Site Reconnaissance and Conceptual Design for Dam Removal – Indian Head Dam

Hanover and Hanson, Massachusetts

June 30, 2021
Revised March 29, 2022

Prepared for:

Massachusetts Division of Ecological Restoration
Attn: Chris Hirsch
251 Causeway Street, Suite 400
Boston, Massachusetts 02114

Prepared by:

Stantec Consulting Services Inc.
136 West Street, Suite 203
Northampton, Massachusetts 01060

SITE RECONNAISSANCE AND CONCEPTUAL DESIGN FOR DAM REMOVAL – INDIAN HEAD DAM

June 30, 2021 (Revised March 29, 2022)

Revision	Description	Author		Quality Check		Independent Review	
A	Draft for Review	GEC	2021.06.10	MRC	2021.06.11	GF	2021.06.14
B	Final	MRC	2021.06.27	GEC	2021.06.28	GJF	2021.06.28
C	Final (Revised)	MRC	2022.03.29	GEC	2022.03.29	GJF	2022.03.29

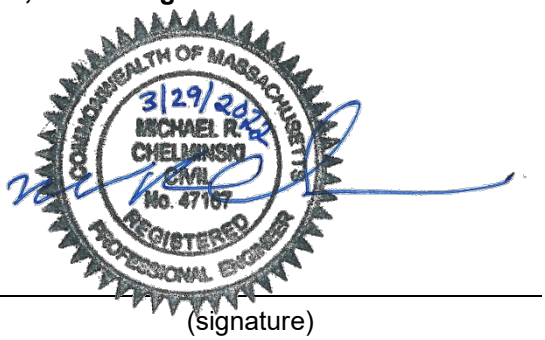
Revisions on March 29, 2022, follow on questions received from the Massachusetts Department of Environmental Protection as part of work for contaminant releases upstream from the subject dam and impoundment. Revisions to this report are provided in red text. The only revision in the body of this report in Table 3. Headings are updated to reflect the revision and the Table of Contents was updated.

SITE RECONNAISSANCE AND CONCEPTUAL DESIGN FOR DAM REMOVAL – INDIAN HEAD DAM

June 30, 2021 (Revised March 29, 2022)

This document entitled Site Reconnaissance and Conceptual Design for Dam Removal – Indian Head Dam was prepared by Stantec Consulting Services Inc. ("Stantec") for the account of Massachusetts Division of Ecological Restoration (the "Client"). Any reliance on this document by any third party is strictly prohibited. The material in it reflects Stantec's professional judgment in light of the scope, schedule and other limitations stated in the document and in the contract between Stantec and the Client. The opinions in the document are based on conditions and information existing at the time the document was published and do not take into account any subsequent changes. In preparing the document, Stantec did not verify information supplied to it by others. Any use which a third party makes of this document is the responsibility of such third party. Such third party agrees that Stantec shall not be responsible for costs or damages of any kind, if any, suffered by it or any other third party as a result of decisions made or actions taken based on this document.

Prepared by *Revisions reviewed in telephone conversion between MRC and GEC on 3/29/2022*
(signature)
Gordon E. Clark, Civil Designer



Reviewed by _____
(signature)
Michael Chelminski, Principal, P.E. (Massachusetts License Number 47167)

Independent Review by *Revisions reviewed in telephone conversion between MRC and GJF on 3/29/2022*
(signature)
Gerard Fortin, Senior Principal, P.E. (Massachusetts License Number 33513)

Table of Contents

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

1.0 INTRODUCTION

This report documents a preliminary assessment and conceptual design for removal of Indian Head Dam (National Dam ID No. MA01066) on the Indian Head River in Hanover and Hanson, Massachusetts (Project). The approximate coordinates of the dam are: 42.0956° N, 70.8496° W. The dam is reportedly owned by the Town of Hanover[1], although the town boundary data available on MassGIS shows the boundary between Town of Hanover and the Town of Hanson being along the middle of the dam. Stantec Consulting Services Inc. (Stantec) was contracted by the Massachusetts Department of Fish & Game, Division of Ecological Restoration (DER) to perform a preliminary assessment and develop a conceptual design for removal of Indian Head Dam.

Appendix A contains representative photographs of the Project site. Appendix B contains a conceptual basemap of existing conditions (Figure B.1) at the Project site as well as a conceptual proposed conditions plan (Figure B.2) for dam removal. Appendix C contains a table with additional information on opinions of probable cost for construction.

This report is not a dam inspection/evaluation report and is intended solely for use in evaluating the potential for removal of Indian Head Dam. This report includes information and inferences by Stantec based on information provided by others; Stantec has relied on and is not responsible for verifying or validating information provided by others.

1.1 PROJECT GOALS AND OBJECTIVES

The primary Project goals and objectives include:

1) Restoring connectivity of aquatic habitat and fluvial processes (e.g., biotic and abiotic fluxes) in the Indian Head River at Indian Head Dam;

2) Restoring aquatic habitat in the Indian Head Dam impoundment; and

3) Improved public safety and eliminating required dam maintenance.

Indian Head Dam is a barrier to upstream movement of fish and other aquatic fauna in the Indian Head River. The dam is a barrier to upstream fish passage. Removal of the dam will restore opportunities for volitional aquatic organism passage and is expected to substantially restore free-flowing conditions in the impounded reach of the river.

1.2 SITE VISIT AND BACKGROUND INFORMATION

Information used in the preparation of this report included observations and surveys during a site visit on Friday, May 14, 2021, background information provided by DER, and readily available information

[1] The 2006 Phase I Dam Inspection and Evaluation Report prepared by Weston & Sampson dated November 30, 2006, lists a single owner (Town of Hanover).

obtained by Stantec. Background information provided by DER included information provided with DER Bid Request dated March 16, 2021, and subsequent information provided to Stantec by DER.

Relevant information on Indian Head Dam and the adjacent reach of the Indian Head River that was reviewed in the preparation of this report includes:

1) The "Jurisdictional Determination" documentation, for [Indian Head Dam] prepared by Fuss & O'Neil and dated June 30, 2006[2] ;

2) The "Inspection/Evaluation Report" for Indian Head Dam (MA01066), dated November 30, 2006, prepared by Weston & Sampson (2006 I/E Report);

3) The "Application to Change Hazard Classification of Dam" prepared by Amory Engineers, P.C., and dated October 4, 2017.

4) The "Change in Hazard Classification of Dam" correspondence from the Massachusetts Department of Conservation and Recreation Office of Dam Safety dated October 12, 2017 (2017 Change in Hazard Classification Document);

5) The drawings for the "Proposed Bridge, Hanson, State Street over Indian Head River," prepared by Steinman for the Massachusetts Highway Department and dated July 13, 1995 (State Street Bridge Drawings);

6) Federal Emergency Management Agency (FEMA) Flood Insurance Study (FIS) for Plymouth County, Massachusetts (FIS# 25023CV001C) as revised November 4, 2016 (FEMA FIS);

7) FEMA Flood Insurance Rate Map (FIRM) Nos. 25023C0201J and 25023C0202J, Effective Dates July 17, 2012 (FEMA FIRM panels);

8) The "Final Supplemental Phase II Report, National Fireworks Site, RTN 4-0000090, Hanover, MA" prepared for the Fireworks Site Joint Defense Group by Tetra Tech and dated June 2018; and

9) Information obtained from the Massachusetts Cultural Resource Information System (MACRIS) online data server in June 2021 in Hanover, Massachusetts.

10) Information obtained from the Sanborn Fire Insurance Map from Hanover, Plymouth County, Massachusetts, created by the Sanborn Map Company in November 1917.

Information obtained during the site visit is provided in the following section.

[2] Note that a Massachusetts Office of Dam Safety Jurisdictional Verification Form was filed by Fuss & O'Neil on June 28, 2006, which appears to have mistakenly identified the upstream "Indian Head Dam" (MA01066) as Curtis Crossing Dam (MA00428).

1.2.1 Site Visit

Stantec visited the Project site on Friday, May 14, 2021, with representatives from DER. The site visit began at approximately 2:00 PM and concluded at approximately 5:00 PM. Areas observed by Stantec during the site visit included Indian Head Dam and the associated impoundment, and the adjacent upstream and downstream reaches of the Indian Head River.

Representatives of DER who participated in the site visit included:

- Christopher Hirsch (DER, Ecological Restoration Specialist); and
- Joseph Gould (DER, Ecological Restoration Specialist).

Representatives of Stantec who participated in the site visit included:

- Michael Chelminski (Stantec, Principal); and
- Gordon Clark (Stantec, Civil Designer).

Areas that were visited during the site visit and compose the Project area include:

1) The footprint of Indian Head Dam, the associated impoundment and immediately adjacent areas, including State Street Bridge[3]; and

2) The adjacent reaches of the Indian Head River approximately 4,800 feet (ft) upstream and 100 ft downstream from Indian Head Dam.

Information obtained by Stantec during the site visit included:

1) Representative photographs of the Project area (Appendix A);

2) Bathymetric and sediment probe data measurements in the dam impoundment and upstream reach of Indian Head River using a graduated survey rod; and

3) Sediment samples within the dam impoundment.

Locations where the bathymetric, sediment probe, and sediment sample data were collected and documented using a Global Navigation Satellite System (GNSS)-enabled Global Positioning System (GPS) receiver. These locations are presented in the figures in Appendix B and are discussed in Section 2.0 of this report.

Observations and information obtained during the site visit are described in subsequent sections of this report.

