Public Comment Submittal to the Warner's Pond Task Force

The following questions and supporting information are submitted as public comment by:

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As a concerned citizen with interest in Warner's Pond and its wetland system, I reviewed publicly available information that provides an overview of conditions, issues, past studies and alternatives. I had hoped to be on the Warner's Pond Task Force but was not selected. I have general questions relative to the deliberation process and specific questions relative to the Alternatives Analysis Report scoring of the alternatives. The publicly available information that I reviewed is summarized in attachments to this request, in case it may be useful to the Task Force. Some (but not all) of this information is from the reports on in the Task Force website (note that the 1999 reports provide useful information but are not on the Task Force website).

Since I have a technical background in civil engineering (although not in wetlands, ecology, fisheries or planning), I want to be clear that *the information presented in the attachments, comments and questions is provided solely for the purpose of public comment and submittal of public questions to be addressed by the Town and their professionals during Task Force deliberations. The attachments, comments and questions shall not be considered as fact or a professional opinion nor shall they be relied upon by the Task Force or the Town or any other party in any way.*

General Questions:

1. *Why has an analysis of the community benefits of maintaining Warner's Pond, by qualified urban planners, not been part of the supporting documentation and deliberations, given that the community value of the Warner's Pond and wetlands is not limited to ecological, natural resource considerations and that there likely are professional planning metrics available to objectively evaluate the community benefits of this type of resource?*

Given that there appears to be both means and methods available to maintain the pond that are likely similar in cost to removing the dam and pond, the <u>first and primary decision</u> facing the Town is whether or not the Town citizens want to preserve Warner's Pond and the surrounding wetlands, compiling about 86 acres of wetlands (not including connected wetlands), as a community resource as it has been over the last 160 years. The location of this resource proximate to West Concord Junction makes its value to the Town and citizens so significant that this decision is a big one with long term impacts and implications for the future of West Concord. West Concord, including Concord Junction, is rapidly evolving. The Town has just completed construction of the Gerow Recreation Area. The Bruce Freeman Rail Trail (this section) has just been completed. Recreational use of the pond is quite active. There are two major commercial properties currently under consideration for development in the immediate area of the pond. The MCI property is under consideration.

This decision transcends a typical wetlands functions and values analysis performed by an ecology consulting firm. It is also why this decision, it seems, should not be under the purview of the NRC and would be better suited for the Select Board and Town vote. And it seems that the Task Force is not qualified to make this type assessment without professional urban planning expertise and documentation, or by simply reviewing Envision Concord Bridge to 2030 Plan.

2. *Why is this process and decision being so rushed? Given the magnitude of this decision, will the Task Force consider a recommendation of a No Action alternative to allow more time (possibly a year or more) for the appropriate information (see question above) to be available and considered by stakeholders including the citizens of Concord?*

The Town has been performing technical evaluations of Warner's Pond since at least as early as 1999, and then in 2011/2012 and again is 2023. Over that time, there has been gradual eutrophication, but there is no imminent adverse condition requiring immediate response. The dam, per the 2023 Phase I Dam Inspection Report, is in Satisfactory condition. Further, the Dam Inspection suggested that a reduction of the Dam Hazard Potential may be warranted. The dam, pond and wetlands are Town-owned. As noted above, the Town has just completed construction of the Gerow Recreation Area; the Bruce Freeman Rail Trail (this section) has just been completed; recreational use of the pond is quite active, even with the gradual eutrophication; there are two major commercial properties currently under consideration for development in the immediate area of the pond; and the MCI property is under consideration with implications for Warner's Pond. The single bid received on the Dredging Construction project appears not to be indicative of the actual costs of dredging alternatives.

The recommendation by the NRC for dam removal was quite sudden, contrary to the long-term policy of the Town regarding Warner's Pond and not realized by many West Concord citizens until the last few months. As evidenced by the recent public meeting held by the Task Force at Harvey Wheeler Community Center this Summer, there appears to be sentiment by many Concord citizens to keep Warner's Pond. Up until very recently, the Town position (based on Town vote, action and investment) has been to preserve the pond and wetlands. There is precedence for Town pond management investment, such as White Pond. And any fisheries benefits associated with dam removal (the primary objective of dam removal) <u>to the areas upstream of the dam</u>, which there may be, are well in the future and not now.

3. *Given the significance of the loss of a major community resource resulting from dam removal, why is a "hybrid" solution including installation of a naturalized (rock ramp) fish pass at the Auxiliary Spillway, along with a program of pond management to: 1) maintain and manage an open water area within to the eastern side of the pond (via a one-time partial dredge, on-going mechanical and hand harvesting and periodic herbicide treatments); 2) leaving the western, inlet side "as is", not being considered further (indicated as sub-optimal in the Alternatives Analysis report)?*

This approach would appear to be cost competitive, provide fisheries benefits and allow the Pond and wetlands to remain. And as noted above, there is precedence for Town pond management investment at other Town ponds.

