Ipswich Mills Dam Partial Feasibility Study

Preliminary analysis of three primary factors that may influence the cost and feasibility of the removal of the Ipswich Mills Dam, Ipswich, MA

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NOAA
Commonwealth of Massachusetts Division of Ecological Restoration
GEI Consultants
CLEAN SOILS ENVIRONMENTAL LTD
Horsley Witten Group Sustainable Environmental Solutions

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The Town of Ipswich thanks the following companies and organizations for their contribution to the Study:

- Clean Soils Environmental, Ltd. and Horsley Witten Group, Inc., provided pro-bono services to prepare sections of this report.
- Inter-Fluve, Inc. assisted with sediment sampling and field processing.
- Roux Associates, Inc. and Alpha Analytical, Inc. partnered to provide sediment analysis at reduced rates.
- The Ipswich River Watershed Association provided project management support and community outreach to this study in addition to coordinating ongoing citizen science monitoring efforts that complement the project.

A technical team planned and guided the Study. The Technical Team was comprised of the NOAA Restoration Center, MA DER, Ipswich River Watershed Association, Horsley Witten Group, Inc., and various Town of Ipswich departments and committees (e.g. Planning, Conservation, Public Works, Town Manager, Fire and Rescue Services). Technical Team members were integral to developing detailed scopes of work for the project components, reviewing draft documents and engaging other stakeholders.

EXECUTIVE SUMMARY

This document is a compilation of three preliminary assessment studies that comprise a partial feasibility study to evaluate the removal of the Ipswich Mills Dam. This work was partially funded by a grant jointly awarded from the Conservation Law Foundation and the National Oceanic and Atmospheric Administration (NOAA) Restoration Center, and managed by a Steering Committee representing the Town of Ipswich, the Ipswich River Watershed Association (IRWA), the Massachusetts Division of Ecological Restoration (MA DER), and the NOAA Restoration Center. The three studies presented herein are as follows:

1. Preliminary Hydraulic/Hydrologic Assessment of the Potential Removal of the Ipswich Mills Dam (Horsley Witten Group, Inc.)
2. Evaluation of Potential Impacts on EBSCO Buildings from the Proposed Removal of Ipswich Mills Dam (GEI Consultants)
3. Sediment Management Preliminary Review (Clean Soils Environmental, Ltd.)

Together these preliminary assessments provide a basis for future investigation, analysis and decision-making with regard to the potential removal of the Ipswich Mills Dam. In short, the reports provide competent professional assessments that conclude the following:

- The removal of the dam would lower the level of the water upstream of the dam such that the water elevation likely would be governed by the rock ledge identified by IRWA in a preliminary site survey extending approximately 10 feet upstream from the dam structure;
- The preliminary assessment of the dam environment suggests that sediment trapped by the dam may have little contamination and may not pose a threat to human or aquatic health; and
- The lowering of the water elevation upstream of the site as a result of dam removal could pose a biodeterioration threat to the foundation of the EBSCO building on the river bank just upstream of the Ipswich Mills Dam. Methods exist to mitigate these potential impacts.. More information is required to understand better the existing foundation structure and elevation.

Background

The Ipswich Mills Dam is a run of the river dam that was built for the purpose of generating power for nearby buildings and manufacturing processes. It no longer serves that purpose and now stands as a relic structure in the river. A run of the river dam is operated such that the volume of water released below the dam is equal to the volume of water flowing in the stream or river above the dam on a continuous, real-time basis. Put another way, water is not stored in the impoundment to be released at a later time. Rather, the dam simply increases the head in the river, providing a power source that can be captured. This is typical of many small New England dams.

The current dam is constructed out of cut stones with concrete at some locations and is a run of the river dam with the spillway extending across most of the width of the river. The main spillway is 132 feet wide. A 3-foot-wide low level stop-log spillway is at the right end of the main spillway. The spillway crest is at El. 9.71 and the low level stop-log spillway invert is at El. 8.7. The dam also has a

4.5-foot-wide by 3-foot-high low level gated outlet with an invert at El. 7.5 on the right side of the dam. The right side of the dam also includes a fish ladder and a non-overflow granite block wall or pier that extends approximately 45 feet into the river and abuts the right end of the spillway. It has five low level gates that, when originally installed, could be removed manually to adjust the water level in the River. However, as described in the 2009 dam safety inspection report (Haley and Aldrich, 2009), three of those gates have since been plugged, one has been fitted with a stainless steel slide gate operated by a handwheel and one controls flow to the fish ladder.

A number of buildings have been built over the years adjacent to the Ipswich River and the Ipswich Mills Dam. Most notable is the EBSCO complex, which includes one particular building that sits directly on the edge of the river upstream of the dam, such that the foundation appears to be submerged. This suggests that lowering the elevation of the river water along the building foundation could potentially expose the foundation to air, which could cause biodeterioration of the foundation.

In addition, the long history of development upstream and surrounding the historic dam suggests that there is a potential for contaminated sediments to build up behind the dam over time. Therefore, evaluating these sediments and managing them appropriately during any dam removal process is essential to protect the health of humans and the environment.

Preliminary Hydraulic/Hydrologic Assessment

The Ipswich Mills Dam itself was not constructed to provide flood control for the area downstream of the dam, and does not serve that purpose by default. The dam provides relatively little storage (small head pond) by detaining flow behind the dam, and what is detained is actually occupying or using up a small portion of the flood storage capacity that would naturally be available in the flood plain in the absence of the dam. Because of its minimal storage capacity, this dam does not provide flood mitigation for areas downstream of the dam. Flows downstream of the river are essentially equal to what they would be in the absence of the dam because the river has created an equilibrium in which water flowing to the dam equals water flowing over and downstream from the dam. It is presumed that a ledge outcrop and falls extend from the dam toe to approximately 10 feet upstream of the dam.

According to Haley and Aldrich (2009), the impoundment from the dam extends upstream approximately 12,500 feet at an average width of 70 feet, and has a total surface area less than 1% of its contributing watershed area. Conversely, preliminary field reconnaissance by IRWA suggests that the impoundment extends only 7,500 feet upstream to the commuter rail bridge (MacDougall, email correspondence, November 6, 2010).

A preliminary site survey by IRWA staff identified a rock ledge extending from the dam toe to approximately 10 feet upstream of the Ipswich Mills Dam. In this case, it is reasonable to expect that once the dam is removed, the falls will become the new defining element in the river and will establish the new upstream water surface elevation during normal or low flow conditions. However, during flood flows, the existing dam and the rock ledge outcrop (or Upper Falls as it is commonly referenced) appear to have little impact on the water surface elevation or the river discharge due to the presence of numerous other impediments to flow, including the Choate Bridge, the pedestrian foot bridge, downstream tidal influence, and the sharp bend in the river downstream of the Choate

Bridge. The amount of influence each of these impediments has on the current system is unknown at this time but can be estimated with future evaluation.
Many factors must be considered when deciding whether to remove a dam, including the hydrologic and hydraulic factors presented in this preliminary assessment. Based upon the information compiled and reviewed for this assessment, it seems relatively clear that the dam no longer serves its initial intended purpose of providing a small-scale energy source for the surrounding mill activities. Because of the dam's basic design and relatively small size, it does not provide active (regulated) flood mitigation services for areas downstream of the dam. While the head pond created behind the dam is relatively small in comparison to the average annual and average monthly discharge passing over the dam, the dam does raise the surface elevation of the water upstream of the dam above what would exist in the absence of the dam.

Based on historical records and anecdotal observations reported during low flow conditions, it is generally believed that the dam was constructed on top of or at the toe of a rock ledge outcrop that created the Upper Falls. The extent of that ledge is yet to be determined, but it is expected that, in the absence of the dam, the height of the rock ledge will be a primary factor in determining the normal or low water surface elevations.

The next steps for this feasibility assessment are to develop a more detailed understanding of the flows (discharge, surface elevation, velocities) in the river under existing conditions from the area upstream of the Ipswich Mills Dam to downstream of the Choate Bridge, and to use that information to predict the conditions in the river under the potential dam removal scenario. It is important for the town to understand what impact the dam is having on the flow regime in the river (both high flows and low flows) and to develop an understanding of the potential risks and benefits from dam removal. This includes estimating the future river water surface elevations and the flow velocities in the area of the dam if it were to be removed. This would need to be evaluated under all flow conditions (i.e., low, normal, and flood flows) to gain an informed understanding of the impact of dam removal. HW recommends using the HEC-RAS model, which is publically available from the Army Corps of Engineers and is the industry standard in modeling river and stream hydraulics, together with current detailed cross-sectional data and flow data, using current data from the USGS gauge at the Willowdale Dam located just upstream of the Ipswich Mills Dam.

Evaluation of Potential Impacts on EBSCO Buildings from Proposed Removal of Ipswich Mills Dam

The portions of the EBSCO buildings along the Ipswich River are supported most likely on timber piles given the soil conditions along the river and the age of the buildings. However, the preliminary assessment was not able to identify any information regarding the elevation of the tops of the suspected timber piles. GEI reviewed logs from three borings performed in 2009 immediately south of the southeast corner of EBSCO's Building No 10-A, and concluded that at least some portion of the EBSCO buildings along the river are likely supported on deep foundations that consist of driven timber piles.

GEI also observed that some of the existing and former buildings pre-date the construction or reconstruction of the existing dam. It is possible that the tops of the foundations supporting the buildings that pre-date the current dam were constructed when the impoundment behind the dam was maintained at a lower elevation. Consequently, the tops of the timber piles supporting these older buildings could have been established based on a lower impoundment elevation and may not be at risk of biodeterioration from removal of the dam.

Assuming that portions of the EBSCO buildings are supported on timber piles, the tops of the timber piles need to be below water to protect them from rapid deterioration (biodeterioration). Methods that have been implemented on other projects to protect timber piles have included artificially raising groundwater levels to keep the piles submerged, lowering the tops of the piles below the expected future groundwater level, or a combination of raising groundwater levels and cutting off the tops of the piles.

Consequently, it is still uncertain if the removal of the dam would likely expose the tops of the piles causing them to deteriorate resulting in damage to the building. The assessment concludes with recommendations to perform the following additional work: literature search for historic records of the former dams; lowering of the impoundment for maximum exposure of the EBSCO foundation wall along the river; soil probing along the EBSCO foundation wall in the river; a more extensive river sounding program; and possibly coring through the EBSCO foundations or excavating test pits inside the EBSCO building to expose the foundations.

Sediment Management Preliminary Review

At this time, the impounded sediment within the future channel is (conceptually) proposed to be discharged downstream within the tidal waters of the Ipswich River. This study evaluates the quality of the impounded sediment in relation to human and ecological health thresholds, an important factor in evaluating dam removal options.

The sediments found behind Ipswich Mills Dam have a very low likelihood of toxicity when viewed independently and in relation to other dams across Massachusetts. The U.S. Geological Survey (USGS) and the Massachusetts Department of Fish and Game, Division of Ecological Restoration (MassDFG) collaborated to collect baseline information on the quantity and quality of sediment impounded behind 32 selected dams in Massachusetts, which can be used as a point of reference for other dams. As part of this study, USGS collected two sediment cores in the vicinity of the Ipswich Mills Dam impoundment. That study concluded that the Ipswich Mills impoundment had a 13% likelihood of toxicity of bottom sediments. In addition, the IRWA and staff from Interfluve, Inc. collected three (3) sediment cores from the impoundment area on May 31, 2012 and had them analyzed in the laboratory for Total Heavy Metals, SVOCs, PAHs, Volatile Organic Compounds (VOCs), Extractable Petroleum Hydrocarbons (EPH), and Physical Characteristics such as Percent of Total Organic Carbon (TOC), Percent of Water, and Percent of Grain Size Distribution. Generally, both sampling events indicate that the sediment is below applicable ecological impact benchmark limits. The assessment concludes that laboratory data to date indicate a condition of 'No Significant Risk' may exist within the sediment from the impoundment of the Dam. This is logical based on the past development and uses in the vicinity of the dam, which include mainly residential uses with little industrial use. The concentrations of metals, SVOCs, pesticides, VOCs, and EPHs measured within the sediment appear to be consistent with surface water runoff non-point sources (e.g., roadways and farming).

Recommendations from the assessment include estimating the volume of sediment that is contained within the impoundment and the volume of sediment that would be dredged or mobilized as part of a dam removal project so that the required number of samples can be estimated and collected, as well as conducting further testing of sediments above and below the impoundment with an emphasis on the area downstream of the impoundment. In particular, testing is suggested immediately upstream of the Ipswich Mills Dam, as well as further upstream in depositional areas subject to potential mobilization during storm events, which will help evaluate material that is 'moving through the system' regardless of actions taken at the dam.

SECTION 1:

Preliminary Hydraulic/Hydrologic Assessment of the Potential Removal of the Ipswich Mills Dam

Horsley Witten Group, Inc.

18 Pages

Preliminary Hydraulic/Hydrologic Assessment
of the Potential Removal of the Ipswich Mills Dam
Ipswich, MA

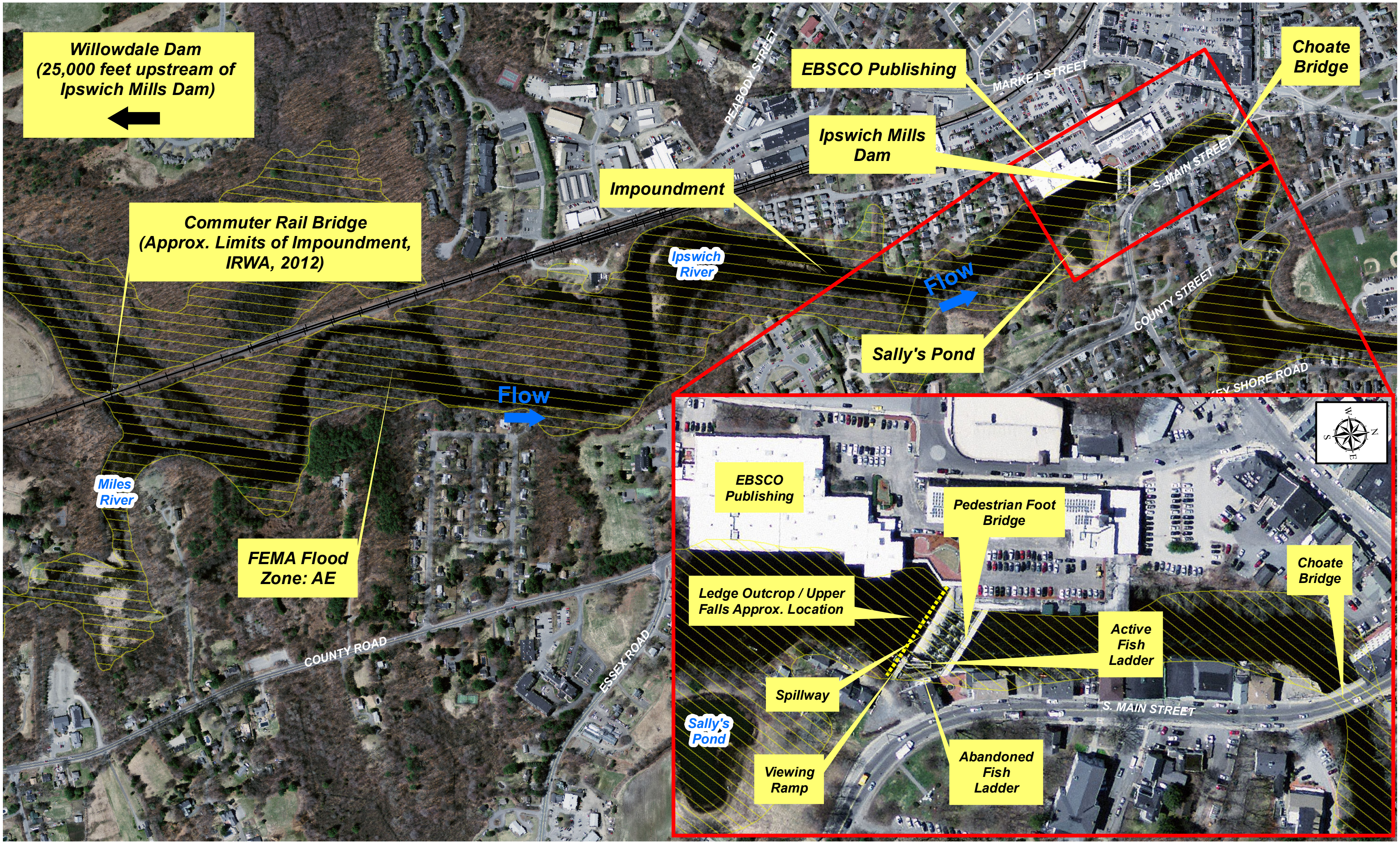
1. Introduction

The Horsley Witten Group (HW) has been retained by the Town of Ipswich to compile and present a basic assessment of the hydrologic and hydraulic implications associated with the removal of the Ipswich Mills Dam on the Ipswich River, using existing information. This work is a portion of a partial feasibility study to evaluate the removal of the Ipswich Mills Dam, funded by a grant jointly awarded from the Conservation Law Foundation and the National Oceanic and Atmospheric Administration (NOAA) Restoration Center, and managed by a Steering Committee representing the Town of Ipswich, the Ipswich River Watershed Association (IRWA), the Massachusetts Division of Ecological Restoration (MA DER), and the NOAA Restoration Center. To perform this task, HW has reviewed existing data and reports on the subject and performed a site visit to aid in the investigation. This report describes the results of the assessment and presents recommendations for a future, more detailed dam removal feasibility study.

