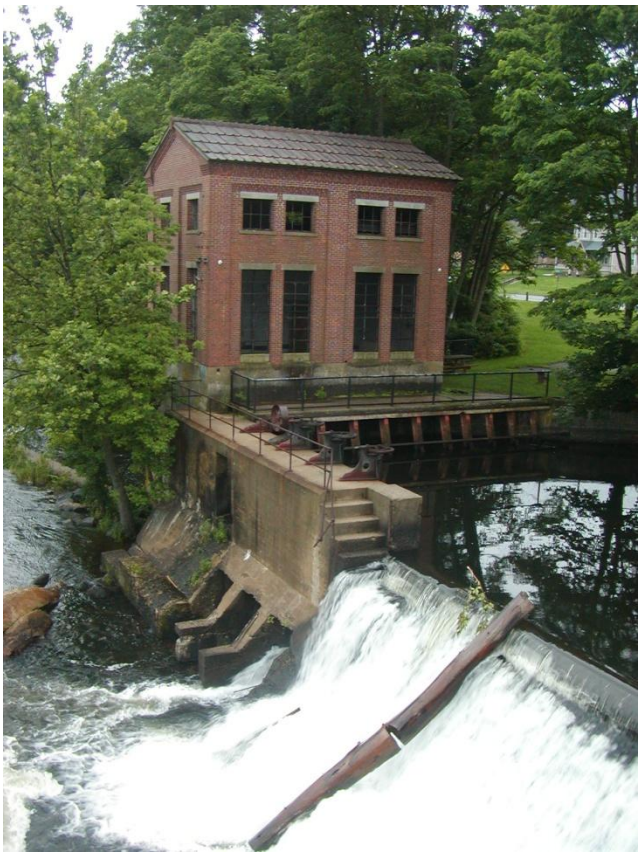
PROPOSED

UPPER AND LOWER COLLINSVILLE DAMS HYDROELECTRIC PROJECT

TOWN OF CANTON, CONNECTICUT

PRE-FEASIBILITY STUDY FOR RE-POWERING THE UPPER AND LOWER COLLINSVILLE DAMS ALONG THE FARMINGTON RIVER

Prepared by:
GZA GeoEnvironmental, Inc.



Prepared for:
The Town of Canton, CT
May 3, 2011

GZA
GeoEnvironmental, Inc.

Engineers and
Scientists

May 3, 2011
File No. 01.0170760.00

Mr. Jerome Shea, P.E.
Town of Canton
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Re: Upper and Lower Collinsville Pre-Feasibility Study
Proposed Hydroelectric Power Generation
Dalton, MA

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Dear Mr. Shea:

GZA GeoEnvironmental, Inc. (GZA) is pleased to present to the Town of Canton and its Temporary Hydro Advisory Committee this Pre-Feasibility Study for Re-Powering the Upper and Lower Collinsville Dams along the Farmington River. This study has been prepared by GZA and its sub-consultants for the purpose of assisting the Town in considering the viability of further action by the Town towards redevelopment of hydropower at the Upper and/or Lower Collinsville Dam sites.

GZA has enjoyed working with the Town and the Committee on this project. We appreciate the thoughtful consideration which has been given to our findings to date. Should the Town choose to move forward with additional steps towards the development of this project, GZA would of course be pleased to have the opportunity to provide continued assistance. Should you have questions about the contents of this pre-feasibility study report, please contact Chad Cox at (781) 278-5787.

Very truly yours,

GZA GEOENVIRONMENTAL, INC.

FOR Celeste Fay
Project Manager

David M. Leone
Consultant / Reviewer

Chad W. Cox
Principal-In-Charge

Upper and Lower Collinsville Dams Hydroelectric Project
Canton, Avon, and Burlington, CT

Town of Canton, CT

EXECUTIVE SUMMARY

The Upper and Lower Collinsville Dams are both located along the Farmington River, the Upper in the Town of Canton, CT and the Lower in Avon and Burlington, CT. Both dams were originally constructed for hydropower but have long since ceased generation. With grant assistance from the Connecticut Clean Energy Fund, the Town of Canton (Town) has commissioned this pre-feasibility study to explore the potential for redeveloping the dams to generate clean, renewable hydroelectricity and provide other benefits to the Town and region.

The scope of the study, prepared by GZA GeoEnvironmental (GZA), includes preliminary analysis of the technical, financial, and environmental aspects of constructing and operating hydroelectric projects at the Upper and Lower Collinsville Dams. A specific focus was given to identifying potential issues which might be considered as "fatal flaws" that would preclude project development. Baring any obvious fatal flaws, the study examined several options for project configuration, power and energy generation potential, preliminary estimated project costs, and potential project financial benefits.

The Town currently holds a Preliminary Permit issued by the Federal Energy Regulatory Commission (FERC) for both sites. The Preliminary Permit allows the Town to study potential development and provides priority in applying for Licenses for the sites, but does not give permission to develop the sites. FERC issued the Preliminary Permit to the Town in January 2009 for a three year period. In addition, legislation titled the "Collinsville Renewable Energy Promotion Act" has been filed (re-filed in both the US House and Senate on April 4, 2011) to transfer FERC licenses issued to a previous developer (and subsequently revoked) to the Town of Canton.

It was assumed that low-impact hydropower development at either of the sites would operate exclusively in an "instantaneous run-of-the-river" mode without any cycling of the impoundments. Analysis by GZA indicates that the hydrologic characteristics of the river would support a turbine design flow of approximately 820 cfs at both sites. However it is noted that the previous FERC license at the Upper Dam authorized only 292 cfs for the turbine due to concerns about aesthetic flows over the Upper Dam. The pending legislation which would transfer the existing Licenses appears to limit the Town to this reduced turbine design flow.

This pre-feasibility study has assumed that flashboards are used to raise the levels of the Upper and Lower impoundments by 3 feet and 5 feet respectively. This provides additional head (and thus power generation capacity) at the Lower Dam. Additional gross head is not produced at the Upper Site due to backwater affect from the Lower impoundment if the full 5 feet of flashboards are added to the Lower Dam. It is noted that some concern has been raised regarding the use of flashboards and alternate methods for raising the impoundments have been suggested by some fisheries agencies. Use of the existing power canal and location of the powerhouse site at the Lower Site provides additional head and has therefore been judged advantageous.

On the basis of the estimated flow and head available at each site, GZA assessed a number of conceptual alternatives for hydropower development at each site. At each site, GZA chose to advance the alternative with the lowest cost per kilowatt to the financial analysis stage. In addition, GZA assessed the costs and benefits of developing the Upper Site with the restrictions contained in the previous License. GZA

assumed that the level of both impoundments would be raised. At the Upper Site, the level of power and energy production was estimated both with and without simultaneous development at the Lower Site to assess the potential advantage to eliminating the backwater affect caused by raising the Lower Dam impoundment. It is noted that utilizing the more advantageous flow at the Upper Site will likely require modifications to the existing powerhouse to accommodate the larger turbines which would be needed. The development alternatives advanced by GZA are summarized as follows:

Alternative	Flashboards Installed at…	Turbine Flow	Peak Power	Ave. Annual Energy	Estimated Cost (using flashboards)
U1	Both Dams	292 cfs	395 kW	2,223 MWh	$4,560,000
U1	Upper Only	292 cfs	457 kW	2,584 MWh	$4,560,000
U3	Both Dams	820 cfs	1,080 kW	3,474 MWh	$6,590,000
U3	Upper Only	820 cfs	1,255 kW	4,038 MWh	$6,590,000
L1	Both	820 cfs	876 kW	3,023 MWh	$7,100,500

As part of the pre-feasibility study, potential environmental issues were considered. Available information was reviewed and preliminary comments were solicited from a number of potential stakeholders. The primary environmental concern which was identified is the issue of fish passage. Both upstream and downstream fish passage will be required as part of any hydropower project at either Site. These facilities will add cost to the development but are judged to be necessary to secure necessary Licenses, permits, and support from the Lower Farmington Wild and Scenic River Study Committee.

Financial analyses of potential hydropower development at the Collinsville sites considered two general scenarios: 1) Energy produced is sold to the local electric service provider (CL&P) for "wholesale" prices; or 2) Energy produced is used at Town facilities to off-set existing electricity purchases, thus creating a "retail" value for the hydropower. The "wholesale" value of electricity in the early years of the financial analysis period was estimated to be approximately 5 cents per kilowatt hour (kWh) while the "retail" value was estimated at approximately 8 cents / kWh. In order to realize the "retail" value of the energy, the Town must have the means to directly utilize the electricity, either through a physical direct connection to Town facilities or through a net metering arrangement. A sole use distribution line could theoretically be built from the Upper Site powerhouse to several Town facilities, but the cost would be over $1 million (for a primarily underground line), the Town would become responsible for its operation and maintenance, and it is not clear that appropriate rights-of-way for the line could be secured. A "virtual" net metering arrangement wherein credits generated at one directly connected Town-owned meter could be applied to other Town-owned meters is a more efficient way to maximize the value of the energy produced. However, virtual net metering is currently not permitted in Connecticut. Clarifications to regulations and/or new legislation may change this situation in the future. It is also important to understand that the Town of Canton alone does not have enough demand to utilize all the energy capable of being produced by both the Upper and Lower Sites combined, therefore not all energy would be valued at the "retail" level unless additional loads from the other towns could also be included.

GZA analyzed the financial returns of the three advanced alternatives over a 30 year period. Two financing scenarios were studied: 1) 30 year bonds with 3.5 percent interest; and 2) 15 year bonds with 1.5 percent interest. The analyses looked at annual cash flow, final net present value, and final internal rate of return. Project capital costs were estimated based on preliminary equipment quotes from turbine manufacturers and customary cost estimating methods at a concept level. A 25 percent contingency was added. Energy prices were forecast based on US Department of Energy guidance.

Under the 30 year bond financing scenario, none of the project alternatives which were assessed returned a positive net present value over the 30 year study period when "wholesale" energy values were assumed. If "retail" energy value is assumed for all energy generated along with the use of flashboards to raise the impoundments, the following results are generated:

Scenario	IRR (30 years)	~NPV (30 years)
U1	0%	$40,000
U3	5%	$1,400,000
U3 (Upper Dam Only)	12%	$3,400,000
L1	n/a	-$1,000,000
U3/ L1 (combined)	1%	$400,000

The most financially attractive option therefore is to develop the Upper Dam site only, using a design flow of 820 cfs and raising the impoundment 3 feet with flashboards. However, this assumes virtual net metering, which is currently not allowed, and full retail value for all energy produced.

In order to provide conditions which would generate a positive cash flow from the first year of operation under the "wholesale" and "retail" energy value scenarios (for all energy produced), grant assistance in the following amounts would be necessary, based on current cost and benefit assumptions:

Scenario	Grant Needed for Year 1 Positive Cash Flow (Wholesale)	Grant Needed for Year 1 Positive Cash Flow (Retail)
U1	$2,600,000	$1,400,000
U1*	$2,200,000	$750,000
U3	$3,300,000	$1,400,000
U3*	$2,600,000	$450,000
L1	$4,300,000	$2,600,000
U3 / L1 (combined)	$7,500,000	$4,000,000

*Assumes no raising of water surface elevations at Lower Dam therefore, full head is achieved at Upper Dam without backwater restrictions from Lower Dam

This pre-feasibility study indicates that redevelopment of hydropower at the Upper and Lower Collinsville sites is technically feasible and that there are no obvious "fatal flaws" which would prevent development. However, the financial viability of the hydropower projects is less straightforward. Assuming a "wholesale" value of energy for electricity sold directly to the grid, GZA estimates that negative cash flow will result from almost all development alternatives, based on current conceptual cost estimates and assuming no grant assistance. If energy generated can be used to off-set existing Town demand, then it appears possible to develop hydropower at the sites in ways that are at least revenue neutral and potentially cash flow positive. Grant funding would improve project viability under these scenarios. A major caveat however isthat there is currently no mechanism for the Town to be able to use the power generated at either site. Virtual net metering is currently not allowed in Connecticut.

It is GZA's opinion that hydropower development at the Upper and Lower Collinsville Dams warrants further consideration by the Town beyond this pre-feasibility study. Development of one or both of the projects offer the Town the opportunity to generate essentially all of the power consumed by Town

facilities through clean, renewable hydropower. Development of the sites would facilitate fish passage at the dams, which is an important goal in itself. Hydropower at the Upper and Lower Collinsville Dams is also consistent with the history of the Town and its surroundings and restores a valuable resource to productive use. The Town's exclusive rights to pursue a License for one or both of the Sites will expire at the end of December 2011. GZA therefore recommends that the Town consider taking the following steps in advance of that deadline:

- Further investigate the potential avenues for maximizing the value of any energy produced through discussions with the CT Dept. of Public Utility Control, CP&L, and the legislature.
- Further investigate unresolved issues raised in this report
- Submit Notice of Intent and Pre-Application Document based upon U3 and L1
- Hold discussions with Burlington and Avon regarding potential joint participation in development of the Lower Site.
- Hold initial site visit with Stakeholders and discuss study plan
- Pursue grant opportunities
- Continue to monitor status of "Collinsville Renewable Energy Promotion Act" as re-filed on April 4, 2011.

The intent of these actions is to allow the Town to better understand the potential advantages and disadvantages of proceeding with the project while at the same time making incremental steps towards filing License applications on one or both of the sites prior to January 1, 2012, if that should ultimately be judged to be desirable. If the Town does not file License applications in advance of this deadline (or if the "Collinsville Renewable Energy Promotion Act" does not become law), the there is the risk that another developer will file for a preliminary permit. GZA recommends that separate filings be made for the Upper and Lower Sites. Ultimately, the Town of Canton might choose to proceed with development of the Upper Site only for a variety of reasons. Proceeding with separate filings at both sites preserves future flexibility.

Proceeding with the steps outline above will not commit the Town to submitting License application or to developing the sites. However, these steps are judged to be prudent if the Town is interested in potentially moving forward. GZA estimates the cost to the Town of this course of action is approximately $75,000 to $100,000 for outside legal and engineering assistance. The risk to the Town is that these funds are expended but the Town ultimately decides against hydropower development at the sites. However, it is GZA's opinion the above tasks will be useful even in the event that the "Collinsville Renewable Energy Promotion Act" is passed because the information will be relevant to the new Environmental Assessment, additional permitting needs, and final design. The Town may also seek to extend its Preliminary Permit at the end of the current term, but there is no guarantee that FERC will grant an extension if there are competing applications.

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1.0 INTRODUCTION

1.1 Authority

GZA GeoEnvironmental Inc. (GZA) of Norwood, Massachusetts was contracted by the Town of Canton (Town) to perform a pre-feasibility study of re-powering the Upper and Lower Collinsville Axe Company Dams for hydroelectric generation. GZA's scope of services for this project is as defined in our proposal dated July 10, 2009. GZA was authorized to conduct the work by the Town's Contract executed November 3, 2010 and the Notice to Proceed signed by the Town and dated November 8, 2010. This report is subject to the limitations contained in **Appendix A.**

1.2 Purpose

The overall purpose of this study is to perform a pre-feasibility study for the rehabilitation and re-powering of the hydroelectric generating systems located at the Upper and Lower Collinsville Axe Company Dams on the Farmington River. The goals of the pre-feasibility study are to:

- Compile enough project information for the Town to make a "go / no-go" decision regarding future project study, licensing, and development;
- To provide the Town with basic project information (i.e. scope of permits required for project, conceptual estimate of costs, power and energy production estimates, etc.) that will serve as a foundation for decision-making and possible future implementation of the projects;

Provide a list of potential studies required to better define project elements such as environmental resources and economic impacts. These studies are those that may be needed to better understand the feasibility of the projects and/or which may be required for as a part of future FERC licensing efforts. The intended use of the report is to assist the Town and its Hydropower Study Committee (which includes representatives from Avon and Burlington) in their decision-making process regarding further detailed studies and/or proceeding to licensing, final design, and construction of new/restored hydroelectric generation systems at the former Collins Company Dams.

1.3 Scope of Work

GZA's scope of work under its current contract with the Town includes the preliminary investigation of the following items:

Task 1: Evaluation of Existing Civil Works
Task 2: Evaluation of Hydrology and Hydraulics
Task 3: Evaluation of Historical Significance
Task 4: Evaluation of Historical Pre-Historic Impacts
Task 5: Evaluation of Equipment
Task 6: Evaluation of Permitting and Licensing
Task 7: Assessment of Lower Impact Hydropower Certification
Task 8: Evaluation of Environmental Resources

Task 9: Summary of Alternatives
Task 10: Economic Assessment
Task 11: Final Summary

1.4 Acknowledgements

This study was prepared by GZA GeoEnvironmental, Inc. Offices involved in the preparation of the report are located as follows:

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1350 Main Street, Suite 1400
Springfield, MA
T: 413-726-2100

GZA engineers responsible for the preparation of this report included Celeste Fay, Kristina Ekholm, Christine Sotolongo, Anthony Zemba, Harry Jones, and Chad Cox.

Specialists in a variety of professional fields were subcontracted to perform work which has been included in the evaluation of the dam sites. Subcontractors which contributed to this report include:

- AI Engineers
- Archaeological and Historical Services, Inc
- Centerbrook Architects and Planners
- Boreal Renewable Energy Development
- Ichthyological Associates, LLC

Assistance in the preparation of this report was provided by the Town of Canton personnel and GZA gratefully acknowledges the efforts of Jeff Shea and the Canton Hydropower Committee.

The Town of Canton, CT's primary offices are located at:
Canton Town Hall
4 Market Street
P.O. Box 168
Collinsville, CT

A list of reference documents used in developing this report and cited herein is contained in **Appendix B**.

2.0 SUMMARY OF FACILITIES

2.1 Background

The Town of Canton, CT is interested in enhancing the long term sustainability of the Town through evaluating and implementing various conservation and efficiency measures, including using renewable energy to offset the energy demands of Town facilities. The Upper and Lower Collinsville Dams, which were originally constructed to harness the energy available in the Farmington River, provide a unique opportunity for the Town of Canton, as well as the adjacent Towns of Avon and Burlington, to produce renewable, green energy and preserve and improve historic assets which are important to the regional economy and environment.

2.2 Location

The Upper and Lower Collinsville Dams are located on the Lower Farmington River in northwestern Connecticut. The Upper Dam is located within the village of Collinsville, Town of Canton, approximately 25 feet upstream of the State Route 179 crossing over the Farmington River. The Upper Dam is located on the Collinsville USGS Quadrangle Map at coordinates of 41°48.5'N, 72° 55.6' W.

The Lower Dam is located on the Farmington River approximately 1 mile downstream of the Upper Dam. The left side of the dam, including the gatehouse, power canal, and powerhouse, is located within the Town of Avon while the right side of the dam is located within the Town of Burlington. The Lower Dam is located on the Collinsville USGS Quadrangle Map at coordinates of 41°48.0'N, 72° 55.7' W

A site locus map is included in **Appendix C**. Photos of the sites are included in **Appendix D**.

2.3 Site Ownership

GZA understands that the Upper and Lower Collinsville Dams are both owned by the State of Connecticut, and maintained by the Connecticut Department of Environmental Protection. The State's ownership includes the headrace canal and west-side powerhouse at the Upper Dam. At the Lower Dam, the State's ownership is also said to include the east-side gatehouse, power canal, and downstream power house. It is understood that the flowage rights for the impoundments were also transferred to the State along with ownership of the dams. The 1998 Environmental Assessment prepared by the Federal Energy Regulatory Commission states on page 7, "The CDEP owns both dams and the associated water rights. The CDEP also owns the intake structure leading to the Collinsville Company forebay." Please note that actual site deeds were not obtained nor examined as part of this study.

The former Collins Company manufacturing buildings along the forebay on the east side of the river at the upper site are privately owned. These structures include various sluiceways which were previously part of the Collins Company hydropower system.

2.4 Historical Hydropower Development at the Upper and Lower Collinsville Dams

The Upper and Lower Collinsville Dams were both constructed to provide hydropower to the facilities of The Collins Company, once the U.S.'s premier manufacturer of axes and similar implements. A very complete history of the dams and hydropower at the sites is presented at the website www.visitcollinsville.com. A brief summary, complied from this website, FERC documents, and other sources, is as follows:

- 1837: Improved timber crib dam built near the site of the present Upper Dam by Collins & Co.. Water is used to supply hydro-mechanical power to trip hammers.
- 1865: Collins Company constructs Otis Reservoir Dam in Otis, MA to improve supply of water to facilities in Canton.
- 1867: Present Upper Dam constructed of stone masonry immediately downstream of previous timber crib dam.
- Early 1900's: Hydromechanical power in Collins Company facilities on the left (east) river bank converted to hydroelectric generation through installation of nine small turbine/generator sets. Peak capacity said to be 1,500 kW.
- 1912: Lower Dam is constructed, along with gatehouse, power canal, and downstream powerhouse. Facilities constructed to produce electricity for Collins Company via two 500 kW Allis Chalmers turbine/generator sets. Excess power sold to Hartford Electric Light Company.
- 193?: Present powerhouse constructed on right (west) bank of river downstream of Upper Dam, including a Leffle francis-type turbine and a 400 kW Westinghouse generator.
- 1955: Upper and Lower Dams, along with power generating facilities, survive historic flood.
- 1965: The Collins Company closes. The Upper and Lower Dams, with all appurtenant structures, are donated to the State of Connecticut. Hartford Electric Light Company (HELCO) decommissions generating facilities.

2.5 Hydropower Development and FERC Background

Following the closing of the Collins Company in the mid-1960s, a variety of entities have proposed to reinstate hydropower generation at the Upper and Lower Collinsville Dam sites. However, only a few have pursued the project to the extent of commencing the FERC process. The following is a summary of the major FERC-related filings associated with the Upper and Lower Collinsville Projects:

- August 29, 1986 – FERC issues an original License to the Metropolitan District Commission (MDC) to construct and operate 1,500 kW developments at both the Upper and Lower Dams (FERC, 1999)
- 1988 – FERC accepts surrender of MDC license after MDC determines that project is not economically feasible (FERC, 1999)
- September 19, 1989 – Summit Hydropower Company (Summit) filed applications for an original minor license to refurbish and operate a 1,310 kW project at the Upper Dam and to refurbish and operate a 1,310 kW project at the Lower Dam (FERC, 1999)
- September 10, 1999 – FERC issues final Environmental Assessment of projects proposed in September 19, 1989 License Applications (FERC, 1999)

- February 23, 2001 – FERC issues an original license for the Upper Dam and an original license for the Lower Dam to Summit (FERC, 2001; FERC, 2001) See **Attachment 1.**
- December 11, 2007 – FERC issues Order Terminating Licenses for the Upper and Lower Collinsville Dam Projects (FERC, 2007)
- August 6, 2008 – Town of Canton, CT submits to FERC a Preliminary Permit Application to secure rights to develop site and priority for filing of License Application (Town of Canton, 2008)
- January 8, 2009 – FERC issues Preliminary Permit for the Upper and Lower Collinsville Dam Projects to the Town of Canton, CT (FERC 2009) See Attachment 2

2.6 Farmington River Watershed Characteristics

The following has been paraphrased from the August 2003 State of the Farmington River Watershed Report conducted by the Farmington River Watershed Association (FRWA, 2003).

> The Farmington River watershed includes portions of ten towns in Massachusetts and 23 towns in Connecticut. The total river length is 81 miles from its source to its confluence with the Connecticut River with 16 river miles located in Massachusetts and 65 in Connecticut. The watershed is characterized by rolling hills, meadows, trap rock ridges, multiple tributaries, water supply reservoirs, dams, and high quality aquifers. Rising in the Berkshire Hills of Becket, MA at an elevation of 2,180 feet, the River's West Branch flows in a southeasterly direction through Otis, Tolland, and Sandisfield, entering Connecticut in Colebrook at an elevation of approximately 1,300 feet. The upper watershed is characterized by hills with a multitude of wetlands, lakes and ponds.
>
> The River continues southeasterly through Barkhamstead and New Hartford where the confluence of the West Branch and East Branch occurs below Lake McDonough and Barkhamstead Reservoir, creating the Farmington River Main Stem. As the main stem of the Farmington River flows through New Hartford, the significant rapids of Satan's Kingdom are encountered and flow passes through a steep gorge. In Farmington, the River turns north to enter the section known as the "bathtub" referring to the slower moving, warmer, sediment-laden waters. Here the River meanders through floodplains and at times of flooding, this portion of the river becomes a natural storage area with excess water flowing outward and over the floodplain. Tariffville Gorge, where the river turns east restricts water flow to create the meandering area. The towns of east Granby, Bloomfield and Windsor border the river as it flows easterly to meet the Connecticut River at an elevation of approximately 10 feet. Total elevation change of 2,170 feet reflects a fairly dramatic drop in topography from the source waters in Southern Massachusetts to the lowlands where the Farmington ultimately meets the Connecticut River.
>
> Major tributaries to the Farmington River include the Clam and Buck Rivers in Massachsuetts as well as the Still River, Sandy Brook, Mad River, Nepaug River, Cherry Brook, Roaring Brook, Nod Brook, Hop Brook, Stratton Brook, the Pequabuck River, and Salmon Brook in Connecticut.

The Upper and Lower Collinsville Dams are located downstream of the Satan's Kingdom rapids and upstream of the northern swing of the river. The Lower Dam is located approximately 25 river miles upstream of the Farmington River's confluence with the Connecticut River. The Upper Dam is located

approximately 26 river miles upstream of the Lower Dam. There are no major tributaries between the Upper and Lower Dams therefore they both have essentially the same contributory watershed area of approximately 359 square miles.

2.7 Site Characteristics

GZA and several of the associated sub-consultant personnel conducted site visits to each dam on December 1, 2010. Each site was preliminarily assessed with regard to characteristics which might affect the viability of hydroelectric generation. Specifically, the existing structures were evaluated for incorporation into the proposed system. On-site observations were combined with information from existing reports and studies to develop site descriptions. Information from the 1979 Feasibility Study prepared by the Development and Resources Corporation of Sacramento (DRCS, 1979) as well as information from the 1999 Environmental Assessment prepared by FERC (FERC 1999), was relied upon in developing site characteristics. No elevation surveys or formal inspections were conducted. The following are descriptions of the existing structures at the site which may utilized as part of any future hydropower generation project. Site photos taken during GZA's field visits are included in **Appendix D**.

2.7.1 Upper Site

The Upper Dam impounds the river such that water may be provided to each of the two flow-ways, located on the left and right side of the dam. The flow-way on the left (east) side of the dam is controlled by multiple slide gates and directs water into the forebay adjacent to the buildings of the former Collins Company. These buildings reportedly had nine operating turbines within the various factory structures, and some of the sluiceways may still be partially active. The flow-way structure on the right (west) side of the dam is the headrace canal which leads to the existing powerhouse which housed a single turbine. The focus of this study is on the right (west) side headrace canal and powerhouse. The former Collins Company buildings adjacent to the left (east) forebay are privately owned.

2.7.1.1 Upper Dam

The Upper Dam consists of a masonry spillway, approximately 325 feet long, to the right of an approximately 335 foot long earthen embankment. The eastern earthen embankment also serve as the road embankment for Route 179 is faced on its upstream side by a vertical masonry retaining wall which has been partially reconstructed with concrete. The earthen embankment separates the main impoundment from the forebay area to the south. Towards the center of the embankment is a 62 foot long concrete bulkhead with eight sluice gates. The downstream side of the bulkhead section consists of a vertical masonry retaining wall. Flow from the gates passes beneath the Route 179 highway bridge and into the forebay for the adjacent former Collins Company factory buildings. The forebay is impounded by a 110 foot long low masonry weir similar in construction to the main spillway. At the right end of the forebay dam are a 42 inch square sluice and a 60 inch diameter low level outlet pipe. Connecticut Route 179 runs along the top of the embankment. A single span bridge crosses above the inlet to the forebay, and then a four span bridge crosses the main channel of the Farmington River immediately downstream of the main spillway. The total structural height of the embankment portion of the dam is approximately 32 feet.

The primary spillway of the dam is an approximately 18.5 foot high, gravity structure constructed of stone masonry. The primary spillway is 325 feet long and located immediately upstream of the Route 179 bridge. It is believed that the spillway is founded on bedrock for its entire length. According to available sectional drawings, the base width of the spillway is approximately 11.3 feet. The overflow elevation of the spillway has been typically raised by up to three feet through the addition of flashboards to the crest of the masonry structure.

Near the right (west) end of, and perpendicular to the spillway section, is a 200 foot long concrete training wall which forms the eastern (river-side) side of the headrace canal. The headrace directs flow downstream from the impoundment to the existing powerhouse. At the upstream end of the headrace canal, there is a 20 foot long notch in the main spillway with a maximum depth of 3 feet below the spillway crest. The river-side training wall includes a section which serves as a 160 foot long spillway at an elevation one foot lower than the main dam spillway (typically controlled by flashboards) and also includes a 40 foot long non-overflow section housing one mid-level and three low level outlets. The main dam spillway, the concrete headrace canal training wall overflow section and the masonry forebay dam spillway are all able to accommodate flashboards.

2.7.1.2 Headrace Canal and Intake Structure

The headrace canal which serves the existing right (west) side powerhouse is located on the right side of the dam, along the right abutment. This channel leading up to the powerhouse intake is approximately 50 feet wide and extends for approximately 190 feet downstream from the main spillway. Adjacent to the primary spillway is a submerged weir which reaches across the entrance to the headrace canal. The primary length of the weir is at approximately elevation 286.0 ft, however, approximately at the center of the channel, for a length of 20 feet, the elevation is 283.0. This notch is presumed to have been provided to improve they hydraulic capacity of the weir. It is thought that this weir is part of the existing spillway structure which extended straight across the river channel to the right abutment prior to the construction of the right (west) powerhouse and headrace canal.

In the area adjacent to the powerhouse, the depth of the headrace canal from bottom to the top of the training wall is approximately 22 feet. The intake to the powerhouse is protected by a trashrack structure which stretches across the upstream width of the powerhouse, parallel to the upstream side of the powerhouse and 90 degrees to the direction of flow. The existing trash rack is approximately 40 feet wide. Immediately downstream of the trashrack is a headgate. The existing headgate is reportedly a timber horizontal roller gate which was previously operated from a deck outside the powerhouse.

2.7.1.3 Powerhouse

The powerhouse consists of a brick superstructure atop a concrete substructure which is reportedly founded on bedrock. The powerhouse is approximately 30 foot high at the peaked roof and consists of a single accessible room which formerly housed the generator and other control equipment. The finished floor level is at approximately elevation 292.2, with windowsills around the room at approximately elevation 296.7. A circular structure inside the powerhouse was where the generator was previously located. The existing turbine was housed in the substructure, which appears to have been configured in the "water box" style to permit radial flow through the turbine wicket gates.

Once flow had passed through the turbine, it apparently discharged through a draft tube into a plunge pool below the powerhouse. It appears there is a second chamber below the west portion of the powerhouse (nearest the shore). There is some indication this may be a bypass structure which permits flow to be discharged without passing through the turbine.

There is currently no utility service to the powerhouse. The original gantry crane remains in place.

Discharge from the powerhouse is into a tailrace channel bounded on the left by a low concrete training wall and on the right by a dry laid stone regaining wall and riverbank. The powerhouse tailrace channel is confined on the left by a low concrete training wall and on the right side by a dry laid stone training wall.

Additional description of the powerhouse is containing in a memorandum from Centerbrook Architects contained in **Appendix E**.

2.7.1.4 Existing Turbine

It is reported that the original turbine was a single vertical Francis turbine. It is understood that the turbine was manufactured by the James Leffel Company and is a type 2 wheel rated at 400 kva at 154 RPM. It is believed that this turbine may still be in place, but this could not be visually confirmed.

2.7.1.5 Existing Generator

There is no existing generator in the Upper Dam west side powerhouse. It has been reported that it was removed by HELCO when the site was decommissioned. It is reported that the original generator was a 400 kW synchronous Westinghouse unit with a speed of 154 RPM, assuming a direct connection.

2.7.1.6 Existing Controls, Protection, and Transformers

There are no existing controls, protection gear, switch gear, transformers, or any other equipment in the powerhouse.

2.7.1.7 Transmission Lines and Interconnection

There are currently no transmission lines or interconnections associated with this site. There is an active utility pole located on the corner of Bridge Street and Torrington Avenue approximately 75 feet from the powerhouse.

2.7.2 Lower Site

2.7.2.1 Lower Dam

The Lower Dam is a concrete gravity structure approximately 400 feet long with a 300 foot long spillway with an adjacent canal and powerhouse. The dam reportedly has a structural height of approximately 33 feet (toe of dam to top of training walls). The dam consists of a 40 foot long non-overflow section adjacent to the right abutment and a 300 foot long run-of-the-river spillway with an ogee crest. Three 4 foot by 4 foot low-level sluice gate outlets are located in the right-side (west) non-overflow section with manually cranked floor stands in a wooden beam. Flows into the approximately

640 foot long power canal at the left (east) end of the dam are controlled via a gatehouse structure at the left abutment. Flow is controlled via six, 6 foot by 8 foot sluice openings. These sluice gates are controlled by manually operated worm gear hoists inside the brick gatehouse structure. There is an approximately 400 foot long concrete retaining wall along the right side of the impoundment upstream of the dam and an 115 foot long curved retaining wall at the left end upstream side of the dam, creating small bay upstream of the gatehouse.

The spillway structure has a hydraulic height of approximately 21 feet (toe to crest). The width of the structure at the base is reported to be 27.8 feet, based on available drawings. These drawings also indicate that the spillway is both founded on and keyed into bedrock (USACE, 1978).

2.7.2.2 Gatehouse, Power Canal, and Intake Structures

A brick gatehouse built atop the 24 foot wide left abutment houses six worm gear sluice gate hoists which appear to be non-operational. The gate hoists control flow through six 6-foot by 8-foot openings to the power canal.

The canal structure is approximately 640 feet long and appears to have been excavated from the riverbank. The canal extends from the left abutment gatehouse to the powerhouse at its downstream end. The canal is presently somewhat silted in and is currently vegetated with species typical of wet habitats. The canal is confined on the left (bank side) by a dry laid stone retaining wall and on the right (river side) by a concrete wall for the first 150 feet downstream of the spillway. The concrete wall extends from the main dam abutment to a section of the old riverbank which was left in place. The concrete wall then continues as a retaining wall along the portion of natural ground to the waste weir adjacent to the powerhouse at the downstream end of the canal. The waste weir is approximately 50 feet long and has a trapezoidal cross section at the right downstream end of the canal between the concrete canal wall and the concrete substructure of the powerhouse. The crest and downstream face were reportedly resurfaced in 1966 and reinforcing bars protrude from the structure. There is a low level sluice gate through the weir abutment; however, the hand wheel appears to be broken.

The canal is bounded on the right side by a concrete retaining wall for the first several hundred feet and then by fill/natural ground for the remaining length. The left side is formed by the excavated hillside. In all locations where the canal is fill or natural ground, there is a dry laid stone retaining wall. The powerhouse consists of a brick superstructure atop a concrete substructure. There is a 50 foot wide waste weir and a low level canal discharge sluice gate immediately upstream of the power house and adjacent to the concrete canal wall. Intake to the powerhouse is through wood slide gates and discharge is into a tailrace leading to the river channel immediately downstream of the powerhouse where there is a granite-gneiss masonry retaining wall along the river bank.

2.7.2.3 Powerhouse

The powerhouse consists of a brick superstructure atop a concrete substructure. The powerhouse housed two turbines which were fed by a 14-foot by 9-foot openings in the upstream concrete bulkhead of the powerhouse. Flow through the turbines was controlled by a timber slide gate with upstream trashrack protection. Flow into the turbines was via an open “water box” type arrangement rather than a penstock or scroll case. At the downstream outlet of the powerhouse, there is a granite

masonry retaining wall which appears to protect sliding of the adjacent riverbank into the tailrace. The tailrace is heavily silted. The roof of the powerhouse has fallen in and the entire structure is open to the elements.

2.7.2.4 Existing Turbine

It is reported that the existing turbines located at the Lower Dam consists of two vertical Francis turbines. The turbines were manufactured by the Allis-Chalmers Company and are rated at 425 kW at 90 RPM [1]. The turbines are located within the subsurface portion of the existing powerhouse and the remaining portions are partially visible through the generator stand portals located in the main floor. It appears that the debris associated with the collapsed roof as well as sediment have partially filled the turbine pit and obscured the turbine. A preliminary evaluation of the turbines as compared to the existing drawings of the lower powerhouse indicates that the turbine runners and gatecases may have fallen into the top portion of the draft tubes.

