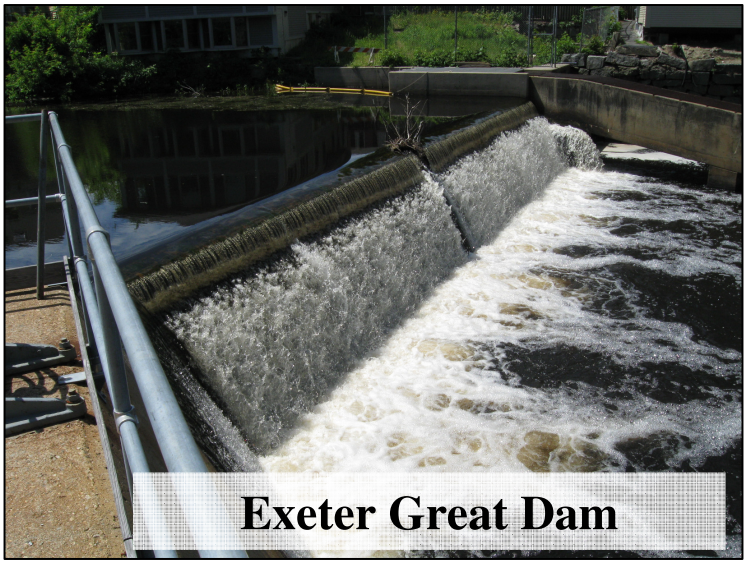
Weston&Sampson®

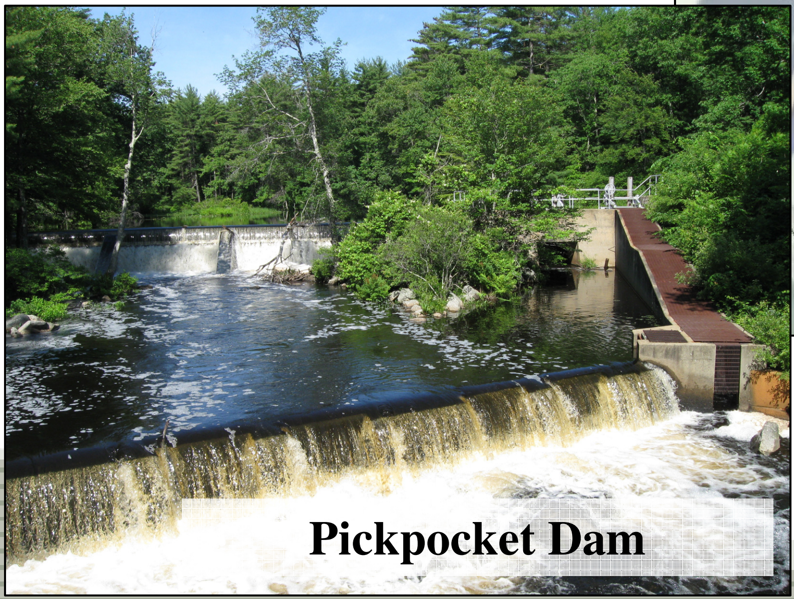
Town of Exeter, New Hampshire

Hydroelectric Review Assessment

March 31, 2011



Exeter Great Dam



Pickpocket Dam

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Town of Exeter, NH
WSE Project Number 2070533

March 31, 2010

Mr. Paul Vlasich, P.E.
Town Engineer
Town of Exeter
13 Newfields Road
Exeter, NH 03833

Dear Mr. Vlasich:

Weston & Sampson, Inc. (Weston & Sampson) is submitting this letter report to summarize our review of historical Exeter River hydroelectric generation potential information. Our analysis included the following elements:

- Review of the historical hydropower documents
- Update of flow and cost/benefit analyses and assessment of current-day system components
- Inventory of current licensing and permitting requirements for a similar project

The results of our analysis, as well as a brief history of dams on the Exeter River and a review of potential for development of hydroelectric energy at the Site, are described in the following document. I have also attached a copy of the presentation that was given to the River Study Committee on March 24, 2011.

Weston & Sampson appreciates the opportunity to assist the Town of Exeter with reviewing the 1981 Hydroelectric Study and Applications. We look forward to the Town's comments regarding this draft assessment. If you have any questions or comments about this report, please feel free to contact me at (603) 431-3937.

Very truly yours,

WESTON & SAMPSON, INC.

Brian F. Goetz
Project Manager

Attachment(s)

Executive Summary

Two historical documents related to proposed hydroelectric generation projects on the Exeter River were provided to Weston & Sampson by the Town of Exeter, New Hampshire:

1. "*Exeter Hydropower and District Heating & Cooling (DHC) Study – July 1981*" [Study]
2. "*The Federal Energy Regulatory Commission – Application for License for a Minor Hydroelectric Power Project – Pickpocket Dam/Exeter 1 Dam Hydroelectric Project*" [Application].

The information presented in the following pages summarizes updated engineering, environmental, permitting and cost considerations associated with the use of the Pickpocket and Great Dams for hydroelectric power generation. Based on the information provided in the assessment, Weston & Sampson updated the construction cost estimates, financing and potential revenues as presented in the 1981 Study and Application. They are as follows:

Opinion of Probable Hydropower Construction Costs

	Pickpocket Dam		Great Dam	
Capital Cost	$	1,580,000	$	1,964,000
Contingency (approx 20%)[1]	$	316,000	$	393,000
Engineering and Permitting[2]	$	150,000	$	200,000
Total	**$**	**2,046,000**	**$**	**2,557,000**

Notes:
1. For planning-level purposes, the Contingency allowance is based on 20 percent of the capital cost estimate. Exact quotes for construction estimates are difficult to summize without a more detailed design and sizing of system components.
2. The Engineering and Permitting allowance is an estimate based on an assumed level of effort and a significan amount of contingency due to the unknowns with respect to FERC licensing requirements.

Hydroelectric Operating Revenue Based on 2011 Conditions and Electrical Rates

Dam	Estimated Power kW	Estimated Revenue
Great Dam	290,965	$26,328
Pickpocket Dam	221,009	$22,101
Total	**511,974**	**$48,429**

- Based on 2011 updated flow analysis
- Operating in the Months of January through June using a 100 kW turbine
- Electricity rate of $0.077/kWh
- All of the electricity net-metered and paid back at the higher retail rate

Hydroelectric Capital Projects – 2011 Financing Estimate

	Total Bonded		Year Initiated	Years Bonded	Annual Payment	
Pickpocket Dam Hydroelectric	$	2,046,000	2012	20	$	148,344
Great Dam Hydroelectric	$	2,557,000	2012	20	$	185,939
Debt Financing - Hydroelectric Projects	**$**	**4,603,000**			**$**	**334,283**

We also evaluated the pros and cons of the potential hydroelectric redevelopment as proposed in the 1981 Study and Application. They are as follows:

Pros

- Use existing dam structures and available river gradient and flows for generation of potentially "green" electricity
- Retrofitting effort and environmental impacts can be minimized via significant use of existing structures
- Net metering configuration is easier to implement then going through FERC permitting a new system that wholesales the power
- Future carbon offsets (if enacted by Federal or State regulators) could make project more feasible in the long term
- Electric rates will most likely increase over time while the cost to operate a turbine will remain fairly fixed over the life of the system
- Newer micro-turbine and hydroelectric technologies may make future facilities possible on this reach of the river; however, they may not require the need for using the existing dam in its current configuration.

Cons

- Significant up-front cost related to construction and permitting. It is also a very time-consuming and lengthly process which other studies have mentioned may take at least 3 to 7 years.
- Many environmental permitting unknowns that could increase project costs and operating constraints. This has been pointed out in other studies as a major hinderance to small and moderately sized hydroelectric systems.
- Expenses outweigh income: $334K annual finance cost vs. $26-$47K income (annually) with a 100 kW turbine at the Great Dam
- It is most likely that only the Great Dam would have capability to net meter electricity back to electrical grid as the Pickpocket Dam is far away from any of the Town's existing electrical services
- Net metering would require the bundling of Town and/or other electric customers as the utility only provides full credits to power production up to the monthly load. The credit is significantly reduced for loads beyond what the customer uses (future regulations may change this arrangement).
- Significant down-time and stranded assets due to the large sizing and high flow need of the turbines
- Preliminary fish passage concerns voiced from regulatory agencies and scrutiny of environmental agencies and groups may to be intense
- May trigger an in-stream flow assessment and potential restrictions on river flows, which may also impact current surface water withdrawal for the Town's drinking water system
- According the FERC communications; other communities have inquired about these project potentials but none have come forward with actual applications

In summary, it appears that the facilities put forward in the 1981 Study and Applications were sized too large for an efficient and cost-effective operation. A smaller, more efficient configuration may prove to be more feasible for the Town's two dam sites.