2. History and Background

The Ipswich Mills Dam is located on the Ipswich River in the Town of Ipswich, Massachusetts, approximately 700-feet south (upstream) of the Route 133/South Main Street/Choate Bridge crossing. The spillway spans 136-feet from the western riverbank, near the EBSCO Publishing Company, to the eastern riverbank, near a private residence on Route 133. A locus map is presented in Figure 1 depicting the dam location and other significant surrounding features. The dam is currently owned and operated by the Town of Ipswich Utilities Department (Haley & Aldrich, 2009).

Historical records show that a dam has existed in the vicinity of the Ipswich Mills Dam site since 1637 (Haley & Aldrich, 2009). In 1908, the structure was modified to its current structural design to supply nearby mill buildings with a reliable source of power; however, the dam no longer serves its industrial purpose. The design of the Ipswich Mills Dam is referred to as a “run-of-the-river” dam or “channel dam.” For the purposes of this study, the term “run-of-the-river” dam can be defined as a dam that creates an impoundment that is completely contained within the banks of a river and provides only limited, short-term, storage capacity (ICF Consulting, 2005). Typically, these types of dams are no more than fifteen feet tall. They are designed to allow all flowing water to pass over the crest of the dam (ICF Consulting, 2005). A run of the river dam serves a different purpose than a flood control dam; It is used to create head and therefore generate small scale power from the change in elevation between the top of the dam and the downstream water surface. It does not serve to prevent or mitigate flooding downstream of the dam since it is generally sized to allow water to flow over the dam during all typical flows.



Path: H:\Projects\2011\11101 Ipswich Mills Dam Feas.Study\GIS\Maps\Figure_1.mxd

Legend

Commuter Rail Service

FEMA AE Zone: The base floodplain (100-yr flood zone), or areas with a 1% annual chance of flooding and a 26% chance of flooding over the life of 30-year mortgage. Base flood elevations have been provided.

Feet
750

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Ipswich Mills Dam and Surrounding Area
Ipswich, MA

Date: 3/15/2012

Figure 1

During recent years, a number of modifications to the dam have occurred to allow and improve fish passage. There is a three-foot wide low level spillway at the eastern end of the dam that can be controlled with stop-logs (Haley & Aldrich, 2009). There are two additional outlets in the spillway, one that regulates flow to an active denil style fish ladder and one that is controlled by a manually operated slide-gate. The slide-gate was closed, and the outlet non-operational, when HW observed the dam on November 3, 2011.

The Ipswich Mills Dam receives river flows contributed from a 148 square-mile watershed of the Ipswich River upstream of the dam. The watershed is made up of primarily forested land, wetland areas, residential properties, agricultural land, and some commercial/industrial zones. About 160,000 people, in parts of 21 towns, live throughout the watershed (IRWA, 2012). The Ipswich River flows nearly 40 sinuous miles from its headwaters in Burlington, Wilmington, and Andover, MA, to its mouth in Plum Island Sound, and loses approximately 115 feet in elevation along its course. The soils in the watershed are comprised primarily of Merrimac-Hinckley-Urban land and Paxton-Montauk-Urban land. The former is an excessively drained, loamy, sandy soil that was formed in outwash deposits. The latter is a well drained, loamy soil formed in glacial till. Canton-Woodbridge-Freetown soil also exists in the upper parts of the watershed but to a lesser extent than the other soil types. This soil type is a well to moderately-well drained, loamy soil formed in glacial till (USDA SCS, 1981).

3. Summary of Existing Data

A wealth of data and reports exists for the Ipswich Mills Dam and the surrounding area of the Ipswich River, as well as rich photographic and historic documentation of the dam during various periods in history and during recent severe flood events. Flood studies, dam inspections, and bathymetric and sediment surveys have been completed in recent decades. The particularly pertinent items received and reviewed by HW for this assessment include the following:

- Flood Insurance Study, Town of Ipswich, Massachusetts, Essex County. Federal Emergency Management Agency. February 5, 1985.
- Ipswich Mills Dam Phase I Inspection / Evaluation. Haley & Aldrich. October 20, 2009.
- Ipswich River Longitudinal Profile and Cross-Sectional Data (upstream of Mills Dam). Ipswich River Watershed Association (IRWA). November 3, 2011.
- Feasibility Study for Willowdale Dam Fish Passage Project. Alden Research Laboratory, Inc., for MA Division of Marine Fisheries. August 2006.

In addition, the USGS maintains a gage located 200 feet downstream from the Willowdale Dam, or 25,000 feet upstream of the Ipswich Mills Dam, and has continuously recorded water surface elevation and discharge data as far back as June 1930. Monthly mean flows at the Willowdale Dam between 1930 and 2009 range from 42.0 cubic feet per second in August to 446 cubic feet per second in March. Appendix A presents the monthly gage data according to the USGS analysis of data between June 1930 and 2009. The highest flow on record of 4,600 cfs occurred on May 16, 2006. Two photos of the

Ipswich Mills Dam on May 16, 2006 are provided below (Figures 2a and 2b), showing that the dam is virtually drowned out by the discharge in the river.

Figure 2a. Ipswich Mills Dam on May 16, 2006, facing southwest (photo provided by IRWA)

Figure 2b. Ipswich Mills Dam on May 16, 2006, facing northwest (photo provided by IRWA)

Because of the severity of this flood event, as well as other lesser but significant flood events in recent years, the area of the dam during flood flows has been very well photographed. Some of these photographs have been provided by IRWA for this assessment and are useful in describing the functionality of the dam with respect to flood flows.

The Federal Emergency Management Agency (FEMA) Flood Insurance Study (FIS) describes the existence and severity of flood hazards in the Town of Ipswich, MA (1985). Peak discharges and peak elevations along the Ipswich River are calculated and presented for the 10-, 50-, 100-, and 500-year floods, and summarized in Table 1. Since no gauging station was present at the Ipswich Mills Dam, peak discharges just below the dam (i.e., Central Street as described in the FIS) were obtained by scaling measured upstream flows at the Willowdale Dam. Peak flood elevations were computed through the use of a U.S. Army Corp of Engineers (ACOE) HEC-2 (Hydrologic Engineering Center) step-backwater computer analysis. A longitudinal profile with expected flood elevations is presented in the report for the nearly 30,000-foot length of the Ipswich River, beginning at the river mouth near Plum Island Sound and ending at the headwaters.

Table 1: Published FEMA flood results at Ipswich Mills Dam, Ipswich, MA (1985)

Flood Recurrence Interval	Water Surface Elevation* (feet)	Peak Discharge (cubic feet / second)
10-year	12.8	2,023
50-year	13.8	3,016
100-year	14.1	3,251
500-year	14.7	4,196

*Elevations referenced are based on the National Geodetic Vertical Datum of 1929 (NGVD)

There are several reasons to consider the current applicability of the FIS-predicted flood elevations for the area of the Ipswich Mills Dam:

- As is common throughout eastern Massachusetts, increasing development has altered the natural hydrologic response of the watershed to precipitation. As impervious coverage in a watershed increases, runoff conveyed quickly and directly to the river increases while groundwater recharge decreases. As a result streamflow tends to become "flashier" with higher peak storm flows and lower summer baseflows. According to Ipswich River Watershed Association (www.ipswichriver.org//issues/land-use/), the population of the watershed increased by 9 percent between 1980 and 2000, yet residential land use increased by 35 percent. In addition, between 1971 and 1999, the area of forested land in the Ipswich River watershed is estimated to have decreased by more than 15 percent. In addition, increasing groundwater withdrawals for irrigation and drinking water, combined with wastewater transfers out of the watershed have decreased the quantity of groundwater available to support summer baseflows (www.ipswichriver.org/issues/low-flows-floods/).

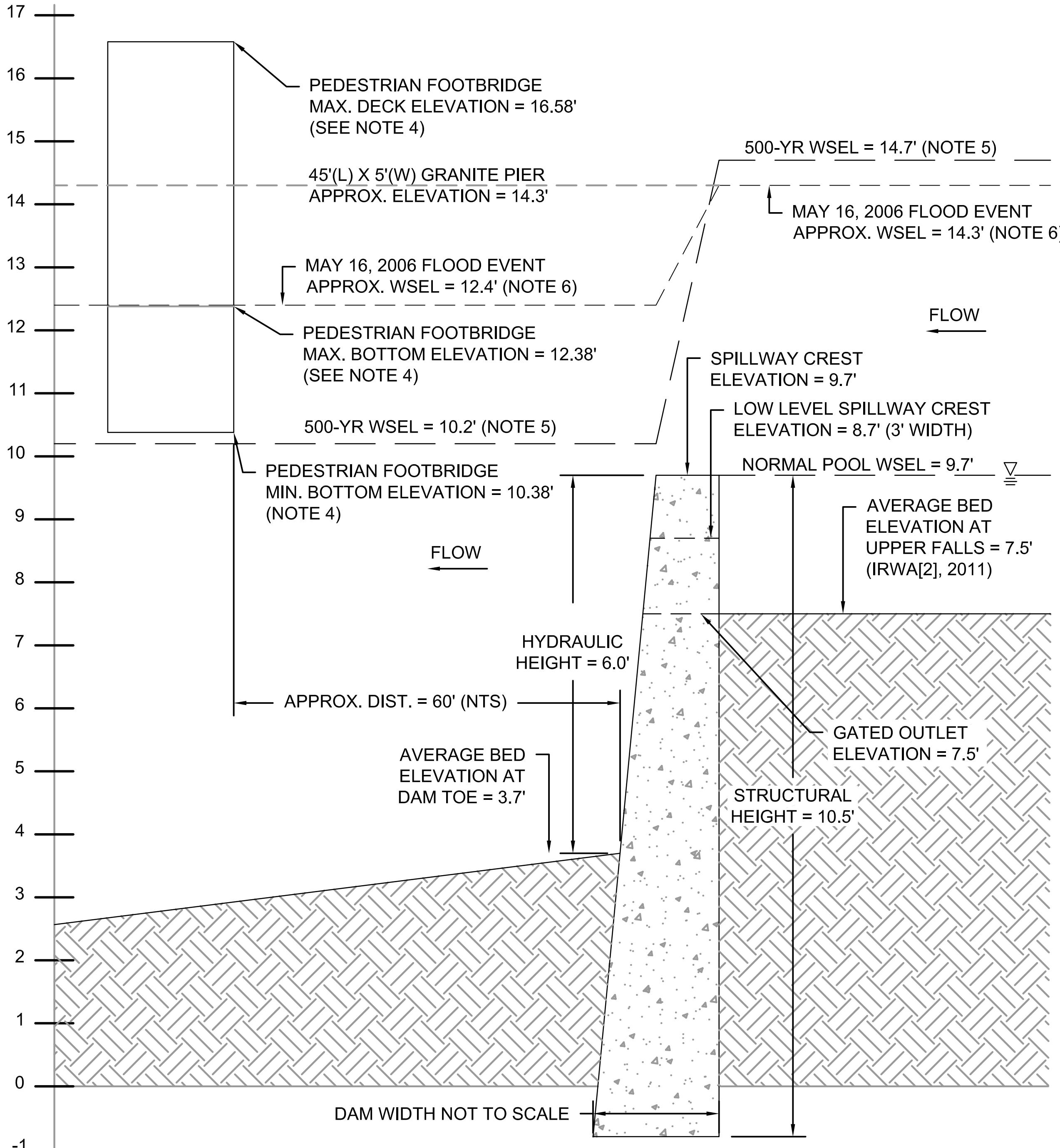
- There is also documented evidence showing that average annual precipitation in New England has increased, particularly among higher frequency storm events, and that flood frequency and intensity have also increased, particularly since 1970. This upward trend in flood series has been observed in 25 out of 28 New England watersheds with dominantly natural streamflow (meaning that climatically-induced impacts on hydrology have occurred independently of the effects from human development) (Collins, 2009). Collins analysis suggests that FEMA flood prediction methodologies should be more flexible and should be looking at precipitation after the 1970 climatologic shift to more conservatively estimate the more frequent (1-10 year) flood events, since rainfall patterns appear to have shifted in the early 1970s. As concluded in a subsequent research paper by Armstrong, Collins and Snyder (2011), "New England rivers appear to be shifting toward flow regimes that flood more frequently and with greater magnitude. Statistical flood frequency estimates calculated using pre-1970 data, or even the entire record, may underestimate discharges calculated for post-1970 data alone -particularly for high-frequency, low-magnitude events." In short, rainfall patterns and resulting flood frequency in New England are changing and the 1985 FIS does not capture that change in its assessment.

- Limited cross-sectional data in the area of the Ipswich Mills Dam for the 1985 FIS. The cross-sections for the HEC-2 model in the vicinity of the dam stop at the toe of the dam, upstream of the Choate Bridge. Therefore, the impacts of the Choate Bridge are not accurately reflected in the model. A new model would need to be developed with additional cross-sectional data to present more accurate predictions of water surface elevations.

- FIS-mapped flood plains do not appear to reflect real world experience. According to comments from the Dam Removal Feasibility Technical Committee, the water surface elevations observed in the river during specific flood events appear to be noticeably higher than those predicted by the FEMA FIS.

The Ipswich Mills Dam Phase I Inspection / Evaluation was completed by Haley & Aldrich, Inc. in October, 2009. The report highlights the significant features of the Ipswich Mills Dam, including dimensions, elevations, hydraulic capacity, structure design, and condition of the dam. The significant design elevations and dimensions for the dam and its appurtenances are summarized and illustrated in Figure 3.

As stated by Haley & Aldrich (2009), this dam is classified by the MA Office of Dam Safety as an Intermediate dam with Significant Hazard Potential, and failure of the dam would cause property damage and may result in loss of life if the failure occurred without warning and people were within the initial flood-wave. The report also documents the structural condition of the dam at the time of inspection and recommends minor repairs to prevent failure. The safety status of the Ipswich Mills Dam with respect to the need for repair was judged as “satisfactory” by Haley & Aldrich.



NOTES:

1. ALL ELEVATIONS REPORTED ARE IN FEET AND ARE BASED ON THE NATIONAL GEODETIC VERTICAL DATUM OF 1929 (NGVD).
2. WSEL = WATER SURFACE ELEVATION
3. UNLESS OTHERWISE NOTED, REPORTED ELEVATIONS AND DIMENSIONS IN THIS FIGURE WERE OBTAINED FROM THE IPSWICH MILLS DAM PHASE INSPECTION / EVALUATION REPORT (HALEY & ALDRICH, 2009).
4. ELEVATIONS WERE OBTAINED FROM THE *PEDESTRIAN BRIDGE OVER THE IPSWICH RIVER CONSTRUCTION PLANS* (BETA GROUP, INC. & MASSHIGHWAY, 2001).
5. ELEVATIONS WERE OBTAINED FROM THE IPSWICH, MA FLOOD INSURANCE STUDY (FEMA, 1985).
6. ELEVATIONS WERE APPROXIMATED BY IRWA FROM PHOTO DOCUMENTATION ON MAY 16, 2006 (SEE FIGURES 2A & 2B) IN CONJUNCTION WITH THE REFERENCES LISTED IN NOTES 3 AND 4.