[3] Note that the MassHighway plans for this bridge (Bridge No. H-07-004) refer to the bridge name as “State Street Bridge”. Dam inspection reports and FEMA refer to the upstream bridge as “Cross Street Bridge”.

2.0 PROJECT AREA

This section presents information on the Project Area obtained during the site visit and readily available information obtained by Stantec. See Figure B.1 in Appendix B for the existing conditions basemap.

2.1 INDIAN HEAD DAM

Information on Indian Head Dam in this section is based on information presented in the 2006 I/E Report as well as observations and data collected by Stantec during the May 14, 2021, site visit.

Indian Head Dam (National ID: MA01066; State ID 7-12-123-3) is located within Plymouth County in the towns of Hanover and Hanson, Massachusetts[4]. The dam is located just east of State Street[5] within the village of South Hanover in Hanover on the Indian Head River, a tributary to the North River. The dam is classified as a Non-Jurisdictional dam according to the 2017 Change in Hazard Classification Document. Indian Head Dam appears to have originally consisted of an earthen embankment and a stone masonry spillway with stone masonry foundation walls forming the former mill complex that was situated at this site. The dam spillway was reportedly substantially breached in 1973 with only remnants approximately 4- to 5-ft high remaining. The original spillway weir was reportedly 7- to 8-ft tall with a caplog weir over a stone masonry foundation. Based on the 2006 I/E Report, the dam is currently in Poor condition.

Based on the 2017 Change in Hazard Classification Document, the Indian Head Dam's structural height[6] of the remnant of the dam is less than 6 ft and was noted to not be capable of creating an impoundment. Therefore, the remaining dam appears to have been relegated from the approximately 270 ft long earth embankment, of which the majority included State Street (see footnote 5), with primary spillway and outlet works as presented in the 2006 I/E Report, to just the portion of the remaining 49 ft of spillway within the Indian Head River.

The Indian Head Dam spillway is located immediately downstream of the State Street Bridge and consists primarily of granite blocks and large boulders. There are old stone masonry bridge abutments that flank the spillway on both sides just downstream. The spillway approach consists of the channel under the State Street Bridge with a small forebay area between State Street Bridge and the former stone masonry bridge abutments. The spillway is an uncontrolled broad crested weir with an approximately 4 to 5 ft drop to the downstream riverbed. The weir elevation varies across the spillway due to the staggered placement of the granite blocks and boulders due to the breach. Based on the information reviewed in the State

[4] Note that the plans reviewed for the State Street Bridge indicate that the town line is located at the town line sign post approximately 175 ft north from the centerline of the dam spillway, and the dam and State Street Bridge appear to both be located in the Town of Hanson.
[5] Note that this location is also referred to as Cross Street. Cross Street appears to be the name of the road within the Town of Hanover and State Street appears to be the name of the road within the Town of Hanson. Design plans reviewed as part of this Project refer to the bridge as "State Street Bridge".
[6] Structural height is defined by the Commonwealth of Massachusetts Department of Conservation and Recreation Office of Dam Safety as the measured vertical height of the dam from the streambed at the toe to the crest of the dam. Hydraulic height is defined as the measured vertical height from the streambed at the downstream toe to the spillway crest.

Street Bridge Drawings, the approximate elevation of the spillway crest is 33.5 ft (National Geodetic Vertical Datum of 1929 [NGVD29]). The spillway discharges flow between the two stone masonry former bridge abutment walls downstream from the current State Street Bridge.

There is a former mill flume approximately 150 ft to the north of the spillway center that consists of an approximately 6 ft internal diameter reinforced concrete pipe. The headwall at the flume inlet is concrete cast against granite block masonry wing walls. The headwall at the inlet has stoplog slots cast into the concrete. The pipe exits through a granite block headwall with granite block wingwalls. The flow from the former flume enters a small (width approximately 10 ft), stone-lined channel that discharges to the Indian Head River approximately 270 ft downstream.

2.2 INDIAN HEAD DAM IMPOUNDMENT

This section presents information on the Indian Head Dam impoundment and accumulated sediment.

2.2.1 Impoundment Characteristics

The 2006 I/E Report provides information on the dam impoundment, including estimates of surface area and storage volumes for normal pool and maximum pool (i.e., top-of-dam). These estimates are based on a normal pool elevation as represented by the spillway crest as well as a maximum pool elevation based on a structural height of the dam of 13 ft. As previously noted, however, the dam is partially breached on no longer impounds water at the higher elevation associated with the reported structural height (see Section 2.1).

The normal pool surface area and storage reported in the 2006 I/E Report are 10.9 acres and 37 acre-ft, respectively, which appears to be based on the outline of open water upstream of the dam in the United States Geological Survey (USGS) Hanover Topographic Quadrangle. Note that the 2006 Jurisdictional Determination Form reports the normal pool volume as 4.6 acre-ft, but it is uncertain how this estimate was obtained and what assumptions were used. Based on observations made during the site visit and review of aerial imagery, Stantec estimates that the impoundment area is between 7 and 8 acres and extends approximately 4,800 ft upstream of the dam spillway.

Bathymetric and sediment probe data were collected in the Indian Head River upstream from Indian Head Dam to the approximately 4,800 ft reach upstream of the dam spillway. The most upstream measurement was taken at the approximate estimated limit of the impoundment and where the riverine characteristics changed to more of a vegetated wetland dominated system (see Location 13 in Figure B-1). Measurements for the bathymetric and sediment probing data were obtained by manual probing from a canoe with a graduated survey rod. Locations of these data were obtained and documented using a GNSS-enabled GPS receiver and are presented in Table 1 and depicted on the existing conditions basemap (Appendix B, Figure B.1). Note that the ‘Northing’ and ‘Easting’ values reflect the Massachusetts State Plane, North American Datum 1983, coordinate system (units in ft). Information obtained from the bathymetric and sediment probing was used to characterize conditions in the Project reach of Indian Head River upstream from Indian Head Dam, including depth of water and depth and composition of accumulated sediment. This information was used to identify general characteristics of the

impoundment and impoundment sediment such as sediment quantity, approximate distribution, and composition.

The impoundment generally has a southwest-northeast orientation and is surrounded by a wooded swamp buffer on the north side and a medium-density residential land cover on the south side. Based on observations from the site visit and review of aerial imagery, the impoundment was divided into two zones, the Northeast Impoundment Zone and the Southwest Impoundment Zone, which defined a broader impoundment zone with approximately 900 ft of the dam and a more riverine component of the impoundment from approximately 900 ft upstream of the dam to approximately 4,800 ft upstream of the dam, respectively. The impoundment is narrow with a high aspect-ratio (length/width), with an average width of approximately 70 to 90 ft towards the downstream end of the impoundment (Northeast Impoundment Zone) within approximately 900 ft of the dam, and tapering to approximately 20 ft at the upstream extent (Southwest Impoundment Zone), which blends into adjacent vegetated wetland areas including scrub shrub and forested wetland. The impoundment resembles a low gradient riverine system consistent with low flow speeds during the site visit. There is some large woody material along the banks, especially approximately 2,500 ft upstream of the dam, some of which has fallen into the river.

The morphology of the impoundment appears to reflect some legacy characteristics associated with higher water levels prior to the reported substantial breaching of the dam in 1973. These characteristics include relatively low-lying and flat floodplains composed of finer sediment (e.g., sand and finer material) to the edge of the adjacent valley section and vegetation including herbaceous plants, shrubs, and trees. Larger trees along the floodplain could be aged to evaluate whether the breach and lower water surface elevations provided suitable conditions for growth.

The maximum recorded depth of water in the normal-pool impoundment based on bathymetry and sediment probing during the site visit was approximately 4.0 ft, which was within the Northeast Impoundment Zone located within 900 ft upstream of the spillway in the middle of the impoundment. This value corresponds roughly with the estimated normal-pool hydraulic height of the dam of approximately 4 to 5 ft. Typical depths of water in the normal-pool impoundment were generally between 1 to 3 ft. There did not appear to be a large presence of rooted aquatic vegetation in the impoundment in the areas where there is likely active flow. However, as previously noted, there are bordering vegetated wetlands throughout the length of the impoundment.

Table 1. Summary of bathymetry and sediment probing data collected on May 14, 2021; reference Figure B.1 in Appendix B for locations of these data points

LocID	Northing (ft)	Easting (ft)	Water Depth (ft)	Depth of Probe (ft)	Depth of Sediment (ft)	Probe Description	Probe Location
1	2860573.5	832679.9	4.0	6.3	2.3	muck sand to firm	Northeast Impoundment Zone
2	2860275.8	832432.9	4.0	4.7	0.7	sand to firm	Northeast Impoundment Zone
3	2860308.7	832226.2	3.9	4.6	0.7	sand to firm	Northeast Impoundment Zone
4	2860470.3	831663.5	2.9	2.9	0.0	gravel to hard refusal	Southwest Impoundment Zone
5	2860331.5	831496.5	3.5	3.5	0.0	gravel to hard refusal	Southwest Impoundment Zone
6	2860102.4	831285.6	1.4	3.2	1.8	muck to firm	Southwest Impoundment Zone
7	2859856.0	831166.9	1.5	3.5	2.0	muck to sand firm	Southwest Impoundment Zone
8	2859596.5	831234.2	3.2	3.2	0.0	gravel and cobble	Southwest Impoundment Zone
9	2859121.6	830798.7	2.8	2.8	0.0	gravel to firm	Southwest Impoundment Zone
10	2858798.9	830115.4	2.7	2.7	0.0	gravel to hard refusal	Southwest Impoundment Zone
11	2858751.1	830122.0	1.4	2.4	1.0	sand to firm	Southwest Impoundment Zone
12	2858425.9	829733.5	2.0	2.1	0.1	gravel to sand	Southwest Impoundment Zone
13	2858249.8	829574.3	1.3	3.0	1.7	sand to firm	Southwest Impoundment Zone
14	2858428.5	829790.3	1.3	3.0	1.7	sand to firm	Southwest Impoundment Zone
15	2858426.0	829789.9	-	-	-	sediment sample (IHD-1)	Southwest Impoundment Zone
16	2859902.9	831137.7	-	-	-	sediment sample (IHD-2)	Southwest Impoundment Zone
17	2860627.0	832709.6	-	-	-	sediment sample (IHD-3)	Northeast Impoundment Zone

2.2.2 Impoundment Sediment

Impoundment sediment was characterized based on observations and manual probing during the May 14, 2021, site visit.

