplain forest (S2), Sugar maple – ironwood – short husk floodplain forest (S1), Sugar maple – silver maple – white ash floodplain forest (S1S2), Swamp white oak floodplain forest (S1), Sycamore floodplain forest (S1)
Author: Peter J. Bowman, New Hampshire Natural Heritage Bureau

Element 1: Distribution and Habitat

1.1 Habitat Description

Floodplains occur in river valleys adjacent to river channels and are prone to periodic flooding. Floodplains are often comprised of forests, oxbows, meadows, and thickets. The habitats, vegetation, and hydrologic regime of floodplains are strongly influenced by watershed size, gradient, and channel morphometry. Most open or partially wooded floodplain communities occur on low floodplains. Sloughs, oxbows, vernal pools, and other depressions in the floodplain tend to be inundated for longer periods than low floodplains (Sperduto 2004). Floodplain soils range from well-drained coarse sand on levees to poorly drained silts and mucks in depressions, and tend to be moderately to strongly minerotrophic (Sperduto 2004).

Montane/near-boreal floodplains are found primarily along rivers in the White Mountains or northern New Hampshire, and have relatively high gradients and flashy flood regimes compared to other floodplain systems. Sugar maple and balsam fir are dominant trees, and riparian wetlands such as oxbows and sloughs are uncommon in these high-gradient floodplains.

M*ajor river silver maple floodplains* occur primarily along the Connecticut and Merrimack Rivers, and occasionally on lower reaches of major tributaries. These floodplains are often interspersed with oxbow marshes and shrub communities. The forested areas are characterized by a canopy of silver maple (*Acer saccharinum*) over a lush herbaceous layer, with a sparse shrub layer.

Temperate minor river floodplains are found along large streams and small rivers in central and southern New Hampshire. These ecosystems are usually comprised of a mosaic of red maple forests, oxbows, vernal pools, and shrub thickets. Minor river floodplains generally have reduced flood intensity and duration compared to large river floodplains. In addition to red maple, sycamore and swamp white oak floodplain forests occur less commonly (Sperduto and Nichols 2004).

1.2 Justification

Riparian forests support diverse natural communities, protect and enhance water quality (they filter and sequester pollution), and control erosion and sediment (NHOSP 1989, Welsch 1991, Dahl 2000). Tockner and Stanford (2002) estimate that in Europe and North America, up to 90% of flood plains are under cultivation and are functionally extinct.

Riparian forests support a variety of wildlife resources. They provide breeding habitat for a number of bird species, including the red-shouldered hawk (*Buteo lineatus*), veery (*Catharus fuscescens*), cerulean warbler (*Dendroica cerulea*), American redstart (*Setophaga ruticilla*), warbling vireo (*Vireo gilvus*), Baltimore oriole (*Icterus galbula*), and chestnut-sided warbler (*Dendroica pensylvanica*) (Foss et al. 2000a, Hunt 2005). They also provide habitat for migratory and upland breeding birds (Foss et al. 2000b). Mammals associated with rivers and streams, particularly beaver (*Castor canadensis*), mink (*Mustela vison*), and river otter (*Lutra canadensis*), rely on riparian forests. Floodplain wetlands, such as vernal pools and oxbow marshes, are important breeding areas for a number of amphibians, including Jefferson salamander (*Ambystoma jeffersonianum*) and northern leopard frog (*Rana pipiens*). These wetlands also provide habitat for reptiles, such as wood turtle (*Glyptemys insculpta*), Blanding's turtle (*Emydoidea blandingi*), and spotted turtle (*Clemmys guttata*).

1.3 Protection and Regulatory Status

- Any laws that deal with regulation of freshwater wetlands would apply in portions of the floodplain considered jurisdictional wetlands (RSA 482-A).
- FEMA administers the National Flood Insurance Program, which works with local jurisdictions to regulate development in floodplains, with the primary purpose of minimizing future flood damage (FEMA 2005).
- The Shoreland Protection Act (NHDES, RSA 483-B) requires that farmers follow BMPs as established by the New Hampshire Department of Agriculture. Most of these BMPs pertain to the storage and/or application of fertilizers and pesticides near waterways for maintaining water quality and do not address floodplain habitats. The Shoreland Protection Act also limits the amount of tree removal and other activities within 250 ft of rivers and requires a primary structure setback of at least 50 ft.

1.4 Population and Habitat Distribution

Floodplain forests are found along rivers throughout New Hampshire. The *montane/near-boreal floodplain system* is found primarily in the White Mountains and North Country, although there are some examples in the Sebago-Ossipee region and along the Pemigewasset River south of the White Mountains. M*ajor river silver maple floodplains* are found along the main stems of large rivers, such as the Merrimack, Connecticut, Pemigewasset, and Androscoggin Rivers, and the lower stretches of major tributaries. *Temperate minor river floodplains* occur on rivers and large streams throughout central and southern New Hampshire (Sperduto 2004).

1.5 Town Distribution Map

See attached.

1.6 Habitat Map

The majority of floodplain forest element occurrences (NHNHB 2005) encompassed an elevation range of up to 21 feet up the bank away from the river. Thus, all areas within 21 feet of elevation change of a river were mapped, using the most recent state plane grid derived from the digital elevation model (Complex Systems Research Center 1999). Resulting polygons that extended into lakes, the ocean, or unreasonably far from the river were clipped to extend no more than 500m from a river, or 1000m from a river if they also were within 250m of a tributary stream. This resulted in a base floodplain layer. Areas within this floodplain layer that were dominated by forest cover (Complex Systems Research Center 2001) were selected. In addition, floodplain wetlands that were adjacent to a selected forest polygon were also selected. The resulting polygons were merged, creating the floodplain forest layer.

All polygons within 1 km of major rivers (USEPA 1998) were classed as *major river silver maple floodplain systems* (Sperduto 2004). Polygons that did not fall into this system classification, and which occurred within the 4 northern ecoregion subsections (Connecticut Lakes, Mahoosic-Rangeley, Vermont Piedmont, and White Mountains), and which overlapped coniferous or mixed forest (from the New Hampshire Landcover Assessment 2001) were classed as *montane/near-boreal floodplain systems*. *Montane/near-boreal floodplain systems* often have both a deciduous and coniferous component (Sperduto 2004), so in addition, any non-coniferous floodplain polygons within 1 km of the same river segment as the coniferous floodplain polygons were also classed as *montane/near-boreal floodplain system*. All of the floodplain polygons not falling into one of these 2 systems were assigned to the third system, the *temperate minor river floodplain*. Mapped floodplain forest polygons (see element 1.6) were grouped into complexes of polygons within 500m of each other, and attributes characterizing habitat quality and quantity were assigned using available GIS data layers.

Data limitations: Errors in the elevation data could create some error in the base floodplain layer. In most cases, this creates an over prediction of habitat rather than an under prediction. Potential inaccuracy in landcover classification would also cause some errors in the data. Because of the limitations of the modeling process, some floodplain polygons have been assigned to systems incorrectly. As a result, a single floodplain complex may contain polygons from different systems. Despite some polygons being incorrectly attributed, the predicted area of floodplain forest systems can provide an informative picture of floodplain habitat in the state.

1.7 Sources of Information

NHNHB publications, State and Federal Agency web sites, NatureServe website, textbooks, and peer-reviewed literature.

1.8 Extent and Quality of Data

See section 1.6

1.9 Distribution Research

Surveys should verify predicted floodplain forests, particularly for rare communities within the temperate minor river floodplain system, such as basswood–white ash–black maple floodplain forest (S1), swamp white oak floodplain forest (S1), and Sycamore floodplain forest (S1). Rare wildlife should be incorporated into habitat-based inventories.

Element 2: Species/Habitat Condition

2.1 Scale

Mapped floodplain forest polygons were assessed within 10 digit watershed units (HUC-10).

2.2 Relative Health of Populations

The average area of floodplain forest in a watershed was 633 ha ± 565 SD and varied from 23 to 2792 ha. The *temperate minor river floodplain* system comprised approximately half of all mapped floodplain hectares in the state. The remaining floodplain polygons were divided roughly evenly between the *major river silver maple floodplain* and the *montane/near-boreal floodplain*. This imbalance is due in part to the number of small rivers in southern New Hampshire, and in part to the amount of *major river silver maple floodplain* that has been converted to agriculture. The greatest area for the *montane/near-boreal floodplain* was in the Upper Ammonoosuc River drainage, while the Middle Androscoggin River watershed had the largest amount of *major river silver maple floodplain*. Both of these watersheds are in northern New Hampshire. The largest area of *temperate minor river floodplain* was in the Lamprey River watershed, in the seacoast region.

2.3 Population Management Status

Otter, mink, other furbearers, and waterfowl, are managed by NHFG.

2.4 Relative Quality of Habitat Patches

A number of habitat quality attributes were computed through GIS for the mapped floodplain forest polygons, but because of the number of polygons and attributes, they will not be described here. Also, a number of exemplary floodplain forest natural communities have been identified across the state. Many floodplain forests near developed areas (e.g., much of the Merrimack River floodplain) have been invaded by exotic plants (see element 3.3.3- Invasive Species) or are fragmented by roads or agriculture.

2.5 Habitat Patch Protection Status

Protected floodplain forest habitat (area, percent) was calculated for HUC 10 watersheds (n=72) using the conservation lands data layer (UNH Complex Systems, GRANIT). The mean protected floodplain forest within watersheds was 24 % ± 22 SD (0-92%). Eight watersheds had greater than 50% protection. However, these statistics can be misleading in some cases because of varying hectares of habitat within watersheds. For example, approximately 75% of the floodplain forest habitat in the Lower Pemigewasset River watershed was on protected land (in WMNF), totaling 350 ha. In comparison, only 18% of the habitat in the Lamprey River watershed was on protected land, but this totaled 496 ha. There were 7 watersheds in which none of the mapped habitat was on protected lands (e.g., Upper and Lower Millers River, Littleton Tributaries) or had relatively low amounts of habitat (185 ha, range: 34-655 ha).

There was some variation in the percentage of protected land among the 3 floodplain forest systems: 22% for *temperate minor river floodplain* habitat, 24% for *major river silver maple floodplain* and 34% for *montane/near-boreal floodplain* systems. The higher percentage of *montane/near-boreal floodplain* protected reflected its occurrences on WMNF land and the Second College Grant, owned and managed by Dartmouth College. Although the *temperate minor river floodplain* system had the lowest percentage of protected land of the 3 systems, it had the greatest area of protection.

2.6 Habitat Management Status

In New Hampshire and throughout the country, USACE is working with TNC to develop strategies for managing dams and waterways (USACE 2005). The New Hampshire chapter of TNC is currently working with USACE on management of dams and river flows in the Ashuelot River watershed and may expand this work to other managed river systems.

2.7 Sources of Information

Condition of floodplain habitats was based entirely on available GIS analyses. GIS data layers were attained from various sources (see Metadata for details).

2.8 Extent and Quality of Data

Condition of floodplain habitats was based largely on available GIS analyses (see section 1.6). A portion of predicted floodplain forests has been designated as exemplary natural communities by the NHNHB.

2.9 Condition Assessment Research:

Conduct GIS analyses to categorize quality of floodplain forest complexes (e.g., high, moderate, low). Attributes have been assigned to floodplain forest complexes but these variables need to be weighted. A subset of high quality sites should be field verified. Floodplain forest sampling should include an assessment of habitat availability for at-risk wildlife. This work can be conducted by NHFG with assistance from other wetland and wildlife experts. Ranked floodplain forest complexes should be incorporated into NHDES wetland permit review and mitigation prioritization and selection.

Element 3: Species and Habitat Threat Assessment

3.1.1 Development (Fragmentation, Habitat Loss and Conversion)

(A) Exposure Pathway
Floodplain habitats are restricted to relatively narrow bands that occur discontinuously along rivers, and are naturally fragmented by changes in topography or underlying geology along a river's course. However, fragmentation by human activities can be a serious threat to wildlife that use these floodplains. Agricultural fields, roads, and residential and commercial development all contribute to the fragmentation of floodplain forests, with agriculture having the greatest impact.

(B) Evidence
The effects of habitat fragmentation on many types of wildlife are well documented. Open upland habitats

(agricultural and old fields) present a significant barrier to amphibian dispersal (Gibbs 1998, Rothermel and Semlitsch 2002). Literature regarding the effects of fragmentation on forest birds is even more extensive (Blake and Carr 1987, Darveau et al. 1995, Hobson and Bayne 2000).

3.1.2 Altered Hydrology, Altered Natural Disturbance

(A) Exposure Pathway
Floodplain forests are periodically flooded, and this regular disturbance creates and maintains these communities (Bornette and Amoros 1996). There are over 5000 dams in New Hampshire, and a large percentage of New Hampshire's floodplain forests occur along stretches of river that have had their flow and flood regimes modified by dams.

(B) Evidence
Dams significantly alter natural flood regimes. Higher floodplain terraces that may have naturally flooded every 20-100 years may never receive flooding after a dam is built to regulate flow (Nislow and Magilligan 2000). Water storage dams often have different effects on floodplains than "run-of-river" dams that allow for normal river flow outside periods of high water. Water storage dams often permanently alter the species composition and structural diversity of downstream floodplains, whereas such effects are much less severe below run-of-river dams (Nilsson et al. 1997). On a heavily dammed river, Kingsford and Thomas (2004) found dramatic declines in all bird groups that used floodplain wetlands. Both storage dams (NHNHB 1998, NHNHB 1999, NHNHB 2000) and run-of-river dams (NHNHB 1996, NHNHB 1997) have been built in New Hampshire. The changes in vegetation resulting from these impoundments can also impact the wildlife that use these habitats.

3.1.3 Introduced Species

(A) Exposure Pathway
Invasive plant species are a serious threat to natural systems (Stein et al. 2000). Invasive alien plants threaten natural communities by out-competing native plants for light, nutrients and space, altering the physical structure of the vegetation, and altering nutrient cycles. Many native plants support host-specific invertebrates, which could be impacted by competition from invasives. Floodplain habitats are particularly vulnerable to invasive plants because the frequent disturbances from flooding give aliens opportunities to establish, and because these species tend to thrive in the nutrient rich soils characteristic of floodplains.

(B) Evidence
In New Hampshire, there are several exotic plants that are particularly problematic in floodplain habitats, including Oriental bittersweet (*Celastrus orbiculatus*), Japanese knotweed (*Polygonum cuspidatum*) and black swallow-wort (*Vincetoxicum nigrum*) (ISI 2005). Although research into specific effects of invasive plants on wildlife has been limited, at least one study has shown that Japanese knotweed can have measurable negative impacts on amphibians (Maerz and Blossey 2002).

3.2 Sources of Information

Literature reviews, state and federal agency websites, fact sheets, and reports were used to assess the exposure pathway and evidence of threats to floodplain forest systems in New Hampshire. GIS data layers were gathered from GRANIT, NHDES, USGS, and NHDOT to assess threats.

Initially, a list of threats was identified by NHFG and sent out for review. A group of wetland and wildlife experts met on 27 January 2005 to rank threats to marsh and shrub systems (participants included Kim Babbitt, Kim Tuttle, Pam Hunt, Carol Foss, Chris Martin, Laura Deming, Heather Hermann, Benjamin Nugent, and Matthew Carpenter), and at this meeting threats to floodplain habitats were ranked and further modified based on expert review and new information.

3.3 Extent and Quality of Data

Some threats to floodplain forest habitats and the associated flora and fauna are well understood (e.g., habitat destruction/fragmentation). Other threats (e.g., invasive plants, alteration of river flows) need further study.

3.4 Threat Assessment Research

- Collect vegetation data along impounded rivers to gauge effects of river flow modification.
- Collect invasive plant data to identify current threat areas and species, and target sites for invasive management, in conjunction with the efforts of the Invasive Plant Atlas of New England (IPANE) project (IPANE 2005).

Element 4: Conservation Actions

Many of the habitat protection strategies described in watershed profiles will benefit floodplain forests. These include managing river impoundments to simulate natural water flows, removing non-functioning dams, strengthening the Shoreland Protection Act (RSA 483-B), and protecting the highest quality sites.

4.1.1 Identification of potential floodplain forest restoration sites, and development of a floodplain forest restoration plan, Restoration and Management

(A) Threats
Development (Fragmentation, Habitat Loss and Conversion, Non-Point Source Pollution (Chemical Contaminants, Runoff and Sedimentation)

(B) Justification

- A successful restoration plan will identify sites that will connect patches of fragmented floodplain forest, preclude the conversion of floodplain agricultural fields to residential or commercial development, and reduce the effects of agricultural runoff by replacing agricultural fields and enhancing riparian buffers to remaining fields.
- Successful restoration will create or restore quantifiable areas of habitat and will enhance connectivity between extant habitat patches.
- Monitoring of the restoration sites will allow managers to assess successional processes at restoration sites and modify management strategies as necessary.

(C) Conservation Performance Objective

The objective of identifying floodplain forest restoration sites and developing a restoration plan is to restore floodplain forest habitat in areas currently used for agriculture. The plan will set goals for the number of restoration sites and the number of restored hectares within the first 5 years of the project. Success will be measured by determining whether these goals were met, and subsequently, by monitoring of the sites to ensure that the restoration sites are developing toward floodplain forest composition and structure, as defined by New Hampshire natural community and natural community system descriptions.

(D) Performance Monitoring

The restoration plan should select sites based upon their ability to connect existing blocks of floodplain forest habitat. Sites will also need to be in areas in which a natural flood regime still exists (i.e., the stretch of river is not influenced by impoundments). Site selection should ensure that sites are distributed among affected watersheds throughout the state.

(E) Ecological Response Objective

The desired ecological response to floodplain forest restoration is to increase and enhance New Hampshire's floodplain forest habitat. Successful habitat restoration would result in the creation of floodplain forest communities and systems as described by the NHNHB. These restored habitats would also support the range of affected wildlife species, where appropriate, as listed in the plan.

(F) Response Monitoring

Once work begins on given sites, monitoring will require annual visits to ensure that floodplain forest vegetation is developing and that invasive species are not threatening to inhibit floodplain habitat development. These monitoring visits will provide the necessary information to determine if succession is proceeding as desired, or if additional management (invasive control, further planting) is needed.

(G) Implementation

Prior to the development of the plan, maps will be created showing existing floodplain forest habitat and agricultural areas within floodplains, to enable the selection of potential restoration sites. The restoration plan, including prioritized sites, will be written in consultation with experts in riparian ecology and ecological restoration, and completed within 1 year. Once the plan is written and sites are identified, the first projects should begin within 3 years.

(H) Feasibility

A restoration project of this sort is large-scale and resource intensive and will require the participation of outside experts and organizations as well as willing landowners. Projects will have to occur on public land, or access will need to be gained on private land, either through cooperation with the landowner, landowner incentive programs, or direct acquisition. Funding for this project will probably need to be procured through federal grant programs.

4.1.2 Develop and implement invasive plant species management plan for floodplain forests, Restoration and Management

(A) Threats
Invasive plants

(B) Justification

- An invasive species management plan will identify high-quality floodplain forest habitat that is threatened by invasive plant species and will develop strategies to control them. Evaluations of habitat quality will include the presence of at-risk wildlife species.
- Controlling invasive plant species will allow for the restoration and enhancement of native vegetation, which will benefit an array of wildlife.
- Management will be targeted to specific sites, because invasive plant control can be time and labor intensive.
- Because the spread of invasive plants is a relatively slow process, management activities can extend over a period of many years.
- Monitoring sites for decreases in the abundance of invasive plants and a subsequent increase in the cover of native vegetation will allow for refinement of management techniques.

(C) Conservation Performance Objective

The objective of developing and implementing an invasive plant species management plan is to alleviate the impact of invasive plant species on floodplain forests, using standardized methods developed by other organizations (IPANE). Success will be indicated by the creation and implementation of the plan within 2 years.

(D) Performance Monitoring

In the first season, invasive species surveys should be conducted on at least 25 floodplain forest sites. Following site evaluation, an invasive species control plan will be developed for selected sites, with an associated site monitoring plan.

(E) Ecological Response Objective

The desired ecological response is a reduction in the abundance of invasive plant species in floodplain forests. Successful invasive control will be indicated by a measurable reduction in the cover of invasives, and a resultant increase in the cover of native vegetation.

(F) Response Monitoring

Management sites will be sampled for cover of invasive plant species and cover of native plant species using standard fixed vegetation plot techniques. The effects of control methods on both native and exotic species will be monitored by regular re-sampling of these fixed plots. The analysis of these plot data will provide an assessment of the efficacy of the control treatments and will direct any alterations of the management plan.

(G) Implementation

Floodplain forest sites will be selected from the habitat map for invasive sampling. Once data have been gathered at the sites, an invasive control plan will be developed in collaboration with experts in invasive species management. At the sites, fixed vegetation plots will be established to measure the effects of the control techniques. Vegetation data will be collected before and after treatment, with return visits in subsequent years to monitor the site and conduct additional control measures.

(H) Feasibility

The implementation of an invasive species control plan would be very labor intensive and would likely require help from volunteer organizations. Herbicides and mechanical devised could be very expensive. An effective control project is a long-term endeavor which will require an equivalent commitment of resources.

4.2.1 Conservation Action Research

- The development of the restoration plan will require considerable research into the best current methods in ecological restoration. The restoration projects themselves will require extensive monitoring to evaluate their success in restoring floodplain forest habitat.
- Thorough inventories of invasive species in floodplain habitats will need to be conducted prior to developing a management plan. Development of a series of permanent plots will be necessary to monitor changes following management activities.

Element 5: References

5.1 Literature

Blake, J.G., and J.R. Karr. 1987. Breeding birds of isolated woodlots: Area and habitat relationships. Ecology 68: 1724-1734.

Bornette, G., and C. Amoros. 1996. Disturbance regimes and vegetation dynamics: role of floods in riverine wetlands. Journal of Vegetation Science 7: 615-622.

Complex Systems Research Center. 2001. Digital elevation model. http://www.granit.sr.unh.edu/data/datacat/pages/dem.pdf. Accessed 22 February 2005.

Complex Systems Research Center. 2001. New Hampshire Land Cover Assessment 2001. http://www.granit.sr.unh.edu/data/datacat/pages/nhlc01.pdf Accessed 9 July 2003.

Dahl, T.E. 2000. Status and trends of wetlands in the conterminous United States 1986 to 1997 U.S. Department of the Interior, Fish and Wildlife Service, Washington, D.C. 82 pp.

Darveau, M., P. Beauchesne, L. Belanger, J. Hout, and P.LaRue. 1995. Riparian forest strips as habitat for breeding birds in the boreal forest. Journal of Wildlife Management 59: 67-78.

Federal Emergency Management Agency (FEMA). 2005. National Flood Insurance Program. Website: http://www.fema.gov/fima/nfip.shtm.

Foss, C.R., P.D. Hunt, and D.B. Wells. 2000a. New Hampshire Floodplain Forest Project: Effects of patch size on breeding bird community composition and nesting success in floodplain forest fragments in the Merrimack River watershed. Report to New Hampshire Department of Environmental Services.

Foss, C.R., P.D. Hunt, and D.B. Wells. 2000b. New Hampshire Floodplain Forest Project: Landbird use of selected floodplain forests in the Merrimack River watershed during spring migration. Report to New Hampshire Department of Environmental Services.

Gibbs, J.P. 1998. Distribution of woodland amphibians along a forest fragmentation gradient. Landscape Ecology 13:263-268.

Hobson, K.A., and E. Bayne. 2000. Effects of forest fragmentation by agriculture on avian communities in the southern boreal mixedwoods of western Canada. Wilson Bulletin 112(3):373-387.

Hunt, P. 2005. A regional perspective on New Hampshire's Birds of Conservation Priority: objectives, threats, research needs, and conservation strategies. Audubon Society of New Hampshire, Concord, New Hampshire, USA.

Invasive Plant Atlas of New England. 2005. http://invasives.eeb.uconn.edu/ipane/.

Invasive Species Initiative. 2005. http://tncweeds.ucdavis.edu/index.html.

Kingsford, R.T. and R.F. Thomas. 2004. Destruction of wetlands and waterbird populations by dams and irrigation on the Murrumbidgee River in arid Australia. Environmental Management 34(3):383-396.

Maerz, J.C. and B. Blossey. 2002. The Impact of

Japanese Knotweed Invasions on the Pre-Migratory Foraging of Green Frogs. Unpublished study. Available at: http://www.invasiveplants.net/japim.htm.

New Hampshire Department of Environmental Services. 2004. Dam removal and river restoration program. Website: http://www.des.state.nh.us/Dam/DamRemoval/.

NH Natural Heritage Bureau. 2005. Database of rare species and exemplary natural community occurrences in New Hampshire. Department of Resources and Economic Development, Division of Forests and Lands. Concord, New Hampshire, USA.