Project Number:	Registration:	Prepared For:	Plan Set:	
11101		*Town of Ipswich* *25 Green Street* *Ipswich, MA 01938*	*IPSWICH MILLS DAM* *CROSS-SECTION* *IPSWICH, MASSACHUSETTS*	**Horsley Witten Group, Inc.** **Sustainable Environmental Solutions** **90 Route 6A** **Sandwich, MA 02563** **508-833-6600 voice** **508-833-3150 fax**
Sheet Number: *1 of 1*			Plan Title: *FIGURE 3*	Date: 06/04/2012 · Designed By: -- · Drawn By: KH · Checked By: EB

Historic accounts indicate that the Ipswich Mills Dam was built upon or just downstream of a rock ledge outcrop or small rock rapids, referred to as the 'upper falls.' According to Dam Removal Feasibility Technical Committee, the 'upper falls' likely extends from the Ipswich Mills Dam upstream approximately 10 feet. Reference to the upper falls is made in the historic accounts the Proceedings at the Annual meeting of the Ipswich Historical Society XIII, December 7, 1903, Page 24, and is supported by a diagram of downtown Ipswich in the late 17th century indicating a fording location on the river, which would naturally be a shallow firm surface, at approximately the location of the Ipswich Mills Dam before it was built (Ipswich in the Massachusetts Bay Colony 1633-1700; Thomas Franklin Waters, 1905). IRWA performed a preliminary field survey of the stream cross section approximately 10 feet upstream of the dam and observed refusal at the stream bottom, strongly suggesting the presence of ledge rather than sediment on the river bottom. This ledge outcrop is not identified in the FEMA FIS analysis but is visible during low flows.

4. Results and Discussion

The Ipswich Mills Dam is a run of the river dam that was built for the purpose of generating power for nearby buildings and manufacturing processes. It no longer serves that purpose and now stands as a relic structure in the river. A run of the river dam is operated such that the volume of water released below the dam is equal to the volume of water flowing in the stream or river above the dam on a continuous, real-time basis. Put another way, water is not stored in the impoundment to be released at a later time. Rather, the dam simply increases the head in the river, providing a power source that can be captured. This is typical of many small New England dams. It has five low level gates that, when originally installed, could be removed manually to adjust the water level in the River. However, as described in the 2009 dam safety inspection report (Haley and Aldrich, 2009), three of those gates have since been plugged, one has been fitted with a stainless steel slide gate operated by a handwheel and one controls flow to the fish ladder.

The dam itself was not constructed to provide flood control for the area downstream of the dam, and does not serve that purpose by default (Figure 4a). The dam provides relatively little storage (small head pond) by detaining flow behind the dam, and what is detained is actually occupying or using up a small portion of the flood storage capacity that would naturally be available in the flood plain in the absence of the dam. Because of its minimal storage capacity, this dam does not provide flood mitigation for areas downstream of the dam. Flows downstream of the river are essentially equal to what they would be in the absence of the dam because the river has created an equilibrium in which water flowing to the dam equals water flowing over and downstream from the dam.

As presented in Figure 3, there is only one foot of elevation difference between the low flow spillway crest and the overflow spillway crest. The storage volume between the two spillway crests is therefore minimal. The FEMA FIS plainly states in Section 2.4 Flood Protection Measures under the description of the Area Studied that 'These dams [including the Ipswich Mills Dam] are used for water power, and none affects flood flows." The exact extent of the impoundment is not clear from previous reports and estimates. According to Haley and Aldrich (2009), the impoundment from the dam extends upstream approximately 12,500 feet at an average width of 70 feet, and has a total surface area less than 1% of its contributing watershed area. The total volume of the impoundment at these measurements would be about 100 acre-feet, or about half the volume between the Mills and Willowdale dams. Conversely, preliminary field reconnaissance by IRWA suggests that the impoundment extends only 7,500 feet upstream to the commuter rail bridge (MacDougall, email correspondence, November 6, 2010).

In contrast, flood control dams and large power generation dams generally do not allow significant flows over the dam because the flows are regulated through a designated discharge near the base of the dam (Figure 4b). The significant storage volume behind the dam allows the dam to detain water so that flows downstream can be regulated, thus mitigating floods.

Typically, the removal of a run of the river dam would result in a reduction of the water surface elevation at and upstream of the dam location such that a new equilibrium is established (or rather, restored), while downstream water surface elevations typically do not change. Essentially, the relatively small volume of water stored behind the dam is 'released', but the flow toward the dam still equals the flow out below the dam and the natural water surface elevation is re-established.

In the case of the Ipswich Mills Dam, where it is presumed that a ledge outcrop and falls extends from the dam toe to approximately 10 feet upstream of the dam, it is reasonable to expect that once the dam is removed, the falls will become the new defining element in the river and will establish the new upstream water surface elevation during normal or low flow conditions. However, during flood flows, the existing dam and the rock ledge outcrop (or Upper Falls as it is commonly referenced) appear to have little impact on the water surface elevation or the river discharge due to the presence of numerous other impediments to flow, including the Choate Bridge, the pedestrian foot bridge, downstream tidal influence, and the sharp bend in the river downstream of the Choate Bridge. The amount of influence each of these impediments has on the current system is unknown at this time but can be estimated with future evaluation.

One of the most accurate and widely used methods for predicting and quantifying flood flows and water surface elevations is to create a hydraulic model using U.S. ACOE HEC software. A good example of a relevant HEC model was performed as part of the 2006 Feasibility Study for the Willowdale Dam Fish Passage Project (Alden Research Laboratory, 2006) upstream of the Ipswich Mills Dam. HEC analyses are also commonly used by FEMA for estimating flood zones and flood elevations. Models such as these can provide insight into how a dam or other flow impediments may contribute and affect flood elevations. In order to create such a model, it is necessary to obtain detailed cross-sectional geometry for the stream reach of interest. In the case of the Ipswich Mills Dam, cross-sections would be needed above and below the following locations: the Choate Bridge crossing at Route 133/South Main Street, the Ipswich Mills Dam, the Boston/Maine railroad crossing near the confluence with the Miles River, the Willowdale Dam, and any intermediate road crossings. Some of these data were collected by FEMA in 1985 and modeled for the 1985 Flood Insurance Study but how well they reflect current conditions is uncertain.

Figure 4a. The Ipswich Mills Dam is a run-of-the-river mill dam formerly used to power the nearby mills. (Horsley Witten Group, November 2011)

Figure 4b. The Westville Lake Flood Control Dam on the Quinnebaug River in Southbridge, MA serves to control flooding to downstream areas. This dam serves an entirely different purpose than the Ipswich mills Dam. (US Army Corps of Engineers)

A HEC analysis is not part of this report's scope of work, but would be a key task in the next phase of a feasibility study, should such a study be undertaken. Instead, two other dam removal feasibility studies that rely on HEC analyses for flood predictions are presented and discussed as examples here in order to correlate results and make educated assumptions for the Ipswich Mills Dam project area.

In 2008, a dam removal feasibility study was completed for the Mill River in Taunton, MA which utilized HEC-RAS to estimate flood elevation changes associated with the removal of three existing "run-of-the-river" dams. The modeling results show that the depths at and upstream of the dam locations were expected to decrease under all flow conditions up to and including the 100-year frequency storm event (Woodlot Associates, Inc. & Inter-fluve, Inc., 2008). Typically, the largest decreases in water levels were shown just upstream of the existing dam locations, or at the deepest part of the reservoirs. The expected reduction in water depth declined upstream, moving away from the influence of the impoundment. Little to no change in water surface elevation was shown at the most downstream location following dam removal.

These same hydraulic changes were predicted by a similar dam removal feasibility study completed in 2010 for the Curtis Pond Dam in Danvers, MA. The Curtis Pond Dam removal feasibility study evaluated the expected water level change upstream and downstream of the dam for the 2-, 10-, 25-, 50-, and 100-year frequency events. Water levels were anticipated to drop approximately five-feet in Curtis Pond following removal and no change in water level was predicted downstream of the dam (Pare Corporation, Kleinfelder/SEA Consultants, IRWA; 2010).

When considering the effects on the Ipswich Mills Dam system, a predicted decrease of upstream water depth and water surface elevation will likely result in proportionally decreased local groundwater levels (greatest groundwater declines closest to the dam removal site). Loss of nearby wetland resource areas upstream of the dam is also a possibility, but further investigation would be required to identify the wetland areas of concern and determine if they are primarily groundwater or surface water dependant. It is not expected that a groundwater level decrease would impact drinking water availability since there are no documented pumping sources in the vicinity of the impoundment area (Ipswich Utilities, 2012). Long-term downstream water elevations are not anticipated to change because the amount of water impounded by the dam is insignificant in relation to the normal flow of the river.

One factor at the project area that may play an important role in governing the downstream flow conditions, perhaps more so than the Ipswich Mills Dam itself, is the Choate Bridge river crossing. The Choate Bridge currently acts as a flow restriction due to its limited open cross-sectional area. The extent of this flow restriction and the impacts of the bridge span on the flow of the river during various high flow scenarios are not known at this time. In addition, given that the Ipswich Mills Dam represents the approximate head of tide in the river, the tide itself creates an additional influence on the downstream flow in the river and the resulting flood elevations. In order to more fully understand the likely impact of the Choate Bridge and head of tide on the river flow and elevation under both current and potential dam removal conditions, a detailed hydraulic and hydrologic analysis, including a HEC model, must be performed. This involves measuring the cross-sections of the river and evaluating the surficial characteristics (roughness) at various key locations extending from upstream of the dam to well downstream of the Choate Bridge, and then creating a three-dimensional model of the river through which various flows can be input to estimate the water surface elevations throughout the study area.

5. Conclusions

Many factors must be considered when deciding whether or not to remove a dam, including the hydrologic and hydraulic factors presented in this preliminary assessment. Based upon the information compiled and reviewed for this assessment, it seems relatively clear that the dam no longer serves its initial intended purpose of providing a small scale energy source for the surrounding mill activities. Because of the dam's basic design and relatively small size, it does not provide significant active (regulated) flood mitigation services for areas downstream of the dam. While the head pond created behind the dam is relatively small in comparison to the average annual and average monthly discharge passing over the dam, the dam does raise the surface elevation of the water upstream of the dam above what would exist in the absence of the dam. Based on historical records and anecdotal observations reported during low flow conditions, it is generally believed that the dam was constructed on top of or at the toe of a rock ledge outcrop that created the Upper Falls. The extent of that ledge is yet to be determined, but it would be expected that in the absence of the dam, the height of the rock ledge rock ledge will be a primary factor in determining the normal or low water surface elevations. The Mill River and Curtis Pond dam removal feasibility studies serve as good examples of how to evaluate the expected conditions associated with removing a run of the river mill dam.

6. Scope of Work for Full Hydrologic and Hydraulic Analysis of Ipswich Mills Dam Removal

The next steps for this feasibility assessment are to develop a more detailed understanding of the flows (discharge, surface elevation, velocities) in the river under existing conditions from the area upstream of the Ipswich Mills Dam to downstream of the Choate Bridge, and to use that information to predict the conditions in the river under the potential dam removal scenario. It is important for the town to understand what impact the dam is having on the flow regime in the river (both high flows and low flows) and to develop an understanding of the potential risks and benefits from dam removal. This includes estimating the future river water surface elevations and the flow velocities in the area of the dam if it were to be removed. This would need to be evaluated under all flow conditions (i.e., low, normal, and flood flows) to gain an informed understanding of the impact of dam removal.

A basic tool in developing this understanding is the HEC-RAS model, which is publically available from the Army Corps of Engineers and is the industry standard in modeling river and stream hydraulics. Data requirements for this type of analysis include obtaining detailed cross-sectional data and Manning's roughness coefficient inputs that are representative of current conditions in the river. As previously described, data originally used by FEMA in the 1985 Flood Insurance Study are unlikely to represent current conditions due to continued development in the watershed since the time the data were collected and subsequent changes to flow rates, flow patterns, rainfall, erosion and sedimentation. It is highly probable that the current hydrology for the Ipswich River Watershed varies greatly from the conditions observed at the time the Flood Insurance Study was prepared. Development and land use changes can have significant impacts on a river's flow regime. Therefore, the flow rates at the Ipswich Mills Dam should be reassessed, which can accurately be performed since flow measurements have been recorded for the last 80 years at the Willowdale Dam. The USGS has published and made available sufficient resources and documentation to develop a new discharge-frequency relationship for the project area. Any necessary revisions can be applied to the HEC analysis and used to develop more representative flood predictions for current hydrologic conditions, as well as possible future scenarios.

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APPENDIX A. USGS Water Data Report 2009, Ipswich River Gage near Willowdale Dam

Water-Data Report 2009

01102000 IPSWICH RIVER NEAR IPSWICH, MA

MASSACHUSETTS-RHODE ISLAND COASTAL BASIN
IPSWICH RIVER SUBBASIN

LOCATION.--Lat 42°39′35″, long 70°53′39″ referenced to North American Datum of 1927, Essex County, MA, Hydrologic Unit 01090001, on left bank 200 ft downstream from Willowdale Dam, 1.5 mi downstream from Howlett Brook, and 4 mi upstream from Ipswich.

DRAINAGE AREA.--125 mi^2.

SURFACE-WATER RECORDS

PERIOD OF RECORD.--Discharge: June 1930 to current year. Water-quality records: water years 1954, 1976-79.

REVISED RECORDS.--WSP 1621: 1930-58 (monthly runoff). WDR MA-RI-84-1: Drainage area.

GAGE.--Water-stage recorder with satellite telemeter. Datum of gage is 20.63 ft above National Geodetic Vertical Datum of 1929.

COOPERATION.--Massachusetts Department of Conservation and Recreation, Water Resources Commission; Massachusetts Department of Environmental Protection, Office of Watershed Management; and Massachusetts Executive Office of Energy and Environmental Affairs.

REMARKS.--Records good except those for estimated daily discharge, which are poor. Diversions upstream for municipal supply of Reading, Lynn, Peabody, Danvers, Salem, and Beverly. Some regulation by reservoirs upstream.

01102000 IPSWICH RIVER NEAR IPSWICH, MA—Continued

DISCHARGE, CUBIC FEET PER SECOND
WATER YEAR OCTOBER 2008 TO SEPTEMBER 2009
DAILY MEAN VALUES
[e, estimated]

Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	442	135	380	e569	192	506	320	227	89	253	977	211
2	431	131	410	e530	199	416	328	206	87	295	590	203
3	391	130	440	e481	204	411	327	189	82	352	441	179
4	351	125	443	e436	198	429	349	175	78	410	389	152
5	314	123	413	380	192	417	375	168	64	451	348	130
6	274	122	358	e359	186	391	412	176	68	456	311	114
7	241	137	313	326	177	397	485	200	66	431	273	103
8	211	150	e264	330	175	443	541	230	58	431	239	95
9	189	161	203	e344	178	474	558	254	54	423	213	89
10	166	167	187	e335	180	530	521	261	51	411	193	82
11	148	164	198	299	183	589	479	249	47	387	170	78
12	134	150	416	285	207	654	451	227	67	368	150	91
13	122	135	767	e275	251	646	423	203	77	342	135	96
14	112	129	1,020	e250	287	603	397	182	103	314	122	94
15	104	126	1,050	e236	313	547	365	167	138	292	110	93
16	95	136	925	e214	323	498	334	152	154	262	103	96
17	88	135	801	193	313	459	303	145	157	230	97	95
18	83	134	697	179	297	424	279	139	157	211	91	91
19	78	135	595	169	298	393	260	134	175	190	85	84
20	74	126	441	165	319	367	241	120	185	170	80	76
21	72	116	398	162	341	343	260	108	194	154	73	71
22	71	108	376	158	361	319	312	96	219	148	69	68
23	67	100	e390	157	420	297	368	87	244	145	68	65
24	67	95	e379	156	462	278	403	80	261	267	74	60
25	67	123	e385	159	471	262	400	74	268	477	86	56
26	79	177	e442	159	449	243	372	68	269	583	93	50
27	85	242	460	157	437	235	341	63	256	588	99	48
28	99	316	597	154	498	233	312	67	233	527	100	50
29	115	358	897	161	---	246	287	71	218	444	133	61
30	129	359	740	172	---	272	252	81	231	429	172	61
31	134	---	e636	181	---	297	---	87	---	542	204	---
Total	5,033	4,745	16,021	8,131	8,111	12,619	11,055	4,686	4,350	10,983	6,288	2,842
Mean	162	158	517	262	290	407	368	151	145	354	203	94.7
Max	442	359	1,050	569	498	654	558	261	269	588	977	211
Min	67	95	187	154	175	233	241	63	47	145	68	48
Cfsm	1.30	1.27	4.13	2.10	2.32	3.26	2.95	1.21	1.16	2.83	1.62	0.76
In.	1.50	1.41	4.77	2.42	2.41	3.76	3.29	1.39	1.29	3.27	1.87	0.85

