PRELIMINARY DESIGN TECHNICAL MEMORANDUM

HOLMES PLAYGROUND DAM REMOVAL

TOWN BROOK RESTORATION PROJECT
PLYMOUTH, MASSACHUSETTS

January 30, 2015

MMI #1982-05

Prepared for:

Town of Plymouth
11 Lincoln Street
Plymouth, Massachusetts 02360

Prepared by:

MILONE & MACBROOM, INC.
99 Realty Drive
Cheshire, Connecticut 06410
(203) 271-1773
www.miloneandmacbroom.com

TABLE OF CONTENTS

1.0 INTRODUCTION 1
1.1 Work Completed 1

2.0 EXISTING CONDITIONS 1
2.1 Town Brook 1
2.2 Holmes Playground Dam 2
2.3 Buried Culvert 3
2.4 Newfield Street Crossing 3
2.5 Utilities 3
2.6 Surrounding Land Uses 4
2.7 Bathymetric, Ground, and Aerial Survey 4
2.8 Wetlands 4
2.9 Sediment Sampling and Analysis 6
2.10 NRCS Soil Map 8

3.0 HYDROLOGY AND HYDRAULICS 9
3.1 FEMA 9
3.2 Basis for Hydraulic Modeling 10

4.0 PROPOSED DESIGN ALTERNATIVES 12
4.1 Analysis of Practicable Alternatives 12
4.1.1 No Action 13
4.1.2 Alternative 1 – Channel Through Fish Ladder 13
4.1.3 Alternative 2 – Channel Through Dam Center 13
4.1.4 Alternative 3 – Channel with Rock Ramp 14
4.1.5 Alternative 4 – Channel Through Existing Culvert 14
4.1.6 Selection of Preferred Alternative 14
4.2 Description of Proposed Design 15
4.2.1 Channel Restoration 15
4.2.2 Planting Plan 16
4.2.3 Holmes Playground Park Improvements 17
4.3 Sediment Management 17

5.0 CONSTRUCTION SEQUENCE AND SEDIMENT AND EROSION CONTROL 18
5.1 Construction Access and Sequence 18
5.2 Sediment and Erosion Control 19

6.0 ANTICIPATED PERMIT REQUIREMENTS 19

1.0 INTRODUCTION

Milone & MacBroom, Inc. (MMI) has been retained by the Town of Plymouth to design the removal of the Holmes Playground dam, located on Town Brook just upstream of Newfield Street in Plymouth, Massachusetts. The Holmes dam is the last remaining structure that impedes the migration of anadromous fish species in Town Brook. The removal of the dam will build upon numerous other efforts undertaken by the Town and associated Project Partners over the past two decades to remove barriers to fish passage and improve the habitat and ecology of Town Brook.

1.1 WORK COMPLETED

The following tasks have been completed to date:

- Review of existing data, including:
  - HEC-RAS Hydraulic Modeling (by MMI)
  - Sediment Sampling (by UMass)
  - FEMA 2006 Plymouth County Flood Insurance Study
  - Holmes Playground Dam Phase I Inspection/Evaluation Report dated January 3, 2007 by Tighe & Bond
  - Holmes Playground Dam Draft Phase I Inspection/Evaluation Report dated August 24, 2012 by Tighe & Bond
  - Holmes Playground Dam Draft Phase I Inspection/Evaluation Report dated July 31, 2014 by Tighe & Bond
  - Hydraulic and Hydrologic Analysis dated August 3, 2006 by PARE Engineering Corporation
  - Emergency Action Plan dated April 2007, updated October 2012, by Tighe & Bond
- Site Inspection (completed November 5, 2014)
- Identification and Delineation of Wetland Resources (completed September 15, 2014)
- Topographic and Bathymetry Survey(completed September 24, 2014)
- Sediment Sampling (completed October 14, 2014)
- Additional Site Inspection (completed November 5, 2014)
- Review of Existing Data and Town Mapping
- Completion of Conceptual Design (completed November 12, 2014)
- Completion of Preliminary Design (January 30, 2015)

2.0 EXISTING CONDITIONS

2.1 Town Brook

Town Brook is a 1.5 mile river that flows from the 269-acre Billington Sea in a northeasterly direction before it outlets into Plymouth Harbor. The Town Brook watershed is 6.0 square miles in size. The Town of Plymouth and the Town Brook Partners (a partnership of local, state and federal agencies) are currently involved in a phased restoration program for the river and its

anadromous fish runs. To date, such work has included stormwater improvements, fishway improvements, wetland construction, a partial dam breach and two dam removals.

Town Brook has been extensively modified by human activity, the history of which goes back hundreds of years. One of the main reasons the Pilgrims landed in Plymouth was the existence of Town Brook, which empties into Plymouth Harbor next to Plymouth Rock. The first mill in the United States was built on Town Brook in 1636, approximately 1,400 feet upstream of Plymouth Harbor. Jenney Grist Mill and its associated dam are located approximately one half mile downstream of the Holmes Playground dam. Town Brook within the project reach varies between artificially created impoundments, artificially constrained channel sections, and man-made restoration sites.

2.2 Holmes Playground Dam

The Holmes Playground Dam (State Dam ID #7-12-239-5 and NID#MA00908) is a 275-foot long earth fill dam with a stone masonry and concrete wall forming the downstream face. The dam has a maximum structural height of 16 feet and impounds a maximum capacity of 67 acre-feet. The crest of dam varies in width from 25 to 65 feet. The upstream face is sloped at approximately 2H:1V and has a chain link fence that crosses the spillway and runs along the left embankment at the top of the slope.

The spillway, located near the left abutment of the dam, is an 8-foot long, broad crested concrete weir with provisions for stop logs. Two sets of wooden stop logs span from steel slots in the spillway training walls to a center guide/support. Flow discharges through a concrete box culvert that runs through the dam embankment and enters another box culvert that travels underground approximately 400 feet until it daylights on the east side of Newfield Street.

An existing fishway runs through a box culvert from the right embankment of the dam and exits the embankment as an uncovered sloped flume (Denil) fishway that runs along the right abutment. Two concrete headwalls are located near the upstream end of the fishway. Immediately downstream of the Holmes Playground Dam is a skateboard park and playground as well as residences and businesses.

The condition of the Holmes Playground dam is fully documented in the Phase I Inspection/Evaluation Report completed by Tighe & Bond, Inc. on July 31, 2014. The report found the dam to be in fair condition based on the Office of Dam Safety's September 2008 rating guidelines, as a result of a number of identified deficiencies noted during the inspection. The 2014 report indicates that conditions had worsened since the prior, 2012 inspection report had been issued.