New Hampshire Natural Heritage Inventory. 1998. A natural features survey of the Surry Mountain Lake Project. Department of Resources and Economic Development. Concord, New Hampshire, USA.

New Hampshire Natural Heritage Inventory. 1999. A natural features survey of the Hopkinton-Everett Lakes Project. Department of Resources and Economic Development. Concord, NH.

New Hampshire Natural Heritage Inventory. 2000. A natural features survey of the Edward MacDowell Lake Project. Department of Resources and Economic Development. Concord, NH.

New Hampshire Natural Heritage Program. 1996. A natural features survey of the Franklin Falls Dam property. Department of Resources and Economic Development. Concord, New Hampshire, USA.

New Hampshire Natural Heritage Program. 1997. A natural features survey of the Blackwater Dam property. Department of Resources and Economic Development. Concord, New Hampshire, USA.

Nilsson, C., R. Jamsson, U. Zinko. 1997. Long-term responses of river-margin vegetation to water-level regulation. Science 276:798-800.

Nislow, K.H., and F.J. Magilligan. 2000. Hydrologic alteration in a changing landscape: effects of impoundment in the upper Connecticut River basin, USA.

Poff, N.L., J.D. Allan, M.B. Bain, J.R. Karr, K.L. Prestegaard, B.D. Richter, R.E. Sparks, and J.C. Stromberg. 1997. The Natural Flow Regime: A paradigm for river conservation and restoration. BioScience 47(11):769-784.

Rothermel, B.B., and R.D. Semlitsch. 2002. An experimental investigation of landscape resistance of forest versus old-field habitats to emigrating juvenile amphibians. Conservation Biology 16(5): 1324-1332.

Sperduto, D.D. 2004. Wetland Ecological Systems of New Hampshire. NH Natural Heritage Bureau, Concord, New Hampshire, USA.

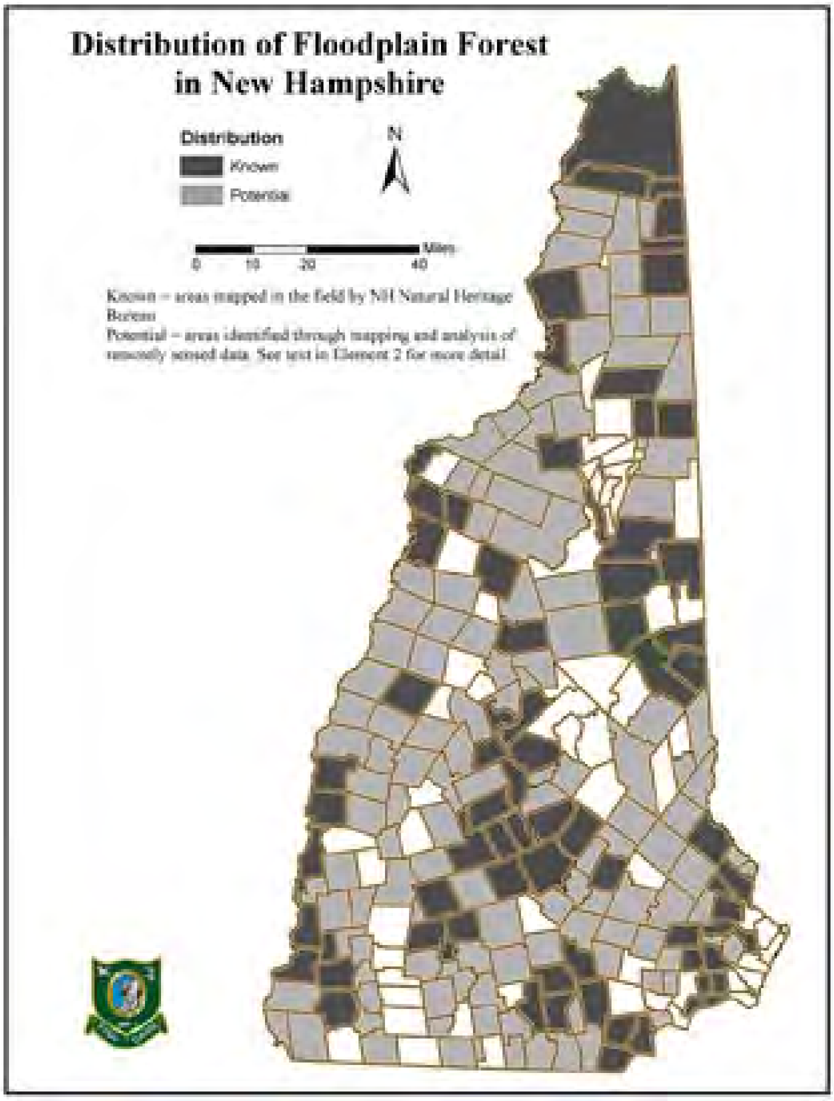
Sperduto, D.D., and W.F. Nichols. 2004. Natural Communities of New Hampshire. NH Natural Heritage Bureau, Concord, NH. Pub. UNH Cooperative Extension, Durham, New Hampshire, USA.

Stein, B.A., L.S. Kutner and J.S. Adams, eds. 2000. Precious Heritage: The status of biodiversity in the United States. Oxford University Press. New York, NY.

United States Army Corps of Engineers. 2005. River project brings together Corps, The Nature Conservancy.

Available at: http://hq.environmental.usace.army.mil/Corps_Environment/story10.htm.

United States Environmental Protection Agency. 1998. US EPA Reach File 3. http://www.fgdl.org/metadata/fgdc_html/eparr3.fgdc.htm Accessed 2000.


Distribution of Floodplain Forest
in New Hampshire
Distribution
Known
Potential
N
Miles
0
10
20
40
Known = areas mapped in the field by NH Natural Heritage Bureau
Potential = areas identified through mapping and analysis of remotely sensed data. See text in Element 2 for more detail

SPECIES PROFILE

Least Bittern

Ixobrychus exilis

Federal Listing: Not listed
State Listing: Species of Special Concern
Global Rank: G5
State Rank: S1
Author: Kim A. Tuttle, New Hampshire Fish and Game

Element 1: Distribution and Habitat

1.1 Habitat Description

The least bittern is the smallest member of the heron family. Its laterally compressed body, long toes, and curved claws are well suited to sliding through and grasping the stems of the tall, emergent vegetation where it often clings in order to fish over deep, open water (Gibbs et al. 1992). Least bitterns are associated with cattail (*Typha* spp.) marshes in northern regions, including managed impoundments, lake coves with stable water regimes, and occasionally sedgy bogs (Gibbs et al. 1992). It prefers freshwater or brackish marshes with scattered woody vegetation.

Least bitterns may build small foraging platforms at the best feeding sites, enabling them to hunt over water 25-60 cm deep, as deep as is used by the largest herons (Gibbs et al. 1992). Small fish are the primary prey, though snakes, frogs, tadpoles, crayfish, insects (primarily *Odonata* and *Orthoptera)*, small mammals (shrews and mice), and vegetation may be eaten (Gibbs et al. 1992). Least bitterns nest in dense stands of emergent vegetation near or over open water (DeGraaf and Yamasaki 2001).

1.2 Justification

The least bittern is thought to have declined in many areas of the eastern United States and adjacent Canada (Gibbs et al. 1992). Palustrine freshwater and brackish emergent wetlands, where least bitterns make their homes, are among the most threatened habitats in the country (Gibbs et al. 1992). The least bittern is listed as endangered in Massachusetts (Massachusetts Natural Heritage Program 2003), threatened in Connecticut (Connecticut Department of Environmental Protection 2004) and is a species of special concern in Vermont and New Hampshire. Pollution, sedimentation and invasion by purple loosestrife (*Lythrum salicaria)* and phragmites (*Phragmites australis)* degrade cattail-dominated wetlands (Gibbs et al. 1992), especially in southern New Hampshire, where development pressures are highest. Although least bitterns seem tolerant of human presence and may persist in highly urbanized areas if wetlands remain relatively undisturbed, they may be subject to increased predation by generalist predators such as snapping turtle (*Chelydra serpentina)*, crow (*Corvus brachyrhynchos*), and raccoon (*Procyon lotor)* that are also tolerant of human activity (Gibbs et al. 1992).

1.3 Protection and Regulatory Status

Protection under the Federal Migratory Bird Treaty Act of 1918.

1.4 Population and Habitat Distribution

The least bittern is a rare and local breeder in New England. It is found primarily in eastern Massachusetts and Rhode Island, as well as Connecticut, Vermont and coastal Maine (DeGraaf and Yamasaki 2001). It has apparently always been rare in New Hampshire, where historical sightings were few and were concentrated in the southern part of the state. There are historical records from Concord, Hampton, Seabrook and the Connecticut River valley, of which some may have been migrants (Vernon 1994). There were no breeding records at the time of the compilation of the *Atlas of Breeding Birds in New Hampshire,* although it was thought that the species had likely nested here (Vernon 1994). Multiple individuals seen during the mid to late 1980s at Eel Pond in Rye and recently at Stubbs Pond in Newington (2002), and a lone juvenile observed at the Exeter sewage lagoons in early September 1994, suggest possible breeding at these locations.

Similarly, single occurrences of least bittern over several years during the mid 1980s at Cascade Marsh in Sutton indicate potential breeding habitat for the species. Towns with single records are Durham, Derry, Candia, and Newmarket. A 1997 least bittern record in a cattail wetland at Pondicherry Wildlife Refuge in Jefferson, Coos County, is the northernmost record in New Hampshire.

1.5 Town Distribution Map

Not completed for this species.

1.6 Habitat Map

See Habitat Map for Marsh and Shrub Wetlands.

1.7 Sources of Information

NatureServe (2005) was used for status and ranking information. New Hampshire Wildlife Sightings (2005) and NHNHB databases (2005) and Vernon (1994) were the primary sources of locality records. Habitat and life history information was taken from published literature, including the *Atlas of Breeding Birds in New Hampshire* (Foss 1994).

1.8 Extent and Quality of Data

In New Hampshire, the least bittern appears to be limited to a few suitable cattail marshes, mainly in the southern part of the state. Because its secretive nature makes it unlikely to be detected even in the most suitable habitat, the lack of sightings does not imply the absence of the least bittern (P. Hunt, NHA, personal communication). Among the few least bittern records, recent distribution data are largely the result of records submitted to the New Hampshire Wildlife Sightings web page from NHBR.

1.9 Distribution Research

Experienced birders should identify and report least bittern locations. Standardized census techniques, including the use of tape-recorded vocalizations to elicit responses from breeding birds, are needed to provide more information regarding distribution. The least bittern, American bittern, Virginia rail, sora, and other elusive wetland birds should be incorporated into comprehensive wetland bird monitoring efforts.

Element 3: Species Threat Assessment

The loss of wetlands likely poses the most significant threat to least bittern in the northeastern United States (Gibbs et al. 1992). See Threats in Marsh and Shrub Wetlands profile.

Element 4: Conservation Actions

See Marsh and Shrub Wetlands habitat profile for relevant conservation strategies. Tall grass-like emergent vegetation, especially cattail, should be maintained at the borders of ponds and wetlands. Management of federal and state impoundments to encourage dense, emergent vegetation, especially cattails, will create potential breeding habitat (Gibbs et al. 1992).

Element 5: References

5.1 Literature

Connecticut Department of Environmental Protection Natural Diversity Database webpage 2004. Connecticut Department of Environmental Protection. Hartford, Connecticut. Available http://dep.state.ct.us/burnatr/wildlife/factshts/cmoorhen.htm. Accessed 18 February 2005.

DeGraaf, R. M., and M. Yamasaki. 2001. New England wildlife: habitat, natural history, and distribution. University Press of New England, Hanover, New Hampshire, USA.

Gibbs, J.P., F.A. Reid and S.M. Melvin. 1992. Least Bittern. *In* The birds of North America, No. 17, A. Poole, P. Stettenheim, and F. Gill, editors. The Birds of North America, Inc., Philadelphia, Pennsylvania, USA.

Massachusetts Natural Heritage Program webpage 2005. Massachusetts Rare and Endangered Wildlife. Division of Fisheries and Wildlife. Westborough, Massachusetts. Available http://www.mass.gov/dfwele/dfw/nhesp/nhfacts/galchl.pdf. Accessed 18 February 2005.

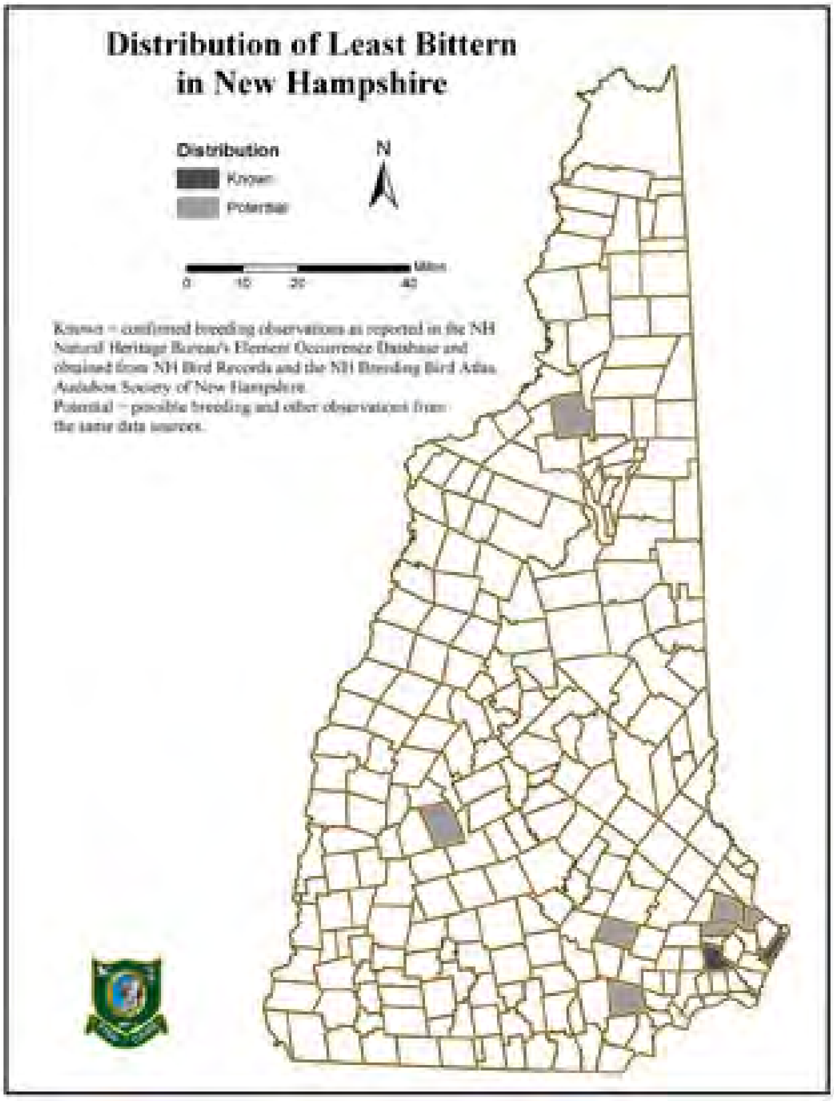
NatureServe. 2005. NatureServe Explorer: An online encyclopedia of life [web application]. Version 4.2. NatureServe, Arlington, Virginia. http://www.natureserve.org/explorer. Accessed 2005 March 3.

Vernon, R.C. 1994. Accounts of historically or potentially breeding species, least bittern. Pages 370-371 *in* Atlas of breeding birds in New Hampshire, C.S. Foss, editor. Arcadia, Dover, New Hampshire, USA.

5.2 Data Sources

New Hampshire Natural Heritage Bureau. 2005. Database of Rare Species and Exemplary Natural Community Occurrences in New Hampshire. Department of Resources and Economic Development, Division of Forests and Lands. Concord, New Hampshire, USA.

Wildlife Sightings database. Maintained by the University of New Hampshire Complex Systems, Durham, New Hampshire, USA. Accessed 15 February 2005.


Distribution of Least Bittern in New Hampshire
Distribution
Known
Potential
N
Miles
0
10
20
40
Known = confirmed breeding observations as reported in the NH Natural Heritage Bureau's Element Occurrence Database and obtained from NH Bird Records and the NH Breeding Bird Atlas, Audubon Society of New Hampshire.
Potential = possible breeding and other observations from the same data sources.

SPECIES PROFILE

Osprey

Pandion haliaetus

Federal Listing: Not listed
State Listing: Threatened
Global Rank: G5
State Rank: S2B
Author: Christian Martin, New Hampshire Audubon

Element 1: Distribution and Habitat

1.1 Habitat Description

The osprey has a cosmopolitan distribution, occurring nearly everywhere in the world except Polar Regions during various portions of their annual cycle (Poole et al. 2002). Most ospreys in North America are long-distance migrants, traveling up to 5,000 mi (8,000 km) to and from their wintering areas in the Caribbean, Central America, and South America (Henny and Van Velzen 1972, Environment Canada 2001). Satellite tracking studies (Martell et al. 2001) show that ospreys that breed on the east coast of the United States winter primarily in northern South America and sometimes in Cuba and in Florida. Ospreys breeding in Florida, California, and other southern U. S. locations are essentially non-migratory (Poole et al. 2002). Female ospreys from most North American breeding populations usually winter farther south than do their male counterparts, and individuals of both sexes display strong fidelity to wintering and breeding sites.

Osprey do not make their first northward spring migrations from the tropics until they are nearly 2 years old, and generally do not establish breeding territories until they are at least 3 years old (Poole et al. 2002). When attempting to establish a breeding territory, young ospreys often settle within 32 mi (50 km) of natal areas, which contributes to the species' slow rate of colonizing vacant territory.

When ospreys return to New Hampshire from the tropics, they usually arrive in coastal areas first. Dispersal inland often involves travel upstream on the Connecticut, Merrimack, Piscataqua, Saco, and Androscoggin rivers. Local breeding territories are reoccupied beginning in late March and early April; early arrival dates reported for New Hampshire nest sites include March 24 at Great Bay, March 26 in the lower Merrimack River valley, March 29 in the Lakes Region, and April 6 in Pittsburg (Evans 1994, Martin et al. 2004). From April to mid-May, many individuals pass through the state en route to breeding areas far north of the state's border with Canada. During this spring migratory interval, ospreys are seen on all of the state's major rivers and lakes, as well as on many smaller streams and minor ponds, where they are able to obtain prey to fuel their migration.

Ospreys breed from Newfoundland across to Alaska up to and even beyond the tree limit, and they occur in every province in Canada and across the entire U. S. In northern New England and the Canadian Maritimes, ospreys typically establish breeding territories near large lakes, major rivers, and coastal estuaries. For example, a habitat model developed for the Gulf of Maine watershed (USFWS 2000) found that 90% of 200 osprey nests examined in Maine were located within 0.6 miles of major rivers or lakes of greater than 100 acres in size. Another key breeding habitat is wetland ponds, where flooding by beavers produces dead snags for nesting and shallow waters for fishing. Shallow water is preferred because it offers better access to aquatic prey. Suitable breeding habitat (Poole et al. 2002) included the following:

- Areas with dependable fishing sources located within 2 to 3 miles (Poole 1989), but occasionally as far as 8 miles (Prevost 1979, Hagan and Walters 1990) from potential nesting sites,
- Standing trees or other structures located in wetlands,

- An ice-free period of no less than 20 weeks, long enough to permit egg-laying (3 weeks), incubation (5 weeks), raising young (8 weeks), and post-fledging foraging skill development (4 weeks).

Breeding ospreys generally defend their nest site only (typically a perimeter of 50 to 100 m), rather than a much larger feeding territory. Spacing between adjacent nesting pairs is highly variable and is dependant upon regional prey abundance and distribution and upon availability and type of nest substrate (Poole et al. 2002). For example, mean distance reported between neighboring nests for a tree-nesting population in New York State averaged 410 m, whereas a platform-nesting population in salt marshes in southeastern Massachusetts nests averaged only 140 m apart. A boreal forest population in New Brunswick averaged a much more diffuse one pair per 51 ha (Stocek and Pearce 1983).

1.2 Justification

Ospreys have been closely monitored in the United States ever since severe population declines were first documented both in North America and elsewhere between the 1950s and the 1970s (Henny and Ogden 1970, Poole et al. 2002). The number of pairs nesting in coastal areas of southern New England declined about 90% during this period, Chesapeake Bay area pairs declined by about 50%, and populations in the Great Lakes region also dropped significantly. Research demonstrated that population losses during that period resulted primarily from presence of high levels of DDT and other persistent organochlorine pesticides in the aquatic food web, which caused severe eggshell thinning and extremely poor hatching success (Spitzer et al. 1978, Wiemeyer et al. 1988).

Ospreys can serve as valuable bio-indicators of general environmental quality in aquatic systems because they rapidly accumulate chemical contaminants, such as the organochlorine pesticide DDT and its metabolite DDE, contained in fish. A dramatic osprey population decline, caused by DDT contamination, occurred across much of North America beginning in the 1940s and continued until 1970 (Ogden 1977). Osprey populations have rebounded strongly since the banning of the use of DDT, with the most dramatic increases occurring in traditional or historical nesting areas rather than in newly colonized areas (Houghton and Rymon 1997).

1.3 Protection and Regulatory Status

Ospreys are protected in the United States under the Migratory Bird Treaty Act of 1918, which prohibits the possession or killing of most non-game birds and the collection of their eggs or nests. The species was first listed as threatened by the State of New Hampshire in 1979 (R.S.A. 212-A: 1 et seq.), and is still so classified. Other federal measures that indirectly provide protection include the Federal Insecticide, Fungicide, and Rodenticide Act (7 U.S.C. 136) for new and existing pesticide registration and use, the National Forest Management Act (16 U.S.C. 1600), and the Federal Land Management and Policy Act (43 U.S.C. 1701). Ospreys are also protected from unregulated international trade by an agreement of the 1975 Convention on International Trade in Endangered Species of Wild Flora and Fauna.

1.4 Population and Habitat Distribution

Osprey populations across much of North America have rebounded strongly since the banning of the use of DDT. Estimates in the mid-1980s indicated that North America then supported about 18,000 to 20,000 pairs of breeding ospreys (about 57 to 84% of the world population) and that about two thirds of those bred in Canada and Alaska (Poole 1989). Recent population estimates suggest that about one third of the world's breeding ospreys nest in Canada (Environment Canada 2001). There were an estimated 8,000 breeding pairs in the contiguous U. S. in 1981, but 14,200 pairs in 1994 (Houghton and Rymon 1997), an estimate that increased further to 16,000 to 19,000 pairs by 2001 (Poole et al. 2002). Annual population growth rates ranging from 6 to 15% have generally been reported across North America over the past 30 years (Ewins 1997). Specifically, average annual rates of population increase in northern Michigan, Wisconsin, southern Ontario, and upper New York State have been 7%, 8%, 10-15%, and 10%, respectively (Environment Canada 2001).

A summary of the recent population status of breeding ospreys in states adjacent to New Hampshire is summarized in Table 1. In New Hampshire, ospreys have been reported as migrants for more than a century, though they were historically documented as common summer residents only in the Umbagog Lake area (Maynard 1871, Brewster 1925).

Aerial surveys of Coos County, New Hampshire, conducted by the USFWS in 1970 and 1971, located a total of 7 and 12 osprey nests, respectively, and the Umbagog area breeding population was believed to number only 3 or 4 pairs by 1977 (Smith 1979). There are relatively few historical references about ospreys breeding in other parts of the state (see Allen 1902, Dearborn 1898, Scott 1921), and there are no comprehensive estimates of statewide historical distribution or population size prior to fieldwork initiated by the New Hampshire Audubon (NHA) and New Hampshire Fish and Game (NHFG) beginning in 1980 (Smith and Ricardi 1983). Since 1980, these two organizations have partnered to conduct extensive annual field monitoring of the state's breeding osprey population (Martin et al. 2004).

Surprisingly, there is only one historical reference to nesting ospreys in New Hampshire's Great Bay area (Scott 1921). Early population declines in New Hampshire may have resulted in part from removal, by loggers, of large pines for nest sites, especially those located on river and lake shorelines and in wetlands. Logging-related population declines have been documented elsewhere in North America (Ewins 1997).

New Hampshire classified the osprey as state threatened in 1980 and soon began to conduct field monitoring and management of the breeding population. During the 1980s, nest sites were limited almost completely to the Androscoggin River watershed. The first nesting in New Hampshire's coastal watershed was documented near Great Bay in 1989, followed by first nesting in the Connecticut River watershed in 1993, and in the Merrimack River watershed in 1996. New Hampshire osprey productivity for the 25-year period from 1980 to 2004 is shown in Table 2. Known available, active, and successful osprey nests in New Hampshire from 1980 to 2002 are shown in figure 2. Osprey fledglings produced at successful nests in New Hampshire from 1980 to 2002 are shown in figure 3.