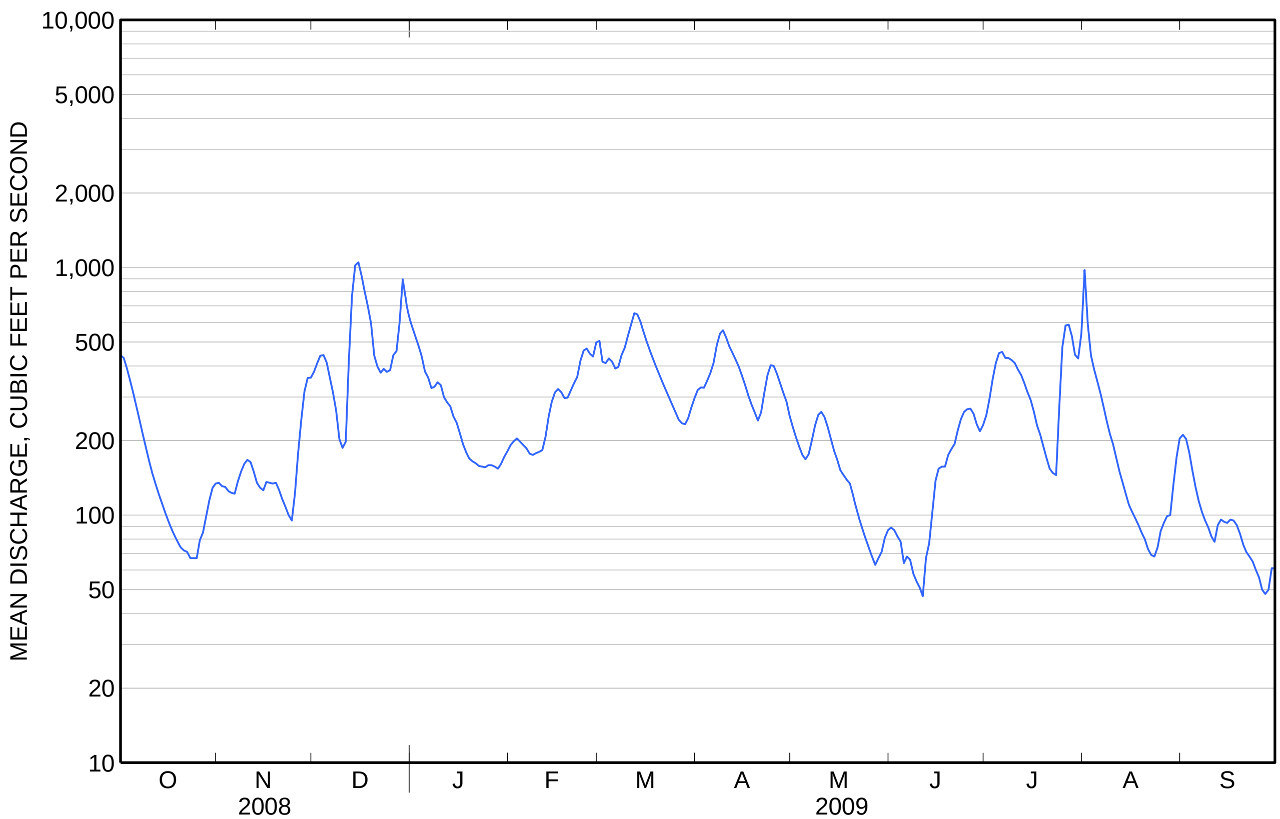
STATISTICS OF MONTHLY MEAN DATA FOR WATER YEARS 1930 - 2009, BY WATER YEAR (WY)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Mean	81.5	140	198	212	247	446	443	257	160	64.7	42.0	43.7
Max	749	525	621	566	675	1,158	1,233	1,309	821	518	356	390
(WY)	(1997)	(1933)	(1997)	(1958)	(2008)	(1983)	(1987)	(2006)	(1982)	(1938)	(1938)	(1954)
Min	4.75	6.87	11.5	14.4	16.4	75.0	97.1	83.5	25.6	5.75	2.13	1.49
(WY)	(1998)	(1966)	(1966)	(1966)	(1980)	(1989)	(1985)	(1999)	(1976)	(1957)	(1965)	(2005)

01102000 IPSWICH RIVER NEAR IPSWICH, MA—Continued

SUMMARY STATISTICS

	Calendar Year 2008		Water Year 2009		Water Years 1930 - 2009	
Annual total	105,459		94,864			
Annual mean	288		260		194	
Highest annual mean					374	2006
Lowest annual mean					57.7	1966
Highest daily mean	1,560	Mar 10	1,050	Dec 15	4,550	May 16, 2006
Lowest daily mean	24	Sep 5	47	Jun 11	0.59	Sep 21, 1978
Annual seven-day minimum	33	Aug 31	55	Sep 24	0.90	Oct 1, 2005
Maximum peak flow			1,120	Aug 1	4,600	May 16, 2006
Maximum peak stage			5.54	Aug 1	10.53	May 16, 2006
Instantaneous low flow			20	Jun 5	0.34	Sep 20, 1978
Annual runoff (cfsm)	2.31		2.08		1.55	
Annual runoff (inches)	31.38		28.23		21.11	
10 percent exceeds	668		472		454	
50 percent exceeds	178		211		118	
90 percent exceeds	55		78		12	



SECTION 2:

Evaluation of Potential Impacts on EBSCO Buildings from the Proposed Removal of Ipswich Mills Dam

GEI Consultants

16 Pages

Memo

To: Mr. Glenn Gibbs, Town of Ipswich

From: Michael A. Yako, P.E.

c: Brian Kelder, Ipswich River Watershed Association
Giuliana Zelada-Tumialan, P.E., Simpson Gumpertz & Heger, Inc.

Date: Revised February 14, 2014,December 13, 2013

Re: Evaluation of Potential Impacts on EBSCO Buildings from Proposed Removal of Ipswich Mills Dam
Ipswich, Massachusetts
GEI Project No. 1325760

The purpose of this memorandum is to present the results of our evaluation of the potential impacts of the removal of the Ipswich Mills Dam on the EBSCO buildings. We prepared this interim memorandum based on: our review of documents provided by the Town of Ipswich, Ipswich River Watershed Association, and EBSCO; discussions with you and Mr. Brian Kelder; and our August 27, 2013 site visit.

Our work for this project was authorized by a signed agreement between the Town of Ipswich and GEI dated May 14, 2013. GEI was assisted on this project by Ms. Giuliana Zelada-Tumialan of Simpson Gumpertz & Heger, Inc. (SGH).

Summary

The portion of the EBSCO buildings along the Ipswich River are likely supported on timber piles given the soil conditions along the river and the age of the buildings. We were unable to identify any information regarding the elevation of the tops of the suspected timber piles; consequently, we don't know if the removal of the dam would likely expose the tops of the piles causing them to deteriorate resulting in damage to the building.

As discussed in more detail below, we recommend performing the following additional work: literature search for historic records of the former dams; lowering of the impoundment for maximum exposure of the EBSCO foundation wall along the river; soil probing along the EBSCO foundation wall in the river; a more extensive river sounding program; and possibly coring through the EBSCO foundations or excavating test pits inside the EBSCO building to expose the foundations.

Background Information

We understand that the Town would like to remove the Town-owned Ipswich Mills Dam on the Ipswich River. The location of the dam is shown in Figs. 1 and 2. It is expected that removal of the dam would enhance fish passage and ecological connections between the river, estuary, and ocean, and reduce the Town's liability and maintenance costs associated with the dam. However, removal of the dam could affect the foundations supporting the EBSCO buildings. In particular if the buildings are supported on timber piles and if the river level drops below the tops of the piles, the piles could deteriorate leading to settlement and damage to the buildings.

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Our work is part of a larger study that also included an evaluation of the influence of the dam on upstream and downstream flooding and an evaluation of the quality of the sediment behind the dam.

Ipswich Mills Dam and River Bed Topography

The first dam at this location was constructed in 1637. A number of larger dams were constructed over the years with the current dam being constructed or reconstructed in about 1908. The dams were constructed to provide power to the industries along the river. The dam is currently owned by the Town of Ipswich and no longer serves its original purpose.

The current dam is located about 4 miles from the mouth of the Ipswich River and sits on a bedrock outcrop referred to as the Upper Falls. The river is tidal below the dam.

The current dam is constructed out of cut stones with concrete at some locations and is a run of the river dam with the spillway extending across most of the width of the river. The main spillway is 132 feet wide. A 3-foot-wide low level stop-log spillway is at the right end of the main spillway. The spillway crest is at El. 9.7[1] and the low level stop-log spillway invert is at El. 8.7. The dam also has a 4.5-foot-wide by 3-foot-high low level gated outlet with an invert at El. 7.5 on the right side of the dam. The right side of the dam also includes a fish ladder and a non-overflow granite block wall or pier that extends approximately 45 feet into the river and abuts the right end of the spillway.

We were provided the results of soundings performed across the width of the river 10 feet upstream of the dam. The information from the soundings is provided in Appendix A. We were told that the soundings represent the top of bedrock upstream of the dam. Consequently, if the dam is removed, the river should not drop below the lowest elevation of the bedrock upstream of the dam or El. 6.3. This would represent a drop of 3 feet below the dam spillway elevation and a drop of 1.2 feet below the invert of the low level outlet.

EBSCO Buildings

The EBSCO Information Services' buildings that are the subject of this evaluation are the buildings located on the west side of the river immediately upstream of the dam as shown in Figs. 1 and 2. These buildings, which are identified as Nos. 9, 10, and 10-A in the plan in Appendix B, were constructed between approximately 1901 and 1912. Building Nos. 6, 7, 8, and a portion of No. 9 no longer exist. No other plans are reportedly available for the buildings.

As shown in the plan in Appendix B and in Figs. 1 and 2, the east side of Building Nos. 9, 10, and 10-A are located immediately on the property line and buildings directly abut the river for most of their length. As shown in Figs. 1 and 2 and based on our observations and review of historic aerial photographs, the ground surface is above the river level along a portion of the buildings.

Mr. Thomas Wheeler of EBSCO provided GEI with the logs of three soil borings that were performed in 2009 immediately south of the southeast corner of Building No. 10-A. The general location of the borings is shown in Fig. 1 and a more detailed plan showing the boring locations is provided in Appendix C. Logs of the borings are also contained in Appendix C. The two borings closest to the river (B-3 and B-4) both encountered about 16 feet of loose fill, soft to medium stiff

[1] Elevations in this report are in feet and are based on the National Geodetic Vertical Datum (NGVD).

clay, and organic soils (peat) overlying very dense glacial till. Boring B-2, which is located further from the river encountered 10 feet of fill overlying very dense glacial till. B-2 did not encounter clay or peat.

The fill, clay, and peat are not a suitable bearing layer for support of the buildings. Consequently, it is our opinion that at least some portion of the EBSCO buildings along the river are likely supported on deep foundations. Given the age of the buildings, we anticipate that the deep foundations likely consist of driven timber piles. Portions of the buildings further from the river are likely supported on spread footings where the glacial till is much shallower and where the foundation excavations could be dewatered and not impacted by large groundwater inflows from the river.

Some of the existing and former buildings pre-date the construction or reconstruction of the existing dam. The crest elevation of the former dams and the elevation of the river at the time of construction of the older buildings are not known. It is possible that the tops of the foundations supporting the buildings that pre-date the current dam may have been constructed when the impoundment behind the dam was maintained at a lower elevation. Consequently, the tops of the timber piles supporting these older buildings could have been established based on a lower impoundment elevation and may not be at risk of biodeterioration from removal of the dam.

We were able to view a very limited portion of the exterior brick façade at the southeast corner of Building 10-A. The façade appeared to be in good condition with no readily visible signs of distress.

Mr. Wheeler provided a tour of the interior of their buildings to Ms. Zelada-Tumialan of SGH and Mr. Michael Yako of GEI. We did not observe any building features that provided any indication as to the type of foundations supporting the buildings along the river. We observed some dishing of the first floor slab indicating that the slab is a slab-on-grade and that the soils underlying the slab are compressible and had settled. This is consistent with the soils encountered in the borings discussed above.

Following our August 27, 2013 site visit, we visited the Building Inspector’s office and reviewed their files for the EBSCO buildings; however, we were not successful in finding any information in the Town’s files about the EBSCO building foundations.

We requested permission to probe along the foundation wall along the river to try and identify the bottom of the foundation wall. This would provide some information about the tops of the piles for the exterior foundation wall along the river. However, EBSCO required that the Town and GEI assume all liability in the event contaminated materials were encountered while probing or performing any other intrusive investigations. Since the Town and GEI couldn’t assume the liability, no intrusive investigations were performed.

Methods of Protecting EBSCO’s Timber Piles

Assuming that portions of the EBSCO buildings are supported on timber piles, the tops of the timber piles need to be below water to protect them from rapid deterioration (biodeterioration).

Methods that have been implemented on other projects to protect timber piles have included artificially raising groundwater levels to keep the piles submerged, lowering the tops of the piles below the expected future groundwater level, or a combination of raising groundwater levels and cutting off the tops of the piles.

Artificially raising the groundwater level involves installing a series of discrete points or pipes below the building floor slab through which water is recharged into the ground. Instrumentation to monitor groundwater levels is needed to confirm that the groundwater level is maintained above the tops of the piles and below the floor slab. A significant amount of work would need to be performed from inside the building. To improve the effectiveness of the recharge system, a barrier wall may be needed in the river immediately alongside the EBSCO building. The purpose of the barrier wall is to retain the recharged water below the building to reduce the volume of water required to be recharged and to help maintain relatively uniform water levels below the building. The 550- to 600-foot long barrier wall could be constructed using steel or vinyl sheet piles. A barrier wall may not be needed if the existing foundation walls extend into the clay layer, which would serve to retain the water below the building because of its relatively low permeability.

Other significantly more costly and intrusive methods include cutting off the tops of the timber piles that extend above the future water level and replacing the cutoff section of pile with a steel post encased in concrete, or providing entirely new foundations such as drilled mini-piles or helical piers to replace the existing timber piles. To perform this work, groundwater levels below the building would need to be lowered at least 5 to 6 feet below the bottom of the existing floor slab. To lower the groundwater below the building, a steel sheet pile cofferdam would need to be installed along the river side of the building and the south side of the building. Sheet piles cannot be driven on the north side of the building because of the existing granite block retaining wall. Some other means such as jet grouting would need to be used to create a cofferdam.

As discussed below, additional information would be required to evaluate the most appropriate method(s) to protect the timber piles. Based on our experience on other projects, we would expect the cost of installation of a recharge system plus a barrier wall to be in the hundreds of thousands of dollars, and we would expect the cost to cut and post the timber piles would be in excess of a million dollars. These estimates are very preliminary and are intended to only provide an indication of the relative magnitude of the possible cost for the methods discussed. Additional information would be required to refine the estimates.

Recommendations for Additional Work

We recommend that the town consider performing the following additional work:

1. Literature Search – Review the Town's historic records for information on the former dams. In particular information on the date of construction and spillway elevations of the dams may provide information on the top of pile elevations for the various buildings. In addition, newspaper articles from the early 1900s may include information on the construction of the EBSCO buildings.

2. Lower the Impoundment – During a period of relatively low flow, fully open the low level gated outlet to lower the impoundment as far as possible. This will provide maximum exposure of the EBSCO foundation wall along the river and may provide some useful information. However, we expect that the EBSCO foundation walls extend deeper than El. 7.5, the invert of the low level gated outlet. It would be helpful to confirm this.

3. Probe Along the EBSCO Foundation Wall – Based on the plan in Appendix B, the EBSCO buildings are located immediately on the property line. The Town could probe the river bottom along the building off of EBSCO property. This information will supplement the information from the borings, and provide some indication of the extent of the EBSCO

buildings that may be supported on timber piles. No soil or sediment samples would be collected during the probing. If the probe contacts the foundation wall, it may be possible to estimate the elevation of the bottom of the foundation wall/pile cap, which would provide information on the elevation of the tops of the piles along the river side of the EBSCO buildings. The piles supporting interior columns and other portions of the building could be cutoff at different elevations. This probing should be performed in conjunction with lowering the impoundment.

4. Perform River Soundings – Perform a more extensive sounding program to better define the top of bedrock elevations upstream of the dam to evaluate the expected elevation of the impoundment adjacent to the EBSCO building should the dam be removed.

5. Coring Through EBSCO Foundations – If EBSCO provides access to the interior of their buildings, it may be possible to core vertically down through the foundation walls of the three buildings along the river and through the foundations supporting the interior columns of the buildings. This would provide information on the bottom of the foundations/pile caps and the tops of the piles. The coring could be performed on weekends to limit disturbance to EBSCO's operations. A site visit would be required to evaluate whether coring is feasible based on ceiling heights, access to the work areas, and existing use of the space.