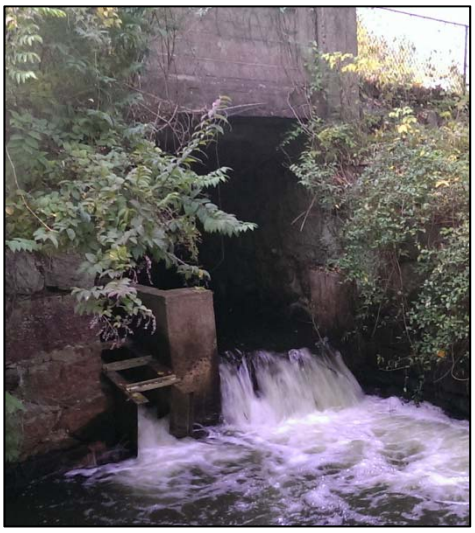
The Holmes Playground dam was previously identified as an intermediate size, high hazard (class I) structure in accordance with MA Dam Safety guidelines. Those regulations specify that the spillway design flood (SPF) for a high hazard dam is one half the probable maximum flood (1/2 PMF).

2.3 Buried Culvert

The channel between the Holmes Playground dam and Newfield Street flows through an approximately 400-foot long buried culvert. The restoration vision includes dam removal, excavation and removal of the culvert in conjunction with channel daylighting, and park restoration. The exact dimensions and depth of the culvert are unknown, but are estimated based on the outlet size at Newfield Street and FEMA profile mapping. The upstream inlet to the culvert is comprised of a weir that is set between concrete retaining walls. The invert drops significantly on the downstream face of the weir. The culvert may also change in dimension and slope within the 400-foot reach between the dam and Newfield Street.

2.4 Newfield Street Crossing

The Newfield Street crossing is a 10-foot, single-span culvert. The bridge is approximately 42-feet wide and is skewed relative to the roadway alignment, with an additional bend in the culvert approximately 24 feet beyond the east parapet wall. The downstream culvert opening is 11.25 feet in width and 10 feet in height. The fish ladder is mounted along the southern side of the culvert, and its invert is set 1.7-feet below the culvert invert. The photograph to the right was taken from the downstream side of the culvert, looking upstream at the outlet and fish ladder entrance. A detailed description of the crossing can be found in the September 2, 2014 Technical Memorandum by Tighe & Bond.



2.5 Utilities

Town-provided GIS mapping indicates three stormwater outfalls located near a pedestrian bridge, known locally as the Boy Scout bridge, at the upstream end of the Holmes Playground dam impoundment. The outfalls discharge stormwater that is conveyed from collection structures in Summer Street. No other outfalls to the Holmes Playground Dam impoundment have been observed or identified on available mapping.

A catch basin located at the southeast corner of the Holmes Playground skate park collects runoff from the concrete area in the park and is assumed to discharge to the existing box culvert structure that conveys Town Brook underground through the park.

An existing sanitary sewer main and a water main span Town Brook via the upstream Boy Scout Bridge. Both utilities run alongside the southern edge of the impoundment, landward of the existing dirt/gravel trail. Cross-country overhead power lines are also located along this swath of land. The overhead power lines cross the dam to an existing substation south of the park. A

significant utility pole system is located approximately 13 feet south of the box culvert, representing a significant logistical and cost factor in the design of improvements.

2.6 Surrounding Land Uses

The current land use surrounding the project area is residential along the north side of the impoundment. Residences along Summer Street include single family and multi-family dwellings, many with lawn or landscaped lots extending to the edge of water. Some parcels have docks along the edge of the impoundment. The parcels south of the impoundment and east of the dam are owned by the Town of Plymouth.

A gravel/dirt walking trail provides pedestrian access through the vegetated area on the southern side of the pond, crossing Town Brook at the Boy Scout bridge at the upstream end of the project. The trail extends from Plymouth Rock at Plymouth Harbor, to the Off-Billington Street bridge, located approximately ¼ mile upstream of the Holmes Playground dam. The parcel to the east of the dam contains a skate park, basketball court and aging playground equipment. The original dam, likely constructed before 1893, was associated with historic mill and industry. The entire project area has been impacted by human activity.

2.7 Bathymetric, Ground, and Aerial Survey

Mapping of the project site was compiled from Town-provided GIS LiDAR data supplemented with ground survey and bathymetry performed by Milone and MacBroom, Inc. (MMI) on September 24, 2014. Ground survey completed by Tighe & Bond for the land downstream of the park, including Newfield Street, was also incorporated into the base mapping. Assessors' mapping and utility information was provided by the Town of Plymouth.

2.8 Wetlands

On September 25, 2014, Matthew Sanford, MMI Professional Wetland Scientist and Certified Soil Scientist delineated wetlands and the watercourse within the project site in accordance with Massachusetts state regulations and the United States Army Corps of Engineers (USACE) Regional Supplement to the Corps of Engineers Wetland Delineation Manual for Northcentral and Northeast Region. The Natural Resource Conservation Service (NRCS) web soil survey mapping shows water and upland soils within the project site. The ordinary high water mark was delineated along the edge of impoundment and is primarily represented by the toe of slope.

Eastern shoreline of Impoundment

The southern shoreline of the impoundment is well vegetated with red maple, white oak, red oak, black cherry, highbush blueberry, sweet pepperbush, northern arrowwood, common winterberry, speckled alder, multiflora rose, catbrier, Virginia creeper, and poison ivy. The eastern shoreline (dam end) is predominantly covered by intermediate sized riprap with some emergent wetland vegetation present at the waterline, including pickerelweed, American burred, nodding beggar tick, lurid sedge, soft rush, and broad leaved cattail. The northern shoreline consists of several private residential properties where wetland plant diversity is somewhat limited. Some areas of the shoreline consist of maintained lawn, while others have a narrow riparian zone consisting of jewelweed, broad leaved cattail, willows, soft rush, and lurid sedge.

Palustrine Forested Seep Wetland

Palustrine forested seep wetlands were delineated upstream of the inlet to the impoundment. These seep areas have organic muck soils underlain by stratified drift deposits. The wetlands typically support red maple, Norway maple, American elm, silver leaved willow, pussy willow, multiflora rose, sweet pepperbush, spicebush, northern arrowwood, Japanese knotweed, jewelweed, and skunk cabbage.