2.7.2.5 Existing Generator

The generators which would have been associated with the existing turbines are not currently present at the sites.

2.7.2.6 Existing Controls, Protection, and Transformers

There are no existing controls, protection gear, switch gear, transformers, or any other equipment in the powerhouse.

2.7.2.7 Transmission Lines and Interconnection

There are currently no transmission lines or interconnections associated with this site. The electric utility company, CL&P, has a medium voltage distribution class overhead three phase feeder installed in a right of way along the access road extension adjacent to the site. This feeder connects to the CL&P substation near the intersection of Spring Street and New Road.

2.8 Suitability of Existing Structures

GZA has completed site visits of the Upper and Lower Collinsville Dams and ancillary structures as well as completed a literature review of the available documents pertaining to the sites. Detailed studies are outside the scope of services for this stage of the project. However, based upon the available information it was found that many of the existing structures are generally well suited for hydropower generation, though perhaps in need of repair or rehabilitation. This is primarily due to the fact that the sites were originally designed and constructed for the purpose of hydroelectric generation.

Any developer of hydropower at one or both of the dam sites will need to acquire the rights to utilize the property from the current owner, the CTDEP. This arrangement could take several forms, including a lease agreement or an outright purchase. GZA notes that if the Town or other development entity does seek the legal right to develop hydropower at one or both of the Collinsville Dams, the Town (or other development entity) will need to carefully establish who will have ultimate responsibility for any needed repairs to the dams, as well as future operation and maintenance. If that responsibility passes to

[1] US Department of Energy, and Town of Canton. *Feasibility Study Canton Hydroelectric Project*. Publication. Vol. 1. Print

the Town, additional costs will likely be incurred. Dam ownership also brings with it general and specific liabilities associated with potential mis-operation or dam failure.

2.8.1 Upper Site

2.8.1.1 Dam

In general, the Upper Dam is suitable for hydropower generation. There are however, potential condition deficiencies as well as modifications which may be required to integrate the dam with some of the new ancillary features. The following are items which may result in modifications to the Upper Dam:

- Existing Dam Safety Deficiencies, known and potential;
- Construction of Upstream and Downstream fish passage; and
- Raising of Spillway Crest.

Limited information with regards to the existing condition of the Upper Collinsville Dam is available and a dam safety inspection is not within the scope of this study. There is however, a "Sufficiency Report" which was completed in 2004 and gives a brief overview of the potentially existing dam deficiencies. The Sufficiency report is located in Attachment 3 and provides the following summarized information with regards to deficiencies:

- **Dam Crest** –General settlement, depressions, defects; spalling, cracking, erosion, exposed rebar in concrete; cracking, open joints, loose stones in masonry section.
- **Upstream Face** – Spalling, cracking and erosion of concrete; open joints, missing stones, loose stones in masonry section.
- **Downstream Face** – Spalling, cracking, erosion, exposed reinforcement in concrete; cracking of masonry surfaces.
- **Primary Spillway** – Spalling, cracking, erosion, exposed rebar in concrete;
- **Primary Spillway Discharge Channel** – Spalling, cracking, erosion of concrete;
- **Outlet Works -** May require rehabilitation

In addition to these visually identified deficiencies, the issue of the factors of safety against structural instability was raised by the 1979 Feasibility Report (DR, 1979. p. 28). The report indicated insufficient factors of safety against sliding for the Upper Dam primary spillway on the basis of a preliminary analysis. A more detailed investigation is therefore warranted. It is noted that the spillway has survived significant floods in the past, but that this does not necessarily indicate that the factors of safety meet recommended minimums. If stability improvement is necessary, post tensioned tie-down anchors are one possibility for addressing the deficiency.

The need for modifications to the dam for fish and eel passage is dependent upon the final Stakeholder recommendations and final design. It is likely that the installation of said passage will require some dam modifications. Upstream passage will likely require modification of the primary spillway in the area adjacent to the embankment section on the east side of the primary spillway. These modifications will allow for the installation and anchoring of the upstream end of the upstream passage to the existing dam structures. For all alternatives, downstream fish passage can likely be provided by modifying the existing mid level outlet structure located immediately upstream of the powerhouse on the east side approach channel wall to meet the U.S. Fish & Wildlife's (USFWS) downstream passage

criteria. The Upper Collinsville Dam historically has had three feet of flashboards installed on the spillway crest (including at the headrace channel and forebay weir) to effectively raise the normal water surface elevation of the impoundment. These flashboards are not currently present on the dam and are not currently being maintained. Replacement of these flashboards or other steps to raise the normal impoundment elevation is a key component of the proposed hydropower development at the site. Changes in impoundment water level and resulting changes in driving forces and uplift must be considered in any future structural analysis. GZA has included a preliminary evaluation of options for raising the Upper Collinsville Dam impoundment in Section 3 of this report. These options include re-installing flashboards, installation of a so-called bladder dam on the spillway crest, or installation of a traditional crest gate on the spillway crest. A different level of structural modifications to the spillway would be necessary for each option, as well as potentially different levels of remedial repairs.

2.8.1.2 Headrace Canal and Intake Structures

The existing headrace canal begins adjacent to the primary spillway and conveys flows to the intake structure located at the powerhouse. Adjacent to the primary spillway, is the submerged weir which is thought to be a function of an older configuration of the Upper Dam. See Photo 2-1. Preliminary flow calculations indicate the without the addition of flashboards (or other option for raising water surface levels), the flow capacity of the intake to the approach channel is approximately 100 cfs which is insufficient for all development alternatives (as discussed in Section 3). However, when the flashboards are installed on the dam, the flow capacity of the intake structure increases to approximately 1,200 cfs which is sufficient flow capacity for all development alternatives.

Photo 2-1: Submerged Weir located on West Side of Dam, Adjacent to Primary Spillway

It is thought that the surface outlet located along the downstream/east side of the headrace canal training wall (adjacent to the powerhouse) can be utilized to accommodate downstream passage for development alternatives 1, 2, and 3. Furthermore, the remaining three low level outlets, located adjacent to the surface outlet can remain in place and be utilized as drains during and after construction and should any future maintenance to the headrace canal be required.

Note that for development alternative 4, a new means of conveying fish species downstream (rather than modifying the surface outlet) will be required due to placement of trashracks and the potential for entrainment around the tube turbines.

Based on visual observations, it appears that there is sediment accumulation in the headrace channel which may need to be dredged in order to provide sufficient hydraulic capacity at the intake and permit reconstruction of the trash racks. There is currently no information available on sediment physical or chemical characteristics in this area and so sampling and testing will be necessary during future study phases.

2.8.1.3 Powerhouse

The existing powerhouse was originally designed & constructed to house hydroelectric generating equipment, however; it has not operated as such in many years. It is noted that the location of the powerhouse appears to provide a benefit with respect to the amount of gross head available for hydropower generation. The location of the powerhouse, combined with the configuration of the tailrace (and tailrace wall) appears to allow discharge beyond a riffle area downstream of the dam. This appears to add several feet to the total available gross head, when compared to the hydraulic head of the spillway.

The Upper Powerhouse exterior enclosure is in fair condition and shows no major visible deterioration of the brick walls. The condition of the shell will make it easier to provide an addition to the exterior shell, if needed for accommodating larger generating equipment such as that proposed under development Alternative 3. (Centerbrook, 2010)

To rehabilitate the existing powerhouse as an operable component of the project, some base work will be required including the following (Centerbrook, 2010):

- Removal of any potentially hazardous materials (guano, asbestos, etc.)
- Masonry repair and restoration of exterior walls, including mortar re-pointing, and cleaning
- New exterior windows including glazing. Some new pre-cast sills may be required.
- New exterior doors.
- New clay tile roof and substrate to provide watertight enclosure.
- Cleaning and repainting or complete removal of existing paint for exposed brick surface.

The powerhouse does pose some challenges with respect to physical constraints. The existing powerhouse was originally constructed to house a single 292 cfs turbine which, when compared to the available river flows, is relatively small. At the time of construction, the Collins Company was also generating power on the east side of the river. The size of the existing powerhouse will be sufficient to house the turbines proposed for development Alternatives 1, 2, and 4; however; expansion of the footprint will be required for the two turbines proposed under Alternative 3. This is consistent with the proposals made in the 1979 Feasibility Study (DR, 1979. p. 32). Additional structural analysis of the structure for stability under modern wind, snow, and seismic loads will be necessary under final design. The existing gantry crane should be replaced.

Due to the historic nature of these sites, the methods and materials used for rehabilitation and/or expansion of any existing structures, including the powerhouse, will likely require

consultation with the applicable resources agencies and may require specific study. Any expansion (if allowed) would likely need to use similar architectural style and construction. The need to provide historically sympathetic construction will likely result in a premium cost to construction.

2.8.1.4 Existing Turbine

Although technically feasible, the existing turbine (if still in place) is not likely suitable for rehabilitation and re-use during the development of the Upper Site. Although there is a possibility of procuring a used turbine for the site, it is likely that a new turbine will be required. See Section 3-4 for further discussion of equipment.

2.8.1.5 Existing Generator

There is not an existing generator associated with the Upper Dam hydroelectric facilities; therefore, a new generator will be required.

2.8.1.6 Existing Controls, Protection and Transformers

There is no existing electrical equipment associated with the Upper Dam including control and protection systems and transformers. All electrical equipment will need to be purchased for the site development.

2.8.1.7 Transmission Lines and Interconnection

As there are no existing transmission lines or interconnection, these components will need to be installed new.

2.8.2 Lower Site

2.8.2.1 Dam

In general, the Lower Dam is suitable for hydropower generation. There are however, potential condition deficiencies as well as modifications which may be required to integrate the dam with some of the new ancillary features. The following items may result in modifications to the Lower Dam:

- Existing Dam Safety Deficiencies, known and unknown;
- Construction of Upstream and Downstream fish passage; and
- Raising of Spillway Crest.

Limited information with regards to the existing condition of the Lower Collinsville Dam is available and a dam safety inspection is not within the scope of this study. There is however, a "Sufficiency Report" which was completed in 2004 and gives a brief overview of the potentially existing dam deficiencies. The Sufficiency report is located in Attachment 1 and provides the following summarized information with regards to deficiencies:

- **Dam Crest** –Spalling, erosion of concrete.
- **Upstream Face** – Spalling, erosion of concrete.
- **Downstream Face** – Spalling, erosion of concrete.
- **Primary Spillway** – Spalling, cracking, erosion, exposed rebar in concrete;
- **Primary Spillway Discharge Channel** – Spalling, cracking of concrete;
- **Outlet Works -** May require rehabilitation

Factors of safety against structural instability for the primary spillway were studied in the 1979 Feasibility Report (DR, 1979. p. 28). In general, that report indicated a more robust factors of safety against sliding for the Lower Dam in comparison to the Upper Dam. This is consistent with cursory assessment of the cross-section drawing of the spillway which indicates the structure to have a relatively wide base and to be keyed into bedrock. Further analysis is likely prudent, in GZA's opinion.

A proposed upstream fish passage facility is currently proposed to be installed on the right (west) side of the downstream river channel extending upstream to the impoundment by way of the right abutment / non-overflow section. Further study will be required with respect to the potential impact of fish passage installation around the right abutment. However, there is a potential that some dam modifications will be required such that the integrity of the dam is not affected. The proposed downstream fish passage will be likely be located on the primary spillway adjacent to the existing gatehouse (or possibly at the waste weir in the power canal). As per U.S. Fish & Wildlife Standards, a notch (3 feet by 2 feet) is generally required to ensure safe downstream passage over the dam. This notch would be provided through primary spillway or the flashboards.

It is understood that the Lower Collinsville Dam historically has had five feet of flashboards installed on the spillway crest to effectively raise the normal water surface elevation of the impoundment. These flashboards are not currently present on the dam and have not been installed in the recent past. Replacement of these flashboards or other steps to raise the normal impoundment elevation is a key component of the proposed hydropower development at the site. Changes in impoundment water level and resulting changes in driving forces and uplift must be considered in any future structural analysis. GZA has included a preliminary evaluation of options for raising the Lower Collinsville Dam impoundment in Section 3 of this report. These options include re-installing flashboards, installation of a so-called bladder dam on the spillway crest, or installation of a traditional crest gate on the spillway crest. A different level of structural modifications to the spillway would be necessary for each option.

2.8.2.2 Gatehouse, Power Canal, and Intake Structures

The existing gatehouse was originally designed and constructed as a flow control structure, regulating flow into the power canal. Although the general condition of the gatehouse has deteriorated over time, it appears that the gates are sealed with minor leakage. The subsurface portion of the gatehouse was not assessed due to water levels however; in general, the concrete appeared to be in satisfactory condition. The original gate operators are still in place and appear that with minor rehabilitation, they may still be in operating condition. Based upon the observed water levels upstream and downstream of the gates and the assumption that the actual gates are wooden, it is likely that the gates will require full replacement. Visual observation of the area upstream of the gatehouse indicates significant sedimentation varying in elevation but typically at the water surface elevation. This indicates that there is approximately 10 feet of sediment depth upstream of the gatehouse which will require removal for all development alternatives. There is currently no information available on sediment characteristics in this area and so sampling and testing will be necessary during future study phases.

The full length of the Canal appears to have accumulated significant quantities of sediment which likely passed through the gatehouse during operations and/or washed down off of the adjacent hillside. Some portion of this material may also require removal if the canal structure is to be utilized. Some additional investigation of the river side concrete retaining wall may be necessary.

Repairs to the masonry retaining walls will likely be necessary. It is noted that the power canal is currently dewatered.

2.8.2.3 Powerhouse

The existing powerhouse was originally designed & constructed to house hydroelectric generating equipment, however; it has not operated as such in many years. In general, the condition of the powerhouse is poor. The entire roof has collapsed and the interior of the structure appears to have been open to the elements for many years. It is noted that the location of the powerhouse appears to provide a benefit with respect to the amount of gross head available for hydropower generation. The location of the powerhouse, combined with the configuration of the tailrace (and tailrace wall) appears to allow discharge beyond a riffle area downstream of the dam. This appears to add approximately 2 feet to the total available gross head, when compared to the hydraulic head of the spillway. This benefit with respect to gross head, combined with a need to address the condition of the structure in some manner, argues for some form of rehabilitation to the structure.

The exterior masonry shell of the powerhouse is in poor condition with visible signs of masonry damage, mortar deterioration, mildew, and efflorescence. Mildew and efflorescence on the brick indicate moisture penetration which has likely incurred internal damage to the walls. The condition of the foundation is unknown but there are no obvious signs of settlement.

There are a total of 32 windows in various conditions ranging from bricked over to remains of windows present. The roof structure has completely failed with remaining debris hanging from an overhead crane.

One option for rehabilitation of the Lower Site gatehouse is to maintain and stabilize the shell of the structure through the construction of a new structural frame inside the existing footprint. The new roof would be supported by new structural elements, which would also serve to brace the existing masonry envelop. This would result in essentially as "building within a building" that would maintain the external appearance of the existing building while provide a new structure for the powerhouse. A second option is to completely raze (demolish) the superstructure and rebuild a new structure.

The tailrace for the Lower Site powerhouse discharges downstream directly into the river channel. There is, however, a sand bar which appears to have formed in the tailrace area which may require dredging for hydraulic efficiency and fisheries concerns.

2.8.2.4 Existing Turbine

Although rehabilitation is theoretically feasible, the existing turbines appear to be in very poor condition and are not likely suitable for rehabilitation and re-use during the development of the Lower Site. Although there is a possibility of procuring a used turbine(s) for the site, it is likely that a new turbine(s) will be required. See Section 3-4 for further discussion of equipment.

2.8.2.5 Existing Generator

There are no existing generators associated with the Lower Dam hydroelectric facilities; therefore, a new generator(s) will be required.

2.8.2.6 Existing Controls, Protection, and Transformers

There is no existing electrical equipment associated with the Lower Dam including control and protection systems and transformers. All electrical equipment will need to be purchased for the site development.

2.8.2.7 Transmission Lines and Interconnection

As there are no existing transmission lines or interconnection, these components will need to be installed new.

3.0 HYDROPOWER TECHNICAL ANALYSES

Hydroelectricity is the production of electrical power through the use of the gravitational potential force stored in falling water. The amount of electrical generation potential at a given location is, in most simplistic theoretical terms, a function of the amount of available flow, the net head, and the overall efficiency of the hydroelectric generation equipment.

3.1 Available Flow

3.1.1 Flow Duration Curve

The available flow for hydropower generation is typically a function of the hydrologic characteristics of the drainage basin upstream of the hydroelectric project less any conservation flows that cannot be directed through the energy generation equipment.

GZA completed a review of available data for USGS gauges on the Farmington River near the project site, as listed in **Table 3-1**.

Gage No.	Location	Drainage Area (Square Miles)	Period of Record
01186000	Riverton, CT (West Branch)	131	10/1/1955 to 11/8/2010
01187980	Collinsville, CT	360	11/1/1962 to 9/30/1977
01188090	Unionville, CT	378	10/1/1977 to 11/8/2010

Table 3-1: Summary of USGS Gauges on Farmington River Near the Collinsville Dams

The Goodwin and Colebrook Dams have operating hydroelectric facilities and are located upstream of the project. These two projects do not necessarily operate in a run-of-river mode. Per the State of Connecticut's Legislative act, the Goodwin Dam is required to make releases into the Farmington River based upon accounted inflows from the 120 square mile drainage area watershed into the Colebrook River Lake with the following conditions:

- Releases are calculated and adjusted on a weekly basis depending upon the previous week's inflows
- A minimum release flow of 50 cfs is required at all times regardless of calculated inflows
- Calculated inflows between 0-150 cfs must be released and are categorized as "natural flows"

Inflows exceeding 150 cfs may be stored in the Colebrook River Lake or the West Branch Reservoir. The hydropower facilities at the Goodwin Dam were constructed in 1986 and the hydropower facilities at the Colebrook dam began operations in 1988. Therefore, flow data from the above gages before the commencement of hydropower operations at the Goodwin and Colebrook Dams may not be representative of the operations of these facilities. Although the Goodwin and Colebrook Dams do not divert flows out of the river (all flow into the reservoirs is eventually released), they do regulate the release of flows meaning that during times of high flows some may be retained and released during lower flow times of the year. In general, these operations would benefit any proposed hydropower projects at the Upper or Lower Collinsville Dams by providing attenuated and less variable flows.

GZA reviewed the available data at the Unionville gage over the full period of record and for the period of 1989 to present. GZA also analyzed data from the other two relevant gages listed above. Flow data from all gages were normalized to the dam by applying a drainage area ratio to develop flow duration data which describes the frequency at which various flow rates are available as a percentage of an average year. The graphical results (flow duration curves) are shown in **Figure 3-1** and tabulated results for the normalized data from the Unionville gage for the periods analyzed are shown in **Table 3-2**.

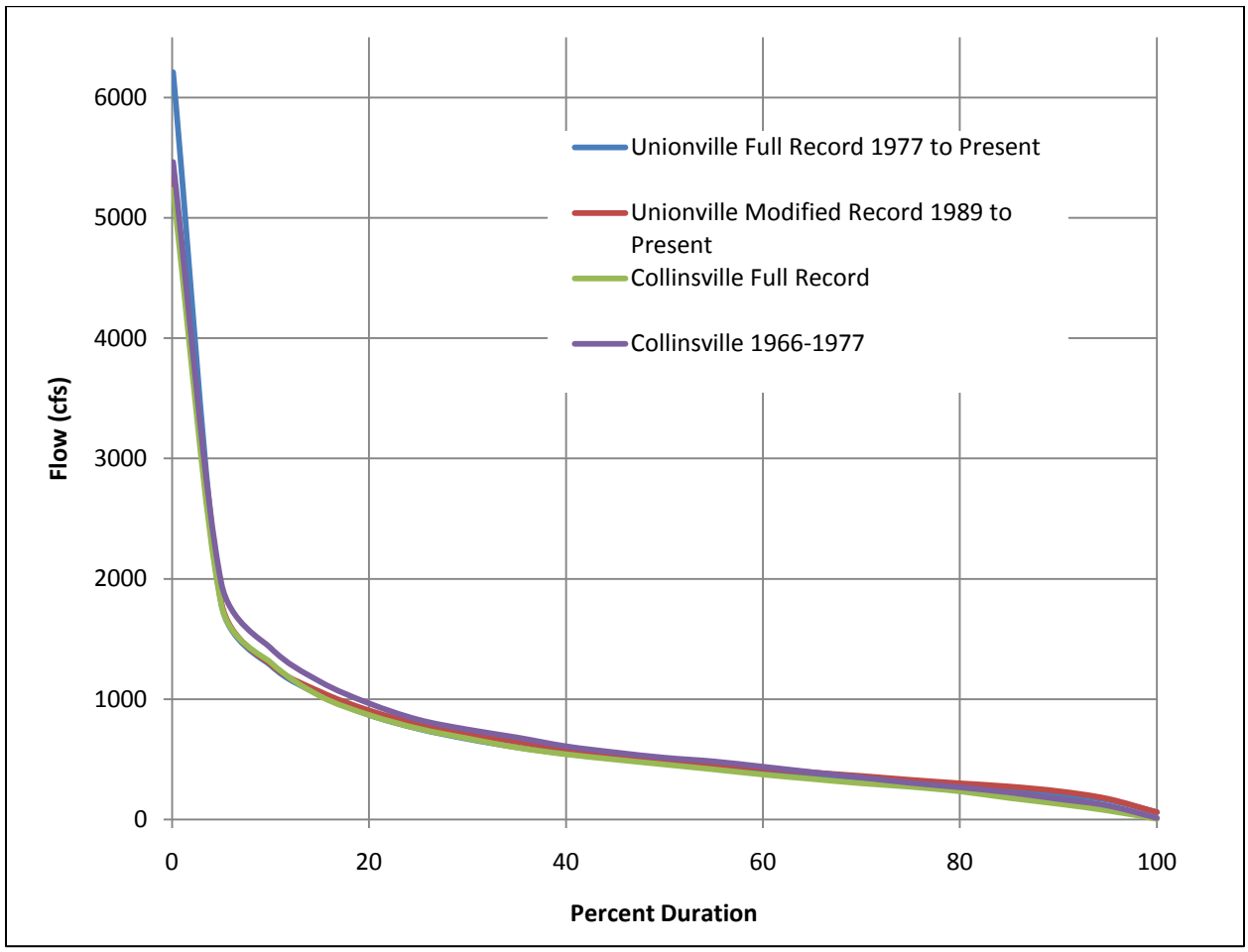


Figure 3-1: Normalized Collinsville Dams Flow Duration Curves

The Unionville Gauge has a drainage area of approximately 378 square miles and the Upper and Lower Collinsville Dams have a drainage area of approximately 359 square miles. Therefore, the drainage area ratio used to normalize the Unionville Gage data to the dam sites is 0.95. Ratios for the Collinsville gage and the Riverton gage were and 1.00 and 2.74, respectively. Note that the Lower Dam in actuality has a slightly larger drainage area, but for the purposes of this study the difference is trivial and therefore has been ignored.

The difference between the flow duration curves for the two different data sets for the Unionville gage is noticeable but relatively minor. It is not clear from this level of analysis whether the difference stems from the operation of the two upstream dams or from normal hydrological variation. It is noted that neither of the data sets contains data from the significant drought of the mid-1960s. GZA chose to utilize the data from the Unionville gage for the data period from 1989 to the present for all subsequent analyses. This data would better capture any influence from the two upstream projects and is reasonably close to all other flow data sets studied in any event.

Note that a flow duration curve is a statistical device which describes an "average" year. In any actual year, variations in weather and hydrologic conditions can lead to more or less water being available and changes to the time such flows are available for that particular year.

The operating scheme of the proposed Upper and Lower Collinsville Sites has been assumed to be restricted to instantaneous run-of-the-river mode. Under this mode, the flow through the system is always equal to the inflow from the river. This results in a stable impoundment elevation. No "ponding" or "store and release" operations have been considered due to environmental considerations. Therefore flows for hydropower and conservation purposes are always equal to flows in the river.

Not all of this flow is available to generate hydropower. Flows which are not available to the turbine are those which must be routed over or through other structures for other purposes. These other purposes include, but are not limited to water quality maintenance, habitat preservation, downstream fish passage, upstream fish passage, aesthetics, and others.

To evaluate potential conservation flows requirements, GZA reviewed the Environmental Assessment (EA) document prepared by FERC in 1999 as part of the previous licensing effort. This document compiled and summarized the results of recommendations from consultations regarding to flow to the bypass reaches, aesthetic flows, and fish passage flows, and flows to the forebay at the Upper Site. **Table 3-3** is a summary of the recommendations for conservation flows which were contained in the FERC EA and subsequently written into the previous licenses.

Duration	Normalized Flows at Collinsville Dams (source data: Unionville gage)	
	Data Set Period: 1977 to Present	**Data Set Period: 1989 to Present**
		DATA SET USED IN GZA STUDY
0.1	6211	**5376**
5	1795	**1804**
10	1282	**1292**
15	1035	**1064**
20	869	**907**
25	754	**795**
30	670	**713**
35	600	**647**
40	546	**587**
45	504	**538**
50	465	**500**
55	428	**461**
60	398	**425**
65	369	**391**
70	340	**362**
75	314	**330**
80	286	**301**
85	255	**274**
90	208	**236**
95	163	**173**
100	61	**61**

Table 3-2: Normalized Collinsville Dams Flow Duration Data

Flow Use	Upper Site	Lower Site
Bypass Reach (minimum flow over spillway)[1]	180 cfs	180 cfs
Fish Passage Flow[2]	37 cfs	37 cfs
East Side Forebay[3]	27	---
Maximum Total Conservation Flow:	207 cfs	180 cfs

1. Flow over spillway to equal inflow when inflow less than 180 cfs
2. Can be included in the total 180 cfs requirement for bypass reach.
3. Includes 9 cfs for veil flow over the forebay weir and 18 cfs for the Collinsville canals

Table 3-3: Estimated Conservation Flow Requirements (as per FERC EA, 1999)

Additional discussion of the need for these flows is contained in Section 4 of this report. It is noted that future licenses might change these requirements - conservation flow rates could be increased, seasonal requirements could be issued, etc. For the purposes of this report, the totals listed in **Table 3-3** have been adopted. One this basis, new data was generated to describe the flow duration relationship for flows available for hydropower generation, as shown in **Table 3-4a** for the Upper Site and **Table 3-4b** for the Lower Site. The flow available for hydropower at each site is the equal to the flows into the impoundment minus the conservation flow requirement. Note that for somewhere between 5 to 10 percent of each year, there is no flow left over for hydropower generation after accommodation of the recommended conservation flows.

	Normalized Flows at Collinsville Dams (source data: Unionville gage)		
Duration	**Inflows to Impoundment**	**Conservation Flow Requirements**	**Flow Available for Hydropower Generation**
5	1804	207	1597
10	1292	207	1085
15	1064	207	857
20	907	207	700
25	795	207	588
30	713	207	506
35	647	207	440
40	587	207	380
45	538	207	331
50	500	207	293
55	461	207	254
60	425	207	218
65	391	207	184
70	362	207	155
75	330	207	123
80	301	207	94
85	274	207	67
90	236	207	29
95	173	173	0
100	61	61	0

Table 3-4a: Estimated Flow Available for Hydropower Generation – Upper Site

Duration	Normalized Flows at Collinsville Dams (source data: Unionville gage)		
	Inflows to Impoundment	Conservation Flow Requirements	Flow Available for Hydropower Generation
5	1804	180	1624
10	1292	180	1112
15	1064	180	884
20	907	180	727
25	795	180	615
30	713	180	533
35	647	180	467
40	587	180	407
45	538	180	358
50	500	180	320
55	461	180	281
60	425	180	245
65	391	180	211
70	362	180	182
75	330	180	150
80	301	180	121
85	274	180	94
90	236	180	56
95	173	173	0
100	61	61	0

Table 3-4b: Estimated Flow Available for Hydropower Generation – Lower Site

3.1.2 Design Flow

The flow duration curve describes the availability of various flows rates over a typical year. One use for this data is to assist with the selection of the design flow rate for a hydropower site. The design flow is the maximum flow rate which a turbine (or set of turbines) is capable of utilizing to generate power. Typical practice is to select a design flow rate somewhere in the range of a 10 to 25 percent exceedance flow on the flow duration curve after accounting for conservation flows which would not be available to the turbine(s). A higher design flow will allow for a larger turbine and therefore a higher peak power generation capacity. The benefits of a high design flow must be weighed against the downsides, which are: a higher shutoff flow leading to diminishing energy production returns (can be mitigated by using multiple turbines) and higher capital costs.

GZA examined the flow duration data for the Upper and Lower sites, as developed above in Section 3.1.1. GZA also examined information on proposed design flows presented in the 1999 FERC EA and previous FERC licenses. The previous license applicant had requested permission to size turbines at both the Upper and Lower Sites for 820 cfs of flow. At both sites, this flow rate is exceeded between 15 to 20 percent of a typical year, and is therefore in line with usual recommendations for initial design flow selection.

The 2001 license for the Lower Site authorized 820 cfs. GZA's examination of the 1999 FERC EA and 2001 license for the Upper Site indicated, however, that the Upper Site had only been authorized for up to 292 cfs of flow for the turbine. This reduced flow rate is just over a third of the flow rate requested by the previous license applicant and is expected to be available approximately 50 percent of the year (after conservation flows have been accounted for). The 1999 FERC EA states that this flow rate was selected on the basis of its ability to preserve aesthetic flows over the Upper Dam primary spillway. **Table 3-5** below, which is reproduced from the 1999 FERC EA, describes the results of the analysis prepared by FERC which was the basis for the recommendation of the reduction of the design flow to 292 cfs. The FERC analysis compared Flow Alternative 2 (820 cfs for turbine) and Flow Alternative 5 (292 cfs for turbine) and found that the two alternatives maintained a minimum of 1 inch of veil flow over the primary spillway and forebay weir for the same percentage of time. However, FERC found that reducing the turbine flow led to moderate increases in the percent of time a minimum of 6 inches of flow was available at the Upper Dam primary spillway during the spring months. It appears that FERC staff recommended the 292 cfs design flow for the Upper Site on this basis. The issue of aesthetic flows is discussed further in Section 4.7 of this report. Another factor discussed by FERC in its recommendation of the 292 cfs turbine flow rate is that it would result in a turbine which would not require significant modifications to the Upper Site powerhouse.

Veil Flow	Month	2001 License Proposal (1)	Flow Alternative 1 (2)	Flow Alternative 2 (3)	Flow Alternative 3 (4)	Flow Alternative 4 (5)	Flow Alternative 5 (6)
Flows Over Upper Dam							
6-inches	March	15%	25%	20%	40%	55%	45%
	April	30%	40%	25%	55%	65%	65%
	May	15%	20%	20%	30%	40%	40%
	June	15%	100%	100%	40%	100%	100%
1-inch	July	<5%	100%	100%	5%	100%	100%
	August	<5%	100%	100%	25%	100%	100%
	September	<5%	100%	100%	15%	100%	100%
	October	<5%	100%	100%	25%	100%	100%
Flows Over Forebay Dam							
1-inch	Year Round	0%	0%	90%	0%	0%	90%

(1) Includes 820 cfs turbine, 180 cfs minimum flow turbine, seasonal 37 cfs for fish passage, and 3 cfs for the Collinsville Company
(2) Includes 820 cfs turbine, seasonal 37 cfs for fish passage, 3 cfs for Collins Company, 180 cfs minimum flow provided over dam
(3) Includes 820 cfs turbine, seasonal 37 for fish passage, 27 cfs for the Collinsville Company, and 143 cfs over the dam (assumes fish passage flows are part of the agencies' required minimum flow
(4) Includes 292 cfs turbine, 180 cfs minimum flow turbine, seasonal 37 cfs for fish passage, and 3 cfs for the Collins Company
(5) Includes 292 cfs turbine, seasonal 37 cfs for fish passage, 3 cfs for the Collinsville Company, and 180 cfs minimum flows provided over dam.
(6) Includes 292 cfs turbine, seasonal 37 cfs for fish passage, 27 cfs for the Collinsville Company, and 143 cfs over dam (assumes fish passages flows are part of agencies; required minimum flow)

Table 3-5: FERC Analysis of Effects of Turbine Flow on Aesthetic Flows – Upper Site

Because power production is directly correlated to turbine flow, the decision by FERC to reduce the Upper Site design flow by approximately two-thirds would result in a similar reduction in turbine generation capacity. Because the previous license had authorized 292 cfs as the flow rate and there is the potential for this license to be reinstated, GZA believed it prudent to examine the financial implications of a new hydropower development at the Upper Site using this flow rate. GZA also believed it would be useful to explore the possibility of an intermediate flow rate which would utilize the most flow possible without the need to increase the footprint of the Upper Site powerhouse. Through examination of the characteristics of a number of turbines, GZA roughly approximated this flow to be on the order of 600 cfs. **Table 3-6** lists the turbine design flows considered by GZA at both sites.

Design Flow Option	Flow Rate
Upper Site – Optimum	820 cfs
Upper Site – Intermediate	600 cfs
Upper Site – Low	292 cfs
Lower Site	820 cfs

Table 3-6: Turbine Design Flow Options – Upper and Lower Sites

3.2 Head for Hydropower Production

3.2.1 Existing and Potential Available Head

The gross head available for power generation is typically a function of the difference in elevation between the upstream impoundment water surface elevation and the tailwater elevation. Net head is equal to the gross head minus the hydraulic losses throughout the system.

GZA utilized a variety of resources to evaluate the available head at the Upper and Lower Collinsville Dam sites including the 1979 DOE Feasibility Study, the 1979 USACE Phase I Dam Inspection report, the FEMA FIS channel profile for the Farmington River, and preliminary field measurements. It should be noted that throughout these references, there was some discrepancy among the estimated values, and varying datum were utilized. GZA has estimated the gross head available at the Upper and Lower Collinsville Dams assuming existing conditions (without flashboards) as well as with the addition of flashboards on both dams as proposed under the previous licenses.

Based upon our understanding of historic conditions, as well as the previous licenses issued by FERC in 2001 for the dams, it has been assumed that flashboards on the Upper Dam would be 3-feet in height and that flashboards on the Lower Dam would be 5-feet in height. The benefits of the addition of the flashboards (other other means of raising the impoundment) do not appear to be as straightforward as might initially be expected. An evaluation of the river channel (FEMA FIS) and pertinent dam elevations appears to indicate that when 5 feet of flashboards are installed on the Lower Dam, the raised Lower impoundment water surface elevation will backwater the tailwater of the Upper Dam, as indicated in **Figure 3-2**. This backwater effect appears to raise the tailwater at the Upper Dam by approximately 3 feet, thereby eliminating any net benefit of the proposed 3 feet of flashboards at the Upper Dam. However, in the event that 5 feet of flashboards is installed at the Lower Dam without the proposed 3 feet of flashboards on the Upper Dam, there would be a net decrease in gross head at the Upper Dam. This scenario was judged to be undesirable and was not studied by GZA. GZA did however consider that hydropower development might occur at the Upper Site only, in which case the addition of 3 feet of flashboards would result in an increase to gross head of 3 feet. Development of the Lower site only without the Upper Site was judged unlikely, so no consideration was given to flashboards at the Lower Site without flashboards at the Upper Site.