2.2.2.1 Sediment Composition

Sediment composition in the impoundment generally consisted of sand and gravel with some overlying finer material and organics (i.e., muck). There was not a substantial variation spatially across the impoundment with respect to sediment composition, although there appeared to be slightly more finer material and muck in the Northeast Impoundment Zone. Overall depths of probed sediment were relatively shallow and ranged from less than 1 ft to 2.3 ft, with average and median depths of sediment of 0.9 ft and 0.7 ft, respectively. In five locations out of the fourteen total sediment probing locations, there was a sediment depth of 0 ft (i.e., no sediment). In the field, it was observed that areas closer to the expected channel thalweg has little to no finer sediment and the areas further away from the expected channel thalweg, such as closer to a bordering vegetated wetland area along the banks, had a greater amount of fine sediment accumulation. This is consistent with the expected cross-sectional energy profile across the river channel and the associated distribution of material sizes and type.

The lack of finer sediment is likely due to both the effects of a limited sediment supply from upstream due to the presence of the upstream Factory Pond Dam, and the vegetated wetlands that dominate the system upstream of the impoundment. Large amounts of fine material are likely not transported downstream from Factory Pond Dam. Similarly, fine material that discharges into the reach downstream of Factory Pond Dam likely settles out in the vegetated wetland areas at the upstream limit of the impoundment.

2.2.2.2 Sediment Volumes

Estimates of total and readily mobile volumes of accumulated sediment were developed using information obtained during the site visit, readily available information (e.g., aerial photographs), and experience based on other dam removal projects. The limited sediment probe data collected during the site visit suggest that the Northeast Impoundment Zone had more fine sediment deposition compared to the Southwest Impoundment Zone, which generally appeared to have less sediment deposition and more sand and gravel. For the purposes of the sediment volume analysis in this report, the sediment values are subdivided into these two independent zones.

In addition, there is evidence to suggest that the vegetated wetland riparian areas along the impoundment are likely areas where sediment was historically deposited before the dam spillway was breached and the impoundment was lowered. In particular, there were two areas in the impoundment that are currently forested swamp and scrub shrub wetlands that have formed on these likely historical sediment deposition areas. Based on field probing along the edges of the channel during the site visit, it is estimated that there may be around 2 ft of sediment accumulation in these areas. Figure 1 below presents the approximate locations of these historical sediment deposition areas.

Figure 1. Approximate areas of potential historical sediment deposition areas in the Indian Head Dam impoundment

There was some variation in probed sediment depth measurements. The greatest depths of probed sediment were 2.3 ft and 2.0 ft, located within the middle of the impoundment in the Northeast Impoundment Zone approximately 170 ft upstream from the dam spillway and on the side of the impoundment next to a vegetated wetland area approximately 2,200 ft upstream of the dam spillway, respectively. In general, the average probed sediment depth was 1.2 ft in the Northeast Impoundment Zone. The probed sediment depths were less in the Southwest Impoundment Zone with an average of 0.8 ft and there were more occurrences of firm refusals to gravel and sand compared to the Northeast Impoundment Zone.

Based on the typical probed depths of sediment and observations in the field, estimated volumes of total accumulated sediment and readily-mobile sediment in the impoundment of Indian Head Dam were developed using an estimated typical depth of 2 ft in the Northeast Impoundment Zone and 0.8 ft in the Southwest Impoundment Zone, a total impoundment surface area of 7.3 acres, and a post-dam removal channel width of 45 ft ± 10ft. Estimates of the readily mobile volume of sediment following dam removal are typically developed based on an estimated channel width through accumulated sediment.

Estimated channel widths are developed based on expected channel widths that would naturally form. A channel width of 45 ft was used in the calculations for evaluation of readily mobile sediment based on an approximation of bankfull width observed in the field in the downstream reach of Indian Head Dam during the site visit and also based on the USGS StreamStats bankfull width with the standard estimate error of prediction of approximately 10 ft. The intent of using the range of bankfull widths is that it facilitates bounding of some of the uncertainty inherent to sediment volume estimation.

The historical sediment deposition areas were also assumed to be sediment that contributes to the total sediment in the impoundment. Table 2 presents a summary of the total accumulated sediment and readily mobile sediment volumes for Indian Head Dam. Sediment volume data is presented in cubic yards (CY).

Table 2. Summary of total accumulated and readily mobile sediment volumes[7].

Location	Total Accumulated Sediment Volume (CY)	Readily Mobile Sediment Volume (CY)	Estimated Dewatered Volume of Readily Mobile Sediment (CY)
Northeast Impoundment Zone	6,500	2,800 (2,200 to 3,500)	1,900 (1,500 to 2,300)
Southwest Impoundment Zone	6,800	5,000 (3,900 to 6,100	3,400 (2,600 to 4,100)
Historical Sediment Deposition Areas	9,100	-	-
Total Impoundment Area	22,400	7,800 (6,100 to 9,600)	5,300 (4,100 to 6,400)

The estimated total volume of sediment in the Indian Head Dam impoundment is of approximately 22,400 CY of which approximately 7,800 CY is estimated to be readily mobile as a result of a dam removal project. Note that the estimated volumes of total and readily mobile sediment do not consider potential effects of shallow bedrock in the impoundment, which could reduce the estimated sediment volumes. Also note that the estimated volumes of total and readily mobile sediment do not consider effects of consolidation. Based on experience with similar dam removal projects, the volume of consolidated (i.e., dewatered) sediment is often about two-thirds of the unconsolidated volume. The estimated dewatered volume of readily mobile sediment is estimated to be approximately 5,300 CY.

2.2.2.3 Sediment Quality Analysis

Stantec collected three sediment samples from the impoundment area during the May 14, 2017, site visit for laboratory analyses. The sediment samples were collected using a manual bucket auger and the sample locations were documented using a GPS. Table 3 presents the sediment sample locations, sample collection information, and the sample identifier.

[7] Precision of the reported values results in small variations in the reported values relative to the estimated dewatered consolidation factor of two-thirds.

Table 3: Sediment Sample Locations and Depths

Location ID	Northing (ft)	Easting (ft)	Sample Collection	Identifier
15	2858426.0	829789.9	~~Bucket auger in 1.3 ft of water with 1.7 ft penetration into sediment.~~ Bucket auger at water surface along bank	sediment sample (IHD-1)
16	2859902.9	831137.7	Bucket auger at water surface along bank	sediment sample (IHD-2)
17	2860627.0	832709.6	~~Bucket auger at water surface along bank~~ Bucket auger in 1.3 ft of water with 1.7 ft penetration into sediment.	sediment sample (IHD-3)

Sediment samples were analyzed by Alpha Analytical, a Massachusetts-certified testing laboratory for a broad range of analytes and are identified as “Lab No. 2125580”. Sediment samples were analyzed by Alpha Analytical for metals, volatile organic compounds (VOCs), polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs [by congener]), total extractable hydrocarbons, DDT, DDE, DDD, Aldrin, Endrin, Dieldrin, total organic carbon, and grain size. Additional sediment analyses for methyl mercury were performed by Eurofins Frontier Global Sciences (Eurofins FGS). The laboratory IDs assigned by Eurofins FGS are IE00109-04, IE00109-05, and IE00109-06 for sample locations IHD-1, IHD-2, and IHD-3, respectively. Eurofins FGS is not a Massachusetts-certified testing laboratory for analyses of methyl mercury but was approved by DER for this testing.

Stantec entered the results of the laboratory analyses into a spreadsheet template provided by DER that included ecological and human exposure threshold criteria and Massachusetts Contingency Plan (MCP) Method 1 Standards criteria for soil and groundwater (S-1/GW-1) and used conditional formatting to compare the laboratory results with criteria provided by DER in the spreadsheet template. “Undetected” compounds based on the reported laboratory results were not compared to the threshold criteria. This comparison used the freshwater ecological threshold criteria in based on the sample locations being in freshwater. This comparison identified multiple exceedances of metals, PAHs, and pesticides for the ecological threshold Threshold Effects Concentration (TEC) and Probable Effects Concentration (PEC).

Of particular note is that report concentrations of two metals (lead [Pb] and mercury [Hg]) were high relative to the comparison criteria. Concentrations of Pb exceeded the PEC for sample IHD-2 (198 milligrams/kilogram [mg/kg] Pb) and that this value is marginally lower than the Method 2 (S-1) Human Exposure Threshold (200 mg/kg Pb). Concentrations of Hg exceeded the PEC each of the samples, sample IHD-1 (23 mg/kg Hg) exceeded the Method 2 (S-1) Human Exposure Threshold (20 mg/kg Hg) and the MCP Method 1 Standards criteria (20 mg/kg Hg), and sample IHD-2 (54.6 mg/kg Hg) exceeded the Method 2 (S-2) and Method 2 (S-3) Human Exposure Thresholds (30 mg/kg Hg) and the MCP Method 1 Standards criteria (20 mg/kg Hg).