The following two figures show an overlay of the 1981 site plans, overlayed on an arial photograph of the current site conditions:

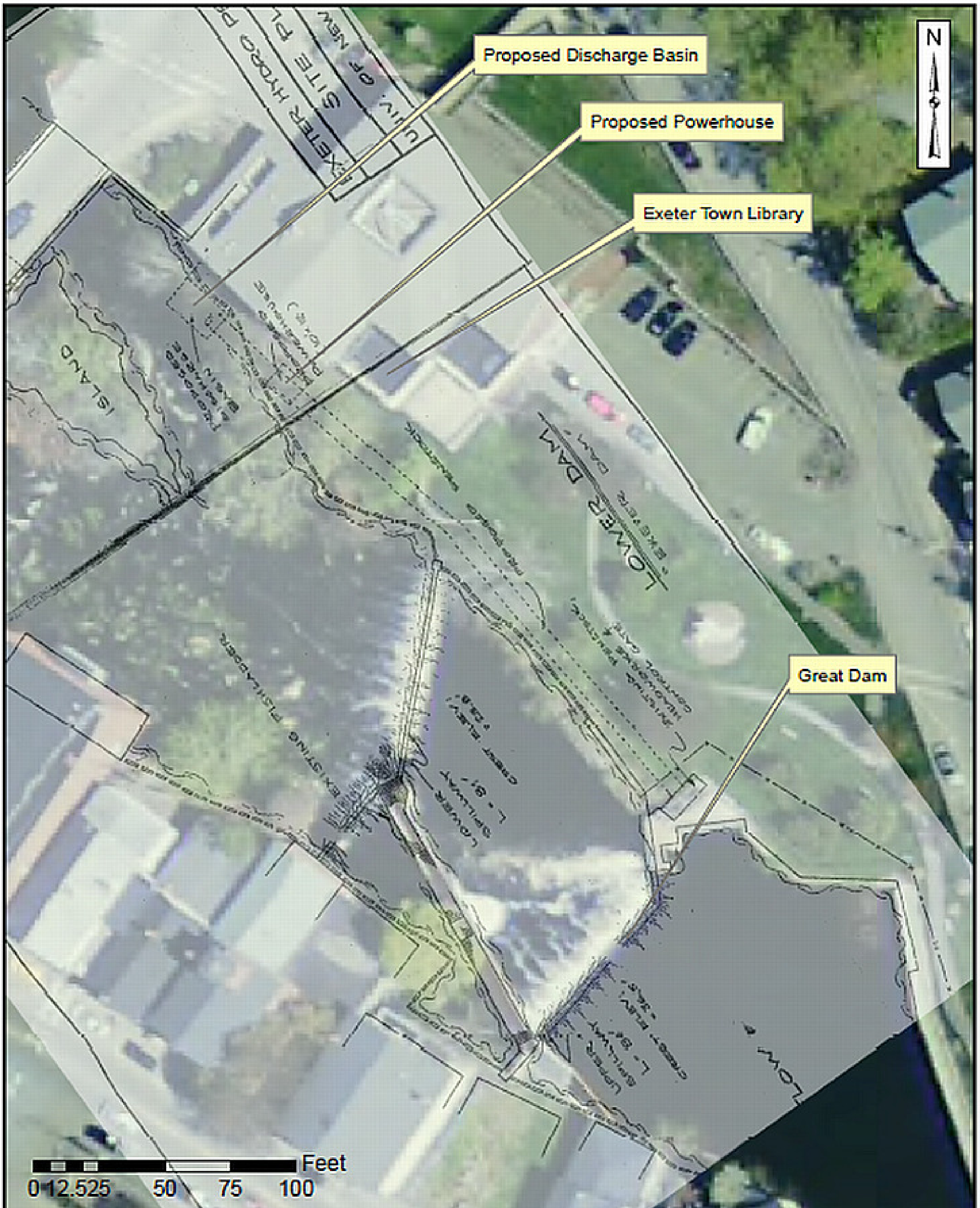


FIGURE 1

GREAT DAM - CONCEPT 2

HYDROELECTRIC REPORT REVIEW
TOWN OF EXETER, NH

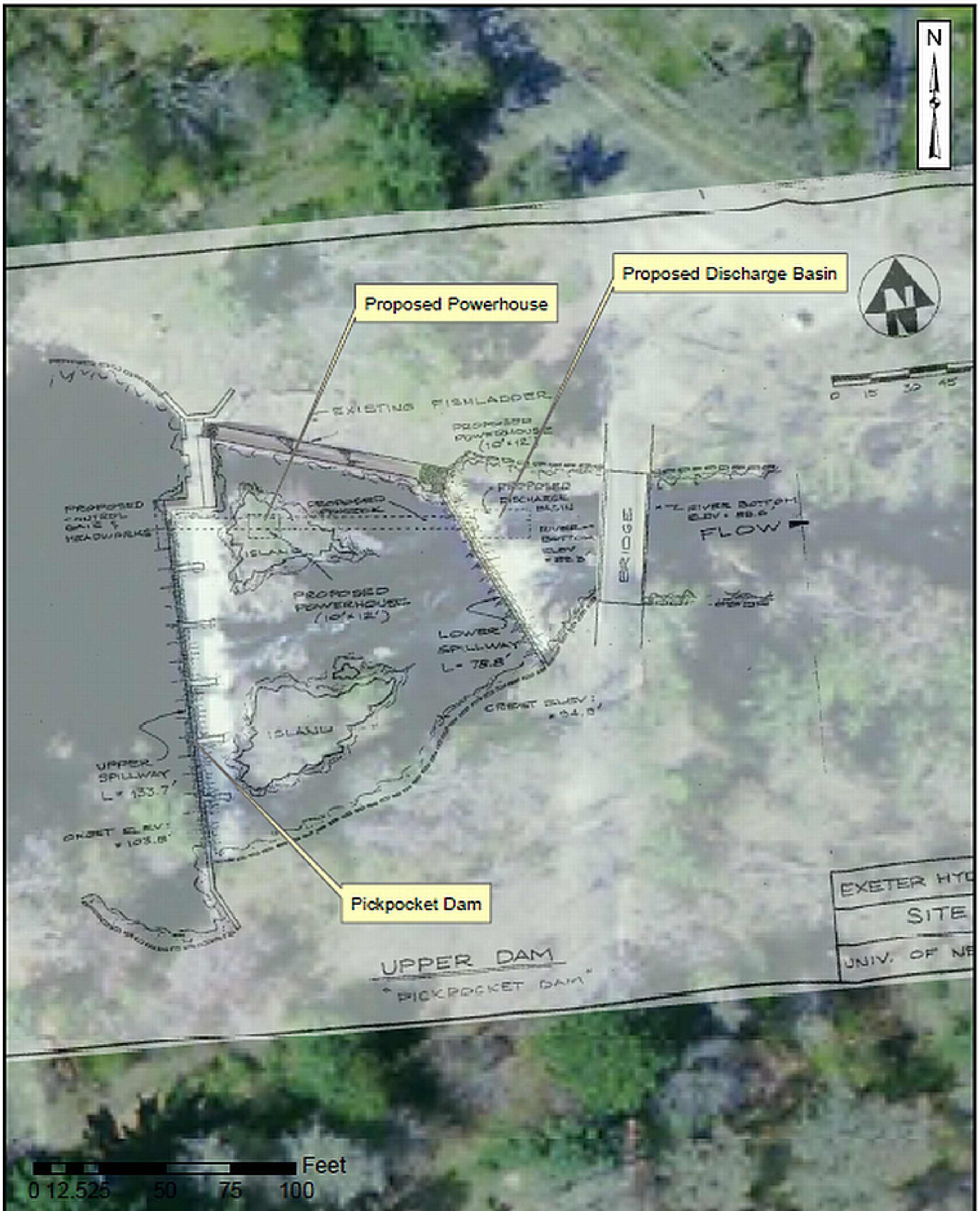


FIGURE 2

PICKPOCKET DAM

HYDROELECTRIC REPORT REVIEW
TOWN OF EXETER, NH

Section 1 - Exeter River Dams: Background and Hydroelectric History

The freshwater portion of the Exeter River drains approximately 108 square miles, flowing 33 miles from its spring-fed headwaters to the Great Dam. Downstream of the Great Dam, water enters the tidally-influenced Squamscott River, a primary tributary of the Great Bay.

The earliest account of dams and use of the Exeter River for power supply has been documented in Charles Bell's History of the Town of Exeter (1888). His account states that a grinding mill was built near the island adjacent to the String Bridge in 1651. Since that time, numerous dams and mills have been constructed, commissioned and decommissioned on the river. The existing Great Dam, located in downtown Exeter, and Pickpocket Dam, located approximately six miles upstream of the Great Dam, were built in the early 1900's to facilitate power generation for mills on the River. The Town acquired both dams from the mills in 1981. Great Dam and its impoundment have been managed as a water resource for the last thirty years, including use as a seasonal potable water supply source. There are seven other dams upstream of the Great Dam (all nine dams are shown on Figure 3).

In 2010, while investigating potential modifications and/or the feasibility of removing Great Dam, the Town felt that reinvestigation of hydropower potential was necessary. During the ensuing investigation, historical documents resurfaced related to the possible use of the dams for hydroelectric power generation. Subsequently, the Town contracted Weston & Sampson to review the documents and conduct an update of the historical analysis.