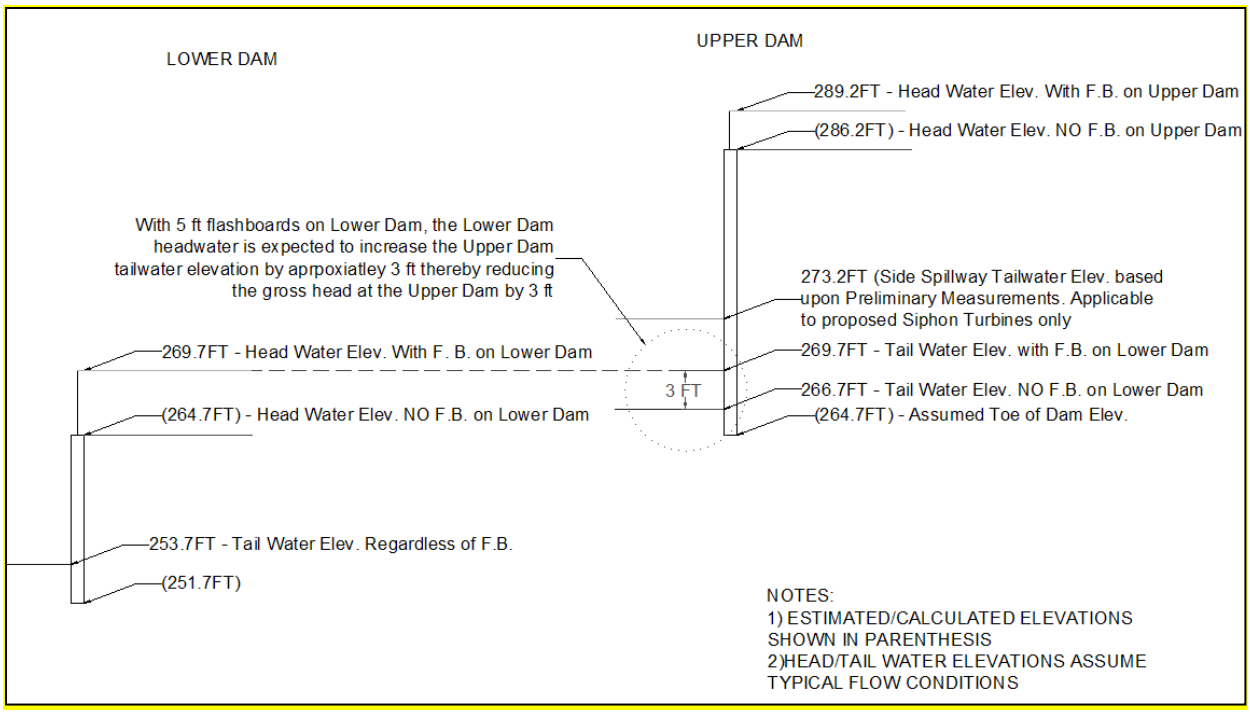


Figure 3-2- Summary of Pertinent Gross Head Elevations and Estimated Effect of Lower Dam Flashboards (5 ft) on Upper Dam Tailwater

The implication of this backwater effect is that it creates varying gross heads depending upon the flashboard arrangement. **Tables 3-7a, 3-7b** and **3-7c** summarize the estimated available gross based upon three scenarios: 1) No flashboards installed at the Upper Dam, No flashboards installed and the Lower Dam, 2) Three feet of flashboards installed at the Upper Dam, five feet of flashboards installed at the Lower Dam, and 3) Three feet of flashboards installed at the Upper Dam, No Flashboards installed at the Lower Dam. Additionally, it should be noted that Upper Development Alternative 4 includes the installation of siphon turbines over the approach channel side weir. The side weir tail water elevation during typical conditions has been estimated at approximately 273.2 feet which is higher in elevation than the estimated Lower Dam headwater elevation with flashboards (169.7 ft). Therefore, the tailwater elevation and effectively the gross head available to the siphon turbines will not be effected by the Lower Dam flashboards. Finally, it should be noted that the gross head available at the Lower Dam is affected by the installation location of the turbines. In general, approximately two feet of additional head is gained by placing the turbines at the end of the power canal structure (i.e. at the location of the current powerhouse) versus placing the turbines closer to the dam.

Location	Headwater Elevation (ft)	Tailwater Elevation (ft)	+/- Estimated Net Head (ft)
Upper Dam (Utilizing Existing Tailrace)	286.2	266.7	19.5
Upper Dam (At Side Weir)	286.2	273.2	13.0
Lower Dam (At Existing Powerhouse)	264.7	253.7	11.0
Lower Dam (At Dam)	264.7	255.7	9.0

Table 3-7a: Gross Head – Flashboard Arrangement Case 1 (No flashboards installed at the Upper Dam, No flashboards installed at the Lower Dam)

Location	Headwater Elevation (ft)	Tailwater Elevation (ft)	+/- Estimated Net Head (ft)
Upper Dam (Utilizing Existing Tailrace)	289.2	269.7	19.5
Upper Dam (At Side Weir)	289.2	273.2	16.0
Lower Dam (At Existing Powerhouse)	269.7	253.7	16.0
Lower Dam (At Dam)	269.7	255.7	14.0

Table 3-7b: Gross Head – Flashboard Arrangement Case 2 (Three feet of Flashboards installed at the Upper Dam, Five feet of flashboards installed at the Lower Dam)

Location	Headwater Elevation (ft)	Tailwater Elevation (ft)	+/- Estimated Net Head (ft)
Upper Dam (Utilizing Existing Tailrace)	289.2	266.7	22.5
Upper Dam (At Side Weir)	289.2	273.2	16.0

Table 3-7c: Gross Head – Flashboard Arrangement Case 3 (Three feet of Flashboards installed at the Upper Dam, No flashboards installed at the Lower Dam)

Depending upon the flashboard arrangement, the gross head available at the Upper Dam (utilizing the tailrace, not the headrace training wall) ranges from 19.5 ft to 22.5 ft. The gross head at the Lower Dam ranges from 9 ft to 16 ft., again depending on flashboard configuration and turbine location. Note that at the Upper Dam, the gross head remains the same (19.5 ft) for both Case 1 and Case 2. This is the result of the decrease in head due to the Lower Dam backwater (3ft) equaling the increase in head due to the addition of flashboards on the Upper Dam (3ft).

Hydraulic losses which result in a head loss may include losses through the intake structure, trashrack, any conduits, and the tailrace discharge channel, among others. For the purposes of this report, GZA has assumed varying head losses ranging between 0.5 feet and 1.0 feet depending upon the estimated peak turbine flows and general civil works/equipment arrangements of each development Alternative. **Tables 3-8a, 3-8b** and **3-8c** summarize the assumed hydraulic losses and estimated net head available for hydropower generation for each development Alternative depending upon the flashboard arrangement. The development alternatives considered by this study are defined in Section 3.3.

Alternative	+/- Estimated Gross Head (ft)	+/-Assumed Head Losses (ft)	+/- Estimated Net Head (ft)
U-1	19.5	0.5	19
U-2	19.5	1.0	18.5
U-3	19.5	1.0	18.5
U-4 (Kaplan)	19.5	1.0	18.5
U-4 (Siphons)	13.0	0.5	12.5
L-1	11.0	1.0	10.0
L-2	9.0	1.0	8.0
L-3	9.0	1.0	8.0

Table 3-8a: Net Head – Flashboard Arrangement Case 1 (No flashboards installed at the Upper Dam, No flashboards installed at the Lower Dam)

Alternative	+/- Estimated Gross Head (ft)	+/-Assumed Head Losses (ft)	+/- Estimated Net Head (ft)
U-1	19.5	0.5	19.0
U-2	19.5	1.0	18.5
U-3	19.5	1.0	18.5
U-4 (Kaplan)	19.5	1.0	18.5
U-4 (Siphons)	16.0	0.5	15.5
L-1	16.0	1.0	15.0
L-2	14.0	1.0	13.0
L-3	14.0	1.0	13.0

Table 3-8b: Net Head – Flashboard Arrangement Case 2 (Three feet of Flashboards installed at the Upper Dam, Five feet of flashboards installed at the Lower Dam)

Alternative	+/- Estimated Gross Head (ft)	+/-Assumed Head Losses (ft)	+/- Estimated Net Head (ft)
U-1	22.5	0.5	22.0
U-2	22.5	1.0	21.5
U-3	22.5	1.0	21.5
U-4 (Kaplan)	22.5	1.0	21.5
U-4 (Siphons)	16.0	0.5	15.5

Table 3-8c: Net Head – Flashboard Arrangement Case 3 (Three feet of Flashboards installed at the Upper Dam, No flashboards installed at the Lower Dam)

The vertical elevation difference between the headwater and tailwater is typically a function the hydraulic height of the dam (spillway) but can also vary with the flow rate in the river. As a result of variation in widths between the spillway and the downstream river channel at a site, it is not unusual to see the gross head decrease during significant increases in river flows. That is, as the river flows increase (typically this occurs during high flows), it is common for the tailwater elevation to rise at a higher rate than the headwater, effectively decreasing the gross head. Preliminary estimates indicate that during higher flows gross head may be decreased by up to 1ft-1.5 ft. Detailed headwater and tailwater curves are beyond the scope of this study and a consistent gross head has been assumed for this report. Because this effect generally occurs only during low frequency flood events, the effect on annual energy generation is typically relatively minor in most cases.

3.2.2 Options for Increasing Head

GZA has made a preliminary evaluation of some of the issues which may need consideration if the impoundment water surface elevations are to be raised at one or both of the Collinsville Dams. The effects of raising the impoundment water surface elevations on gross head are described in the Section 3.2.1. In general, an increase in head is directly related to an increase in power generation capacity.

The simplest method for raising the impoundment water surface elevation at an existing dam is through the installation of flashboards on the spillway crest. Flashboards are typically horizontal boards or a series of boards that are attached to a series of vertical pins which are anchored to the spillway crest. The normal pressure of the water secures the boards against the pins. The pins, which are located on the downstream side of the boards, restrain the boards from passing over the dam. See **Figure 3-3**. Flashboards are, by definition, very carefully designed to fail (or "flash") when the water surface elevation over the boards reaches a certain limit. During flooding conditions, as the water elevation in the impoundment begins to rise, the hydrostatic pressure on the flashboards begins to rise, leading to increased stress on the vertical pins. At such a point that the water pressure reaches the design limit on the pins, they will "fail" by bending forward (in the downstream direction) and the boards will slide off into the river. When the boards slide off, the control elevation is no longer defined by the elevation of the flashboards but by the elevation of the crest of the spillway. The advantage of flashboards is that during normal flow conditions, they will raise the impoundment water surface elevation and head will be gained however, when flooding conditions occur, they will fail and provide additional flow capacity to mitigate upstream flooding. After the flooding condition has passed, the dam will be left without flashboards, which must be replaced in order to re-established the raised water surface elevation. The advantage of raising the impoundment elevation through the use of flashboards is that the initial installation cost is significantly less than it is for other means of raising the normal surface water elevation of the impoundment, however; it should be noted that there are some drawbacks to the installation of flashboards:

- Flashboards are designed to fail on a regular basis and typically cannot be reinstalled until conditions are safe. Depending upon when they fail, replacement may not be possible for some time. An example is that if they fail during spring floods and ice-out, it may not be possible to replace them until summer low flow conditions occur.

- During times when the flashboards have failed and cannot be replaced, a head loss will be seen by the turbines which will result in a decreased generation. Additionally, depending upon the turbine/generation equipment utilized, the turbines may not operate at all at the reduced head.
- During times when the flashboards have failed, fish passage facilities will not operate properly unless specially designed to accommodate variable head.
- Increased Operations and Maintenance efforts and costs will result as flashboards will require periodic replacement. (The frequency at the Upper Site was described as approximately every three years in the 1999 FERC EA.)
- GZA's experience is that often Operators of a site become tired of replacing the flashboards which have been lost (due to pin failure) on a regular basis and replace the pins with a sturdier material (higher grade steel). The result is that during times of river flooding, the pins do not fail as they were engineered to do and unsafe water conditions are seen upstream.

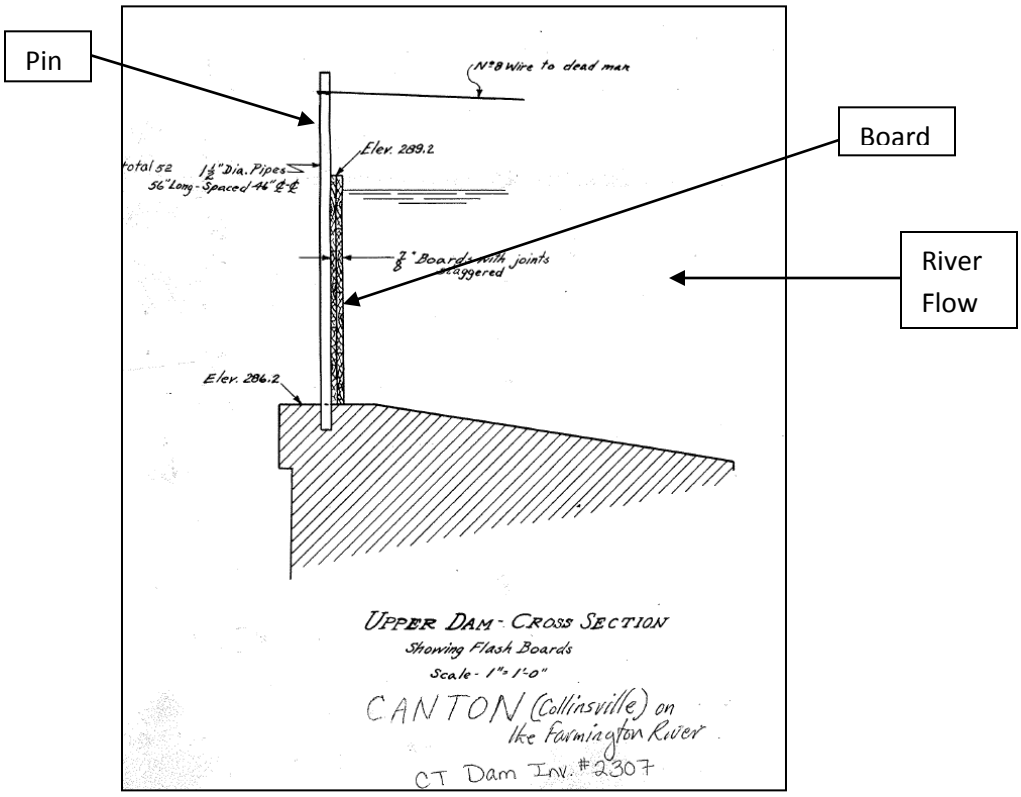


Figure 3-3: Section through Typical Flashboard Arrangement (Collins Company, 1942 – See Attachment 3)

Flashboards which do not fail under increased water surface elevations are called stoplogs. Stoplogs can be used to raise the normal elevation of an impoundment, but they cause increased upstream water surface elevations during flooding as well. If the consequences of increased upstream flooding are acceptable, stoplogs may be an appropriate alternative to flashboards. Hydraulic investigations beyond the scope of this study are necessary to make this determination. The capital costs of flashboards and stoplogs are similar.

Other means of raising the normal water surface elevation of an impoundment include the installation of a so-called "bladder dam" or the installation of a crest gate. These two options are actively controlled systems that can be lowered prior to or during a flood to provide increased spillway capacity and then easily raised again to re-establish normal pool elevation. These two systems thus to not suffer from the drawback that flashboards have with respect to the need to be replaced after floods. Bladder dams have significantly higher capital costs when compared to flashboards, and crest gates typically could be expected to cost more than bladder dams. Both systems also require active control on the part of the operator to mitigate upstream flooding.

A bladder dam (also known as a rubber dam) is a pneumatically operated rubber bladder which is fixed to the crest of the spillway. See **Figure 3-4**. As the rubber bladder is inflated with air, it expands in size in a similar manner as a balloon, and increases in elevation. The installation of a rubber dam requires ancillary systems such as an air compressor and control system to operate. Depending upon the Development Alternative pursued, there is a potential that there will not be available space within the powerhouse or gatehouse to house these ancillary systems and a separate building will be required.

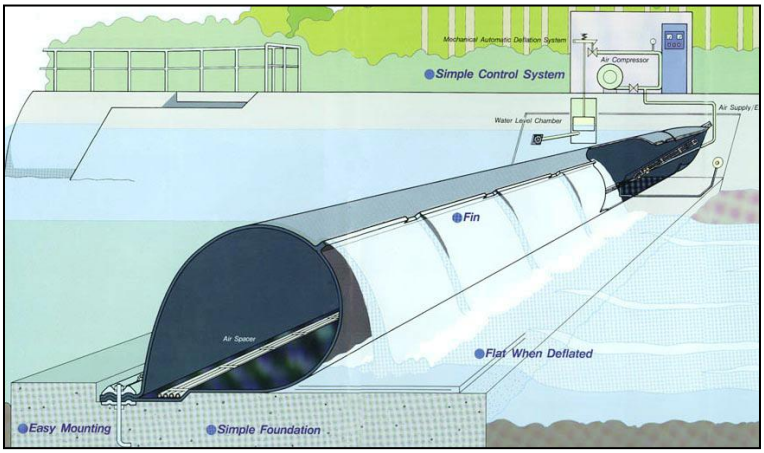


Figure 3-4: Figure of Bladder Dam (Obermeyer Hydro)

Although there are numerous operating examples of bladder dam installations, there are some drawbacks, which include:

- Inflatable membrane is exposed to damage from river ice, debris, and mischief
- Replacement of an entire span is often required if a smaller damaged areas cannot be repaired
- Discharge along crest is non-uniform if bladder is deflated.

A crest gate is fundamentally similar to a bladder dam in the sense of having a refined control over the impoundment water surface elevation however; the means to accomplish the control is a different. A crest gate is typically a rigid structure with a bottom hinge fixed to the crest of the spillway. Crest gates are typically constructed of steel and can be operated via electric motors or hydraulic pistons. Installation of either a bladder dam or a crest gate at the Upper and/or Lower Site spillways would require modifications to the crest of the spillway to prepare an appropriate base and affix the feature to the existing structure.

Although historically the Upper and Lower Dams are reported to have had flashboards installed, some engineering analysis will be required to evaluate the potential of sliding and overturning of the structures under increased water surface elevations. This will be necessary regardless of the means of raising the water surface elevation.

If the decision to raise the impoundment water surface elevations is made, the selection of the method to do so will be influence by a number of factors, including but not limited to: 1) cost; 2) operations and maintenance requirements; and 3) compatibility with fish passage facilities.

3.3 System Layout and Development Alternatives

Several different site configurations were considered for the re-development of hydropower generation at the Upper and Lower Collinsville Dam sites. The alternatives were developed to give consideration to various options for the size, location, and configuration of turbines at both sites.

As part of the initial consideration of options for the two Sites, the appropriateness of general turbine types was considered. This process is described in Section 3.4.1 of this report. The type of turbine selected for the primary turbines (Kaplan) was carried through all development Alternatives.

Ultimately, four development Alternatives were considered for the Upper Site and three development Alternatives were considered for the Lower Site. The development Alternatives are summarized as follows (Conceptual figures depicting each development Alternative are located in Appendix **C**):

Upper Site

- **U-1**: Single Kaplan turbine located within the existing powerhouse with a Qmax = 293 cfs (low design flow)

- **U-2**: Single Kaplan turbine located within the existing powerhouse with a Qmax = 600 cfs (intermediate design flow)

- **U-**3:Two Kaplan turbines located within expanded powerhouse with total Qmax = 820 cfs ("optimum" design flow)

- **U-4**: Single Kaplan turbine located within the existing powerhouse with a Qmax = 600 cfs and four-siphon turbines located adjacent to the headrace channel (on the non-overflow section of the training wall adjacent to powerhouse) with a combined Qmax = 140 cfs. Total Qmax = 740 cfs

Lower Site

- **L-1**: Single Kaplan turbine located within existing powerhouse with a Qmax = 820 cfs
    - **L-1(a)**: Same as L-1 except that generating equipment is two Kaplan turbines with total Qmax = 820 cfs

- **L-2**: Four Siphon turbines cfs located on the power canal retaining wall adjacent to gatehouse with total Qmax = 620

- **L-3**: Two Kaplan turbines located within new powerhouse located immediately downstream of gatehouse with total Qmax = 820 cfs
    - **L-3(a)**: Same as L-3 except that instead of breaching the canal wall to discharge turbine flow, turbine discharge flow continues down the existing canal structure to discharge through existing powerhouse tailrace.

Development Alternatives U-1 and L-1 are fundamentally similar to the proposed projects which were granted FERC licenses in 2001. These Alternatives have been considered and are important to understand as they are representative of the projects that would apparently be authorized to be constructed and operated should the "Collinsville Renewable Energy Promotion Act" be passed into law and the currently revoked 2001 FERC licenses be reinstated. Note that a condition of reinstatement of the Licenses under this Act is the completion of a new Environmental Assessment (EA) study which may result in the alteration of some terms of the Licenses. More information of the Collinsville Renewable Energy Promotion Act can be found in Section 5.1 of this report.

3.3.1 Upper Site Development Alternatives

All of the Upper Site Development Alternatives include the installation of a new trashrack located upstream of the existing powerhouse structure in the headrace channel. The trashrack would be installed at an angle to the river flow such that debris will be washed down and away from the intake structure. The trashrack will be accessible from a new platform downstream and adjacent to the new trashrack. Additionally, all Alternatives have assumed the installation of an automated trashrack cleaning system which will be integrated into the control system to rake the racks at both regular intervals at specific times when the debris load requires raking. All Alternatives also include similar provisions for upstream and downstream passage of fish and eels.

Development Alternative U-1 includes the installation of a single Kaplan turbine located within the existing powerhouse with minimal civil or site modifications. The peak design flow would be the same as that licensed in 2001, 292 cfs. This flow is reportedly also the same peak flow at which the existing turbine operates previously operated. The turbine would be seated in approximately the same location as the existing turbine. Portions of the subsurface concrete would likely need to be removed to install the new draft tube.

Development Alternative U-2 is aimed at maximizing the site potential while utilizing the existing powerhouse without alterations. The limiting factor in this development is the size of the turbine which could potentially fit into the existing powerhouse structure without powerhouse expansion.

Additionally, as there is potential historic and cultural concerns, Alternative U-2 does not include the addition of turbines outside of the powerhouse area (such as are proposed in Alternative U-4) thereby reducing potential aesthetic concerns due to exterior modifications.

Development Alternative U-3 is intended to optimize the site potential based strictly on the available flow at the site. Based upon the flow duration curve and the peak design flow Licensed at the Lower Site in 2001, 820 cfs was chosen as the peak design flow. This Alternative would include the expansion of the existing powerhouse towards the bank (west) side to accommodate a pair of Kaplan turbines with a peak design flow of 410 cfs each.

Development Alternative U-4 is fundamentally similar to Alternative U-2 but includes the addition of smaller turbines located on the approach channel side wall. This Alternative provides an opportunity to maximize the potential power which can be generated utilizing a turbine within the powerhouse (no modifications) while also increasing the overall site capacity through the addition of a series of smaller turbines. It is envisioned that the series of small turbines located on the side wall would be turbines which require minimal civil modifications or construction. Typically, tube turbines or siphon turbines require minimal civil works and could likely be installed in the area with minimal modifications. These turbines would however, would be visible on the wall and the extent of the potential concerns with regard to historic and visual resources will not ultimately be known until a formal consultation process with stakeholders is underway. Alternative U-4 has been presented a means for increasing the peak power capacity and annual energy generation which would be anticipated for Alternative U-2 without the modifications to the existing powerhouse proposed in Alternative U-3. Note that Figure U-4 found in **Appendix C** details a tube turbine layout; however, in concept these could be a variety of low-civil impact turbines including siphon turbines (see detail of L-2 for siphon turbine concept).

3.3.2 Lower Site Development Alternatives

All of the Lower Site Development Alternatives include the installation of a new trashrack located upstream of the existing gatehouse structure at the left (east) bank of the impoundment. The trashrack would be installed at an angle to the river flow such that debris will be washed down and away from the intake structure. The trashrack will be accessible from a new platform downstream and adjacent to the new trashrack. Additionally, all Alternatives have assumed the installation of an automated trashrack cleaning system which will be integrated into the control system to rake the racks at both regular intervals at specific times when the debris load requires raking. All Alternatives also include similar provisions for upstream and downstream passage of fish and eels.

Development Alternative L-1 includes the installation of a single Kaplan turbine within the existing powerhouse. Re-inundation of the power canal and use of the existing powerhouse was approved under the previous license issued to the Lower Site in 2001. This Alternative would utilize the existing gatehouse for water control and the existing canal structure for flow conveyance from the dam to the powerhouse. The turbine would utilize a peak design flow of 820 cfs as was licensed in 2001. In addition to the trashrack structure discussed above which will be located upstream of the gatehouse, a secondary coarse trashrack located immediately upstream of the powerhouse intake (at same location as current) will be required to protect the turbines from any debris which may enter the canal downstream of

the gatehouse and to protect any individuals which may fall into the canal from passing though the turbines. Alternative L-1(a) will be briefly discussed as a potential alternative to L-1. L-1(a) includes all of the features of L-1 except that it will utilize two Kaplan turbines with a total peak design flow of 820 cfs (410 cfs each). Even with the same peak design flow, the utilization of two smaller turbines rather than a single large turbine provides several advantages:

- The turbine units themselves are smaller requiring reduced vertical excavation.
- The existing powerhouse was originally constructed to utilize two "smaller" turbines which would likely make retrofitting the existing powerhouse for two new Kaplans rather than a single large Kaplan less expensive.
- Utilizing two turbines rather than one creates a redundancy and reduces the dependency on a single unit. Depending upon the site design, if one unit requires maintenance or repairs, the other can still operate.
- Utilizing two turbines rather than one increases overall site efficiency as the total peak power will remain the same however, each turbine can operate to lower flows.

At this level of analysis, the differences between L-1 and L-1(a) with regards to system layout, total power and energy as well as project costs are deemed negligible. Therefore although Alternative L-1(a) has been presented for consideration as the project moves forward throughout this report, including in further discussions, site figures, power/energy, and economic analysis only Alternative L-1 will be discussed. Should the project move forward, further consideration should be given to L-1(a) in light of the potential advantages discussed above.

Alternative L-2 is proposed to provide an alternative for development of the Lower site which would reduce some rehabilitation costs while limiting the civil construction costs. Alternative L-2 includes the installation of a series of tube or siphon turbines over the side of the existing power canal retaining wall. Upstream water control to the turbines would be achieved through the rehabilitation of the existing gatehouse. The turbines would be located on the section of training wall located immediately downstream of the gatehouse. The turbines would discharge close to the toe of the dam thereby significantly reducing or even eliminating the bypass reach (as compared with discharging at the location of the existing powerhouse). As noted in Section 3.2, discharging turbine flow close to the toe of the dam would result in the reduction of available gross head by approximately two feet (when compared to the existing powerhouse location). This Alternative would anticipate the abandonment of the majority of the existing canal structure and the existing powerhouse. An earthen berm could be constructed just downstream of the turbines, if necessary, to create a forebay area which would limit the extent of re-inundation of the existing canal structure and thus minimize changes to the environment which has developed within the power canal. A structure to house and protect the turbines will be constructed and will include a secondary coarse trashrack system to prevent any debris which may have entered the forebay area (downstream of the gatehouse trashrack) as well as preventing any individuals which may fall into the intake area from passing though/ being sucked into the turbines. The rehabilitated gatehouse would not only serve as water control but would also house the electrical switchgear and controls systems. Note that Figure L-2 found in **Appendix C** details a siphon turbine layout on the canal wall however, in concept these could be a variety of low civil impact turbines including tube turbines (see detail of U-4 for tube turbine concept).

Alternative L-3 is similar in equipment and configuration to Alternative L-1(a). However, rather than rehabilitating the existing powerhouse for use, the turbines will be installed in a new powerhouse located immediately downstream of the gatehouse. Alternative L-3 will utilize two Kaplan turbines with a total peak design flow of 820 cfs (410 cfs each). A secondary coarse trashrack system will not be required for this development as the powerhouse will be directly connected to the downstream side of the gatehouse. The existing canal retaining wall, downstream of the new powerhouse will be breached to allow for the discharge of flow back into the river in the area near the toe of the dam. An earthen berm would be constructed just downstream of the new powerhouse within the existing canal structure to limit the extent of re-inundation of the existing canal structure and thus minimize changes to the environment which has developed within the power canal. This Alternative would anticipate the abandonment of the majority of the existing canal structure and the existing powerhouse. Alternative L3 (a) will be briefly discussed as a potential alternative to L-3. L-3(a) includes all of the features of L-3 except that it will utilize the full canal structure to discharge flow to the tailrace area at the existing powerhouse. This has the potential to provide an increase in gross head of approximately 2 feet (subject to additional study and confirmation) and eliminate the need for the earthen berm construction. This modification would however result in a bypass reach in the river similar to placing the turbines at the existing powerhouse and would involve re-inundation of the power canal.

At this stage in the project, the differences between L-3 and L-3(a) with regards to system layout, total power and energy as well as project costs have not been quantified. Alternative L-3(a) has been presented here in concept only. Only Alternative L-3 will be discussed in the remainder of this report with respect to power/energy estimates and economic analysis.

3.4 Generation Equipment

3.4.1 Turbines

Energy generation equipment is typically selected based upon the range of flow and heads that are estimated at a site. The Upper and Lower Collinsville sites are assumed to be restricted to run-of-the-river operating mode and thus not to have large fluctuations in the gross head available as the proposed sites. The Upper and Lower powerhouses were constructed and utilized to house hydroelectric generating equipment, some of which is still located on-site. GZA has evaluated the type and condition of the existing equipment, contacted vendors with regards to rehabilitating existing equipment or procuring used equipment, and conducted preliminary consultations with turbine manufacturers with respect to new equipment.

There are two main categories of turbines; impulse and reaction. A turbine is described as an “impulse turbine” when the rotor is moved by a direct push or “impulse” from the water impinging upon the blades. When the rotor is moved by force of reaction to pressure differential across the turbine runner, the turbine is said to be a reaction turbine. The Pelton, Turgo and crossflow turbines are categorized as impulse turbines while the Francis and Kaplan turbine are categorized as reaction turbines.

The suitability of the various turbines with respect to the design flow, design head, efficiency, annual energy output, and cost to purchase was evaluated at the pre-feasibility level for the sites. GZA also considered the configuration and physical size of the turbine and generating equipment, requirements for preventing cavitation, level of required O&M, and fisheries considerations. In evaluating the turbines, GZA took into consideration turbine information within the hydropower industry's literature and information provided by manufactures.

Preliminary estimates of available gross head and design flows at the Upper and Lower sites as shown in above were compared with the optimal head ranges and flow ranges for different types of turbines.

The Pelton turbine is best suited for medium to high head applications (design head between 165 to 3,300 feet) and the Turgo turbine is best suited for medium head application (design heads between 165 to 825 feet). The cross-flow type turbine however, can operate under lower heads (between 3 feet and 330 feet). The Francis turbine is best suited for medium high head application (design heads between 30 to >1000 ft) and the Kaplan turbine is best suited for low head and medium head applications (design heads up to 230 feet). The Crossflow and Pelton turbines have a similar range of design flows, between a few cfs (depends upon available head) and approximately 350 cfs. Peltons can operate at up to 2,100 cfs. The Kaplan and Francis turbines have similar ranges of design flows, between a few cfs (depending upon the head available) and 36,000 cfs.

The relatively low head and moderate flow rate available at the sites were factors in selecting appropriate equipment. GZA believes that the feasibility of the overall project would be improved if the same or similar equipment and configurations could be installed at each site. GZA reviewed the availability of turbines suitable for head and flow available at the sites and from the chart below (**Figure 3-5**) and found that Crossflow, and Kaplan (propeller) turbines are likely candidates for the sites. These turbines can be obtained with either fixed or adjustable runner blades or/or guide vanes. Turbines with adjustable blade or vanes are typically more efficiency over a range of flows than turbines that are non-regulated (i.e. have a fixed blade angle), with double regulated units providing the most efficiency. Turbines with fixed blades are typically less expensive as they are less complex equipment. Given the range of flows expected, regulated or double regulated equipment is preferred.

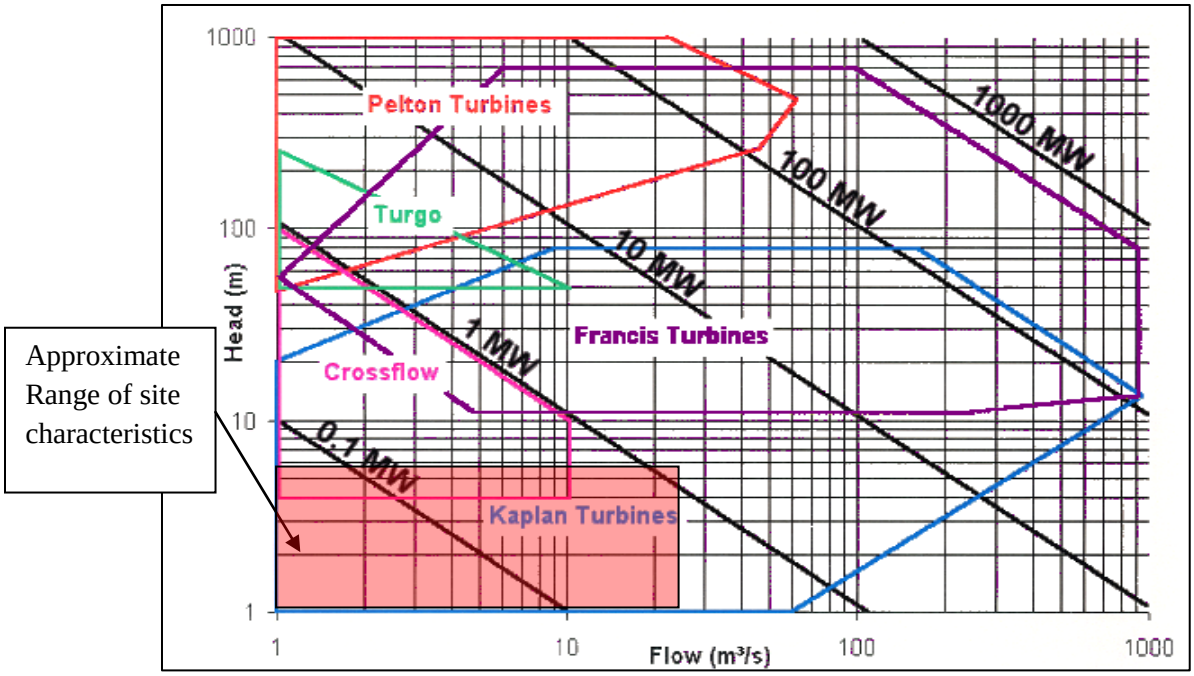


Figure 3-5: Turbine Application Chart

It should be noted that the existing equipment is of the Francis type which does not fall within the site's characteristics on the application chart. The application chart is an indicator of optimum operating range however, is not an absolute tool for equipment selection but only a starting point for turbine selection. At the time that the original project was developed, there is a potential that the Francis was the optimal turbine technology available.

3.4.1.1 Existing Equipment

It is understood that the existing equipment at the Upper Dam within the powerhouse located on the right side of the dam consists of a single vertical Francis turbine. The turbine was manufactured by the James Lefell Company and is a type 2 wheel rated at 400 kva at 164 RPM. The existing equipment located at the Lower Dam within the powerhouse located at the downstream end of the Canal consists of two vertical Francis turbines. The turbines were manufactured by the Allis-Chalmers Company and are rated at 425 kW at 90 RPM (DRCS, 1979). A concept drawing of a typical Francis turbine arrangement (with scroll case) is shown in **Figure 3-6**.

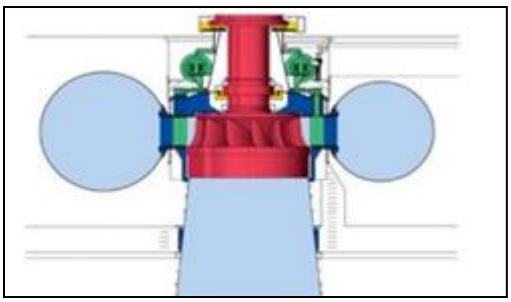


Figure 3-6: Typical Vertical Francis Turbine

Although there would be clear benefits were it possible to utilize the existing turbines, it is GZA's opinion that the re-use of this equipment is not the best development option for the sites for the following reasons:

- The majority of the existing equipment components which were associated with the turbines are not available including the generators, governors, switchgear, controls.
- An inspection of the turbines was not permissible due to the location of the Upper Site turbine and due to safety concerns at the Lower Site. However, based upon: (1) the age of the existing turbines, (2) the brief view of the Lower turbines from overhead and, (3) the general condition and apparent level of maintenance of the visible structures, it is believed that the existing turbines are generally in poor condition and would require significant and unquantifiable rehabilitation to return them to operable condition.
- It will be very difficult, if not impossible to find a contractor that will be willing to provide a guarantee on peak generation power and a warrantee on condition of the turbines.
- As only portions of the equipment are available, the remaining equipment will have to be purchased to match any existing equipment. This will result in piecemeal equipment rather than an equipment package that was originally designed to work together.