1.5 Distribution Map

1.6 Habitat Map

Several habitats were mapped that are relevant to ospreys, including marsh and shrub wetlands and known great-blue heron rookeries. This information, along with new and available (e.g., rivers, lakes) data, will be used to map potential osprey habitat.

1.7 Sources of Information

General natural history information and some sources of original research discussed in this document were obtained primarily from The Birds of North America, No. 683: Osprey (Poole et al. 2002). Unless otherwise noted, New Hampshire specific data have been acquired by field monitoring and management activities conducted by NHA from 1980 to 2004 under several cooperative and/or contractual agreements and grants received from NHFG, Public Service Company of New Hampshire, and other funding sources (Martin et al. 2004).

1.8 Extent and Quality of Data

Since 1980, the osprey has been one of the most intensively monitored and managed species in New Hampshire. Breeding site and productivity data are derived from field monitoring conducted for 25 years by NHA staff and trained volunteer observers who use standardized monitoring techniques (Martin et al. 2004).

1.9 Distribution Research

The future distribution and abundance of ospreys in New Hampshire should be monitored by spring breeding surveys of recently active and potential breeding sites. Active breeding territories should be checked annually to determine nest occupancy status and reproductive outcome, and surveys of potential breeding territories should be conducted on a rotating basis, with annual survey intensity determined by available funding and human resources. For example, sites could be checked on a biennial or triennial rotating basis, covering 50% or 33% of potential sites annually.

Element 2: Species/Habitat Condition

2.1 Scale

New Hampshire's 5 major watersheds (Androscoggin, Coastal, Connecticut, Merrimack, and Saco watersheds) will be considered as separate conservation planning units because there are significant differences between watersheds in the physical characteristics, human land use patterns, population distribution, and nest sites utilized by ospreys (see figure 1).

2.2 Relative Health of Populations

2.1.1 Androscoggin River watershed
The Androscoggin River watershed is one of the most pristine and undeveloped major drainages in the state. Umbagog Lake at the Androscoggin's headwaters was the only part of the state that maintained breeding pairs of osprey through the region-wide period of decline in the 1950s through 1970s. The Umbagog Lake population may have been the source for the recolonization of much of the Androscoggin River watershed during early stages of population recovery in the 1980s and early 1990s. Presently, osprey pairs are clustered around two major water bodies, Umbagog Lake and Pontook Reservoir.

During the 2004 breeding season, the Androscoggin River watershed had the highest number of active nests of any major watershed; 14 young fledged from 12 active nests. The 14 young fledged represent 26% of the statewide number of young produced in 2004. Recently, there has been a shift in the distribution of the breeding population, with fewer pairs breeding near Umbagog Lake and more pairs breeding near Pontook Reservoir. The reasons for this shift are unclear, but may be influenced by changing availability of nest trees, forage base, interactions with aerial predators such as bald eagles, or other factors.

The population in this area should remain stable or continue to expand as long as nest tree availability remains high and the forage base remains in good condition. This area is characterized by spruce and fir forests and has high aquatic productivity. Many of the streams and lakes have good fish producing characteristics, such as high oxygen content and suitable substrate. Most of the lakes and streams are stocked annually and there are a high percentage of water bodies that contain warm water species. Land conservation initiatives, such as the establishment and expansion of the Lake Umbagog National Wildlife Refuge, and protection of shoreline by the State of New Hampshire, should protect foraging and nesting habitat in the long-term.

2.2.2 Coastal Watershed

The Coastal watershed in southeastern New Hampshire includes Great Bay and its tributary rivers and streams. Also included within this watershed are extensive coastal salt marshes along the state's immediate coastline and many isolated beaver ponds and wetlands in the headwaters of many of the river drainages mentioned above.

This area has been highly productive for ospreys since breeding pairs began to recolonize the area in 1989. Since the 2000 breeding season, more than 90% of all active nests located in this watershed have been successful. During the 2004 breeding season, this watershed had the highest number of successful nests of any major watershed; 14 young fledged from 9 active nests, 8 of which were successful. The 14 young fledged represent 26% of the statewide total number of young produced in 2004. Ospreys show an affinity for nests within great blue heron rookeries in this watershed. Nesting platforms erected in the coastal watershed have also been successful.

There is high potential for further breeding population expansion in the Coastal watershed due to the numerous lakes and ponds, an abundance of heron rookeries, and a focused effort to install additional platforms and replica nests. Currently there are 4 unoccupied platforms and 1 unoccupied replica nest in the coastal watershed.

2.2.3 Connecticut River Watershed

The Connecticut River watershed extends from the northernmost tip of New Hampshire to the state's southern border with Massachusetts. The Connecticut River flows through several ecoregions and includes several diverse habitats. Northern New Hampshire, characterized by soft and hardwood forests, has a long history of industrial ownership and uses. Agricultural uses are common within the drainage, especially in northern and central sections.

The osprey population in the Connecticut River watershed is in the early stages of recovery. During the 2004 nesting season, 8 young fledged from 5 active nests. The 8 young fledged represent 15% of the statewide total number of young produced in 2004. No active nesting attempts have been documented in the southern two thirds of this watershed, though there are 6 unoccupied platforms available along the southern two thirds of the Connecticut River in New Hampshire.

Foraging areas are plentiful in the northern Connecticut River watershed. The area is a popular destination for fishermen, and NHFG heavily stocks local water bodies with trout. The area also has a high number of low-lying shallow ponds oxbows and streams ideal for osprey hunting. The Connecticut River watershed contains some of the more rural areas left in New Hampshire. Recently, industrial landowners have sold large parcels of land in the northern region, including lands comprising the headwaters of the Connecticut River. As a result, a large portion of the watershed will be conservation land. Incentives are also being provided to farm owners throughout the watershed in an attempt to conserve some of New Hampshire's open field habitats and farms.

Nest site availability is potentially a limiting factor for osprey population expansion in the Connecticut River watershed. In northern areas, supercanopy pines are uncommon due in part to historical logging practices and due to elevation and predominating soil characteristics. The practice of retaining snags during timber harvests is a relatively new management consideration; snag retention became common only within the past 20 years. Therefore, the lack of larger diameter snags in the Pittsburg area may be a result of harvesting that occurred prior to their identification as desired wildlife retention species. Furthermore, soils in the northern extent of the state are not especially suited for white pine production, and spruce and fir characterize much of this area. Agricultural areas found within the northern, central, and southern sections of the Connecticut Watershed contain very few large diameter trees and are managed as fields.

2.2.4 Merrimack River Watershed

The Merrimack River watershed, including the Lakes Region, the upper Merrimack valley, and the lower Merrimack valley, drains an extensive portion of central and southern New Hampshire. Starting at Franconia Notch, the drainage continues south to the Massachusetts border. Water bodies within this area range from deep, cold lakes and ponds to shallow marshes. The Merrimack River is large, includes many oxbow ponds, and provides a substantial amount of potential osprey foraging and nesting habitat.

During the 2004 breeding season, this watershed had the highest number of young fledged; 17 young fledged from 8 active nests. The 17 young fledged represent 32% of the statewide total number of young produced in 2004. A majority of these active nests was located within heron rookeries, which are commonly found in beaver ponds throughout the watershed. There is high potential for ospreys to establish new nesting sites in heron rookeries scattered throughout the watershed, especially within the Lakes Region.

2.2.5 Saco River Watershed

The Saco River watershed located in the east-central portion of New Hampshire is mountainous. Water bodies within this area are typically clear, cold, and deep. Each of these characteristics is less than ideal foraging habitat for ospreys. Warmer, shallow water bodies tend to produce more foraging opportunities for ospreys. However, the sandy soils of the region are also characterized by an abundance of white pine, which are preferred by osprey as nesting trees. Through the 2004 breeding season, there were no known osprey nests located within this watershed.

The Saco River watershed has an abundant growth of supercanopy pine, yet the lack of white pine snags may be a limiting factor. Shallow water bodies and areas historically selected by great blue herons may offer potential osprey nest areas. Deep, oligotrophic lakes in the watershed have limited productivity due to the high abundance of granite and sand and, as a result, these water bodies are deficient in the correct characteristics to produce preferred forage species such as perch and pickerel.

2.3 Population Management Status

Management strategies for ospreys in New Hampshire fall into 3 categories:

1) Locate territorial pairs

From 1980 to 2004, NHA staff biologists solicited and evaluated public reports of ospreys in areas of potential breeding habitat and followed up with field surveys by staff or trained volunteer observers to identify occupied territories. The number of occupied nest sites has risen from 6 in 1980 to a recent high of 44 in 2003, and from presence in only 1 major watershed in 1988 to 4 of the state's 5 major watersheds by

1996 (Martin et al. 2004).

2) Monitor and manage nesting attempts
Nesting attempts have been monitored by trained volunteers observers and NHA staff biologists from 1980 to 2004, resulting in the documentation of 472 active nesting attempts, 296 successful nesting attempts, 613 young fledged (1.30 young/nesting attempt), and 176 nest failures (37% failure rate). The NHA staff installed sheet metal predator guards around the bases of nest trees to deter tree-climbing mammalian nest predators.

3) Augment natural nest sites by installing nesting platforms and replica nests
The NHA and NHFG began installing nest structures in 1977 around Umbagog Lake, but such activity did not begin in earnest until 1994 in the coastal watershed, when cooperation with Public Service Company of New Hampshire began. The primary objectives were to hasten colonization by ospreys of unoccupied areas of the state and to provide additional nesting opportunities for new osprey pairs within already occupied areas. As of the end of 2004, there were a total of 28 human-built structures (22 platforms and 6 replica nests) in place in New Hampshire for ospreys.

4) Public outreach and education
Information on the goals and status of osprey conservation efforts in New Hampshire has been disseminated in a variety of ways and has involved many different audiences. Extensive efforts have been made to educate the public on accurate identification and reporting of osprey. Articles and media news releases on the state's osprey recovery efforts and opportunities for direct public volunteer involvement appear annually in newspapers, on radio, and in newsletters of various natural resource agencies and conservation groups. The NHA staff offers public lectures and conduct volunteer training sessions annually to effective public participation in osprey conservation. Outreach to landowners, developers, and recreationists concerning osprey habitat needs are ongoing and essential.

2.4 Relative Quality of Habitat Patches

Currently occupied breeding habitat appears to provide the key ecological attributes required to support a healthy, expanding breeding population. Ospreys are generalist feeders that catch fish that linger near the water's surface (Poole et al 2002). The state's lakes and ponds, reservoirs, and rivers are well stocked and will likely provide foraging resources to support additional breeding pairs over the coming decade. The state's beaver and great blue heron population are at healthy levels; thus, the future development of new nest site habitat appears secure. Suitable nesting substrate does not appear to be a limiting factor, except perhaps in the Connecticut Lakes area where there are very few supercanopy pines available. The greatest ongoing habitat quality concerns include the following:

- Additional shoreline development near wetlands and on rivers and lakes, especially in the Merrimack River and the Coastal watersheds
- Increasing use of motorized watercraft and growing popularity of kayaks and canoes, especially in the Androscoggin River watershed
- Additional wetland losses, especially in the Merrimack River and the Coastal watersheds

2.5 Habitat Patch Protection Status

Of the 73 known osprey nests and human-built nest sites in 2004, 33 (45%) were located on public lands (16 federal, 12 state, 5 county or municipal government) and 40 (55%) were located on private land. Conservation easements or other formal conservation measures applied to 40 (55%) of the state's nest sites.

2.6 Habitat Management Status

Nest sites on public land are generally managed to promote productive breeding attempts, but few actual zone closures are in effect. Nest sites on private land are subject to landowner decisions, but outreach and education with landowners have usually resulted in land use practices that benefit osprey nesting success. No formal management agreements are currently in effect in the state.

2.7 Sources of Information

Information on the state's breeding osprey population is derived directly from summary reports and field data on monitoring and management activities conducted by ANSH from 1980 to 2004 under annual contracts and grants received from the NHFG, from Public Service Company of New Hampshire and other funding sources (Martin et al. 2004).

2.8 Extent and Quality of Data

Because ospreys have been state-listed as threatened since the late 1970s, few New Hampshire wildlife species have a more complete data set on occurrence, productivity, and nest site condition. Annual summaries of this information are on file at NHA.

2.9 Condition Assessment Research

Long-term baseline monitoring of breeding ospreys in New Hampshire remains an important task in order to detect future threats to a stable or growing population in the state. Formal adoption of the existing draft recovery plan, including specific targets for delisting, should be a priority. Additional research to determine contaminant loads present in New Hampshire osprey chicks should be encouraged and facilitated by NHFG in order to determine the potential impact on statewide productivity and population recovery.

Element 3: Species and Habitat Threat Assessment

3.1.1 Mercury and Non-point Source Pollution

(A) Exposure Pathway
There are many types of anthropogenic pollutants whose toxic residues are known to biomagnify, particularly in aquatic systems, as they reach species that occupy higher trophic levels, such as ospreys. While only infrequently resulting in direct mortality, these pollutants have a range of more common sub-lethal effects, especially in long-lived predators such as ospreys that accumulate toxins over a long period. These various neurotoxins produce reproductive, behavioral, neurological, and physiological changes that can result in reduced vigor and breeding success (Wiemeyer et al. 1988, Steidl et al. 1991, Evers 2005).

Ospreys continue to be exposed to toxic contaminants through the fish they eat. Although industrial discharge to surface waters has been significantly curtailed, toxic chemicals are transported long distances by air currents, and these chemicals enter aquatic systems via atmospheric deposition. Although the use of PCBs and dioxins has received much attention in North America, mercury has become an increasing problem in aquatic systems. One recent study conducted in Ontario and New Jersey found that mercury levels did not reach a level associated with toxic effects (Hughes et al. 1997), though another determined that high levels of mercury are present in adult and nestling ospreys in northern Quebec (Desgranges et al. 1998). Additionally, new pesticides continue to be developed that may have undetermined impacts on osprey and other wildlife.

(B) Evidence
Mercury levels are high and pervasive in northeastern North America in aquatic food webs (Hughes et al. 1997, Desgranges et al. 1998, Evers 2005). Brominated fire retardants, commonly known as PBDEs, are similar in chemical structure to PCBs, and are used in a wide range of synthetic household and consumer products. PBDEs have recently been shown to be accumulating in wildlife populations worldwide, including in raptors (Sharp and Lunder 2004). PCBs and many other organic compounds are also commonly detected in ospreys (Wiemeyer et al. 1998).

3.1.2 Recreation (Lead shot and sinkers)

(A) Exposure Pathway:
In a manner similar to what has been well documented in bald eagles, ospreys may be subject to lead poisoning by consuming lead sinkers associated within living or dead fish that they consume. This could potentially be an important source of anthropogenic morbidity and mortality. Continued use of lead fishing tackle (in violation of state laws) could threaten ospreys in certain areas.

(B) Evidence:
Lead poisoning of bald eagles has been documented in at least 34 states (Buehler 2000). Similar exposure in ospreys is far less well documented, however ospreys utilize a similar prey base of living and dead fish, and therefore would be expected to experience similar exposure. One difference is that ospreys are likely not exposed to lead shot because they do not typically feed on non-piscivorous prey and carrion (Poole et al. 2002).

3.1.3 Recreation (Boats and Jet Skis)

(A) Exposure Pathway
Recreational boating can modify osprey foraging patterns by reducing use of perching and foraging areas, potentially altering food delivery and productivity.

(B) Evidence
Motorized boat traffic on New Hampshire water bodies is increasing, as are the size of vessels and their top speed. Improved access to public waters has the potential to further increase the number of boats on the water. The growing popularity of small personal watercraft (motorized jet skis as well as self-propelled canoes and kayaks) has the added effect of bringing increased human traffic volume into the shallow coves and other areas where ospreys feed, perch, and rest.

3.1.4 Development (Shoreline Development)

(A) Exposure Pathway
Shoreline development and increased recreational on water bodies may disturb nesting adults and reduce availability of perching and feeding sites. Development can limit the future expansion of a recovering population and act to reduce future carrying capacity. New Hampshire is among the fastest growing states in the northeastern U.S. Shoreline real estate development contributes to secondary problems such as increased pollution and water-based recreation, which also have the potential to negatively impact ospreys.

(B) Evidence
Some osprey pairs have been documented to acclimate to frequent human activity at nesting sites, especially where the presence of human activity precedes nest establishment (Ewins 1996, Poole et al. 2002). However, many New Hampshire pairs do not appear to exhibited this high degree of tolerance. Shoreline development affects perching and foraging by ospreys, with possible direct and indirect effects on reproductive success. In Ontario, shoreline development has been suggested as a leading source of reduction in nest site availability (Ewins 1997).

3.1.5 Energy and Communication Infrastructure

(A) Exposure Pathway
Ospreys are attracted to high-tension electricity transmission towers and to smaller wooden utility poles as potential nest sites, and this exposes ospreys to the risk of electrocution (Ewins 1995). Although this is not considered the most significant risk to the state's osprey population, it can be managed through monitoring and collaboration with utility companies.

(B) Evidence
During the past decade, the number of power line osprey nests in New Hampshire has increased from 1 to 7 sites. Although there are no documented instances of electrocution of ospreys in the state, there have been cases where power interruptions have been caused by nest structures.

3.1.6 Development (Habitat Loss and Conversion

(A) Exposure Pathway
Availability of suitable nest sites appears frequently to limit some local breeding populations of osprey (Ewins 1997). Supercanopy pines near wetland edges and dead standing trees located in flooded beaver ponds are both highly attractive to ospreys as nesting sites. Flooded areas reduce the vulnerability of osprey nests to mammalian predators (Poole et al. 2002), and draining or filling of wetlands reduces the ability of these areas to support viable osprey nests.

(B) Evidence
Researchers working in certain parts of Europe have reported that some forestry practices have severely reduced or eliminated suitable supercanopy nesting trees, which resulted in fewer available nest sites for ospreys (Meyburg et al. 1996). In Ontario, timber extraction has been suggested as a leading cause of reduction in nest site availability (Ewins 1997).

3.1.7 Non-point Source Pollution (Pesticides and Herbicides)

(A) Exposure Pathway
Ospreys are exposed to DDT and other organochlorines in the fish they consume. These chemicals may be transported long distances by air and may enter aquatic systems via atmospheric deposition and precipitation. Although the use of DDT and other organochlorines has been much reduced in North America, ospreys may still be exposed on the wintering grounds and in migration.

(B) Evidence
The use of DDT has been greatly reduced in North America, but ospreys are long-distance migrants and are exposed to DDT and other organochlorine compounds in prey species on the wintering grounds and in migration (Elliott et al. 2000).

3.2 Sources of Information

Information on various threats to ospreys was obtained from literature review, from NHA field data, and from consultation with specialists employed by the USFWS, NHFG, and the NHA, all located in Concord, New Hampshire, and from BioDiversity Research Institute in Gorham, Maine.

3.3 Extent and Quality of Data

Most of the threats described above have been examined carefully by researchers working outside of New Hampshire. The negative effects of mercury, PBDEs, PCBs, and DDT on aquatic species are well known and are well documented by researchers nationwide. There are sufficient data on the threat posed by lead to piscivorous bird species in New Hampshire that legislation has recently been passed that prohibits the use of certain size lead sinkers and jigs. There is no substantial New Hampshire specific data set on effects on ospreys of motorized and self-propelled boating activity. There is sufficient concern about shoreline and wetland habitat loss to justify strengthening land use policies and investing in more land protection efforts by federal and state agencies, and by non-profit conservation groups. Electrocution issues are currently being addressed in collaboration with local utility companies.

3.4 Threat Assessment Research

There are several areas where additional threat assessment research is warranted, including:

- Investigation into the likely future extent of wetland and shoreline development on water bodies in New Hampshire, and development of a pro-active plan that would better protect wildlife values associated with shorelines and wetlands.
- Investigation of the tolerance of osprey for recreational boating activity in the vicinity of nest sites and foraging areas
- Additional investigation of current levels of mercury, PCBEs, DDE, and other bioaccumulative pollutants in New Hampshire ospreys.

Element 4: Conservation Actions

4.1.1 Document breeding status, Restoration and Management

To determine occupancy status and reproductive outcome, distribution and abundance of breeding ospreys should be documented by nest site visits. Data on annual osprey productivity are needed to determine when recovery goals are achieved. This can be accomplished largely by training and coordinating a statewide network of volunteer nest site monitors. Direct threats addressed under this conservation action include mercury, PBDEs, PCBs, lead, motorized and self-propelled watercraft, shoreline development, electrocution, wetland loss, DDT, and organochlorines.

4.1.2 Finalize and adopt state recovery plan for ospreys, Regulation and Policy

Formally adopt an existing draft state recovery plan for ospreys (Martin et al. 2004) that includes specific targets for delisting. This conservation action builds on 25 years of ongoing management activities to insure population viability and establish clear targets for population recovery. Direct threats addressed under this conservation action include mercury, PBDEs, PCBs, lead, motorized and self-propelled watercraft, shoreline development, electrocution, wetland loss, DDT, and organochlorines.

4.1.3 Determine contaminant loads, Restoration and Management

Conduct more extensive monitoring of contaminant loads present in New Hampshire osprey chicks to determine the potential impact of toxics on statewide productivity and population recovery. This conservation action builds on 25 years of ongoing management activities to insure population viability and understand the effects of environmental contaminants. Direct threats addressed under this conservation action include mercury, PBDEs, PCBs, lead, DDT, and organochlorines.

4.1.4 Nest site management, Restoration and Management

Install predator guards on nest sites and selectively place additional nesting platforms to disperse the breeding population. To minimize predation by mammalian predators such as raccoons and to increase productivity rates, the NHA and NHFG have installed predator guards on all new nest poles since 1994 and have installed predator guards on a majority of existing natural nest trees since 1985. Consult with local landowners and collaborate with utility companies to install additional nest poles and platforms to encourage colonization by ospreys of unoccupied areas of the state and to provide additional nesting opportunities for new osprey pairs in already occupied parts of the state. Direct threats addressed under this conservation action include motorized and self-propelled watercraft, shoreline development, electrocution, and wetland loss.

4.1.5 Encourage cooperative research, Restoration and Management

There is a need for more information on the effects of certain contaminants, osprey migration, and nest site fidelity. Migration should be studied using satellite tracking of a subset of the New Hampshire population. Current and proposed blood sampling will provide information on environmental contamination of New Hampshire osprey. Banding studies should also be conducted to assess nest site fidelity. In total, this research will improve our understanding of risk factors and will guide future conservation efforts. Direct threats addressed under this conservation action include mercury, PBDEs, PCBs, DDT, and organochlorines.

4.1.6 Provide public outreach materials, Education and Outreach

Enhance educational efforts about osprey biology, habitat, and land conservation issues to promote better local stewardship, reduce nest disturbance, and provide public support for wildlife protection efforts in general. Direct threats addressed under this conservation action include mercury, PBDEs, PCBs, lead, motorized and self-propelled watercraft, shoreline development, electrocution, wetland loss, DDT, and organochlorines.

4.1.7 Promote conservation of great blue heron colonies and healthy beaver populations, Restoration and Management

Particularly in the southern part of New Hampshire, ospreys commonly select great blue heron rookeries located in flooded wetlands as nest sites. To maintain and encourage a self-sustaining population of osprey, heron rookeries, and the beaver populations that produce dead standing trees in wetlands, should be maintained and protected from disturbance. Direct threats addressed under this conservation action include shoreline development and wetland loss.

Element 5: References

5.1 Literature

Allen, G. M. 1902. A list of the birds of New Hampshire. Proceedings of the Manchester Institute of Arts and Sciences 4. Manchester, NH.

Buehler, D. A. 2000. Bald eagle (*Haliaeetus leucocephalus*). *In* The Birds of North America, No. 683 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.

Brewster, W. 1925. The birds of Lake Umbagog region of Maine, Pt. 2. Bulletin of Comparative Zoology 66. Harvard College, Cambridge, Mass.

Dearborn, N. 1898. A preliminary list of the birds of Belknap and Merrimack counties, New Hampshire, with notes. M.S. thesis, New Hampshire College of Agricultural and Mechanical Arts, Durham, New Hampshire.

Desgranges, J.L., J. Rodrigue, B. Tardif, and M. Laperle. 1998. Mercury accumulation and biomagnification in ospreys (*Pandion haliaetus*) in James Bay and Hudson Bay regions of Quebec. Archives of Environmental Contaminants and Toxicology 35:330-341.

Elliott, J. E., M. M. Machmer, L. K.Wilson, and C. J.Henny. 2000. Contaminants in ospreys from the Pacific northwest; organochlorine pesticides, polychlorinated biphenyls, and mercury, 1991-1997. Archives of Environmental Contaminants and

Toxicology 38:93-106.