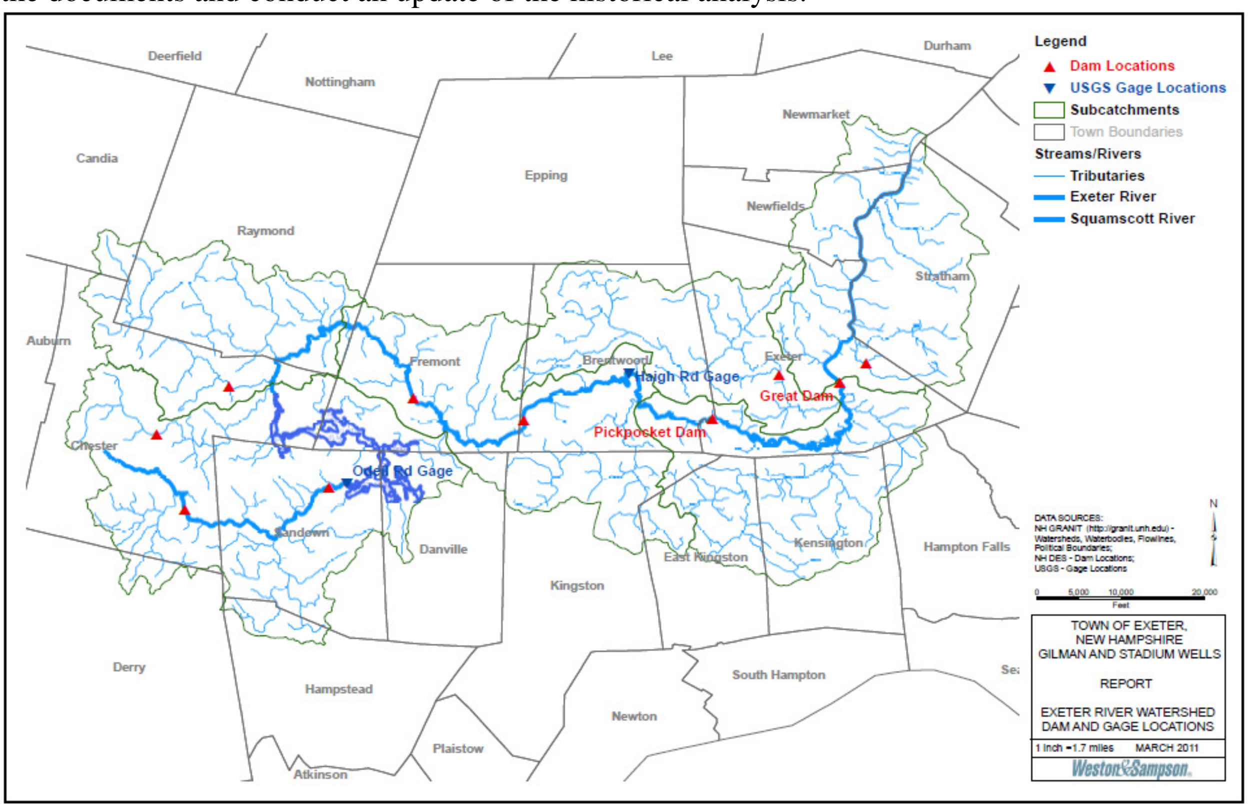


Figure 3. The Exeter River Watershed

<u>Hydropower Study and License Application</u>
Two historical documents related to the proposed historical hydroelectric generation project were provided by the Town:

- "*Exeter Hydropower and District Heating & Cooling (DHC) Study – July 1981*" [Study]
- "*The Federal Energy Regulatory Commission – Application for License for a Minor Hydroelectric Power Project – Pickpocket Dam/Exeter 1 Dam Hydroelectric Project*" [Application].

Although both documents were authored by Dr. Charles Goodspeed of the University of New Hampshire Civil Engineering Department, the copy of the Application available for review by Weston & Sampson was unsigned, leaving a data gap regarding its submission details (date and signatory). In addition, the two documents differ to some degree regarding their conclusions and recommendations. Additional information provided by Dr. Goodspeed provided clarification on this history and that discussion is provided later in this letter report.

The Study reviewed the feasibility of retrofitting the Great Dam in Exeter for production of hydroelectric power, with possible use of the hydroelectricity to drive heat pumps for distribution of heating/cooling energy to the downtown Exeter area. According to the document, "the decision to concentrate the study to this dam was based on the town's direct access to the [Great Dam] and its potential energy supply for a district heating and cooling system." The study indicates that while the proposed heating/cooling system is not likely to be cost effective – at least until the price of oil is approximately 60 times more expensive than electricity – the retrofitting of the dam for generation of electricity using a siphon type turbine installation (discussed in more detail in Section 2 under *Concept Selection*) may be profitable. The Study recommended:

- Development and submission of an exemption package for Exeter River 1 Dam (Great Dam) to the Federal Energy Regulatory Commission (FERC)
- Selection of an engineering firm to complete a design and procure manufacturing bids for a 100 kW turbine/generator
- Development of financing options

The Application provided applicant/agent information and the regulatory background of the proposed project, along with engineer's specifications and drawings, a hydrologic/flow duration analysis and a cost/benefit analysis. In contrast to the Study, the Application proposed two hydroelectric projects – a 269-Kw unit on the Great Dam (referred to alternately in the Application as the "Exeter 1", "Dam 82.01" or "Lower Dam") and a 133-Kw unit on the Pickpocket Dam (also named as "Upper Dam" or "Dam 29.07"). According to the Application's cost/benefit analysis, both locations were financially profitable, even with 100% financing and the recommended half-year of generation inactivity described in the text – turbines were proposed to be operated from January through June to intercept maximum flows and minimize impacts to potential fish migration.

The Application included a section entitled "Environmental Report", which summarized the natural setting of the sites and described potential impacts to fish, wildlife, water quality and quantity, land and recreational use and historical and archaeological resources. The environmental review dismissed impacts related to these concerns except those associated with historical resources, noting that prehistoric artifacts (Indian pottery) were discovered at the Pickpocket Dam site. According to the Application, the hydroelectric development plans were proposed in consultation with a New Hampshire Historical Society Representative.

Personal Communication - Dr. Charles Goodspeed
Weston & Sampson contacted Dr. Goodspeed, who was very helpful with his insight and recollections of the 1981 Study and license Application. We greatly appreciate his willingness to share them with us for this updated report. Dr. Goodspeed recounted the following information related to the project:

- The license application was drafted but was never submitted
- The project at the Great Dam was more feasible if two- or three-foot flashboards were installed on the dam to increase the ability to capture flow and increase the head going to the turbine, which did not prove favorable in discussions following the study due to impoundment and flooding concerns.
- The project originally was designed to have inexpensive turbines installed; however, they were no longer available once the license application was drafted

In closing, Dr. Goodspeed mentioned that the study was brought forward, in part, because the Town was investigating and negotiating with the mills to take over ownership and operation of the two dams. This ownership was transferred soon after as stated on Page 1 of the 1981 Study: "Upon completion of this study Clemson-Millikin Fabrics, owners of the dams (Exeter River 1 and Pickpocket Road dam) offered to deed to the Town of Exeter the dams, water rights, and certain parcels of land fronting along the Exeter River." The report went on to add the cautionary note that the Town, "…may become responsible for the operation and maintenance of the dam facility, which can be considered either an asset or a liability."

Federal Energy Regulatory Commission Database (FERC)
Weston & Sampson reviewed available public records for information related to the Study. No information related to hydropower projects on the Great Dam or Pickpocket Dam were identified on the FERC database. However, records were identified for "the Brentwood Hydro Dam" or "Phillips Dam," located upstream of the Pickpocket Dam.

File correspondence indicated the Brentwood Hydro Dam project was plagued with regulatory infractions to the point of cessation of operations sometime between March 2000 and June 2001. By 2006, letters from FERC indicated that Mr. Phillips had passed away and operation of Exeter River Hydro 1 had discontinued. Mr. Phillips' son, Stephen Phillips, continued correspondence with FERC, indicating that he planned to retain ownership of the dam but had no intention of producing commercial power at the project. In 2007, the New Hampshire Department of Environmental Services submitted recommendations for the surrender of the exemption for the Exeter River Hydro Project. No FERC database information related to hydropower projects on the Great Dam was identified. The following photos, taken by Weston & Sampson during the summer of 2009, show the existing dam and turbine components at the Brentwood Hydro Dam.

Brentwood Hydroelectric Dam and Turbine (2009)

<u>Section 2 – Historical and Updated Hydropower Engineering Considerations</u>

<u>Concept Selection</u>

Weston & Sampson reviewed the three conceptual level designs discussed in the Study for their continued relevance and suitability. In the years since the Study was published and the Application was authored, the Great Dam area has undergone many significant alterations. Those alterations include:

- Construction of the Exeter Town Library downstream of the Dam,
- The creation of Founder's Park complete with modifications to the upstream river channel,
- The conversion of over a dozen mill buildings downstream of the Dam to apartment buildings, and
- Several potential modifications to the spillway, abutments, and penstock of Great Dam itself.

These alterations to Great Dam and the surrounding area impact the three concepts to varying degrees.

Concept One – Using the Existing Penstock and installing a Turbine at the Mill Building

The first concept discussed in the Study was designed to take advantage of the maximum available head, approximately 20 feet, and involved extending the existing penstock through one of the downstream mill buildings and into a proposed discharge basin to be constructed in the tidal reaches of the Squamscott River. This concept was largely discarded based on the significant construction costs, environmental issues, and the location of existing utility lines. Due to the conversion of the particular mill building into apartments and the increased construction costs and environmental permitting costs, this site plan likely remains untenable.

Concept Two – Using the Existing Penstock and discharging water near the String Bridge instead of the Mill Building

The second concept, with a head of approximately 16.5 feet was not favored in the Study but championed in the Application. The concept was developed to take advantage of the existing penstock, ultimately discharging into a proposed discharge basin near the String Bridge Island. This concept is shown in plan view in Figure 1 and profile view in Figure 4. This concept would involve the construction of an additional dam structure to create the necessary discharge basin. While the site of the proposed powerhouse, a 10' x 12' structure, remains open space today, the proximity of that powerhouse and the discharge basin to the new Exeter Town Library would likely increase the difficulty and costs of construction.