The Holmes Playground dam impoundment is classified as a palustrine open water system that has varying water depths. The shallower depth areas are vegetated by emergent wetland plants including American burreed, water willow, pickerelweed, curly leafed pondweed and water shield. However these emergent wetland areas are relatively small and limited within the impoundment.

Holmes Pond Palustrine Open Water

2.9 Sediment Sampling and Analysis

On October 14, 2014, Milone & MacBroom, Inc. personnel conducted sediment sampling at the Holmes Playground dam impoundment and at the downstream Jenney Pond. The sampling included measurement of sediment thickness as well as the collection of samples for subsequent laboratory analysis.

Measurements were made by MMI personnel in an effort to estimate the quantity of sediment that has accumulated behind the Holmes Playground dam. The sediment depth was identified at approximately 11 locations throughout the impoundment, including two downstream locations in Jenney Pond. The results of this analysis were plotted on aerial photography to assess deposition patterns, and to identify locations for further sediment investigation.

Sediment probing was completed using a manually operated steel rod. Results were recorded using a Trimble GPS unit that was calibrated and corrected using WAAS technology such that points could be recorded at sub-meter accuracy.

Appended Figure 1 presents the locations that sediment sampling and probing occurred, along with the originally planned sample locations. Figure 2 presents the depths of sediment measured at each location. Depths ranged from zero to greater than 60 inches. The quantity of sediment in the active channel was estimated to be 11,800 cubic yards based upon the measured sediment depths. This value is consistent with the volume of 12,000 cubic yards calculated from previous data obtained by UMass.

Sample locations were selected to provide an initial understanding of whether the sediment contains levels of anthropogenic contaminants that could have a material effect upon the dam removal project.

Sediment samples were obtained from 11 locations throughout the impoundment and Jenney Pond, located downstream of the Holmes Playground dam. Four samples from the impoundment and one sample from Jenney Pond were subsequently submitted to Complete Environmental Testing, Inc. (CET) for analysis of potential contaminants of concern. CET is a Commonwealth of Massachusetts certified environmental testing laboratory. The remaining six samples will remain in storage at MMI in accordance with the proposed scope of services.

The location of each sample location was recorded with a hand-held GPS unit. Core samples were collected from a flat-bottomed boat and were extracted from the impoundment using clear plastic lexon tubing sleeves. The lexon sleeves were driven by hand to a depth of approximately four feet or to refusal, whichever occurred first. Cores were visually examined for indications of vertical stratification or chemical odors. Neither vertical stratification nor chemical odors were noted in any of the core samples.

All retained samples were placed into laboratory-supplied, pre-cleaned glassware appropriate for the specific analyses requested. All sampling equipment was cleaned between samples using a solution of water and Alconox or other approved detergent. Disposable sample gloves

were worn when handling sample material and sample containers. Each sample jar was labeled with the date of collection, sample location, sample depth, and time of sample collection. Appropriate chain of custody forms were maintained for all samples. Samples were stored on ice at 4° C pending delivery to CET.

Submitted samples were analyzed for the following parameters:

- Extractable Petroleum Hydrocarbons (MA EPH)
- Arsenic, Cadmium, Chromium, Copper, Lead, Mercury, Nickel, Zinc
- Toxicity Characteristic Leaching Procedure (TCLP) (if deemed necessary)
- PCBs (Arochlor only)
- Polynuclear Aromatic Hydrocarbons (PAHs EPA 8270C)
- Volatile Organic Compounds
- Percent Water
- Total Organic Carbon
- Grain Size
- Conductivity
- Organochlorine Insecticides
- Sulfide and Cyanide Reactivity

The results of the analyses were compared to the Massachusetts Department of Environmental Protection (MADEP) S-1 soil standards and also the S-1/GW-3 and S-2/GW-3 standards as detailed in the Massachusetts Contingency Plan (MCP). These standards are applicable to soil and not to sediment and, therefore, the comparisons are made only for planning purposes. The results are included in appended Table 1. The complete laboratory results are also attached.

Testing results indicate that sediment in the Holmes Playground dam impoundment contains relatively low levels of anthropogenic contaminants. Samples Sed-107 and Sed-109, however, contained elevated levels of arsenic, chromium and in the case of Sed-107, lead. TCLP analysis for lead and/or chromium was subsequently requested for samples Sed-101, Sed-107, and Sed-09. No hazardous levels of lead or chromium were noted. The results are briefly summarized below:

Sed-101:

- Benzo(a)pyrene (BAP) was present at 4,800 ug/kg, above the S-1 and S-1/GW-3 standard but less than the S-2/GW-3 standard

Sed-107

- Arsenic was present at 34 mg/kg, above the S-1, S-1/GW-3 and the S-2/GW-3 standards
- Chromium was present at 270 mg/kg, above the S-1, S-1/GW-3 and the S-2/GW-3 standards
- Lead was present at 240 mg/kg, above the S-1 and S-1/GW-3 standard but less than the S-2/GW-3 standard.