Environment Canada. 2001. The fall and rise of osprey populations in the Great Lakes basin. Environment Canada web site (www.on.ec.gc.ca/glimr/data/osprey-glbasin/).

Evans, D. 1994. Osprey. Pp. 42-43 *in* Atlas of breeding birds in New Hampshire. (C. R. Foss (ed.). Arcadia Press, Dover, NH.

Evers, D. C. 2005. Mercury connections: The extent and effects of mercury pollution in northeastern North America. BioDiversity Research Institute. Gorham, ME. 28 pp.

Ewins, P. J. 1995. The use of artificial nest sites by an increasing population of ospreys in the Canadian Great Lakes basin. Pp. 3-13 *in* Raptors in human landscapes (D. M. Bird, D. E. Varlan, and J. J. Negro, eds.). Academic Press, London, U.K.).

Ewins, P.J. 1996. The use of artificial nest sites by an increasing population of ospreys in the Canadian Great Lakes basin. Pp. 109-123, *in* D.M. Bird, D.E. Varland, and J.J. Negro. Raptors in human landscapes: adaptations to built and cultivated environments. Academic Press. 396 pp.

Ewins, P. J. 1997. Osprey (*Pandion haliaetus*) populations in forested areas of North America: changes, their causes, and management recommendations. Journal of Raptor Research 31:138-150.

Gibson, L. 2003. Return of Rhode Island osprey. Osprey newsletter, No. 74. Rhode Island Division of Fish and Wildlife. 4 pp.

Gibson, L. 2005. Return of Rhode Island osprey. Osprey newsletter, No. 78. Rhode Island Division of Fish and Wildlife. 4 pp.

Gobeille, J. 2004. 2003 Vermont osprey nest report. Vermont Agency of Natural Resources. 4 pp.

Green Mountain Audubon Society (GMAS). 2001. Osprey. Green Mountain Audubon Society web site (www.thecompass.org/audubon/conservation/osprey.html) .

Hagan, J. M. and J. R. Walters. 1990. Foraging behavior, reproductive success, and colonial nesting in ospreys. Auk 107:506-521.

Henny, C.J. and J.C. Ogden. 1970. Estimated status of osprey populations in the United States. Journal of Wildlife Management 34:214-217.

Henny, C. J. and W. Van Velzen. 1972. Migration patterns and wintering localities of American ospreys. Journal of Wildlife Management 36:1133-1141.

Houghton, L. M. and L. M. Rymon. 1997. Nesting distribution and population status of U.S. ospreys 1994. Journal of Raptor Research 31:44-53.

Hughes, K.D., P.J. Ewins, and K.E. Clark. 1997. A comparison of mercury levels in feathers and eggs of osprey (*Pandion haliaetus*) in the North American Great lakes. Archives of Environmental Contaminants and Toxicology 33:441-452.

Martell, M. S., C. J. Henny, P. E. Nye, and M. J. Solensky. 2001. Fall migration routes, timing, and wintering sites of North American ospreys as determined by satellite telemetry. Condor 103: 715-724.

Martin, C. J., M. N. Marchand, J. R. Kelly, T. L. Tarr, and J. J. Kanter. 2004. Draft edition of New Hampshire Osprey Recovery Plan. 26 pp.

Maynard, C. J. 1871. A catalogue of the birds of Coos County, New Hampshire, and Oxford County, Maine. Proceedings of the Boston Society of Natural History 14:357-395.

Meyburg, B.-U., O. Manowsky, and C. Meyburg. 1996. The osprey in Germany: its adaptation to environments altered by man. Pp. 125-135, *in* D.M. Bird, D.E. Varland, and J.J. Negro. Raptors in human landscapes: adaptations to built and cultivated environments. Academic Press. 396 pp.

New York State Department of Environmental Conservation (NYSDEC). 2001. Osprey fact sheet. New York State DEC web site (www.dec.state.ny.us/website/dfwmr/wildlife/endspec/osprfs.html) .

Ogden, J. C.(ed.). 1977. Transactions of the North American osprey research conference, College of William and Mary, Williamsburg, VA, 10-12 February 1972. U.S.D.I., National Park Service, Transactions and Proceedings Series, No. 2.

Palmer, R. S. 1988. Handbook of North American birds, Vol. 4. Yale University Press, New Haven, Connecticut. 433 pp.

Parren, S.G. 1997. Vermont osprey recovery plan. Vermont Fish & Wildlife Department. 10 pp. plus appendices.

Poole, A. F. 1989. Ospreys: a natural and unnatural history. Cambridge University Press.

Poole, A. F., R. O. Bierregaard, and M. S. Martell. 2002. Osprey (*Pandion haliaetus*). *In* The Birds of North America, No. 683 (A. Poole and F. Gill, eds.). The Birds of North America, Inc. Philadelphia, PA.

Prevost, Y. 1979. Osprey-bald eagle interactions at a

common foraging site. Auk 96:413-414.
Scott, C. F. 1921. Notes on land birds of southern New Hampshire. M.S. thesis, University of New Hampshire, Durham, NH.
Sharp, R. and S. Lunder. 2004. In the dust: Toxic fire retardants in American homes. Environmental Working Group. Washington, DC and Oakland, CA. Document available at www.ewg.org. 57 pp.
Smith, C. F. 1979. Proceedings of the [New Hampshire] endangered species conference. U.S. Fish and Wildlife Service, Newton Corner, MA.
Smith, C. F. and C. Ricardi. 1983. Ospreys and bald eagles in New Hampshire: status, habitat, and nest site characteristics. Pp. 149-156, *in* Biology and management of bald eagles and ospreys (D. M. Bird, ed.). Harpell Press. Ste. Anne de Bellevue, Quebec. 325 pp.
Spitzer, P.R., R.W. Riseborough, W. Walker, R. Hernandez, A. Poole, D. Puleston, and I.C.T. Nisbet. 1978. Productivity of ospreys in Connecticut-Long Island increases as DDE residues decline. Science 202:333-335.
Steidl, R.J., C.R. Griffin, and L.J. Niles. 1991. Contaminant levels of osprey eggs and prey reflect regional differences in reproductive success. Journal of Wildlife Management 55:601-608.
Stocek, R. F. and P. A. Pearce. 1983. Distribution and reproductive success of ospreys in New Brunswick, 1974-1980. Pp. 215-221, *in* Biology and management of bald eagles and ospreys. (D. M. Bird, ed.). Harpell Press. Ste. Anne de Bellevue, Quebec. 325 pp.
U. S. Fish and Wildlife Service. 2000. Osprey habitat model. Gulf of Maine Coastal Program web site (http://r5gomp.fws.gov).
Vermont Agency of Natural Resources (VANR). 2001. Vermont's osprey population is on the increase. Vermont ANR web site (www.anr.state.vt.us/bridge/fall00/osprey.htm).
Wiemeyer, S. N., C. M. Bunck, and A. J. Krynitsky. 1988. Organochlorine pesticides, polychlorinated biphenyls, and mercury in osprey eggs – 1970-79 – and their relationships to shell thinning and productivity. Archives of Environmental Contaminants and Toxicology 17:767-787.

5.2 Data Sources:

Osprey nest and productivity surveys from 1981-2004, MS Access database, New Hampshire Audubon, Concord, NH.

Element 6: List of Figures

Figure 1. Number of known available, active, and successful osprey nests in New Hampshire from 1980-2002.

Figure 2. Number of osprey fledglings produced at successful nests in New Hampshire from 1980 to 2002.

Figure 3. Distribution of known active osprey nests within five major watersheds in New Hampshire during 1980-1989, 1990-1994, 1995-1999, and 2000-2003.

Figure 4. Number of known active osprey nests within four major watersheds of New Hampshire from 1980-2003.

Table 1. New Hampshire osprey productivity summary: 1980-2004.

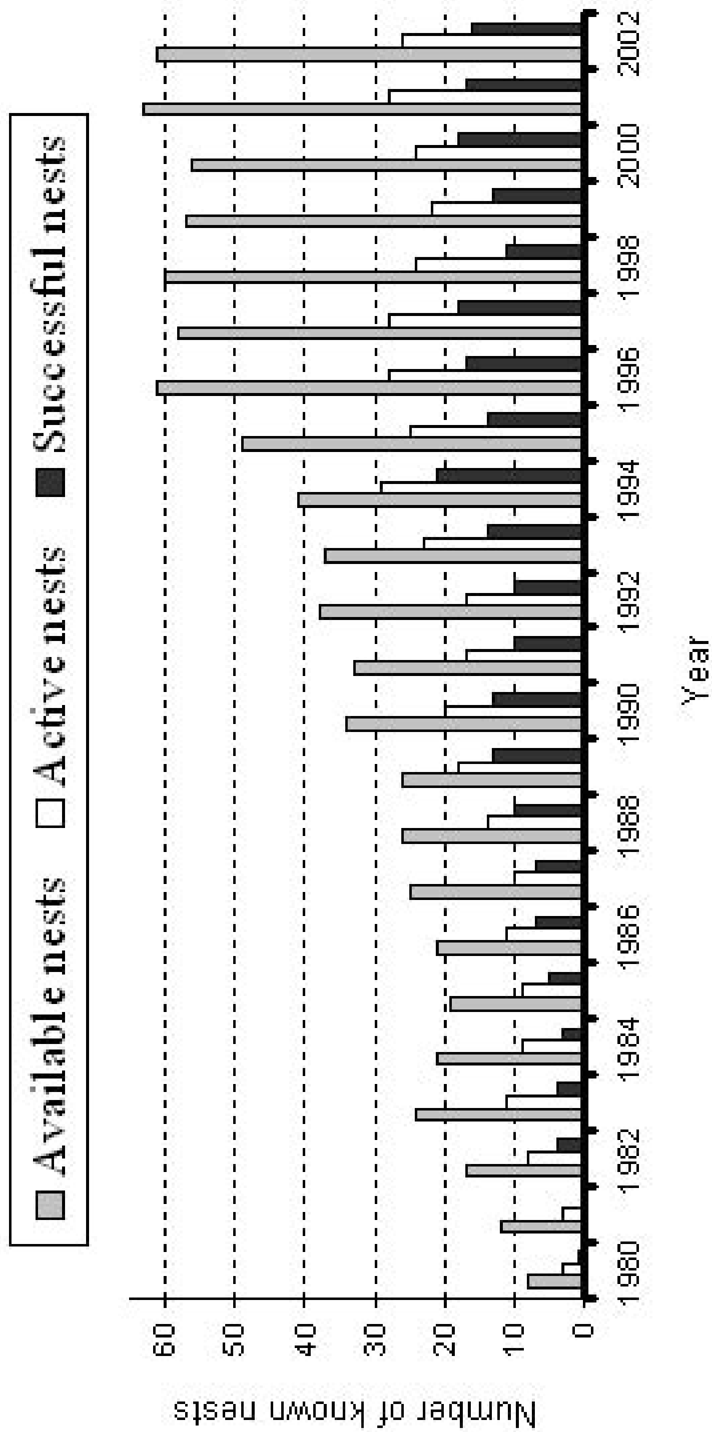


Figure 1. Number of known available, active, and successful osprey nests in New Hampshire from 1980-2002.

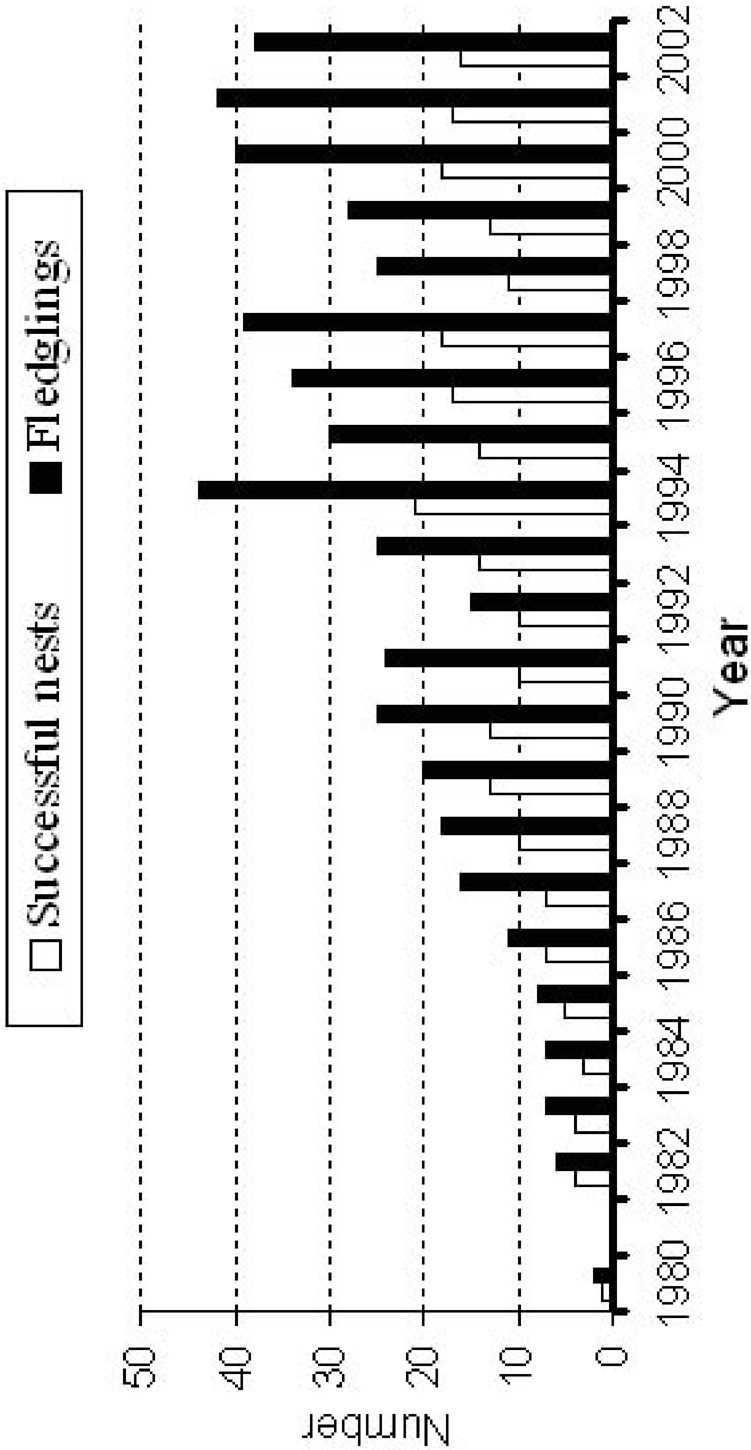


Figure 2. Number of osprey fledglings produced at successful nests in New Hampshire from 1980 to 2002.

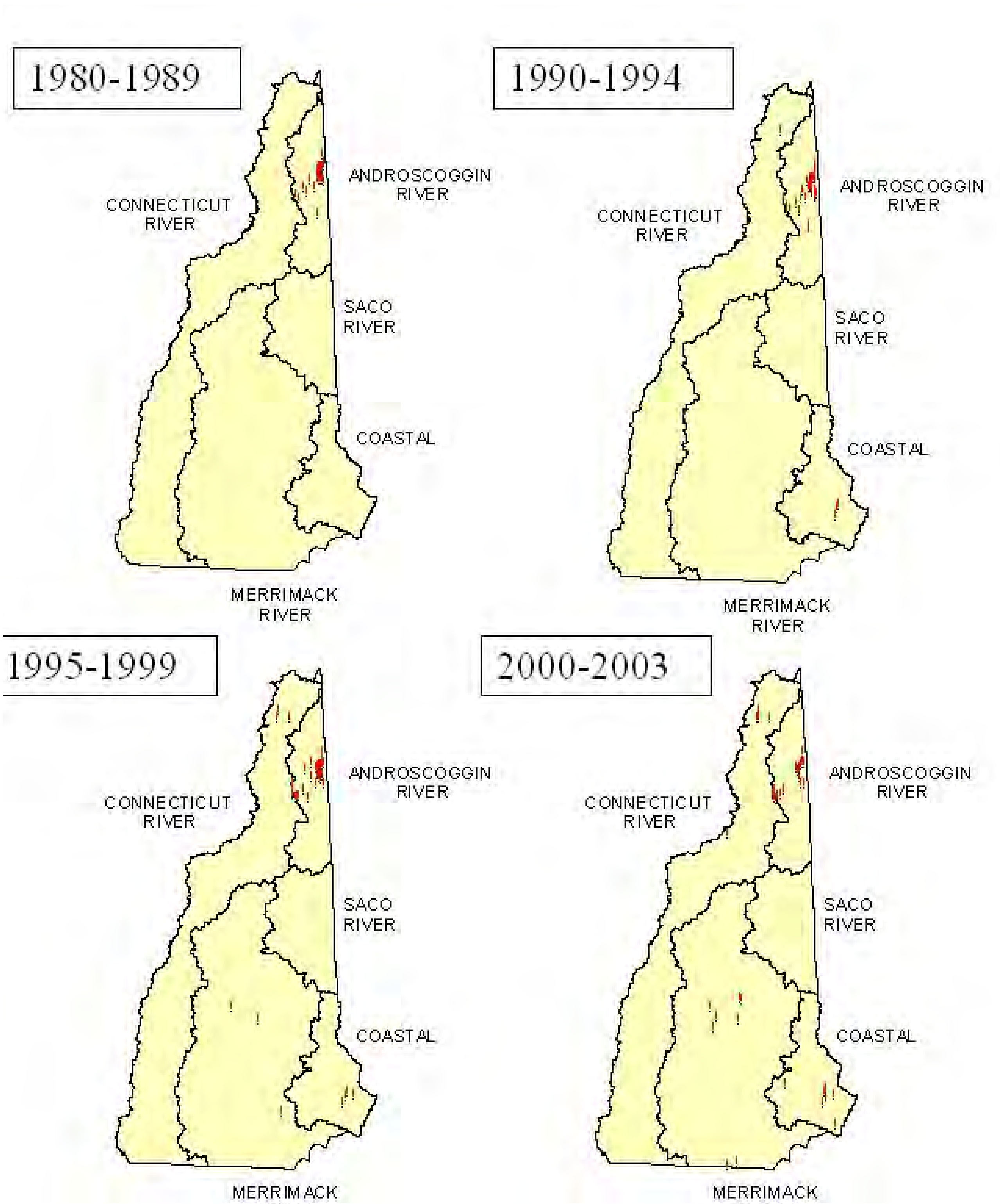


Figure 3. Distribution of known active osprey nests within five major watersheds in New Hampshire during 1980-1989, 1990-1994, 1995-1999, and 2000-2003.

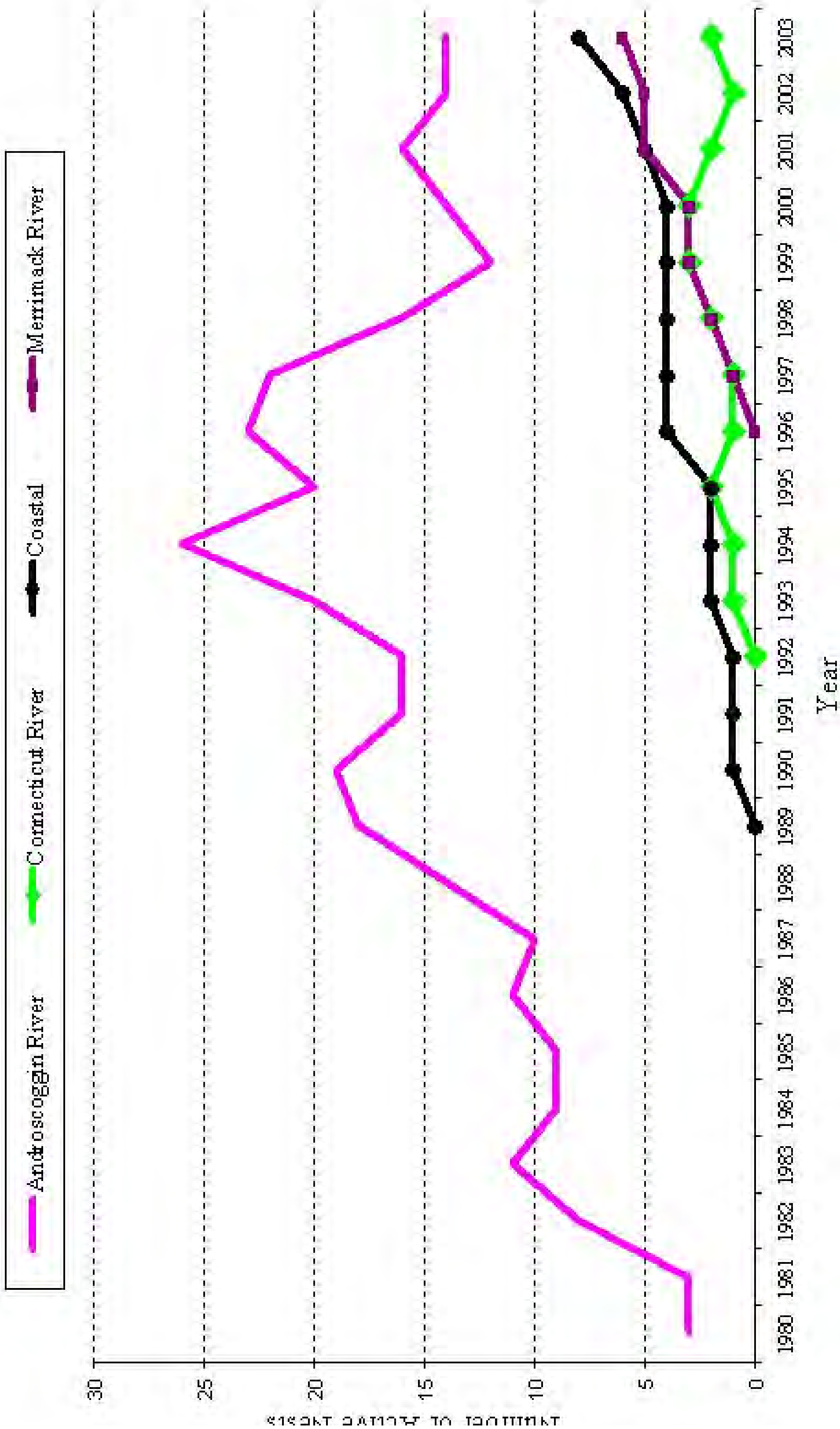
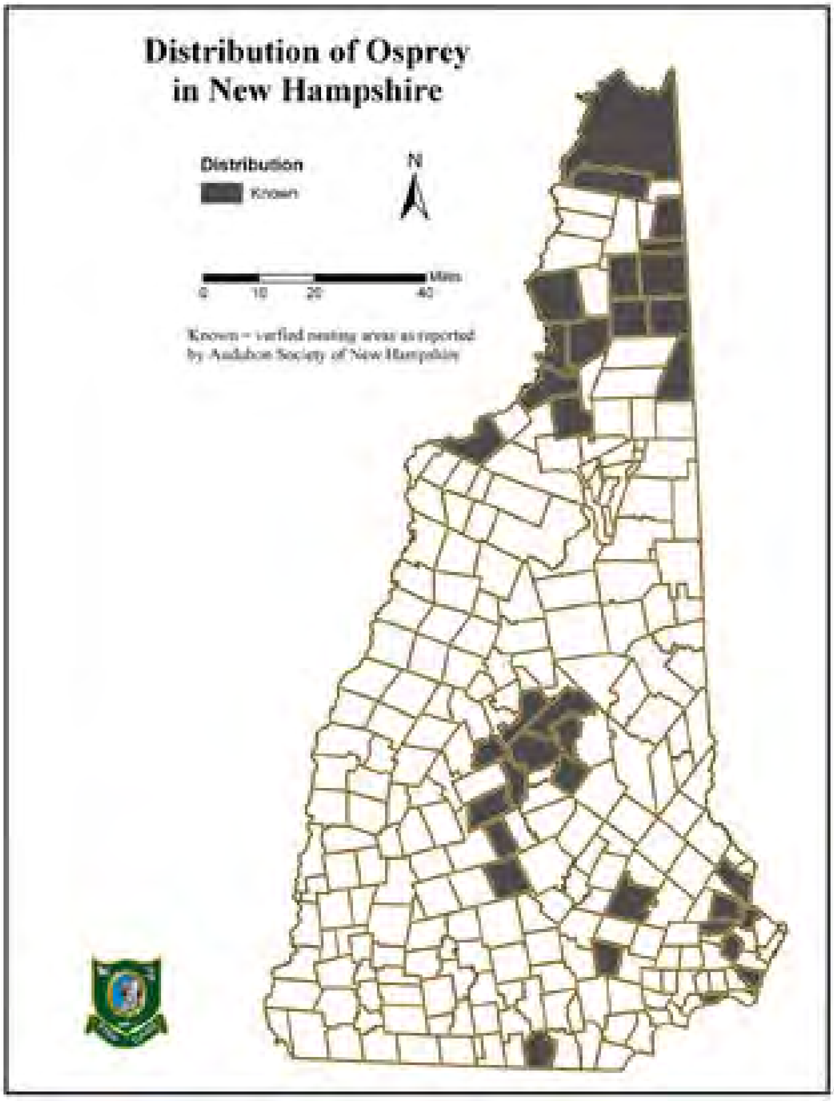


Figure 4. Number of known active osprey nests within four major watersheds of New Hampshire from 1980-2003.