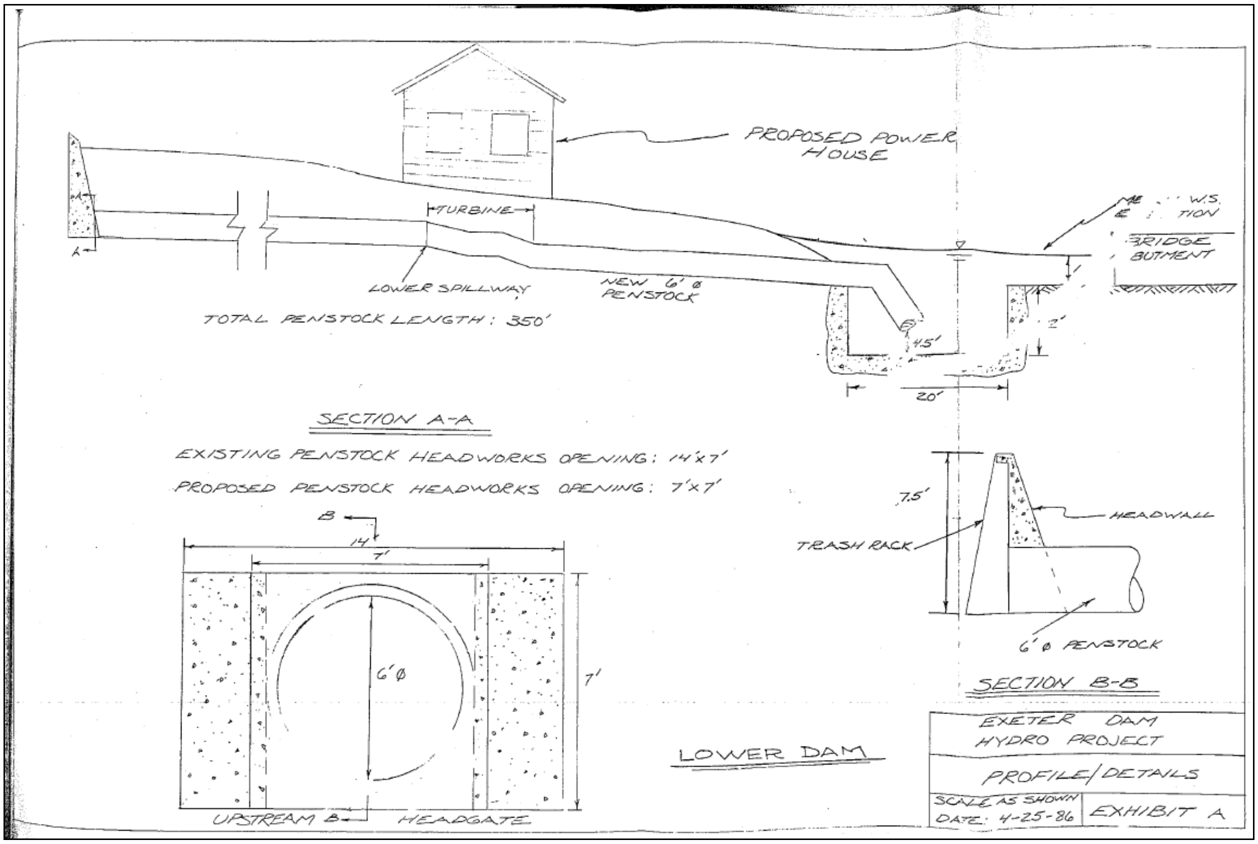


Figure 4. Concept Two Profile View

Concept Three – Retrofitting the Great Dam with a siphon tube turbine

The third and final concept was recommended by Dr. Goodspeed as the preferred alternative in the 1981 Study. This concept involved retrofitting Great Dam with a siphon type turbine installation and using the existing slack water between Great Dam and the downstream fish weir as a discharge basin. Unlike the first two concepts, a siphon type installation requires no powerhouse as the turbine is encased within the piping as shown in Figure 5. While this concept had the lowest head, approximately 10.5 feet, it was nevertheless shown to produce a competitive amount of power while minimizing construction costs and permitting issues. Construction would be limited to an anchor/foundation structure to support a turbine and piping, while permitting issues would be minimized by using existing structures. The feasibility of the third concept would seem largely unchanged today. As in 1981, preliminary assessment suggests that the third concept represents the most cost effective manner with which to retrofit Great Dam for hydroelectric power generation.

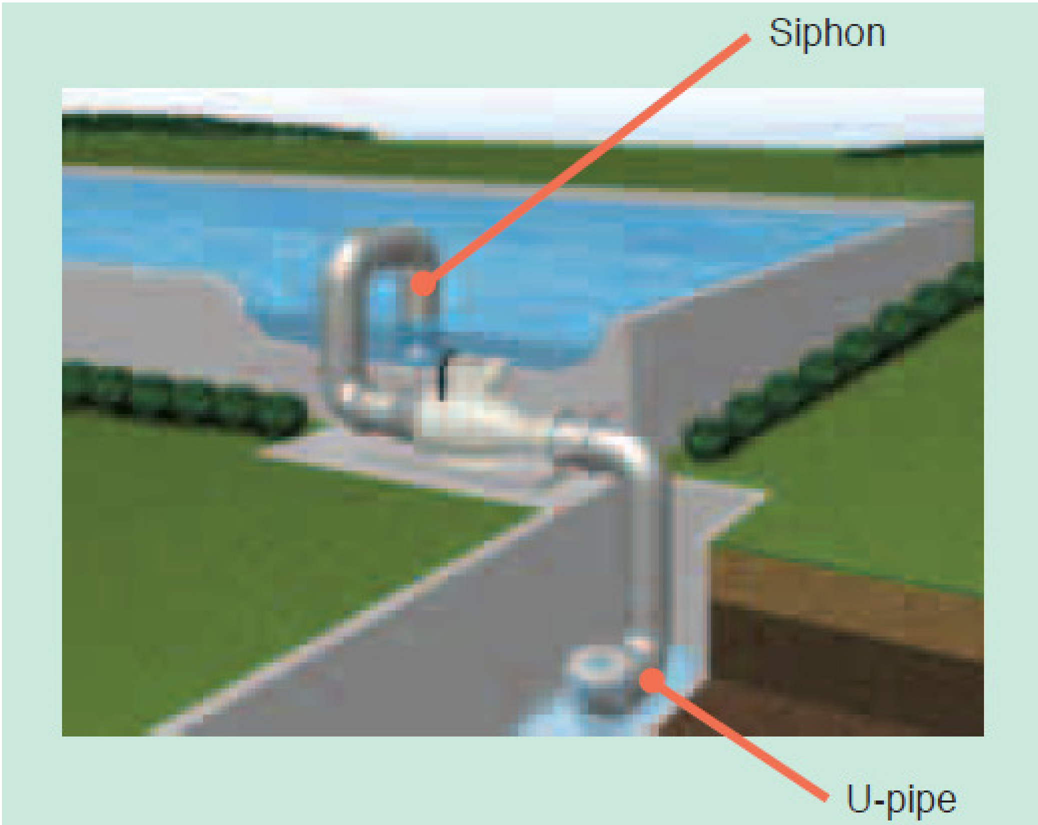


Figure 5. Concept Three Installation Example

As noted above, the Study and Application recommended different infrastructure and turbine installations. The Study recommended the use of Concept Three with a 100-Kw unit, noting its competitive power production and significant advantages regarding construction and permitting efforts. In contrast, the Application calls for the installation of a 269-Kw unit to be installed at Great Dam according to Concept Two. During a recent communication with the author of both documents, Dr. Goodspeed indicated that the 100-Kw turbine recommended by Study became unavailable prior to preparation of the Application. Other turbines available at the time were not suited to the low head of Concept Three, preventing that design from producing enough electricity to be cost-effective. However, as discussed in the following section, a line of turbine/generator units, similar to those initially proposed for Concept Three, is currently available.

<u>System Components</u>

Weston & Sampson reviewed the selection of hydroelectric turbine/generator combinations discussed in the Study. While the Study goes into some detail calculating the potential yield of variously sized turbines and combinations of turbines at Great Dam, it ultimately concludes that siting considerations and installation and maintenance costs outweigh any differences in potential power production. Based on these considerations, the Study proposed the Concept 3 siphon type turbine installation, more popularly known now as a bulb turbine. Bulb turbines are intended for small–scale hydropower facilities with relatively low head and/or low flow. The 1981 report analyzed the efficiency of four such turbines, two from Essex Turbine Corporation and two from Allis-Chalmers. Weston & Sampson's communication with both companies revealed that Essex Turbine no longer constructs new turbines and Allis-Chalmers has since been purchased by Voith Hydro Inc. However, while Voith Hydro has not continued manufacturing the Allis-Chalmers line, they do offer a product line similar to the Allis-Chalmers design, the Fuji Micro Tubular Turbine. The Fuji turbine is intended for smaller sites such as Great Dam, and would cost between $5,000 and 10,000 per kW of power produced. Based on the 100-kW recommendation on Page 2 of the Study, the Fuji turbine would cost between $500,000 and $1,000,000.

<u>Flow Conditions</u>

Weston & Sampson developed an updated assessment of the potential yield of a retrofitted Great Dam based on the Fuji turbine specifications and an updated streamflow record. In both the Study and Application, the potential yield was estimated by examining average daily streamflow data gathered in the adjacent Lamprey River watershed. As streamflow data for the Exeter River were not recorded until the installation of the Haigh Road USGS streamflow gage (USGS 01073587) in the fall of 1996, the Lamprey record, maintained since 1934, represented a logical substitute. Using the standard methodology known as basin averaging, this data transformed the Lamprey River streamflow record to represent Exeter River discharge by multiplying each average daily discharge value by 0.5683, the ratio of the drainage areas for Great Dam (102.7 mi^2) and the Lamprey River gage (183 mi^2). While that methodology represented the best available technique in 1981, additional streamflow records and statistical techniques are now available with which to evaluate the feasibility of producing hydroelectric power at Great Dam.