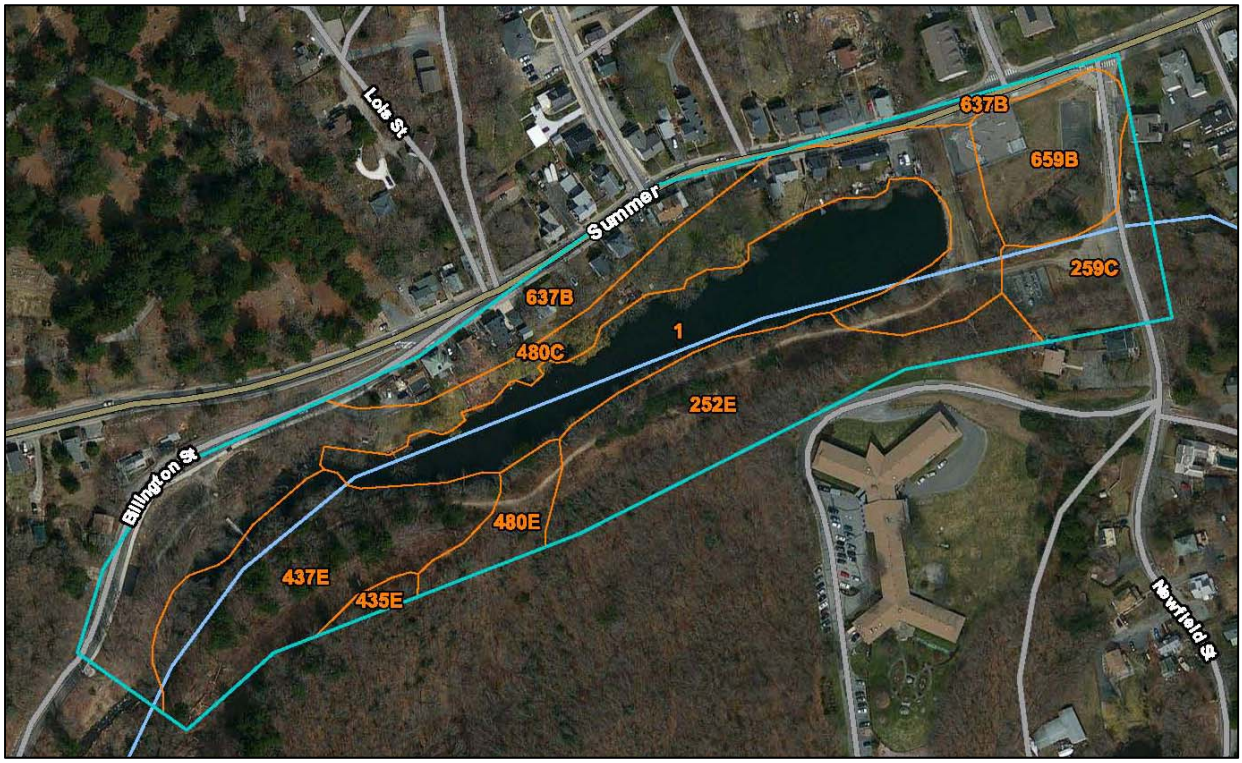
Sed-109

- Arsenic was present at 25 mg/kg, above the S-1, S-1/GW-3 and the S-2/GW-3 standards
- Chromium was present at 150 mg/kg, above the S-1 and S-1/GW-3 standard but less than the S-2/GW-3 standards

The laboratory data suggests that the sediment immediately upstream of the dam will likely require off-site disposal upon removal of the dam. The quantity of sediment that may require disposal will be further evaluated as the design progresses.

2.10 NRCS Soil Map

NRCS soils mapping indicates that the northern and eastern perimeter of the Holmes Playground dam impoundment is dominated by the Plymouth-Carver complex, 8-15% slopes (480C); the southeast perimeter is dominated by Carver coarse sand, 15-35% slopes (252E); a small portion of the southwest perimeter is denoted as Plymouth-Carver complex, 15-35% slopes (480E); and the upstream portion of the project reach is denoted as Plymouth loamy coarse sand, 15-35% slopes, bouldery (437E). The delineated soil type in the area downstream of the dam includes Udorthents (659B) on the north side of the culvert and Carver loamy coarse sand on the south side of the culvert (259C). See image below.



The Plymouth-Carver complex and Plymouth loamy coarse sand area described as being formed in outwash plains and moraines, with the top six inches comprised of decomposed plant material underlain by loamy coarse to gravelly sand. Carver coarse sand and loamy coarse sand area described as being formed in outwash plains and moraines, with the top three inches comprised of decomposed plant material underlain by coarse sand.

3.0 HYDROLOGY AND HYDRAULICS

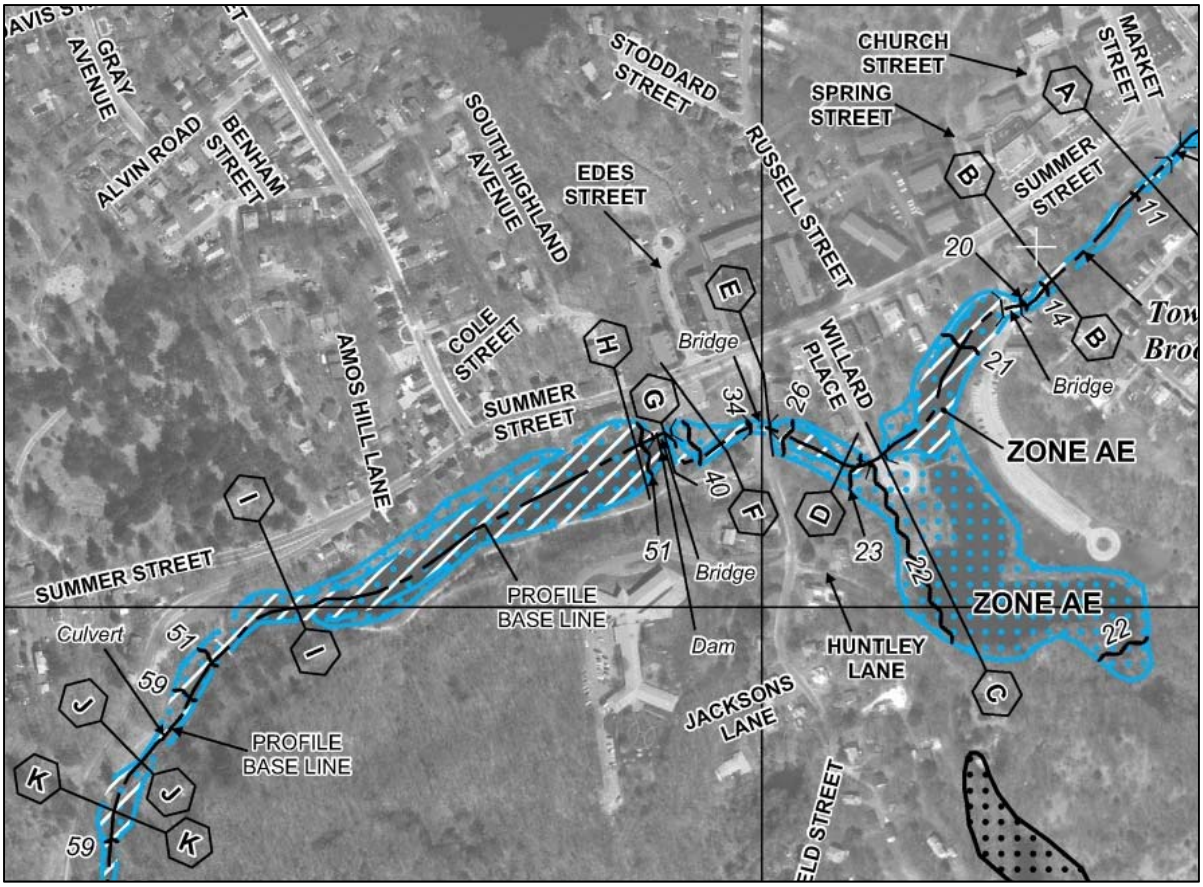
3.1 FEMA

The current FEMA Flood Insurance Rate Maps (FIRM), Effective Date July 17, 2012, depict both a floodplain and a regulatory floodway. The floodway is depicted as generally following the alignment of the buried culvert downstream of the dam. The limits of the 500-year (0.2% chance annual flood) are not indicated on the FEMA FIRM.