The results of the sediment analyses are not unexpected based on the historical presence of manufacturing facilities, such as the National Fire Works Site, along the upstream reach of the Indian Head River.

The laboratory results, including documentation received from Alpha Analytical and Eurofins FGS, and the DER spreadsheet, were provided separately to DER are not are included as appendices to this report.

2.3 UPSTREAM WATERSHED

The upstream watershed is approximately 28.2 square miles with a mean basin elevation of 103 ft (North American Vertical Datum 1988 [NAVD88]). In general, the topography is relatively low gradient with a mean basin slope of about 1 to 3 percent (%). The drainage area for Indian Head Dam extends through the communities of Hanover, Hanson, Rockland, Abington, and Norwell. Primary land use and cover in the drainage area includes dense residential and commercially developed areas (~52%), forested land (~24%), and wetlands (~20%). The total impervious area is approximately 18%. Upstream tributaries to the Indian Head River include Indian Head Brook, Drinkwater River, French Stream, Cushing Brook, Ben Mann Brook, Shinglemill Brook and Longwater brook. Approximately 2.6 % of the land area in the drainage area includes open water bodies. Ponds located along the tributaries within the drainage area include Wampatuck Pond, Maquan Pond, Indian Head Pond, Factory Pond, Forge Pond, Studley's Pond, Hackett's Pond and Shinglemill Pond. Little Cedar Swamp, Beech Hill Swamp, Hell Swamp and the Abington/Rockland Reservoir are also located in the drainage area to Indian River Dam.

State Street Bridge is the first bridge located upstream, approximately 20 ft upstream from the dam. Winter Street Bridge is the second bridge located upstream, approximately 6,100 ft upstream from the dam. Factory Pond Dam (MA00391) is located approximately 6,950 ft upstream from Indian Head Dam and is the first dam upstream.

The former National Fireworks Site is located on Indian Head River upstream from Indian Head Dam. The National Fireworks Site comprises approximately 240 acres in the Towns of Hanover and Hanson and is currently owned by more than 40 different public and private entities. Past activities within this area, including manufacturing of fireworks and pyrotechnics, development and manufacturing, storage, and testing of munitions for the U.S. Department of Defense from World War II, have resulted in release of various chemical contaminants, primarily mercury and lead. This site is currently in the process of being remediated under the Massachusetts Contingency Plan.

2.4 HISTORICAL REFERENCES

The preliminary review of the data available through MACRIS for the towns of Hanover and Hanson on Cross Street and the Village of South Hanover indicated that the only inventoried historical feature in proximity to the Project appears to be a shed that remains from the "Philips Tack Factory" with Inventory No. "HNV.331". It is anticipated that this site, located at 249 Cross Street on the upstream side of Cross Street to the left[8] (north) of the former flume pipe, would not be impacted by a dam removal project. There may be additional historical significance at this site related to the Indian Head Dam, which should be investigated in future phases of the Project.

[8] "Left" and "right" refer to an observer facing downstream.

2.5 PROJECT REACH OF INDIAN HEAD RIVER

This section presents descriptions of the reaches of the Indian Head River upstream and downstream from Indian Head Dam. Information contained in these sections is based on observations during the site visit as well as review of publicly available data.

2.5.1 Upstream Reach

The upstream reach of Indian Head Dam between the dam and the upstream Winter Street Bridge is a single channel, low sinuosity (<1.3) channel buffered by vegetated wetland riparian areas along the flood prone areas of the river and banks. The channel has a very mild (~0.1%) slope. The left (north) side of the river has a large forest buffer and the right (south) side of the river has some medium-density residential for a portion of the reach with some forested and vegetive buffer.

The estimate of bankfull geometry from the USGS StreamStats online tool, which was based on a drainage area of 28.2 square miles and a mean basin slope of 2.7%, calculated a bankfull width of 47 ft (±10 ft), a bankfull depth of 2.2 ft (±0.4 ft), a bankfull area of 103 square ft (±29 square ft), and a bankfull streamflow of 220 cubic ft per second (±55 cubic ft per second).

Indian Head Brook, a relatively major tributary to the Indian Head River, discharges to the river approximately 3,500 ft upstream from the dam. Winter Street Bridge is located approximately 6,100 ft upstream from the dam. At approximately 4,800 ft upstream of Indian Head Dam, the river becomes increasingly dominated by vegetated wetlands. Aerial imagery indicates a channel runs through this area up to the Winter Street Bridge, however, it is much narrower and flow appears to be dispersed across the wetland area.

The former dam spillway prior to the breach resulted in a higher normal pool water surface elevation in the impoundment. There is apparent evidence of historical sedimentation along the inner banks along the upstream reach (see Section 2.2.2.2). These historically sedimented areas are now dominated by successional vegetative species that are tolerate of the wet conditions at these locations and are indicated as shrub swamp and wooded swamp according to the Massachusetts Department of Environmental Protection (MassDEP) wetlands data layer.

2.5.2 Downstream Reach

Immediately downstream of Indian Head Dam the channel is steeper gradient (~1% slope), which then transitions to a lower gradient channel approximately 500 ft downstream from the dam. There are large boulders lining the sides of the downstream channel on river left. The channel bed appears to consist of cobbles and large gravel, consistent with the lack of upstream sediment supply. The downstream reach generally flows east and is surrounded by forested swamp with a forested upland buffer. The confluence with Rocky Run is located approximately 1,750 ft downstream from the dam. Downstream of the Rocky Run confluence, the river continues to flow east towards the remnants of Tack Factory Pond Dam (MA03149), which is located approximately 4,150 ft downstream from Indian Head Dam. Curtis Crossing

Dam (MA00428) is the next dam located downstream and is approximately 7,850 ft downstream from Indian Head Dam and is also reportedly owned by the Town of Hanover.

2.5.3 FEMA FIS Data

The FEMA FIS report for Plymouth County, Massachusetts as revised November 4, 2016, was reviewed in preparation of this report. Through this review, it was identified that the Indian Head Dam (not explicitly called out in the FEMA FIS report) is located within a regulatory floodway with a Zone AE designation (base flood elevation determined by detailed study methods) on the Indian Head River. A small weir is evident in the flood profile data presented in the FEMA FIS report located just downstream of the Cross Street Bridge (i.e., State Street Bridge). The regulatory floodway extends upstream and downstream from the dam.

In addition, the FEMA FIS report provides information regarding flood frequency discharge curves developed by FEMA and peak flow data, which may be useful references in future studies and design phases for the Project.

2.6 ADJACENT AREAS

This section presents information on identified features adjacent to the dam and impoundment based on observations during the site visit and review of readily available information.

2.6.1 Natural Resources

Based on the publicly available MassDEP wetlands data layer, there are bordering vegetated wetlands along Indian Head River upstream and downstream of Indian Head Dam. Wetland types include shrub swamp to wooded deciduous swamp and wooded mix swamp, and deep marsh habitat. Wetland areas adjacent to the existing impoundment may see some reduction in local surface and sub-surface water levels as a result of dam removal.

The Natural Heritage Endangered Species Program (NHESP) priority habitats of rare species data layer does not depict priority habitat in the vicinity of Indian Head Dam but identifies priority habitat (PH 892) located downstream of Curtis Crossing Dam along Indian Head River before its confluence with North River. This area appears to be consistent with the portion of Indian Head River that experiences more tidal influence and also greater areas of shallow marshes and shrub swamps.

Anadromous fish species are present in the downstream reach of the Indian Head River, especially below Curtis Crossing Dam. This is evidenced by the presence of the fishway at Curtis Crossing Dam. In addition, the Department of Fish and Game's "Anadromous Fish" point layer indicates that the downstream reach of Indian Head Dam is a known coastal anadromous fish run and spawning habitat.

2.6.2 Upstream and Downstream Infrastructure

The following section contains background information on upstream and downstream infrastructure relevant to the removal of Indian Head Dam. Information noted in this section is based on available plans reviewed in the preparation of this report as well as observations from the site visit.

2.6.2.1 Bridges

State Street Bridge (Bridge No. H-07-004) is located approximately 20 ft upstream of Indian Head Dam. The bridge appears to have been rehabilitated in 1995 based on the information presented in the State Street Bridge Drawings. The rehabilitation appears to have included replacement of the bridge superstructure. The clear span opening of the bridge is 49 ft and the low chord of the bridge is approximately 5 ft above the normal water surface. There is no information in the State Street Bridge Drawings that indicate the depth of the bottom of the abutment footings aside from a detail that estimates concrete to be poured to an elevation of approximately 30.5 ft (NGVD29) with actual elevations determined in the field during excavation. The existing stone abutment was to remain as indicated in the drawings. Based on this information, the abutments may be approximately 3 ft below the Indian Head Dam spillway weir. Therefore, removal of Indian Head Dam should include considerations for protection of the abutments, including the potential need for scour countermeasures.

Winter Street Bridge is located approximately 6,100 ft upstream from Indian Head Dam. It is not anticipated that dam removal would impact the Winter Street Bridge.

2.6.2.2 Other Infrastructure

There are overhead utility wires along State / Cross Street upstream of the dam. No other utilities were noted based on observations in the field as well as preliminary review of the State Street Bridge Design Drawings. The former mill building complex located at the dam site is no longer present aside from a shed located at 249 Cross Street (see Section 2.4).

No other infrastructure was identified as part of this Project.