3.4.1.2 Used Equipment

Used hydroelectric generating equipment is often an economical solution for re-powering an existing hydropower site. Many dam sites were originally constructed to generate hydroelectric power and are now non-operational similar to the Collinsville sites. These abandoned sites often offer the used equipment to trade companies or the equipment is available for direct removal, rehabilitation, and reinstallation. There is a potential that used generating equipment can be found which will match the site characteristics of the Upper and Lower Dam sites. Used equipment as an alternative to new equipment is an alternative which offers the potential for significant cost savings.

GZA contacted a number of used equipment dealers including North American Hydro, New Hampshire Water Power, and Belyea Power to discuss and compare their inventory of used equipment with the proposed site characteristics. The companies indicated that they did not have any equipment at this time which was a direct match for the site. The availability to purchase used equipment is subject to a variety of factors as it is an open market with limited availability. GZA has requested of each of the companies contacted that as they conduct business that they keep the site parameters (head and flow) in mind and contact GZA if viable equipment becomes available.

The procurement of Used Equipment will result in some of the same concerns as utilization of the existing equipment including guarantees and warrantees. It is also noted that when the previous licensee proposed the use of used equipment, a license condition was imposed that required documentation of the historic impacts (resulting from the equipment removal) to the site from which the equipment was obtained.

3.4.1.3 New Equipment

Based upon both the turbine application chart (**Figure 3-5**) and GZA's experience, if new equipment is procured, a Kaplan turbine is judged to be most suitable for installation. A concept drawing of a typical vertical Kaplan turbine arrangement is shown in **Figure 3-7**.

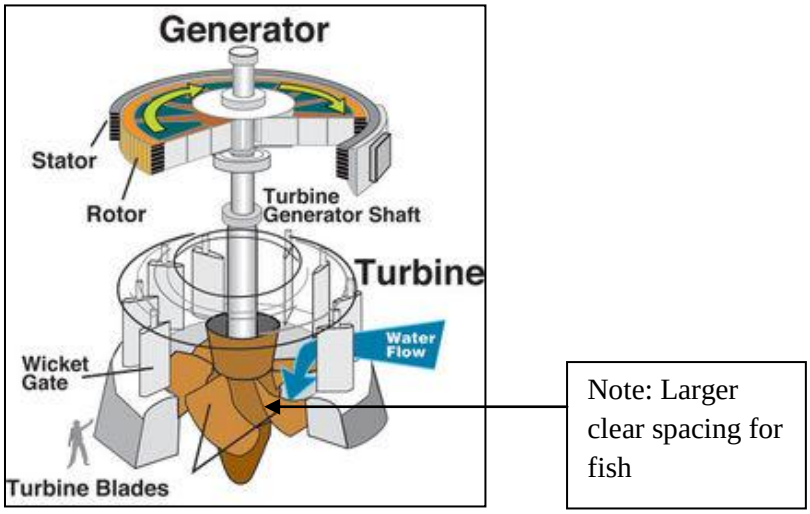


Figure 3-7: Typical Vertical Kaplan Turbine

The turbine application chart indicates that a Crossflow turbine would also be suitable; however, a Crossflow turbine (as shown below in **Figure 3-8**) is typically associated with high fish and eel mortality due to the small runner spacing. A Crossflow turbine is also oriented horizontally (which would make for a tight fit in the existing structures, particularly the Upper Site) and must be located near the tailwater to prevent cavitation (which would require a lower floor elevation at the Upper Site). As previously mentioned, a Francis turbine is clearly technically feasible at the sites given that they were previously used. However, a Kaplan turbine has better efficiency over a wider range of flow and can typically operate and generate electricity down to 20 percent of the peak design flow while a Francis can typically only turn down to approximately 50 percent of the peak design flow. This indicates that for a given turbine, a Kaplan provides a better overall plant factor than a Francis turbine and will typically generate more annual energy for the same heads and flows under conditions similar to those at the Upper and Lower Collinsville sites.

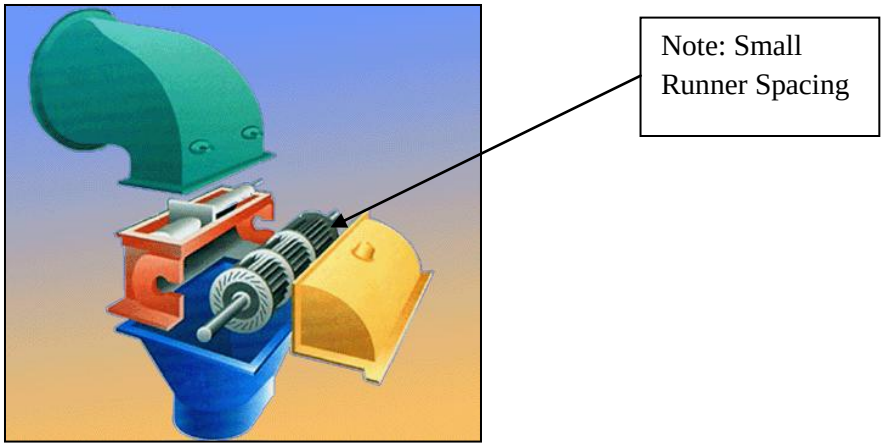


Figure 3-8: Typical Crossflow Turbine

A Kaplan turbine is a propeller type turbine which has adjustable wicket gates if it is of the regulated type and also adjustable blade angles if it is double regulated. The Kaplan is an inward flow reaction turbine which means that there is a change in water pressure as it moves through the turbine. Kaplans are well suited to sites where there is a low head and a larger discharge available such as at the Collinsville Dams. The adjustable runner blades enable high efficiency even during partial loads. The Kaplan turbine can be installed either vertically, horizontally or at an intermediate angle. Because the turbines are adjustable, the guide vanes and turbine blades will adjust when available flows are less than that of the peak design flow. This allows the turbine to have a high efficiency over a range of flows. Typical adjustable Kaplan turbines have a peak efficiency of approximately 92 percent and will operate at flows down to 20 percent of the design flow. The Kaplan turbines are available in sizes which can accommodate the design flows proposed in each of the development alternatives. GZA has advanced the use of double regulated Kaplan turbines as the primary turbines in each development alterative considered.

GZA contacted several turbine manufacturers for preliminary quotations for the site. In general, it takes some time to receive the quotations as manufactures must do some preliminary work to estimate the appropriate equipment package. As the quotation requests were sent out early in the study process, manufacturers were requested to provide quotations for up to a peak design flow of 1,000 cfs. Although this is not the exact flow that was ultimately recommended for the development alternatives, the turbine quotations provide a good idea of the type of turbine, general arrangement and approximate cost of potential equipment. As the project moves forward, it is likely that the Town will work closely with manufacturers to update quotations (as project parameters are clearly defined) and ultimately choose the optimal equipment package. See **Appendix F** for turbine quotations.

3.4.2 Generators

There are two broad categories of generators: induction and synchronous. A synchronous generator runs at a constant speed and draws its excitation from a power source external or independent of the load it is supplying. It has an exciter that enables the synchronous generator to produce its own "reactive" power and to also regulate its voltage. A synchronous generator can operate in parallel with the

utility or in "stand alone" mode. This means that depending on where the excitation is coming from, a synchronous generator (depending on interconnection and switchgear set up) can operate during a black out. An induction generator is not self-exciting, meaning that it requires an external supply to produce a rotating magnetic flux. The external supply can be supplied from the electrical grid or from the generator itself, once it starts producing power. The rotating magnetic flux from the stator induces currents in the rotor which also produces a magnetic field.

The type of generators which would have accompanied the existing turbines at the Upper and Lower Collinsville sites are unknown to GZA however, it is likely that due to the age of the sites Synchronous generators were used. There are not any generators located on site as they were removed at some point in the past. It is possible to find used or purchase new Synchronous generators for the Upper and Lower sites; however it is not the optimum solution for the lower site due to the low speed (90 RPM) of the turbine. Typically, the lower the speed of the generator, the more poles required, the larger it is and the more costly it is. Both the Upper and Lower existing turbines (if restored) could use an induction generator with a speed increaser to maintain synchronous speed. Speed increasers (gearbox) are typically approximately 99 percent efficient. Manufacturers of new equipment will typically allow the owner to choose what type of generator is provided with the equipment package. Synchronous generators are typically larger than induction generators and require a larger quantity of copper, making them more expensive. Induction generators typically operate at a higher speed than their synchronous equivalent resulting in a higher level of noise. The control system and required switchgear components are typically simplified for an induction generator. This is because the frequency and voltage of the power generated with the induction generators are governed by the frequency and voltage of the incoming electric utility line. This eliminates the need for synchronization and the associated components.

Either of the generators would work at these sites. However, it is likely that the induction generator will be a preferable choice due to the lower cost and smaller size. The need for a speed increaser will be evaluated during a more detailed design process. Generator voltage will be a function of the end use of the power, but it is likely that a relatively low voltage generator would be selected, with voltage stepped up by a transformer if sent to the existing utility distribution system. Typical voltages which small hydropower generate at are 480 V and 600 V. Ultimately, the output voltage of the generators will be finalized during the final stages of equipment selection and based upon discussions with manufacturers. At this time, it has been assumed that the generators will produce at 480V.

3.4.3 Switching Equipment, Transformers, Controls, and Misc. Electrical

Switchgear is a series of disconnects, fuses and/or circuit breakers which must be installed on high voltage equipment and at the interface between the system with electrical grid. The switchgear must provide protection for the generators, transformers, and electrical grid. New switchgear will be required for all of the sites.

A transformer is required to convert electricity from one voltage to another. Electrical grids move electricity at a variety of voltages but are typically in the thousands of volts. The hydroelectric system will likely be generating below line voltage and to sell the energy to the grid, it will require transforming up to the line voltage. Similarly, if the energy is used on-site at Town facilities

through the use of a direct transmission line it is likely that transformers will be required to step the voltage down to a useable level at each load location.

For any existing or proposed buildings, a new 208/120V 3 phase 225A distribution system will be installed to provide for the building station service. This will provide an external electrical (not generated on-site) supply such that there is basic electrical service available within the powerhouse when the generators are not operating. Also, an induction generator requires an external power source to operate. A 75kva step down transformer will be provided to connect the building distribution system to the building service entrance equipment. (AI, 2011)

New electrical service will be provided. New service entrance equipment will be installed in the building. This equipment will be the point of connection for the new electrical generation equipment, the electrical utility service and the building distribution. The utilization voltage for the service entrance will be 480V (assumed), three phase. The service entrance equipment will include an isolation switch for the electrical generation equipment, an isolation transformer for the generators and a utility disconnect switch. A utility transformer shall be installed outside the building. Utility disconnects and switches shall be installed on the poles for the local medium voltage overhead three phase feeder. The ampacity and configuration of the service entrance equipment will vary depending upon the scenarios.

New transformers will need to be purchased for each site as there are none currently associated with the hydropower facilities. The transformers can be housed within the powerhouses, or located on an exterior (enclosed) pad. The switchgear will also require grounding to protect from dangerous electrical conditions in the event of insulation failure. See **Appendix G** for more details on the required transformers, protections and other switchgear components for development.

The main control and automation works in a hydroelectric power system are associated with start and stop sequences for the unit as well as flow control and optimum running control of the power and protection systems. The complexity of a control system can vary widely but some components such as manual start/stop mechanisms and automatic protection from over/under speed, temperature, and low flow conditions are required. Automation that detects the available river flows and adjusts the turbine blades and wicket gates through a governor will likely be required to regulate flows through the turbine. This is typically done through pressure sensors which measure the impoundment elevation and send a signal to a programmable logic controller (PLC) which adjusts flow controls to maintain a constant elevation. Additionally, the governor for use as system protection will be required in the event that the utility grid has an outage.

The switchgear and controls are typically purchased as part of a water-to-wire turbine package. Depending on the type of transformer required, it may also be part of the water-to wire package or be purchased separately.

3.4.4 System Limitations

3.4.4.1 Size

An important physical limitation at the Upper Site is the space available for the power generating equipment at the existing Upper powerhouse. Physical limitations for alternative U1 will be minimal as the size of the turbine will be similar to that which the powerhouse was designed for. Alternatives U2 and U4 have been conceptualized to utilize only the existing space available in the powerhouse as it is now. However, these alternatives do not maximize the site potential. Note that although it is estimated that these turbines proposed under Alternatives U1, U2, and U4 will fit within the footprint of the existing powerhouse, significant subsurface modification to the powerhouse will be required. The proposed Kaplan turbines will utilize a draft tube that is designed and constructed for the turbines by the manufacturer and the installation type and setting of the Kaplan turbines will be different than the existing turbine. Therefore, the majority of the subsurface elements associated with the existing Upper powerhouse will likely be removed to allow for the installation of the turbine. Should the project move forward, a further evaluation of the powerhouse will be required to better understand the existing subsurface conditions and modifications that will be required to install a new turbine.

Alternative U3 aims to maximize site potential through the installation of dual 410 cfs turbines. The installation of these turbines requires the expansion of the existing powerhouse to increase the physical space available for turbine installation. The powerhouse will be expanded by approximately 10 feet in the westerly direction.

The existing powerhouse at the Lower Site is judged large enough to accommodate one or two turbines sized for a total design flow of 820 cfs. Installation of two smaller turbines (Alternative L1(a)) may be easier than one single larger turbine due to a reduced need for subsurface modifications.

3.4.4.2 Flooding

Flooding of the hydroelectric projects due to high water is a concern at both sites. Flooding is not so much a concern for the turbine but for the electrical components including the generator, controls and switchgear. A review of the FEMA flood insurance studies for the Towns of Canton and Avon provided the flood elevations (NGVD) shown in **Table 3-9**.

	10 year flood elevation (feet)	**50 year flood elevation (feet)**	**100 year flood elevation (feet)**	**500 year flood elevation (feet)**
Upper Collinsville Dam Impoundment (spillway elevation: 286.2 ft)	291.2	295.0	297.0	303.7
Lower Collinsville Dam Impoundment (spillway elevation:264.7 ft)	270.0	276.2	275.7	281.8

Table 3-9: FEMA Flood Surface Elevations – Both Sites

Flood resistance construction features (windows, doors, etc.) may be necessary at both powerhouses. Certain equipment may need to be elevated to keep it above the 100 year flood level.

3.5 Powerhouse

As discussed in Section 2.8.1 of this report, the existing powerhouse will be utilized (with modifications) at the Upper Site for all development alternatives considered under this study. Alternative U3 will require that the existing powerhouse be enlarged.

As discussed in Setion 2.8.2 of this report, alternative U1 (and U1(a)) will utilize the existing powerhouse at the Lower Site, but major rehabilitation work will be required. Alternatively, the existing structure could be demolished and a new structure built in the same location. For alternative U2, a small structure will be required along with equipment installation in the existing gatehouse. For alternative U3, a completely new powerhouse will need to be constructed, likely of reinforced concrete.

3.6 Interconnection, Transmission, and Distribution Systems

Upper Site

The type of transmission and distribution system will be dependent upon the development Alternative pursued and the type of interconnection. As discussed in section 3.8, the following interconnection types are possible for the Upper Site (AI, 2011):

a. Direct Sale: This approach assumes all generated power is sold to the utility. In this case the facility connects to the utility at the local feeder and no electrical connections or metering agreements exist. All the generated power is sold directly to the utility. The only equipment to be installed and maintained is at the upper power plant.

b. Direct net metering: This approach is currently permitted in Connecticut. In this approach, the power generated at the plant is distributed by Town-owned electrical cables to various town properties. In addition to the equipment at the plant, the town will need to install and maintain a medium voltage (5kv) electrical line to the selected town sites. At each individual site, a net meter and related service equipment will be installed and maintained. The generated power reduces the total power purchased by the town at each site and the town receives the individual billing for each site showing the remaining net consumption for that site. Current regulations permit net energy billing service for hydroelectric self-generators with a direct connections to its load, a maximum generating capacity of less than or equal to 2,000 kW, and a service rate category of 1, 5, 7, 27, 30, 35, 37, 40, 41, 55, 56, 57, or 58. Under the CLP Rider N, excess sales to the grid are made on an annual basis and reimbursed at a "wholesale" rate (average hourly RT-LMP). Under these terms, the total amount of energy which would be valued at "retail" price would be limited to the total consumption of the Town-owned sites which are directly connected to the hydroelectric generation facility. This is estimated at approximately 2,837,072 kwh per year based on preliminary direct connection concepts (refer to sketch SK-1in **Appendix G** for additional information). A primary complication of this approach is, however, the need to construct (as well as operate and maintain) a dedicated power distribution system to connect the generating sites to the demand locations (Town-owned facilities). No such transmission lines

currently exist and therefore would have to be constructed at additional cost. Additionally, Connecticut laws and regulations provide for certain restrictions regarding crossing of public utility right-of-ways which may complicate or restrict the Town's ability to construct the electrical distribution system should such crossings be required.

c. Virtual Net Metering: This approach is not currently permitted in Connecticut but legislation and DPUC decisions are pending that may permit this approach. In this case, the facility connects directly to the local feeder and the generated power is applied against the total power consumption of the town. The same equipment required for part 3a (direct sale) above is used. The generated power reduces the total power purchased by the town and the town receives billing showing the remaining net consumption. If all Town-owned facilities could be virtually net metered, this will provide for approximately 3,358,805 kwh of total consumption which could be valued at a retail rate, with the remaining generation valued as wholesale energy. It is important to note that this is based on current direct connection net metering rules, the virtual net metering regulations could be different, such as requiring that the town remains a net consumer of electrical power, which would limit the size of generator which could be installed. The participation of Avon and Burlington in a virtual net metering program could provide for additional demand which could result in more energy being valued at "retail" rates.

Based upon these interconnection types, the following equipment will be required (AI, 2011):

1. Scenario U1 will have 800A equipment with a 500 kva isolation transformer and UL 1741 protective relaying for interconnection type 'a' or 'c'. Interconnection type 'b' will delete the UL 1741 protective relaying and isolation from the plant and add it to each town site.

2. Scenario U2 will have 1600A equipment with a 1000 kva isolation transformer and UL 1741 protective relaying for interconnection type 'a' or 'c'. Interconnection type 'b' will delete the UL 1741 protective relaying and isolation from the plant and add it to each town site.

3. Scenario U3 will have 2000A equipment with a 1250 kva isolation transformer and UL 1741 protective relaying for interconnection type 'a' or 'c'. Interconnection type 'b' will delete the UL 1741 protective relaying and isolation from the plant and add it to each town site.

4. Scenario U4 will have 2000A equipment with a 1000 or 1250 kva isolation transformer and UL 1741 protective relaying for interconnection type 'a' or 'c'. Interconnection type 'b' will delete the UL 1741 protective relaying and isolation from the plant and add it to each town site.

Lower Site

The type of transmission and distribution system will be dependent upon the development Alternative pursued and the type of interconnection. It is understood that the virtual net metering regulations which are in the process of potentially becoming lawful require that a single entity which owns the project to utilize the energy. Depending upon the ownership structure which is ultimately pursued by the Town of Canton, there may be a means for virtual net metering energy to the Towns of Avon and Burlington or some other private entity. Additionally, at this time, it has been assumed that a direct transmission line to the Town of Canton from the Lower Dam is not feasible. This is for two reasons 1) the additional cost, and 2) unless the on-site electrical demand of the Town of Canton increases

significantly, there is not a demand for energy from the Lower Plant in addition to the Upper Plant. Although some assumptions have been made in the financial discussion of this report with regards to utilizing all energy generated on-site, for the technical discussion of the Lower Dam, it has been assumed that the energy will have to be sold to the grid. However, options to utilize energy generated at the Lower Dam would be improved if the project were developed by a consortium of towns which included not only Canton, but also Avon and/or Burlington. Development by a consortium of Towns could improve the chances of being able to Net Meter energy production from the Lower Site by both allowing demand from facilities in Avon and/or Burlington to be counted as part of total demand and potentially providing for more opportunities for direct connections to facilities with load.

Therefore, depending upon the development Alternative, the following equipment will be required (AI, 2011):

1. Scenario L1 is the only scenario that proposes to install equipment at the lower power plant. This approach will use 1000A/1600A equipment with a 750/1000 kva isolation transformer and UL 1741 protective relaying for interconnection type 'a'. The exact equipment rating will depend on the flashboard option selected.
2. Scenario L2: This approach will use 800A equipment with a 500 kva isolation transformer and L 1741 protective relaying for interconnection type 'a'.
3. Scenario L3: This approach will use 800A/1200A equipment with a 500/750 kva isolation transformer and UL 1741 protective relaying for interconnection type 'a'. The exact equipment rating will depend on the flashboard option selected.

3.7 Estimated Production

Using the flow and head information developed above and typical efficiency data, the peak power output has been calculated for each proposed development Alternative. Power production has also been estimated for the full flow range at the site for each 5 percent interval. These power estimates were multiplied by the appropriate time duration (365 days * 24 hr/day * 5% = 438 hours) to compute estimated energy production, then energy from each interval was integrated to estimate average annual energy production. An estimated 5 percent reduction factor has been applied to account for down time resulting from floods, and regular operations and maintenance considerations. Estimates were made for the three scenarios with regard to the potential modifications to the impoundment normal water surface elevations. Estimates of peak power and average annual energy generation are summarized in **Tables 3-10a and 10b** for the Upper and Lower Sites, respectively. Power and energy estimate worksheets are presented in **Appendix H**. Note that in **Tables 3-10a and 10b**, "No raising of dams" indicates that flashboards (or equivalent) will not be placed on either dam, "Both raised" indicates that flashboards will be placed on both dams (3ft at Upper Dam and 5ft at Lower Dam) and, "Only Upper Raised" indicates that flashboards will only be placed on the Upper Dam.

Development Alternative	U1		U2		U3		U4	
	Peak Power (kW)	Average Annual Energy Generation (kWh)	Peak Power (kW)	Average Annual Energy Generation (kWh)	Peak Power (kW)	Average Annual Energy Generation (kWh)	Peak Power (kW)	Average Annual Energy Generation (kWh)
No Raising of Dams	395	2,233,450	856	3,266,005	1,080	3,474,625	973	3,352,645
Both Dams Raised	395	2,233,450	856	3,266,005	1,080	3,474,625	1,001	3,402,235
Only Upper Raised	457	2,584,475	995	3,796,105	1,255	4,038,450	1,140	3,912,290

Table 3-10a: Estimates of Peak Power and Average Annual Energy for Upper Dam Site

Development Alternative	L1		L2		L3	
	Peak Power (kW)	Average Annual Energy Generation (kWh)	Peak Power (kW)	Average Annual Energy Generation (kWh)	Peak Power (kW)	Average Annual Energy Generation (kWh)
No Raising of Dams	584	2,012,765	275	1,002,630	467	1,646,350
Lower Dam Raised	876	3,023,280	447	1,630,485	759	2,673,965

Table 3-10b: Estimates of Peak Power and Average Annual Energy for Lower Dam Site

These estimates are based upon the specific flow operations, structural configuration, hydrologic conditions, and equipment efficiency used and may vary based on final configuration and actual hydrologic conditions.

3.8 Energy Use

There are several different options for utilizing the energy generated; (1) Sell all energy directly to Connecticut Light and Power (CL&P), (2) Net Meter at each Town-owned facility via a hardwired connection to the generating facilities; (3) Net Meter the energy through one Town-owned facility [Virtual or Community Net Metering]; (4) Power Purchase Agreement with CL&P; or (5) Sell Energy directly to Private/Commercial entity. Each of these options carries benefits and drawbacks including varying levels of required infrastructure and varying values of energy, both of which impact the financial analysis of the project. All options will require some form of interconnection agreement with Connecticut Light and Power.

3.8.1 Sell All Energy to CL&P

The Public Utilities Regulatory Policies Act (PURPA) is a law that was passed in 1978 by the United States Congress as part of the National Energy Act. It is meant to promote the greater use of renewable energy by creating a market for non-utility electric power producers. PURPA requires electric utilities to purchase power from non-utility generators at the "avoided cost" rate, which was the cost the electric utility would incur were it to generate or purchase from another source. Although a Federal law, the implementation was left to the States and a variety of regulatory regimes developed and in New

England, the value of energy is dictated by ISO New England as well as specific Connecticut regulations. If the Town chooses to sell all of the energy generated directly to the electrical service provider for the Town of Canton, Connecticut Light and Power, each site individually will require an interconnection agreement with CL&P. Adjacent to the Upper Powerhouse, the electric utility company, CL&P, has a local medium voltage overhead three phase feeder installed along the east side of Burlington Avenue. There is a pole located on, or immediately adjacent to, the facility. There is a small direct metered service, meter # 34346670, at this location that may have provided general purpose power for the facility at one time. Adjacent to the Lower Powerhouse and Gatehouse, CL&P, has a medium voltage distribution class overhead three phase feeder installed in a right of way along the access road extension adjacent to the site. This feeder connects to the CL&P substation near the intersection of Spring Street and New Road.

Typically in New England when generated electricity is sold directly to the utility, the energy is sold for ISO New England Real Time LMP values. These values are calculated based upon the instantaneous electrical supply and demand and are subject to significant fluctuation.

Sale of energy directly to CL&P is the most straightforward option for the electricity generated by the proposed hydroelectric facilities. The interconnections are technically and legally uncomplicated and the contractual mechanisms are well known. The downside is that this option creates the lowest value for the energy produced.

3.8.2 Use Energy On-site to Offset Existing Electrical Demands

Typically, when evaluating the amount of energy used on-site, several years' worth of data from electric bills are analyzed to understand the average annual energy demand and to evaluate for any trends. As the utility bills were not available, GZA utilized two alternate sources. A presentation to Canton's Board of Selectmen by the Canton Temporary Energy Task force in December 2007 summarized the on-site energy use of a variety of town owned facilities. Additionally, Connecticut Light and Power (CL&P) provided summary data for some of the town owned facilities which present average daily use of the facilities typically over several years. The data provided by CL&P was analyzed to estimate an average annual energy demand for those facilities which data was available. These average annual energy demands (based upon the CL&P data) were compared to the data presented the Canton Board of Selectmen. Although the annual energy values for the facilities were not exact matches (it would not be expected that they would be as the annual energy demand would be expected to vary for any one year), they were comparable to the extent that the data presented to the Canton Board of Selectmen was deemed reasonable and has been utilized in this report. **Table 3-11** summarizes average annual energy data used in this report based upon the Board of Selectmen presentation.

Location	Ave KWh
Canton Jr. High School	1,483,200
Sewage Treatment Plant	394,880
BOS - Community Center and Library	284,320
Middle School	237,120
Cherry Brook School	464,493
Town Hall	226,080
Parks and Rec. Dept	57,240
Volunteer Fire Dept	37,472
Town Administration	34,658
Pump Station	9,040
Sewage Treatment Plant	6,876
BD of ED Offices	6,514
Gazebo	3,208
Town Administration	4,341
Fairgrounds	721
Boden Field Scoreboard	217
Total	**3,250,380**

Table 3-11: Summary of On-Site Electrical Demand of Town Owned Facilities (Solar, 2007)

The actual available energy which can be offset at the Town-owned facilities will require further study should the project move forward. Of particular importance would be the actual Town-owned facilities which could be physically connected to the hydroelectric station via a dedicated distribution system. Based on preliminary concepts, it could be expected that a direct distribution system might connect to approximately 2,800,000 kWh of annual load.

Preliminary inquiries were made regarding total electrical demand for town-owned facilities in both Avon and Burlington. This information would be relevant should one or both Towns choose to become part of a consortium to develop the hydropower projects at the Upper and Lower Dams. The legal aspects of such a consortium would need to be researched and established, but it is possible that through this mechanism, multiple Towns could use net metering to offset existing electrical demand. Based on preliminary contact with officials from Avon, the Town uses approximately 1,120,000 kWh/ yr for Avon Town Buildings and pump stations, however, this figure does not include streetlights and schools which are tracked separately. Demand at the five school facilities is likely to substantially increase the total annual demand for Avon. Burlington indicated that it spends approximately $100,000 annually on street lighting, but no general information on electrical energy usage for Burlington buildings was provided. It is noted that Burlington has a number of municipal facilities including a town hall and library which will have electrical service.

3.8.2.1 Physical Distribution System to Town Facilities

It is theoretically possible to physically connect the generation facilities at the hydropower sites to facilities owned by the Town of Canton (and possibly facilities in Avon and Burlington) so that energy generated could be used "behind the meter" to directly power these facilities. The primary advantage to this is that it increases the value of the energy produced by offsetting the cost of electricity that would otherwise be purchased at "retail" rates. To do this, would require the construction (and also operation and maintenance) of a dedicated distribution system separate from and parallel to the existing CL&P lines. Such dedicated electrical lines could be above ground on poles or underground (or a combination). A step up transformer would be needed at the generating site and then step down transformers at each load site. A potential route from the Upper Site to several Town owned facilities is shown in the AI Report in **Appendix G** as Figure SK-1. This route requires approximately 2 miles of transmission line.

As discussed, the Town has a variety of facilities of which energy can be offset. However, due to the costs associated with a direct transmission line, not all town facilities can be included in a physical distribution system. If utilizing a direct transmission line, it is important to have a concentrated on-site demand located around the route of the transmission line. Facilities which are not clustered within the downtown Collinsville such as the Cherry Brook School as well as facilities which have minimal demands have not been included in the estimates of energy which can be offset utilizing a direct transmission line. Town-owned facilities in Canton which are proposed to be within a direct transmission line distribution system, and their assumed level of annual energy demand are listed in **Table 3-12**.

Town of Canton Facility	Est. Annual Energy Demand
Town Hall	226,080
Waste Water Treatment Plant	394,880
Town Garage (1)	37,000
Police Department (1)	37,000
Community Center/Library	384,320
Middle School	237,120
Fire Department	37,472
High School	1,483,200
TOTAL:	**2,837,100**

Note: (1) The actual demand of the Town Garage and Police Department were not available therefore, based upon the demand of other Town facilities, estimates of on-site demand have been assumed for these facilities.

Table 3-12: Estimated Annual Energy Demand for Facilities Owned by the Town of Canton which Would be Included in a Direct Transmission System.

While this option for energy use is technically feasible, at least in theory, it has numerous problems:

- The hydropower facilities cannot produce a firm power so all loads would need to remain interconnected to the CL&P distribution system.
- Production and demand timing will not necessarily correspond.
- Under some Alternatives (and definitely if both Sites are developed), production will exceed demand so excess energy will need to be sold back to the grid.

- This system will essentially require the Town to become a mini electric utility with respect to operations and maintenance
- The cost of the dedicated distribution system will add approximately a mimimum of $1,000,000 to the project cost.
- It will be difficult (and perhaps legally impossible) to secure agreements to cross existing CL&P right-of-ways with a dedicated distribution system.

3.8.2.2 Net Meter Through a Single Town Facility

There is pending regulation / legislation (see attachment) in Connecticut which proposes to allow for multi-site net metering. Through this process (also sometimes referred to as virtual or community net metering), net metering credits accumulated at one site can be transferred to other sites owned by the same entity. The single meter could be a meter on the utility connection at the powerhouse which meters energy used by ancillary systems (lighting, HVAC, controls, etc). This mechanism would be the simplest and least costly way to increase the value of the energy produced by the proposed hydropower facilities. There are several problems with this concept however:

- Net metering credits likely to exceed total demand in Town of Canton facilities, remaining power would be sold back to grid at the wholesale price. It is possible that inclusion of facilities from Avon and Burlington could assist with this issue.
- The regulatory/legal mechanism for this process is not yet available (or at least not yet clarified by the CTDPU)
- One version of pending regulation would limit this concept to producers who do not (and cannot) produce more power than they utilize.

Should the Town be able to utilize a means of multi-meter net metering, it is anticipated that approximately 3,250,000 kWh of demand per year (see Table 3-10) will be able to be off-set each year. As the costs associated with net-metering are significantly less than those associated with a direct transmission line, it is anticipated that all town owned facilities can be included in the total annual off set. There is a potential that there are additional town owned facilities which are not included in Table 3-10 which can increase the 3,250,000 kWh value. Additionally, if the hydropower facility is generating more average annual energy than the Town of Canton can utilize, there is a potential that the Town of Canton can enter into an agreement with a surrounding Town to offset some of their on-site demand.

3.8.3 Power Purchase Agreement with CL&P

It is possible that CL&P might be willing to consider executing a power purchase agreement for the energy produced by the hydropower facilities at a price above that generally paid to independent producers. CL&P might consider such an agreement as an alternative to going through the process of clarifying the "virtual" net metering rules and thus establishing a precedent which might be cited by other generators.

3.8.4 Sell Energy Directly to a Private Entity

Much of the power produced by the Upper and Lower Collinsville Sites was once consumed solely by the Collins Company. If there was a nearby single private entity who could consume the energy, then an agreement with and connection to that business could be established to sell electricity directly at a price above "wholesale" (good for the Town) but below "retail" (good for the energy consumer). However, no such private entity with sufficient load currently exists in the area.

4.0 ENVIRONMENTAL, HISTORICAL AND REGULATORY ISSUES

This section contains a summary description of the environmental setting of the proposed project including vegetative cover, fish and wildlife resources, water quality and quantity, land and water uses, recreational uses, historical and archaeological resources, and scenic and aesthetic resources. This information was compiled from publically available data. No site specific field studies were performed.

The sections below also contain a description of potential impacts to the natural and cultural environment and methods for mitigating potential impacts, when judged appropriate. All discussion of impacts assumes that any hydropower project will operate exclusively in an instantaneous run-of-the-river mode. A discussion of the regulating authorities that may need to be consulted with respect to specific issues is also included below.

This section was prepared through reference to existing information and available documents covering the region in general and the two sites specifically. In addition, letters were sent to a number of potential stakeholders / regulators to solicit preliminary feedback with respect to environmental issues which may be present at the site. **Table 4-1** summarizes the groups /agencies which were contacted as well as the comments and issues which were received. Copies of the information request letters and copies of the responses (when available) are included in **Appendix J**.

AGENCY/ ORGANIZATION	CONTACT INFORMATION	COMMENTS/ISSUES
FEDERAL		
NOAA NMFS	National Oceanic and Atmospheric Administration Fisheries Service Protected Resources Division Northeast Regional Office 55 Great Republic Drive Gloucester, MA 01930	NMFS determined that there were no jurisdictional resources present
NPS	Joyce Kennedy Raymes Study Coordinator Lower Farmington River/Salmon Brook Wild & Scenic Study 749 Hopmeadow Street Simsbury, CT 06070 (Work) 860 658 4442 x203	Proposed restoration of hydroelectric power is consistent with pending wild and scenic designation Project should meet: ▪ the standards of the Low Impact Hydropower Institute ▪ include provision for state-of-the-art fish passage, upstream and downstream, for all fish species that may travel through this section of the Farmington River. Project should incorporate the following into project planning: ▪ Updates and improvements of the original FERC license provisions at state and federal level ▪ Access for recreational fishing and paddling ▪ Provision for portage around the dams for canoes and kayaks, with access to the existing Greenway ▪ Provision of educational/ interpretive resources related to how hydropower works, its benefits, associated disadvantages and what mitigate measures were included ▪ Development of educational/ interpretive related resources on the subject of the Outstanding Resource Values of the river, including American Indian and post colonial Use
USFWS	U.S. Fish and Wildlife Service 70 Commercial Street Suite 300	Concerns outlined in December 2008 correspondence to the Town of Canton related to the following: ▪ Diadromous fish passage ▪ Minimum bypass flows

AGENCY/ ORGANIZATION	CONTACT INFORMATION	COMMENTS/ISSUES
	Concord, NH 03301-5087	▪ Sufficient flow to create a zone for fish passage ▪ Impacts of raising the impoundment water levels on free flowing riverine habitat
ACOE	U.S. Army Corps of Engineers New England District 696 Virginia Road Concord, MA 01742-2751 Attention: Diane Ray, CT Permitting/Regulatory Branch	If mitigation for lost wetlands (e.g., due to dredging or other impacts) is required, then in-kind, in-place mitigation within the project area may be a challenge. If no suitable mitigation site is found, then impacts may be off-set via alternative net environmental benefit measures TBD via coordination with ACOE and CTDEP
STATE		
CTDEP NDDB	CT DEP Natural Diversity Database dep.nddbrequest@ct.gov	Rare species listed in the state ESA; Anadromous fish passage; other species of conservation concern
DPU	Consumer Services Department of Public Utility Control Ten Franklin Square New Britain, CT 06051	CTDPU reported no jurisdiction but suggested project perhaps might be subject to regulation via CT Siting Council. CTDEP reported that FERC licensing would have precedence and therefore the project would not come under jurisdiction of the Siting Council.
QUASI-PUBLIC		
MDC	Planning Director The Metropolitan District Commission 555 Main Street Hartford, CT 06103	No response to consultation letter received during coordination period.