Year	Occupied Nests	Active Nests	Successful Fledged	Young	Young per Nesting Pair
1980	6	3	1	2	0.67
1981	9	3	0	0	0
1982	14	8	4	6	0.75
1983	20	11	4	7	0.64
1984	15	9	3	7	0.77
1985	14	9	5	8	0.89
1986	15	11	7	11	1
1987	18	10	7	16	1.6
1988	21	14	10	18	1.29
1989	23	18	13	20	1.11
1990	26	20	13	25	1.25
1991	21	17	10	24	1.49
1992	33	17	10	15	0.88
1993	37	23	14	25	1.09
1994	32	29	21	44	1.52
1995	33	25	14	30	1.2
1996	43	28	17	34	1.21
1997	39	28	18	39	1.39
1998	36	24	11	25	1.04
1999	34	22	13	28	1.27
2000	39	24	18	40	1.67
2001	39	28	17	42	1.5
2002	32	27	17	40	1.48
2003	44**	30	23	54**	1.80**
2004	43	34**	26**	53	1.56
Totals for 1980-2004	**472**	**296**	**613**		**1.3**

Table 1. New Hampshire osprey productivity summary: 1980-2004.


Distribution of Osprey
in New Hampshire
Distribution
Known
N
0 10 20 40
Miles

APPENDIX A

Species Profiles

Part Two: Fish

SPECIES PROFILE

Alewife

Alosa pseudoharengus

Federal Listing: Not listed
State Listing: Not listed
Global Rank: G5
State Rank: S5
Author: Matthew A. Carpenter, NHFG

Element 1: Distribution and Habitat

1.1 Habitat Description

Alewives use various freshwater spawning habitat including riverine oxbows, ponds, and mid-river sites. Juveniles remain in freshwater until late summer and early fall when they migrate into estuaries and eventually to the ocean. When not spawning, adult alewives congregate in areas of the Nantucket Shoals, Georges Bank, and the shores of the Gulf of Maine.

1.2 Justification

Dams severely limit accessible anadromous fish spawning habitat, and alewives must use fish ladders for access to spawning habitat during spring spawning runs. River herring are a key component of freshwater, estuarine, and marine food webs (Bigelow and Schroeder 1953). They are an important prey for many predators, and they contribute nutrients to freshwater ecosystems (Macavoy et al. 2000).

1.3 Protection and Regulatory Status

The taking of river herring in New Hampshire waters is open only to residents, and no fish may be taken on Wednesdays. A harvest permit is required to take river herring by any form of netting. Herring caught at sea are further regulated, and when the season is closed between 21 September and 19 October, the maximum incidental catch is to 2,000 lbs daily. The alewife is protected under the Anadromous Fish Conservation Act.

1.4 Population and Habitat Distribution

The alewife ranges from Newfoundland to South Carolina. Some populations, such as those in the Great Lakes, are landlocked (Atlantic States Marine Fisheries Commission 1999). In New Hampshire, alewives spawn in the Merrimack River and the seacoast drainages (Scarola 1987).

1.5 Town Distribution Map

Not completed for this species.

1.6 Habitat Map

Alewives inhabit the lower section of the Merrimack River and the coastal watersheds of New Hampshire. See the Non-Tidal Coastal Watershed, Connecticut River Mainstem Watershed, and Tidal Coastal Watershed profiles.

1.7 Sources of Information

Literature reviews and historical records of fish passage at dams in New Hampshire and Massachusetts were used to identify distribution and habitat requirements.

1.8 Extent and Quality of Data

River herring are monitored annually at fishways on the Connecticut, Merrimack, and coastal rivers.

1.9 Distribution Research

The stream reaches used as spawning habitat by anadromous fish in New Hampshire are relatively unknown. Research in New Hampshire may identify quality spawning habitat upstream from impassable dams. A GIS map of the stream reaches accessible to anadromous species, combined with a map of potential spawning habitat, would facilitate restoration efforts.

Element 2
Not completed for this species

Element 3
Not completed for this species

Element 4
Not completed for this species

Element 5: References

Atlantic States Marine Fisheries Commission [ASMFC]. 1999. Amendment 1 to the Interstate Management Plan for Shad and River Herring. ASMFC Fishery Management Report No. 35.

Bigelow H., and W. Schroeder. 1953. Fishes of the Gulf of Maine. Fishery Bulletin of the Fish and Wildlife Service. No. 74. Vol 53.

MacAvoy, S.E., S.A. Macko, S.P. McIninch, and G.C. Garman. 2000. Marine nutrient contributions to freshwater apex predators. Oecologia 122:568-573.

Scarola J. 1987. Freshwater Fishes of New Hampshire. New Hampshire Fish and Game Department. 132p.

SPECIES PROFILE

American Eel

Anguilla rostrata

Federal Listing: Not listed
State Listing: Not listed
Global Rank: G5
State Rank: S5
Author: Matthew A. Carpenter, NHFG

Element 1: Distribution and Habitat

1.1 Habitat Description

American eels use marine, estuarine, and freshwater habitat (Atlantic States Marine Fisheries Committee (ASMFC) 2000). American eels breed collectively in the Sargasso Sea, a large area of the western Atlantic Ocean. After hatching, larval eels (leptocephali) drift in ocean currents to the shores of eastern North America, northeastern South America, Europe, and North Africa where they transform into glass eels and then pigmented elvers. Elvers migrate into estuaries and freshwater where they remain for most of their lives. Adults spend 10 to 25+ years in freshwater, where they are referred to as yellow eels. Eventually, yellow eels metamorphose into silver eels that then migrate back to the Sargasso Sea to spawn and die.

1.2 Justification

The American eel is in decline throughout its range (Haro et al. 2000), and yellow eel abundance has dropped dramatically in the St. Lawrence River over the past 20 years (Castonguay et al. 1994). Causes of eel declines may include commercial harvest, dams, unfavorable environmental conditions in marine and freshwater environments, pollution, and climate change (Haro et al. 2000). A long life span, combined with extensive migration and a single breeding event, make the American eel population vulnerable to collapse (ASMFC 2000).

1.3 Protection and Regulatory Status

In New Hampshire, there is a creel limit of 50 American eels per day, and each must be 6 inches long. American eels may be taken year-round except downstream from a fishway, where they may be taken only from June 15 to October 1. A harvest permit is required if eels are taken by any other method than angling.

1.4 Population and Habitat Distribution

The American eel is found in coastal watersheds from northeastern South America to Greenland (ASMFC 2000). In New Hampshire, American eels are found in the seacoast watersheds and portions of the Merrimack and Connecticut River watersheds (Scarola 1987).

1.5 Town Distribution Map

Not completed for this species.

1.6 Habitat Map

American eels inhabit sections of the Merrimack River, Connecticut River, and the coastal watersheds of New Hampshire. See the Non-Tidal Coastal Watersheds (systems 11 and 12), Connecticut River Mainstem Watersheds (systems 1 and 2), Coastal Transitional Watersheds (systems 10 and 14), Northern Upland Watersheds (systems 5 and 7), and Tidal Coastal Watersheds (system 13) profiles.

1.7 Sources of Information

Little is known about the distribution of American eels in New Hampshire. Data collected at fish ladders during the spring spawning runs of anadromous fish document the accumulation of elvers below dams at the head of tide on coastal rivers.

1.8 Extent and Quality of Data

There has been no comprehensive survey of American eels in New Hampshire waters. Data on American eel distribution are scattered in field notes and records from surveys of other species.

1.9 Distribution Research

Due to the rapid decline in recruitment of American eel, priority should be placed on developing or facilitating upstream and downstream passage at dams rather than on establishing the distribution of the species. Distribution research should be linked to evaluations of efforts to improve access to freshwater habitats.

Element 2

Not completed for this species

Element 3

Not completed for this species

Element 4

Not completed for this species

Element 5: References

Atlantic States Marine Fisheries Commission (ASMFC). 2000. Interstate Fishery Management Plan for American Eel. ASMFC Fishery Management Report No. 36. 79 p.

Atlantic States Marine Fisheries Commission. 2004. Review of the Atlantic States Marine Fisheries Commission Fishery Management Plan for the American Eel (*Anguilla rostrata*). American Eel Review Team.

Castonguay, M., P.V. Hodson, C.M. Couillard, M.J. Eckersley, J.D. Dutil, and G. Verreault. 1994. Why is recruitment of the American eel (*Anguilla rostrata*) declining in the St. Lawrence River and Gulf? Canadian Journal of Fisheries and Aquatic Sciences 51:479–488.

Haro, A., W. Richkus, K. Whalen, A. Hoar, W.D. Busch, S. Lary, T. Brush, and W. Dixon. 2000. Population decline of the American eel: implications for research and management. Fisheries 25: 7–16

Scarola, J. 1987. Freshwater Fishes of New Hampshire (2nd Edition). New Hampshire Fish and Game Department. 132p.

SPECIES PROFILE

American Shad

Alosa sapidissima

Federal Listing: Not listed
State Listing: Not listed
Global Rank: G5
State Rank: S3
Author: Matthew A. Carpenter, NHFG

Element 1: Distribution and Habitat

1.1 Habitat Description

American shad are anadromous fish that spawn in moderate to large freshwater rivers along the Atlantic coast. Spawning occurs between 12-20^{0}C and flows of 10-132 cm^2/sec. The nonadhesive eggs drift in the current until they hatch. Dissolved oxygen levels below 5 mg/l are detrimental to shad at all life stages. In the ocean, shad prefer temperatures between 7-13^{0}C and migrate to deeper water during winter. During summer and fall, shad congregate in the Gulf of Maine and the Bay of Fundy (Bigelow and Schroeder 1953).

1.2 Justification

Commercial shad harvests along the U.S. Atlantic coast have declined from an estimated peak of 50,499,000 lbs in 1896 to around 8,134,000 lbs in 1960 (Weiss-Glanz et al. 1986). Catches have continued to decline over the past 40 years due to the cumulative effect of dams, pollution, and over-fishing (Weiss-Glanz et al. 1986). Impassable dams have reduced available river spawning habitat in Maine by 95%, and in New Hampshire dams restrict shad to a fraction of their historical spawning habitat.

1.3 Protection and Regulatory Status

In New Hampshire, there is a 2-fish daily limit that must be caught by angling. There are no length or weight limits. American shad taken by any other method must be released. There is no commercial fishery for American shad in New Hampshire, and incidental catch of shad in other fisheries cannot exceed 5% of the total landing per trip (Atlantic States Marine Fisheries Commission 1999). The American shad is protected under the Anadromous Fish Conservation Act.

1.4 Population and Habitat Distribution

American shad spawn in rivers from Florida to Newfoundland, though they are most abundant from Connecticut to North Carolina. They were recently introduced to the Pacific coast. In New Hampshire, the largest historic populations spawned in the Connecticut and Merrimack rivers. The distribution of historical shad spawning areas in the coastal rivers is not well documented.

1.5 Town Distribution Map

Not completed for this species

1.6 Habitat Map

American shad inhabit the lower section of the Merrimack River and the coastal watersheds of New Hampshire. See the Non-Tidal Coastal Watersheds (systems 11 and 12), Mainstem Watersheds (systems 1 and 2), and Tidal Coastal Watersheds (system 13) profiles.

1.7 Sources of Information

Literature reviews and historical records of fish passage at dams in New Hampshire and Massachusetts were used to identify distribution and habitat requirements.

1.8 Extent and Quality of Data

Shad returns are monitored annually at fishways on the Connecticut, Merrimack, and coastal rivers.

1.9 Distribution Research

Spawning habitats for anadromous fish in New Hampshire are relatively unknown. Research may identify quality spawning habitat upstream from impassable dams. A GIS map of the stream reaches currently accessible to each anadromous species, combined with a map of potential spawning habitat that is inaccessible, would facilitate restoration efforts.

Element 2

Not completed for this species

Element 3

Not completed for this species

Element 4

Not completed for this species

Element 5: References

ASMFC (Atlantic States Marine Fisheries Commission). 1985. Fishery Management Plan for the Anadromous Alosid Stocks of the Eastern United States: American Shad, Hickory Shad, Alewife, and Blueback Herring: Phase II in Interstate Management Planning for Migratory Alosids of the Atlantic Coast. Washington, D.C. XVIII + 347 pp.

ASMFC [Atlantic States Marine Fisheries Commission]. 1999. Amendment 1 to the Interstate Management Plan for Shad & River Herring. ASMFC Fishery Management Report No. 35. 77 p.

Bigelow, H., and W. Schroeder. 1953. Fishes of the Gulf of Maine. Fishery Bulletin of the Fish and Wildlife Service. 74(53)

United States Fish and Wildlife Service. 2004. Fish Facts- American Shad. Available http://www.fws.gov/r5crc/Fish/zb_alsa.html. (Accessed May 2005).

Weiss-Glanz, L.S., J.G. Stanley, and J.R. Moring. 1986. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (North Atlantic)--American shad. United States Fish and Wildlife Service Biol. Rep. 82(11.59). U.S. Army Corps of Engineers, TR EL-82-4. 16 pp.

SPECIES PROFILE

Banded Sunfish

Enneacanthus obesus

Federal Listing: Not listed
State Listing: Not listed
Global Rank: G5
State Rank: S3
Author: Matthew, A. Carpenter, NHFG

Element 1: Distribution and Habitat

1.1 Habitat Description

Banded sunfish prefer vegetated areas of ponds, lakes, and the backwaters of lowland streams (Scarola 1987). Banded sunfish are highly tolerant of acidic water and can withstand pH levels as low as 4.0 (Gonzales and Dunson 1989). Tolerance for acidic water may be an adaptation that provides banded sunfish with access to habitats unavailable to other fish species (Graham and Hastings 1984, Gonzales and Dunson 1991) and may provide the banded sunfish with refuge from both native and introduced species of predaceous fish (Graham 1993).

1.2 Justification

Little is known about the ecology or distribution of the banded sunfish in New Hampshire. Most records are from the southeastern part of the state where human populations are rapidly increasing. Of 37 known records, 16 were collected in a statewide biological inventory conducted in the late 1930s by NHFG (Gordon 1937, Bailey 1938, Bailey and Oliver 1939).

1.3 Protection and Regulatory Status

Banded sunfish may not be used as bait in New Hampshire.

1.4 Population and Habitat Distribution

Banded sunfish inhabit the Atlantic coastal plain from southern New Hampshire to Florida (Scarola 1987). In New Hampshire they are found in lowland areas of the Merrimac River and in coastal watersheds (Scarola 1987). A population has also been documented in the upper Millers River system, which drains into the Connecticut River (Bailey and Oliver 1939). Though populations may be locally abundant, they are not widely distributed.

1.5 Town Distribution Map

Before 20 years ago, banded sunfish occurred in the towns of Hudson, Manchester, Merrimack, Nashua, New Ipswich, Nottingham, Pelham, Rindge, Salem, South Hampton, and Windham. Within the last 20 years, sightings have occurred in Amherst, Bedford, Brookline, East Barrington, Hampton, Hollis, Lee, Londonderry, Madbury, Manchester, Merrimack, Milford, New Ipswich, North Hampton, Peterborough, and Rindge.

1.6 Habitat Map

More research will be necessary to determine the current distribution and habitat requirements of this species in New Hampshire. A map of low-gradient streams and pond habitat in the coastal watersheds (refer to system 13), the Merrimac watersheds (refer to system 11 and system 12), and the Millers River watershed in the Connecticut River drainage (refer to system 9), would facilitate future surveys.

1.7 Sources of Information

Records of banded sunfish came from Biological Surveys by NHFG from 1937 to 1939, NHFG) Fishing

For the Future project, the Environmental Protection Agency EMAP pilot fish sampling summary from the Northeast Lakes Monitoring Project, the New Hampshire Department of Environmental Services Biomonitoring Program, and reports from independent biologists.

1.8 Extent and Quality of Data

Records of banded sunfish were gathered from federal, state, and private monitoring projects. The distribution of the species cannot be established with available data because none of these projects specifically targeted banded sunfish or their habitat. Available records may be used to guide future surveys of the banded sunfish in New Hampshire.

1.9 Distribution Research

Survey work from the 1930s and the NHFG Fishing for the Future project provide evidence for the presence of banded sunfish in certain water bodies. The first priority should be to check for the presence of the species at sites with historic records. Once historical records are verified, a more conclusive statewide distribution of the species can be established by sampling waters in close proximity to known populations.

Studies of the factors that limit the distribution and abundance of banded sunfish will likewise be helpful. Data collected from sites with known populations may be used to recommend new survey sites. Data should be entered into a GIS database to help identify variables that may predict the presence of banded sunfish and to track the distribution of the species over time.

Element 2
Not completed for this species

Element 3
Not completed for this species

Element 4
Not completed for this species

Element 5: References

5.1 Literature

Bailey J.R., and J.A. Oliver. 1939. The fishes of the Connecticut watershed. In: A biological survey of the Connecticut watershed. New Hampshire Fish and Game Dept., Survey Report No. 4:150-189.

Bailey, R.M. 1938. The fishes of the Merrimack watershed. In: A biological survey of the Merrimack watershed. New Hampshire Fish and Game Department Survey Report No. 3:149-185.

Gonzales, R.J., and W.A. Dunson. 1989. Differences in low pH tolerance among closely related sunfish of the genus *Enneacanthus*. Environmental Biology of Fishes 26(4):303-310.

Gonzales, R.J., and W.A. Dunson. 1991. Does water pH control habitat segregation of sibling species of sunfish *Enneacanthus*? Wetlands 11(2):313-324.

Gordon, M. 1937. The fishes of eastern New Hampshire. In: A biological survey of the Androscoggin, Saco, and Coastal watersheds. New Hampshire Fish and Game Department, Survey Report No. 2:101-118.

Graham, J.H., and R.W. Hastings. 1984. Distributional patterns of sunfishes on the New Jersey coastal plain. Environmental Biology of Fishes 10: 137-148.

Graham, J.H. 1993. Species diversity of fishes in Naturally acidic lakes in New Jersey. American Fisheries Society. 122:1043-1057.

Scarola J. 1987. Freshwater Fishes of New Hampshire. New Hampshire Fish and Game Department, Concord, New Hampshire, USA.

5.2 Data Sources

Biomonitoring Program. 1995-2005. New Hampshire Department of Environmental Services, Watershed Management Bureau. www.des.state.nh.us/wmb/biomonitoring/sites/index.html >. Accessed 2004 December 12

SPECIES PROFILE

Blueback Herring

Pomolobus aestivalis

Federal Listing: Not listed
State Listing: Not listed
Affected Species: Not listed
Global Rank: G5
State Rank: S4
Author: Matthew A. Carpenter, NHFG

Element 1: Distribution and Habitat

1.1 Habitat Description

Blueback herring are anadromous fish that spawn over various substrata in fast and slow rivers and streams (United States Fish and Wildlife Service 2001). Adults return to the ocean after spawning, and young of the year migrate to the ocean by autumn. Little is known about ocean movements, but both blueback herring and alewives (*Pomolobus pseudoharengus)* have been known to congregate on Georges Bank, the Nantucket Shoals, and the perimeter of the Gulf of Maine during the fall (Bigelow and Schroeder 1953).

1.2 Justification

Dams severely limit accessible spawning habitat, and river herring (alewives and blueback herring) depend on fish ladders to ascend dams and reach spawning habitat. River herring are a key component of freshwater, estuarine, and marine food webs. They are an important prey item of many marine predators and they contribute nutrients to freshwater ecosystems (Durbin et al. 1979, Macavoy et al. 2000).

1.3 Protection and Regulatory Status

The taking of river herring is open only to New Hampshire residents, and no fish may be taken by any method on Wednesdays. A harvest permit is required to take river herring by any form of netting. Herring caught at sea are further regulated, and between September 21 and October 19, the maximum incidental catch is limited to 2000 lbs per day. The blueback herring is protected under the Anadromous Fish Conservation Act.

1.4 Population and Habitat Distribution

The blueback herring is found along the Atlantic coastal plain from Florida to Nova Scotia (Atlantic States Marine Fisheries Commission 1999). In New Hampshire the blueback herring spawning runs occur in the Connecticut River, the Merrimack River, and the seacoast drainages (New Hampshire Fish and Game 2004, Greenwood 2005).

1.5 Town Distribution Map

Not completed for this species

1.6 Habitat Map

Blueback herring inhabit the lower section of the Merrimack River and the coastal watersheds of New Hampshire. See the Non-Tidal Coastal Watersheds (systems 11 and 12), Mainstem Watersheds (systems 1 and 2), and Tidal Coastal Watersheds (system 13) profiles.

1.7 Sources of Information

Literature reviews and historical records of fish passage at dams in New Hampshire and Massachusetts were used to identify distribution and habitat requirements.

1.8 Extent and Quality of Data

River herring returns are monitored at fishways on the Connecticut, Merrimack, and coastal rivers.

1.9 Distribution Research

Spawning habitats for New Hampshire's anadromous fish are relatively unknown. Research may identify quality spawning habitat upstream of impassable dams. A GIS map of the stream reaches accessible to each anadromous species, combined with a map of the potential spawning habitat that is currently inaccessible, would facilitate restoration.

Element 2
Not completed for this species

Element 3
Not completed for this species

Element 4
Not completed for this species

Element 5: References

ASMFC (Atlantic States Marine Fisheries Commission). 1985. Fishery Management Plan for the Anadromous Alosid Stocks of the Eastern United States: American Shad, Hickory Shad, Alewife, and Blueback Herring: Phase II in Interstate Management Planning for Migratory Alosids of the Atlantic Coast. Washington, D.C. XVIII + 347 pp.

ASMFC [Atlantic States Marine Fisheries Commission]. 1999. Amendment 1 to the Interstate Management Plan for Shad & River Herring. ASMFC Fishery Management Report No. 35. 77 p.

Bigelow H., and W. Schroeder. 1953. Fishes of the Gulf of Maine. Fishery Bulletin of the Fish and Wildlife Service. No. 74. Vol 53.

Durbin, A.G., S.W. Nixon, and C.A. Oviatt. 1979. Effects of the spawning migration of the alewife on freshwater ecosystems. Ecology 60:8-17.

Greenwood J. 2005. Anadromous Fisheries in New Hampshire. http://www.wildlife.state.nh.us/Fishing/fisheries_management/anadromous.htm>. Accessed 2005.

New Hampshire Fish and Game Department. 2004. New Hampshire Marine Fisheries Investigations. Grant F-61-R. 171p.

United States Fish and Wildlife Service (USFWS). 2001. River Herring Habitat Model. Available http://www.fws.gov/r5gomp/gom/habitatstudy/metadata/river_herring_model.htm.

United States Fish and Wildlife Service (USFWS). 2004. Anadromous fish returns – Merrimack River [Internet]. Central New England Fishery Resource Office. Available: http://www.fws.gov/r5cneafp/returns.htm

United States Fish and Wildlife Service (USFWS). 2005. Management Plan for River Herring in the Connecticut River Basin. Available http://www.fws.gov/r5crc/herring_plan.html. (Accessed May 2005)

SPECIES PROFILE

Bridle Shiner

Notropis bifrenatus

Federal Listing: Not listed
State Listing: Not listed
Global Rank: G3
State Rank: S3
Author: Matthew, A. Carpenter, NHFG

Element 1: Distribution and Habitat

1.1 Habitat Description

Bridle shiners inhabit backwater streams and ponds with little or no current (Harrington 1948b; Finger 2001). They feed and spawn among submerged and emergent vegetation in shallow water (Harrington 1948*a*; Harrington 1948*b*).

1.2 Justification

The bridle shiner is declining over most of its range (Sabo 2000). In Pennsylvania, where the bridle shiner is listed as endangered, its range has been reduced to 1 site out of 31 historical sites (Finger 2001). Although the reasons for the decline of the bridle shiner are poorly understood, the long-term effects of urbanization, such as increased turbidity and changes in hydrology, have been attributed to the decline of other cyprinids (Weaver and Garman 1994, Fairchild et al. 1997). The range of the bridle shiner in New Hampshire is almost entirely in the southeast, an area undergoing the fastest rate of urbanization in New England.

1.3 Protection and Regulatory Status

The bridle shiner is listed as a legal bait species in New Hampshire.

1.4 Population and Habitat Distribution

The bridle shiner was once widely distributed throughout the Atlantic coastal plain from North Carolina north to the St. Lawrence River and eastern Ontario (Scott and Crossman 1973). Records of the bridle shiner in New Hampshire are limited to the Merrimack and coastal watersheds. The current distribution of the bridle shiner in New Hampshire is not well known.