An updated streamflow record for the Exeter River was performed in this analysis by extending the flow record of the Exeter River gage with a 65-year old streamflow gage on the nearby Parker River that dates back to 1945 (USGS 01101000). Several gages located in nearby watersheds with records of greater than 20 years were examined for cross-correlation with the Exeter gage, including those in the Lamprey, Oyster, Ipswich, and Parker Rivers. The Parker gage was most closely correlated to the Exeter gage; a correlation coefficient of 0.824 indicates that 82.4% of the variability in the Exeter River record is also captured by the Parker River record. While the Lamprey River is also well correlated with the Exeter River, the Parker correlation is simply superior as shown in Figure 5:

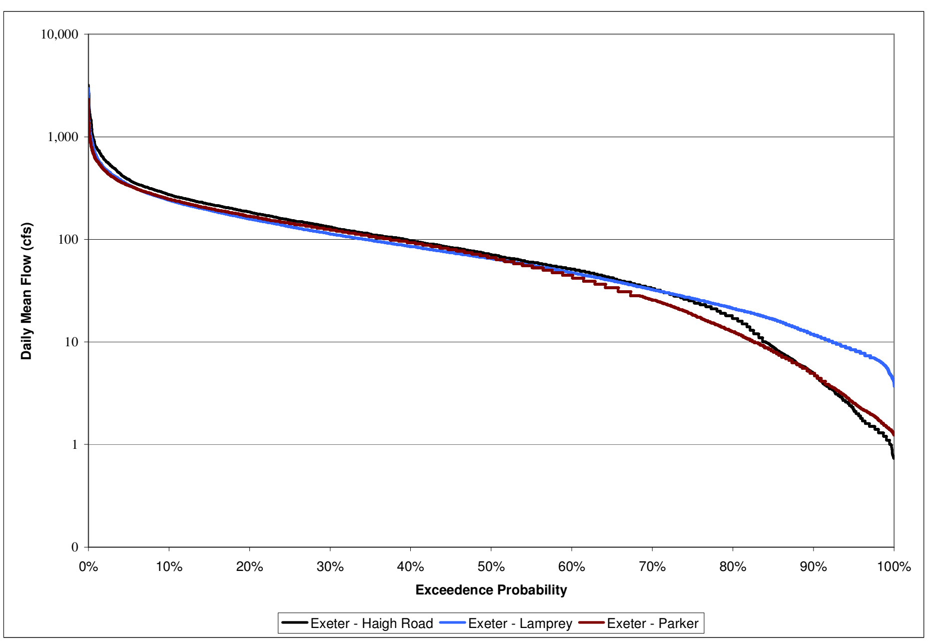


Figure 6. Correlation of Parker and Lamprey Rivers with Exeter River

By examining both the Exeter and Parker River streamflow data over their shared range of October 1996 through September 2010, Weston & Sampson developed a linear equation to translate streamflow values in the Parker River into daily average discharge in the Exeter River. Assessing potential power yield from this synthesized dataset of 65 years provides a better long-term assessment than the 14-year streamflow record taken directly from the Exeter River as the past 14 years have been relatively wet.

Electricity Generation Potential

Based on the synthesized streamflow record, the Concept 3 design recommended by the Study, and on the Fuji turbine specifications, Weston & Sampson developed an updated assessment of the potential yield of a retrofitted Great Dam. The estimated annual potential yield of energy in kilowatt-hours, kWh, is given by the equation:

$E = P_{exc}TP$	where	P_{exc}	is the percentage of time the turbine is operational
		T	is the total number of hours in a year, 8760 hours
	and	P	is the power produced by the turbine in kW

In the Application, the percentage of time the turbine was predicted to be operational was determined as the percentage of days in the streamflow record that the daily mean flow exceeded the greater of the proposed turbine's minimum required discharge and the minimum flow of 55 cfs recommended by the U.S. Fish and Wildlife as noted on Page 17 of the Application. The Fuji turbine requires a minimum flow of approximately 44.85 cubic feet per second (cfs) so the updated power yield estimate is based on a minimum required flow of 55 cfs. The power produced by a hydroelectric turbine varies with regard to operating head and discharge rate. Both the Study and the Application employ an average power produced by the proposed turbines with a head equivalent to a normal operating pool. With a head of 10.5 feet at Great Dam, using the third site plan discussed above, and a minimum flow rate of 55 cfs, the Fuji turbine produces power at an average rate of 100 kW. Based on those values and a 5% loss of production during startup and shutdown, the annual potential yield of energy is estimated at 458,459 kWh. Despite differences in the turbine size (100 kW vs. 95 kW), minimum required flow rates (55 cfs vs. 130 cfs), and streamflow records (average daily flow of 120.9 cfs vs. 159.4 cfs), this estimated yield is relatively similar to the 470,000 kWh value published in the Study.

In contrast to the Study, the Application included estimates of potential yield for hydropower turbines and generators at both Great Dam and Pickpocket Dam. A review of the site plans that were included in the application for Pickpocket Dam indicates that the proposed plans may still be applicable today. While the precise turbines proposed in the Application are unknown, the layout and design head suggested in both site plans should work with a Fuji turbine. If a Fuji turbine were installed at Pickpocket Dam, the turbine would produce an estimated 379,897 kWh annually.

Operating Scheme

The Application suggests an operating scheme for the proposed hydropower facilities at both dams that would limit their operation to the months of January through June to avoid the relatively cost-inefficient and environmentally sensitive period of lower flows during the summer and fall. A review of the updated streamflow record would seem to agree with this assessment. The proposed turbine would be operational for less than 50% of the time during the months of June through October and less than 20% of the time during the months of July through September. In fact, approximately 78%

of the anticipated power produced annually at Great Dam would be generated in the months of December through May. A similar pattern was observed for Pickpocket Dam. The percentage of time the proposed turbine at Pickpocket Dam would be operational exceeds 50% only during the December-May window, during which time approximately 82% of annual energy would be produced.

A December-May operating window would also align well with the existing minimum flow goal schedule for Great Dam Management Plan. This plan was reviewed and discussed in detail as part of Weston & Sampson's 2010 Water Supply Alternatives Study for the Town of Exeter. The Management Plans goals, 88 cfs April 1 through June 30th and 17 cfs July 1st through October 30th, coincide with fish migration patterns and are designed to preserve adequate flow conditions during those critical periods. If hydropower facilities were operated during either of those periods, additional losses in generating potential would be expected due to higher minimum required flows and shorter operating windows.

<u>Section 3 - Environmental Permitting</u>

The Application developed by Dr. Goodspeed provides an overview of the permitting process. Weston & Sampson has reviewed the list of potential permits from the Application and developed the following revised permitting recommendations for a similar project, permitted in 2011.

Notification and/or submission of a permit application related to engineering or environmental concerns/impacts are required by several Federal and State agencies, as described below. The name of the agency, together with a brief summary of the permit and/or its applicability, is provided. In some cases, information related to varying permitting scenarios is provided. Agencies/permits listed provide a summary of potential permits required; specific design considerations will govern actual permits needed.

Federal Energy Regulatory Commission (Federal)

- **Preliminary Permit**. Maintains priority of application for license while the permittee studies the Site and prepares to apply for a license
- **Hydropower License Exemption**. A small hydroelectric project of 5 megawatts (MW) or less may be eligible for a 5 MW exemption. The applicant must propose to install or add capacity to a project located at a non-federal, pre-2005 dam, or at a natural water feature. An environmental assessment consistent with the National Environmental Protection Act guidelines may be required. No filing fees are required, and no annual fees are charged by FERC for projects up to 1.5 MW. A megawatt (MW) is 1,000 kW.
- **Hydropower License** (integrated, traditional or alternative methods). If the project does not qualify for an exemption under the 5 MW exemption clause, a license from the Commission is required to construct, operate, and maintain a non-federal hydroelectric project. Licenses may be issued for up to 50 years terms and must be renewed at the end of each term. A license gives the licensee the power of "eminent domain" to obtain lands or other rights needed to construct, operate, and maintain the hydroelectric project. Effective July 23, 2005, the Integrated Licensing Process (ILP) is the default process for filing an application for an original, new, or subsequent license. The ILP process requires extensive study of the site from environmental, historical, cultural and engineering perspectives.

Environmental Protection Agency (Federal)

- **National Pollutant Discharge Elimination System (NPDES) General Permits for Discharges at Hydroelectric Generating Facilities in New Hampshire**. General permit covers discharge of noncontact cooling and direct cooling water, equipment and floor drain water, equipment backwash water, and specific maintenance waters to certain waters of the State of New Hampshire. Within New Hampshire, no discharges to any Class A waters are eligible for permit coverage. According the the NHDES, The Exeter River has been designated a Class B water by the General Court and the river is currently fully supporting the standards of this water quality goal. In addition, the flow of water through a turbine or over a dam is not regulated by the general permit.
- **Water Quality Certification (Section 401)**. Required for projects requiring a FERC license

Army Corps of Engineers (Federal)

- **Work in Navigable Waters (Section 10)**. All structures and work in a navigable water of the United States. Jurisdiction extends to ordinary high water line. Jurisdiction under Section 10 of the Rivers and Harbors Act of 1899 shall be exercised for these waters. The New England District of the Army Corps of Engineers maintains a list of these waters but notes that "represents only those waterbodies for which affirmative determinations have been made; absence from this list should not be taken as an indication that the waterbody is not navigable." Therefore, should a hydroelectric project application proceed it is recommended that the Corps be contacted regarding the need for a permit.
- **Discharge of Dredged or Fill Material (Section 404)**. Jurisdiction extends to upland/wetland boundary. Construction of facilities would most likely require significant excavation and would also potentially require a temporary drawdown of the river to allow for certain components to be built.