AGENCY/ ORGANIZATION	CONTACT INFORMATION	COMMENTS/ISSUES
LOCAL		
Town of Burlington	Planning Department Burlington Town Hall 200 Spielman Highway Burlington, CT 06013	No Response. Municipal Planner position vacant during consultation period.
Town of Avon	Steven Kushner AICP Director of Planning and Community Development/Zoning Enforcement Officer Avon Town Hall 60 West Main Street Avon, CT 06001	No natural resource concerns raised other than requirement for maintaining river flows and re-establishing fish passage
Town of Canton	Consultation via Hydropower committee and conversations with Jeff Shea, Neil Pade, Conservation Commission, etc.	Concerns related to potential impacts to the following species and faunal groups: ▪ Raptors (esp. Bald Eagle) ▪ Shorebirds (impact of inundation of sand bars, flats, and shorelines) ▪ Waterfowl ▪ Waders ▪ Diadromous Fish ▪ Aquatic invertebrates of conservation concern (e.g., mussels, etc.) Concerns for impacts of inundation compounded with releases from MDC reservoirs.
TRIBAL NATIONS		
Mashantucket Nation	Mashantucket Pequot Museum & Research Center 110 Pequot Trail Mashantucket, CT 06338	Kathleen Knowles (Mashantucket THPO) Requested Phase I Archeological Surveys be conducted.

AGENCY/ ORGANIZATION	CONTACT INFORMATION	COMMENTS/ISSUES
	Attn: Ms. Kimberly Hacher-White	
Mohegan Nation	Mohegan Tribe Cultural Department 5 Crow Hill Road Uncasville, CT 06382	No Response Received
NGO		
Farmington River Watershed Association	Eileen Fielding - Executive Director Farmington River Watershed Association 749 Hopmeadow Street Simsbury, CT 06070	No Response Received
Trout Unlimited (TU)	Carl Swanson – Farmington Valley Chapter President Carl.swanson@comcast.net Jim Glowienka – National Leadership Council Chair Jim Glowienka@optonline.net Jeff Yates – National Leadership Council jeffyates@aol.com	No Responses Received

AGENCY/ ORGANIZATION	CONTACT INFORMATION	COMMENTS/ISSUES
American Rivers	American Rivers Northeast Region Chapter 516 Westhampton Road Northampton, MA 01062	No Response Received

Table 4-1: Summary of Stakeholder/Regulator Preliminary Consultation

4.1 Vegetation and Wetlands

4.1.1 Existing Vegetation and Wetlands

The area around the Upper and Lower Dams and their respective impoundments includes developed and undeveloped sections. The Upper Dam, located in the center of Collinsville is in a highly developed area.

The reach of the Farmington River downstream of the Upper Collinsville Dam is depicted on National Wetlands Inventory (NWI) mapping as a Riverine Upper Perennial Permanently Flooded Watercourse with Unconsolidated Bottom (R3UBH). Despite the benthic classification in the NWI mapping unit, portions of the downstream reach of the river proximal to the Upper Collinsville Dam have a bedrock dominated substrate. Downstream of the river reach dominated by bedrock, the substrate is a mixture of boulder, cobble, gravel, and sand, the latter prevailing in areas of lower flow and backwater eddies.

Using the Cowardin (*et al.*, 1979) classification system, the NWI mapping depicts the impounded portion of the Farmington River upstream of the Upper Collinsville Dam as a Lacustrine unconsolidated bottom, permanently flooded, Diked/Impounded unit (L1UBHh). This unit extends from the Upper Collinsville Dam, upstream to approximately the location of the Town Bridge Road bridge. Further upstream, the Farmington River is depicted as a Riverine Upper Perennial Unconsolidated Bottom, permanently flooded system (R3UBH), bordered by Palustrine Forested Broad-leaved Deciduous Temporarily Flooded Wetland (PFO1A), Palustrine Forested Broad-leaved Deciduous Seasonally Flooded (PFO1C) and Palustrine Unconsolidated Bottom Permanently Flooded (PUBH) wetland units. See **Figures 4-1 through 4-4**.

Figure 4-1: Wetland Cover Types Mapped along the Farmington River between and in the Vicinity of the State Route 202 crossing and the Town Bridge Road Bridge.

Source: NWI Wetlands Mapper Accessed online 13January 2010 at http://www.fws.gov/wetlands/Data/Mapper.html

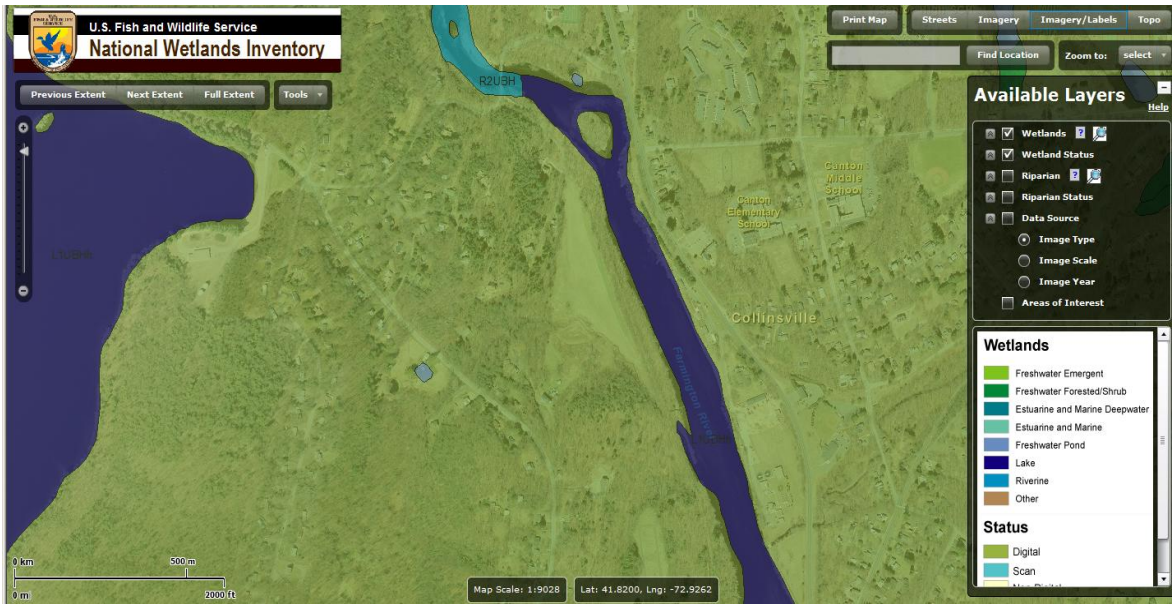


Figure 4-2: Wetland Cover Types Mapped along the Farmington River between and in the Vicinity of the Town Bridge Road Bridge and the Canton Wastewater Treatment Plant.

Source: NWI Wetlands Mapper Accessed online 13January 2010 at http://www.fws.gov/wetlands/Data/Mapper.html

Figure 4-3: Wetland Cover Types Mapped along the Farmington River between the Intersection of River Road and Maple Avenue Intersection and the Upper Collinsville Dam.

Source: NWI Wetlands Mapper Accessed online 13January 2010 at http://www.fws.gov/wetlands/Data/Mapper.html

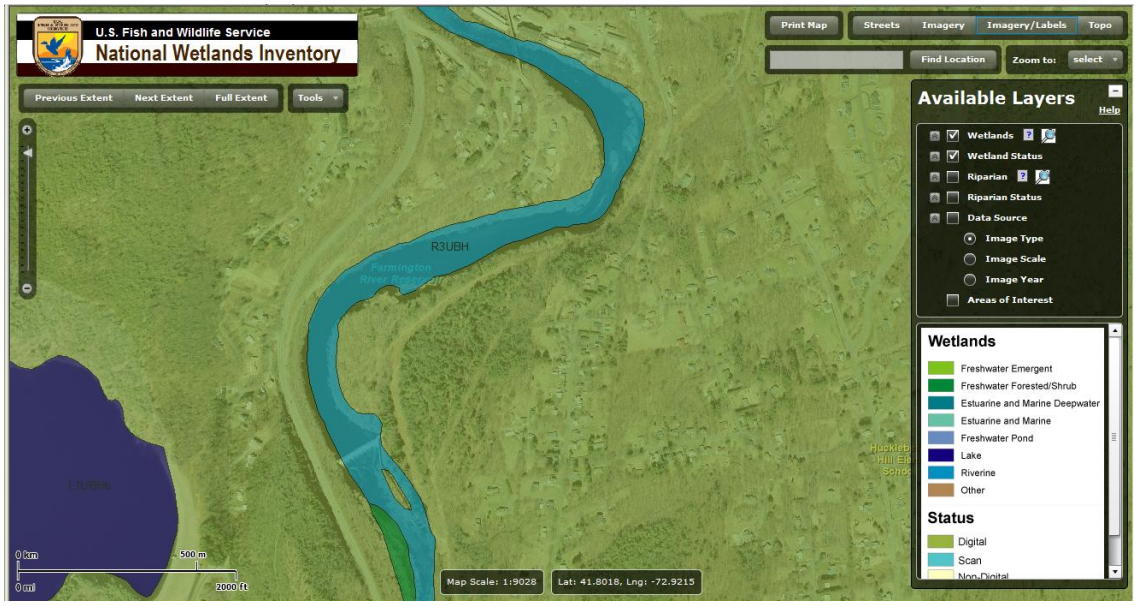


Figure4-4: Wetland Cover Types Mapped along the Farmington River between the Upper and Lower Collinsville Dam.

Source: NWI Wetlands Mapper Accessed online 13January 2010 at http://www.fws.gov/wetlands/Data/Mapper.html

Palustrine emergent non-persistent wetland dominated by various hydrophytic gramminoids and interspersed with hydrophytic shrubs has formed within the head race and tail race of the lower Powerhouse. This area is too narrow and limited in extent to be mapped and depicted by the NWI mapping. As a vegetated resource area, the tail race would be subject to protection under Connecticut's Inland Wetlands Act.

4.1.2 Potential Consequences for Hydropower Development

Direct impacts to vegetation and wetlands due to construction associated with the re-powering of the sites at the Upper and Lower Collinsville Dams is likely to be limited. Construction will be limited primarily to areas in and immediately around existing structures. However, due to the proximity of these areas to the River and associated wetlands, a comprehensive sediment and erosion control plan for all construction activities will need to be developed. The plan will need to include all areas affected by construction, including access roads and staging areas.

Impacts to wetlands due to hydropower operations are assumed to be fundamentally no-existent provided that the systems operate in run-of-the-river mode. Impacts to wetland areas due to the raising of the impoundment normal levels behind the Upper and Lower Dams may be of concern.

The restoration of historic freeboard to the dam apex to raise the water elevation of the impounded portion of the Farmington River will cause an upstream expansion of the L1UBHh unit, a shift in the R3UBH unit and shifts or reductions in PFO1A and PUBH units. Three channel bars would likely also be flooded. These bars provide safe resting sites for waterfowl and the shallows around the bars provide spawning sites for warm-water fish species, and perhaps suitable living substrate for freshwater mussels and other benthic invertebrate fauna.

Prior assessments focused primarily on a net loss basis for wetland impacts, meaning the impacts were quantified mainly by way of assessing the change in inundation area assumed to be calculated based upon surface elevations of area surrounding the impoundment. The analysis contested that upland areas would be inundated and would become wetland areas, thereby offsetting currently vegetated zones that could be impacted by a deeper water inundation. In actuality, the special habitat attributes currently provided to the flora and fauna known or expected to inhabit the site could be impacted by the inundation in more subtle ways. For instance the newly inundated shallow water areas in the surrounding former upland would not necessarily have the same sediment characteristics, organic matter content, vegetation, or other characteristics as the existing peripheral littoral zone. The CTDEP expressed concern regarding the inundation of shallow riffle or gravel bar areas at the northern limits of the existing impoundment and perhaps rendering these areas unsuitable for salmonid spawning. Two Significant Natural Communities of Conservation Concern identified during the Farmington Valley Biodiversity Project (Gruner et al 2006) likely occur within the anticipated area of impact from inundation. They are the "Acidic Pond Shore" and "Riverbank Beach/Shore" communities. Other stakeholders report concerns regarding the inundation of shorelines and channel bars and the potential for impact to shorebirds, waterfowl, and waders that frequent these riverine features.

The extent of changes within the mapped and existing wetland units and natural communities cannot be accurately determined without a detailed topographic survey depicting surface elevations at a contour interval resolution of at least one feet or less. Existing baseline bathymetry within

the existing impoundment should be collected with greater area resolution within the shallow littoral areas. This information should be coupled with topographic data collected at a similar resolution in the adjacent upland areas. Information on benthic substrate (e.g., grain size and relative % organic composition, etc.) would need to be ascertained as well in order to more accurately assess the potential for impact to the wetland and riparian habitats.

The previous licensee proposed removing trees and vegetation below the new water line in the Lower impoundment, but the FERC EA recommended maintaining this vegetated area. More recent consultations raised the issue of inundation of wetland and upland areas in the Upper impoundment. Upland areas along the River provide seasonal and permanent habit for a variety of species including mallards, black ducks, wood ducks, raccoons, opossums, rabbits, hawks and Owls. The marshy/wetland areas provide habitat for muskrat, rabbit, geese, and other waterfowl and marsh wildlife. It is expected that the habitat would adjust to new water levels, but this is an issue likely to need further study.

Conditions now existing in the Lower Dam power canal may lead to discussion during permitting regarding its transformation back to an open water (riverine) condition for the purposes of once again conveying water to the Lower Site powerhouse. It is noted that the power canal is a man-made structure and that historically it was used as a water conveyance channel. It is also noted that no objection to the renewed use of the power canal was raised during the previous licensing effort nor in any of the more recent consultation letters.

Consultations will be necessary with the US Army Corps of Engineers, CTDEP, and the Canton Inland Wetlands and Watercourses Agency, among others, regarding wetland impacts.

4.2 Wildlife

Numerous species of terrestrial and avian wildlife utilize the habitats surrounding the Farmington River in the vicinity of the project site. Discussions of wildlife issue in this report are limited to those species which are listed as endangered or threatened under state or Federal regulations.

4.2.1 Endangered and Threatened Wildlife

Information regarding the presence of rare species was obtained from the CTDEP Geographic Information Center's Natural Diversity Database (NDDB) indicated that there are records for rare avifauna and herpetofauna from the vicinity of the project area (Refer to **Appendix J**).

"Rare" species are defined as any of Connecticut's flora or fauna included on the Connecticut Department of Environmental Protection (CTDEP) list of endangered, threatened, and special concern species (CTDEP, 2009). Any species federally designated as threatened or endangered, by Connecticut definition, is also listed as such in Connecticut. As established by Public Act 89-224, the definition of endangered, threatened, and special concern species in Connecticut is as follows:

- *"Endangered Species"* (E) means any native species documented by biological research and inventory to be in danger of extirpation[2] throughout all or a significant portion of its range within the state and to have no more than five occurrences in the state, and any species determined to be an "endangered species" pursuant to the federal Endangered Species Act.

- *"Threatened Species"* (T) means any native species documented by biological research and inventory to be likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range within the sate and to have no more than nine occurrences in the state, and any species determined to be a "threatened species" pursuant to the federal Endangered Species Act, except for such species determined by the Commissioner to be endangered in accordance with Section 4 of the Act.

- *"Species of Special Concern"* (SC) means any native plant species or any native nonharvested wildlife species documented by scientific research and inventory to have a naturally restricted range or habitat in the state, to be at a low population level, to be in such high demand by man that its unregulated taking would be detrimental to the conservation of its population or has been extirpated from the state.

The CTDEP NDDB reported having records of a state threatened species, the Bald Eagle (*Haliaeetus leucocephalus*) and two species of special concern, Wood turtle (*Glyptemys insculpta*) and Eastern Box turtle (*Terrapene carolina*) in the vicinity of the project area. Descriptions of the habits and habitats of these species is provided as follows:

Eastern Box Turtle

Eastern box turtles (*Terrapene carolina carolina*) are a terrestrial species characterized by a domed carapace with yellow/orange blotching on a brown/black background and a hinged plastron allowing the turtle to completely enclose itself within its shell. Due to increased habitat loss, fragmentation, predation, and road mortality, eastern box turtle populations throughout Connecticut are declining.

Their habitats consist of upland woodlands including logged areas, lowland wetlands, wet meadows, and old fields including power line cuts (Klemens, 1993). Box turtles typically reside in small home-ranges that encompass a mosaic of these habitat types and can usually be found in the same area year after year. They tend to use these habitats at different times throughout the year (Dodd Jr., 2001). They are often found near small streams and ponds, the adults are completely terrestrial but the young may be semiaquatic, and hibernate on land by digging down in the soil from October to April. Since the Eastern Box Turtle may occur within vegetated wetlands regularly during hottest months of the year, they are a species that could potentially be impacted by the use of heavy construction vehicle equipment travelling the unimproved access roads to reach the dams, buildings, and other appurtenances.

[2] "Extirpation" is defined as local (in this case state-wide) extinction.

Wood Turtle

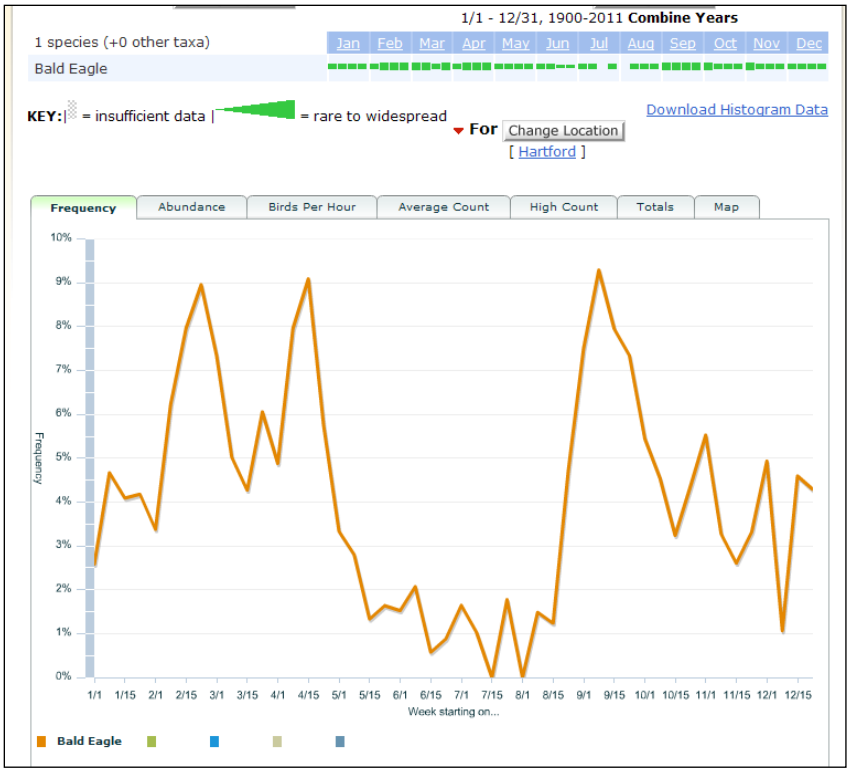
Wood turtles require riparian habitats bordered by floodplain, woodland or meadows. They hibernate in the banks of the river in submerged tree roots. Their summer habitat includes pastures, old fields, woodlands, powerline cuts and railroad beds bordering or adjacent to streams and rivers. Both of these species are dormant from November 1 to April 1 and have been negatively impacted by the loss of suitable habitat.

If Wood or Eastern Box turtle habitat exists on the proposed site and will be impacted by your project, the Wildlife Division recommends that a herpetologist familiar with the habitat requirements of this species conduct surveys between April and September to see if they are present. A report summarizing the results of such surveys should include habitat descriptions, reptile species list and a statement/resume giving the herpetologist' qualifications. The DEP doesn't maintain a list of qualified herpetologists. A DEP Wildlife Division permit may be required by the herpetologist to conduct survey work, you should ask if your herpetologist has one. The results of this investigation can be forwarded to the Wildlife Division and, after evaluation, recommendations for additional surveys, if any, will be made.

Bald Eagle

After perhaps the last successful reported nesting site at hamburg Cove in Lyme in the 1950s, there was a period in Connecticut's history when the Bald Eagle was extirpated as a breeding resident. Since perhaps the mid-1980's this federally-protected species has been re-establishing itself as a consistent member of Connecticut's breeding avifauna, and wintering populations on the lower Connecticut River and the Housatonic River at the Shepaug Dam have elevated the bird's status from rare winter visitor, to rare summer resident, uncommon winter visitor. Zeranski and Baptist (1990) reported it as a "rare to uncommon migrant from early August through October, less frequent in Spring from early April to mid-May". Since then, it now occurs with more regularity throughout all seasons, but still exhibits the bimodal frequency of occurrence reported by others (Zeranski and Baptist 1990; Haniseck 2005). **Figure 4-5** depicts the frequency distributions of sightings made in Hartford County that have been reported to the Cornell laboratory of Ornithology.

As long as the surface waters remain unfrozen, Bald Eagles frequently winter along the Farmington River. Bald Eagles regularly use the shoreline trees for perching and feeding from December – March whenever and wherever there is open water during the winter months. Waterside old growth trees at or exceeding 12" dbh are typically used for perching for extended periods in the winter as the birds conserve energy during the coldest portions of the day. To avoid affecting wintering eagles the Wildlife Division recommends that no work be conducted along the water from December 31 to March 1.



Source: eBird

Figure 4-5: Frequency Distributions of Bald Eagles in Hartford County

Avifauna

The impoundment behind the Upper Collinsville Dam is frequented by a number of avifauna that changes through the season. Shorebirds moving through the area frequent shorelines, point bars, channel bars, and diamond bars within the river. Waterfowl congregate during late fall and early winter lingering as long as the impoundment remains ice free. Belted Kingfishers, Common Mergansers, and more recently Double-crested Cormorants frequent the impoundment to hunt fish. Osprey, another piscivore, visits the impoundment from time to time during spring and autumn migration. Rough-winged Swallows, Cliff Swallows, and Eastern Phoebes feed on insects above the impoundment and may nest under the Route 179 Bridge. Vegetated shoreline areas provide food, cover, and roosts for a variety of passerine ("songbird") species as well. Standing dead wood, especially, has wildlife value. Abandoned woodpecker holes and decaying heartwood is used by a variety of cavity - nesting birds and rodents. Larger branches of standing dead wood are used as perches and nest sites for raptors and Great Blue Herons. Therefore, due to the importance of vegetation along the impoundment shore to wildlife and as erosion control, vegetation along the shorelines and riparian bank should be left in place, as safety permits.

4.2.2 Potential Consequences for Hydropower Development

Potential impact to the dwarf wedgemussel will likely need further study prior to any proposed hydropower-related construction. It is noted that dwarf wedgemussel larvae (glochidia) must attach to the gills or fins of fish during their early life stage. They remain attached to their "fish host" for several weeks, drawing nourishment from the fish while they develop into juvenile mussels. They do not hurt their "fish host." The juvenile mussels then detach from the fish host and drop to the bottom of the

stream where they continue to develop, provided they land in a suitable place with good water conditions. It is therefore possible that any improvements to fish passage (upstream and downstream) resulting from proposed hydropower development may also benefit dwarf wedgemussel populations in the Farmington River.

Further consultation with the Wildlife Division is warranted should the project advance through planning and into a permitting phase, as the time of year when the anticipated work would take place would likely affect the listed herpetofauna should they be present on the site when the work commences. Time of year restrictions for certain types of scheduled work, preconstruction search surveys, use of environmental monitors during construction, contractor education, contingency planning in the event an individual is encountered and other measures are typically used to avoid, reduce, or mitigate potential impacts to these rare species. The January 6, 2011 letter from the CTDEP recommends that NO work be performed along the waterway from December 31 to March 1 to avoid affecting wintering eagles. Additional studies and or mitigations may be necessary to avoid or minimize impacts to Wood turtles and Eastern Box turtles. Impacts to turtles and other amphibians may be a particular source of discussion during conversations with regulators regarding the raising of the impoundments. Consultations with DEP Wildlife Division and USFWS, among others, will be necessary during licensing and permitting.

The need to acquire state permits or other state involvement would envoke the specific restrictions or conditions relating to the measures required to mitigate impact to these species. Once more detail is known regarding the magnitude and scale of required construction activity, additional evaluation of the proposal by the DEP Wildlife Division should be requested. The CTDEP NNDB files are routinely updated every six months. Therefore, NDDB requests should be updated accordingly prior to the submittal of any permit applications to the State if construction activity associated with the proposed project has not been initiated within 12 months of the last NDDB review. The status of most if not all of the species assessed in the former EA (FERC, 1999) has since changed and would need to be updated to reflect the status change and to address the species listed by CT DEP NDDB outlined above.

Standard protocols for protection of wetlands should be followed and maintained during the course of the project. Additionally, all silt fencing should be removed after soils are stable so that reptile and amphibian movement between uplands and wetlands is not restricted. The CTDEP Wildlife Division typically requires additional details regarding the presence or potential for the species presence within the proposed work areas. This may include detailed timetables and typical sequencing of anticipated construction work activities associated with project implementation. Site-specific surveys will likely be required to support information provided in environmental assessments.

4.3 Fisheries and Aquatic Habitat

The Farmington River and many of its tributaries are heavily used by anglers who visit the watershed to fish its cold-water species. Warm-water species (e.g., Bluegill, Pumpkinseed, bass, pickerel) are likely sought from the impoundment above the Upper Collinsville Dam. Other fisheries resources found within the Farmington River are characterized by data collected by the CTDEP at various tributary streams at their confluences with the Farmington River. Summary Data Tables are located in **Appendix I**.

Diadromous fish are fish that partake in regular, periodic (typically seasonal), and obligatory movements between fresh and marine water habitats. These movements are further classified into one of three categories: anadromy, catadromy, and amphidromy.

Atlantic Salmon and American Eel are two diadromous fish species whose upstream movements may be restricted by the Lower Collinsville Dam. Diadromous fish are an important resource of the river in that their ecological roles include but are not necessarily limited to the following: they are important source of prey to many top predatory and game fish marine species, and aid in the distribution of certain freshwater mussel species since they are obligate hosts to some of the freshwater mussels' parasitic larvae. As federal trust species, they have priority for conservation efforts. Atlantic Salmon are the subject of ongoing restoration efforts along the Farmington River, and the American Eel is the subject of recent petitions for listing under the Endangered Species Act.

Sediment plumes generated by in-water work or via upland erosion washing into riverine systems may interfere with diadromous fish species movements to and from spawning areas, or they may avoid returning to their spawning areas altogether, potentially affecting their reproductive success for the season (Gibson, 1987). Sedimentation can also impact preferred breeding substrates by changing the sediment texture. Dams that alter river hydrology may seriously disrupt the movements of these species between upstream breeding grounds and post breeding downstream dispersal reaches. Following the breach of the dam in Tariffville Gorge and installation of a fish ladder at the Rainbow Reservoir, the Lower Collinsville Dam has become the upstream limit of diadromous fish runs along the Farmington River.

The potential impact to diadromous fish in the Farmington River can also be avoided or minimized through time-of-year restrictions on in-water work, diligent and effective use of erosion and sedimentation controls in upland work areas, and via the proper design, placement, operation, and maintenance of fish passage measures established at the dam sites.

Ichthyological Assoc., LLC (Ichthyological Assoc) of Mount Savage, Maryland was subcontracted by GZA to investigate four issues regarding fisheries and aquatic habitat which have the potential to affect the development of hydropower at the site. The four issues were: 1) fish species of concern; 2) fish and eel passage; 3) potential minimum in-stream flow requirements; and 4) other potential environmental impacts to the aquatic environment. The Memorandum issued by Ichthyological Associates is contained in **Appendix K**. The memorandum is not intended to be a comprehensive report on fisheries resources in the Farmington River, rather, it is intended to identify issues which may influence project development, may require further investigations, and/or may necessitate avoidance measures or mitigations. A summary of findings by Ichthyological Assoc. and from other references is provided below:

4.3.1 Fisheries and Aquatic Wildlife Resources

The Farmington River is known to be a habitat for Anadromous fish species. Anadromous fish are born in fresh water, spend the majority of their adult lives in salt water and migrate back to fresh water streams to spawn. Human activities, including the construction of dams, have affected Anadromous fish habitat and passage in the Farmington River. Since the 1960s there has been an ongoing Anadromous fish restoration program the Connecticut River and its major tributaries, including

the Farmington River, centered on the Atlantic salmon. More recently, this program has also begun targeting other Anadromous species including American shad, alewife, blueback herring, and sea lamprey. Restoration of the Catadromous (spawn in salt water, adult in fresh water) American eel is also now of concern. Fishery Management Plans specific to the Connecticut River Basin including the Farmington River were located for Atlantic salmon and river herring. The Connecticut River Coordinator's Office also references the Atlantic States Marine Fisheries Commission management plans for American eel and American shad.

More than two dozen other fish species are also know to existing in the area of the Upper and Lower Dams, including various trout. There are several Trout Management Areas (TMA) on the Farmington River which offer year-round, high quality fishing. A TMA has been established from the downstream of the Lower Collinsville Dam to the Route 4 bridge and is managed year-round under the catch-and-release regulations. The TMA's on the Farmington River support the highest volume of fishing measured on any stream in Connecticut. Trout are stocked throughout the watershed to meet the demand for recreational fishing. The CT DEP annually stocks approximately 46,000 trout over a 28-mile stretch of river, however, stocking is concentrated in the section of river between the Route 202 bridge in Canton to the Route 4 bridge in Farmington. This area is typically stocked prior to opening day in April with approximately 1,100 brook, 5,600 brown, and 400 rainbow trout. In-season stocking of approximately 600 brook, 2,300 brown, and 1,000 rainbow trout occurs until September.

Currently, there are fish passage facilities at neither the Upper nor the Lower Collinsville Dams. No facilities exist for upstream passage and no facilities are present for downstream passage. There is no active management of flows for fish passage.

There are three fish passage impediments downstream of the Lower Collinsville Dam. The Rainbow Dam, an operating hydroelectric facility, is located approximately 8 miles from the confluence of the Connecticut River. In 1976 the CT DEP constructed a fishway around the 60-foot high dam to facilitate upstream fish passage. It is since been found that significant improvements to the fish passage area required due to its ineffectiveness in passing certain species. It is understood that the CT DEP is currently making strides to install a fish elevator to create improved passage. The Spoonville Dam (Tariffville Gorge) is located approximately 12.5 miles from the confluence of the Connecticut River and is a partially breached dam. It is understood that fundraising efforts are ongoing to complete a final engineered breach that will facilitate upstream fish passage. The Winchell Smith Dam is located approximately 20 miles from the confluence of the Connecticut River and is understood to be a relatively small dam. As with Spoonville, it is understood that there is an ongoing fundraising effort to fund an engineering study for upstream passage at the Winchell Smith Dam.

While the effectiveness of the upstream fish passage facilities is not optimal, some fish do pass the Rainbow Dam, which permits them to reach the Lower Collinsville Dam. The Lower Dam is the downstream-most dam on the Farmington River with no fish passage facilities. Once the Rainbow Dam fish passage renovations are completed and the Spoonville Dam and Winchell Smith Dam fish passage facilities are constructed, passage for target species at the Upper and Lower Collinsville Dams will likely be judged to be more critical.

The Upper and Lower Collinsville Dams create long stretches of slow moving water providing habitat for water fisheries typically found in lakes and ponds. This results in a higher diversity of fish species within the impoundments of the Upper and Lower Collinsville dams than is found on the majority of the River. Species in the Upper and Lower Collinsville impoundments typically include yellow perch, calico bass, largemouth and rock bass and pickerel.

4.3.2 Potential Consequences for Hydropower Development

Impacts on fisheries resources are typically one of the most controversial aspects of hydropower development. In the case of the Upper and Lower Collinsville project sites, there are existing dams at both locations; therefore, the barriers to fish passage exist with or without hydropower. Proposed hydropower development at these sites offers the potential for improvements which may benefit fisheries resources. Fish passage (upstream and downstream) and habitat protection are certain to be key issues of discussion during the FERC licensing process for any hydropower projects proposed at the sites. Section 16 of the FPA provides that the Commission shall require the construction, operation, and maintenance by a licensee of such fishways as the Secretaries of Commerce or the Interior may prescribe. The US Fish and Wildlife Service, CTDEP Fisheries, and numerous other agencies and interest groups (such as Trout Unlimited) will be part of the consultation process for any license or new environmental assessment report. Fish passage is almost certainly a non-negotiable requirement. The previous licenses required construction of Denil fish ladders, downstream passage systems, and bypass reach channel modifications at both the Upper and Lower Dams primarily for the purpose of facilitating Atlantic salmon passage. Subsequent communication from fisheries agencies has made clear that a broader agenda will be pursued for future hydropower proposals. Fish passage facilities will be required to be designed and operated for the benefit of multiple species, including American eel. The CTDEP stated the following in a letter dated November 26, 2008 responding to the Town of Canton's Preliminary Permit application:

> "We appreciate the fact that a basic fish passage plan including the provision of minimum flows for the bypass reaches at both dams was developed by a previous licensee and that that information has served as a helpful starting point for the town. We note, however, that there have been new developments with fish management on the Farmington River and in the field of fish passage, in general, and anticipate that the circa 1991 approach may not be entirely suitable at this time. Our agency as well as the U.S. Fish & Wildlife Service will need to be consulted early in the planning process to ensure that all natural resource concerns are effectively addressed. "

A similar opinion was expressed by the USFWS in a letter dated December 3, 2008 (referenced in the January 2011 consultation response from USFWS):

> "…it appears that the preliminary permit application relied on information developed as part of the now defunct licensing proceedings for the Upper and Lower Collinsville Projects (ERC Project Nos. 10822 and 10823). While this information gives some valuable background information and provides assessment of some project effects, the issues, study needs and ultimately the recommendations of the Department's Fish and Wildlife Service and other resource agencies are likely to differ from that proceeding given changes in the river resources, resource management plans and review criteria."

On this basis, it may be expected that a number of conditions regarding fisheries and aquatic habitat will be required by Federal licensing and / or other permits, including, but not limited to, as follows:

4.3.2.1 Upstream Fish Passage

Upstream fish passage will almost certainly be required at both the Upper and Lower Dams. Ichthyological Assoc. reviewed existing information and previous licensing requirements to develop concepts for upstream fish passage (conceptual drawings contained in **Appendix K**). Final locations, configurations, and operations plans for upstream fish passage facilities will need to be reviewed and approved by fisheries agencies. As a preliminary concept however, it is proposed that Denil type fish ladders be utilized at both the Upper and Lower Dams. These fish ladders would likely be reinforced concrete structures with moderate (1:8) slopes and wooden baffles. As proposed by Ichthyological Assoc., each ladder would have periodic resting pools and would be provided with two gated exits to accommodate impoundment water surface elevations with and without flashboards. Switchbacks for the fish ladder channel will be required to maintain the desired channel slope. The entrances to the fish ladders would be located near the toe of the spillways. This type of fish ladder is generally suitable for the wide range of fish species targeted for restoration in the Farmington River.

At the Upper Dam, it is envisioned that the most likely location for the fish ladder is on the left (east) side of the river channel, under the highway bridge and adjacent to the east bridge abutment. While this location will not be advantageous to public viewing, it will reduce the potential for poaching from the ladder. Coordination with and permits from the CTDOT will likely be necessary due to the location. This location may require modifications to the bedrock river channel to provide for an appropriate zone of passage channel to the fish ladder entrance. The previous license also stipulated bar screens at the downstream end of the tail race of the Upper Site powerhouse to prevent inadvertent attraction by turbine flow.

At the Lower Dam, it is envisioned that the most likely location for a fish ladder is near the right (west) side of the structure at the juncture between the spillway and non-overflow portion of the dam (where the sluice gates are located). This location may offer the chance for public viewing. The downstream channel will need to be studied for compatibility with this location.