6. Test Pits in EBSCO Building – The most definitive way to determine whether the EBSCO buildings are supported on timber piles and the elevations of the timber piles is to perform a series of test pit excavations from inside the building. We would expect that a minimum of 6 test pits would be required. Dewatering of the test pits could be very difficult and costly given the close proximity of the river.

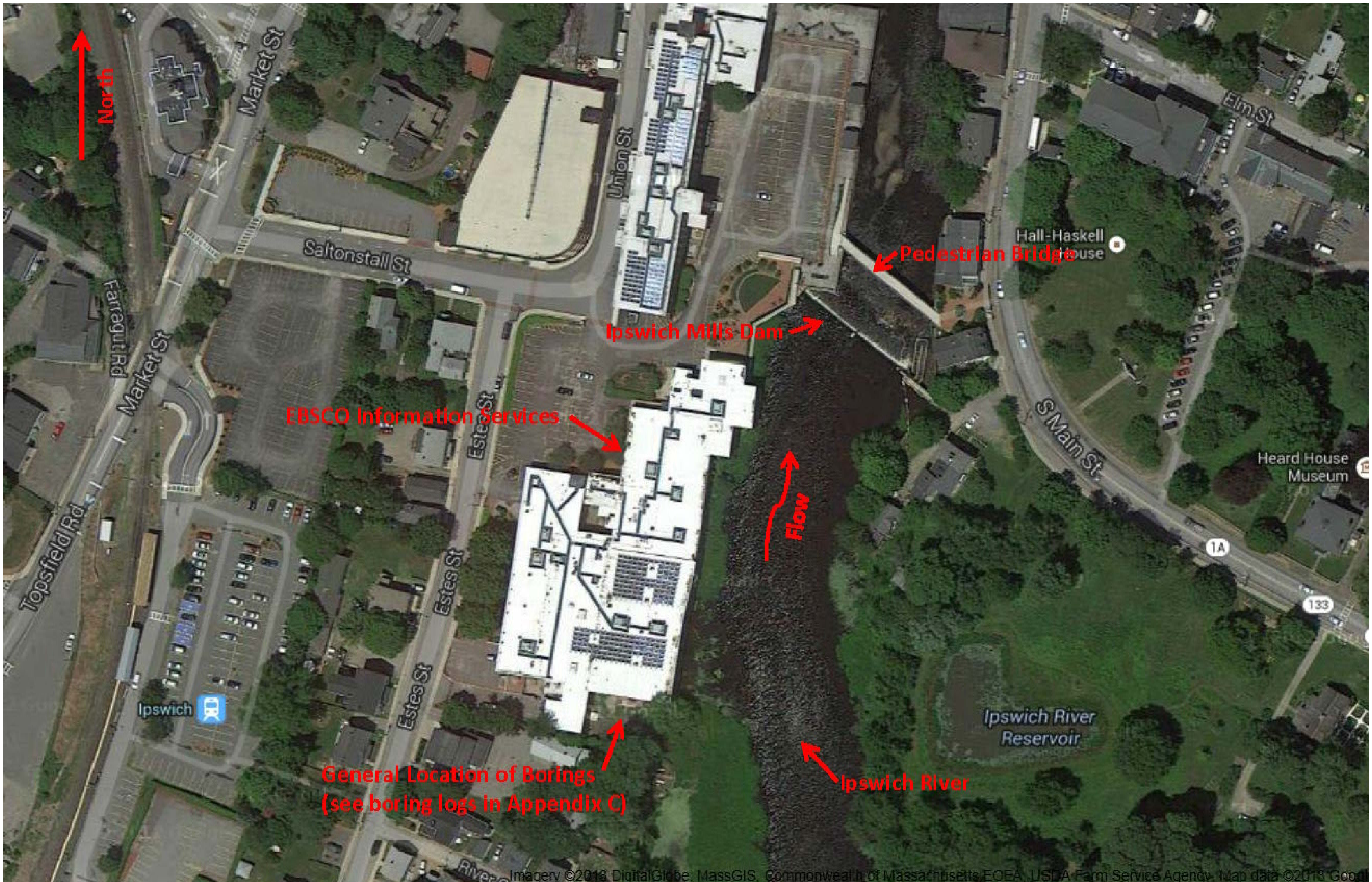
We appreciate the opportunity to be of service to the Town and would be pleased to meet with you to discuss the results of our evaluation.

Please call (781-721-4043) or e-mail (myako@geiconsultants.com) if you have any questions.

Attachments:

Fig. 1 - Aerial View of Project Area
Fig. 2 – EBSCO Building Nos. 9, 10, and 10-A
Appendix A – Riverbed Soundings Data and Plot
Appendix B – Historic Plan Showing EBSCO Building Locations
Appendix C – Boring Location Plan and Boring Logs

MAY:mrb
M:\PROJECT\2013\132576\GEI Evaluation Memo\Evaluation of Dam Removal on EBSCO Buildings 2-14-2014.docx.



Source: **Google Maps**

0 150 300

APPROXIMATE SCALE, FEET

Evaluation of Ipswich Mills Dam Removal
on EBSCO Buildings
Ipswich, Massachusetts

Town of Ipswich
Ipswich, Massachusetts

GEI Consultants

Project 1325760-0

AERIAL VIEW OF
PROJECT AREA

December 2013

Fig. 1

M:\DRAFTING\2013\1325760 Ipswich Mills Dam\1325760-01

Source: **Bing Maps**

Evaluation of Ipswich Mills Dam Removal on EBSCO Buildings Ipswich, Massachusetts	GEI Consultants	EBSCO BUILDING Nos. 9, 10, AND 10-A	
Town of Ipswich Ipswich, Massachusetts	Project 1325760-0	December 2013	Fig. 2

M:\DRAFTING\2013\1325760 Ipswich Mills Dam\1325760-01

Appendix A

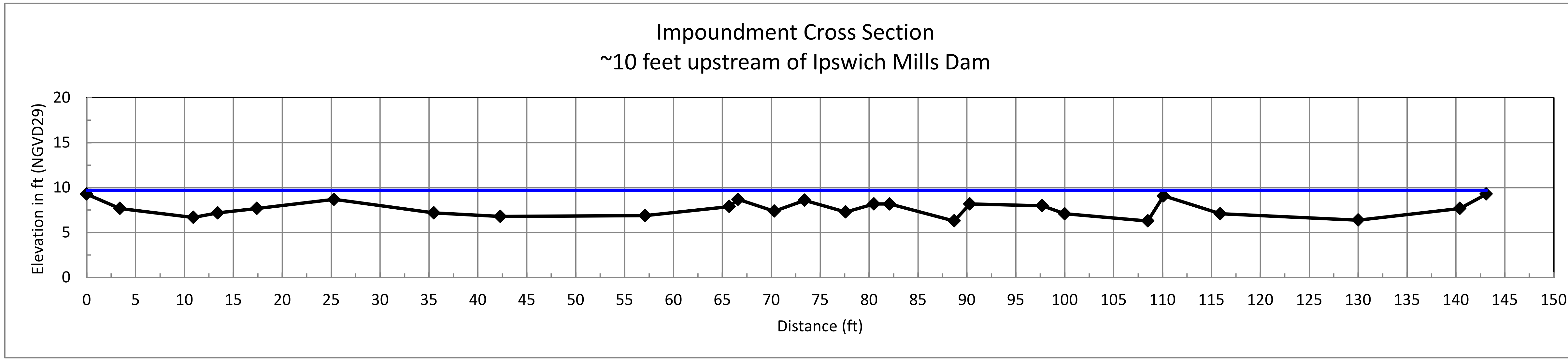
Riverbed Soundings Data and Plot

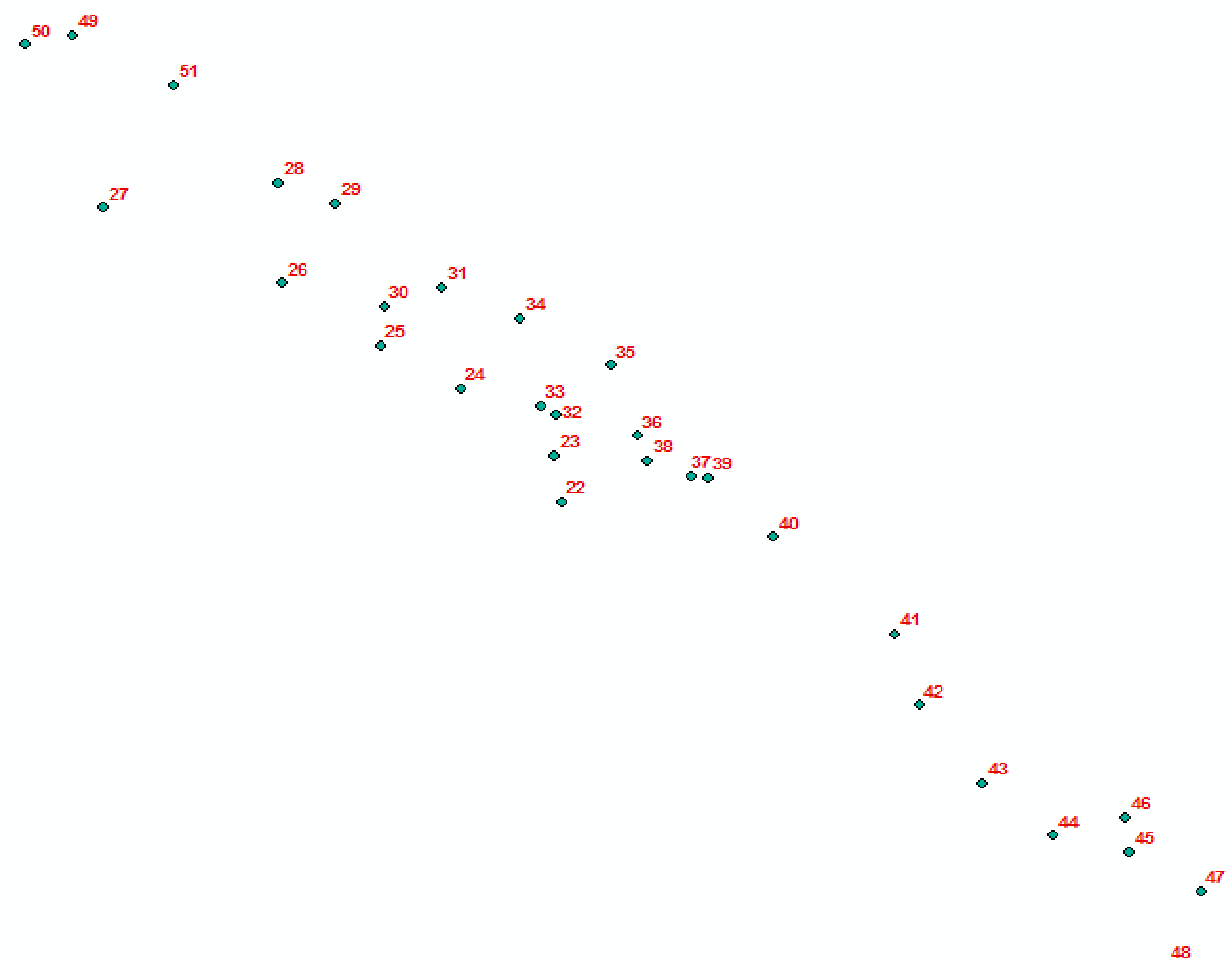
Pt		Depth	Station	Elevation
48	0	0.0	0.0	9.3
47	0	1.6	3.4	7.7
45	0	2.6	10.9	6.7
46	0	2.1	13.4	7.2
44	0	1.6	17.4	7.7
43	0	0.6	25.3	8.7
42	0	2.1	35.5	7.2
41	0	2.5	42.3	6.8
40	0	2.4	57.1	6.9
39	0	1.4	65.7	7.9
37	0	0.6	66.6	8.7
38	0	1.9	70.3	7.4
36	0	0.7	73.4	8.6
23	2	2.0	77.6	7.3
32	0	1.1	80.5	8.2
33	0	1.1	82.1	8.2
24	3	3.0	88.7	6.3
34	0	1.1	90.3	8.2
31	0	1.3	97.7	8.0
30	0	2.2	100.0	7.1
26	3	3.0	108.5	6.3
29	0	0.2	110.1	9.1
28	0	2.2	115.9	7.1
51	0	2.9	130.0	6.4
49	0	1.6	140.4	7.7
50	0	0.0	143.1	9.3

Data not used in the cross section

35	0	0.6		8.7
22	3	3.0		6.3
25	2	2.0		7.3
27	4	4.0		5.3

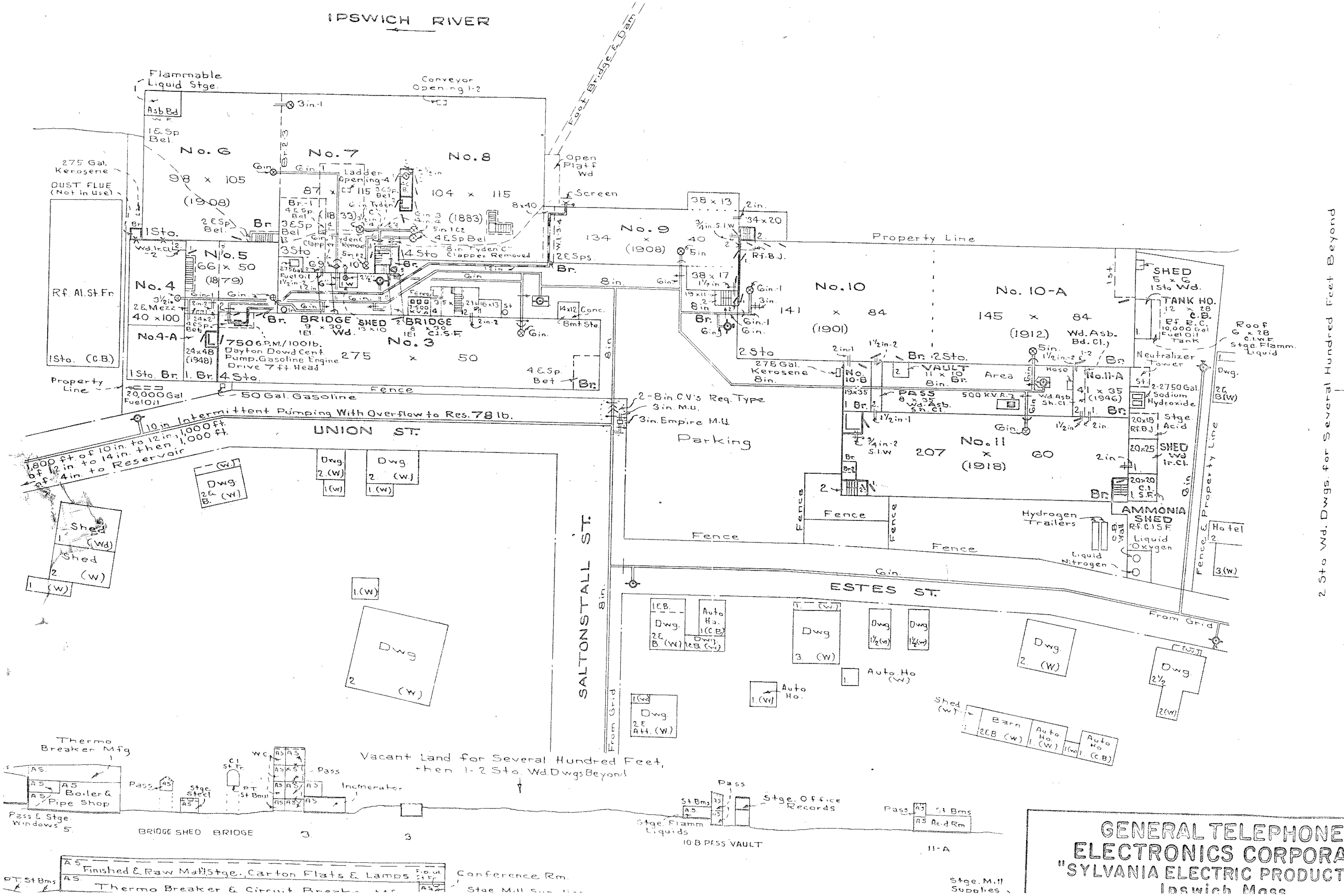
5 inches below spillway		Spillway crest
9.3	0	9.7
	143.1	9.7