1.5 Town Distribution Map

Canterbury, Concord, Conway, Durham, Eaton, Epping, Epsom, Farmington, Freedom, Hillsborough, Hooksett, Lee, Loudon, Madison, Meredith, Merrimack, Middleton, Milton, Moultonborough, New Hampton, Nottingham, Northwood, Pittsfield, Rochester, Salem, Sanborton, South Hampton, Strafford, Webster, Windham

1.6 Habitat Map

More research is necessary to determine the distribution and habitat requirements of this species in New Hampshire. A map of low-gradient streams and pond habitat in the coastal watersheds (refer to the system 13) and the Merrimac watersheds (systems 10, 11, 12, and 14) would help target future survey work.

1.7 Sources of Information

Bridle shiners have been caught during the Fishing for the Future Project conducted by New Hampshire Fish and Game (NHFG) and the Biomonitoring Program of the New Hampshire Department of Environmental Services. Historical records are from biological surveys conducted by the NHFG from 1937 to 1939.

1.8 Extent and Quality of Data

Twenty-nine of 49 records come from biological surveys by NHFG in the 1930s. No surveys have specifically targeted bridle shiners or their habitat in New Hampshire. A systematic survey will be necessary to establish the range of the species in the state.

1.9 Distribution Research

Habitat studies are needed to better understand the potential distribution of bridle shiners in New Hampshire. Resurveying historical sampling sites may show changes in the range of this species. All data on the distribution of bridle shiner, as well as other fish species native to New Hampshire, should be consolidated into a central database.

The bridle shiner is one of 4 fish species of concern—including redfin pickerel, banded sunfish, and swamp darter—that depend on vegetated stream and pond habitats of southeastern New Hampshire. The ecology of this aquatic system is poorly understood. Fish surveys in these habitats can be used as a baseline for monitoring the effects of urbanization and for measuring the success of future restoration or protection efforts.

Element 2

Not completed for this species

Element 3

Not completed for this species

Element 4

Not completed for this species

Element 5: References

5.1 Literature

Bailey, R.M. 1938. The fishes of the Merrimack watershed. In: A biological survey of the Merrimack watershed. New Hampshire Fish and Game Dept., Survey Report No. 3:149-185

Fairchild, G.W., R.J. Horwitz, D.A. Nieman, and M.R. Boyer. 1998. Spatial variation and historical change in fish communities of the Schuylkill River drainage, southeastern Pennsylvania. American Midland Naturalist 139:282-295.

Finger, B.L. Life History and Range of Pennsylvania's endangered Bridle Shiner. 2001. M.S. Thesis, Pennsylvania State University, University Park.

Harrington, R.W. 1946. A contribution to the biology of the bridled shiner, *Notropis bifrenatus* (Cope). M.S. Thesis, Cornell University, Ithaca.

Harrington, R.W. 1948a. The food of the bridled shiner, *Notropis bifrenatus* (Cope). American Midland Naturalist 40:353-361.

Harrington, R.W. 1948b. The life cycle and fertility of the bridled shiner, *Notropis bifrenatus* (Cope). American Midland Naturalist 39(1):83-92.

Sabo, M.J. 2000. Threatened fishes of the world: *Notropis bifrenatus* (Cope, 1867) (Cyprinidae). Environmental Biology of Fishes 59:384

Scott W., and E. Crossman. 1973. Freshwater Fishes of Canada. Fisheries Research Board of Canada. 966p.

Weaver, L.A., and G.C. Garman. 1994. Urbanization of a watershed and historical changes in a stream fish assemblage. Transaction of the American Fisheries Society 123:162-172

5.2 Data Sources

Biomonitoring Program. 1995-2005. New Hampshire Department of Environmental Services, Watershed Management Bureau. < www.des.state.nh.us/wmb/biomonitoring/sites/index.html >. Accessed 2004 December 12

NatureServe. 2005. NatureServe Explorer: An online encyclopedia of life [web application]. Version 4.2. NatureServe, Arlington, Virginia. Available http: //www.natureserve.org/explorer. (Accessed: February 2, 2005).

SPECIES PROFILE

Rainbow Smelt

Osmerus mordax

Federal Listing: Not listed
State Listing: Not listed
Global Rank: G5
State Rank: G5
Author: Matthew, A. Carpenter, NHFG

Element 1: Distribution and Habitat

1.1 Habitat Description

Marine smelt concentrate in estuaries and harbors. Coastal smelt populations move into rivers shortly after the break up of ice to spawn at the head of tide. During spawning they seek out gravel substrate with swift current (Scarola 1987). Freshwater smelt populations are mainly found in deep, cold, clear lakes. Some freshwater populations are found in unstratified warmwater ponds. Landlocked populations will spawn up tributary rivers of lakes and ponds or along lakeshores with sand, gravel, or fallen leaves (Scarola 1987).

1.2 Justification

Rainbow smelt populations are important forage bases for several marine and freshwater fishes as well as for a variety of bird species (Scarola 1987, National Marine Fisheries Service (NMFS) 2004). Barriers, sedimentation, and water quality degradation can affect smelt recruitment success (NMFS 2004). Recent data suggest rainbow smelt populations are declining in the Great Bay system and other waterbodies of New Hampshire (NHFG 2004, John Viar, NHFG, personal communication).

1.3 Protection and Regulatory Status

A fishing license is required for the taking of rainbow smelt inland of Memorial Bridge in Newington-Portsmouth. There is a daily limit of 10 liquid quarts with heads and tails intact. Handheld bow nets and dip nets may be used on the Oyster, Squamscott, Bellamy, and Lamprey Rivers between 16 December and 28 February. Nets and weirs are prohibited from 1 March to 15 December inland of Memorial Bridge.

Two different methods can be used to take freshwater smelt. Both methods (angling and dip netting) have a daily limit of 2 liquid quarts. Angling seasons for rainbow smelt vary by waterbody management type. A limited number of waterbodies are open to dip net fishing. The season for taking smelt with a dip net is between 15 March and 30 April between sunset and midnight.

1.4 Population and Habitat Distribution

Rainbow smelt are found along the coast of North America in both the north Atlantic and the north Pacific Oceans (Scarola 1987). Great Bay, and the rivers that flow into it, are important spawning areas and nursery habitat for coastal smelt populations. Native landlocked populations are believed to exist in Winnipesaukee, Winnisquam, and Squam lakes (Scarola 1987). Several other waterbodies throughout New Hampshire are believed to contain introduced smelt populations. As many as 105 waterbodies currently have or once held smelt populations (NHFG unpublished data).

1.5 Town Distribution Map

Maps for native and stocked freshwater smelt populations are provided.

1.6 Habitat Map

Anadromous rainbow smelt inhabit rivers, harbors, and estuaries of southeastern of New Hampshire.

See the Tidal Coastal Watersheds profile (system 13). Freshwater landlocked populations of rainbow smelt are residents in several lakes and ponds scattered throughout New Hampshire. See the Northern Upland Watersheds (systems 5 and 7), Mainstem Watersheds (systems 1 and 2), Southern Upland Watersheds (systems 3 and 9), Montane Watersheds (systems 4, 6, and 8), Coastal Transitional Watersheds (systems 10 and 14), and Non-Tidal Coastal Watersheds(systems 11 and 12) profiles.

1.7 Sources of Information

Published literature, a rainbow smelt profile from the National Marine Fisheries Service, and NHFG unpublished data were used to determine distribution and habitat requirements of the species.

1.8 Extent and Quality of Data

Distribution of rainbow smelt is well known but the population status is not. Ice-angling creel and egg deposition surveys would provide a good measure of relative abundance over time.

1.9 Distribution Research

- Determine the presence or absence of rainbow smelt populations that are not already monitored
- Monitor known populations of anadromous and landlocked populations for trend data
- Identify factors that may limit the spawning productivity of smelt populations within coastal watersheds

Element 2

Not completed for this species

Element 3

Not completed for this species

Element 4

Not completed for this species

Element 5: References

Scarola, J. 1987. Freshwater Fishes of New Hampshire (2nd Edition). New Hampshire Fish and Game Department, Concord, New Hampshire, USA.

National Marine Fisheries Service [NMFS]. 2004. Rainbow Smelt Profile. Available <http://www.nmfs.noaa.gov/pr/species/concern/profiles/rainbow_smelt.pdf>. (Accessed April 2005).

New Hampshire Fish and Game Department [NHFGD]. 2004. New Hampshire Marine Fisheries Investigations. Grant F-61-R. 171p.

SPECIES PROFILE

Redfin Pickerel

Esox americanus americanus

Federal Listing: Not listed
State Listing: Not listed
Global Rank: G5T5
State Rank: S4
Author: Benjamin, J. Nugent, NHFG

Element 1: Distribution and Habitat

1.1 Habitat Description

Redfin pickerel inhabit slow-moving, acidic, tea-colored streams with dense vegetation. The species is commonly found within brush piles or beneath overhanging vegetation (Scarola 1987, Fishbase 2005). Redfin pickerel also have been observed in brackish waters and swampy areas with low dissolved oxygen levels (Steiner 2004). Spawning occurs in shallow flood margins of stream habitats with thick vegetation. Redfin pickerel spawn mainly in the early spring, but there is some indication of spawning in the fall (Scott and Crossman 1973, Scarola 1987). Wintering habitat is often associated with leaf litter (Fishbase 2005).

1.2 Justification

Scarce data on this species may indicate low population levels. Redfin pickerel appear to be restricted to southeastern New Hampshire, and rapid urbanization in this region makes the species susceptible to poor water quality and other habitat related threats (Richter et al. 1997). The introduction of other Esox species into aquatic systems with low redfin pickerel populations may compromise the genetic identity of the species. Kramer (2002) recognizes the importance of the redfin pickerel as a top-level predator in certain aquatic communities.

1.3 Protection and Regulatory Status

There are no specific protection or regulations for this species.

1.4 Population and Habitat Distribution

The redfin pickerel inhabits watersheds in the Atlantic coastal plain of the eastern United States and southeastern Canada (Scarola 1987). All evidence suggests that the species occurs exclusively in the coastal and lower Merrimack watersheds within New Hampshire (Gordon 1937, Bailey 1938, New Hampshire Fish and Game (NHFG) unpublished data, New Hampshire Department of Environmental Services (NHDES) Biomonitoring data).

1.5 Town Distribution Map

A map is provided.

1.6 Habitat Map

More research will be necessary to determine the current distribution and habitat requirements of this species in New Hampshire. A map of low gradient streams and pond habitat in the coastal watersheds (refer to the system 13) and the Merrimac watersheds (System 11 and system 12) would facilitate future surveys.

1.7 Sources of Information

Published literature provided information on distribution and habitat requirements. NHFG unpublished data, NHDES Biomonitoring data, and watershed biological surveys conducted by NHFG from 1937 to 1939 were used in defining population locations of the species within New Hampshire.

1.8 Extent and Quality of Data

Data on the distribution of the redfin pickerel in New Hampshire were collected in other studies and monitoring projects. No surveys have been conducted that specifically target redfin pickerel or their habitat. The NHDES Biomonitoring program provides the most recent information on the presence of redfin pickerel at certain sampling sites in southeastern New Hampshire. All records of redfin pickerel should be viewed with caution because the species is easily mistaken for a juvenile chain pickerel (Scarola 1987).

1.9 Distribution Research

Distribution data for redfin pickerel in New Hampshire should be obtained. The NHDES Biomonitoring data could be used to guide future sampling efforts to establish the range of the species. Studies of factors that limit the distribution and abundance of redfin pickerel would be helpful. Habitat data collected from sites with known populations may be used to identify new survey sites. Data should be entered into a GIS database to help identify variables that may predict the presence of redfin pickerel and to track the distribution of the species over time.

Element 2
Not completed for this species

Element 3
Not completed for this species

Element 4
Not completed for this species

Element 5: References

5.1 Literature

Bailey R.M. 1938. The Fishes of the Merrimack Watershed. In: A Biological Survey of the Merrimack Watershed. New Hampshire Fish and Game Department, Survey Report No. 3:149-185.

Gordon, M. 1937. The Fishes of Eastern New Hampshire. In: A Biological Survey of the Androscoggin, Saco and Coastal Watersheds. New Hampshire Fish and Game Department, Survey Report no. 2: 101-118.

Kramer, N. 2002. Nonsport and Commercial Management Plan. Maine Division of Inland Fisheries and Wildlife, Division of Fisheries and Hatcheries, Augusta, Maine, USA.

Richter, B.D., D.P. Braun, M.A. Mendelson, and L.L. Master. 1997. Threats to imperiled freshwater fauna. Conservation Biology 11:1081-1093.

Scarola, J. 1987. Freshwater Fishes of New Hampshire. New Hampshire Fish and Game Department, Concord, New Hampshire, USA.

Scott, W., and E. Crossman. 1973. Freshwater Fishes of Canada. Fisheries Research Board of Canada. 966p.

Steiner L. 2004. Pennsylvania Fishes. http://sites.state.pa.us/PA_Exec/Fish_Boat/pafish/fishhtms/chap14.htm (Accesed 2005 Feb 8)

5.2 Data Sources:

Biomonitoring Program. 1995-2005. New Hampshire Department of Environmental Services, Watershed Management Bureau. www.des.state.nh.us/wmb/biomonitoring/sites/index.html >. Accessed 2004 December

Fishbase. 2005. Redfin pickerel species summary page. < www.fishbase.se/Summary/SpeciesSummary.cfm?genusname=Esox&speciesname=americanus%20americanus>. Accessed 2005 Dec.

SPECIES PROFILE

Sea Lamprey

Petromyzon marinus

Federal Listing: Not listed
State Listing: Not listed
Global Rank: G5
State Rank: S4
Author: Matthew A. Carpenter, NHFG

Element 1: Distribution and Habitat

1.1 Habitat Description

Sea lampreys spend their adult lives in the ocean as a parasite on other fish. After 20 to 30 months at sea they migrate into freshwater, following pheromones from larvae (ammocoetes) upstream (Vrieze and Sorenson 2001). Sea lampreys construct nests in gravel/cobble riffle sections of freshwater streams (Scarola 1987). Once hatched, the larvae float downstream to slow moving pools where they burrow into the substrate and filter feed on organic detritus drifting in the water column (Scarola 1987).

1.2 Justification

Sea lampreys are blocked from much of their spawning habitat by dams, and in New Hampshire depend on fishways to reach spawning habitat. Although Atlantic coastal populations are not currently endangered, there have been significant declines in lamprey populations throughout the northern hemisphere (Renaud 1997). A complex life cycle, which is dependent on multiple habitats in freshwater and marine ecosystems, makes the sea lamprey vulnerable to the effects of urbanization in coastal watersheds (Creel 2003).

1.3 Protection and Regulatory Status

A permit is required to collect lampreys for research.

1.4 Population and Habitat Distribution

The sea lamprey is native to rivers from Florida to Nova Scotia in the West Atlantic, and from Western Europe to northern Africa in the east Atlantic. In New Hampshire, sea lampreys are restricted to rivers with actively managed fish ladders. During the spring spawning runs of river herring and American shad, lampreys use the Connecticut River, Merrimack River, and coastal rivers (Scarola 1987).

1.5 Town Distribution Map

Not completed for this species

1.6 Habitat Map

Sea lampreys inhabit the lower section of the Merrimack River and the coastal watersheds of New Hampshire. See the Non-Tidal Coastal Watersheds (systems 11 and 12), Mainstem Watersheds (systems 1 and 2), and Tidal Coastal Watersheds (system 13) profiles.

1.7 Sources of Information

Sea lamprey numbers are recorded during the monitoring programs for other fish. (eels are catadromous)

1.8 Extent and Quality of Data

Data on sea lamprey returns are often incidental to data collected on the spawning runs of other fish.

1.9 Distribution Research

The actual locations of sea lamprey spawning habitat and ammocoete habitat within New Hampshire watersheds are unknown.

Element 2
Not completed for this species

Element 3
Not completed for this species

Element 4
Not completed for this species

Element 5: References

Creel, L. 2003. Ripple Effects: Population and Coastal Regions (Washington, D.C.: Population Reference Bureau)

Renaud, C.B. 1997. Conservation status of Northern Hemisphere lampreys (Petromyzontidae). Journal of Applied Ichthyology 13(3):143-148.

Scarola, J. 1987. Freshwater Fishes of New Hampshire (2nd Edition). New Hampshire Fish and Game Department, Concord, New Hampshire, USA.

Vrieze, L.A., and P.W. Sorensen. 2001. Laboratory assessment of the role of a larval pheromone and natural stream odor in spawning stream localization by migratory sea lamprey. Canadian Journal of Fisheries and Aquatic Science 58:2374-2385.

SPECIES PROFILE

Swamp Darter

Etheostoma fusiforme

Federal Listing: Not listed
State Listing: Not listed
Global Rank: G5
State Rank: S3
Author: Benjamin, J. Nugent, NHFG

Element 1: Distribution and Habitat

1.1 Habitat Description

The swamp darter inhabits lakes and ponds in shallow areas of soft muddy substrate, dense vegetation, and accumulated detritus. Stream habitats include both swift and slow moving water with patches of thick vegetation (Schmidt and Whitworth 1979, Scarola 1987). Research in Connecticut streams and ponds found swamp darters to be more abundant in ponds than in streams, and stream populations were usually found near known pond populations. Spawning activity was not observed in streams, indicating that stream populations may depend on recruitment from ponds (Schmidt and Whitworth 1979). Swamp darters are dependent on vegetation for spawning (Toth et al. 1998).

1.2 Justification

Swamp darter populations appear to be restricted to watersheds in the southeastern corner of the state. New Hampshire is near the northern extent of the swamp darters' global range. The short life span of the swamp darter (1 to 2 years), combined with aquatic habitat degradation caused by increasing development in southeastern New Hampshire, make the species vulnerable to extirpation from state waters (Schmidt 1983). There is little information available on the distribution, abundance, or health of swamp darter populations in New Hampshire.

1.3 Protection and Regulatory Status

This species is not protected.

1.4 Population and Habitat Distribution

The species inhabits watersheds in coastal plains of the eastern United States from Maine to North Carolina (Scarola 1987). Gordon (1937) and Bailey (1938) found populations of swamp darters in both lentic and lotic environments in the lower Merrimack and coastal watersheds. Populations in these areas were later observed in the mid 1980s (NHFG unpublished data).

1.5 Town Distribution Map

Within the last 20 years, swamp darters have been observed in Auburn, Barrington, Durham, Lee, Manchester, Merrimack, Milford, Salem, and Windham; before then, they were observed in Chester, Madbury, Nottingham, Raymond, and Strafford.

1.6 Habitat Map

More research is needed to determine the distribution and habitat requirements of this species in New Hampshire. A map of low gradient streams and pond habitat in the coastal watersheds (refer to the system 13) and the Merrimac watersheds (refer to system 11 and system 12) would help target future survey work.

1.7 Sources of Information

Published literature and Internet sources were used to define the species' global distribution and habitat requirements. Statewide distribution data for the swamp darter were obtained from NHFG survey sites during the mid 1980s and from historical biological surveys of the Merrimack and Coastal watersheds. Historical distribution data were confirmed using samples contained in a museum database (UMMZ Fish Collection 2005).

1.8 Extent and Quality of Data

Information on the current distribution of the swamp darter within the state is limited, though statewide sampling data confirm that the species is restricted to southeastern New Hampshire. However, the range of the swamp darter population within this region is not well understood. The swamp darter can be confused with the tessellated darter.

1.9 Distribution Research

Of 19 known swamp darter records, 12 came from biological surveys by NHFGD in the 1930s. Resurveying historical sample sites should be the first step toward assessing the status of the swamp darter population. Habitat data collected from sites with known populations may be used to identify new survey sites. Data should be entered into a GIS database to help identify variables that may predict the presence of banded sunfish and to track the distribution of the species over time.

Element 2
Not completed for this species

Element 3
Not completed for this species

Element 4
Not completed for this species

Element 5: References

5.1 Literature

Bailey, R.M. 1938. The Fishes of the Merrimack Watershed. In: A Biological Survey of the Merrimack Watershed. New Hampshire Fish and Game Department, Survey Report No. 3:149-185.

Gordon, M. 1937. The Fishes of Eastern New Hampshire. In: A Biological Survey of the Androscoggin, Saco and Coastal Watersheds. New Hampshire Fish and Game Department, Survey Report No. 2:101-118.

Scarola, J. 1987. Freshwater Fishes of New Hampshire. New Hampshire Fish and Game Department, Concord, New Hampshire, USA.

Schmidt, R., and W. Whitworth. 1979. Distribution and habitat of the swamp darter (*Etheostoma fusiforme*) in southern New England. American Midland Naturalist 102:408-413.

Schmidt, R. 1983. The Swamp Darter. American Currents: Publications of the North American Native Fishes Association. <http://www.nativefish.org/Articles/E_fusiforme.htm>. Accessed 2005 Jan.

Toth, L., S. Melvin, D. Arrington, and J. Chamberlain. 1998. Hydrologic Manipulations of the Channelized Kissimmee River. BioScience 48:757-764.

5.2 Data Sources

Biomonitoring Program. 1995-2005. New Hampshire Department of Environmental Services, Watershed Management Bureau. www.des.state.nh.us/wmb/biomonitoring/sites/index.html >. Accessed 2004 December 12

NatureServe. 2005. NatureServe Explorer: An online encyclopedia of life [web application]. Version 4.2. NatureServe, Arlington, Virginia. <http://www.natureserve.org/explorer> (Accessed: February 5, 2005).

University of Michigan Museum of Zoology (UMMZ). 2005. Fish Collection Search. <http://141.211.243.52/UMMZ/.> (Accessed: January 3, 2005).

SPECIES PROFILE

Tessellated Darter

Etheostoma olmstedi

Federal Listing: Not listed
State Listing: Not listed
Global Rank: G5
State Rank: S4
Author: Benjamin, J. Nugent, NHFG

Element 1: Distribution and Habitat

1.1 Habitat Description

The tessellated darter inhabits pools of warm upland streams and shallow areas in large lakes and rivers (Scarola 1987). It is usually found over mud or sand substrates (Scarola 1987). Slow to moderate flow in rivers and streams are preferred, although larger individuals may be found in rocky riffles (Schmidt 1980). Spawning occurs in the spring under an overhanging rock or log in shallows (Schmidt 1980).

1.2 Justification

The tessellated darter is one of 3 New Hampshire fish species that serve as hosts to the federally and state endangered dwarf wedgemussel (*Alasmidonta heterodon*) (Nedeau et al. 2000), and healthy populations of tessellated darter in the Connecticut and Ashuelot Rivers likely contribute to the persistence of dwarf wedgemussel populations in New Hampshire. The slimy sculpin (*Cottus cognatus*) and Atlantic salmon (*Salmo salar*) are the only other New Hampshire fish species that act as hosts for the dwarf wedgemussel (Nedeau et al. 2000, B. Wicklow, Saint Anselm College, personal communication). The disappearance of a self-sustaining Atlantic salmon population from the Connecticut River watershed has increased the importance of tessellated darter as a host species. A Massachusetts study suggests that the ability of dwarf wedgemussels to colonize new areas may be limited by the movements of tessellated darters (McLain and Ross 2005). Monitoring of the distribution and health of tessellated darter populations is needed to help protect the dwarf wedgemussel.

1.3 Protection and Regulatory Status

There is no specific protection of this species at the state, regional, and federal levels.

1.4 Population and Habitat Distribution

Populations of tessellated darters are found in Atlantic drainages from the St. Lawrence River to Florida. In New Hampshire, the species had been reported to exist exclusively in the Connecticut River watershed, with no records in the extreme northern reaches (Scarola 1987). Bailey and Oliver (1939) found abundant populations of tessellated darters in the middle and lower portions of the Connecticut River and its tributaries. Tessellated darters have recently been documented in the Merrimack River watershed (NHDES Biomonitoring Program).

1.5 Town Distribution Map

A map is provided.

1.6 Habitat Map

A map of pond, stream, and lake habitat in the Connecticut and Androscoggin Headwaters (refer to the systems 5 and 7), Connecticut River (refer to the systems 1 and 2), Western Hills (refer to the systems 3 and 9), and Merrimack River (refer to the systems 10, 11, and 12) would facilitate future surveys.

1.7 Sources of Information

NHFG unpublished data, NHDES Biomonitoring data, and historic watershed surveys were used to define known and potential locations of tessellated darters within the state.

1.8 Extent and Quality of Data

Extensive survey work by NHFG and NHDES has documented the presence of tessellated darters in certain watersheds. Data suggest that the tessellated darter is not present in the coastal and Androscoggin watersheds. However, the possible presence of the species in these watersheds cannot be ruled out. Existing data are qualitative and are insufficient to identify population trends. Tessellated darters are often misidentified as swamp darters.