2.6.3 Sanborn Fire Insurance Maps

The November 1917 Sanborn Fire insurance Map of the village of South Hanover area of Hanover was reviewed as part of the Project (see Figure 2). The map illustrates the location and extent of the old Diamond Tack and Nail Works E. Phillips & Sons Branch factory infrastructure at Indian Head Dam. Building locations are outlined as well as locations of bluing facilities, lead melting areas, and iron storage. A railroad track appears to be located approximately 300 ft north of the factory building. The location of the flume is shown on these maps. In addition, an additional tailrace is shown between the main channel of the Indian Head River and the flume tailrace that was observed during the site visit, which appears to have since been abandoned.

2.6.4 Abutters and Public Access

Based on observations from the site visit, there does not appear to be designated public access or trails at the location of Indian Head Dam. There is a small parking area located between the Indian Head Dam spillway and the former flume culvert on the east side of Cross Street. From this parking area, it is possible to access both the dam and adjacent areas as well as the upstream impoundment.

There are residential properties that abut the Indian Head Dam impoundment, including approximately ten on the left (north) side and approximately eight properties on the right (south) side. Most of these properties have access to the Indian Head River. These properties are generally within approximately 2,000 ft upstream of Indian Head Dam.

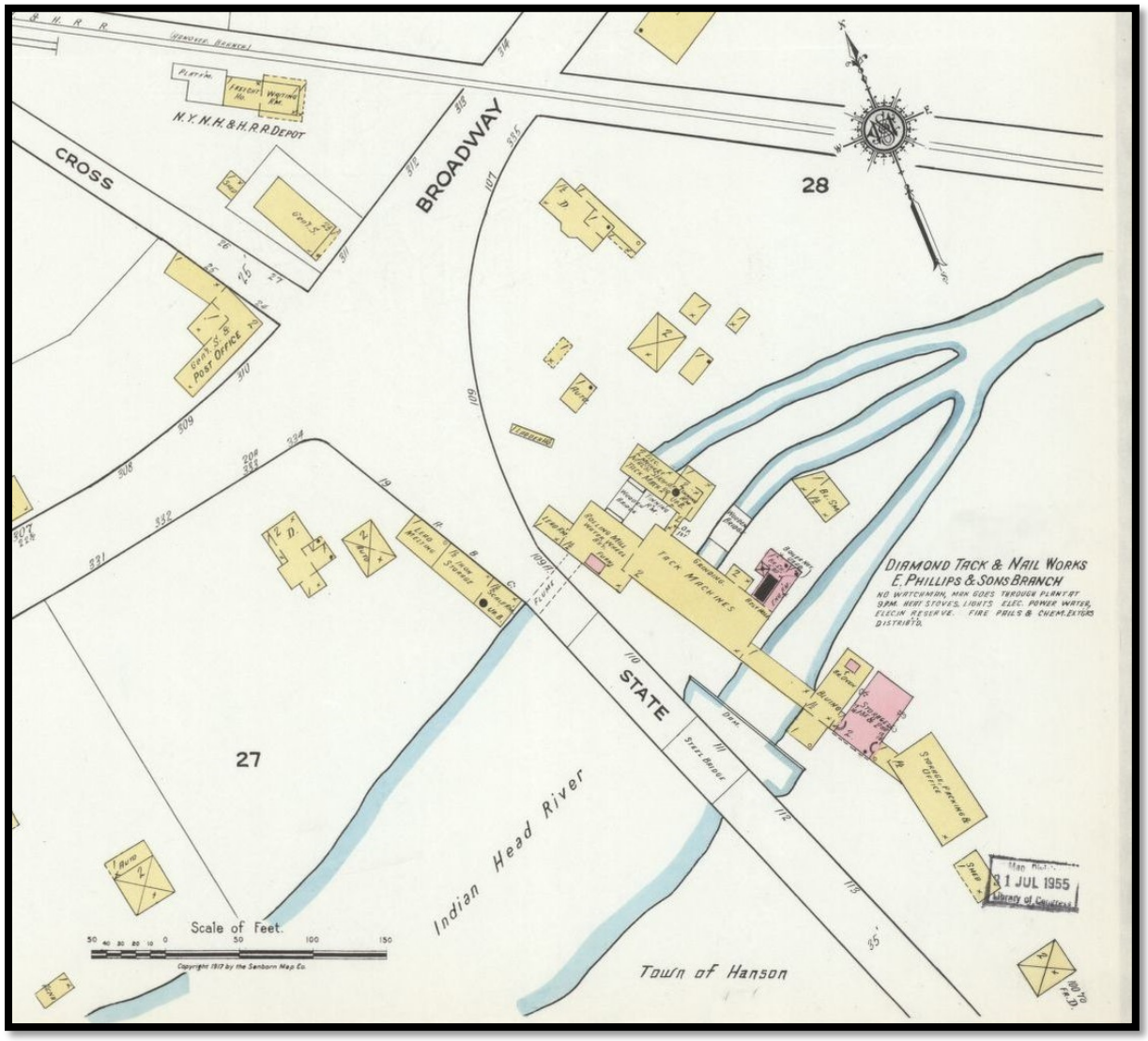


Figure 2. Zoomed in image from the Sanborn Fire Insurance Map November 1917 Hanover Massachusetts panel of South Hanover.

3.0 DAM REMOVAL OPPORTUNITIES AND CONSTRAINTS

This section presents identified opportunities and constraints associated with removal of Indian Head Dam. Refer to Figures B.1 and B.2 in Appendix B for the existing conditions basemap that depicts existing elements within the Project Area, and the conceptual design dam removal approach, respectively.

3.1 NATURAL RESOURCES

Indian Head Dam has created a fragmented and discontinuous reach of Indian Head River. This results in several deleterious effects on the aquatic ecosystem, eliminating effective transport of downstream sediment and nutrients, and limiting passage of fauna upstream and downstream of the dam. Removal of the dam would result in a more free-flowing section of Indian Head River at this location and would restore the flux of biotic and abiotic elements of the natural system. The former flume and downstream old millrace is an attractive nuisance for migratory fish species. There is also the opportunity to convert the existing man-made, relatively shallow impoundment to a natural, free-flowing river, which would be similar to the upstream and downstream reaches of Indian Head River.

3.2 SAFETY

Indian Head Dam is a relatively small dam which has already been breached. Therefore, the safety concerns for the general public are reduced at this location. However, due to the deteriorating condition of the dam, there are additional safety concerns related to dam failure and uncontrolled release of water and sediment, which may be of significant concern due to the upstream state environmental clean-up site (i.e., National Fire Works Site) and the potential for mobilization of contaminated sediment into the downstream reach. Also, failure of this dam could potentially impact the upstream State Street Bridge, which may have shallow abutment footings. Therefore, removal of the dam would eliminate safety hazards associated with this deteriorating, relic piece of infrastructure as long as scour countermeasures are considered at the bridge along with the dam removal.

3.3 HISTORICAL

Additional assessment of the potential historical significance of Indian Head Dam is recommended given the previous history with the mill industries in this location, most recently the Diamond Tack and Nail Works facility. Documentation of the demolition may be required pending historical review. Similar to other dam removal projects throughout the Commonwealth of Massachusetts, there may be an opportunity for providing interpretive signage that acknowledges any noted historical significance at this site.

3.4 CONSTRUCTION ACCESS AND STAGING

The area surrounding Indian Head Dam was part of a factory complex, which has since been demolished. There are no buildings or infrastructure, aside from the upstream State Street Bridge, adjacent to the

dam. The area around the dam is currently overgrown with woody vegetation and small trees. Based on site observations and review of materials as part of this reconnaissance report, it appears as though the best route for construction access to the dam would be through using the existing parking area on the east side of State Street (Cross Street) between the dam spillway and the former flume. The land surrounding this parking could be cleared to provide both construction access and staging for dam removal. This area could be restored following dam removal. It is anticipated that dam removal could be accomplished from the left side of the dam spillway and a temporary conduit or similar water control measures could be employed to facilitate access to the right side of the dam spillway.

The overhead transmission wires on the east side of State Street (Cross Street) may need to be considered for project construction. However, this is not considered a significant constraint.

There were no significant constraints identified at the site for construction access and staging.

3.5 SEDIMENT MANAGEMENT

Relevant factors that are typically addressed for sediment management as part of design and permitting for removal of small dams in Massachusetts include the volume, composition, and quality of accumulated sediment. The composition and estimated volume of sediment in the dam impoundment appear typical of other, similar impoundments associated with small dams on small waterways and do not appear to represent a significant constraint to removal of the dam. Based on documented releases of environmental contaminants at the National Fire Works Site and the historical presence of manufacturing facilities at other locations along the Indian Head River, it is expected that due care would be required for development of an appropriate and permittable sediment management approach for removal of Indian Head Dam.

Based on the estimated volume of readily mobile sediment impoundment formed by Indian Head Dam presented in Section 2.2.2.2 (7,800 CY), elevated concentrations of environmental contaminants identified in analyses of sediment samples collected as part of this project, and the presence of the National Fire Works Site along the upstream reach of the Indian Head River, it is expected that a site-specific sediment management plan would need to be developed for removal of Indian Head Dam. Such as plan would likely need to address both the quantity and quality of accumulated sediment in the dam impoundment.