The project area is located on Sheets 01P and 02P in the FEMA Flood Insurance Study (FIS). The Holmes Playground dam is located at cross section G in the FEMA flood profiles on Sheet 02P. The Newfield Street crossing is located at cross section E on Sheet 01P. The FEMA FIS indicates that the existing bridge at Newfield Street overtops during the 100-year flood and that the existing Holmes Playground dam spillway has the capacity to pass the 500-year frequency flood. A hydraulic and hydrologic analysis, dated August 3, 2006 performed by Pare Engineering Corporation concluded that the concrete broad-crested weir spillway capacity is 530 cfs, a flow equivalent to the 500-year design flood.

The Base Flood Elevation (BFE) is 51 feet for the entirety of the Holmes Playground pond impoundment, extending to the upstream face of the dam, 40 feet at the downstream face of the dam, 34 feet at the upstream face of Newfield Street, and 26 feet at the downstream face of Newfield Street.

The limits of the regulatory floodway are primarily coincident with the 100-year floodplain along the perimeter of the impoundment just upstream of the dam, and narrow upstream towards the Boy Scout bridge. The floodway limits downstream of the dam appear to flank the location of the existing fish ladder, despite the channel being underground in this reach. (See image on the following page).



3.2 Basis for Hydraulic Modeling

According to the Massachusetts Department of Conservation and Recreation (DCR), the total contributing watershed area of Town Brook is approximately 6.0 square miles. Additional hydrologic and hydraulic data on Town Brook is available in the FIS for Plymouth, prepared by FEMA. The watershed size reported in that study is 3.9 square miles. The discrepancies in watershed size may be due to the complicated nature of the upper watershed. There are a number of topographic sinks, ponds, wetlands, and stratified glacial drifts in the northwestern and southeastern portions of the watershed that do not have surface drainage to Town Brook under normal flow conditions. These portions of the watershed delineated by DCR were likely not included in the hydrologic model created for the FEMA study.

The upper regions of the Town Brook watershed are lightly developed, but have seen recent commercial development in areas such as Route 44 and Route 80. Areas near the Billington Sea and its associated wetlands have light residential development. The small portion of the watershed east of the Route 3 embankment and downstream of the project area is highly developed, specifically as the brook flows into the commercial center of the Town of Plymouth.

Much of the watershed is underlain by the Plymouth-Carver aquifer, the second largest stratified drift aquifer in Massachusetts with an aerial extent of 140 square miles. The aquifer consists of glacial outwash and recessional moraines pitted with several hundred kettle ponds. The Billington Sea is one such pond.

The storage provided by the Billington Sea, combined with the high infiltration rates of the dominant soils in the watershed, limits the peak flow rates of extreme events in the watershed and has the effect of moderating flows in Town Brook. During flood events, water is stored in the Billington Sea and groundwater aquifers, attenuating downstream flows. During the drier times of year, the Sea and the aquifer sustain base flows to Town Brook. As a result, peak flows and base flows of Town Brook do not vary greatly, especially in relation to typical New England watercourses.

The statistical 10-, 50-, 100-, and 500-year flood flows have been computed and published by FEMA. Although only two flow change locations have been published in the effective Flood Insurance Study (FIS), many interim flow changes were used in the original hydraulic (HEC-2) model that FEMA used to generate the FIS. The original HEC-2 data was consulted, and peak flow rates that occur downstream of the project site were selected as the design flows for the Holmes Playground dam. Peak flows downstream of the site were larger and therefore selected to be more conservative for scour and armoring concerns.

The United States Geologic Survey (USGS) *StreamStats* program has not been fully developed for the Plymouth and Cape Cod area at this time, and could not be used to check the validity of the FEMA study. The USGS does not have any active or historic gauge sites located anywhere on Town Brook. Therefore, the FEMA peak flow rates were used as the basis of design for the Holmes Playground dam removal, channel restoration, and Newfield Street bridge replacement.

Lower summer flows were modeled to ensure that a proposed channel can sustain ecological habitat quality through the lowest flows expected to be seen on an annual basis. Average spring flows were used to assess the brook's capacity to provide adequate fish passage during the peak migration seasons, which is the main project objective. Mean annual flood, springtime and low flows used for the subject analysis are based on analysis conducted immediately upstream at the site of the former Billing Street dam.

The full range of flow rates used in the hydraulic analysis for Holmes Playground dam is shown in Table 1 below.

TABLE 1
Flow Rates Used in HEC-RAS Hydraulic Model

Flow Event	Peak Flow (cfs)
Summer	14.6
Spring	22
Mean Annual Flood	80
10-year	116
25-year	126
50-year	138
100-year	155
500-year	192

4.0 PROPOSED DESIGN ALTERNATIVES

The design alternatives analyzed for the Holmes Playground dam removal and channel restoration reflect the various site constraints and the predicted post-dam removal channel geometry. Concept plans were developed for four alternatives (summarized below) for the reach extending 190 feet upstream of the dam to a point 70 feet downstream of the Newfield Street culvert. Note that the channel restoration within the Holmes Playground impoundment remains the same for all alternatives.

4.1 Analysis of Practicable Alternatives

As part of the 2006 Feasibility Study, a variety of alternatives were examined for the dam and the culverted portion of Town Brook. Ultimately, only removal of the dam and daylighting the culverted reach met all the goals set forth for the project by the partners. Because these proposed activities will restore an important diadromous fish run and enhance the ecological functions of Town Brook, the proposed project stands as a net benefit to trust resources. The following descriptions summarize the conceptual alternatives shown on the appended figures, and highlight the pertinent design constraints for each alternative.

Tighe & Bond is responsible for the design of the downstream Newfield Street culvert replacement. Design data relative to the structure can be found in their September 2, 2014 Technical Memorandum. Their initial design proposed a ConSpan arch opening, at a span of 24 feet, providing a maximum clear opening height above the streambed of seven feet. The design intent was to provide sufficient clear opening area to pass the 100-year flood with greater than one foot of freeboard, and under normal flows allow a riparian shelf to establish underneath the bridge to allow better development and sustainability of the habitat through the corridor.