1.9 Distribution Research

Areas of potential coincidence of tessellated darters and dwarf wedgemussels should be a priority for distribution research. Reproduction of dwarf wedgemussel depends on populations of tessellated darters, therefore, there is a great need to obtain current distribution data. Resurveying sites with historical records may show changes in tessellated darter distribution patterns. Surveying additional locations in Connecticut and Merrimack River watersheds would provide better information on the statewide distribution of the species. Studies of the factors that limit the distribution and abundance of the species would aid in choosing survey sites. A better effort should be made to record observations of tessellated darter, as well as other nongame fish, during surveys of other species. Records of tessellated darter should be entered in a central database to track the distribution and status of all New Hampshire fish species.

Element 2

Not completed for this species

Element 3

Not completed for this species

Element 4

Not completed for this species

Element 5: References

5.1 Literature

Bailey J.R., and J.A. Oliver. 1939. The fishes of the Connecticut watershed. In: A biological survey of the Connecticut watershed. New Hampshire Fish and Game Dept., Survey Report No. 4:150-189

Bailey, R.M. 1938. The Fishes of the Merrimack Watershed. In: A Biological Survey of the Merrimack Watershed. New Hampshire Fish and Game Dept., Survey Report No. 3:149-185.

McLain, D.C., and M.R. Ross. 2005. Reproduction based on local patch size of *Alasmidonta heterodon* and dispersal by its darter host in the Mill River, Massachusetts, USA. Journal of the North American Benthological Society 24:139-147.

Nedeau, E.J., M.A. McCollough, and B.I. Swartz. 2000. The Freshwater Mussels of Maine. Maine Department of Inland Fisheries and Wildlife, Augusta, Maine, USA.

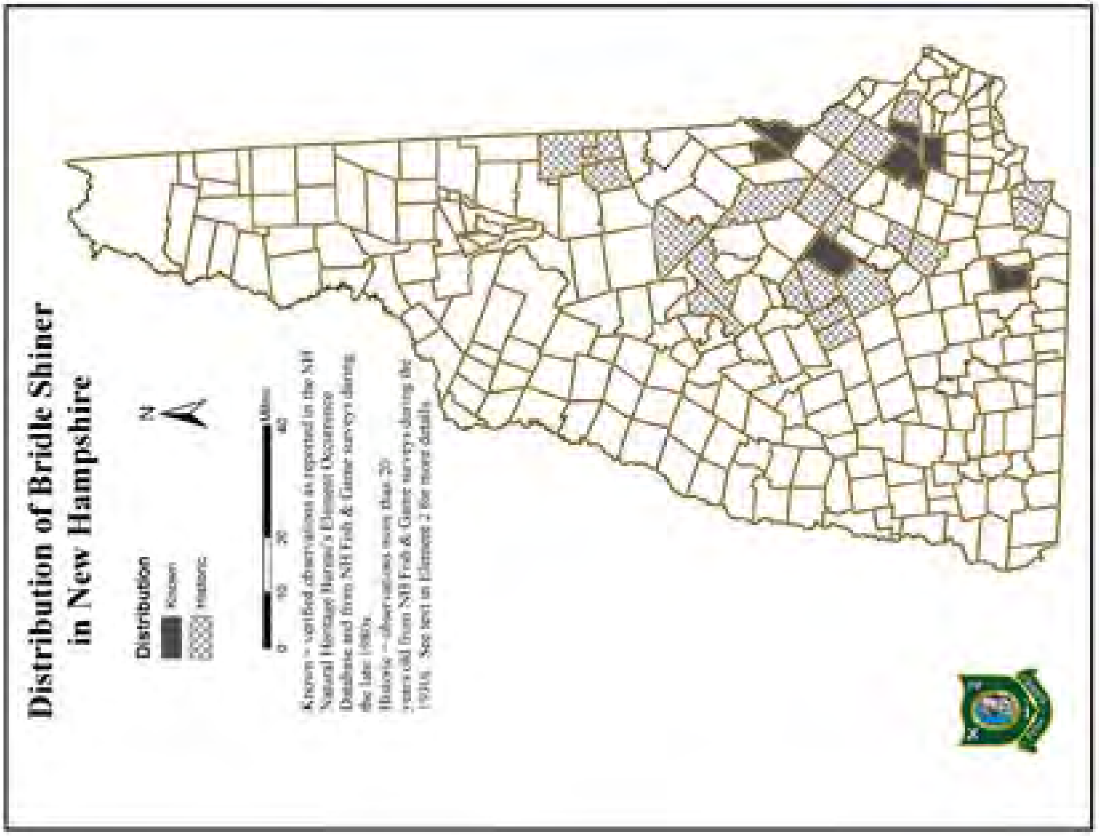
Scarola, J. 1987. Freshwater Fishes of New Hampshire (2nd edition). New Hampshire Fish and Game Department, Concord, New Hampshire, USA.

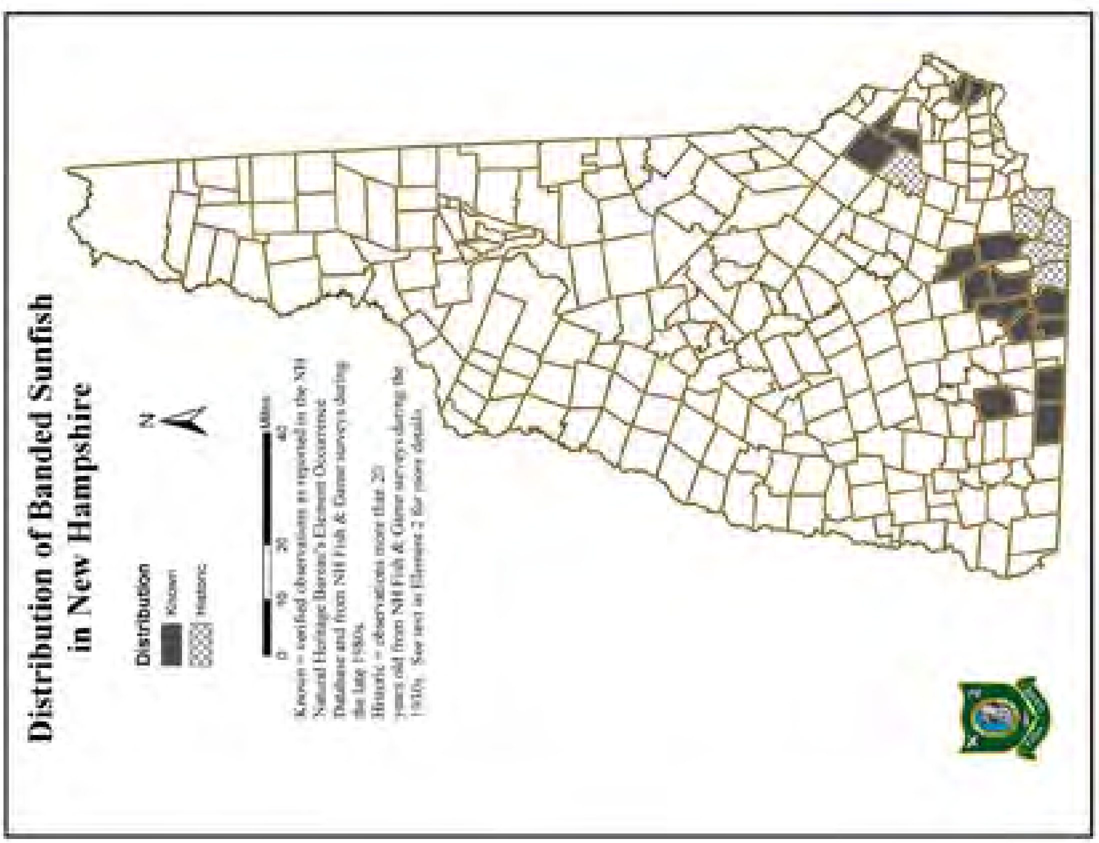
Schmidt R. 1980. The tessellated darter. North American Native Fish Association. <http://www.nativefish.org/Articles/E_olmstedi.htm>. Accessed 2005 Feb 4.

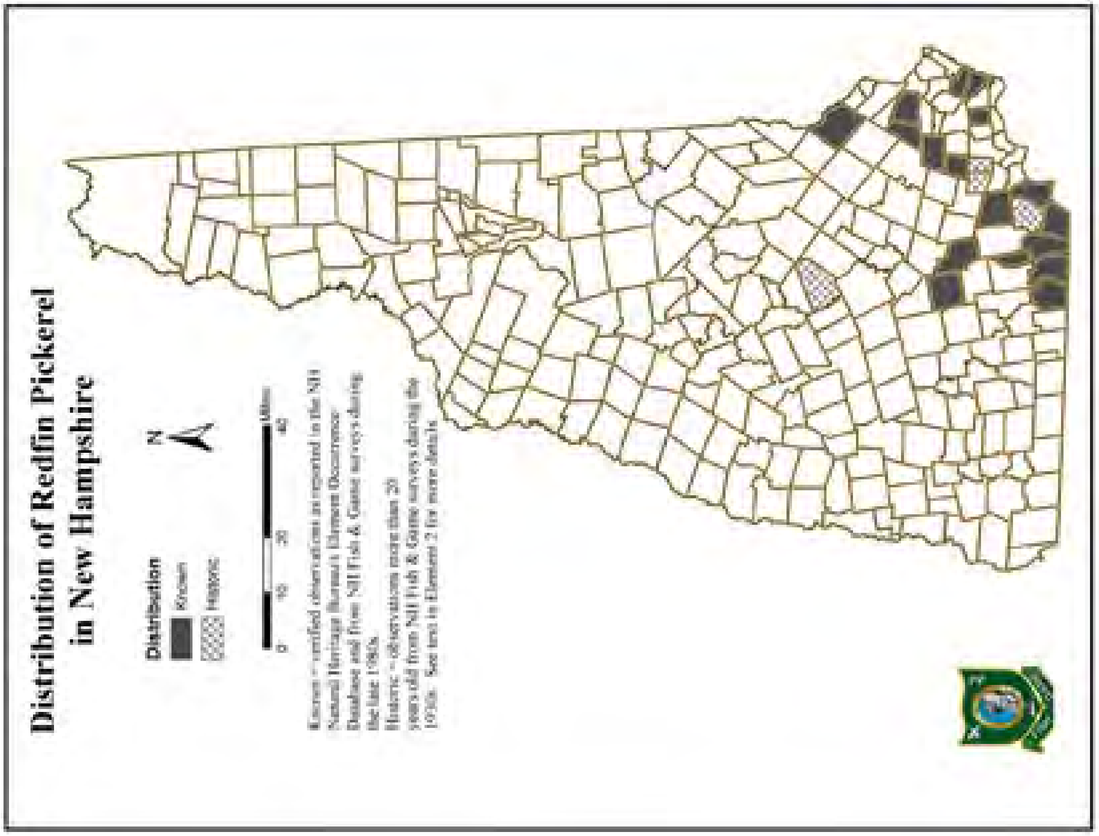
5.2 Data Sources

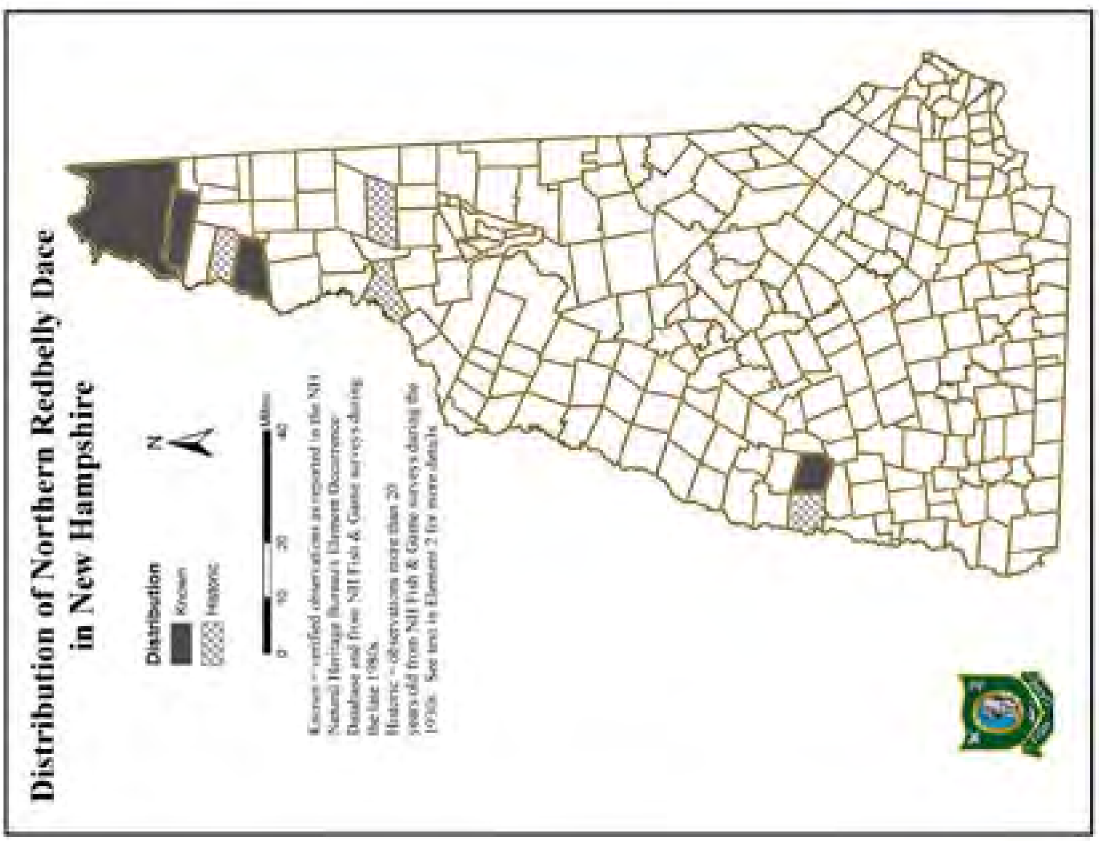
Biomonitoring Program. 1995-2005. New Hampshire Department of Environmental Services, Watershed Management Bureau. < http://www.des.state.nh.us/wmb/biomonitoring/sites/index.html >. Accessed 2004 December 12

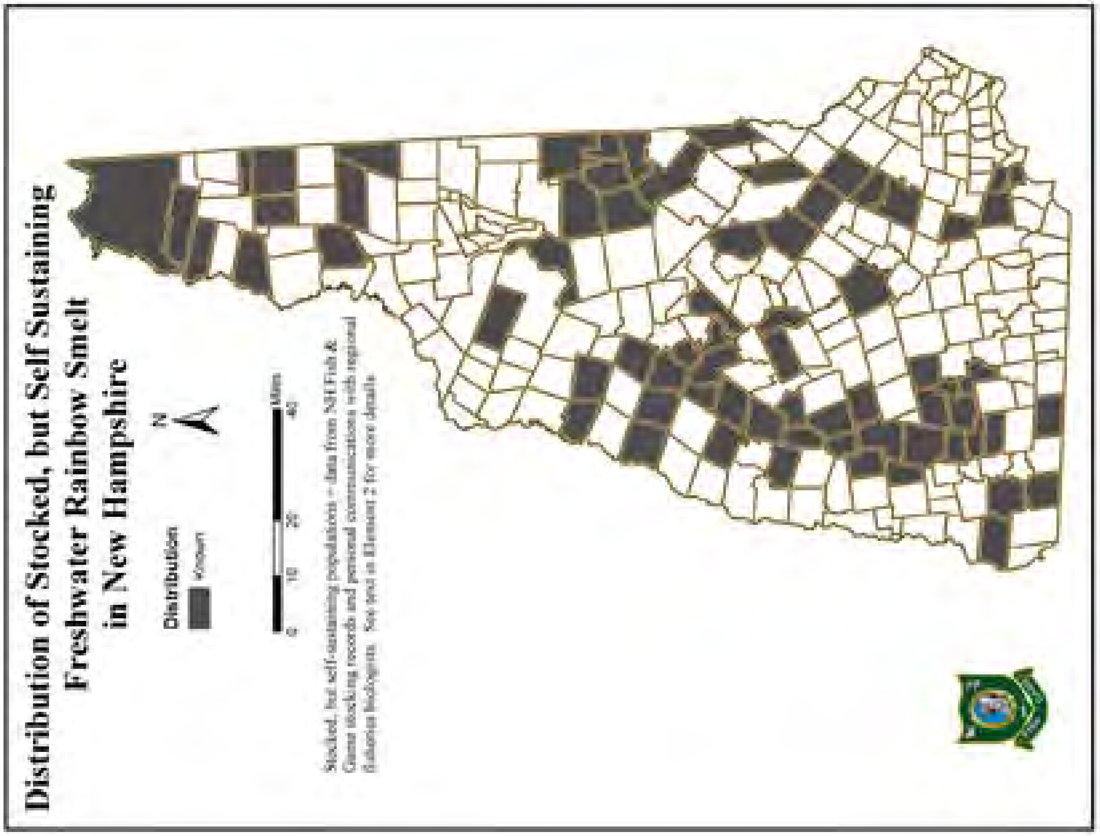
Fish Maps

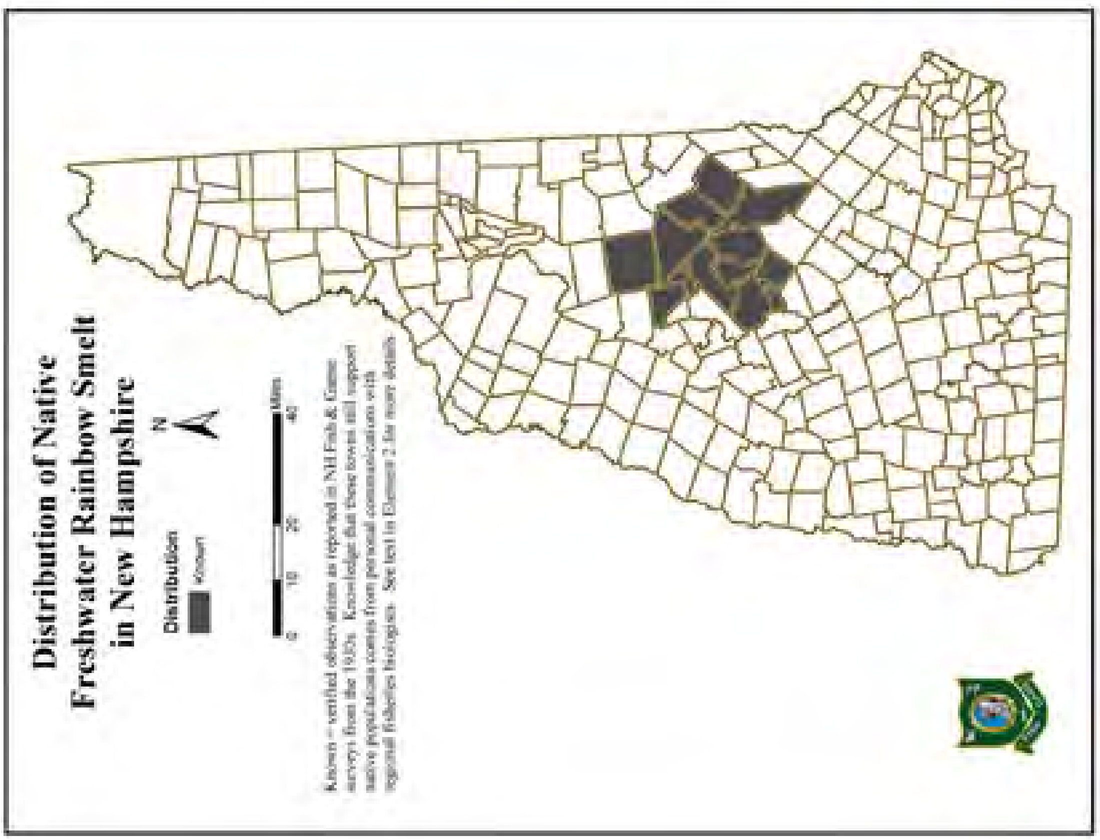

Distribution of Bridle Shiner
in New Hampshire
Distribution
Known
Historic
0 10 20 40 Miles
N
Known = verified observations as reported in the NH Natural Heritage Bureau's Element Occurrence Database and from NH Fish & Game surveys during the late 1980s.
Historic = observations more than 20 years old from NH Fish & Game surveys during the 1930s. See text in Element 2 for more details.


Distribution of Banded Sunfish
in New Hampshire
Distribution
Known
Historic
0 10 20 40 Miles
N
Known = verified observations as reported in the NH Natural Heritage Bureau's Element Occurrence Database and from NH Fish & Game surveys during the late 1980s.
Historic = observations more than 20 years old from NH Fish & Game surveys during the 1930s. See text in Element 2 for more details.


Distribution of Redfin Pickerel in New Hampshire
Distribution
Known
Historic
N
0 10 20 40 Miles
Known = verified observations as reported in the NH Natural Heritage Bureau's Element Occurrence Database and from NH Fish & Game surveys during the late 1980s.
Historic = observations more than 20 years old from NH Fish & Game surveys during the 1930s. See text in Element 2 for more details.


Distribution of Northern Redbelly Dace in New Hampshire
Distribution
Known
Historic
N
0 10 20 40 Miles
Known = verified observations as reported in the NH Natural Heritage Bureau's Element Occurrence Database and from NH Fish & Game surveys during the late 1980s.
Historic = observations more than 20 years old from NH Fish & Game surveys during the 1930s. See text in Element 2 for more details.


Distribution of Stocked, but Self Sustaining
Freshwater Rainbow Smelt
in New Hampshire
Distribution
Known
N
0 10 20 40 Miles
Stocked, but self-sustaining populations = data from NH Fish & Game stocking records and personal communications with regional fisheries biologists. See text in Element 2 for more details.


Distribution of Native
Freshwater Rainbow Smelt
in New Hampshire
Distribution
Known
N
0 10 20 40 Miles
Known = verified observations as reported in NH Fish & Game surveys from the 1930s. Knowledge that these towns still support native populations comes from personal communications with regional fisheries biologists. See text in Element 2 for more details.