General approaches to sediment management as part of dam removal projects includes “passive” (“instream”) and active (e.g., dredging) approaches. The Elm Street Dam removal project at head-of-tide on the Jones River in Kingston, MA was completed in 2019 and used a passive sediment management approach that allowed for natural remobilization of approximately 3,000 CY of sediment into the downstream reach of the Jones River along with dredging on offsite disposal of some accumulated material located immediately upstream from the dam spillway. Primary factors that resulted in implementation of passive sediment management for the Elm Street Dam removal project included relatively low concentrations of contaminants and receipt of permits for instream sediment management. Conversely, removal of multiple dams on Town Brook in Plymouth, MA, such as removal of Holmes Dam

in 2020, included active sediment management approaches to address elevated contaminant concentrations in the accumulated sediment.

Based on the quantity of sediment and elevated concentrations of environmental contaminants and the presence of the National Fire Works Site along the upstream reach of the Indian Head River, it is expected that receipt of permits for removal of Indian Head Dam based on a passive sediment management approach that would be challenging. A hybrid sediment management approach may represent a feasible and permittable approach at Indian Head Dam. Such an approach could include targeting removal of sediment in areas with higher contaminant concentrations while allowing for passive sediment management in areas with lower contaminant concentrations. Given the low height of Indian Head Dam and the presence of floodplain that appear to have resulted from deposition of sediment prior to the substantial breaching of Indian Head Dam in 1973, hydraulic and sediment transport modeling could inform the potential mobility of legacy sediments adjacent to the existing channel of the river upstream from the dam.

Active management (e.g., dredging/excavation and offsite disposal) of sediment in the primary, normal-pool impoundment is not explicitly included in the construction sequence described below. If active sediment management is identified as necessary for removal of Indian Head Dam, it is expected that it would be performed following the initial drawdown of the impoundment. Active sediment management could include onsite repositioning of sediment (e.g., placement of sediment along the sides of the impoundment) and off-site disposal.

The assimilative capacity of the downstream reach of Indian Head River between the dam and the downstream Tack Factory Pond Dam appears to be relatively high, based on the relatively shallow slope of the majority of this reach, the bordering vegetated wetland areas along the reach, and the historical lack of transport of finer materials downstream of Indian Head Dam. However, sediment transported downstream would likely eventually end up in the Curtis Crossing Dam impoundment. If Curtis Crossing Dam is removed, there would be additional assimilative capacity downstream as the sediment would be transported further downstream to the downstream end of the Indian Head River and the confluence with the North River where there is an increasing presence of shallow marshes and other bordering vegetated wetlands. Based on the relatively large volume of expected readily-mobile sediment, development and use of a coupled, numerical hydraulic/sediment transport model is recommended to evaluate opportunities and constraints associated with allowing accumulated sediment in the impoundment to naturally erode following dam removal.

There may be some potential for aggradation of the downstream channel of Indian Head River in the near-term following dam removal due to the shallow slope just upstream of Tack Factory Pond Dam. As previously noted, sediment transported downstream would also likely settle out in the Curtis Crossing Dam impoundment unless that dam is removed. Consideration of downstream effects from a release of sediment from the dam following removal would also need to be further evaluated. For example, there may be natural resources in the downstream reach of Indian Head River that could be affected by remobilization of sediment.

3.6 ADJACENT INFRASTRUCTURE

State Street Bridge is located approximately 20 ft upstream of Indian Head Dam. Based on the limited information on the State Street Bridge abutment footings in the construction drawings reviewed as part of this reconnaissance study, removal of Indian Head Dam may require countermeasures for protection against undermining of the footings.

An opportunity associated with installation of countermeasures, for example rock riffle structures, is that this may provide an opportunity for maintaining or limiting transport of impoundment sediment downstream. This may be considered an opportunity to reduce the risk of spreading contaminated sediment downstream given the upstream legacy of the National Fire Works Site. Installation of scour countermeasures should be coordinated in conjunction with the sediment management plan developed during the dam removal design and permitting phase.

It is not anticipated that removal of Indian Head Dam would have impacts to other bridges or infrastructure along Indian Head River identified in this report. Since the dam is not a flood control dam, is a run-of-river type design, and has limited impoundment storage, downstream flood flows are not anticipated to substantially increase as a result of dam removal. Upstream flood water surface elevations are expected to be reduced along Indian Head River as a result of dam removal. Additional study, including hydraulic modeling is necessary to evaluate potential impacts of dam removal on adjacent infrastructure.

3.7 ABUTTERS AND PUBLIC ACCESS

Typical of similar dam removal projects in the region, there are both opportunities and potential constraints associated with abutters and public access. Early coordination and consensus building with abutters and the general public may mitigate against possible adversarial responses to a dam removal project.

This site currently has limited public access, which appears to be primarily from the small parking area on the east side of Cross Street between the dam spillway and the former flume. Similar to other dam removals, there are educational and learning opportunities for public engagement as part of this type of ecological restoration project.

During the dam removal project construction phase, which is anticipated to be over the course of approximately six weeks, the public would have restricted access to the active construction work zone in the area around the dam. An identified opportunity associated with dam removal is to improve the existing ad hoc paths adjacent to the dam. Construction access for removal of the dam would require grading for construction access and the Project design could include construction of improved paths for pedestrian access to the left side of the river adjacent to the dam.

4.0 CONCEPTUAL DAM REMOVAL APPROACH

The following sections present a brief overview of a conceptual dam removal approach and construction sequencing for the removal of Indian Head Dam.

4.1 OVERVIEW

Dam removal projects typically require identification and evaluation of opportunities and constraints. Physical conditions that are often evaluated include impacts to natural resources (e.g., wetlands), sediment quality and quantity, adjacent infrastructure, and historical resources. Social factors also arise as part of the dam removal project process and are typically associated with perceptions associated with expected alteration of dam impoundments from lentic (e.g., ponds, lakes) to lotic (e.g., rivers, streams) conditions. Mitigation of physical impacts, such as installation of scour countermeasures at impacted bridges and culverts, may be identified as necessary as part of a given dam removal project. Similarly, accommodation of social concerns may also be identified as appropriate, such as construction of trails and installation of signage for documentation or pre-dam removal conditions.

The primary identified constraints to removal of Indian Head Dam are 1) coordination between the Towns of Hanover and Hanson regarding dam ownership, 2) the upstream State Street Bridge, and 3) sediment management. The basis for identification of coordination between stakeholders as a primary constraint is that the dam is reportedly owned by the Town of Hanover, however the dam appears to be situated in between the Town of Hanover and the Town of Hanson based on review of data available on MassGIS. Therefore, a joint, shared vision for the site is important.

The basis for identification of the upstream State Street Bridge as a primary concern is the potential impact of dam removal on the structural integrity of the bridge abutment footings. It is not uncommon for dams and bridges to be located in close proximity. However, when a dam is removed, there is potential for upstream head-cutting and lowering of the stream channel, which can undermine these structures. Several options for countermeasures are available to address this potential problem and are discussed in Section 4.2 below.

The basis for identification of sediment management as a primary constraint is the relatively large volume of accumulated sediment in the primary, normal-pool impoundment and the presence of a relatively large-scale environmental contamination remediation site located in the upstream watershed at the National Fire Works Site.

4.2 DAM REMOVAL

Coordination with the Towns of Hanover and Hanson to develop a shared vision and pathway for dam removal would be the first step in the dam removal process. Dam removal design and permitting would follow and is anticipated to include development of a sediment management plan, hydrologic and hydraulic study, additional investigation of the potential impacts of dam removal to the upstream bridge, development of design plans, and permitting. Following completion of dam removal design and

permitting, the next step would include the construction phase. The general dam removal elements are discussed below within the context of this framework.

Based on observations by Stantec during the site visit, the area on the east side of State Street (Cross Street), including the existing parking area, would provide suitable construction access and staging. The basis for this initial assessment is that accessing the dam from upstream of State Street (Cross Street) is not possible given the relatively low height opening between the river channel and the low chord of the State Street Bridge. Also accessing the dam from river right is not as easy as river left due to the presence of the existing parking area and the historical presence of the mill building infrastructure on river left. Clearing of brush and trees would be required to facilitate access to the dam spillway. In addition, some grading and temporary rock installation for ramping down to the dam spillway may also be necessary to allow for large equipment access. Figure B.2 in Appendix B presents an overview of the proposed conceptual construction access and staging.

As previously identified, removal of Indian Head Dam may impact the State Street Bridge and therefore requires further investigation. Based on the design drawings reviewed as part of this reconnaissance study, the bridge abutment footings may be at risk of being undermined if the dam is removed (see Section 2.6.2.1). Therefore, countermeasures to mitigate against head-cutting, future erosion and scour, and potential failure of State Street Bridge may be a primary constraint for dam removal. The boring log data presented on Sheet 2 of 12 of the State Street Bridge Drawings suggest that the bridge footings may be founded on medium dense fine sand and coarse gravel. Based on observations in the field, existing scour countermeasures under the bridge appear to consist of large rock material. Therefore, design and installation of rock riffles may be an appropriate approach for mitigating against scour, head-cutting, and undermining at the bridge, although there is currently some uncertainty. Additional investigation should include development of a longitudinal profile from downstream of the dam and into the upstream impoundment as well as exploration and research on the depth of the bridge abutment footings and is recommended as part of the dam removal design process.

Prior to removal of the dam and if deemed appropriate, scour countermeasures should be installed at State Street Bridge. If dewatering of the impoundment is necessary for installation of countermeasures at State Street Bridge, it may be possible to use cofferdams to isolate and divide flows between the bridge and spillway to work in the “damp” (in standing water). Alternatively, a cofferdam installed upstream of the bridge could potentially create a surcharged upstream condition so that flow would be diverted through the former flume culvert.