Based on discussions with various representatives of the Town of Plymouth and the Tighe & Bond design team, there was consensus that the bridge design should be modified in conjunction with the upstream channel restoration design. As such, the alternatives analysis assumed that the bridge could be realigned to provide a smoother transition to the downstream channel and to reduce the skew of the opening for more efficient conveyance. Additionally, all

alternatives assume that some modification of the island downstream of Newfield Street will be required to provide a steady transition from the restored channel to the existing downstream channel. It is anticipated that a portion of the island's northern retaining wall will be removed and rebuilt further south to provide adequate channel width.

4.1.1 No Action

The "No Action" alternative would leave the dam and fish ladder in place. Although this option would be the least costly, it would not achieve fish passage goals for Town Brook and would make the replacement of the Newfield Street bridge both complicated and costly. The existing fish ladder is in poor condition and leaking. The existing support walls at Newfield Street are crumbling. The poor condition of the site infrastructure makes the replacement of the Newfield Street bridge mandatory, while the poor condition and performance of the fish ladder is detrimental to fish passage through the extent of Town Brook and specifically acting as an impediment to fish passage at the dam. In addition, the sanitary sewer main through the project reach is leaking and clogged; further evidence of necessary infrastructure upgrades. This option leaves the maintenance and liability of the high hazard dam with the Town of Plymouth. The No Action alternative is undesirable from both a public infrastructure standpoint and a fish passage standpoint.

4.1.2 Alternative 1 – Channel Through Fish Ladder

This alternative involves breaching the dam and constructing a new 24-foot wide bankfull channel in the location of the existing fish ladder, tying the channel into the proposed Newfield Street bridge. This alternative would result in a channel bed slope of approximately 2.12% through the park and a 1% slope through the Newfield Street culvert. The alternative would require the construction of a retaining wall to protect an existing double utility pole located on the dam and bridge headwalls to enable proposed channel grading.

The required grading under this alternative would result in a cut of 12 to 14 feet. Additionally, he proximity of the proposed channel to the southern property line would necessitate the construction of a 14-foot high retaining wall spanning nearly the entirely of the NSTAR property line. The wall installation would also require the relocation of approximately 300 linear feet of 8-inch sewer main through NSTAR property, to be coordinated with the existing water main.

4.1.3 Alternative 2 – Channel Through Dam Center

This alternative involves breaching the dam at the low point in the upstream impoundment, constructing a 24-foot wide bankfull channel at 2.25% grade channel through the Holmes Playground parcel, and connecting to the proposed Newfield Street culvert at a 1% slope. The alternative would require the construction of a retaining wall to protect an existing double utility pole located on the dam and bridge headwalls to accommodate proposed grading, and the required grading would result in a cut of approximately 9 feet to channel grade.

4.1.4 Alternative 3 – Channel with Rock Ramp

This alternative involves breaching the dam through the low point in the upstream impoundment, constructing a 24-foot wide bankfull channel at a 1.1% grade channel through the Holmes Playground parcel and transitioning to a steeper slope (5%) under the proposed Newfield Street culvert. The 5% segment of channel would extend an additional 70 feet downstream of the Newfield bridge culvert opening in order to tie into existing channel grades. The steeper section would require stone-armoring for stability and to effectively reduce the channel slope through the park. The reduced slope through the park would be similar to upstream improvements at the Off-Billington dam removal site, where the restored channel slope is 1.5% with riffle-pool geometry. This approach requires less vertical cut to achieve the proposed channel grade, approximately 6 feet as compared to 9 feet in Alternative 2 and 12 to 14 feet in Alternative 1. This alternative would also require the construction of a retaining wall to protect an existing double utility pole located on the dam and bridge headwalls to accommodate proposed grading.

As with all alternatives, this concept removes a portion of the downstream island below Newfield Street. The steeper section would require a longer portion of island modification to provide a standard width channel and transitioning slope geometry.

4.1.5 Alternative 4 – Channel Through Existing Culvert

This alternative involves breaching the dam through its center, constructing a 24-foot wide bankfull channel in the location of the existing underground culvert, and tying in to the proposed Newfield Street culvert at a 1% slope through the crossing. This alternative would result in a channel bed slope of approximately 2.38%. It would require the construction of a 15-foot high bank and 75-foot long retaining wall connecting to the existing concrete/stone masonry wall on the downstream face of the dam to avoid grading on private property. Locating the channel in the area of the existing culvert also places it close enough to the existing double utility pole on the dam that the poles would need to be removed and the primary feed from the substation up Summer Street would have to be relocated around the park. The required grading would result in a cut of approximately 9 feet to channel grade.

4.1.6 Selection of Preferred Alternative

A conference call with project partners was held on November 18, 2014 to review and discuss the concept alternatives. In addition to constructability and fish passage, the presence of the public park ties in the importance of visitor accessibility and brook visibility. The selected alternative must provide for a channel slope that is conducive to fish passage as well as restoring an important town watercourse for the enjoyment of park visitors.

Alternative 1 would require the construction of a 14-foot high retaining wall along the site's southern property line, greatly increasing the cost of the project. The steep slope along the southern bank would also preclude visitors from accessing the riverbank from the walking trail. The construction of the channel in the location of the fish ladder would also necessitate the complete excavation and removal of the concrete walls to achieve channel grading. Site grading

associated with the other alternatives would allow the concrete walls to be left in place and subsequently filled over.

Alternative 2 met with the most approval, providing both a fish passable channel and river access and visibility, in recognition that the grading would most likely need to be modified to increase accessibility. A pedestrian bridge could potentially be incorporated into a future design to utilize the wall. The retaining wall around the existing utility pole on the dam would need to be further evaluated for aesthetics.

Although Alternative 3 results in the least amount of cut to channel grade, the steep rock ramp through Newfield Street was regarded as both a maintenance issue and a possible impediment to fish passage. The additional downstream island modification for the rock ramp section would also result in an undesirable impact to historic and ecological resources in that river reach.

Alternative 4 would have the greatest impact on land available for park improvements and would also be the most difficult to construct in terms of water control. The other three alternatives would allow the existing culvert to convey brook flows during channel construction.

Based on feedback and discussion of the presented concepts, Alternative 2 was selected as the preferred alternative, with the modification that the channel grading would be revised to incorporate a steeper section through the Newfield Street culvert to reduce the proposed slope through the park channel. The steeper section would have a slope on the order of 3.0 to 3.5%, with armored with stone, but not constructed as a rock ramp. Bank grading would also be revised to provide a walkway adjacent to the brook. Downstream improvements along the northern edge of the island were to be evaluated and included in the final alternative design.