Appendix B

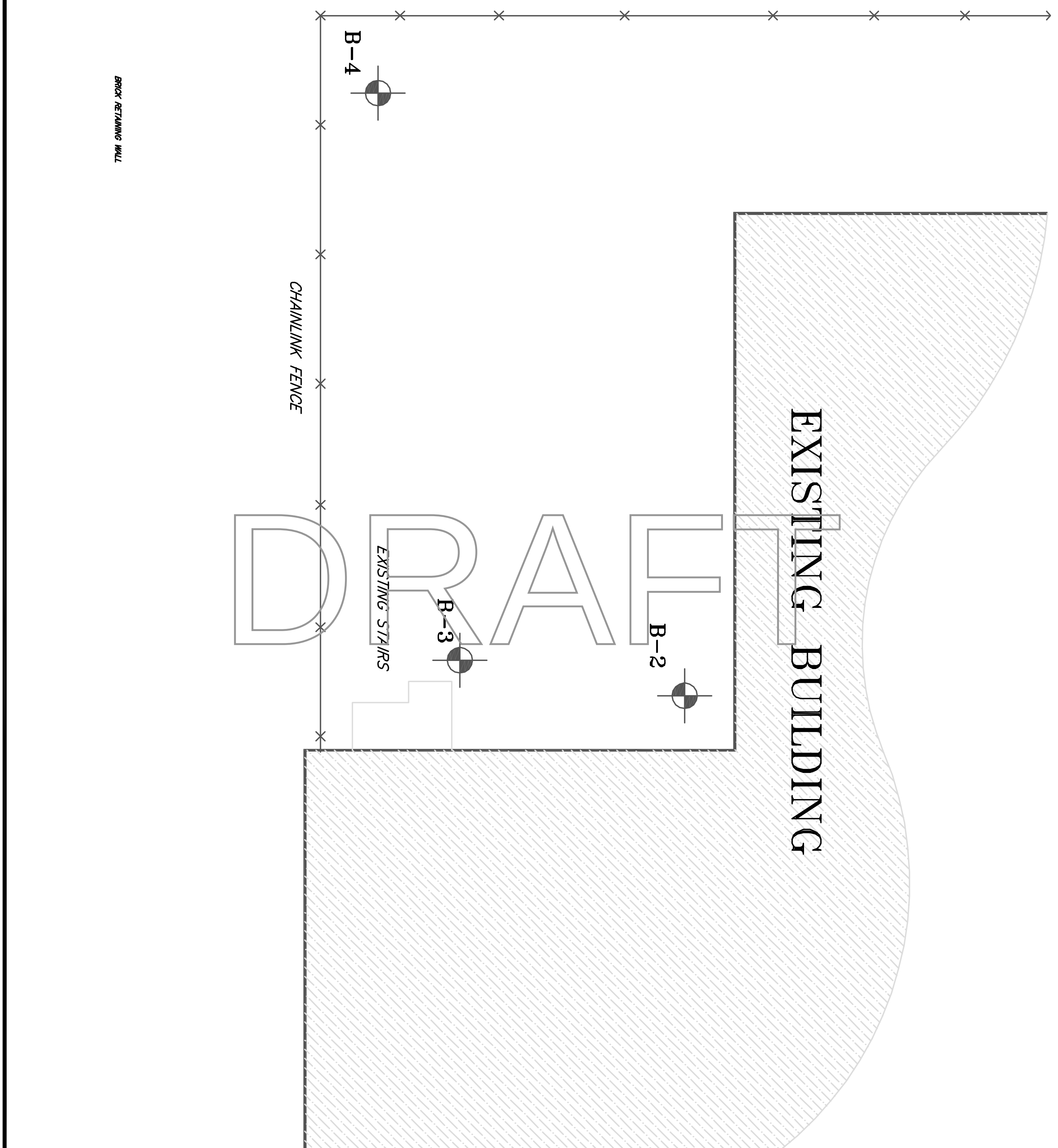
Historic Plan Showing EBSCO Building Locations



GENERAL TELEPHONE & ELECTRONICS CORPORATION
"SYLVANIA ELECTRIC PRODUCTS, INC.
Ipswich Mass

Appendix C

Boring Location Plan and Boring Logs



TITLE:

BORING LOCATION PLAN

PROJECT: **EBSCO PUBLISHING WAREHOUSE EXPANSION**
IPSWICH, MASSACHUSETTS

CLIENT: **PARK CONSTRUCTION CORPORATION**
FITZWILLIAM, New Hampshire

GEOTECHNICAL SERVICES INC.
18 COTE AVENUE, UNIT #11, GOFFSTOWN, NH 03045
TEL. (603) 624-2722 FAX. (603) 624-3733

DATE: JUNE, 22 2009

DESIGN BY: H. WETHERBEE, P.E.
DRAWN BY: D. HAYNER
CHECKED BY: H. WETHERBEE, P.E.

PROJECT No. ???
SHEET No. 1 of 1
SCALE: NONE

Geotechnical Services, Inc. ◆ 18 Cote Avenue, Goffstown, NH 03045 Tel. 603.624.2722 Fax. 603.624.3733 ◆ 12 Rogers Road, Haverhill, MA 01835 Tel. 978.374.7744 Fax. 978.374.7799

GSI

TEST BORING LOG

Boring No. B - 2

Project	Ebsco Publishing Warehouse Add	GSI Project No.		Elevation	n/a		
Location	Ipswich, MA	Project Mgr.	Glenn Zoladz	Datum			
Client	Ebsco Publishing	Inspector	Denis Hayner	Date Started	6/19/2009		
Contractor	New Hampshire Boring	Checked By		Date Finished	6/19/2009		
Driller	Gregg-Mike	Rig Make & Model	Scout Rig				

Item:	Auger	Casing	Sampler	Core Barrel		Truck		Skid		Hammer Type:
Type	HS		SS			Track	X	ATV		Safety Hammer
Inside Diameter (in).	2.25		1-3/8			Bomb		Geoprobe	X	Doughnut
Hammer Weight (lb)			140			Tripod		Other		Automatic
Hammer Fall (in.)			30			Winch		Cat Head	X	Roller Bit / Cutting Head

Depth (ft)	Casing (Blows/ft)	Sample Data No.	Depth (ft)	Rec (in.)	SPT (Blows/ 6-in.)	Rock RQD (%)	PID Rdg. (ppm)	SOIL AND ROCK CLASSIFICATION-DESCRIPTION BURMISTER SYSTEM (SOIL) U.S. CORPS OF ENGINEERS SYSTEM (ROCK)
0		S1	0-2	5	5-8			Top 3" loose Dark Brown fine to medium Sand, little Silt, trace to little Organics (TOPSOIL)
1					7-5			
2		S2	2-4	7	1-4			Very Loose to loose wet Brown/Black fine Sand and Silt, trace to little Organics (FILL)
3					6-6			
4								
5								
6		S3	5-7	12	2-1			Very Loose, Moist, Brown/Black fine Sand and Silt, trace organics
7					1-1			
8								
9								
10		S4	10-12	16	10-17			Light Brown, medium dense, wet fine to coarse Sand and Gravel, trace to little Silt (TILL)
11					19-15			
12								
13								
14								
15								
16		S5	15-17	9	15-15			Light Brown, medium dense, wet fine to coarse Sand and Gravel, trace to little Silt
17					21-16			
18								
19								
20								
21		S-6	20-22	18	44-45			Light Brown, dense, wet fine to coarse Sand and Gravel, trace to little Silt
22					38-45			
23								Boring terminated at 22.0 feet without refusal
24								
25								
26								
27								
28								
29								
30								

Water Level Data

Date	Time	Depth (ft) to: Bott. of Casing	Bott. of Hole	Water
6/19	11:30	n/a	n/a	1.0 ft

Sample Identification
O = Open Ended
U = Undisturbed
S = Split Spoon
C = Rock Core
G = Geoprobe

Cohesive Soils N-Value
0 to 2: Very Soft
2 to 4: Soft
4 to 8: Medium Stiff
8 to 15: Stiff
15 to 30: Very Stiff
Over 30: Hard

Granular Soils N-Value
0 to 4: Very Loose
4 to 10: Loose
11 to 30: Medium Dense
31 to 50: Dense
Over 50: Very Dense

Trace (0 to 5%) Little (10 to 20%) Some (20 to 35%) And (35 to 50%)

Standard Penetration Test (SPT) = 140# hammer falling 30", Blows are per 6" taken with an 18" long x 1.5" I.D. split spoon sampler in accordance with ASTM D 1586, unless otherwise noted.

REMARKS: The stratification lines represent the approximate boundary between soil types and the transition may be gradual. Water level readings have been made in the test borings at times and under conditions stated on the test boring logs. Fluctuations in the level of the groundwater may occur due to other factors than those present at the time measurements were made.

Notes:

B-2

Geotechnical Services, Inc. ◆ 18 Cote Avenue, Goffstown, NH 03045 Tel. 603.624.2722 Fax. 603.624.3733 ◆ 12 Rogers Road, Haverhill, MA 01835 Tel. 978.374.7744 Fax. 978.374.7799

GSI

TEST BORING LOG

Boring No. B - 3

Project	Ebsco Publishing Warehouse Add	GSI Project No.		Elevation	n/a
Location	Ipswich, MA	Project Mgr.	Glenn Zoladz	Datum	
Client	Ebsco Publishing	Inspector	Denis Hayner	Date Started	6/19/2009
Contractor	New Hampshire Boring	Checked By		Date Finished	6/19/2009
Driller	Gregg-Mike	Rig Make & Model	Scout Rig		

Item:	Auger	Casing	Sampler	Core Barrel		Truck		Skid		Hammer Type:
Type	HS		SS			Track	X	ATV		Safety Hammer
Inside Diameter (in).	2.25		1-3/8			Bomb		Geoprobe	X	Doughnut
Hammer Weight (lb)			140			Tripod		Other		Automatic
Hammer Fall (in.)			30			Winch		Cat Head	X	Roller Bit / Cutting Head

Depth (ft)	Casing (Blows/ft)	Sample Data: No.	Depth (ft)	Rec (in.)	SPT (Blows/ 6-in.)	Rock RQD (%)	PID Rdg. (ppm)	SOIL AND ROCK CLASSIFICATION-DESCRIPTION BURMISTER SYSTEM (SOIL) U.S. CORPS OF ENGINEERS SYSTEM (ROCK)
0		S1	0-2	5	2-5			Top 3" Very loose to loose Dark Brown fine to medium Sand, little Silt, trace to little Organics (TOPSOIL)
1					4-3			
2								
3		S2	2-4	18	7-5			Top 6" Loose Dark Brown fine to medium Sand and gravel, little Silt, trace to little Organics (FILL)
4					5-5			Loose, Moist, Light Brown fine Sand and Silt (FILL)
5								
6		S3	5-7	18	1-1			Grey, wet, very soft Clay ,trace black fine sand (in seams) (CLAY)
7					1-1			--- q_u = 1.0 tsf using a pocket penetrometer
8								
9								
10		S4	10-12	18	1-2			Grey, wet, very soft Clay ,trace black fine sand (in seams) --- q_u = 1.0 tsf using a pocket penetrometer
11					2-2			Bottom 4" Black, Wet, fine Sand and Silt with some organics (PEAT)
12								
13								
14								
15								
16		S5	15-17	16	2-7			Light Brown, wet, loose to medium dense fine to medium Sand and Silt with some Clay (TILL)
17					14-17			Bottom 4", Light Brown, medium dense, Wet fine to coarse Sand and Gravel, trace to little Silt (TILL)
18								
19								
20								
21		S-6	20-22	14	33-44			Light Brown, dense, wet, fine to coarse Sand and Gravel, trace to little Silt
22					48-35			
23								
24								
25		S-7	25-27	14	5-19			Light Brown, medium dense, wet, fine to coarse Sand and Gravel, trace to little Silt
26					25-28			
27								
28								Boring terminated at 27 feet without refusal
29								
30								

Water Level Data

Date	Time	Depth (ft) to: Bott. of Casing	Bott. of Hole	Water
6/19	9:30	n/a	n/a	3.5 ft

Sample Identification
- O = Open Ended
- U = Undisturbed
- S = Split Spoon
- C = Rock Core
- G = Geoprobe

Cohesive Soils N-Value
- 0 to 2: Very Soft
- 2 to 4: Soft
- 4 to 8: Medium Stiff
- 8 to 15: Stiff
- 15 to 30: Very Stiff
- Over 30: Hard

Granular Soils N-Value
- 0 to 4: Very Loose
- 4 to 10: Loose
- 11 to 30: Medium Dense
- 31 to 50: Dense
- Over 50: Very Dense

Trace (0 to 5%) Little (10 to 20%) Some (20 to 35%) And (35 to 50%)

Standard Penetration Test (SPT) = 140# hammer falling 30", Blows are per 6" taken with an 18" long x 1.5" I.D. split spoon sampler in accordance with ASTM D 1586, unless otherwise noted.

REMARKS: The stratification lines represent the approximate boundary between soil types and the transition may be gradual. Water level readings have been made in the test borings at times and under conditions stated on the test boring logs. Fluctuations in the level of the groundwater may occur due to other factors than those present at the time measurements were made.

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TEST BORING LOG

Boring No. B - 4

Project	Ebsco Publishing Warehouse Add	GSI Project No.		Elevation	n/a
Location	Ipswich, MA	Project Mgr.	Glenn Zoladz	Datum	
Client	Ebsco Publishing	Inspector	Denis Hayner	Date Started	6/19/2009
Contractor	New Hampshire Boring	Checked By		Date Finished	6/19/2009
Driller	Gregg-Mike	Rig Make & Model	Scout Rig		

Item:	Auger	Casing	Sampler	Core Barrel		Truck		Skid		Hammer Type:
Type	HS		SS			Track	X	ATV		Safety Hammer
Inside Diameter (in).	2.25		1-3/8			Bomb		Geoprobe	X	Doughnut
Hammer Weight (lb)			140			Tripod		Other		Automatic
Hammer Fall (in.)			30			Winch		Cat Head	X	Roller Bit / Cutting Head

Depth (ft)	Casing (Blows/ft)	Sample Data No.	Depth (ft)	Rec (in.)	SPT (Blows/ 6-in.)	Rock RQD (%)	PID Rdg. (ppm)	SOIL AND ROCK CLASSIFICATION-DESCRIPTION BURMISTER SYSTEM (SOIL) U.S. CORPS OF ENGINEERS SYSTEM (ROCK)
0		S1	0-2	4	4-4			Top 3" Very loose to loose Dark Brown fine to medium Sand, little Silt, trace to little Organics (TOPSOIL)
1					4-3			
2		S2	2-4	18	2-1			Very Loose Dark Brown fine to medium Sand and gravel, little Silt, trace to little Organics (FILL)
3					2-3			
4								
5								
6		S3	5-7	18	3-3			Very Loose, Moist, Brown/Black fine Sand and Silt, trace organics
7					2-3			
8								
9								
10		S4	10-12	18	1-5			Grey, Wet, soft Clay ,trace black fine sand (in seams) --- q_u = 1.0 tsf using a pocket penetrometer
11					3-3			Bottom 5" Black, Wet, fine Sand and Silt with some organics (PEAT)
12								
13								
14								
15								
16		S5	15-17	9	16-21			Light Brown, medium dense to dense, wet fine to coarse Sand and Gravel, trace to little Silt (TILL)
17					33-22			
18								
19		S-6	18-20	5	67-38			Light Brown, dense to very dense, wet fine to coarse Sand and Gravel, trace to little Silt
20					60-5"			
21								Refusal at 19.5 feet
22								Boring terminated at 19.5 feet
23								
24								
25								
26								
27								
28								
29								
30								

DRAFT

Water Level Data

Date	Time	Depth (ft) to: Bott. of Casing	Bott. of Hole	Water
6/19	1:30	n/a	n/a	3.5 ft

Sample Identification
O = Open Ended
U = Undisturbed
S = Split Spoon
C = Rock Core
G = Geoprobe

Cohesive Soils N-Value
0 to 2: Very Soft
2 to 4: Soft
4 to 8: Medium Stiff
8 to 15: Stiff
15 to 30: Very Stiff
Over 30: Hard

Granular Soils N-Value
0 to 4: Very Loose
4 to 10: Loose
11 to 30: Medium Dense
31 to 50: Dense
Over 50: Very Dense

Trace (0 to 5%) Little (10 to 20%) Some (20 to 35%) And (35 to 50%)

Standard Penetration Test (SPT) = 140# hammer falling 30", Blows are per 6" taken with an 18" long x 1.5" I.D. split spoon sampler in accordance with ASTM D 1586, unless otherwise noted.

REMARKS: The stratification lines represent the approximate boundary between soil types and the transition may be gradual. Water level readings have been made in the test borings at times and under conditions stated on the test boring logs. Fluctuations in the level of the groundwater may occur due to other factors than those present at the time measurements were made.