Following installation of scour countermeasures, a gradual removal of the large granite blocks and boulders that comprise the dam spillway would begin the dam removal process. Since the remaining granite and boulder remnants of the former spillway at Indian Head Dam compose the primary stream barrier and dam at this site, removal of these materials would substantially result in free-flowing conditions at this site. There may be an opportunity to reuse the granite blocks and boulders from the dam spillway as part of the design of rock riffles at this site, if these features are incorporated into the dam removal design.

While some of the original dam embankment could be graded back as part of dam removal, preliminary observations suggest that this does not appear to be necessary to achieve the goals and objectives for dam removal at this location. Therefore, removal of the dam spillway to eliminate the stream barrier at this location should be the focus of dam removal.

As part of the dam removal, the former flume concrete culvert would be formally decommissioned and capped on the upstream end. This concrete culvert no longer serves its original intended purpose and serves as an attractive nuisance to upstream migrating fish. The outlet of the culvert is perched and is not passable by aquatic organisms in its existing configuration. Abandoning and decommissioning the culvert would need to be coordinated with the hydraulic studies as part of the dam removal planning and design process. During high flows, the former flume may reduce water surface elevations upstream. Additional investigation is therefore recommended.

The work would likely be performed during the low-flow season, which would be July through September. Following the removal of the dam, the latent seed bed in any exposed areas of the former impoundment would start to revegetate within one growing season. Additional plantings and seeding of the former impoundment may not be necessary and typically increases project costs but could help increase the rate of establishment of early successional species if this is identified as a future project objective.

4.3 CONSTRUCTION SEQUENCING

This section presents a conceptual construction approach for removal of the Indian Head River Dam, including the conceptual construction-phase water management, as described in the conceptual dam removal approach presented in Section 4.2. This approach reflects the ongoing evolution of dam removal construction practice in Massachusetts.

Active sediment management (e.g., dredging/excavation and offsite disposal) in the primary, normal-pool impoundment is not explicitly included in the construction sequence described below. If active sediment management is identified as necessary for removal of Indian Head Dam, it is expected that it would be performed following the initial drawdown of the impoundment.

The following list presents the sequence of the conceptual construction and water management approach. Note that each phase begins and ends with a description of water management associated with that phase.

1) Construction Mobilization
    a. Clear trees and brush as necessary to provide access to the dam from the left side of the spillway.
2) Phase 1: Dewatering Impoundment:
    a. Remove granite blocks and boulders incrementally to lower the upstream water surface elevation. Monitor the State Street Bridge for excessive scour. Flow is discharged through the spillway as granite blocks and boulders are removed.
    b. Install scour countermeasures for State Street Bridge (if necessary).

3) Phase 2: Dam Removal
    a. Maintain flow through the breach in the spillway.
    b. Continue to remove the remnants of the dam spillway until the full vertical extent of the dam is removed within the Indian Head River.
    c. Material removed as part of the dam removal is staged then removed off site.
    d. Abandon and decommission the former flume culvert to the left of the dam.
4) Phase 3: Final Site Grading, Cleanup, and Demobilization
    a. Maintain flow through the former location of the spillway.
    b. Remove temporary access roads and staging areas, and restore areas that were directly impacted by construction.
    c. Demobilize.

5.0 ENVIRONMENTAL PERMITTING

It is anticipated that environmental regulatory review and permitting requirements for this Project would be similar to those encountered as a part of other small dam removal projects in Massachusetts and will include local, state, and federal regulatory coordination and permits. Early coordination with the Hanover and Hanson Conservation Commissions during the stakeholder outreach process, as well as pre-application coordination with other local, state, and federal environmental regulators, is recommended to facilitate an efficient regulatory review process.

Anticipated regulatory coordination, review, and permit requirements may include:

- Expanded Environmental Notification Form under Massachusetts Environmental Protection Act;
- Water Quality Certification from MassDEP;
- Notice of Intent under the Massachusetts Wetlands Protection Act and the Towns of Hanover and Hanson Wetlands Bylaws;
- Authorization under Category II of the General Permit from the U.S. Army Corps of Engineers;
- Chapter 253 Permit from the Massachusetts Department of Conservation and Recreation Office of Dam Safety would be required for dam removal; and
- Chapter 91 Waterways authorization. It was not determined whether the Project site is located in a geographic area that is within the jurisdiction of the Massachusetts Public Waterfront Act (Chapter 91). Potential requirement for a Chapter 91 License and/or Permit for this Project would need to be evaluated during the design and permitting process.

Additional permits or authorizations may be required based on Project development and coordination with environmental regulators. Potential additional permits and authorizations not included in the opinion of probable cost (OPC) provided in this report may include:

- Massachusetts Endangered Species Act Coordination: If the Project is determined to have the potential to impact state-listed species, additional coordination (e.g., including development of a Habitat Management Plan) may be required. A cursory review of the Massachusetts Natural Heritage Endangered Species Program suggests that there are no priority habitats or estimated priority habitats of rare species and wildlife located within the impoundment, upstream reach, immediately downstream of the dam, or within the dam footprint. There is a priority habitat located approximately 1,900 ft downstream of the Curtis Crossing Dam along Indian Head River (PH 892).
- Additional Municipal Review and/or Permits: Additional municipal permits or reviews may be identified based on a review of municipal ordinances and related coordination with Town officials.
- Review by the Massachusetts Historical Commission.

- Compliance with Section 106 of the National Historic Preservation Act.

6.0 DISCUSSION ON ADDITIONAL RECOMMENDED DATA COLLECTION

Coordination between the Towns of Hanover and Hanson was identified as a primary constraint for the removal of Indian Head Dam. Coordination and planning for a shared vision at this location should begin during the early phases of the Project to facilitate communication between all parties.

Additional data collection and study recommendations for advancing dam removal design at Indian Head Dam include the following:

1) Investigation of the Upstream State Street Bridge Abutments

   A primary constraint to dam removal at this site is the presence of the bridge immediately upstream of the dam. Removal of the dam would likely drop the channel bed elevation in the upstream reach, especially within the footprint of the bridge. There it is recommended that additional information on the depth and type of abutment footings on State Street Bridge be collected to determine if countermeasures and more extensive water management is needed as part of dam removal and to reduce the uncertainty related to this component.

2) Bathymetric and Sediment Data Collection of the Impoundment

   Although the effective size of the primary, normal-pool impoundment is not particularly large (approximately 7 acres), the identified volumes of accumulated and readily-mobile sediment are large and warrant additional study. Collection of additional bathymetric data and quantification of the volume and composition of accumulated sediment is recommended for dam removal planning and design.

3) Sediment Sampling Analysis

   Analysis of the sediment samples in conjunction with the sediment sampling effort being performed at the National Fireworks Site along the upstream and downstream reaches of Indian Head River should be performed as part of dam removal planning and design. Additional sampling within the impoundment and in the downstream reach may be identified during this process. This effort would play an important role in the development of a sediment management plan for dam removal.

4) Hydraulic and Sediment Transport Analyses

   Based on the relatively large volume of accumulated sediment and potential for transport of contaminated sediment, development and application of a coupled, numerical hydraulic/sediment transport model is recommended to evaluate approaches for sediment management for removal of Indian Head Dam. It is suggested that a coupled, numerical hydraulic/sediment transport model

be developed for the reach of Indian Head River from the upstream limit of the Project reach for this study to the confluence of the river with the North River. The suggested approach is to evaluate whether there is a good quality, existing hydraulic model for Indian Head River (e.g., a model developed as part of the FEMA FIS) and modify this model to include sediment transport.

5) Historical Resources Investigation

Stantec has not determined whether structures or districts within the project area are currently listed or eligible for listing as historic resources. Nor has any investigation considered potential archeological sensitivity. A firm that specializes in historic and archeologic assessment should be hired to investigate these matters and advise the owner on compliance with related state and federal regulations. See Section 2.4 for discussion regarding historical references and earlier investigations, including those by MACRIS.

7.0 CONCEPTUAL PROJECT OPC AND SCHEDULE

This section presents a conceptual, order-of-magnitude opinion of probable cost (OPC) for design, permitting, and construction removal of Indian Head Dam as described in Section 4.0. The OPC is presented in Table 4, and was prepared for planning purposes and is commensurate with the conceptual design phase of the Project. The OPC does not include costs for external project management or active sediment management as part of project construction. Development of cost estimates for active sediment management during construction would require a more defined sediment management plan. The OPC does not include the potential need for legal guidance or associated costs that may arise as part of the dam removal process.

Phase 4 of the OPC includes items for “Construction-Phase Professional Services – Office” and “Construction-Phase Professional Services – Field”. The former item is for office services by the engineer, such as review of submittals, review and responses to requests for information, and construction close-out documentation. The latter item is for the engineer or their representative onsite during project construction for a period of 6 weeks. The opinion of probable construction cost (OPCC) for removal of Indian Head Dam in Table 4 is provided in Appendix C. Note that the OPC and the OPCC are based on information reviewed in the preparation of this report and the general approach to dam removal presented in this report. Actual costs could vary widely. For example, Stantec’s experience suggests that the construction cost for removal of the Indian Head Dam spillway without consideration of constraints associated with the upstream bridge and sediment could cost less than $50,000. Based on the information presented in this report, Stantec does not recommend a simplified approach that does not address these and other identified constraints to removal of this dam.