4.2 Description of Proposed Design

4.2.1 Channel Restoration

The appended preliminary design (30% - 50%) plan set graphically depicts the proposed dam removal, in both plan and profile view. Approximately 110 linear feet of the Holmes Playground dam spillway will be removed. A portion of the northern dam and retaining walls will remain to provide protection of the existing utility poles. The full extent of the southern portion and fish ladder exit weir will be removed. The southern wall of the fish ladder will remain and be backfilled to reduce required bank grading on the right side of the restored channel.

Channel geometry for Town Brook was determined using the Stable Channel Design functions Copeland routine within HEC-RAS. The Copeland method uses an analytical approach to solve stable channel design variables of depth, width, and slope. Computations indicate a channel between 20 to 25 feet wide to accommodate a bankfull capacity of 80 cfs. This is in keeping with the restoration completed at the upstream Plymco and Off-Billington impoundments, which utilized a bankfull width of 24 feet and a riffle-pool-run planform having an average slope of 0.015 ft/ft.

After removal of the dam, the proposed natural channel will be approximately 24 feet wide at bankfull discharge and approximately 10 feet wide (top width) under August flows. The channel slope will be approximately 1.5 percent through the impoundment, and 1.21 percent through the park. Both slopes typically support a riffle-pool type channel form. A 115-linear foot section through the Newfield Street culvert will be constructed at a 3.5-percent slope with a rapids planform. The steeper slope allows for the shallower slope upstream and reduces the amount of impacts downstream of the culvert, as described in the alternatives analysis above. The channel modifications will extend approximately 95 linear feet downstream of the Newfield Street crossing and will entail removal and reconstruction of existing bank walls.

The post-dam removal channel will be a sand, gravel, and cobble bed channel with a meandering planform and alternating pools and riffles. Pools tend to be located around meander bends, while riffles form on the straight sections between.

Instream and channel features will provide habitat variety, which in turn will improve biological diversity. Proposed instream channel features included in the Town Brook restoration design include riffles, root wad revetments, and boulder clusters. Ten riffles are proposed between Newfield Street and the existing upstream end of the impoundment. In addition to providing important habitat functions, riffles will also provide important channel grade control and decrease upstream scour. Each of the riffles will be paired with a rootwad revetment and upstream pool area, providing important flow and habitat diversity while increasing flow deflection away from the outer banks of curves.

Coir log with boulder revetment and short areas of boulder revetment are proposed along the outer curves of the sinuous channel. Boulder revetment is proposed in the lower reach through the removed dam section where bank slopes are proposed at 3:1.

Proposed conditions hydraulic modeling indicates that even during the 100-year flood, flow through the restored channel will remain subcritical, and not be highly erosive in nature. Given the height of the dam to be removed, the proposed channel restoration will result in significant decreases in predicted water surface elevations upstream of Newfield Street and through the impoundment reach. Predicted 100-year water surface elevations will tie into existing elevations approximately 1,550 feet upstream of the dam. Predicted summer low flows will tie into existing elevations approximately 1,170 feet upstream of the dam.

Low flow depth conditions are important for the evaluation of fish passability through the restored channel reach. The proposed low flow channel will convey the summer and spring flows of 14 cfs and 22 cfs respectively, with predicted depth for the summer low flow of approximately 8 inches. Average velocities during the summer flows are predicted between 2 and 3 feet per second.

4.2.2 Planting Plan

A planting plan has been developed for both the impoundment area and the park. The proposed plantings have been limited to native species of trees and shrubs in combination with

restoration seed mixes appropriate to the area. All graded areas and land to be exposed post-drawdown will be topsoiled and seeded with New England Conservation/Wildlife Seed Mix, whereas the park areas will be seeded with Turf Restoration seed mix. The existing organic sediments within the impoundment have a large seed bank, and following dewatering it is anticipated that this seed bank will germinate. A similar situation was recently encountered on the Off-Billington Street dam removal project. The existing seed bank will add to the diversification provided within the proposed restoration seed mix.

Riparian plantings are proposed along the channel corridor and in the park. Primary tree species within the riparian planting zone include red maple, pin oak and swamp white oak. Woody shrub species include bayberry, black chokeberry, nannyberry, sweet pepperbush, silky dogwood, meadowsweet, northern arrowwood, elderberry, speckled alder, pussy willow, lowbush blueberry, grey stemmed dogwood, and shadblow.

4.2.3 Holmes Playground Park Improvements

The proposed channel alignment through the Holmes Playground park will allow for both the skate park and basketball court to remain. The design proposes a six-foot wide walking trail through the park, with access from the remaining section of the dam at Summer Street and the sidewalk at Newfield Street. The trail has been designed at a slope that meets ADA-accessibility requirements and will require the installation of retaining walls with protective fence along the river side of the pathway. Plantings included in the planting plan will enhance the aesthetics of the park.

4.3 Sediment Management

Most of the sediment management will occur between the existing dam and the upstream end of the existing impoundment. Significant sediment removal is not anticipated from the portion of the brook currently contained within the underground culvert through the park. Sediment management strategies pertain to two classes of sediment at the site. The first is material that is excavated through the impounded sediments to form the channel. The second is impounded sediments that will be exposed on the overbank areas.

Deposited sediments within the Holmes Playground dam impoundment are generally fine grained and silty in nature. A portion of these sediments are proposed to be reused on-site as a topsoil treatment. These fine-grained sediments may either be used in their natural form or mixed with topsoil. However, laboratory data suggests that the sediment immediately upstream of the dam will likely require off-site disposal upon removal of the dam. Every effort will be made to reuse as much sediment as possible given the quality of the material.

Exposed bank sediments will dewater in place, and are expected to re-vegetate within the first growing season. Exposed sediments will be stabilized with erosion control blanket, seeded and planted.

5.0 CONSTRUCTION SEQUENCE AND SEDIMENT AND EROSION CONTROL

5.1 Construction Access and Sequence

Construction access for the dam removal and all channel restoration elements is anticipated to be from Newfield Street, as graphically depicted on the appended design plans. The general sequence of construction assumes all requisite permits have been obtained. The following sequence is proposed:

1. Clear and grub for construction access road.

2. Install construction access road from Newfield Street.

3. Remove weirboards at the dam to dewater the impoundment prior to construction. Install a temporary cofferdam at the existing fish ladder to isolate flow through existing culvert.