Notes:

B-4

SECTION 3:

Sediment Management Preliminary Review

Clean Soils Environmental, Ltd.

10 Pages

November 22, 2013 Via e-Mail Only: bkelder@ipswichriver.org

Mr. Brian Kelder
Restoration Program Manager
Ipswich River Watershed Association
143 County Road
Ipswich, MA 01938

Re: **Sediment Management Preliminary Review**
Ipswich River Watershed Association
Ipswich Mills Dam Removal Project
Ipswich, MA

Dear Mr. Kelder:

Clean Soils Environmental, Ltd. (CSE) is pleased to provide the Ipswich River Watershed Association (IRWA) with a preliminary review of sediment testing results collected from the impoundment of the Ipswich Mills Dam on the Ipswich River, hereinafter referred to as the "Dam". CSE understands the Town of Ipswich is investigating the option to remove the Dam. The Dam is owned by the Town of Ipswich and located behind EBSCO Publishing in the vicinity of the Historic Ipswich Riverwalk. See the attached Figure for the location of the Dam, Historic Ipswich Riverwalk, and EBSCO's facility locations in this vicinity.

INTRODUCTION

The preliminary study being conducted by the IRWA is focused, at this time, on determining contaminant levels upstream of the Dam, the Dam's effect on upstream and downstream flooding, and potential effects of removing the Dam (i.e., lowering the water table) on the foundations of the historic mill buildings in the vicinity of the Dam. The results of the preliminary study will help the Town of Ipswich decide whether to undertake a more detailed study to further investigate the possibility of removing the Dam or continue to maintain the Dam in place.

CSE'S SCOPE OF WORK

The IRWA has requested Pro bono services from CSE to assist with a small portion of the preliminary study concerning the existing data from sediment testing to date and prepare a short letter report with CSE's opinion and recommendations. This preliminary review of sediment testing by CSE is meant to help the IRWA evaluate any potential contaminants in relation to ecological and human health thresholds. This preliminary assessment is the first step towards determining an appropriate sediment management strategy, should the Town decide to remove the dam.

Typical sediment management strategies associated with dam removal include 1) downstream release; 2) excavation and on-site reuse for grading; and 3) excavation and off-site reuse or disposal. Each dam removal project is unique, and the appropriate sediment management strategy for each project is developed based on chemical analysis of the sediment; evaluation of downstream infrastructure and ecosystems; and thorough discussions and coordination with agencies such as the MA Department of Environmental Protection, the MA Division of Marine Fisheries, and the MA Division of Ecological Restoration.

The most cost-effective way to manage sediment trapped by a dam is to allow the sediment to migrate slowly downstream over time. This approach has been used successfully in several dam removal projects in Massachusetts and many other projects across the country. Many factors go into making the decision to release sediment downstream. One of those factors is the chemical analysis of the sediment and comparison of the results with ecological and human health thresholds.

CSE's preliminary sediment assessment may help determine whether the sediment behind the impoundment of the Dam can be discharged naturally downstream according to 314 CMR 9.00 without significant affects to human health and the environment. This is a preliminary assessment only with the goal of comparing the sediment quality with human and ecological health thresholds. Future work will include 1) additional sediment testing, 2) quantification of the volume of sediment expected to be dredged or released downstream; and 3) evaluation of upstream and downstream infrastructure that could be affected under various sediment management strategies.

IRWA'S JUSTIFICATION FOR THE PROPOSED DAM REMOVAL

The primary goal of the Dam removal is to restore the habitat and passage for species throughout the Dam impoundment, restore ecological conditions and processes such as the movement of sediment and organic matter via cooler, free flowing water and tidal fluctuations, and eliminate further maintenance costs and liability to the Town of Ipswich associated with the Dam. Therefore, the primary goal of this project is to restore the natural ecological system that exists within the vicinity of Dam before its construction many years ago.

HUMAN HEALTH AND THE ENVIRONMENT

At this time, the impounded sediment within the future channel is conceptually proposed to be discharged downstream within the tidal waters of the Ipswich River. See the attached Figure for this location of the Ipswich River including the tidal areas. Please note it is likely some sediment will remain in place or on the banks of the redeveloped channel above the Dam, though restoration will occur in these areas over time that will likely develop a new vegetative bank and/or meadow. The sediment released from the impoundment will be discharged and/or reused downstream of the Dam. Therefore, this sediment management plan has the potential of affecting human health and the environment. Many factors must go into a decision to release sediment downstream. This study evaluates one such factor, the quality of the sediment in relation to human and ecological health thresholds.

SEDIMENT SAMPLES COLLECTED FROM THE IMPOUNDMENT BY USGS

The U.S. Geological Survey (USGS) and the Massachusetts Department of Fish and Game, Division of Ecological Restoration (MassDFG) collaborated to collect baseline information on the quantity and quality of sediment impounded behind selected dams in Massachusetts, including sediment thickness and the occurrence of contaminants potentially toxic to benthic organisms. The thicknesses of impounded sediments were measured, and cores of sediment were collected from 32 impoundments in 2004 and 2005. Cores were chemically analyzed, and concentrations of 32 inorganic elements and 108 organic compounds were quantified. As described below, the sediments found behind Ipswich Mills Dam have a very low likelihood of toxicity when viewed independently and in relation to other dams across Massachusetts.

On September 8, 2005, the United States Geological Survey (USGS) collected two (2) cores in the vicinity of the Ipswich Mills impoundment (Site 7, located at Lat: 42.677648, Long: -70.837756) shown on the attached Figure. CSE understands the USGS collected sediment samples and laboratory analyzed the samples for Total Heavy Metals, Semi Volatile Organic Compounds (SVOC), Polycyclic Aromatic Hydrocarbons (PAHs), and Total Polychlorinated Biphenyls (PCBs).

According to Table 6 in the report, "Estimated Sediment Thickness, Quality, and Toxicity to Benthic Organisms in Selected Impoundments in Massachusetts";

> The Ipswich Mills Impoundment has a mean probable effects concentration quotient (PECQ) of 0.132, in other words, the estimated likelihood of toxicity of bottom-sediment cores is 13%.
>
> The average probable effects concentration quotient for a site (PECQx) is the average of the PECQs for arsenic, cadmium, chromium, copper, lead, nickel, and zinc, total polycyclic aromatic hydrocarbons (PAHs), total polychlorinated biphenyls (PCBs), and total dichlorodiphenyl-trichloroethylene (DDTs). For the purposes of this report, total DDTs comprise the sum of dichlorodiphenyl-trichloroethane and dichlorodiphenyl-dichloroethylene compounds. Total PAHs comprise the sum of the concentrations of anthracene, 9H-fluorene, naphthalene, phenanthrene, benzo(a)anthracene, benzo(a)pyrene, chrysene, fluoranthene, and pyrene.

According to Table 7 in the report, "Estimated Sediment Thickness, Quality, and Toxicity to Benthic Organisms in Selected Impoundments in Massachusetts";

> The total drainage area is 150 mi^2, with 53 dams within the drainage area, with 11.2% being impervious. There are 45 21E sites within the drainage area and 22 factories in the 1830s.

Based upon the results of all 32 impoundments, the estimated probability of toxicity of bottom sediment ranged from about 8 to 70 percent among the sampling locations and averaged slightly under 30 percent. This put the Ipswich Mills impoundment at the low end of toxic bottom sediment range with a 13% likelihood.

SEDIMENT SAMPLES COLLECTED FROM THE IMPOUNDMENT BY IRWA

On May 31, 2012, the IRWA and staff from Interfluve, Inc. collected three (3) sediment cores from the impoundment area (Lat: 42.6825, Long: -70.8236). The sediment samples were identified as IM-1, IM2, and IM-3. See the attached Figure for the approximate sample locations. Sediment samples were laboratory analyzed for Total Heavy Metals, SVOCs, PAHs, Volatile Organic Compounds (VOCs), Extractable Petroleum Hydrocarbons (EPH), and Physical Characteristics such as Percent of Total Organic Carbon (TOC), Percent of Water, and Percent of Grain Size Distribution.

IRWA SAMPLE LABORATORY ANALYSES

The laboratory results are tabulated on the attached table that was developed by the MassDFG. This table and/or spreadsheet were used to compare the initial sediment testing results to a screening benchmarks or criteria. The sample results from the USGS and IRWA were tabulated within this MassDFG table and/or spreadsheet for this preliminary review.

The table and/or spreadsheet compare the sediment sampling results to the conservative Massachusetts Contingency Plan (MCP) cleanup standards for soil only within a residential scenario including groundwater suitable for human consumption (i.e., drinking water). These conservative cleanup standards are being used since sediment will likely be left in place below the existing water levels and/or above the newly developed channel after the Dam is removed. Thus, it is possible that the impounded sediment may come in contact with humans in the future, and therefore it's important to know how its quality compares with human health thresholds.

The table and/or spreadsheet also compare the sediment sampling results to Threshold Effects Concentrations (TECs), Probable Effects Concentrations (PECs), Threshold Effect Levels (TELs), and Probable Effect Levels (PELs). The TECs and TECs are considered background concentrations and typically are interpretive as 'No Significant Risk' to the ecological environment. The PECs and PELs are considered potential actions levels and a significant exceedance might indicate that negative ecological affects are possible, such as impairments to benthic dwelling organisms.

INTERPRETATION OF THE LABORATORY DATA COLLECTED BY THE IRWA

Generally, both sampling events indicate that the sediment is below applicable ecological benchmark limits in regard to the freshwater PEC, marine PEL, and human health MCP Method 1 Cleanup Standard S1/GW1 screening criteria measured at this time. Therefore, it appears, the laboratory data to date indicates that a condition of 'No Significant Risk' may exist within the sediment from the impoundment of the Dam.

These results do make some sense, at this time, since the upstream past history in the vicinity of the area has mainly been residential with little industrial effects. The concentrations of metals, SVOCs, pesticides, VOCs, and EPHs measured within the sediment appear to be mainly from surface water run off non-point sources (e.g., roadways and farming).

RECOMMENDATIONS

CSE recommends the continuation of the feasibility study to remove the Dam. However, a significant volume of work is still required to permit the removal of the Dam and manage the sediment in place and downstream of the Dam.

At this time, CSE recommends estimating the volume of sediment that is contained within the impoundment and the volume of sediment that would be dredged or mobilized as part of a dam removal project. CSE understands the regulators typically request one (1) sediment sample per 1,000 cubic yards of dredged or mobilized material. Therefore, the next step should focus on estimating the sediment volume to help determine how many more samples should be collected in order to complete the sediment contaminate level study. It appears to CSE that this is likely a very important component to the entire study to help permit the removal of the Dam. CSE also believes a focus on characterizing the sediment immediately upstream of the Dam is also important since these are likely to be the quickest sediments to mobilize and discharge to the environment or tidal waters of the Ipswich River following removal of the dam. This is also the location of the former Ipswich Mills and may exhibit different contamination levels than the sites sampled upstream of the former mill.

CSE also believes further sediment testing should be conducted above and below the impoundment with an emphasis on downstream of the impoundment. CSE suggests at least three to four (3 – 4) sample locations downstream of the impoundment, one recommendation being the meander or cove between Country Street and Turkey Shore Road as shown on the Map. A significant volume of sediment from street sanding has accumulated within this vicinity for years including fines from organic matter and possibly discharges from the former mills. This is also likely the location where sediment will accumulate within the tidal waters of the Ipswich River (see Figure for this location).

One or more upstream samples (from depositional areas subject to potential mobilization during storm events) will help evaluation material that is ‘moving through the system’ regardless of actions at the dam. If upstream source areas are contaminated, then actions such as dredging with the dam impoundment may not affect sediment quality in the longer-term.

Please note the intention of the above interpretation and recommendation are preliminary and this project will be complicated by the entire regulatory process required for this project in the Commonwealth of Massachusetts. Please do not hesitate to call if you have any questions.

Respectfully submitted,
CLEAN SOILS ENVIRONMENTAL, LTD.

William H. Mitchell, Jr., LSP
President/Geologist

Kevin L. McAndrews
Environmental Geologist

Enclosures: Figure
Table Instructions
Table
Cross Sections

REFERENCES

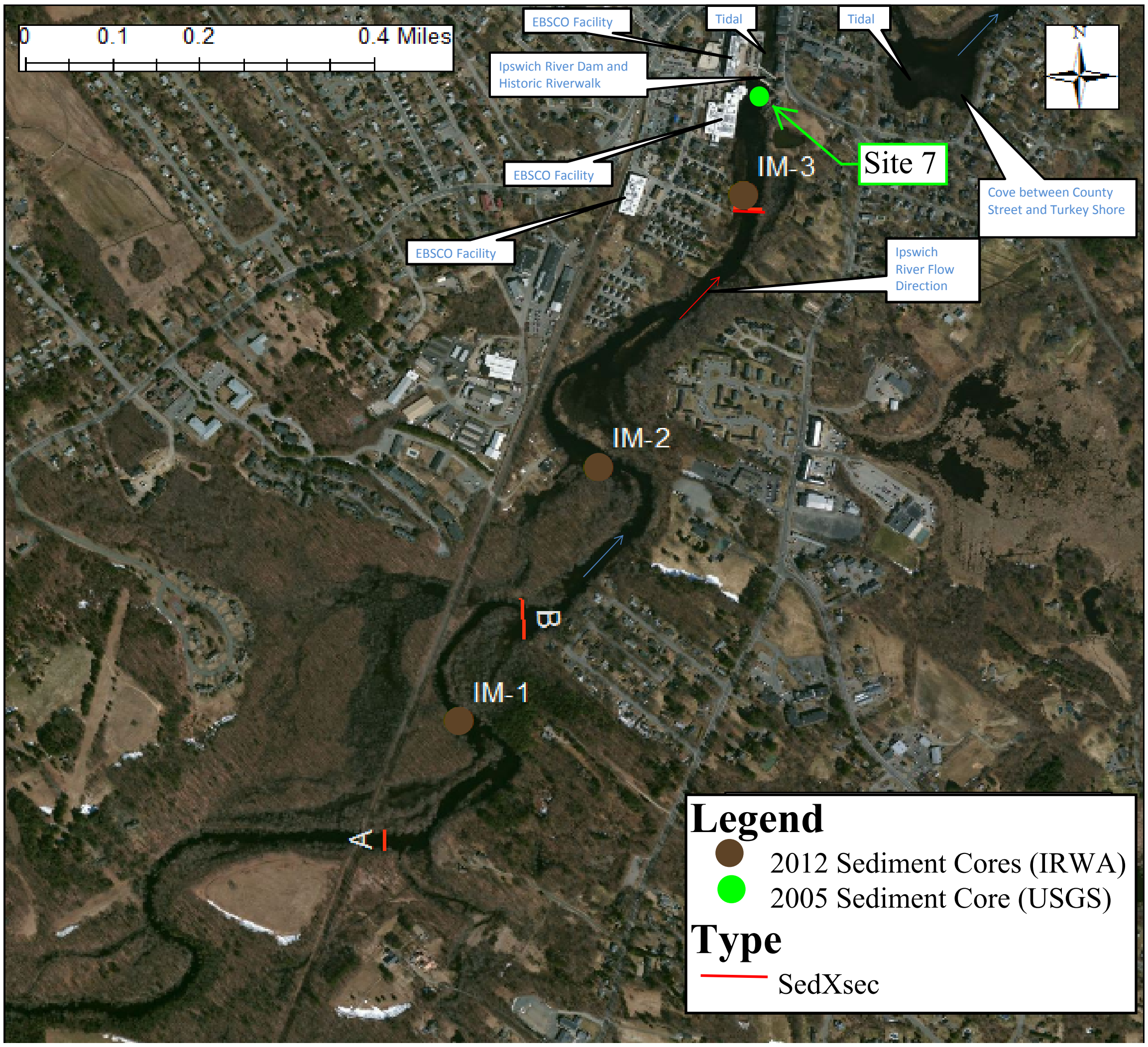
Breault, R.F., Sorenson, J.R., and Weiskel, P.K., 2013, Estimated sediment thickness, quality, and toxicity to benthic organisms in selected impoundments in Massachusetts: U.S. Geological Survey Scientific Investigations Report 2012–5191, 42 p., at http://pubs.usgs.gov/sir/2012/5191/.