Fish ladders require specific flow rates to operate appropriately and to provide for attraction flow to guide the fish to the ladder entrance. Ichthyological Assoc. estimates that a flow of 15 cfs would be appropriate for the proposed fish ladders, which would be part of the total conservation flow which must be passed over the dam. The 1999 FERC EA estimated total fish passage flow needs to be 37 cfs. Due to the need to accommodate upstream passage for multiple species, it will likely be necessary to operate the fish ladders during a period from at least April 1 to November 15.

American eels require separate upstream passage facilities. Eelways are typically simple trough-type structures with roughened or textured surfaces which allow the eels to move upstream. Flow through the eelway is limited to the minimum amount necessary to wet the surface and generally the eelway exit is above the impoundment water surface. At both the Upper and Lower Dams, it is envisioned that the eelways would be located in the same general location as the fish ladders and be constructed contiguously. However, eelways may be steeper and thus not require the same switchbacks.

4.3.2.2 Downstream Fish Passage

The provision of downstream fish passage is important to prevent fish from being injured or killed while either passing over the dam or through the hydropower turbine. There are two important components to downstream passage: 1) Bar screens to prevent fish (and eels) from passing through the turbines; and 2) A concentrated discharge to move fish from the impoundment elevation to the tailwater. Trashracks must be provided across the flow field (i.e. headrace) at a point upstream of where the flow enters the powerhouse. The preferable configuration is that the trashracks be angled so as to direct downstream traveling fish towards the downstream passage facility. The spacing of the trash rack bars must be tight enough to prevent fish from moving through the bar screen and the approach velocity must be low enough to reduce the chance of fish being pinned against the trash rack. Typically bar spacings of 1-inch center-to-center and approach velocities of less than 2.0 feet per second are recommended. It is noted that some authorities suggest smaller bar spacing and lesser velocities for eels. The downstream passage is typically provided by a surface sluiceway through the crest of the spillway or headrace channel wall. The sluiceway typically must pass at least 2 percent of turbine flows and must discharge to plunge pools or angled troughs to prevent fish from being injured as the result of falling.

At the Upper Dam, the downstream fish passage facility would be located at the downstream end of the tailrace channel and discharge through the channel training wall. At the Lower Dam, the downstream fish passage facility could be located either at the gatehouse at the upstream end of the power canal, or at the downstream end of the power canal immediately upstream of the powerhouse.

4.3.2.3 Water Level Control

As previously discussed, the proposed hydropower developments at both the Upper and Lower Dams have assumed that the water levels in the impoundments would be raised to levels consistent with historic operating pools (i.e. an additional 3 feet at the Upper Dam and an additional 5 feet at the Lower Dam). The previous licensee proposed to make these changes to water surface elevation through the use of flashboards. Both the changes to water surface elevation and the use of flashboards were accepted in the previous licenses issued by FERC. More recently however, some unease has been expressed over the use of flash boards. Flash boards are designed to "trip" or "flash" when water surface elevations reach a certain point in order to prevent upstream flooding. The CT DEP and the Lower Farmington River/Salmon Brook Wild and Scenic Study Committee have expressed the concern that flash boards have the potential to negatively affect fish passage due to changes in water surface elevation in the period after the flash boards have "tripped." Normal pool cannot be restored until flash boards have been replaced, which might not be possible until a period of lower flow.
The CT DEP stated the following in their letter dated November 26, 2008:

> "Flashboards are prone to frequent loss and extended delays in re-installation. Denil fishways are very sensitive to headpond fluctuations and the loss of flashboards would compromise the performance of the fishways. We suggest that the town consider the use of inflatable bladder-type "dams" or "boards" instead of traditional wooden flashboards to address these concerns."

The use of a variable control mechanism such as a rubber bladder dam or a metal crest gate is one way of addressing this concern. However, these mechanisms have significant drawbacks. A bladder dam will be significantly more expensive than flash boards (with a crest gate even more expensive) and will require significant modification to the crest of the spillway. A bladder dam or crest gate will also require active operation to lower the impoundment at the proper time to prevent upstream flooding and raise it again at the proper time. Another means of addressing the concerns raised by flash boards is to construct fish passage facilities (upstream and downstream) which can accommodate the change in water level through multiple exits and/or variable flow controls.

4.3.2.4 Conservation Flows

The maintenance of conservation flows over the spillway to provide water to the bypass reach will almost certainly be a condition of any license. A bypass reach is that portion of the river channel which is between the spillway and the outlet of the hydropower tailrace. The minimum conservation flow helps to maintain habitat in the bypass reach. The previous license required minimum conservation flows of 180 cfs to be maintained at both the Upper and Lower Dam spillways. The value of 180 cfs was developed based on the general rule from the New England Aquatic Base Flow policy that recommends 0.5 cfs per square mile of watershed. It is likely that flow discharged through the fish ladders would be considered part of the conservation flow total. Flows from the downstream passage facilities may or may not count towards the total. It is noted that future environmental studies may require more site specific assessment of minimum conservation flows and may request assessment of seasonal variation. Because conservation flows pass over the spillways at both sites, they are not available for hydropower generation at the powerhouse locations.

4.3.2.5 Upstream Habitat

The CT DEP Inland Fisheries letter dated November 26, 2008, the issue of impacts to the upstream riffle/run type aquatic habitat that exists upstream of the current Upper Dam impoundment was raised. The concern was raised that the addition of 3 feet of flash boards to the Upper Dam may affect this area by transforming the habitat to a more pool-type environment. This issue was raised but not judged to be a concern in the 1999 FERC EA. It is noted that flash boards have been installed at the Upper Dam for many years, even after the end of hydropower generation; however, it may be necessary to conduct additional studies of the aquatic habitat upstream of the Upper Dam (specifically these riffle/run areas) in order to provide support for the proposal to raise the Upper Dam impoundment as a part of future hydropower development.

4.3.2.6 Turbine Type

Certain types of turbines result in higher fish mortality than others. In general, crossflow turbines are thought to result in higher fish mortality and thus be less desirable from the standpoint of fisheries resources.

4.4 Hazardous and Regulated Material Management

Renovation/demolition work associated with the historic structures will require pre-demolition/renovation surveys for potentially hazardous or otherwise regulated materials. For instance, within the Upper Collinsville Dam Powerhouse, Lower Dam Gatehouse, or Lower Dam Power house, among the potential hazardous/regulated materials noted were the following:

Potential Hazardous or otherwise Regulated Material	Example Components / Location(s)
Suspect Asbestos-containing material (ACM)	Window caulking, roof tiles, roofing tar, asphalt shingling and flashing
Lead	Potential Lead-based Paint on any pigmented painted surface
Mercury	Now or Former Turbine components and electrical switches
Polychlorinated Biphenyls (PCBs)	Window caulking, concrete or brick sealers, painted metal surfaces
Biological pathogens	Guano accumulations on floor and other horizontal surfaces which may be a reservoir for pathogens that cause histoplasmosis, cryptococcosis, and other diseases.
Construction/demolition debris	Deteriorated wooden roof members, any non-asbestos containing asphalt shingles; brick, mortar and other exterior wall materials
Pond Sediments	Accumulated sediment within the impoundments of and proximal to the Upper and Lower Collinsville Dams

Table 4-2: Summary of Potential Hazardous/Regulated Materials

Prior to any demolition or disturbance of building components and appurtenances on site, a pre-demolition survey should be conducted to identify which materials may contain hazardous or regulated materials. The pre-demolition survey typically includes bulk sampling, wipe sampling, or some other form of sampling that will generate a representative sample of the building component suspected of containing a hazardous or regulated material. Samples are analyzed via laboratory testing performed by a CT Department of Public Health (DPH)-certified Lab[3] , certified to work in CT and following the Reasonable Confidence Protocol[4]. In some cases, sampling may be invasive, requiring coring or sectioning of multi-

[3] http://www.ct.gov/dph/cwp/view.asp?a=3140&q=387442&dphNav_GID=1828&dphPNavCtr=|#47063
[4] http://www.ct.gov/dep/cwp/view.asp?a=2715&q=324958&depNav_GID=1626

layered components. Care must be taken while sampling to prevent the release or generation of air-borne contaminants. Thus, the pre-demolition inspection should be conducted by an environmental professional with the appropriate certifications to ensure the sampling is done in a safe and effective manner.

An assessment of the need for contaminant testing of sediment prior to its removal and disposal would be required for the Upper and Lower Collinsville Dam, should this activity be deemed necessary for dam inspections, or to increase reservoir volume[5].

Typically, the framework tasks of a dredging project includes the following:

- Surveys are conducted to determine both water depth and sediment thickness, from which the average depth and approximate volume of material can be determined, as can the areas of accumulation. Once the volume and distribution of the material is determined, a proposed pond restoration program can be determined and the desired dredged depth identified.
- Representative sediment samples are taken with a benthic sampler, and physical and chemical analyses are performed at an analytical laboratory. Sediment grain size often determines the potential reuse applications of the material. However chemical testing Grain size, texture, and degree of consolidation combine to dictate the reuse on land or in-water applications without prior treatment or amendments.
- Pond dredging is a highly regulated activity with local, State, and Federal permits required prior to project initiation (Refer to Section 5). Based on recent experience with similar pond dredging projects in Connecticut, it is anticipated that some of these permits may require a year or more between submission of the application and issuance of the permit. Recent LEAN initiatives enacted by the CTDEP may have streamlined the process or reduced the processing time.

4.5 Water Quality

4.5.1 Existing Water Quality

A review of the CT GIS Water Quality Classification layer indicates that the Farmington River in the areas around the Upper and Lower Collinsville Dams (including the impoundments) is classified as Class B waters. CT classified Class B waters are typically associated with the characteristics shown in **Table 4-3**.

[5] FERC OSEC *02/23/2001* in Docket#: P-i0822-000

Parameter	Criteria
Aesthetics	Good to excellent
Dissolved Oxygen	Not less than 5 mg/L of dissolved oxygen at any time
Sludge deposits/solid refuse floating, solids/oils, grease scum	None except for small amounts that may result from permitted waste treatment facilities and none exceeding levels necessary to protect and maintain all designated uses
Color	No visible discoloration of the surface water outside of any designated zone of influence
Suspended and settleable solids	None in concentrations or combinations which would impair the most sensitive designated use; none aesthetically objectionable; none which would significantly alter the physical or chemical composition of the bottom; and none which would adversely impact aquatic organisms living in or on the bottom sediments; shall not exceed 10 mg/L over ambiance concentrations.
Silt or sand deposits	None other than of natural origin expect as may result from normal agricultural, road maintenance, construction activities, dredging activity or discharge of dredged or fill materials provided all reasonable controls or BMPs are used in such activities and all designated uses are protected and maintained.
Turbidity	Shall not exceed 5 NTU over ambient levels and none exceeding levels necessary to protect and maintain all designated uses
Taste and color	None that would impair any uses specifically assigned to this class
pH	6.5 to 8.0
Allowable temperature increase	There shall be no changes from natural conditions that would impair any existing or designated uses assigned to this Class and, in no case exceed 85 degrees F, or in any case raise the temperature of surface water more than 4 degrees F.
Chemical constituents	None in concentrations or combinations which would be harmful to designated uses.
Benthic invertebrates which inhabit lotic waters	Water quality is sufficient to sustain a diverse macro-invertebrate community of indigenous species. All functional feeding groups and a wide variety of macro-invertebrates taxa shall be present, however one or more may be disproportionate in abundance. Waters which currently support a high quality aquatic community shall be maintained at that high quality. Presence and productivity of taxa within the Orders Plecoptera, Emphemeroptera; and pollution intolerant Coleoptera and Trichoptera may be limited due to cultural activities. Macroinvertebrate communities in waters impaired by cultural activities shall be restored to the extend practical through implementation of the department's procedures for control of pollutant discharges to surface waters and through BMPs for non-point sources of pollution.

Table 4-3: Criteria for CT Class B Waters (FRWA, 2003)

A review of the CT State 303(d) impaired waters list from 2002 indicated that the stretch of the Farmington River which includes the Upper and Lower Collinsville Dams is not classified as an impaired water. A cursory review by Ichthyological Associates of water quality data available on-line for the USGS 01188085 (Farmington River at State Highway 4, at Unionville, CT) and USGS 01188090 (Farmington River at Unionville, CT) sites in January 2011 appears to indicate that water quality is generally within Class B standards for parameters measured.

4.5.2 Potential Consequences for Hydropower Development

Water quality during any proposed construction must be protected against temporary degradation through the deployment of appropriate sediment and erosion controls. Typical Best Management Practices (BMPs) will be required to prevent unintended releases of sediment, fuels, or other materials into the water. It is noted that a certain amount of dredging to remove accumulated sediment is likely to be required as part of construction activities. Dredging may be necessary at the Upper Site headrace canal, in front of the Lower Site gatehouse, and adjacent to the Lower Site tailrace. Standard dredging practices, including confinement with turbidity booms and appropriate dewatering methods, will be necessary. Sediment must be lawfully disposed of off-site in an upland area. If testing of sediment indicates contamination, then additional measures may be necessary and a premium cost will be incurred.

A typical concern about hydropower operations is that they have the potential to have negative consequences for water quality. Specifically, the concern is about changes to dissolved oxygen and temperature due to the vertical location of withdrawals from the impoundment. It is judged unlikely that hydropower development at the Upper and Lower Collinsville sites will have a significant impact on water quality. Both impoundments are relatively small and therefore have a relatively short hydraulic residence time under typical flow, and because the proposed projects will be operated in run-of-the-river mode, the hydraulic residence time will not change. Both impoundments are relatively shallow, and therefore will likely have little to no stratification. Thus the depth of withdrawals is less critical. Currently, it is likely that significant re-aeration occurs due to turbulence when flow passes over the spillways at both dams. This effect will be reduced by passing flow primarily through the turbines instead of over the spillways. However, the conservation flows which must remain over the spillway will continue to aerate and increase dissolved oxygen content in the river. It is likely that a pre- and post-operations water quality study may be required to document potential changes to dissolved oxygen and water temperature in the river. Changes to operations or other mitigations might be required if negative impacts are found.

4.6 Noise

4.6.1 Noise Issues

The Upper Site powerhouse is located between the river and a state highway. The development of the land along the Lower Site power canal has been limited by State ownership and an electrical transmission line right-of-way. The zoning includes but not limited to residential, public land, agricultural, and commercial land use. Ambient existing noise levels vary depending on the surrounding land use. In general, current noise issues at the Upper Site are primarily the result of highway traffic.

Noise at the Lower Site is limited. The spillways at both dams generate considerable consistent noise from the action of flowing water falling over the spillway crests.

4.6.2 Potential Consequences for Hydropower Development

Temporary additional noise would result from development activity and would be a direct result of the construction equipment and potential rock excavation. Mitigation of noise associated with construction activity can include properly operated and maintained equipment. The use of optimal muffler systems on construction equipment powered by gasoline or diesel can reduce noise by 10 dB. Impacts due to construction related noise in can be mitigated, if necessary, by implementing time constraints on the hours construction activities are allowed.

Noise associated with the project would result from the operation of the generators. If necessary, this noise can likely be mitigated through the proper installation of soundproofing materials. In general, however, the lack of nearby receptors (i.e. residential houses) likely will mean that operating noise will not be a significant issue at either site. The potential noise impact on wildlife may require further study, but can likely be mitigated if necessary.

4.7 Land Use and Recreation

The majority of the Farmington River watershed is rural and forested with scattered densely populated suburban areas. The watershed includes several sub-basins which service water supply reservoirs for the metropolitan Hartford area.

4.8 Recreational Resources

The Farmington River has a diverse wealth of recreational uses. The Farmington River Watershed Association (FRWA) completed a study of the use and economic importance of the Lower Farmington River in January 2009 which included an evaluation of recreational resources. The study included a mail survey of individuals recruited through brief in-person survey conducted at 15 key recreation access points along the Lower Farmington River and Salmon Brook. Of the individuals surveyed, the primary outdoor activities centered around the Farmington River included:

- Walking/Jogging
- Wildlife observation
- Biking
- Dog walking
- Kayaking/Canoeing
- Fishing
- Picnicking
- Hiking
- Baby/Child walking
- Water Skiing
- Boating
- Educational activities

4.8.1 Potential Consequences for Hydropower Development

During the previous licensing process, a number of conditions were stipulated for improvements to be made with respect to recreation and access in and around the project site. The Licensee was required to construct and maintain certain features at both the Upper and Lower Sites to facilitate recreational use of the river. These included:

(1) Picnic areas;
(2) Foot paths for angler access;
(3) An interpretative display at the powerhouse;
(4) Interpretative tours of the powerhouse;
(5) Canoe portage around the dam; and
(6) Directional signs for canoe portage and anglers.

It is likely that a FERC license for any future development will also include similar stipulations. It is noted that offering tours of the powerhouses may not be desirable from a safety/liability standpoint. An alternative could be to provide windows from which the public could view the powerhouse without actually entering. An interpretive display at the Collinsville Historic Museum which describes the old and new hydropower systems might also serve the same purpose. One additional issue which might be raised with respect to recreation is that of safety signs or barriers upstream of the dams to warn off boaters approaching the spillways.

4.9 Historical and Cultural Resources

Archaeological and Historical Services, Inc. (AHS) of Storrs, CT was subcontracted by GZA to investigate historic, pre-historic, and cultural resources issues which have the potential to affect the development of hydropower at the site. The Summary Report issued by AHS is contained in **Appendix L**. The AHS report is not intended to be a comprehensive report on the history of the site or investigation into potential pre-historic resources, rather, it is intended to identify issues which may influence project development, may require further investigations, and/or may necessitate avoidance measures or mitigations. A summary of AHS findings and other references is provided below:

4.9.1 Historic Resources

The Upper Collinsville Dam project lies within the Collinsville Historic District, which was listed on the National Register of Historic Places on June 23, 1976. The dam and appurtenant structures were previously also considered eligible for inclusion within the Collinsville Local Historic District, but as of April 2011 are not included in the Local Historic District according to the Canton Town Planner. The Upper Dam and its appurtenances were judged to be historically significant due to the role they played in the operations of the Collins Company, which was an important manufacturer of metal implements and developer of early industrial processes. The dam, water conveyances, and hydropower installations are a prime example of how hydropower aided the growth of early American industry.

The Lower Collinsville Dam project area is not listed on the National Register, but the dam, headrace, and powerhouse were determined eligible for listing as a result of the 1999 consultation between FERC and the SHPO (FERC 1999: 71). The Lower Dam, while not as old as the Upper Dam, was also part of the Collins Company operations and therefore eligible for listing for the same reasons as the Upper Dam.

4.9.2 Pre-Historic Resources

AHS conducted a review of the archaeological site files of the SHPO and Office of State Archaeology, and cultural resource management report review in order to help determine the potential for prehistoric archaeological sites to be present within the anticipated Area of Potential Effect (APE). Only one prehistoric site has been reported within one mile of the APE. This is a minor site adjacent to an unnamed small tributary to the Farmington River. However, the Farmington River Valley as a whole, was extensively used by native peoples throughout most if not all periods of prehistory. The APE therefore is judged by AHS to have high potential for containing buried prehistoric archaeological sites in areas which have not undergone development or extensive ground disturbance.

4.9.3 Potential Consequences for Hydropower Development

The historic nature of the project sites and surrounding area were recognized and explored during the previous licensing efforts, as is required. The National Historic Preservation Act of 1976 and the National Environmental Policy Act of 1969 require all federally funded, licensed, or permitted projects to take into account effects on National Register-listed (e.g the Upper Dam site) or eligible (e.g. the Lower Dam site) properties. Parallel State of Connecticut regulations (General Statutes Sections Title 22a, Chapter 439, Section 22a-15 to 22a-19b) apply to state funding, licensing, and permitting. Pre-licensing consultations resulted in the development in 2001 of a "*Programmatic Agreement Among the Federal Energy Regulatory Commission, the Advisory Council on Historic Preservation, and the State of Connecticut, State Historic Preservation Officer, for Managing Historic Properties that may be Affected by Licenses Issuing to Summit Hydropower Company for the Rehabilitation and Operation of the Upper Collinsville and Lower Collinsville Hydroelectric Projects in Connecticut*." This document (attached to this report as **Attachment 5**) stipulated all of the activities the previous licensee was required to perform in order to develop an Historic Properties Management Plan to avoid, minimize, or mitigate impacts to historic properties. It noted that this Plan was specifically to include impacts to any site from which used equipment might be salvaged.

Future development of hydropower at these sites will likely require consultations with relevant stakeholders (including the Connecticut State Historic Preservation Officer (SHPO), the Collinsville Historic District Commission, the Canton Historical Society, the National Trust for Historic Preservation, the Advisory Council on Historic Preservation, US Dept of Interior, US Park Service, and other entities). These consultations will likely result in a Programmatic Agreement (PA) for historic preservation similar to the one developed in 2001. The PA required the engagement of a professional historian or archeologist to develop an Historic Properties Management Plan. It also required that documentation of affected properties be performed according to standards of the Historic American Building Survey-Historic American Engineering Record.

One important aspect of the 2001 PA is that it presumed that hydropower development at the Upper Site would NOT require significant modifications to the superstructure/substructure of the Upper Site powerhouse. Future development at the Upper Site which proposes to enlarge the powerhouse would be subject to comment and perhaps stipulations from agencies and groups concerned with historic preservation.

With respect to potential pre-historic resources, the AHS report states that any portions of the APE which have apparent soil integrity should undergo Phase I Archaeological Reconnaissance Survey in order to identify and evaluate any prehistoric sites which may exist within the APE. Should the Phase I survey identify intact, prehistoric sites which appear to be eligible for listing in the National Register of Historic Places, additional Phase II Intensive Survey may be necessary to conclusively determine the National Register-eligibility of sites. If intact, National Register-eligible sites are found in the APE, impact mitigation measures would likely include avoidance of the site(s) or removal of the archaeological site(s) through Phase III Data Recovery excavations. During the preparation of the 1999 Environmental Impact report by FERC, the US Army Corps of Engineers raised the issue of potential archaeological resources which might be affected by water level changes in the impoundments. This could suggest that preliminary surveys of the impoundment shoreline might be required; however, this did not appear to be an explicit stipulation of the 2001 EA.

4.10 Scenic Resources and Aesthetics

4.10.1 Existing Scenic Resources and Aesthetics Concerns

Currently, virtually all flow in the Farmington River at the Upper Site passes over the primary spillway or over the forebay weir on the left (east) side. These structures are highly visible from certain vantage points (e.g. from the Rt. 179 highway bridge) and give the visual impression of "waterfalls." The scenic value of the Upper Collinsville Dam was emphasized in the 1999 FERC Environmental Assessment (EA). The EA cites correspondence from several individuals and groups raising concerns over the potential effects of hydropower development on the aesthetic value of the dam to the Collinsville area. Concerns were raised by local groups, businesses, politicians, and the Town of Canton regarding the potential for the loss of the "waterfall" at the dam and dewatering of the bypass reach. The owners of the east side mill buildings also raised concerns about the need to maintain flow through existing sluiceways which run through the mill buildings to prevent stagnation.

Concerns about aesthetics appear to have been less of an issue at the Lower Site. The Lower Dam is not visible from business or residential areas. However, the Lower Dam spillway is visible from the trail adjacent to the east side / opposite side of the river.

4.10.2 Potential Consequences for Hydropower Development

While concerns about aesthetics are, to a great part, subjective, this is a **KEY** issue for hydropower development in that could affect the amount of flow available to the hydropower turbines.

To address aesthetic concerns regarding the left (east) forebay adjacent to the former Collins Company buildings, the previous FERC license required that a minimum flow of 27 cfs be maintained into the forebay area through the sluice gates on the upstream face of the embankment. The purpose of this minimum flow is to maintain a minimum of 1 inch of veil flow over the forebay weir

approximately 90 percent of the time (9 cfs), to provide for flow to pass through the factory sluices to prevent stagnation (15 cfs), and to supply water for fire suppression needs (3 cfs). This forebay flow is over and above the minimum conservation (bypass) flow requirement of 180 cfs. It is likely that some flow will be required for the forebay in any future license. Article 403 of the previous FERC license for the Upper Site also required the licensee to obtain real property rights over the systems (i.e. sluice gates, etc.) which control flow into the forebay. This requirement, if repeated, may result in increased costs.

As part of the 1999 EA, FERC staff analyzed flow depths and frequencies over the primary spillway at the Upper Dam. This analysis was performed to address concerns about "aesthetic flows" over the primary spillway. The criteria used by FERC for assessing "aesthetic flows" are separate from the minimum conservation flow criteria (although the conservation flow can be part of the aesthetic flow provided it passes over the spillway and not through a minimum flow turbine). The analysis by FERC staff appears to use the assumption that while 1 inch of veil flow is adequate during certain periods of the year (June through October), a minimum of 6 inches of flow is desirable at other times (March through May). On this basis, FERC staff recommended that the turbine design flow at the Upper Site be reduced from a proposed 820 cfs to 292 cfs, which they estimated would provide for a moderate improvement in the amount of time during which 6 inches of flow would pass over the primary spillway in the spring. This recommendation was adopted in the previous license, leading to a significant decrease in the power and energy production potential for the Upper Site project. This issue must be re-visited early in any proposed plan for future hydropower development at the Upper Site as it has the potential to have a major effect on the project. The criteria used by FERC in making their decision regarding aesthetic flows is not fully understood by GZA based on the available documents.

The 1999 FERC EA states that the Lower Dam is not as visually prominent as the Upper Dam. Therefore it concludes that the minimum conservation flow rate of 180 cfs is sufficient to also provide aesthetic veil flows at the Lower Site, provided the flow passes over the spillway and not through a minimum flow turbine.

5.0 Licensing, Permitting, and Regulation

As is the nature of all projects involving hydropower generation, a significant effort will be required to license and permit the projects at the Upper and Lower Collinsville Dams. Virtually all hydropower is subject to the authority of the Federal Energy Regulatory Commission (FERC), and requires Federal licensure. In addition, other Federal, state, and local permits also must be obtained to construct and operate the hydropower facilities. Due to the rich history and diversity of the Farmington River and the Upper and Lower Collinsville Dams, regulation of the resource involves a complex balance between several agencies. Agencies which regulate the wetlands, fish and wildlife, historic, and recreational resources will be involved with both the direct permitting of the project as well as indirect stakeholders during the FERC process. In addition, non-governmental interest groups will also be involved in the comment and consultation process for licenses and other permits. Finally, the history of FERC licensing at both sites may add a layer of complexity to the process. This section contains a summary discussion of the major licensing and permitting efforts which may be expected in order to re-develop hydropower at the Upper and Lower Sites. Other permits may also be necessary based on future input from regulatory authorities.

5.1 Federal Permits

The Federal permits required for the site will likely include a FERC license, a USACE Section 404 dredge and fill permit, and a Section 401 Water Quality Certificate. In Connecticut, Section 401 duties are delegated to the CTDEP, so this permit is discussed under the section on State permits. Another Federal process involves the status of the Farmington River as a Wild and Scenic River. While this is not a permit which would be issued to the projects, the results of the process are critically important to the viability of hydropower at the Upper and Lower Collinsville Dam sites.

5.1.1 Clean Water Act Section 404

The U.S. Army Corps of Engineers (Corps) regulates the discharge of dredged or fill materials into Waters of the United States, including wetlands under the jurisdiction of Section 404 of the Clean Waters Act. Dams and dikes on navigable waters of the U.S. are also subject to these regulations (33 USC 1344). Under a Programmatic General Permit (PGP), the Corps has divided work under its jurisdiction in Connecticut into three Categories. Work such as routine maintenance and other activities which fall below prescribed thresholds are classified as Category I and may proceed without submitting an application to the Corps. Projects in Category II are subject to screening by the Corps for a determination of whether they require an individual permit or can be conducted in accordance with the general conditions of the PGP. A project falls within Category III if it exceeds review criteria established by the Corps, generally set as impacts to greater than one acre of area within Corps jurisdiction. A Category III project requires an individual permit. Depending upon the development option at each of the control structures, a Corps permit may be required due to the removal of sediment from the Canal bottom and fill from new concrete structures. The Corps may also consider the indirect impacts due to the addition of flashboards at both dams as within their jurisdiction, which would likely place the project into Category III (Individual Permit).

5.1.2 FERC License

Under the Federal Power Act, the Federal Energy Regulatory Commission (FERC) is charged with the authorization and regulation of the nation's non-Federal hydropower resources. A potential developer of a hydroelectric project must file an application with FERC for a license or exemption from licensing if the project is or will be:

(1) located on a navigable waterway of the U.S.;
(2) occupying U.S. lands;
(3) utilizing surplus water or water power from a U.S. government dam; or
(4) located on a body of water over which Congress has Commerce Clause jurisdiction, project construction occurred on or after August 26, 1935, and the project affects the interests of interstate or foreign commerce.

The hydropower project construction/installation will commence after 1935 and the project will be interconnected to a commercial electrical grid. Therefore, the proposed projects at the Upper and Lower Dams will likely be judged to meet the conditions of Item 4. Therefore a FERC application must be filed for the proposed project. FERC issues three types of authorizations:

(1) License – Issued for 30- to 50-year terms. Must be renewed. Gives the licensee the power of "eminent domain" to obtain lands or other rights needed to construct, operate, and maintain the hydroelectric project.

(2) 5-Megawatt (MW) Exemption – Issued in perpetuity. Must be located at the site of an existing dam or use a natural water feature. Must propose increased capacity. The exemptee must own all lands and facilities other than Federal lands to be eligible.

(3) Conduit Exemption – Issued in perpetuity. Must use the potential of a conduit constructed primarily for non-hydropower purpose. The exemptee must own the proposed powerhouse and the lands upon which the powerhouse will be located. A conduit exemption may not use Federal lands.

To be eligible for an exemption, the Town must own all the real property interests in non-Federal lands necessary to develop and operate the project. This includes but is not limited to the shore line surrounding each of the project's impoundments in their entirety. Due to the ownership issues, it is virtually certain that a FERC license will be required to authorize the construction and operation of these projects.

Generally, the estimated time frame for FERC approval of either a license or an exemption is estimated to be between three – five years (or more). FERC appears to be making an effort towards expediting the process for small hydro projects. A 350 kW project was issued an exemption in October 2006 after only 10 months from the date of initial filing. FERC indicates that the estimated time frame for FERC approval is shortest for projects at existing dams that propose little change to water flow and use and are unlikely to affect threatened and endangered species; or need fish passage. The complexity of the issues and the high number of stakeholders (local, state, and Federal agencies plus non-governmental organizations) for this project does not lend itself to an expedited process; however, the fact that the site has been previously licensed in the recent past may help to accelerate the process. The FERC licensing process requires a high degree of consultation with regulatory authorities and stakeholders and likely will be a multi-year process, if required.

The first step towards FERC Licensing is to file a Preliminary Permit Application. This was completed by the Town of Canton for both the Upper and Lower Collinsville Dams in August of 2008, and FERC granted a Preliminary Permit for the sites on in January of 2009 under FERC P-13273. By receiving a Preliminary Permit, the Town secured first priority for applying for a license to develop the hydropower projects (i.e. another project proponent would not have the ability to essentially take the rights to hydropower generation) for three years. The Town's Preliminary Permit expires on January 8, 2011. The Town may request an extension of the Preliminary Permit period; however, FERC is under no obligation to grant such an extension even though the Town has certain advantages as a municipality. Other potential developers could file competing applications with FERC upon expiration of the existing Preliminary Permit and thereby possibly gain priority for licensure.

The typical route to licensure is through an application to the FERC, and the completion of one of the prescribed multi-year licensure processes. However, an alternative route may be available to the Town of Canton. The previous licenses for the Upper and Lower Collinsville Sites (FERC P-10822

and P-10823, respectively)were revoked by FERC in December 2007 due to lack of progress towards construction. Subsequently, a bill was filed in the U.S. legislature to transfer those licenses to the Town of Canton. The Collinsville Renewable Energy Promotion Act (Act) would authorize the Federal Energy Regulatory Commission to: (1) reinstate the license for either or each of the projects numbered P-10822 and P-10823; and (2) extend for two years after the date on which either or each such project is reinstated, the time period which the licensee must commence project construction. The Act would direct FERC to (1) transfer the reinstated licenses to the Town of Canton, Connecticut, if it reinstates them and extends the time period during which the licensee is required to commence project construction; and (2) complete an environmental assessment for the projects and update the environmental analysis performed during the licensing process. This would set a deadline for FERC to make a final decision on reinstatement of either or both projects.

In January 2010, the Collinsville Renewable Energy Promotion Act was introduced into the U.S. House of Representatives. On June 16, 2010, the House of Representatives passed the bill and on June 17, 2010 the bill was referred to the Senate committee. On June 24, 2010 the bill was read by the Senate Committee and referred to the Committee on Energy and Natural Resources. No further action was taken by the Senate in 2010. On April 4, 2011, bills reintroducing the Collinsville Renewable Energy Promotion Act were filed in both the U.S. House and Senate.

Should the bill ultimately become approved and enacted into law, it could be of significant benefit to the project with respect to project schedule. It would likely decrease the project permitting timeline and associated studies. **However**, there are two significant potential caveats to the benefits of the bill. The first is that it appears that the transfer would authorize the Town to develop projects as per the previous licenses. At the Upper Site, the licensed project had a turbine flow limit of 292 cfs, which provided for a peak generation capacity of approximately 373 kW. This is significantly less than the theoretical potential of the site and therefore results in less energy generation (and less revenue) than a higher capacity project. The second caveat is that the bill stipulates that a new Environmental Assessment (EA) must be performed. Based on recent comments from fisheries agencies, it is possible that even more stringent conditions could be applied to the projects on the basis of a new EA. It is possible that during the process of the new EA, arguments about aesthetic flows could be revisited, which might bear upon the authorized capacity of the Upper Site, but such the legal and regulatory issues which would be involved in such a process are beyond the scope of this study.

Currently, the fate of the Collinsville Renewable Energy Promotion Act is unclear. As of the end of the 2010 session, the bill had not advanced in the Senate. Subsequently, bills proposing the Collinsville Renewable Energy Promotion Act were re-introduced into the U.S. House and Senate on April 4, 2011. In the event that the bill does not become law, does not appear to be likely to become a law in a timely manner, or that the Town makes the decision that the terms of the bill may not be favorable, the Town could choose to start the process of filing license application with FERC. This would involve the submission of Notice of Intents and a Preliminary Application Documents, likely one for each Site. This would start the process of applying for new licenses. It is GZA's opinion that it may advantageous to file for a separate license for each site. The efficiencies of licensing both projects together could still be generally realized (both applications would be very similar and all consultations would apply to both site), but certain flexibility would be retained by having separate licenses. New

environmental studies and stakeholder consultations would be required. Consultation with fisheries agencies such as the US Fish and Wildlife Service is mandatory in the FERC licensing process. The timing of such filings will be important to maintain the Town's status of the applicant with priority.

5.1.3 Section 7 of Wild and Scenic Rivers Act Determination

Section 7 of the Wild and Scenic Rivers Act is a provision that protects the free-flowing conditions and other values of designated rivers and congressionally authorized study rivers. Rivers are classified under this act as wild, scenic, or recreational and are protected due to important scenic, recreational, fish and wildlife, and other values inherent to the River. In 1994, 14 miles of the Upper Farmington River, from Colebrook to the New Hartford / Canton town line were added to the National Wild and Scenic Rivers system through an act of Congress. The segment of the Upper Farmington River which is currently designated as Wild and Scenic appears to end just upstream of the normal backwater of the Upper Collinsville Dam impoundment. In the Fall of 2003, the Farmington River Watershed Association commenced an effort to designate portions of the Lower Farmington River as Wild and Scenic.

FERC is prohibited from issuing a license for construction of any dam, water conduit, reservoir, powerhouse, transmission line, or other project works under the Federal Power Act if the project is "on or directly affecting" a designated river. FERC is required to route applications for licenses of new hydroelectric facilities to river-administering agencies for determinations of whether the project is "on or directly affecting" a designated river. This determination is accomplished through a Section 7(a) review. If the project is judged by the river-administering agency to invade the area or unreasonably diminish its scenery, recreation, fish or wildlife values they have the option of prohibiting project development through FERC.