New Hampshire Department of Environmental Services (State)

- **Dredge and Fill (Wetlands Bureau)**. Standard wetlands permit in New Hampshire, required for work in wetlands or within the 100-foot wetlands buffer.
- **Shoreland Impact (Shoreland Program)**. Required for projects involving excavation, fill, or construction activities within 250 feet of lakes and ponds greater than 10 acres in size, rivers or streams which are fourth order or greater, rivers designated under RSA-483, and tidal waters.
- **Alteration of Terrain (Alteration of Terrain Bureau)**. Required whenever a project proposes to disturb more than 50,000 sq. ft. within protected shoreland (or 100,000 square feet otherwise)
- **Dam Reconstruction or Repair Permit (Dam Bureau)**. A Dam Reconstruction permit is required for new hydroelectric energy projects on existing dams. The Dam Bureau requires a $2,000 fee to accompany the application. An additional $100 deposit is required for hydropower projects, and up to $2,000 may be required, depending on the hazard rating of the project (i.e., low or significant/high hazard). Annual dam fees are also assessed by the Bureau.
- **Instream Flows -** It should be noted that any hydroelectric project would most likely trigger the NHDES to review the project with respect to their instream flow rules, as they have with other recent NPDES permits and projects. These rules are still in the formative stages and it is not certain as to how much they might limit the operating parameters of a hydroelectric system.

RSA 483 allows that NHDES "may approve permits and certificates for the construction, operation or maintenance of new hydroelectric power facilities at existing dams provided that:

> (a) The operational mode of any proposed facility shall be run-of-the-river, with project outflow equal to project inflow on an instantaneous basis and the project does not significantly alter the natural flow characteristics of the river;
> (b) The proposed facility does not provide for diversion of the river or segment above or below the existing dam for a significant distance; and
> (c) The height of the impoundment is constant and is not raised above the maximum historic level of impoundment at that site."

In addition, according to RSA 482:19 *Notice Required for Hydro-energy Generation Projects*, every applicant to the Federal Energy Regulatory Commission for the permits and licenses, or modifications of permits or licenses, necessary for the development, construction, or reconstruction of a hydro-energy project shall notify the owners of the dam site of the proposed project and the local governing body, planning board, and conservation commission of each municipality in which the project is sited via newspaper.

Other Potential Requirements

- **Americans with Disabilities Act (ADA)** – May be required if the facility is deamed to effect recreational facilities
- **National Historic Preservation Act (NHPA) –** Though these dams are not currently on the National Register it may not eliminate intervenors and/or others to inquire with respect to the historic nature and use of both the river and the dams.

Reviewing and Commenting Agencies

Agencies requiring permits are likely to review the project and provide comment related to the specific agency's area of expertise. However, agencies without specific permitting requirements may also review the project. Non-permitting agencies to be included in the review process may include State and Federal programs such as New Hampshire Fish and Game Department, Watershed Management Bureau (Rivers Management and Protection Program or Instream Flow Program), Public Utilities Commission/Energy Planning Advisory Board, Natural Heritage Bureau, New Hampshire State Historic Preservation Office and U.S. Fish and Wildlife Service. Weston & Sampson received comment from two such agencies, as described below. Anecdotal guidance related to project feasibility may be obtained from the Granite State Hydropower Association (GSHA). GSHA members include owners of approximately 50 small-scale hydroelectric projects (i.e., those less than 10 MW) located throughout New Hampshire.

- **New Hampshire Fish and Game Department**. Weston & Sampson contacted Cheri Patterson, Supervisor of Marine Programs at the New Hampshire Fish and Game Department (NHFG). NHFG is likely to have considerable comment related to modification of the dam, spillway, fish ladder and a prospective installation of a hydroelectric turbine. According to Ms. Patterson, NHFG is coordinating a review of the information request both internally and with other agencies. NHFG will prepare a formal response in the near future.

  Ms. Patterson commented that NHFG would likely recommend a revision to the January-to-

May operating window recommended in the 1981 hydroelectric report due to required flow needs for fish migrations in the early spring, preferring instead a November through March timeframe.

- **U.S. Fish and Wildlife**. John P. Warner, Energy/Hydropower Coordinator with the New England Field Office of the U.S. Fish and Wildlife Service (FWS) commented the following via telephone and email:

  There are a number of generic issues that the Service would raise in the event a hydro project was formally proposed for the Great Dam in Exeter. Without a specific proposal and based on limited knowledge of the project, it's hard to be too specific, but if a project was pursued, we would look to have the following issues addressed. This list is of course preliminary and would need to be refined based on project specifics:

  - The fish ladder MUST work with any proposed hydro design or it would have to be remodeled or a new fishway constructed.
  - The designs of the fish ladder and its relation to the proposed project configuration MUST be approved/signed off on by FWS prior to license/exemption issuance. This avoids conflicts later on operation of passage facilities and the hydro project configuration.
  - Project operation would need to be defined. We would look for a strict run-of-river operation mode.
  - Impoundment level - we would not agree to raising the impoundment or adding flashboards without study of the inundation zone and mitigation for the lost riverine habitat which is difficult to do.
  - The bypass reach, if any, will require habitat evaluation and a min flow. DES has flow guidance that likely exceeds past 1980's flow assessments. We also have flow guidance in lieu of a site specific study.
  - Upstream passage for American eels would need to be installed.
  - Downstream passage provisions for eels will be needed. The criteria we are currently using is 3/4 inch trash racks and less than 1.5 fps intake velocities with a bypass slot or sluice or nighttime shutdowns throughout DS migration season and a bypass slot or sluice.
  - WQ assessment pre and post will be needed per DES
  - At the end of a FERC process we would codify specifics on these issues in recommendations to FERC (if a License is pursued) or in mandatory conditions (if an Exemption from Licensing is pursued)

Mr. Warner also stated that a number of similar queries have recently been submitted to his office from communities that are evaluating the hydroelectric generation potential of their dams. To date, none of these communities have actually gone forward with official applications to FERC to permit or gain exemptions for installing and operating new facilities.

It was noted during our research and through discussions with regulators familiar with the industry that over the years the siting of hydropower projects below 100 kW has become less economically feasible due to stringent regulations. Many have pointed out that these smaller projects still have to go through the exact same process, whether they are for 100 kW or 10 MW.

Section 4 - Constructability and Cost/Benefit Analysis

System Components

The 1981 License Application included descriptions and diagrams of the proposed infrastructure for both the Pickpocket and Great Dams. Figures 1 and 2, as presented in the Executive Summary of this report, show those proposals superimposed over an arial photograph of existing conditions.

The Application identified the following upgrades were necessary to operate a new hydroelectric generation system:

- Retrofits of both dams are needed to install control gates and headworks
- Construction of a new penstock closer to the river to direct flow through the turbine
- Construction of a discharge basin
- Construction of a electrical generation powerhouse

Historical Capital Cost Estimates

Page 17 of the 1981 Study reported a cost estimate for the Great Dam hydroelectric modifications of $226,000. According to our recent discussions with Dr. Goodspeed, this cost was relatively low due to the fact that the Town had an inexpensive turbine available for purchase. However, he stated that the equipment deal "fell through," so that figure had to be updated for the license application. The cost estimate for equipping the Great Dam project from the 1981 report to the 1981 license Application nearly doubled due to the updated turbine costs.

The 1981 license Application contained preliminary design layouts for the modifications to the Great Dam and Pickpocket Dam, as well as basic cost estimates for each design. The total cost estimate for construction of the two facilities was listed within the application as follows:

- Pickpocket Dam - $324,790
- Great Dam - $447,490

Updated Capital Cost Estimate

As part of the current review, the cost estimates used in the license application were revisited and adjusted to approximate present-day costs. Equipment items included separate costs for purchase and installation. The general guideline for this cost increase was the Boston-area Construction Cost Index (CCI) published monthly since 1908 by the Engineering News-Record (ENR). The CCI includes local costs for labor and construction materials, and is widely used as a benchmark for inflation. The Boston-area CCI for January 1981 was 3,158, and the CCI for January 2012 is projected to be 11,848, suggesting an inflation of approximately 375% for that time period.

For each line item, the 1981 estimated cost, escalated by 375% to account for area-specific construction inflation, was used as a base. For some specific items, additional information was obtained from the weighted bid prices published by the Massachusetts Highway Department (MHD). The cost of the turbines was based on the price obtained for the Fuji turbine, using a mid-point in the obtained range of $500,000 to $1,000,000. Additional allowances were added to account for general types of work that would be required, including electrical work and structural modifications at the dams to account for the new and/or modified gates. The cost estimates put forward in the 1981 hydroelectric license application did not include any contingency; the current Weston & Sampson assessment applied a 20% contingency. The 1981 estimates appear to be low with respect to the engineering, permit and regulatory requirements. If a hydroelectric project were to move forward, specific cost estimates for these items would have to be developed following site visits and inspections by the engineers specializing in these disciplines. Table 1 provides a summary of the current estimate of construction costs for both projects.