Ipswich Mills Dam Removal Feasibility Study

Ipswich River Watershed Association Sediment Core Locations

Sample #	Location	Agency	Date	Latitude	Longitude	Determined by	Description
IM-1	Impoundment	IRWA	5/31/2012	42.661640	-70.844764	GPS (Android-EpiCollect)	0.1 ft fines & organics over 0.8 ft sand to refusal
IM-2	Impoundment	IRWA	5/31/2012	42.670725	-70.841567	GPS (Android-EpiCollect)	fine silt above fine sand core depth ~2.5 ft to refusa
IM-3	Impoundment	IRWA	5/31/2012	42.675602	-70.838249	GPS (Android-EpiCollect)	~3ft fines over 3 inches fine sand to refusal

Figure: Sediment core locations and sediment depth cross sections from 2012 surveys of Ipswich Mills impoundme



Prepared by the Ipswich River Watershed Association (IRWA including notes from Clean Soils Environmental, Ltd. (CSE.

Sediment Quality Spreadsheet

Updated December 2010

Please send comments, questions, or suggested corrections to:
Alex Hackman, Restoration Specialist
Division of Ecological Restoration, MA Dept of Fish and Game
alex.hackman@state.ma.us
617-626-1548

The purpose of this spreadsheet is to organize sediment quality data and provide comparison to relevant ecological and human health screening values.
The format was originally developed by ERM during donated services to the Ox Pasture Project (Rowley) through CWRP (2008).
It has been modified extensively by the Mass Division of Ecological Restoration to include additional parameters, notes, imbedded calculations, and thresholds.
The spreadsheet is structured to provide comparisons useful during **401 Water Quality Certification** via Mass DEP.

Disclaimer: The Department of Fish and Game and the Division of Ecological Restoration (DER) takes no responsibility for the accuracy of the screening threshold values presented in this workbook.
Staff has made every effort to ensure accuracy, but standards change and errors are possible.
Users are encouraged to double check the accuracy of values based upon the most recently available screening thresholds.
All threshold values are rounded to one decimal place (place cursor in cell to see true value)
Evaluating sediment quality findings can be complex, and users are encouraged to consider concentrations upstream, downstream, and in the impoundment for context.

Instructions

1. Enter all data for samples taken from the dam impoundment, upstream, and downstream.
2. Create additional columns if necessary to house data from your sampling locations.
3. If additional columns have been added, check the equations under "Impoundment Sample Statistics" to ensure that all values are being utilized in the automated calculations.
4. For results that are below the laboratory detection limit...
   Enter a value **1/2** of the value of the laboratory detection limit in the appropriate space and color code it green.
   For example, the following cell value indicates a lab result of "below detection limit" and a detection limit of 0.5.
   0.25 The use of 1/2 the detection limit is for developing mean values.
5. Check laboratory methods and units, and update specific parameters if necessary.
6. The table uses conditional formatting to evaluate to following:
   Maximum impoundment values above MCP S1/GW1 standards are show as: **35.34** These values assist in evaluating potential human health risks from the area of highest concentration
   Mean impoundment values above freshwater PECs are show as: **124.5** These values assist in evaluating potential ecological risks from the average concentration of impounded sediment
7. Include information about sample locations and characteristics on the sheet entitled "Map and Sample Info". It is critical to understand how samples were collected (i.e. cores via surficial grab samples) to interpret your results.
8. Note that this spreadsheet uses the MCP Method 1 Cleanup Standards for S-1 (soils) and GW-1 (groundwater). Depending on your project location, a different soil and/or groundwater category may be appropriate.
   S-1/GW-1 is the most conservative. Please refer to 310 CMR 40.0930 (Identification of Site Groundwater and Soil Categories)

Guidance of interpreting values

1. Ecological screening values are important for evaluating downstream release of sediment, including (1) as a sediment management option and (2) for precautions needed during dam removal.
   In general, our experience in MA has been that PECs are the important value. Given our long history of human impact in MA, the TEC values often are considered to be background levels. This may not be the case for more pristine rivers.
   In evaluating downstream release of sediment, it is also important to compare concentrations in the impoundment to those found in downstream depositional areas.

2. Human health screening values (MCP) are important for evaluating shoreline placement and upland re-use options.
   In many cases, adequate regulation under 401 Water Quality Certification may prevent entry into the MCP system, even when values exceed the MCP cleanup standards {see 314 CMR 9.07 (9)]

3. To evaluate off-site disposal options, it may also be necessary to compare sediment quality data to MA DEP screening values for landfill reuse.

References

401 Water Quality Certification Regulation (314 CMR 9.00)
Massachusetts Contingency Plan (MCP; 310 CMR 40.0000)
MCP Method 1 Cleanup Standards for S-1 soils
MA DEP Interim Policy Comm 97-004 (for reuse and disposal at permitted landfills)

COMMONWEALTH OF MASSACHUSETTS
Division of Ecological Restoration

Questions, comments, or concerns?

Please contact Alex Hackman, Restoration Specialist, Mass Division of Ecological Restoration
alex.hackman@state.ma.us / (617) 626-1548

Parameter	CAS No.	Method	Screening Criteria					Dam Impoundment Samples			
(Important: Units listed by category below)			MCP S1 / GW1	TEC	PEC	TEL	PEL	IM-1	IM-2	IM-3	USGS
			Human Health	Freshwater		Marine					
Metals [mg/kg]											
Antimony	7440-36-0	6020A	20.0								0.32
Arsenic	7440-38-2	6020A	20.0	9.8	33.0	7.2	41.6	4.76	13.8	9.68	3.6
Barium	7440-39-3	6020A	1,000.0								
Beryllium	7440-41-7	6020A	100.0								
Cadmium	7440-43-9	6020A	2.0	1.0	5.0	0.7	4.2	0.139	0.503	0.515	0.53
Chromium (TOTAL)	7440-47-3	6020A	30.0	43.4	111.0	52.3	160.4	7.48	15.7	16.4	36
Chromium (III)	7440-47-3		1,000.0								
Chromium (VI)	7440-47-3		30.0								
Copper	7440-50-8	6020A	NC	31.6	149.0	18.7	108.2	3.45	10.7	15.1	13.7
Lead	7439-92-1	6020A	300.0	35.8	128.0	30.2	112.2	9.37	32.7	43.5	33.8
Mercury	7439-97-6	7471A	20.0	0.2	1.1	0.1	0.7	0.047	0.216	0.185	0.066
Nickel	7440-02-0	6020A	20.0	22.7	48.6	15.9	42.8	5.25	9.79	10.9	9.2
Selenium	7782-49-2	6020A	400.0								0
Silver	7440-22-4	6020A	100.0			0.7	1.8				0.22
Thallium	7440-28-0	6020A	8.0								
Vanadium	7440-62-2	6020A	600.0								
Zinc	7440-66-6	6020A	2,500.0	121.0	459.0	124.0	271.0	32.9	80	102	41.4
SVOCs (PAHs)[ug/kg]											
Acenaphthene	83-32-9	8270/8100	4,000.0			6.7	88.9	5.7	5.7	33.5	76
Acenaphthylene	208-96-8	8270/8100	1,000.0			5.9	127.9	27.7	19.5	124	84
Anthracene	120-12-7	8270/8100	1,000,000.0	57.2	845.0			20.3	21.2	145	330
Benz[a]anthracene	56-55-3	8270/8100	700.0	108.0	1,050.0			129	110	673	730
Benzo[a]pyrene	50-32-8	8270/8100	2,000.0	150.0	1,450.0			140	97.9	610	670
Benzo[b]fluoranthene	205-99-2	8270/8100	7,000.0	27.3	13,400.0			135	129	718	550
Benzo[g,h,i]perylene	191-24-2	8270/8100	1,000,000.0					84.3	70	412	360
Benzo[k]fluoranthene	207-08-9	8270/8100	70,000.0					121	104	571	550
Chrysene	218-01-9	8270/8100	70,000.0	166.0	1,290.0	107.8	846.0	153	132	702	740
Dibenz[a,h]anthracene	53-70-3	8270/8100	700.0	33.0	260.0	6.2	134.6	19.2	16.1	108	200
Fluoranthene	206-44-0	8270/8100	1,000,000.0	423.0	2,230.0	112.8	1,493.5	356	279	1410	1500
Fluorene	86-73-7	8270/8100	1,000,000.0	77.4	536.0	21.2	144.4	14.5	10.2	62.8	150
Indeno[1,2,3-cd]pyrene	193-39-5	8270/8100	7,000.0					96.6	77.2	491	380
Phenanthrene	85-01-8	8270/8100	10,000.0	204.0	1,170.0	86.7	543.5	181	93	590	
Pyrene	129-00-0	8270/8100	1,000,000.0	195.0	1,520.0	152.7	1,397.6	296	239	1240	1200
2-Methylnaphthalene	91-57-6	8270/8100	700.0			20.2	201.3				39
Naphthalene	91-20-3	8270/8100	4,000.0	176.0	561.0	34.6	390.6	25.4	15.6	55.3	78
Total PAHs				1,610.0	22,800.0	1,684.1	16,770.4				
Pesticides (ug/kg)											
2,4'-DDD	-	8151a									
4,4'-DDD	72-54-8	8151a	4,000.0			1.2	7.8				
Sum DDD				4.9	28.0						
2,4'-DDE	-	8151a									
4,4'-DDE	72-55-9	8151a	3,000.0			2.1	374.2				
Sum DDE				3.2	31.3						
2,4'-DDT	-	8151a									
4,4'-DDT	50-29-3	8151a	3,000.0			1.2	4.8				
Sum DDT				4.2	62.9						
Total DDTs				5.3	572.0	3.9	51.7				
alpha-Chlordane	57-74-97	8081a		0.5	6.0						
Aldrin	30-90-02		40.0			NC	NC				
Chlordane	57-74-9			3.2	17.6	2.3	4.8				
Dieldrin	60-57-1	8081a	50.0	1.9	61.8	0.7	4.3				
Endrin	72-20-8	8081a	8,000.0	2.2	207.0						
gamma-BHC/Lindane	-	8081a		2.4	5.0	0.3	1.0				
gamma-Chlordane	-	8081a									
Heptachlor epoxide	1024-57-3	8081a	90.0	2.5	16.0						
Hexachlorobenzene	118-74-1	8081a	700.0								
PCBs (ug/kg)											
Aroclor 1016	12674-11-2	8082									
Aroclor 1221	11104-28-2	8082									
Aroclor 1232	11141-16-5	8082									
Aroclor 1242	53469-21-9	8082									
Aroclor 1248	12672-29-6	8082									
Aroclor 1254	11097-69-1	8082									
Aroclor 1260	11096-82-5	8082									
Total PCBs	1336-36-3	8082	2,000.0	59.8	676.0	21.6	188.8				11
VPH (mg/kg)											
C5-C8 Aliphatic Hydrocarbons		MADEP	100.0								
C9-C12 Aliphatic Hydrocarbons		MADEP	1,000.0								
C9-C10 Aromatic Hydrocarbons		MADEP	1,000.0								
Unadjusted C5-C8 Aliphatic Hydrocarbons		MADEP	NC								
Unadjusted C9-C12 Aliphatic Hydrocarbon		MADEP	NC								
VOCs (mg/kg)											
Methyl tert-butyl ether (MTBE)	1634-04-4	MADEP	0.1					3.25	3.25	3.25	
Benzene	71-43-2	MADEP	2.0					1.65	1.65	1.65	
Toluene	108-88-3	MADEP	40.0	4.5	4.5			2.45	2.45	2.45	
Ethylbenzene	100-41-4	MADEP	30.0					1.65	1.65	1.65	
m&p-Xylenes	1330-20-7	MADEP	400.0					3.25	3.25	3.25	
o-Xylene	95-47-6	MADEP	400.0					3.25	3.25	3.25	
EPH (mg/kg)											
C9-C18 Aliphatics		MADEP	1,000.0					5.05	5.05	5.05	
C19-C36 Aliphatics		MADEP	3,000.0					5.05	5.05	16.8	
C11-C22 Aromatics		MADEP	1,000.0					10.3	5.05	22.4	
Unadjusted C11-C22 Aromatics		MADEP						10.3	5.05	22.4	
Physical Characterisitcs											
Total Organic Carbon (%)								0.9835	3.84	2.985	
Percent Water (%)								36.2	62.2	52.1	
Grain Size Distribution (%)		ASTM D422									
Sieve No. 4								0.1	0.1	0	
Sieve No. 10								2.2	1	0.4	
Sieve No. 40								50	17.4	17.4	
Sieve No. 60								40.7	73.2	63.2	
Sieve No. 200								7	8.3	19	

Prepared by:

Massachusetts Department of Fish and Game

Division of Ecological Restoration (DER)

Updated December 2010

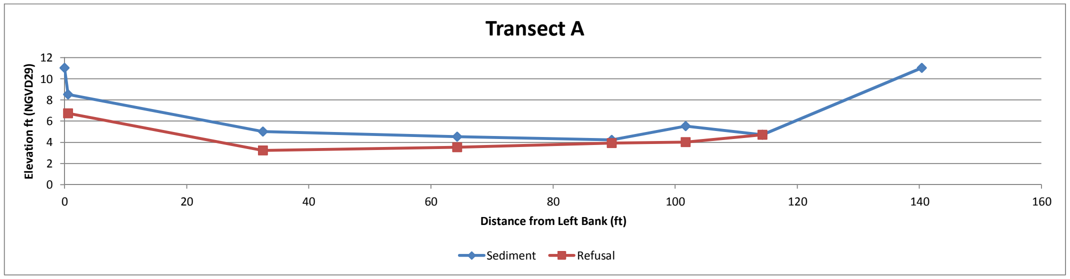
This table is prepared and offered by DER for the benefit of all parties pursuing river restoration projects within Massachusetts.

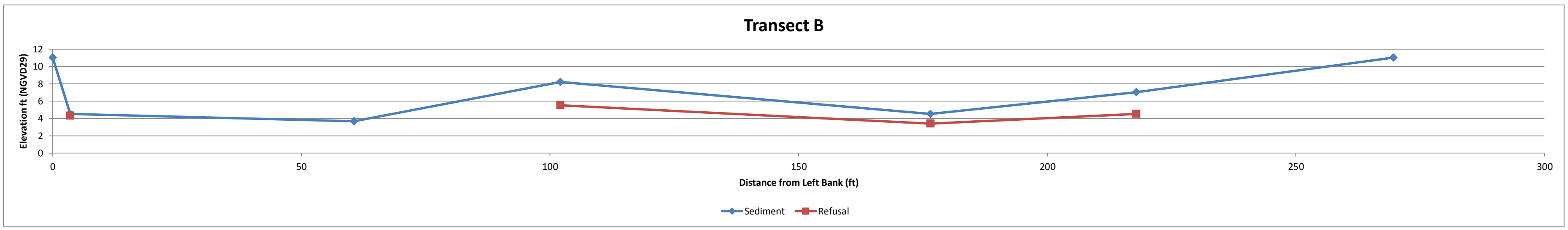
mg/kg = milligrams per killogram

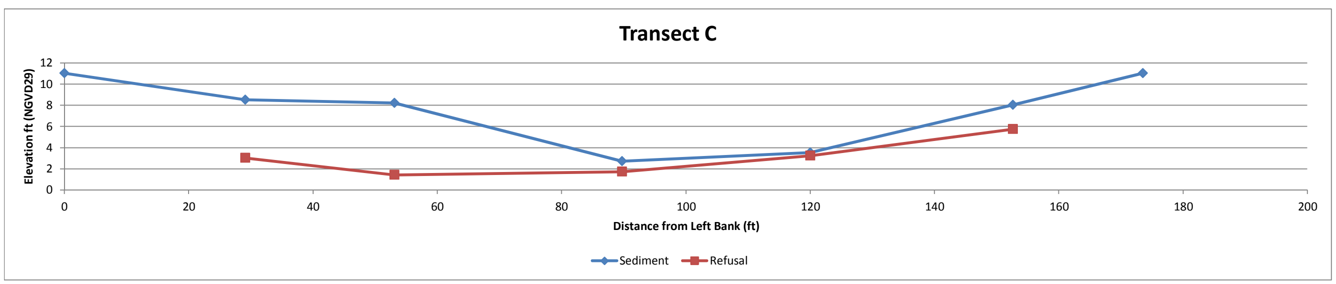
ug/kg = micrograms per killogram

TEC - Threshold Effect Concentration

PEC - Probable Effect Concentration


Transect A
Elevation ft (NGVD29)
0
2
4
6
8
10
12
0
20
40
60
80
100
120
140
160
Distance from Left Bank (ft)
Sediment
Refusal


Transect B
Elevation ft (NGVD29)
0
2
4
6
8
10
12
0
50
100
150
200
250
300
Distance from Left Bank (ft)
Sediment
Refusal


Transect C
Elevation ft (NGVD29)
0
2
4
6
8
10
12
0
20
40
60
80
100
120
140
160
180
200
Distance from Left Bank (ft)
Sediment
Refusal