A review of the October 2010 Draft Management Plan for the Lower Farmington River Wild and Scenic Designation acknowledges the potential of hydropower development at the Upper and Lower Collinsville Dams. Additionally, the Plan indicates that the Upper and Lower Collinsville Dams are being recommended for exclusion from the designated reaches. The description of the Wild and Scenic designation segment is as follows:

Starting from Lower Collinsville Dam Tailrace (approx.) to Estimated Extent of Rainbow Reservoir Dam Impoundment Backwater (approx.). Continuing from Rainbow Dam Tailrace (approx.) to the confluence with the Connecticut River.

Initial consultation with representatives of the National Wild and Scenic Rivers Lower Farmington/Salmon Brook Wild and Scenic Study Committee for the Farmington River was sought to gain insight into how the Wild and Scenic designation of the Lower Farmington could potentially affect the proposed work. In a letter dated Jan 11, 2011, the Study Committee stated that they would be inclined to support re-development of hydropower at the Upper and Lower Collinsville Dam sites, provided that the project:

- Meets the standards of the Lower Impact Hydropower Institute, and
- Includes provisions for state-of-the-art fish passage, upstream and downstream, for all species that may travel through this section of the Farmington River.

The support of the Wild and Scenic Committee is judged vital in that the Wild and Scenic River Study Program could, through an agency of the US Department of the Interior, could make future hydropower development at the sites difficult and potentially impossible in the event of disagreement over project specifics.

5.1.4 NPDES Construction Permit

An NPDES construction stormwater permit is required for projects which will disturb more than an acre of ground and/or required significant construction dewatering.

5.2 State Permitting

5.2.1 CT Water Quality Certification

A Section 401 Water Quality Certification (WQC) is required under the Federal Clean Waters Act for certain activities within wetlands and waters. While a Federal permit, issuance of 401 Water Quality certificates in Connecticut is delegated to the CT Bureau of Water Protection and Land Reuse's Inland Water Resources Division and Office of Long Island Sound Programs. As per section 401 of the Federal Clean Water Act (33 U.S.C. 1314), all projects that will result in any discharge into a navigable water, including all wetlands, watercourses, and natural and man-made ponds must obtain certification from DEP that the discharge is consistent with the federal Clean Water Act and the Connecticut Water Quality Standards. A 401 WQC will be required for the construction and operation of this project.

5.2.2 CT Historic Preservation Officer

Projects which require a US Army Corps of Engineers permit and projects that may impact a property listed on the National Registry of Historic Places must have prior written authorization from the State Historic Preservation Officer (SHPO) through the Section 106 process. The Historic Preservation & Museum Division administers the review procedures with public input. These consultations will likely lead to a new Programmatic Agreement.

5.2.3 CT DEP Inland Wetlands and Watercourses

As per the Connecticut General Statutes (CGS) 22(a)-36 through 22(a)-45(a), any state agency or instrumentality, except a local or regional board of education, proposing to conduct any operation within or use of a wetland or watercourse involving the removal or deposition of material, or any such obstruction, construction, alteration or pollution of such wetlands or watercourses must apply for a permit. Regulated activities include, but are not limited to filling, dredging, clearing, grubbing, grading, piping, culverting, channelizing, diverting, damming, dewatering or otherwise temporarily or

permanently altering wetlands and watercourses. Wetlands permitting under the Inland Wetlands and Watercourses Act and is typically handled through local Municipal Inland Wetlands Agencies (see Section 5.3 below), but State authority can supersede. Many times, a single permit application with CTDEP will serve for multiple permit categories and a single permit document will be issued.

5.2.4 CT DEP Dam Construction Permit

Prior to constructing a new dam, dike, reservoir or similar structure or repairing, altering or removing an existing dam, dike, reservoir or similar structure, a dam construction permit pursuant to CGS Section 22a-403 must be obtained, unless DEP determines that a dam construction permit is not required. Any work (other than routine maintenance), on a dam which, by breaking away or otherwise might endanger life or property, will require a dam construction permit.

5.2.5 CT DEP Stormwater Diversion, Dewatering, Wastewater

Applicable under NPDES Phase II, if the project disturbs less that 1 acre of land, the project is not regulated under NPDES. If the project results in the disturbance of between 1 and 5 acres of land, the project is subject to municipal review to be compliant with NPDES Phase II. If the project results in greater than 5 acres of land disturbance, a phase II stormwater application is required.

5.2.6 CT DEP Water Diversion

Activities within an open channel and for which the watershed above the development activity is greater than 100 acres (or development projects greater than 100 acres) require a water diversion permit.

5.2.7 CT DEP Stream Channel Encroachment

Development or major earthwork riverward or an encroachment or obstruction riverward of stream channel encroachment lines requires a Stream Channel Encroachment Permit. This permit is applicable to activities that "include the removal or deposition of material, any alteration of the land or watercourse or construction of structures, filling, dredging, clearing, grubbing, grading, piping, culverting, channelizing, diverting, damming, dewatering, construction of structures, and any other activity that temporarily or permanently alters the character of the floodplain or watercourse". Permit may not be required, but should be investigated.

5.2.8 CT DEP Flood Management Certification

Projects involving state money and within a floodplain will require flood management certification.

5.2.9 State Transfer of Ownership / Rights

It is understood that both the Upper and Lower Collinsville Dams, and their ancillary structures, are currently owned by the State of Connecticut. Prior to constructing any project at either of the sites, the Town would need to be provided with legal rights to do so through transfer of property ownership from the State or other agreement. An Act of the Legislature may be necessary.

5.3 Local Permitting

5.3.1 CT DEP Inland Wetlands and Watercourses

Connecticut General Statutes (CGS) 22(a)-36 through 22(a)-45(a) authorize local Municipal Inland Wetlands Agencies to issue permits for compliance with the Inland Wetlands and Watercourses Act. An application must be filed and the project presented at a local hearing, although State authority may take precedence. The Upper Site will fall within the Town of Canton's jurisdiction and the Lower Site within the jurisdiction of the Towns of Avon and Burlington. The status of the ownership of the Sites could change jurisdiction to the State.

5.3.2 Collinsville Historic District Commission

Approval for work at the Upper Site may be needed from the Collinsville Historic District Commission due to the historic nature of the existing structures. However, the dam and appurtenant structures are not within the Collinsville Local Historic District as of April 2011, according to the Canton Town Planner.

5.3.3 Building Permits and Zoning Approval

Work on the powerhouses and other structures may require local building permits. Canton also has a special Farmington River Protection Overlay District so a Special Exception may be required. Other zoning issues may need clarification.

5.4 Stakeholder Consultations and Coordination

Application for a FERC license and/or preparation of a new Environmental Assessment will require coordination with regulatory permitting agencies, interested resource agencies and stakeholder groups regarding the proposed project. Coordination will be in the form of notification and soliciting of input from resource management agencies through the regulatory consultation process required by FERC regulations. Where appropriate, pre-application meetings must be held prior to submission of permit applications to permitting agencies. Entities which are likely to be important stakeholders (beyond those which have a direct permitting responsibility) include those discussed in this report, such as, but not limited to:

- U.S. Fish and Wildlife Service
- CT DEP
- Farmington River Wild and Scenic River Study Group
- Town Departments from Canton, Avon, and Burlington
- Farmington River Watershed Association and Other "Friends" Groups
- Historic Preservation Groups
- Indian Tribes

5.5 Low Impact Hydropower Institute

While not required, consultation with the Low Impact Hydropower Institute may be beneficial to the redevelopment of hydropower at the Upper and Lower Collinsville Dam Sites. According to its website (http://www.lowimpacthydro.org), this organization is described as follows:

> "The Low Impact Hydropower Institute (LIHI) is a non-profit 501(c)(3) organization dedicated to reducing the impacts of hydropower generation through the certification of hydropower projects that have avoided or reduced their environmental impacts pursuant to the Low Impact Hydropower Institute's criteria.

The criteria used by LIHI in evaluating a hydropower project (existing or proposed) are as follows:

1. river flows,
2. water quality,
3. fish passage and protection,
4. watershed protection
5. threatened and endangered species protection,
6. cultural resource protection,
7. recreation, and
8. facilities recommended for removal.

LIHI certification is typically sought to meet particular criteria for eligibility for higher value Renewable Energy Certificates (RECs). However, it does not appear to be necessary to obtain LIHI certification to be eligible for Class I RECs in Connecticut. There is some contradictory language in the regulations for which GZA sought clarification. Some of the Connecticut regulations use the phrase "meets the standards of the Low Impact Hydropower Institute;" however, this does not appear to indicate the need for actual certification LIHI.

GZA sent an email to the CT Department of Public Utilities asking for clarification on the need for LIHI certification and the response was: "Connecticut Class I does not have a requirement that a hydro facility have a Low Impact Hydropower Certification in order to qualify. It does have to be a run-of-river, must have a capacity of not more than 5 megawatts, does not cause an appreciable change in river flow and began operation after July 1, 2003." A CTDPU Decision was provided as documentation.

RECs are a commodity that are bought and sold throughout various regions and states for the purposes of meeting state Renewable Portfolio Standards (RPS). Depending upon the definition of a State's RPS, RECs can be purchased from renewable generators outside of the state. Because the REC trade is similar to an open market, the value of RECs will vary by state and region. A higher value of RECs may be available by selling to entities outside of CT but LIHI certification may also be required. An example is Massachusetts, which does require LIHI certification for Class I RECs.

Based upon an initial review of the On-site Renewable DG applications for "best-of-class and public buildings", a specific requirement of the funding is "hydropower meeting the standards of the Low-Impact Hydropower Institute" The wording here is again similar to the wording for the Class I RECs (somewhat ambiguous). It does not state that the Certification is specifically required; however, it is

clearly more straightforward to demonstrate that a project meets the LIHI standards by LIHI obtaining the certification.

Please note that the comments recently received from the Farmington River/Salmon Brook Wild and Scenic Committee specifically recommend that the project meet the standards of LIHI.

GZA also notes that the Dam Sufficiency Report provided by the CTDEP suggests that the Lower Dam is a candidate for breaching. However, this appears to possibly be a judgment by the dam safety consultants engaged to prepare the report rather than an official state recommendation. It is unclear to GZA if there has been any official recommendation for removal of the Lower Dam by resources agencies. If there has been an official recommendation for removal by Resource Agencies, the Lower Site is by default not eligible for LIHI certification.

6.0 ECONOMICS

As with most proposed development projects, decisions as to whether or not to develop a hydropower project often hinge on the financial viability of the proposed project. Project economics are a function of costs of designing, licensing, constructing, operating and maintaining the project, financing costs, the benefits accrued through the operation of the project, and the value of any incentives available, among other items.

The basic financial viability of developing the Upper and Lower Sites for hydropower generation has been estimated using basic pro forma analyses. Each development alternative has been assessed over a 30 year period by developing estimates of annual gross costs and annual gross benefits, and then comparing the two to develop an estimate of total net benefits over time. The annual gross costs have been taken to be the sum of the following:

- The annual debt service payment, including interest, on the borrowed capital used to cover initial capital expenditures,
- Estimated annual operations and maintenance costs and sinking fund payments, and
- Any charges associated with selling RECs, LIHI certification, etc.

The annual gross benefits are the sum of the following:

- The estimated value of energy (based on the total annual energy generation times the value of energy in a particular year– either “wholesale” sales to the grid or “retail” offsets to energy purchases), and
- The estimated value of Class I Renewable Energy Certificates (RECs) (based on the total annual energy generation times the value of RECs in a particular year.)

It is noted that the projected future value of energy is difficult to accurately quantify as future events beyond the control of the Town or any hydropower developer can affect the both the global and local price of energy. Likewise, the value of RECs, which represent the environmental attributes of the power

produced from renewable energy projects and are sold separate from commodity electricity, is also difficult to project into the future as they are traded on the open market and subject to market forces, supply and demand, and the affects of changes in law and regulation. In the early years of the financial analyses developed herein, the value of REC sales accounts for between 13 percent (retail) to 19 percent (wholesale) of total projected project benefits. Loss of REC revenue would result in a commensurate reduction in annual benefits.

The total net annual benefits in any year are thus the difference in annual gross benefits and annual gross costs for that year.

A variety of assumptions such as the future price of electricity, current interest rates and discount rate, and others, have been made in developing the pro formas. These assumptions are discussed throughout Section 6. GZA has reported the results of the financial analysis of each alternative in the form of an Internal Rate of Return and a Net Present Value over a standard period of 30 years of operation.

GZA notes that there are other factors which the Town may wish to consider in the decision-making process regarding developing hydropower at the Upper and Lower Collinsville Sites. There are intangible benefits of producing renewable "green" energy that may also be of interest to the Town. Renewable energy has non-monetary and/or non-quantifiable values including the reduction of emissions of greenhouse and other gasses, serving as a model project for other towns to generate renewable energy, and providing a sense of self-sufficiency and civic pride. The Town and other stakeholders may also place a significant value on the benefits of the associated improvements which will accompany hydropower development, such as the fish passage facilities and recreation improvements. GZA has not attempted to quantify the value of these kinds of benefits, but readily acknowledges their importance. It will be for the Town and its partners to weigh these non-monetary benefits against more readily quantifiable financial benefits.

As an initial step in the financial analysis, a calculation was made of the estimated cost per kW of each of the development alternatives discussed in Section 3 of this report. The results are presented below in **Table 6-1**.

Alternative	Estimated Total Cost (flashboards)	Peak Power (kW) without Flashboards	Cost per kW	Peak Power (kW) with Flashboards	Cost per kW
U1	$4,560,000	395	$9,109	395	$9,109
U2	$5,703,588	856	$5,272	856	$5,272
U3	$6,590,006	1,080	$4,835	1,080	$4,835
U4	$7,484,800	973	$12,908	973	$10,996
L1	$7,100,638	584	$9,641	876	$6,428
L2	$5,950,250	275	$17,128	447	$10,537
L3	$6,759,100	467	$11,472	759	$7,058

Table 6-1: Estimated Cost per Kilowatt for Development Alternatives – Both Sites

Inspection of the cost per kW data shown in the table above indicates that, of the four development Alternatives for the Upper Site, Alternative U3 (which uses the "optimum" flow and produces the most power) is the preferable Alternative. Comparison of the three Alternatives for the Lower Site indicates that Alternative L1 (reconstruction of the existing powerhouse as per the previous license) is the most economical in terms of cost per kW. On this basis, further financial analysis has focused exclusively on these Alternatives (U3 and L1). Due to the potential for the re-instatement of the prior Licenses, GZA also felt it prudent to advance the financial analysis of Alternative U1, which conforms to the prior 2001 FERC license conditions for flow and power. The benefit of raising the water surface elevation of the impoundment is clear when comparing the alternatives with and without flashboards at the Lower Dam. The values at the Upper Dam are the same with and without flashboards (at the Upper and Lower Dam) due to the backwater effect from the Lower Dam. If hydropower were to be developed at the Upper Dam only, the addition of flashboards would increase gross head, which would lead to a higher peak power capacity and a lower cost per kW. In light of this, GZA has only advanced the financial analysis for the selected development alternatives with raised impoundment water surface elevations as discussed in Section 3.

This section of the report first presents information on the potential financial benefits of the selected proposed hydropower development alternatives (U1, U3, and L1). Based on the conceptual configurations of the selected alternatives, GZA has developed preliminary estimates of order of magnitude project costs and project returns. Separate costs estimates were performed to account for either the use of flashboards or a bladder dam to raise water surface elevations. It is important to understand that at this pre-feasibility stage in the project, the costs are conceptual and will require further refinement as the project moves forward. Next the current and expected future energy costs were estimated and used to generate estimates of the total annual value of energy to be produced by the each hydropower alternative. These cost and benefit values were utilized in the financial analyses, including the pro formas.

All cost estimates and financial analyses contained in this report are based on current information regarding materials costs, the value of electrical energy, interest rates, availability of financing, and other factors. It is important to realize that many of these factors fluctuate widely in response to global energy markets, the global financial climate, and other macroeconomic events which are difficult to predict and beyond the control of either GZA or the Town. The price of energy in the future may vary up or down and result in a change to the simple payback period. Energy production, and thus project revenues (benefits), are also a function of the natural hydrologic cycle and the releases of upstream reservoirs. Interest rates on bonds or other financial instruments may fluctuate. All information presented herein is developed at a pre-feasibility / resource assessment level and is intended for use in planning purposes.

The analyses presented herein treat each site individually and have utilized cost estimates that essentially assume that both sites are developed separately. In the event that both sites are developed simultaneously, there may be some efficiencies in design, licensing, and construction costs which may lead to overall cost savings. For instance, more favorable pricing may be available from turbine manufacturers if similar equipment is purchased simultaneously for both sites. GZA has not attempted to quantify such potential efficiencies at this time.

6.1 Preliminary Project Costs

Preliminary conceptual cost estimates have been prepared for the major work items judged necessary to develop the proposed small hydroelectric projects at the Upper and Lower Collinsville Dams. Estimated project costs for each of the advanced Alternatives include the cost of the rehabilitated or proposed structures and equipment including the costs for the powerhouse, intake structure, conveyance structures, turbine / generator set, transformers, controls and ancillary electrical equipment, as applicable to each development scenario. Estimates of general construction costs such as water control, sediment and erosion control, and mobilization are also included. Cost estimates include approximate values for the major mitigations which are expected to be necessary for licensure, including upstream fish passage, downstream fish passage, and other major site improvements. Design, licensing, permitting, and study costs have also been assumed and included. It has been assumed that there are two likely systems which may be used for raising the impoundment water surface elevations: flashboards or bladder dams. Separate total costs have been developed to account for either use of flashboards or a bladder dam. Another possible water surface control system is a crest gate, but this has not been given further consideration due to the expected high cost. These cost estimates are intended for use in planning purposes only. Due to the preliminary nature of these pre-feasibility costs, a contingency of 25 percent has been added to the overall total estimated cost of each Alternative.

GZA estimated the base costs for developing each Alternative considered. Costs are summarized in **Table 6-2**. Additional costs for either flashboards or a bladder dam are estimated in **Table 6-3**. **Table 6-4** presents overall total costs including a water surface control system and a 25 percent contingency.

	Development Alternative		
	U1	**U3**	**L1**
Base Costs			
Intake Rehabilitation	$700,000	$713,600	-
Tailrace Improvements	$43,000	$98,000	$51,200
Canal Improvements	-	-	$523,500
Existing Powerhouse Construction / Rehabilitation	$400,000	$955,400	$802,800
Gatehouse Rehabilitation	-	-	$913,000
Fish Passage	$705,000	$705,000	$705,000
Misc.	$500,000	$500,000	$400,000
Turbine/Generator/Elec.	$650,000	$1,650,000	$1,620,000
Installation, Interconnection, Etc.	$225,000	$225,000	$240,000
Engineering /Permitting	$375,000	$375,000	$375,000
Total Base Costs +Engineering/permitting	**$3,598,000**	**$5,222,000**	**$5,630,500**

Table 6-2: Estimate of Project Base Costs

	Development Alternative		
Optional Costs	**U1**	**U3**	**L1**
Bladder Dam	$1,500,000	$1,500,000	$1,500,000
Flashboards	$50,000	$50,000	$50,000

Table 6-3: Cost Estimates for Water Surface Control Systems

	Development Alternative		
No Direct Transmission Line (Sales to Grid or Virtual Net Metering)	**U1**	**U3**	**L1**
Total Project Cost (with 25% Contingency) - With Bladder Dam	**$6,372,500**	**$8,402,500**	**$8,913,000**
Total Project Cost (with 25% Contingency)- With Flashboards	**$4,560,000**	**$6,590,000**	**$7,100,500**

Table 6-4: Estimate of total Project Development Costs

Note that the following items should be considered when assessing the costs presented above:

- All costs are estimated based upon conceptual development alternatives and will require refinement as the project progresses.
- It has been assumed that all project development alternatives will include raising the upstream impoundment water surface elevations by utilizing either flashboards or a bladder dam. If the height of the impoundment is not raised, the total project cost should be reduced by $50,000. If the dam is raised using a crest gate, an estimated $4,000,000 should be added to the total cost.
- Our experience has shown that even at the time of final turbine selection, it is not unusual for manufacturer quotes for a site to vary significantly.
- Costs presented above assume that the Upper and Lower Sites will be developed individually. If the Sites are developed together, there may be certain efficiencies associated with items such as the purchase of turbine/generator sets as well as certain construction items such as contractor mobilization.
- The cost of any necessary repairs to the dam beyond those required for hydropower development were not estimated since these are independent of any hydropower project
- Cost of interconnection with CL&P has been estimated based upon GZA's experience with interconnections. The actual cost may vary depending upon the results of the interconnection study.
- The cost of permitting has also been estimated based upon GZA's experience but is also subject to change based upon several factors including site specific studies requested by stakeholders.
- Dredging costs assume that the sediment removed is not regulated or contaminated material which would require special disposal.
- Cost presented above are in 2011 dollars. Cost escalation may occur in future years.

6.2 Project Revenue for Hydropower Production

The value of the energy generated is highly dependent upon how and where the energy is used. If the energy can be used "on-site" (i.e. at Town-owned facilities) to displace energy that would otherwise be commercially purchased, the value of the energy is whatever rate is paid by the consumer to the electric utility (exclusive of demand charges and certain other fees). This report will use the term "retail" as shorthand to refer to the value of electricity when it is used to offset utility-supplied energy. However, if the energy is sold to the grid, the producer will only be paid the current market clearing generation price for commercially generated electricity. This report will use the term "wholesale" as shorthand to refer to the value of electricity when it is sold to the electric service provider though a direct connection back into the distribution grid. In general, retail rates are higher than wholesale rates.

It must be understood that "on-site" or "behind the meter" use of energy self-generated by a consumer is generally taken to mean that the energy source (i.e. the generator) and the energy load (i.e. the buildings and machinery with the demand for electricity) are actually physically in proximity to one another, on the piece of property, with a physical hardwired connection served by a single meter. This is not currently the case at either the Upper or Lower Collinsville. While the construction of a dedicated local distribution system is theoretically possible, it is unlikely to be practically feasible for legal and cost reasons. There are regulatory mechanisms in many states which allow for "virtual" net metering where credits generated in one location can be applied by the owner to charges against demand at another location. While these regulations are not currently fully in place in Connecticut, "virtual" net metering appears to be the most likely scenario under which "retail" value for energy produced by the projects could be obtained. More information is presented in Section 3.8. The financial analyses below for which retail rates have been used assume regulations allowing virtual net metering will be in place in the future. The validity of this assumption cannot be guaranteed and MUST be reviewed during future study phases. A more in-depth discussion of net metering issues may be found in **Appendix M**.

For this pre-feasibility level of financial analysis, it has been assumed that if net metering is allowed, **all** energy will be used in Town (or partner) –owned facilities. This assumption must be reviewed under future studies because it may NOT be valid depending on the final selection of development alternatives, the final licensed capacity of the sites, and the participation of towns other than Canton in the project. A change in the use of some or all of the energy generated ("on-site" vs. sale to grid) can have significant implications on the financial returns of the projects. If net metering (either virtual or through a direct physical connection) is not available all energy will be sold to the grid. There are possible avenues for power purchase agreements but these have not been considered at this time. Additional financial value can be found in the sale of Renewable Energy Certificates (RECs).

6.2.1 Energy Sold to Grid

When energy is sold to the local electric service provider through a direct connection to the electrical distribution grid, the project in effect becomes an electrical supplier similar to any other power generation facility which is selling energy in the open market. The value of the energy is therefore based on the fluctuating market clearing rate of electricity paid by the electric service providers to generators. This is, in effect, the "wholesale" price. In some areas, utility companies are obliged to buy

power from small distributed generators at retail rates. This does not currently appear to be the case for hydropower in Connecticut. However, the utility is obliged to buy the electricity. The local electric service provider, Connecticut Light and Power, will pay the Town for electricity sold back to the grid on the basis of the time-varying market clearing price.

The value of electricity used to compute project benefits from energy sales to the electrical grid were estimated based upon an analysis of historic ISO New England real time Locational Marginal Prices (RT LMP) for Connecticut as well as the U. S. Energy Information Administration's (USEIA) projections for value of energy. RT LMPs are in effect the "wholesale" price which is paid for the electricity by the utilities within the ISO New England area. The Town will be paid for the electricity sold back to the gird on the basis of the time-varying market clearing price. The RT LMPs do not project the value of energy; rather they provide a history of the actual value of energy as see in **Figure 6-1**.

The USEIA projections for future wholesale value of energy were based upon the estimated value of Natural Gas which is the primary driver of the value of electricity in the New England Area (Boreal). The USEIA projections also include some limited historic data. Therefore, the historic RTLMP data was compared to the historic USEIA data to evaluate the potential need for calibration. It is GZA's understanding that the USEIA projections did not require calibration as they were reasonably consistent with the historic ISO New England data.

It is estimated that the value of energy sold to the Grid during the project's first year of operations (2013) will be $0.0488/kWh. The projected wholesale average annual wholesale prices for electricity through the 30 year study period used by GZA for the project financial analyses are presented in Table 6-5. Note that the need to make projections of future energy prices introduces considerable uncertainty into the process of the financial analyses of the hydropower development alternatives. The value of electricity is subject to significant fluctuation based on a variety of factors such as supply, demand, value of other fuels (such as natural gas), politics, and current regulations among others. **Table 6-5** summarizes the projected future wholesale cost of electricity.

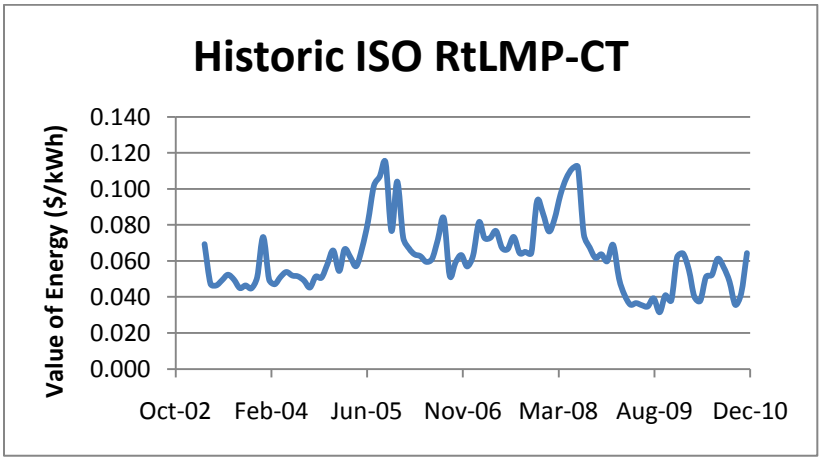


Figure 6-1: Summary of Historic Real Time ISO New England (CT) Value of Energy

Calendar Year	Wholesale Generation $/kWh	Calendar Year	Wholesale Generation $/kWh
2012	0.0488	2028	0.0774
2013	0.0523	2029	0.0802
2014	0.0547	2030	0.0834
2015	0.0544	2031	0.0866
2016	0.0534	2032	0.0897
2017	0.0547	2033	0.0929
2018	0.0562	2034	0.0957
2019	0.0575	2035	0.0974
2020	0.0589	2036	0.0992
2021	0.0603	2037	0.1009
2022	0.0624	2038	0.1027
2023	0.0651	2039	0.1046
2024	0.0672	2040	0.1064
2025	0.0701	2041	0.1083
2026	0.0722	2042	0.1102
2027	0.0745		

Table 6-5: Projected Future "Wholesale" Price of Electricity

Table 6-6 Summarizes the estimated annual value of energy produced by the selected hydropower development alterative at the Upper and Lower Sites based upon first year of operations for the development Alternatives. This represents estimated annual gross revenue in the form of payment from CL&P. Note that this yearly revenue is assumed to increase over the study period based upon the USEIA projections.

Development Alternative	U1	U3	L1
No Raising of Dams	$107,206	$166,782	$96,613
Both Raised	$107,206	$166,782	$145,117
Only Upper Raised	$124,055	$193,846	-

Table 6-6: Value of Wholesale Energy (2013)

6.2.2 Energy Used On-Site

Utilizing the energy "on-site" (i.e. at Town-owned facilities) to offset existing energy demands is another potential end use of the energy which will be generated. The value of electricity used to compute project benefits from avoided cost was estimated based upon USEIA projections of Commercial prices paid for electricity. Note that for some of the Town-owned facilities, a two year contract rate was supplied which provided information on the prices currently paid for energy by the Town. This contract rate was approximately $0.013/kWh higher than the value utilized for the analysis, but because of the short-term nature of the contract, this additional value was not carried through the financial analyses.

A total value for electricity used to off-set "on-site" demand (i.e. retail value) of $0.0792/kWh is assumed for the project's first year of operations, 2013. The projected retail average annual wholesale prices for electricity through the 30 year study period used by GZA for the project financial analyses are presented in **Table 6-7**. Note that the need to make projections of future energy prices introduces considerable uncertainty into the process of the financial analyses of the hydropower development alternatives. The value of electricity is subject to significant fluctuation based on a variety of factors such as supply, demand, value of other fuels (such as natural gas), politics, and current regulations among others.

Calendar Year	Retail Generation $/kWh	Calendar Year	Retail Generation $/kWh
2012	0.0792	2028	0.1203
2013	0.0782	2029	0.1227
2014	0.0805	2030	0.1259
2015	0.0828	2031	0.1284
2016	0.0842	2032	0.1317
2017	0.0861	2033	0.1355
2018	0.0888	2034	0.1394
2019	0.0925	2035	0.1438
2020	0.0962	2036	0.1482
2021	0.1007	2037	0.1528
2022	0.1049	2038	0.1575
2023	0.1098	2039	0.1624
2024	0.1135	2040	0.1674
2025	0.1165	2041	0.1726
2026	0.1174	2042	0.1779
2027	0.1184	-	-

Table 6-7: Projected Future "Retail" Price of Electricity

Table 6-8 summarizes the value of energy used on-site for the first year of operation for each project Alternative, assuming all energy is valued at the retail rate.

Value of Energy (2013)			
Development Alternative	**U1**	**U3**	**L1**
No Raising of Dams	$176,889	$275,190	$159,411
Both Raised	$176,889	$275,190	$239,444
Only Upper Raised	$204,690	$319,845	-

Table 6-8: Value of Retail Energy (2013)

As discussed above, to realize retail rates for the project, energy produced must be offsetting existing electrical demand. As there will not be sufficient demand on-site at the actual properties where the powerhouses are located to off-set the estimated annual energy generation of any of the development alternatives, the energy must be utilized at Town-owned facilities located some distance from the existing powerhouses. Therefore, either a direct transmission line must be constructed and utilized or virtual net metering laws must be passed for retail rate to hold true. The cost of a direct transmission line has been estimated as greater than $1,000,000 for a fully underground line. It may be possible to reduce this cost by as much as 50 percent constructing some or all of the transmission line as overhead lines on poles. It may also be possible to utilized submerged cables on the bottom of the impoundment to avoid some right-of-way issues. Due to uncertainty regarding the legal and regulatory feasibility of construction of the direct transmission line and the potential for regulation or legislation to allow for virtual net metering, the cost of a direct transmission line has not been included in the scenarios subjected to financial analysis. The issue of virtual net metering in the State of Connecticut is under review, but the practice is not currently allowed. If virtual net metering does not become possible in the future, the feasibility and financial implications of the direct transmission line should be revisited. To obtain the full benefit of net metering, qualifying demand must be sufficient to meet or exceed generation capacity, otherwise excess energy generation potential will have less or no value. The analyses in this report which consider "retail" energy value produced in this report assume that all energy generated by any scenario at either dam provides the full "retail" value. This may not actually be the case depending on how final net metering regulations are applied.

6.2.3 Renewable Energy Certificates

Renewable energy certificates (RECs) represent the environmental attributes of the power produced from renewable energy projects and are sold separate from commodity electricity. Compliance markets are created by a policy that exists in many states, including Connecticut, which requires electric companies to supply a certain percent of their electricity from renewable generators by a specified year. Electric utilities must demonstrate compliance with their requirements by purchasing RECs. Certified RECs represent proof that 1 megawatt-hour of electricity was generated from an eligible renewable energy resource. Established in 1998 and subsequently revised several times, Connecticut's renewables portfolio standard (RPS) requires each electric supplier and each electric distribution company wholesale supplier to obtain at least 23% of its retail load by using renewable energy by January 1, 2020. Small hydropower facilities, operating in run-of-river mode with a peak capacity of not more than five megawatts, which do not cause an appreciable change in river flow and began operation after July1, 2003 are eligible to contribute to Connecticut's RES as a Class I renewable energy source.

Similar to the value of energy, the value of RECs is subject to fluctuation based upon many variables. The change in value can be due to supply, demand, regulation, and state compliance standards, among others. Based upon the information available to Boreal Renewable Energy, the value of Class I RECs was estimated as being between $0.012/kWh and $0.015/kWh. The financial analysis assumes that the current and long-term value of RECs for this project is $0.012/kWh. An escalator has not been applied to this value as a historic review indicates that the value fluctuates wildly without a trend. **Table 6-9** summarizes the value of Class I RECs produced each year of operation for each project Alternative. Appendix M provides additional explanation of RECs and discusses the methodology used for estimated REC value for this study.

The Town may wish to consider third party verification of the RECs by Green-e, Environmental Resource Trust, the Low Impact Hydropower Institute or another certification service. Third-party verification of a REC gives customers confidence in the REC that they are purchasing by providing proof that electricity has been generated from a qualifying renewable resource. It will likely be easier to market and sell a REC that has been certified than it will be to sell a REC that has no certification. In addition, many large customers (Commercial & Industrial, federal, state and local governments) require certification in their solicitations. Note that there is often a fee (of several thousand dollars) for the certification. Note also that although LIHI certification is not required, "meeting the standards of LIHI certification" is required for some incentives.

The Green Power Network posts solicitations for purchasing RECs on their website. These solicitations request bids for securing renewable energy credits. They may evaluate proposals upon a number of factors including pricing, type of renewable source, location (region of the country and state), reliability etc. The Town should consider submitting bids for selling RECs to parties posting solicitations. Alternatively, the Town may consider approaching universities, local municipalities; or other large entities in the state in an attempt to directly market the RECs to them. This has the potential of gaining a long-term contract for a stable value.

Value of Energy (2013)			
Development Alternative	**U1**	**U3**	**L1**
No Raising of Dams	$26,801	$41,696	$24,153
Both Raised	$26,801	$41,696	$36,279
Only Upper Raised	$31,014	$48,461	-

Table 6-9: Estimated Value of RECs (All Years)

Note that a fee of approximately 5 percent is typical when utilizing a brokerage firm to sell the RECs.

6.2.4 Total Value of Energy

The total annual benefits of the projects are the sum of the value of energy sold to the grid/used on-site and the value of the RECs. **Table 6-10 and 6-11** summarize the estimated total value of the energy generated to the Town based upon expected energy production from the proposed projects during the first year, estimated REC values, and estimated wholesale/retail values of energy, as appropriate.

Total Estimated Value of Energy (2013) - Wholesale			
Development Alternative	**U1**	**U3**	**L1**
No Raising of Dams	$134,007	$208,478	$120,766
Both Raised	$134,007	$208,478	$181,397
Only Upper Raised	$155,069	$242,307	-

Table 6-10: Estimated Total Annual Value of Energy (Wholesale)

Total Estimated Value of Energy (2013) – Retail			
Development Alternative	**U1**	**U3**	**L1**
No Raising of Dams	$203,691	$316,886	$183,564
Both Raised	$203,691	$316,886	$275,723
Only Upper Raised	$235,704	$368,307	-

Table 6-11: Estimated Total Annual Value of Energy – (Retail)

6.2.5 Operations and Maintenance

In addition to initial engineering, licensing, permitting, and construction capital costs, the proposed hydropower project will require annual operations and maintenance (O&M) efforts. In general, the level of effort, regardless of the project size will be relatively constant. O&M costs are driven in large part by the need to maintain the intake structures free of debris so that the full design flow can pass through the intake structure and through the generation equipment. All development Alternatives include provisions for automatic trash rack rakes thereby equalizing the effort required for each project. Additionally, it has been assumed that new turbine/generating equipment will be purchased for the sites which will reduce the O&M as significant repairs or rehabilitations are not anticipated. It has been assumed that the O&M costs of the project will be approximately $15,000/year.

Due to the design of flashboards, they will periodically fail and require replacement. It has been assumed that an additional $10,000/year will be required to supply a fund to pay for materials and labor expenses for flashboard replacement. Although the flashboards will not require replacement every year, it is anticipated that approximately every three years an estimated $30,000 will be required to replace the flashboards. This amount is intended to provide for replacement of flashboards across the full length of the dam, as well as safe efforts to accomplish the replacement.