For planning purposes Table 4 includes an order of magnitude probable cost with a range of -30% to +50% of the OPC to reflect the uncertainties inherent to this stage of Project planning, which is consistent with the American Society for Testing and Materials (ASTM) E 2516-11 general guidance for accuracy ranges for a Class 5 level estimate. Multiple additional factors may influence the actual costs of the alternative presented in this report, and the results of further studies, coordination, and design

development may substantively affect the cost of the Project. DER and its Project partners may consider adding contingencies to reflect uncertainty commensurate with the early planning phases of a project and the assumptions and exclusions identified above. The schedule presented in Table 4 reflects a relative timeline based on the start date of the Project. The quarters do not necessarily reflect actual quarters of the calendar year.

Table 4. Conceptual OPC and Schedule for Removal of Indian Head Dam

Work Item	Year/Quarter												Opinion of Probable Costs	
	Year 1				Year 2				Year 3					
	1	*2*	*3*	*4*	*1*	*2*	*3*	*4*	*1*	*2*	*3*	*4*	Coordination, Design, and Permitting*	Construction
Project Management														
Phase 1: Feasibility Study and Conceptual Design														
Project Management													$15,000	
Topographic Survey													$10,000	
Wetland Delineation													$5,000	
Bathymetric and Sediment Data Collection													$15,000	
Additional Sediment Sampling Analysis and Reporting													$20,000	
Hydraulic and Sediment Transport Analyses													$25,000	
State Street Bridge Assessment													$10,000	
Conceptual (30%) Design Plan													$20,000	
Conceptual Basis of Design Study													$30,000	
Stakeholder Outreach													$5,000	
													Phase 1 Subtotal:	$155,000	
Phase 2: Preliminary Design														
Project Management													$10,000	
Sediment Management Plan													$15,000	
Basis of Design Report													$15,000	
Draft Preliminary-Level (60%) Design													$40,000	
Preliminary-Level (60%) Design													$20,000	
													Phase 2 Subtotal:	$100,000	
Phase 3: Permitting and Design														
Project Management													$10,000	
Environmental Permitting													$80,000	
Final Dam Removal Design													$20,000	
													Phase 3 Subtotal:	$110,000	
Phase 4: Construction														
Bidding Support														$20,000
Construction														$300,000
Construction-Phase Professional Services - Office														$40,000
Construction-Phase Professional Services - Field														$40,000
													Phase 4 Subtotal:		$400,000
													Subtotals:	**$365,000**	**$400,000**
													Total (Rounded):		**$770,000**
													Minimum / Maximum Probable Cost Range:		**$540,000 - $1,160,000**

*Note: Actual costs for coordination, design, and permitting can vary substantially depending on multiple factors. The OPC presented here is based on Stantec's experience with similar projects.

Appendix A SITE PHOTOGRAPHS

Photo 1. Overview of Indian Head Dam spillway

Photo 2. Overview of Indian Head Dam impoundment facing upstream

Photo 3. Overview of Indian Head River facing downstream from the Indian Head Dam spillway

Photo 4. Overview of right spillway abutment

Photo 5. Overview of left spillway abutment

Photo 6. Overview of State Street Bridge and State Street (Cross Street) from the roadway facing south

Photo 7. Overview of State Street Bridge and State Street (Cross Street) from the roadway facing north; note the location of the parking area to access dam

Photo 8. Overview of former flume concrete pipe inlet on the left side of the dam

Photo 9. Overview of former flume concrete pipe outlet

Photo 10. Overview of the old millrace facing downstream from the former flume concrete pipe outlet

Photo 11. Overview of bordering vegetated wetlands along the upstream Indian Head River channel (typical)

Photo 12. Overview of the right bank along the upstream Indian Head River channel

Appendix B EXISTING CONDITIONS PLAN AND CONCEPTUAL DAM REMOVAL PLAN

V:\19561\active\195602174\03_data\gis_cad\gis\02174-ihd_ex.mxd Revised: 2021-06-11 By: Ele

WINTER STREET BRIDGE

ESTIMATED APPROXIMATE LIMIT OF IMPOUNDMENT

INDIAN HEAD DAM

FLOW

0 750 Feet

1 inch = 750 feet (At page size of 11"x17")

N

REINFORCED CONCRETE CULVERT (FORMER FLUME)

CROSS ST

OLD MILLRACE

SEDIMENT SAMPLE LOCATION (TYP.)

EXISTING IMPOUNDMENT

APPROXIMATE TRANSITION FROM NORTHEAST IMPOUNDMENT ZONE TO SOUTHWEST IMPOUNDMENT ZONE

HANOVER

HANSON

FLOW

SEDIMENT PROBE LOCATION (TYP.)

APPROXIMATE PARCEL BOUNDARY (TYP.)

INDIAN HEAD DAM

STATE STREET BRIDGE

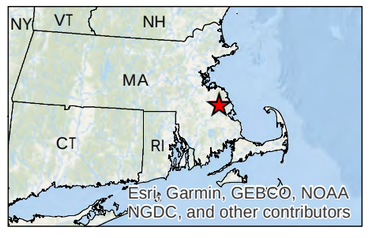
0 75 Feet

1 inch = 75 feet (At page size of 11"x17")

195602174

Stantec
136 West Street Suite 203
Northampton, MA USA 01060
Phone (413) 387-4518

Prepared by EPL on 2021-06-11
Quality Review by GEC/MRC on 2021-06-11
Independent Review by GF on 2021-06-11
02174-ihd_ex.mxd



Notes:

1. This basemap was developed based on observations and GPS data collected in the field by Stantec on May 14, 2021.
2. Contour data, aerial imagery, and tax parcel boundary data depicted herein were accessed and downloaded from the MassGIS Oliver online data clearlinghouse in May 2021.
3. Contour data was derived from the 2011 Northeast LiDAR digital elevation dataset and are based on the North American Vertical Datum of 1988. Aerial imagery is based on the 2019 USGS orthophotoraphy

Tax Parcel Boundary
Town Boundary
Contour (1ft)
Probe Location
Sample Location

Client/Project
Division of Ecological Restoration
Indian Head Dam Removal Recon
Hanover/Hanson, Massachusetts

Figure No.
B.1

Title
EXISTING CONDITIONS

6/11/2021

V:\195601a.act\ve\195602174\03_data\gis_cad\gis\02174-ihd_concept.mxd Revised: 2021-06-11 By: Ele

WINTER STREET BRIDGE

ESTIMATED APPROXIMATE LIMIT OF IMPOUNDMENT

INDIAN HEAD DAM

FLOW

0 750 Feet

1 inch = 750 feet (At page size of 11"x17")

N

DECOMISSION FORMER FLUME

CROSS ST

OLD MILLRACE

ACCESS AND STAGING

SEDIMENT SAMPLE LOCATION (TYP.)

CONCEPTUAL THALWEG ALIGNMENT

EXISTING IMPOUNDMENT

HANOVER

HANSON

CONCEPTUAL EDGE OF BANKFULL CHANNEL (45 FT WIDTH)

REMOVE BOULDERS

SCOUR CONTERMEASURES (IF REQUIRED)

RESTORED RIPARIAN BUFFER (TYP.)

INDIAN HEAD DAM

STATE STREET BRIDGE

SEDIMENT PROBE LOCATION (TYP.)

APPROXIMATE PARCEL BOUNDARY (TYP.)

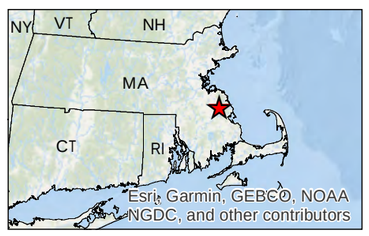
0 75 Feet

1 inch = 75 feet (At page size of 11"x17")

Stantec

136 West Street Suite 203
Northampton, MA USA 01060
Phone (413) 387-4518

Prepared by EPL on 2021-06-11
Quality Review by GEC/MRC on 2021-06-11
Independent Review by GF on 2021-06-11
02174-ihd_concept.mxd



Notes:

1. This basemap was developed based on observations and GPS data collected in the field by Stantec on May 14, 2021.
2. Contour data, aerial imagery, and tax parcel boundary data depicted herein were accessed and downloaded from the MassGIS Oliver online data clearlinghouse in May 2021.
3. Contour data was derived from the 2011 Northeast LiDAR digital elevation dataset and are based on the North American Vertical Datum of 1988. Aerial imagery is based on the 2019 USGS orthophotoraphy

Tax Parcel Boundary
Town Boundary
Contour (1ft)
Probe Location
Sample Location

195602174

Client/Project
Division of Ecological Restoration
Indian Head Dam Removal Recon
Hanover/Hanson, Massachusetts

Figure No.
B.2

Title
CONCEPTUAL PLAN

6/11/2021

Appendix C OPCC FOR INDIAN HEAD DAM

Table C.1. Opinion of Probable Construction Cost; ASTM E 2516-11 Estimate Class 5 Order of Magnitude.

Item	Units	Quantity	Unit OPC Cost	Extended OPC Cost	Notes
Mobilization/Demobilization	Each	1	$50,000	$50,000	20% of Direct Construction
Water Management	Each	1	$40,000	$40,000	Allowance; segregation barriers (e.g., sandbag coffer dams, turbidity curtains)
Demolish Spillway	CY	163	$200	$40,000	49 ft wide x 15 ft long x 6 ft high (est)
Scour Countermeasures	CY	170	$150	$30,000	mix of salvaged material and new; assume in one area 49 ft wide x 30 ft long x 3 ft deep (est)
Channel Grading	Each	1	$50,000	$50,000	Allowance; Area Uncertain
Repair/Restoration of Access/Staging	Each	1	$40,000	$40,000	Allowance; Removal of temporary access roads
Miscelaneous Work & Cleanup	Each	1	$50,000	$50,000	Allowance
	Total Direct Construction			**$300,000**	