Table 1. Opinion of Probable Hydropower Construction Costs

	Pickpocket Dam		Great Dam	
Capital Cost	$	1,580,000	$	1,964,000
Contingency (approx 20%)	$	316,000	$	393,000
Engineering and Permitting	$	150,000	$	200,000
Total	**$**	**2,046,000**	**$**	**2,557,000**

Notes:
1. For planning-level purposes, the Contingency allowance is based on 20 percent of the capital cost estimate. Exact quotes for construction estimates are difficult to surmize without a more detailed design and sizing of system components.
2. The Engineering and Permitting allowance is an estimate based on an assumed level of effort and a significant amount of contingency due to the unknowns with respect to FERC licensing requirements.

<u>Project Financing</u>

The 1981 study suggested two financing options for the Town's consideration: private developer and public. Page 17 of the 1981 Report utilized the cost table that listed the Great Dam project estimate at $226,000. Page 18 listed a tax credit for the private developer option. A number of other factors were significantly different today than they were in 1981, including the private developer interest rate – 16% (Page 18).

The Study provided further detail of project operational costs and also investigated the option of a private developer investing in a hydro-retrofit project. Page 20 mentioned that, "Good hydro-retrofit project are presently returning 200% on investment in less than 5 years. Comparing this with only 59.27% in five years for the Exeter project, it would be unlikely there would be much interest from private developers at this time." Page 21 summarized the public funding option and concluded that, comparing the bond debt service of approximately $21,000 and the adjusted operating income Col. 9 of $19,089 reveals the project is not feasible."

To look at the project costs today, Weston & Sampson used the updated cost estimate and developed a simple analysis of what the annual cost would be for the Town and/or a private developer to finance the project at an interest rate of 4% over a twenty year period of time. These terms are comparable to the current municipal bonding options. Table 2 summarizes the estimated annual bond payments for each of the projects.

Table 2. Hydroelectric Capital Projects – 2012 Financing Estimate

	Total Bonded		Year Initiated	Years Bonded	Annual Payment	
Pickpocket Dam Hydroelectric	$	2,046,000	2012	20	$	148,344
Great Dam Hydroelectric	$	2,557,000	2012	20	$	185,939
Debt Financing - Hydroelectric Projects	**$**	**4,603,000**			**$**	**334,283**

Revenue

The 1981 study utilized PUC rate of 7.7 cents per kilowatt-hour (kWh) for the potential revenue generated by a hydroelectric facility. This rate was set by the PUC to encourage alternative energy projects. According to Weston & Sampson's recent discussion with Steve Mullen at the PUC, "back in the 80's the rates were set and held out for years into the future but that isn't the way it is done right now." He recommended contacting the local energy provider regarding the potential to net meter the system.

Weston & Sampson contacted Unitil, the local energy provider, regarding the net metering option. According to Tim Noonis, Unitil's representative, net metering may be possible providing the project does not exceed 100 kW production. Unitil would view this arrangement as a standard interconnection application and the entity generating the electricity would receive the same rate as their energy service charge, which currently ranges between 8 and 10 cents per kWh. The New Hampshire Public Utility Commission Rules PUC900 addresses the net metering rules in New Hampshire. Section 903.02 states the following:

> (g) The net energy metering calculation shall be made by taking the difference between the electricity supplied over the electric distribution system and the electricity generated by the customer-generator and fed back into the electric distribution system over the billing period, pursuant to RSA 362-A:9.
> (h) Each electric distribution utility shall, pursuant to RSA 362-A:9, offer net energy metering to each customer-generator on terms which shall be identical, with respect to rates, rate structure, and periodic charges, to the contract or tariff to which the same customer-generator would be assigned if such customer-generator was not a customer-generator.

Mr. Noonis mentioned that any generation beyond the 100 kW capacity would have to be sold on the wholesale market but this would be a "very complex" process. Finally, he concluded that there is a good potential that the limit of 100 kW production capacity for interconnected electrical generators is likely to go up.

Page 17 of the 1981 Study used the assumed fixed rate of $0.077/kWh for 470,000 kWhs of hydroelectric generation from the Great Dam, giving an annual Gross Operating Income (GOI) of $36,190. Updating this estimate with the approximate electrical rate in 2011 of $0.10/kWh for 470,000 kWhs of annual generation would give a GOI of $47,000. If the operating parameters were updated to allow generation from November through March, which would generate an estimated 263,278 kWh then the annual GOI is estimated to be $26,328.

According the United States Department of Energy data, the average household in New Hampshire uses 623 kWh/month, or 7,476 kWh annually of electricity. Therefore, the hydroelectric generation potential at the Great Dam would equate to the annual electricity used by approximately 35 homes.

The Study does not make any projection for the potential revenue derived from a facility located at the Pickpocket Dam. To assess the potential revenue for this dam in 2011 we simply used the same formula for the Pickpocket as the Great Dam. We also updated the revenue potential for 1981 to provide a comparable snapshot.

The following tables compare the GOI based on the 1981 and 2011 estimates:

Table 3: Hydroelectric Operating Revenue Based on 1981 Conditions and Electrical Rates

Dam	Estimated Power kW	Estimated Revenue
Great Dam	337,432	$25,982
Pickpocket Dam	263,278	$22,404
Total	**600,710**	**$48,386**

- Based on 2011 updated flow analysis
- Operating in the Months of January through June using a 100 kW turbine
- Electricity rate of $0.077/kWh
- All the electricity net-metered and paid back at the higher retail rate

Table 4: Hydroelectric Operating Revenue Based on 2011 Conditions and Electrical Rates

Dam	Estimated Power kW	Estimated Revenue
Great Dam	290,965	$26,328
Pickpocket Dam	221,009	$22,101
Total	**511,974**	**$48,429**

- Based on 2011 updated flow analysis
- Operating in the Months of January through June using a 100 kW turbine
- Electricity rate of $0.077/kWh
- All of the electricity net-metered and paid back at the higher retail rate

Based on the updated cost and revenue estimate, these two dams would have to produce nearly seven times as much power as they would with the operating scenarios presented in the Study and Application. At a break-even annual cost versus operating revenue for the project financing, the Town would only be able to invest approximately $650,000 for the two combined systems. It must be noted that this estimate only includes the capital costs, not the annual operating and maintenance of the facilities.

A preliminary review of federal stimulus assistance suggests some funds or tax credits may be available to offset construction costs for this project. The stimulus bill extended the project in-service date through December 31, 2013, to be eligible for production tax credits (PTC). Among eligible renewable technologies are small irrigation hydro, incremental hydropower from additions to existing plants, hydropower development at existing non-powered dams, ocean energy, and in-stream hydrokinetic. Another provision would allow new renewable projects to claim a 30 percent investment tax credit in lieu of a PTC for the duration of the PTC extension.

The bill also authorizes $1.6 billion of new clean renewable energy bonds (CREBs) to finance development of facilities that generate electricity from renewables, including the hydro and ocean energy sources listed above. The bonds are offered to entities that are not eligible for the tax credits: state, local, and tribal governments; public power providers; and electric cooperatives. This funding, combined with money made available by the Energy Improvement and Extension Act of 2008, resulted in total available CREBs of $2.2 billion. Of this, hydroelectric projects received about 24 percent.

The New Hampshire state legislature currently has two bills filed that relate in part to hydroelectricity and renewable energy portfolios; HB543 and HB302 have been submitted during the

2011 session. There has also been considerable political discussion regarding the proposed Northern Pass Hydroelectric project powerlines which will run through New Hampshire regarding it's qualification as a "green" project. Proponents stress its low carbon footprint regarding the generation of power while opponents point out the habit issues related to fish passage and the power line locations. This type of debate is most likely to be similar to those that may ensue with any proposed hydropower project associated with Exeter's dams.

Copy of Exeter River Study Presentation

March 24, 2011

Exeter Hydroelectric Study Review
prepared for the
Exeter River Study Committee
March 24, 2011

Weston&Sampson®

Reviewed Two Documents

Both Authored by Dr. Charles Goodspeed

EXETER HYDROPOWER AND DHC STUDY

JULY, 1981

SUBMITTED BY

CHARLES H. GOODSPEED
ASSOCIATE PROFESSOR
UNIVERSITY OF NEW HAMPSHIRE

DOUGLAS MELLIN
EXETER TOWN PLANNER

The preparation of this report was financed in part by the Coastal Zone Management Act of 1972, as amended, administered by the Office of Coastal Zone Management, National Oceanic and Atmospheric Administration and the New Hampshire Office of State Planning.