4. Complete channel construction between the existing dam and Newfield Street per the Layout and Grading Plans.

5. Excavate the downstream portion of the existing box culvert and remove the concrete top. Install a cofferdam within the culvert and pump to divert water such that it discharges downstream of Newfield Street.

6. Complete bridge replacement/culvert installation per structural plans.

7. Direct flow to the newly constructed channel and remove remaining portions of the box culvert, dam, retaining walls, and grading per design plans.

8. Construct the retaining wall at the dam for utility pole protection.

9. Construct a temporary access/haul road along existing gravel trail. Install necessary sediment and erosion control measures.

10. Construct a temporary haul road and cofferdams at approximate locations shown on the design plans to isolate flow from work areas. Work downstream to upstream, completing channel grading and installation of instream features per Layout Plan.

11. Remove temporary culverts and temporary portion of access road on west side.

12. Install plantings, topsoil, and seed all disturbed areas as shown on the planting plan. Complete site improvements at park.

The above sequence will need to be refined as the design progresses and will need to be coordinated with the Newfield Street bridge replacement. Actual timing and time of year for

each step in the sequence should be refined during final design and coordinated through the regulatory permitting process.

5.2 Sediment and Erosion Control

The contractor will be required to conduct construction activities in such a manner so as not to pollute any wetlands, watercourse, waterbody, and conduit carrying water, etc. The contractor will be required to limit, insofar as possible, the surface area of earth materials exposed by construction methods and immediately provide permanent and temporary pollution control measures to prevent contamination of adjacent wetlands, watercourses, and waterbodies, and to prevent, insofar as possible, erosion on the site.

Proposed erosion control and construction safety measures include:

- ✓ Install orange construction fencing as shown on plans.
- ✓ Install construction access pads at construction access road.
- ✓ Install silt fence and haybales down gradient of all proposed grading.
- ✓ Install erosion control blankets with seed mix along areas of proposed grading having slopes 3:1 or greater.
- ✓ Place cofferdam within the channel.
- ✓ Ring temporary stockpile area with silt fence. (Note: Stockpile area to be determined prior to final design.)

6.0 ANTICIPATED PERMIT REQUIREMENTS

The following permits and approvals are likely to be required:

- Section 106 Review
- Environmental Notification Form (ENF), Executive Office of Environmental Affairs, MEPA Office
- MA DEP Bureau of Resource Protection – Wetlands NOI
- USACE 404 Permit
- MA DEP 401 Water Quality Certificate
- Ch. 91 Waterways Permit
- Ch. 253 Dam Safety Permit

APPENDIX

SEDIMENT SAMPLING INFORMATION

Sediment Sampling and Probing Location Map
Sediment Sampling Results

Table 1
Sediment Sampling Data
Holmes Playground Dam
October 14, 2014

	MCP Soil Standard			Sample ID				
	S-1	S-1/GW-3	S-2/GW-3	Holmes/1014/Sed-101 Mill Pond	Holmes/1014/Sed-105 Mill Pond	Holmes/1014/Sed-107 Mill Pond	Holmes/1014/Sed-109 Mill Pond	Holmes/1014/Sed-111 Jenney Pond
Organochlorine Pesticides (ug/kg)								
4,4 - DDD	8,000	8,000	40,000	120	ND <78	ND <140	ND <92	ND <53
MA EPH (mg/kg)								
C11-C22 Aromatic Hydrocarbons	1,000	1,000	3,000	370	100	120	120	110
C19-C36 Aliphatic Hydrocarbons	3,000	3,000	5,000	190	170	200	160	90
PCBs (mg/kg)	1	1	4	ND	ND	ND	ND	ND
PAHs (ug/kg)								
Benzo[a]anthracene	7,000	7,000	40,000	3,500	ND <780	ND <1400	ND <920	ND <530
Benzo[a]pyrene	2,000	2,000	7,000	**4,800**	890	ND <1400	ND <920	660
Benzo[b]fluoranthene	7,000	7,000	40,000	3,700	ND <780	ND <1400	ND <920	590
Benzo[g,h,i]perylene	1,000,000	1,000,000	3,000,000	4,400	ND <780	ND <1400	ND <920	660
Benzo[k]fluoranthene	70,000	70,000	400,000	3,600	ND <780	ND <1400	ND <920	ND <530
Chrysene	70,000	70,000	400,000	4,700	ND <780	ND <1400	ND <920	640
Fluoranthene	1,000,000	1,000,000	3,000,000	9,200	1,300	ND <1400	1,200	970
Indeno[1,2,3-cd]pyrene	7,000	7,000	40,000	4,000	ND <780	ND <1400	ND <920	570
Phenanthrene	500,000	500,000	1,000,000	5,600	890	ND <1400	ND <920	550
Pyrene	1,000,000	1,000,000	3,000,000	6,700	940	ND <1400	ND <920	750
Metals (mg/kg)								
Arsenic	20	20	20	17	10	**34**	**25**	6
Chromium	100	100	200	51	61	**270**	**150**	11
Copper	NA	NA	NA	76	59	130	57	59
Lead	200	200	600	190	83	**240**	110	87
Nickel	600	600	1,000	8	6	12	13	7
Zinc	1,000	1,000	3,000	140	84	220	120	55
Volatiles	--	--	--	ND	ND	ND	ND	ND

Notes: Only those analytes that were detected in one or more samples are shown in this table
units as indicated
ND = Not Detected (laboratory reporting limit indicated)
Bold = concentration greater than one or more MCP soil standard

SOURCE(S):
ESRI Online

N

Figure 1: Sediment Sampling Locations

MXD: P:\1982-05\Design\GIS\Maps\Sediment Sampling Locations.mxd

Holmes Playground Dam

LOCATION: **Plymouth, MA**

Map By: DRM
MMI#: 1982-05-4
Original: 9/3/2014
Revision: 11/4/2014
Scale: 1 in = 200 ft

MILONE & MACBROOM
99 Realty Drive Cheshire, CT 06410
(203) 271-1773 Fax: (203) 272-9733
www.miloneandmacbroom.com

SOURCE(S):
ESRI Online

N

MXD: P:\1982-05\Design\GIS\Maps\Sediment Sampling Depths.mxd

Figure 2: Thickness of Sediment

Holmes Playground Dam

LOCATION: **Plymouth, MA**

Map By: DRM
MMI#: 1982-05-4
Original: 9/3/2014
Revision: 11/4/2014
Scale: 1 in = 200 ft

MILONE & MACBROOM
99 Realty Drive Cheshire, CT 06410
(203) 271-1773 Fax: (203) 272-9733
www.miloneandmacbroom.com