Appendix O

Additional Hydraulic Model Output

Figure O-1. Exeter River Profile, Median September Flows, All Alternatives

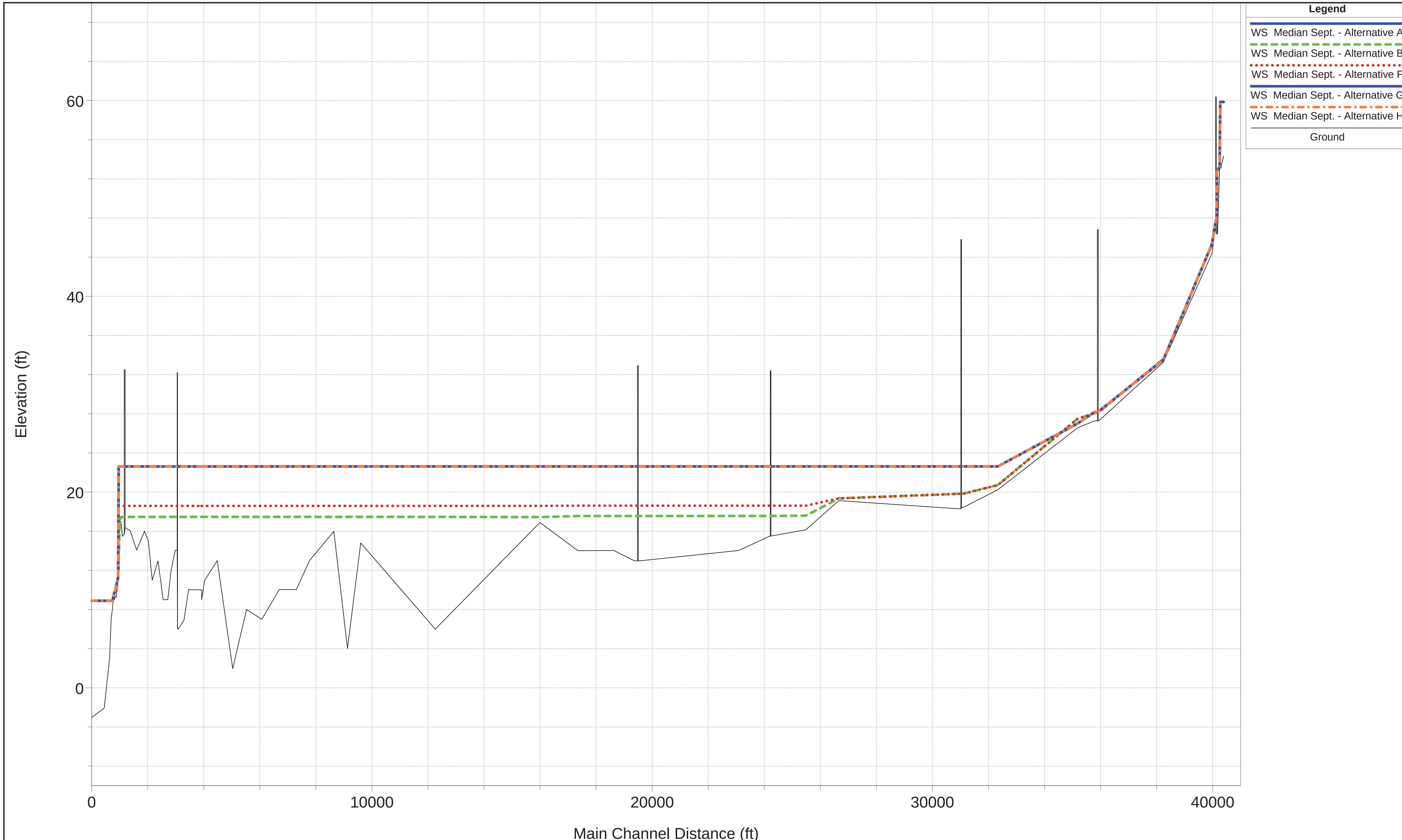


Figure O-1. Exeter River Profile, Median September Flows, All Alternatives

Figure O-2. Exeter River Profile, Median Annual Flows, All Alternatives

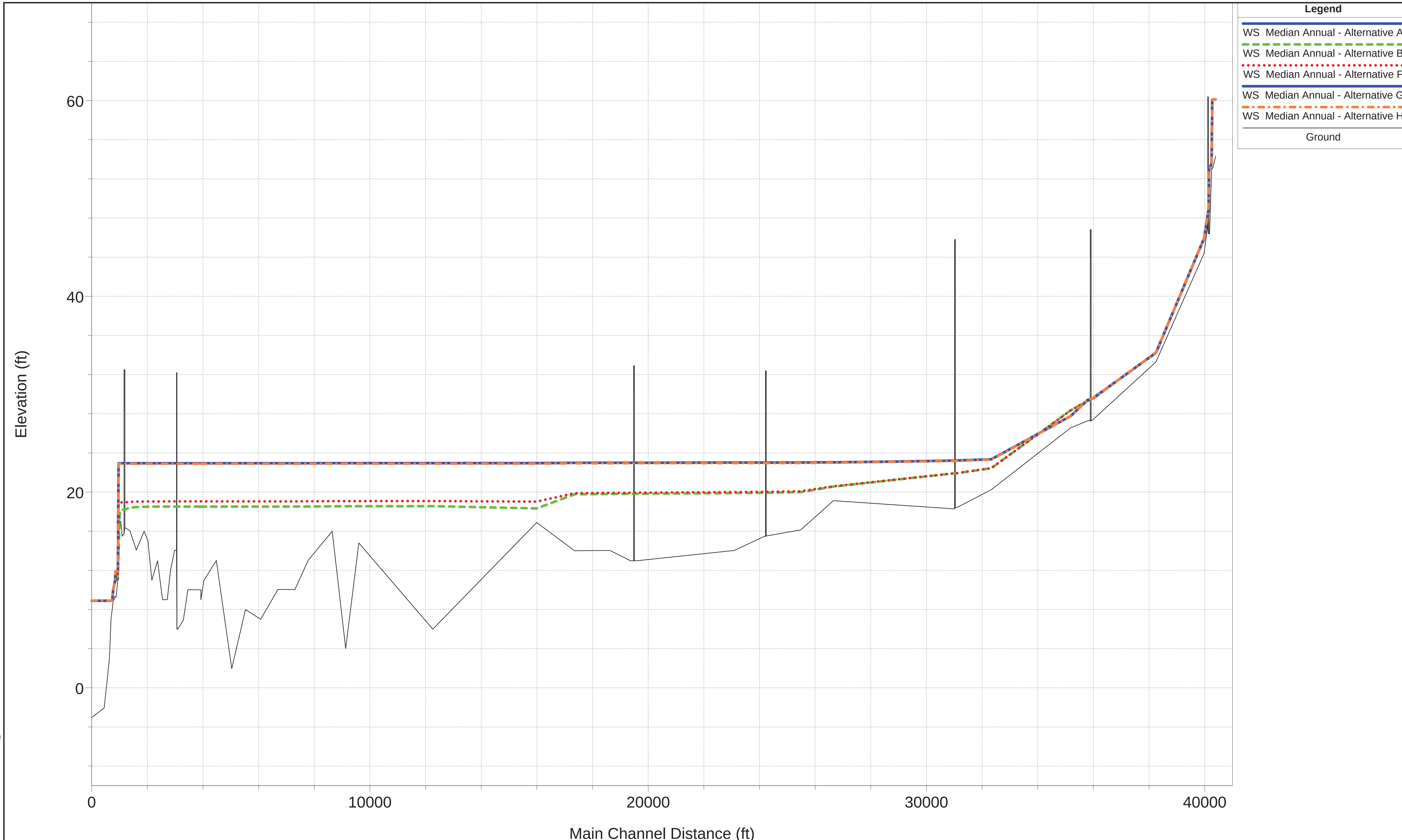


Figure O-2. Exeter River Profile, Median Annual Flows, All Alternatives

Figure O-3. Exeter River Profile, Median May Flows, All Alternatives

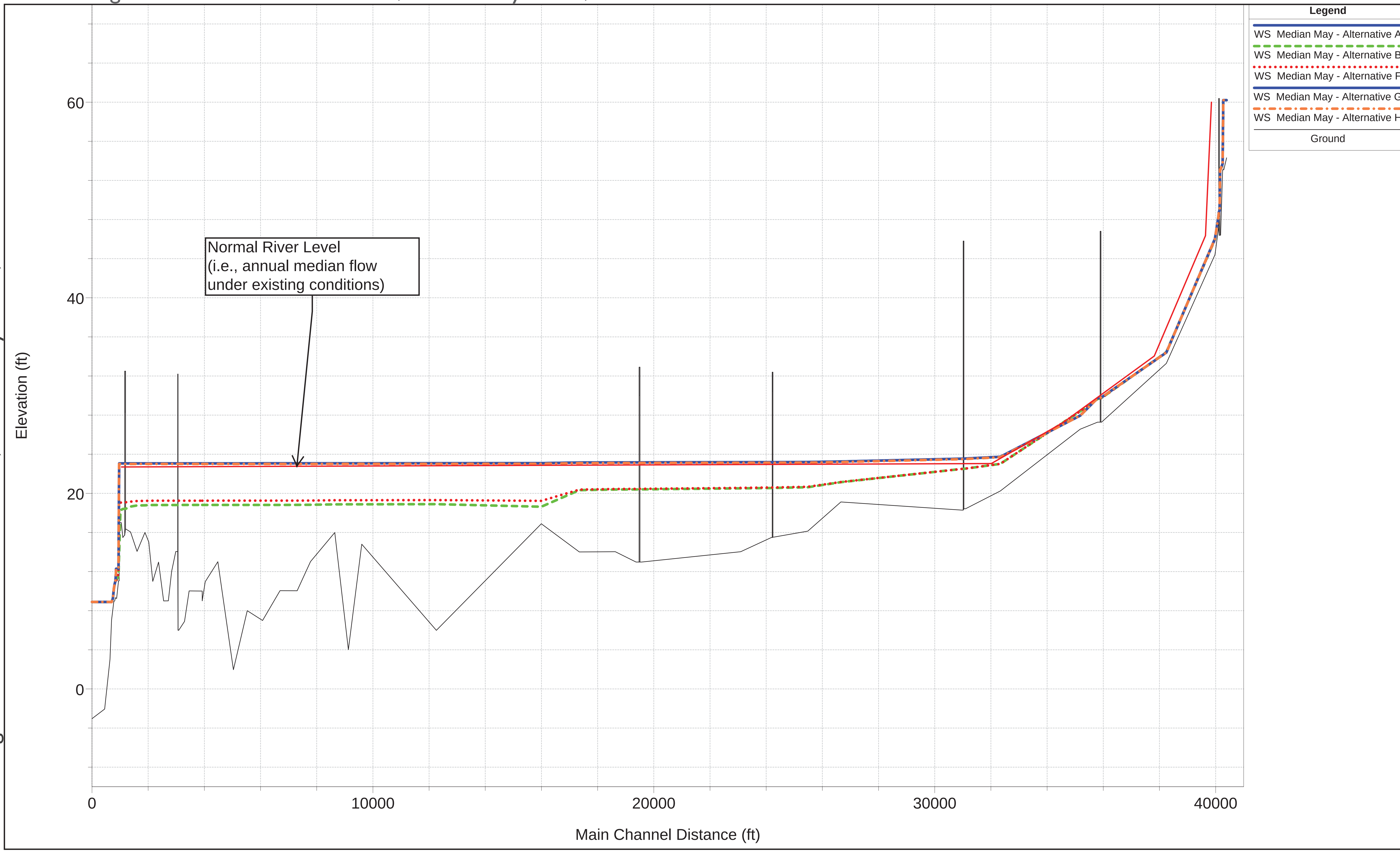


Figure O-3. Exeter River Profile, Median May Flows, All Alternatives

Figure O-4. Exeter River Profile, 2-year Flows, All Alternatives

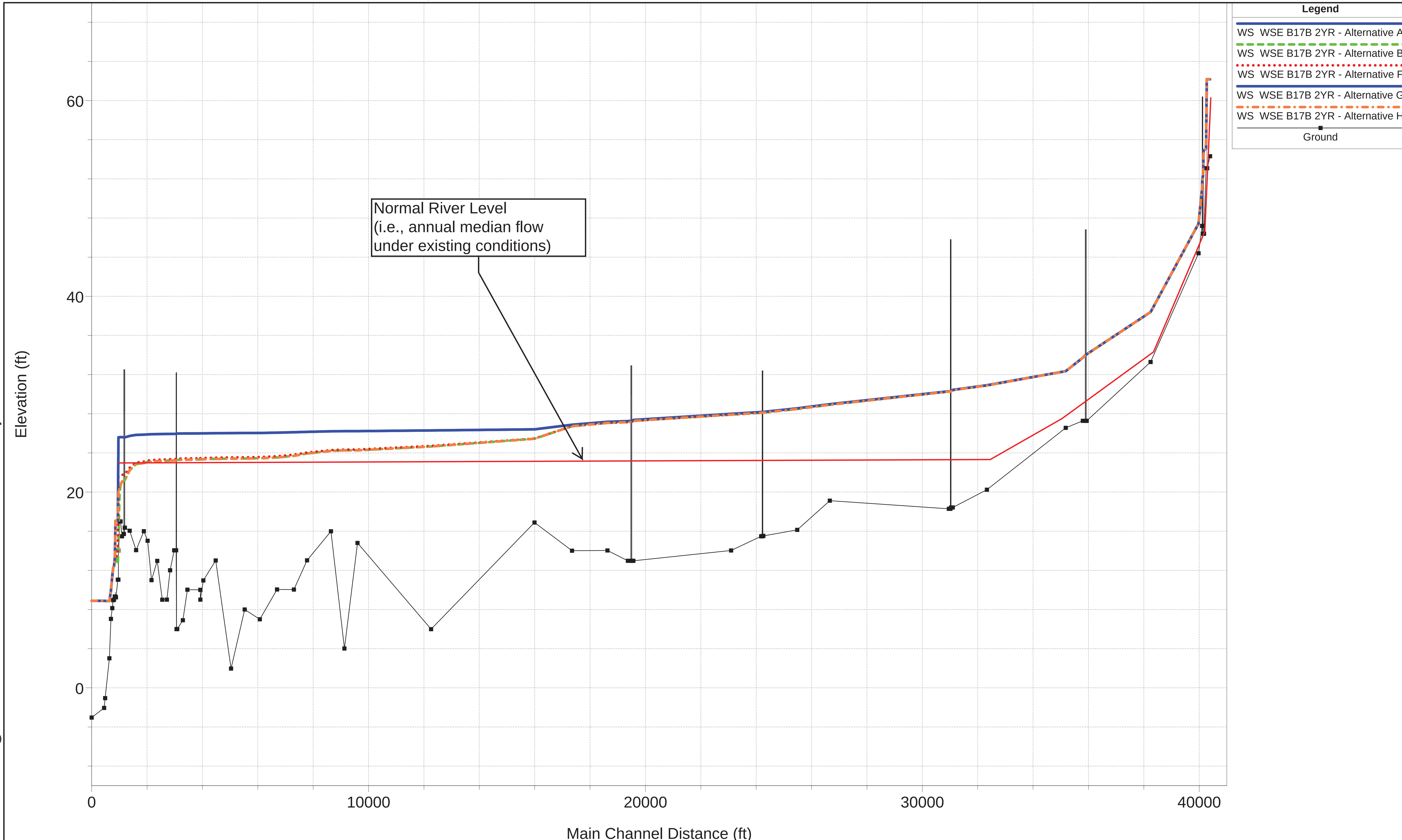


Figure O-4. Exeter River Profile, 2-year Flows, All Alternatives

Figure O-5. Exeter River Profile, 10-year Flows, All Alternatives

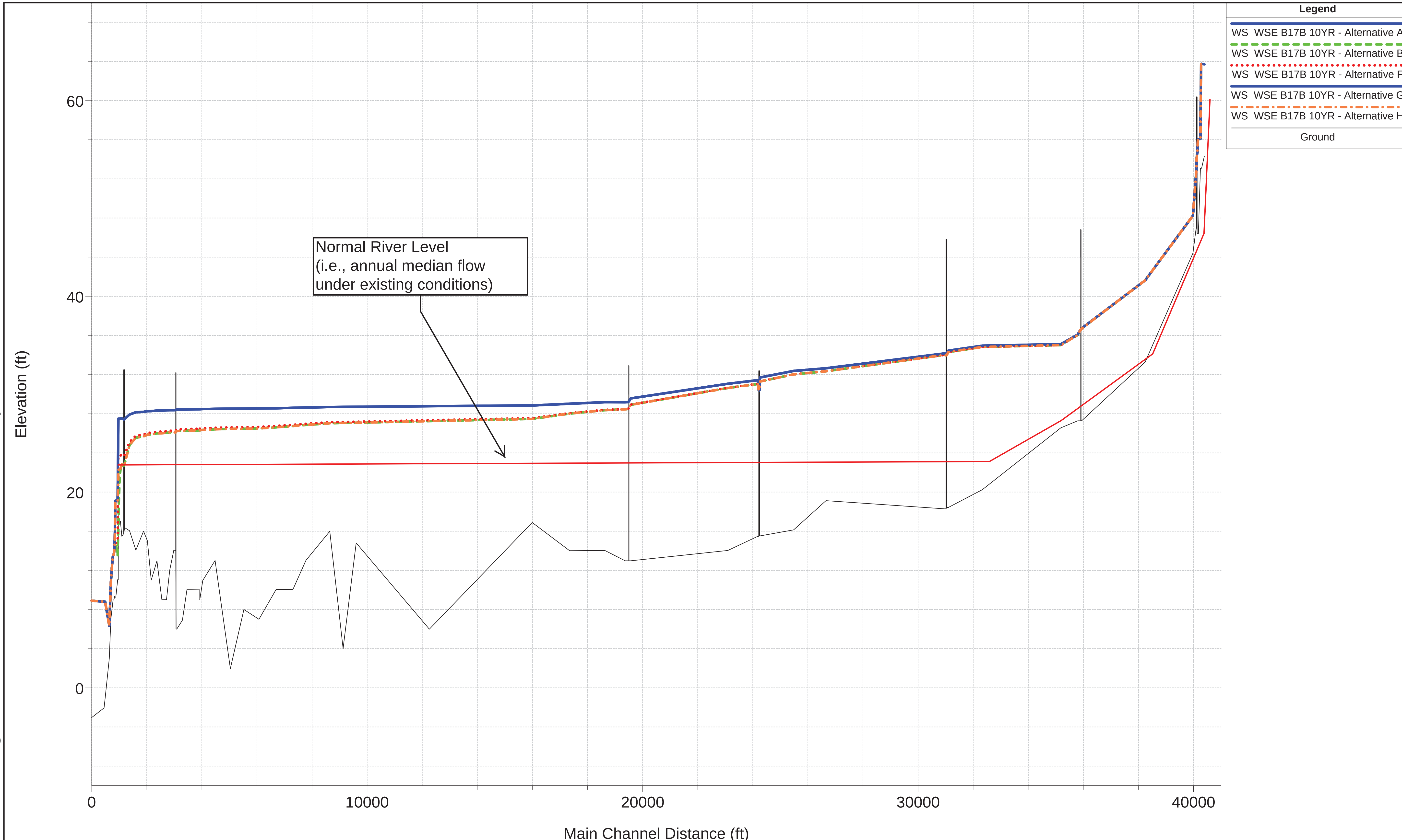


Figure O-5. Exeter River Profile, 10-year Flows, All Alternatives

Figure O-6. Exeter River Profile, 50-year Flows, All Alternatives

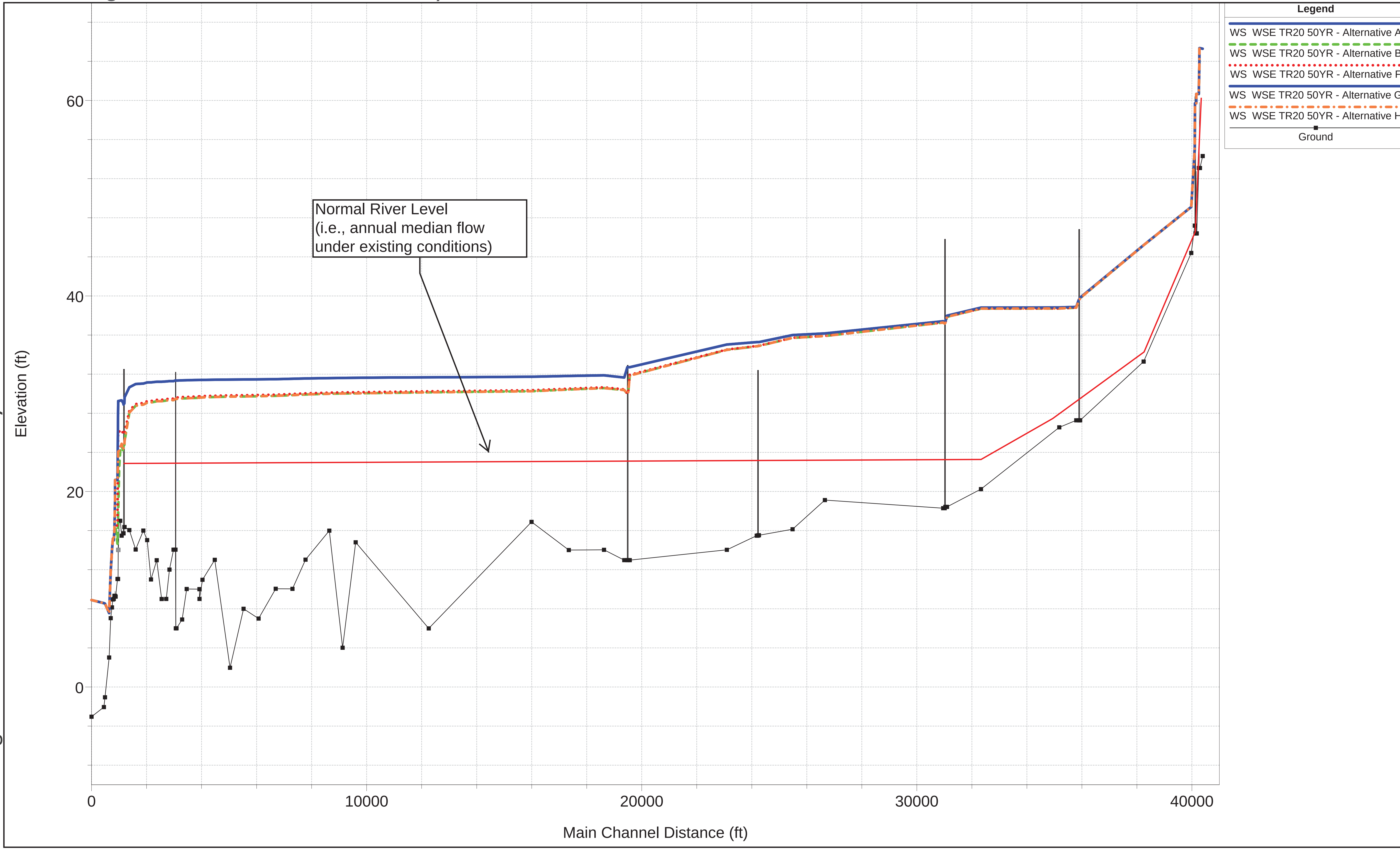


Figure O-6. Exeter River Profile, 50-year Flows, All Alternatives

Figure O-7. Exeter River Profile, 100-year Flows, All Alternatives

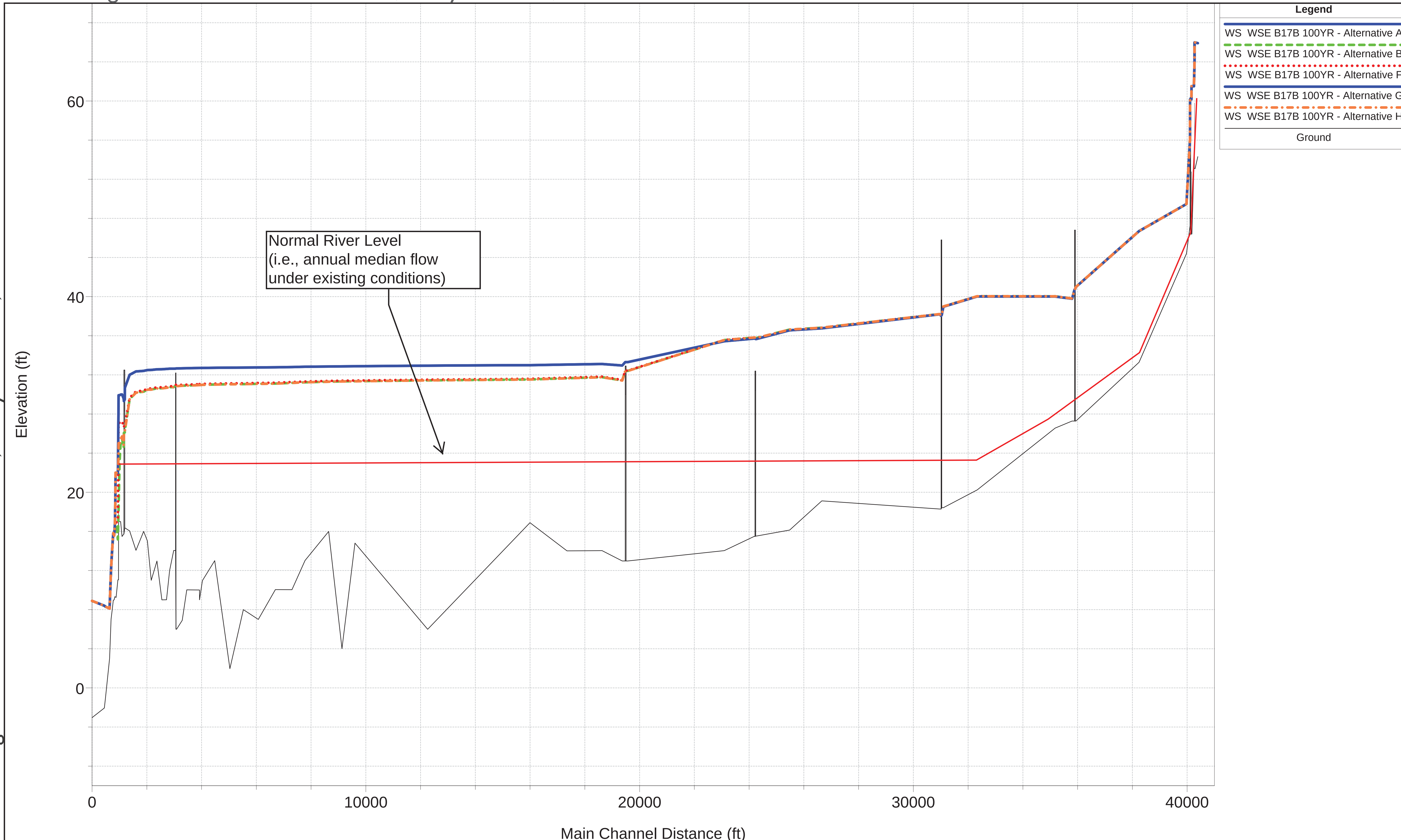


Figure O-7. Exeter River Profile, 100-year Flows, All Alternatives