Depending on what type of lease / ownership arrangement is made with regards to the dams, other costs may be accrued for O&M of the dams and/or any new fish passage structures. Typical annual O&M for

these structures could be expected to be relatively minor. Most tasks (such as exercising gates and cleaning bar screens) could likely be done with Town labor. However, long-term costs to account for anticipated future professional inspections and repairs will need to be considered.

There are several options for O&M of the proposed projects including utilizing existing Town employees, hiring a private company, or executing an agreement with the CT MDC (which operates the two hydroelectric projects upstream of the Collinsville projects). The estimated O&M costs have been incorporated into pro-formas as an annual expense.

6.2.6 Financial Incentives

6.2.6.1 Connecticut Clean Energy Center / On-Site Renewable Distributed Generation Program

The Connecticut Clean Energy Fund (CCEF) offers two grant tracks through its On-Site Renewable Distributed Generation (OSDG) program: "Best in Class" and "Public Buildings". The Public Building portion provides up to $150,000 for renewable energy supplied to municipal buildings. The Best in Class portion is a financial support program for new or refurbished generating equipment for renewable energy generating systems at commercial, industrial, and institutional facilities in Connecticut. Through the OSDG program, CCEF will offer financial support for renewable energy generating projects that are still in their development phase and have yet to commence their construction phase. The level of support for individual awards is not a fixed amount based on size or cost, but will vary based on the specific technology, efficiency and economics of the installation. The intent of the funding is to enable owners of renewable energy systems to "break even" over the life of the project with a fair and reasonable return on the investment, compared to purchasing the equivalent amount of power from the utility. Under the current (Feb. 2011) RFP for this project, CCEF intends to recommend only those Projects that (1) use commercially available technologies, (2) have already achieved substantial progress in permitting and site control, (3) require minimal investment from CCEF, and (4) are ready for deployment.

Minimum eligibility requirements for OSDG "Best-in-Class" funding include:

- Host sites must be commercial, industrial, or institutional facilities. These may include offices, hospitals, municipal and government buildings, schools, manufacturing facilities, universities, libraries, museums, and certain special-purpose educational facilities or centers, among others. Portable or mobile systems will not be considered under this Program. Seasonal, temporary, or limited-use facilities will be closely scrutinized for high value and visibility, and may be excluded.
- The project must use an energy-generation device that is commercially available and offers warranties, spare parts, and service commensurate with commercial status.
- Applicants must be the owner and operator of the property or facility (host) where the project is to be located, or a third-party energy services provider willing to own and operate the energy-generation equipment for the contract term.
- Facilities must be located in Connecticut within the Connecticut Light and Power (CL&P) or United Illuminating (UI) service territories.

- Energy must be generated by a renewable energy electric-generating resource within the scope of CCEF's funding authorization as defined by Conn. Gen. Stat. § 16-245n(a).
- The generating facility must intend to generate energy primarily for consumption at the host site at the moment it is generated. Net metering may be used to accommodate occasional excess production, but if significant excess energy is anticipated the incentive may be calculated on the proportion of the project's capacity that does not result in excess production.
- A specific site location must be identified at the host site.
- Separate facility locations must be presented in separate Application submissions. They may not be combined into one proposal.
- Hydropower projects must be Low Impact Hydropower Institute-certified hydropower
- Meet certain standards that include documentation, operational, warranty and hardware requirements.

GZA has not generally included these potential incentives in the baseline project financial analyses; however, two pro formas were created for two specific scenarios to demonstrate the potential benefits of grant money. It is clear that reduction of initial capital costs via grant funding or other mechanism has be capacity to significantly improve project financial performance. We recommend that the Town further investigate available incentives which would improve project economics. In the event that grant funding is available from CCEF and the projects are found to be eligible, iterative analysis may be necessary to establish the appropriate grant level that provides financial returns which meet CCEF's criteria. Eligibility of the proposed Collinsville hydroelectric projects for funding by the CCEF OSDG program is not certain, given the on-site use criteria described above. Additional discussion of CCEF incentive programs is contained in Appendix M.

6.2.6.2 Clean Energy Renewable Bonds

The federal Energy Tax Incentive Act of 2005, under Title XIII of the federal Energy Policy Act of 2005 (EPAct 2005), established Clean Energy Renewable Bonds (CREBs) as a financing mechanism for public sector renewable energy projects. This legislation originally allocated $800 million of tax credit bonds to be issued between January 1, 2006, and December 31, 2007. Following the enactment of the federal Tax Relief and Health Care Act of 2006, the Internal Revenue Service made an additional $400 million in CREBs financing available for 2008 through Notice 2007-26. In February 2009, as part of the Energy Improvement and Extension Act of 2008, an additional allocation of $1.6 billion was added to the CREB program however, the deadline for applications was December 31, 2009. The IRS reportedly has an additional $200 million for allocation however, at this time; the IRS is not currently accepting applications for CREB allocations. Additional information on CREBs is contained in Appendix M.

CREBs are issued with a zero percent interest rate however, after including fees an estimated 1.5 percent interest rate can be expected. The borrower pays back only the principal of the bond, and the bondholder receives federal tax credits in lieu of the traditional bond interest. Tax credit funds are allocated by the U.S. Treasury Department. The tax credit rate is set daily by the U.S. Treasury Department and may be taken quarterly on a dollar-for-dollar basis to offset the tax liability of the bondholder. If legislation allocating funding for clean energy renewable bonds is renewed the Committee may consider applying for the 0 percent (1.5 percent) interest loans as a means of funding the

project. CREBs are not typically issued for more than a 15 year period. A set of pro formas were completed that utilize the assumption that CREBs may be available and looked at a 15 year financing term at a 1.5% interest rate.

6.2.7 Project Financing Options

The Town has the option of paying for the Project outright as a capital expense (self finance) or obtaining financing for this Project. GZA has assumed that the Town does not have the cash reserves necessary to directly fund the development of one or two hydropower projects, and therefore will seek to fund the project through the issuance of bonds or similar debt instruments. In the pre-feasibility level pro-formas prepared by GZA, two finance scenarios have been assumed: 1) municipal bonds with a 30 year maturity period and a 3.5% interest rate; or 2) Clean Energy Renewable Bonds (or similar, assuming the program is renewed) with a 1.5% interest rate for a 15 year period. Note that the project financial returns are sensitive to both financing period and interest rates and the Town should further study financing options prior. GZA's financial analyses have assumed that project debt payment will be in the form of fixed annual payments covering principal and interest. A bridge loan may be necessary for the construction period.

There are many types of bonds which might be utilized, depending on the Town's (or other development entity's) legal ability to issue. Bond used to finance a hydropower project might be General Obligation bonds, Revenue bonds, or other. Likewise, there may be alternative ways of structuring the annual payments on the bonds, such that variable payments more closely conform to anticipated future annual benefits rather than being equal annual payments. These options may be examined in more detail in future studies.

6.3 Preliminary Pro Forma Analyses

Financial analyses of the selected hydropower development Alternatives have been completed at a pre-feasibility level through the preparation of pro forma spreadsheets. The pro formas, developed by Boreal Renewable Energy, incorporate the estimated project development costs and estimated project benefits, as well as assumptions on project financing, into an economic model for a 30-year time span. The 30 year period was selected as a reasonable period given typical expected hydropower component lifespans. GZA has assumed two project financing scenarios: (1) Municipal bonds for a 30 year period at 3.5% finance rate and, (2) CREB for a period of 15 years at 1.5% finance rate.

The resulting model estimates annual net benefits, accrued project value, net present value, and internal rate of return over the 30 year study period. The project net present value (NPV) was determined based on the discounted net project benefits using a discount rate of 0.5%. The internal rate of return (IRR) is defined as the discount rate for which the net present value of the project is zero. Years to cash flow positive refers to the period of time needed for the cumulative project benefits to become positive. Years to positive net annual benefits refers to the number of years after project initiation when annual benefits exceed annual costs.

A summary of the evaluation criteria generated by the pro forma models is presented in the tables below for the following Alternatives:

- U1 – Upper Site with 292 cfs total turbine flow producing 395 kW of peak power
- U3 – Upper Site with 820 cfs total turbine flow producing 1080 kW of peak power
- L1 – Lower Site with 820 cfs total turbine flow at existing gatehouse producing 876 kW of peak power.

All alternatives assume that the impoundments have been raised. GZA has also considered the U3 scenario in which development occurs ONLY at the Upper Site and therefore an additional 3 feet of gross head is available (due to the absence of the raised backwater from the Lower Dam). For each Alternative, the analysis has been repeated to account for the difference in capital cost between flashboards and a bladder dam. **Table 6-12** presents results assuming a 30 year bond at 3.5 percent and wholesale energy values. **Table 6-13** presents results assuming a 30 year bond at 3.5 percent and retail energy values. **Table 6-14** presents results assuming a 15 year bond at 1.5 percent and wholesale energy values. **Table 6-15** presents results assuming a 15 year bond at 1.5 percent and retail energy values. The analyses in the tables below which consider "retail" energy value produced in this report assume that all energy generated by any scenario at either dam provides the full "retail" value. This may not actually be the case depending on how final net metering regulations are applied and therefore pro formas should be reviewed in the event that net metering appears to be available.

GZA has also considered the potential benefits if external assistance were to be available to help offset some of the expected capital costs of the project. Grants might come from Connecticut Clean Energy Fund or others interested in renewable energy or fish passage. GZA has estimated the total level of grant funding necessary to produce a positive net annual benefit in the first year of operations for several development options. The necessary grant amount and the results of pro forma analysis assuming wholesale and retail energy rates and assuming the remaining cost is financed with a bond at 3.5 percent interest over 30 years is summarized in **Table 6-16** for the U3 (with Lower Dam raised) alternative, in **Table 6-17** for the U3 (Upper Dam Only) alternative, in **Table 6-18** for the U1 (with Lower Dam raised) alternative, in **Table 6-19** for the U1 (Upper Dam Only) alternative, and in **Table 6-20** for the L1 alternative.

A summary of assumptions used in the financial analyses and pro forma summary sheets for these and other alternatives which were advanced to the financial analysis stage are contained in **Appendix N**.

Hydro Scenario	Years to Cash Flow Positive	Years to Positive Net Annual Benefits	IRR-30 Years	NPV-10 Years	NPV-20 Years	NPV-30 Years
U1 Flashboards	-	30	-	$ (1,487,460)	$ (2,356,547)	$ (2,554,125)
U1 BladderDam	-	30	-	$ (2,428,590)	$ (4,070,136)	$ (4,882,119)
U3 FlashBoards	-	30	-	$ (1,867,131)	$ (2,778,819)	$ (2,640,659)
U3 BladderDam	-	30	-	$ (2,808,261)	$ (4,492,408)	$ (4,968,654)
U3 FlashBoards *Only Upper Dam Raised*	-	30	-	$ (1,504,265)	$ (1,973,473)	$ (1,286,393)
L1 FlashBoards	-	30	-	$ (2,454,042)	$ (3,975,666)	$ (4,496,422)
L1 BladderDam	-	30	-	$ (3,395,172)	$ (5,689,256)	$ (6,824,417)

Table 6-12: Pro Forma Summary – 30 year finance period, 3.5% financing, Wholesale Rates

Hydro Scenario	Years to Cash Flow Positive	Years to Positive Net Annual Benefits	IRR-30 Years	NPV-10 Years	NPV-20 Years	NPV-30 Years
U1 FlashBoards	30.6	14	-	$ (800,380)	$ (766,616)	$ 38,534
U1 BladderDam	-	27	-	$ (1,741,510)	$ (2,480,205)	$ (2,289,461)
U3 FlashBoards	23.6	11	5%	$ (798,226)	$ (305,330)	$ 1,392,795
U3 BladderDam	-	20	-	$ (1,739,356)	$ (2,018,919)	$ (935,200)
U3 FlashBoards *Only Upper Dam Raised*	13.7	6	12%	$ (261,909)	$ 901,388	$ 3,401,567
L1 FlashBoards	-	21	-	$ (1,523,985)	$ (1,823,477)	$ (986,904)
L1 BladderDam	-	28	-	$ (2,465,115)	$ (3,537,067)	$ (3,314,899)

Table 6-13: Pro Forma Summary – 30 year finance period, 3.5% financing, Retail Rates

Hydro Scenario	Years to Cash Flow Positive	Years to Positive Net Annual Benefits	IRR-30 Years	NPV-10 Years	NPV-20 Years	NPV-30 Years
U1 FlashBoards	-	15	-	$(2,489,104)	$(2,352,483)	$ (589,881)
U1 BladderDam	-	15	-	$(3,828,365)	$(4,064,457)	$(2,137,133)
U3 FlashBoards	29.33	15	-	$(3,314,684)	$(2,772,945)	$ 198,020
U3 BladderDam	-	15	-	$(4,653,945)	$(4,484,919)	$(1,349,232)
U3 FlashBoards *Only Upper Dam Raised*	26.01	15	2.6%	$(2,951,817)	$(1,967,599)	$ 1,552,286
L1 FlashBoards	-	15	-	$(4,013,759)	$(3,969,338)	$(1,437,786)
L1 BladderDam	-	15	-	$(5,353,020)	$(5,681,312)	$(2,985,038)

Table 6-14: Pro Forma Summary – 15 years, 1.5%, Wholesale

Hydro Scenario	Years to Cash Flow Positive	Years to Positive Net Annual Benefits	IRR-30 Years	NPV-10 Years	NPV-20 Years	NPV-30 Years
U1 FlashBoards	23.5	15	4.4%	$ (1,802,024)	$ (762,552)	$ 2,002,777
U1 BladderDam	28.7	15	-	$ (3,141,285)	$ (2,474,526)	$ 455,526
U3 FlashBoards	21.3	15	6.1%	$ (2,245,779)	$ (299,456)	$ 4,231,474
U3 BladderDam	24.9	15	3.3%	$ (3,585,040)	$ (2,011,430)	$ 2,684,222
U3 FlashBoards *Only Upper Dam Raised*	18.8	15	8.9%	$ (1,709,461)	$ 907,261	$ 6,240,246
L1 FlashBoards	25.3	15	3.1%	$ (3,083,702)	$ (1,817,149)	$ 2,071,732
L1 BladderDam	28.9	15	-	$ (4,422,963)	$ (3,529,123)	$ 524,481

Table 6-15: Pro Forma Summary – 15 years, 1.5%, Retail

Energy End Use	Grant Value	Years to Positive Net Annual Benefits	IRR-30 Years	NPV-30 Years
Retail	**$1,400,000**	1	16.0%	$ 3,508,000
Wholesale	**$3,300,000**	1	18.0%	$ 2,346,000

Table 6-16: Pro Forma Summary with Potential Grant
U3 Development Alternative (flashboards) – Upper Dam (with Lower Dam development)
30 year finance period, 3.5% financing

Energy End Use	Grant Value	Years to Positive Net Annual Benefits	IRR-30 Years	NPV-30 Years
Retail	**$450,000**	1	16.0%	$ 4,082,000
Wholesale	**$2,600,000**	1	16.0%	$ 2,643,000

Table 6-17: Pro Forma Summary with Potential Grant
U3 Development Alternative (flashboards) – Upper Dam Only (no Lower Dam development)
30 year finance period, 3.5% financing

Energy End Use	Grant Value	Years to Positive Net Annual Benefits	IRR-30 Years	NPV-30 Years
Retail	**$1,400,000**	1	17.0%	$ 2,154,000
Wholesale	**$2,600,000**	1	17.0%	$ 1,375,000

Table 6-18: Pro Forma Summary with Potential Grant
U1 Development Alternative (flashboards) – Upper Dam (with Lower Dam development)
30 year finance period, 3.5% financing

Energy End Use	Grant Value	Years to Positive Net Annual Benefits	IRR-30 Years	NPV-30 Years
Retail	**$750,000**	1	15.0%	$ 2,422,000
Wholesale	**$2,200,000**	1	17.0%	$ 1,614,000

Table 6-19: Pro Forma Summary with Potential Grant
U1 Development Alternative (flashboards) – Upper Dam Only (no Lower Dam development)
30 year finance period, 3.5% financing

Energy End Use	Grant Value	Years to Positive Net Annual Benefits	IRR-30 Years	NPV-30 Years
Retail	**$2,600,000**	1	16.0%	$ 2,940,000
Wholesale	**$4,300,000**	1	18.0%	$ 2,000,000

Table 6-20: Pro Forma Summary with Potential Grant
L1 Development Alternative (flashboards) – Lower Dam
30 year finance period, 3.5% financing

At the request of the Town of Canton, GZA also evaluated the U3 and L1 alternatives as a single combined project with respect to financial benefits (merging costs and benefits to treat the project as a single financial entity). No efficiencies have been assumed in the development cost at either site.

It was found that if the U3 and L1 alternatives are considered together as a single project and assessed financially as one entity, a positive internal rate of return and net present value is estimated to be available when retail energy rates are obtained and under the financing conditions assumed. **Table 6-21** summarizes the findings of combining U3 and L1.

Energy End Use	Years to Positive Net Annual Benefits	IRR-30 Years	NPV-30 Years
Retail	14	1.2%	$406,000
Wholesale	30	N/A	$ (7,137,000)

Table 6-21: Pro Forma Summary
Development Alternatives (flashboards) U3 and L1 Combined
30 year finance period, 3.5% financing

If the U3 and L1 alternatives are again considered together as a single project and assessed financially as one entity, it is possible that grant assistance could be utilized to reduce initial capital costs and thereby result in positive net annual benefits from the first year of operation. At the Town of Canton's request, GZA used the pro forma analysis method to estimate the grant amounts necessary for this condition to result, assuming both retail and wholesale prices. The results are presented below in **Table 6-22**.

Energy End Use	Grant Value	Years to Positive Net Annual Benefits	IRR-30 Years	NPV-30 Years
Retail	**$4,000,000**	1	16.2%	$ 6,450,000
Wholesale	**$7,500,000**	1	16.7%	$ 4,200,000

Table 6-22: Pro Forma Summary with Potential Grant
Development Alternatives (flashboards) U3 and L1 Combined
30 year finance period, 3.5% financing

7.0 CONCLUSIONS AND RECOMMENDATIONS

7.1 Summary Findings

The Upper and Lower Collinsville Dams are both located along the Farmington River, the Upper in the Town of Canton, CT and the Lower in Avon and Burlington, CT. Both dams were originally constructed for hydropower but have long since ceased generation. With grant assistance from the Connecticut Clean Energy Fund, the Town of Canton (Town) has commissioned this pre-feasibility study to explore the potential for redeveloping the dams to generate clean, renewable hydroelectricity and provide other benefits to the Town and region.

The scope of the study, prepared by GZA GeoEnvironmental (GZA), includes preliminary analysis of the technical, financial, and environmental aspects of constructing and operating hydroelectric projects at the Upper and Lower Collinsville Dams. A specific focus was given to identifying potential issues which might be considered as "fatal flaws" that would preclude project development. Baring any obvious fatal flaws, the study examined several options for project configuration, power and energy generation potential, preliminary estimated project costs, and potential project financial benefits.

The Town currently holds a Preliminary Permit issued by the Federal Energy Regulatory Commission (FERC) for both sites. The Preliminary Permit allows the Town to study potential development and establishes the Town's priority in applying for Licenses for the sites, but does not give permission to develop the sites. FERC issued the Preliminary Permit to the Town in January 8, 2009 for a three year period.

Previously, a private developer held a FERC License for each site. These licenses were issued in 2001 following an extended period of study and consultation. FERC subsequently terminated these licenses in 2007 due to the developers inability to begin construction at the sites. Legislation titled the "Collinsville Renewable Energy Promotion Act" was passed by the U.S. House of Representatives in 2010 to transfer these previous licenses to the Town of Canton but did not pass the Senate. The legislation was re-introduced to both the U.S. House and Senate on April 4, 2011.

It was assumed that any hydropower development at either of the sites would operate exclusively in an "instantaneous run-of-the-river" mode wherein impoundment levels remain constant and turbine flow at any particular instant is limited by the flow in the river. This operation mode is a pre-condition for any hydropower project to be considered "low impact." Analysis by GZA indicates that the hydrologic characteristics of the river would support a turbine design flow of approximately 820 cfs at both sites. This design flow rate can be utilized even with allowances made for maintaining appropriate flow to accommodate fish passage, habitat protection, water quality, and veil flows over the dams. The previous License authorized the use of 820 cfs for the Lower Site; however, a reduced flow of only 292 cfs was authorized at the Upper Site. The Environmental Assessment report prepared by FERC indicates that this reduced flow was stipulated due to concerns raised by local stakeholders regarding the maintenance of high rates of flow over the Upper Dam for aesthetic purposes. The reduced authorized turbine design flow at the Upper Site results in a reduction of the power and energy generation potential when compared

to what is theoretically possible. It is noted that the pending legislation which would transfer the existing Licenses would appear to limit the Town to this reduced turbine design flow.

Hydropower generation potential is a function of available flow and head. "Gross head" is the vertical distance through which water falls between the water in the impoundment upstream of the dam and the tailwater downstream of the turbine. At both the Upper and the Lower Sites, the location of the existing powerhouse provides additional head when compared to the head available immediately at the location of the dam. Use of the existing power canal and powerhouse site at the Lower Site is therefore judged to be advantageous, even in light of the physically deteriorated condition of the existing powerhouse. Additional head provides for the potential to increase the amount of power and energy that can be generated. The previous Licenses had provisions for the installation of 3 feet of flashboards on top of the Upper Dam spillway and 5 feet of flashboards on top of the Lower Dam spillway. Based on GZA's analysis, this configuration will result in 5 additional feet of gross head at the Lower Dam, but will not provide additional head at the Upper Dam because of the backwater effect caused by raising the Lower Dam impoundment. The addition of flashboards at the Upper Dam will only increase head if the Lower Dam impoundment is not raised (or not raised as much as previously contemplated). It is noted that some concern has been mentioned regarding potential environmental impacts of raising the Upper Dam impoundment level. Other concerns have been voiced about the use of flashboards to raise the impoundments. Comments from fisheries agencies have indicated that a system such as a pneumatic "bladder dam" may be preferable to flashboards.

On the basis of the estimated flow and head available at each site, GZA assessed a number of conceptual alternatives for hydropower development at each site. At each site, GZA chose to advance the alternative with the lowest cost per kilowatt to the financial analysis stage. In addition, GZA assess the costs and benefits of developing the Upper Site with the restrictions contained in the previous License. GZA assumed that the level of both impoundments would be raised. At the Upper Site, the level of power and energy production was estimated both with and without simultaneous development at the Lower Site to assess the potential advantage to eliminating the backwater affect caused by raising the Lower Dam impoundment. It is noted that utilizing the more advantageous flow at the Upper Site will likely require modifications to the existing powerhouse to accommodate the larger turbines which would be needed. The development alternatives advanced by GZA are summarized as follows:

Upper Site Alternative U1 (Previously Licensed Flow)

- Powerhouse: Utilize "as is" with no significant visible changes
- Dam: Re-install three feet of flashboards on crest of dam
- Equipment: single Kaplan turbine.
- Peak Flow Capacity of Turbine: 292 cfs
- Estimated Peak Power (Upper Dam flashboards only / flashboards on Lower Dam also): 457 kW / 395 kW
- Estimated Average Annual Energy Generation (Upper Dam flashboards only / flashboards on Lower Dam also): 2,584 MWh / 2,233 MWh

Upper Site Alternative U3 (Advantageous Flow)

- Powerhouse: Expand to house large turbines
- Dam: Re-install three feet of flashboards on crest of dam
- Equipment: pair of Kaplan turbines
- Peak Flow Capacity of Turbine: 820 cfs
- Estimated Peak Power (Upper dam flashboards only / flashboards on lower dam also): 1,255 kW / 1,080 kW
- Estimated Average Annual Energy Generation (Upper Dam flashboards only / flashboards on Lower Dam also): 4,038MWh / 3,474 MWh

Lower Site Alternative L1 (Advantageous and Previously Licensed Flow)

- Powerhouse/ Gatehouse / Flow Conveyance Structures: Utilize existing gatehouse site at downstream end of power canal
- Dam: Re-install five feet of flashboards on crest of dam
- Equipment: either single Kaplan Turbine or a pair of Kaplan Turbines
- Peak Flow Capacity of Turbine(s): 820 cfs
- Estimated Peak Power: 876 kW
- Estimated Average Annual Energy Generation: 3,023 MWh

As part of the pre-feasibility study, potential environmental issues were considered. Available information was reviewed and preliminary comments were solicited from a number of potential stakeholders. The primary environmental concern which was identified is the issue of fish passage. Both upstream and downstream fish passage will be required as part of any hydropower project at either Site. Fish passage will need to accommodate a variety of species, including, but not limited to, Atlantic salmon, river herring, trout, and American eels. Construction of fish passage facilities is expected to represent a significant portion of the capital costs of project development and will also require future operation and maintenance efforts by the project owner.

The Farmington River upstream of the Upper Dam impoundment has been federally designated as a Wild and Scenic River. A proposal is currently being studied which would also designate a portion of the river downstream of the Lower Site as Wild and Scenic. Hydropower developed within a Wild and Scenic River reach or which would adversely affect a Wild and Scenic River reach is not allowed. Correspondence with the Lower Farmington Wild and Scenic River Study Committee indicates that they are not opposed to hydropower development at the Collinsville sites, provided the proposed projects provide fish passage and meet certain criteria for low-impact development.

Financial analyses of potential hydropower development at the Collinsville sites considered two general scenarios: 1) Energy produced is sold to the local electric service provider (CL&P) for "wholesale" prices; or 2) Energy produced is used at Town facilities to off-set existing electricity purchases, thus creating a "retail" value for the hydropower. The "wholesale" value of electricity in the early years of the financial analysis period was estimated to be approximately 5 cents per kilowatt hour (kWh) while the "retail" value was estimated at approximately 8 cents / kWh. In order to realize the "retail" value of the energy, the Town must have the means to directly utilize the electricity, either through a physical direct connection to Town facilities or through a "virtual" net metering arrangement. A distribution line could

theoretically be built from the Upper Site powerhouse to several Town facilities, but the cost would be over $1 million (assuming a primarily underground system), the Town would become responsible for its operation and maintenance, and it is not clear that appropriate right-of-way for the line could be secured. A "virtual" net metering arrangement wherein credits generated at one directly connected Town-owned meter could be applied to other Town-owned meters is a more efficient way to maximize the value of the energy produced. However, while single site net metering is a legalized process in the State of Connecticut, virtual net metering is currently not permitted in Connecticut. Clarifications to regulations and/or new legislation may change this situation in the future. It is also important to understand that the Town of Canton alone does not have enough on-site demand to utilize all the energy capable of being produced by both the Upper and Lower Sites combined. The energy generated by the Upper Dam alone using the previously licensed flow will be less than the Town of Canton's estimated energy demand. If the advantageous turbine flow is utilized, then estimated average annual energy production from the Upper Dam alone will be similar to the Town's current demand, assuming no flashboards or backwater from the Lower Dam. However, if flashboards are added to the Upper Dam without the affects of backwater from the Lower Dam, the estimated average annual energy production at the Upper Dam will exceed the Town of Canton's current energy demand.

GZA analyzed the financial returns of the three advanced alternatives over a 30 year period. Two financing scenarios were studied: 1) 30 year bonds with 3.5 percent interest; and 2) 15 year bonds with 1.5 percent interest. Energy prices were forecast based on US Department of Energy guidance. The analyses looked at annual cash flow, final net present value, and final internal rate of return. Project capital costs were estimated based on preliminary equipment quotes from turbine manufacturers and customary cost estimating methods at a concept level. A 25 percent contingency was added. The conceptual estimated costs (with contingency and assuming flashboards to raise the impoundments) of the three Alternatives advanced to full financial analysis are as follows:

Upper Site Alternative U1: $4,560,000

Upper Site Alternative U3: $6,590,000

Lower Site Alternative L1: $7,100,500

These costs assume that the raising of the normal water surface elevation of the impoundments are achieved through the installation of flashboards. Installation of bladder dams at one or both of the dams would increase the capital cost of the projects significantly.

Under the 30 year bond financing scenario, none of the project alternatives which were assessed returned a positive net present value over the 30 year study period when "wholesale" energy values were assumed. If "retail" energy value is assumed for <u>all</u> energy produced along with the use of flashboards to raise the impoundments, the following results are generated:

Scenario	IRR (30 years)	~NPV (30 years)
U1	0%	$40,000
U3	5%	$1,400,000
U3 (Upper Dam Only)	12%	$3,400,000
L1	n/a	-$1,000,000
U3/ L1 (combined)	1%	$400,000

The most financially attractive option therefore is to develop the Upper Dam site only, using a design flow of 820 cfs and raising the impoundment 3 feet with flashboards. However, this assumes virtual net metering, which is currently not allowed, and all energy produced is valued at the "retail" rate.

In order to provide conditions which would generate a positive net annual cash flow from the first year of operation under the "wholesale" energy value scenario, grant assistance in the following amounts would be necessary, based on current cost and benefit assumptions:

Scenario	Grant Needed for Year 1 Positive Cash Flow (Wholesale)	Grant Needed for Year 1 Positive Cash Flow (Retail)
U1	$2,600,000	$1,400,000
U1*	$2,200,000	$750,000
U3	$3,300,000	$1,400,000
U3*	$2,600,000	$450,000
L1	$4,300,000	$2,600,000
U3 / L1 (combined)	$7,500,000	$4,000,000

*Assumes no raising of water surface elevations at Lower Dam therefore, full head is achieved at Upper Dam without backwater restrictions from Lower Dam

This pre-feasibility study indicates that redevelopment of hydropower at the Upper and Lower Collinsville sites is technically feasible and that there are no obvious "fatal flaws" which would prevent development. However, the financial viability of the hydropower projects is less straightforward. Assuming a "wholesale" value of energy for electricity sold directly to the grid, GZA estimates that negative cash flow will result from almost all development alternatives, based on current conceptual cost estimates and assuming no grant assistance. If energy generated can be used to off-set existing Town demand, then it appears possible to develop hydropower at the sites in ways that are at least revenue neutral and potentially cash flow positive. A major caveat however is that there is currently no mechanism for the Town to be able to use the power generated at either site and virtual net metering is currently not allowed in Connecticut. Grant funding would improve project viability under all these scenarios

7.2 Project Uncertainties and Risks

At this pre-feasibility level of study, it was not possible to fully explore all potential issues which could affect hydropower development. The following is a summary of uncertainties, issues requiring further investigation, and questions to be answered prior to making final decisions regarding proceeding with hydropower development:

- Future availability of "virtual" net metering to the project (affects costs and value of energy)
- Under any net metering scenario, the total amount of energy produced by the final preferred option that can be valued at "retail" rates verses the amount which may only be worth "wholesale" rates.
- The maximum amount of energy which can be generated while still remaining eligible for net metering benefits.
- Whether or not to raise crest of Upper Dam and/or Lower Dam and/or the optimum combination of increases to the Upper and Lower impoundment water surface elevations (affects available head)
- Actual crest elevations of dams and extent of potential backwater affects of Lower Dam flashboards on available gross head at Upper Dam. GZA analyses utilized best available information but no surveyor-stamped drawings with crest elevations were available.
- Means to raise dam: flashboards, bladder dam, crest gate (affects project costs)
- The feasibility to utilize more than the previously licensed 292 cfs at the Upper Dam (affects power and energy generation) by challenging the prior FERC reduction.
- Total available turbine flow at either dam after consideration of environmental issues by FERC
- Verification of water rights and any other issues associated with the property deeds for the dams held by the CTDEP.
- Development of a direct transmission line (affects total project cost and value of energy)
- Ownership structure of project (may affect ability to use energy and therefore value of energy)
- Availability of bonds including reasonable rates and terms (affects financial returns)
- Additional conservation measures that may be required in addition to those required for the 2001 licenses (affects power/energy, may affect costs)
- Potential cost of acquiring dam and ancillary structures from the State of CT (affect costs)
- Potential presence of constituents in sediments which need to be dredged which would cause them to be treated as regulated or hazardous materials and increased costs for testing, characterizing, and disposing of such sediments
- Potential cost of repairs to dam for compliance with State of CT dam / FERC safety standards (affects costs)
- Final disposition of "Collinsville Renewable Energy Promotion Act" (affects cost and timeline for development)
- If 2001 licenses are reinstated, if there is any opportunity to make changes to previous license such as Upper Dam peak design flow and modification of Lower Dam single turbine to a pair of turbines (affects power/energy)

- If 2001 licenses are reinstated, available timeline for construction (affects costs and financing mechanisms)
- Extent of historic preservation measures which will be required by stakeholders (may affect development alternative pursued, affect costs)
- Potential to secure a fixed power sales contract (affects financial evaluation)
- Total load available to off-set energy production under net metering scenarios (affects project benefits)
- Ability to secure LIHI certification for the project (affects costs, financial evaluation)
- Value of Energy, wholesale and retail (affects financial evaluation)
- Participation by project partners such as Avon and Burlington (affects costs and benefits to Canton)
- Availability of grant assistance
- Cost of insurance
- Additional O&M costs based on final responsibility for dams, fish passage, and other related facilities

As a result of these uncertainties as well as for other reasons there are a series of potential risks for project development. The majority of these risks will be eliminated based upon decisions made by the Town, more detailed stakeholder consultation. Potential project risks may include the following:

- Legal ability to net meter, virtually net meter or install a direct transmission line will affect value of energy. Project may not be viable if energy value is limited to wholesale price.
- Outcome of detailed stakeholder consultation. May affect size of project and capital costs.
- Ability to secure the rights to develop project on what is property currently owned by State of CT (ultimate downfall of last developer)
- Need for unanticipated dam safety repairs which could increase costs
- Outcome of legislation to reinstate previous licenses
- Ability to secure funding for projects at reasonable terms (duration and interest rates)
- Need for sinking fund for development. Not included in financial analysis.

7.3 Recommendations

It is GZA's opinion that hydropower development at the Upper and Lower Collinsville Dams warrants further consideration by the Town beyond this pre-feasibility study. Development of one or both of the projects offer the Town the opportunity to generate essentially all of the power consumed by Town facilities through clean, renewable hydropower. Development of the sites would facilitate fish passage at the dams, which is an important goal in itself. Hydropower at the Upper and Lower Collinsville Dams is also consistent with the history of the Town and its surroundings and restores a valuable resource to productive use. The Town's exclusive rights to pursue a License for one or both of the Sites will expire at the end of December 2011. GZA therefore recommends that the Town consider taking the following steps in advance of that deadline:

- Further investigate the potential avenues for maximizing the value of any energy produced through discussions with the CT Dept. of Public Utility Control, CP&L, and the legislature.
- Further investigate unresolved issues raised in this report
- Submit Notice of Intent and Pre-Application Document based upon U3 and L1
- Hold discussions with Burlington and Avon regarding potential joint participation in development of the Lower Site.
- Hold initial site visit with Stakeholders and discuss study plan
- Pursue grant opportunities
- Continue to monitor status of "Collinsville Renewable Energy Promotion Act" as re-introduced on April 4, 2011.

The intent of these actions is to allow the Town to better understand the potential advantages and disadvantages of proceeding with the project while at the same time making incremental steps towards filing License applications on one or both of the sites prior to January 2012, if that should ultimately be judged to be desirable. If the Town does not file License applications in advance of this deadline (or if the "Collinsville Renewable Energy Promotion Act" does not become law), then there is the risk that another developer will file for a preliminary permit. GZA recommends that separate filings be made for the Upper and Lower Sites. Ultimately, the Town of Canton might choose to proceed with development of the Upper Site only for a variety of reasons. Proceeding with separate filings at both sites preserves future flexibility.

Proceeding with the steps outline above will not commit the Town to submitting License application or to developing the sites. However, these steps are judged to be prudent if the Town remains interested in potentially moving forward. GZA estimates the cost to the Town of this course of action is approximately $75,000 to $100,000 for outside legal and engineering assistance. The risk to the Town is that these funds are expended but the Town ultimately decides against hydropower development at the sites. However, it is GZA's opinion the above tasks will be useful even in the event that the "Collinsville Renewable Energy Promotion Act" is passed because the information will be relevant to the new Environmental Assessment, additional permitting needs, and final design. The Town may also seek to extend its Preliminary Permit at the end of the current term, but there is no guarantee that FERC will grant an extension if there are competing applications.