THE FEDERAL ENERGY REGULATORY COMMISSION
APPLICATION FOR LICENSE
FOR A
MINOR HYDROELECTRIC POWER PROJECT

PICKPOCKET DAM / EXETER 1 DAM HYDROELECTRIC PROJECT

THE TOWN OF EXETER
10 FRONT STREET
EXETER, NH 03833

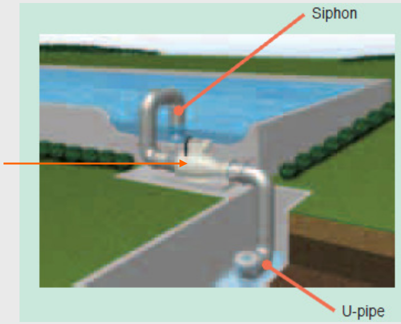
1981 Study

- Focused on the feasibility of hydroelectric power generation at the Great Dam
- Calculates that a combination of a 50kW primary turbine along with a 150kW secondary turbine would produce the most electricity.
- Ultimately recommended a single 100kW siphon turbine at the Great Dam as construction costs would outweigh the increased production achieved by multiple turbines.
- Relied on discharge through the Mill buildings to get the most vertical drop and hydraulic head

1981 Application

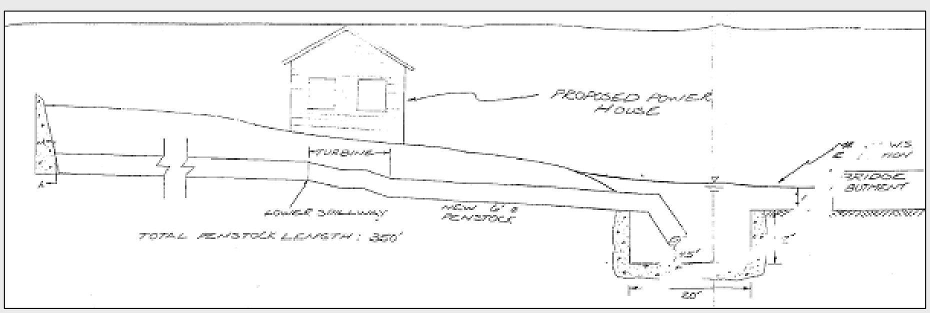
- Proposed two hydroelectric projects
  - A 269-kW unit on the Great Dam and
  - A 133-kW unit on the Pickpocket Dam
- More traditional turbine and discharge
  - Similar to the existing Brentwood Hydro Dam
- Application was prepared but never formally submitted

- Siphon and Turbine



- Brentwood Hydro Dam

1981 Application Components



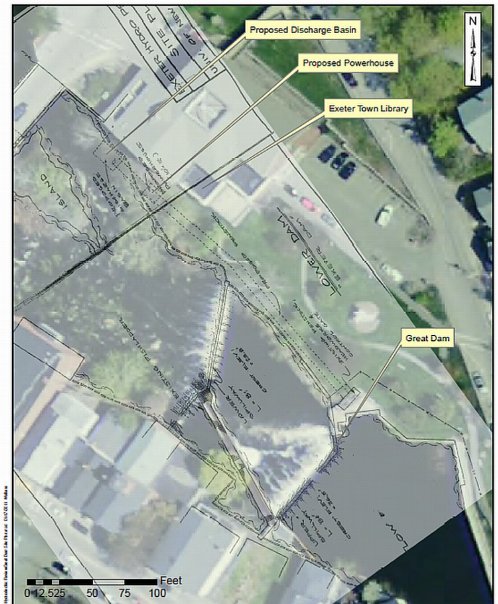


FIGURE 1

GREAT DAM - CONCEPT 2

HYDROELECTRIC REPORT REVIEW
TOWN OF EXETER, NH

1981 Capital Cost Estimate

- The 1981 license Application contained preliminary design layouts for the modifications to the Great Dam and Pickpocket Dam, as well as basic cost estimates for each design as follows:
- Pickpocket Dam - $324,790
- Great Dam - $447,490

2012 Capital Cost Estimate

- Updated utilizing the Boston-area Construction Cost Index (CCI) which has shown an increase of approximately 375%:

Table 1. Opinion of Probable Hydropower Construction Costs

	Pickpocket Dam		Great Dam	
Capital Cost	$	1,580,000	$	1,964,000
Contingency (approx 20%)	$	316,000	$	393,000
Engineering and Permitting	$	150,000	$	200,000
Total	**$**	**2,046,000**	**$**	**2,557,000**

1. Exact quotes for construction estimates are difficult to surmise without a more detailed design and sizing of system components.

2. The Engineering and Permitting allowance is an estimate based on an assumed level of effort and a significant amount of contingency due to the unknowns with respect to FERC licensing requirements.

2012 Financing Estimate
Annual Payment on 20-year Bond
@ 4% Interest

- Pickpocket - $148,344
- Great Dam - $185,939
  - only capital costs, not including operating, depreciation and other potential costs

Revenue for Great Dam Through “Net Metering”

- 1981 Study used the assumed fixed rate of \$0.077/kWh for 470,000 kWhs of hydroelectric generation from the Great Dam, giving an annual Gross Operating Income (GOI) of \$36,190.
- Updating this estimate with the approximate electrical rate in 2011 of \$0.10/kWh for 470,000 kWhs of annual generation would give a GOI of \$47,000.
- If the operating parameters were updated to allow generation from November through March, which would generate an estimated 263,278 kWh then the annual GOI is estimated to be \$26,328.

Revenue Estimate Based on Anticipated 2011 Operating Parameters

Updated Power Yield Analysis Using 2011 Electric Utility Rates

Great Dam		Annually	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Required Flow	*(cfs)*	55.00	55.00	55.00	55.00	55.00	55.00	55.00	55.00	55.00	55.00	55.00	55.00	55.00
Pexc	*(%)*	55.09%	76.96%	84.27%	97.59%	97.99%	87.81%	44.87%	15.36%	8.35%	7.62%	19.42%	51.27%	71.53%
T	*(hours)*	8760	744	678	744	720	744	720	744	744	720	744	720	744
P	*(kW)*	100	100	100	100	100	100	100	100	100	100	100	100	100
Energy	*(kW-h)*	482,588	57,257	57,135	72,610	70,552	65,333	32,305	11,429	6,210	5,486	14,445	36,914	53,219
Energy production w/Losses due to equipment startup and stopping	*(kW-h)*	458,459	54,394	54,278	68,979	67,025	62,067	30,690	10,857	5,899	5,211	13,723	35,069	50,558
kW-h cost (2011 Rate)		\$0.100	\$0.100	\$0.100	\$0.100	\$0.100	\$0.100	\$0.100	\$0.100	\$0.100	\$0.100	\$0.100	\$0.100	\$0.100
Potential revenue (if running entire year)		**\$45,846**	\$5,439	\$5,428	\$6,898	\$6,702	\$6,207	\$3,069	\$1,086	\$590	\$521	\$1,372	\$3,507	\$5,056
Potential revenue (1981 Study Operating Parameters)		**\$33,743**	\$5,439	\$5,428	\$6,898	\$6,702	\$6,207	\$3,069	\$1,086	\$590	\$521	\$1,372	\$3,507	\$5,056
Potential revenue (2011 Estimated Operating Parameters)		**\$26,328**	\$5,439	\$5,428	\$6,898	\$6,702	\$6,207	\$3,069	\$1,086	\$590	\$521	\$1,372	\$3,507	\$5,056

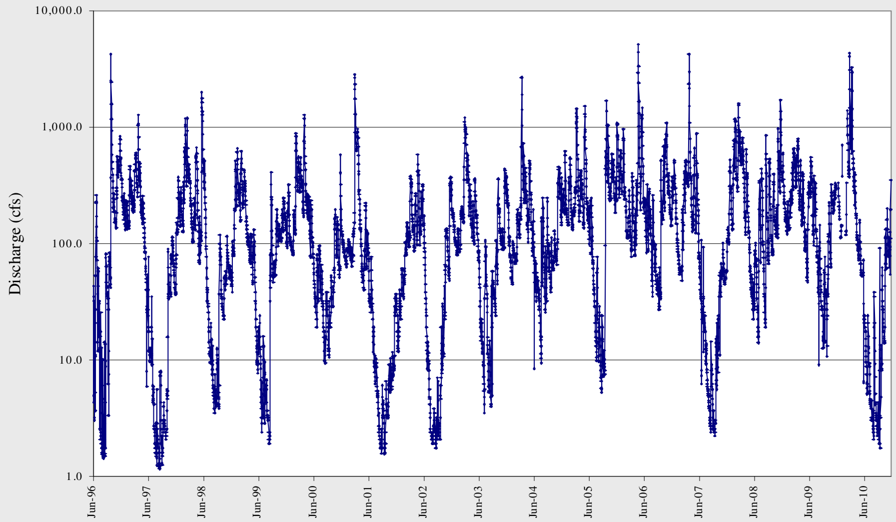
1981 Study – Assuming Operation for the Entire Year

1981 Study – January through June Operation

Anticipated 2012 Operating Parameters – November through March

Turbine would be idle during these periods due to low flow or anticipated operating restrictions

Exeter River Flow Regime



Discussion with Dr. Goodspeed

- The license application was drafted but was never submitted
- The project at the Great Dam was more feasible if two- or three-foot flashboards were installed on the dam to increase the ability to capture flow and increase the head going to the turbine, which did not prove favorable in discussions following the study due to impoundment and flooding concerns.
- The project originally was designed to have inexpensive turbines installed; however, they were no longer available once the license application was drafted
- The potential for hydropower was put forward as another reason the Town might want to acquire the dams.

Discussions with Regulators

- FERC Licensing is intensive process
  - May take 3 to 7 years. This is why many smaller hydro projects are not carried forward
- Fish passage is major issue and would have to be addressed
- Other communities have been inquiring about this potential but they have not come forward with applications
- Instream flow regulations would most likely be triggered
- Multiple agency reviews, comments and requirements

A smaller "micro-hydro" project may be more feasible

- May not have to rely on existing dam and headworks
- Would be able to run a greater % of time
- Counting House Project (funded by the Massachusetts Technology Collaborative) in Amesbury proposed a 24 kW turbine @ an estimated construction cost of $300,000 but hasn't gone forward due to regulatory concerns. This project had a payback estimate of approx 10.5 years.

Questions?