Specific Questions:

The 2022 Alternatives Analysis Report prepared by EA and endorsed by the Town of Concord Natural Resource Commission (NRC), in my opinion, was well done relative to summarizing the previous studies, the site conditions and the issues. The Analysis also utilized a wetlands functions and values scoring approach, including:

- wetland functions and values identified in the United States Army Corps of Engineers (USACE) Highway Methodology (USACE 2019) Supplement
- interests of the Massachusetts Wetlands Protection Act (WPA, M.G.L. c. 131, §40)3
- resource area values identified in the Concord Wetlands Bylaws

Recreational and Visual Quality/Aesthetics were also added. However, broader consideration of community resource values, Town long range planning, etc. appear not to have been included nor within the skills and services of EA.

My specific questions, presented in the following pages, are focused on the scores presented in the Alternatives Analysis Report. Review of the publicly available data brings into question the basis of the scores (and subsequent resulting recommendation) and my questions are specifically related to gaining more information and insight into the findings and conclusions of the report.

The focus of my questions and comments is on:

- **Post Dam Removal Site Conditions**: Future site conditions under the Dam Removal Alternative, in particular existing wetland and habitat transformation, the proposed 4.5-acre pond water level elevation and water depth range under variable flow conditions, and new channel geometry and water depth under variable flow conditions.
- **Water Quality**: Is an assumption that there are (would be) adverse impacts of Warner's Pond on downstream water quality, in particular the Assabet River, should the dam and pond remain supported by data?
- What was the success and efficacy of past herbicide treatments and other past pond management activities?
- **Flood Risk, including FEMA Hazard Mapping**: Flood risk and control, including changes to the effective FEMA FIS and FIRM under the Dam Removal Alternative, including requirements for a FEMA map revision.
- Flood risk and control, including changes to the effective FEMA FIS and FIRM under any alternative in consideration of climate change (increased precipitation intensity) and proposed changes to FEMA mapping procedures, included expected effects on future FEMA flood maps and the Town's insurance rate.
- **Dam Capabilities for Drawdown:** Dam details, including the capacity of the dam for adjustable water level control (drawdown).
- **Dam Hazard Potential:** Dam Hazard Potential and why the option of reduction of the Hazard Potential to Low as presented by Town consultants has not been pursued, which would reduce the risk basis of the dam (from 100-year to 50-year recurrence interval flood event) and extend the inspection requirement to 10 years (from the current 5 years).
- **Future Dam Capabilities:** Consideration of climate change (increased precipitation intensity) on future dam performance, including whether or not these would be offset by a reduction in the Dam Hazard Potential to Low.
- **Dam Suitability for a Fish Pass:** A "hybrid" approach with a naturalized fish pass in the Auxiliary Spillway.
- **Fisheries Benefits and Impacts:** Fisheries benefits associated with the Dam Removal Alternative, including a "non-generic", detailed assessment of the actual, <u>specific</u> benefits (by each target fish species) of dam removal relative to increasing diadromous spawning habitat (in the sub-watershed upstream of the pond). And what are the expected impacts to the existing fish species.
- **Wildlife Benefits and Impacts**: What will be the <u>specific</u> wildlife benefits associated with the Dam Removal Alternative, in particular given uncertainty about associated wetlands habitat

transformation as a result of dam removal. What are the expected adverse impacts to existing habitat.

- **Pond management should the dam remain:** Warner's Pond near and long-term pond management. The details of the 2012 analysis appear to indicate that almost any nutrient level (e.g., phosphorous) including natural background levels is adequate to produce excessive vegetation productivity given the other pond conditions. Therefore, in terms of pond management it appears that pond depth is the primary manageable issue. If Warner's Pond is to remain, what are the details of a sustainable pond management plan. The 1999 and 2012 studies evaluated and presented near-term and long-term methods and there have been past Town maintenance efforts including mechanical and hand vegetation removal and an herbicide treatment. The general conclusion appears to be that a pond management program could include: a one-time partial dredging of the pond, along with ongoing localized mechanical and hand vegetation control and periodic herbicide treatment.
- **Eutrophication and management of the proposed 4.5-acre pond:** Similarly, if the dam is removed what will be water quality and vegetation productivity of the proposed 4.5-acre pond and what pond management will be required for that.
- **Dredge Alternatives Design Basis:** What is the basis for the dredge alternatives design, beyond water depth (e.g., mitigation extent, percent desirable vegetation in littoral zone, etc.)
- Was the dredge design (submitted for bid) dredge depth based on a water level assumption of 116.5 feet NAVD88? If so, why was the dredge design dredge depth based on a pond water level of 116.5 feet NAVD88 and not the pond Normal Pool Elevation (118.8 feet NAVD88)? It seems like the Normal Pool Elevation reflects the water level during growing season even during low flow conditions. I assume that there was a basis for using Elevation 116.5 but the question is asked because this 2-foot difference in water depth would be reflected in reduced dredging depth, quantity and cost. If, in fact the Normal Pool Elevation of 118.8 feet was used, why was the dredge depth extended to Elevation 107.5 feet NAVD88 (a depth of 11.3 feet)? The Dredge Feasibility Report refers to a dredge depth of 9 feet.
- What is the appropriate design dredge depth and elevation? There appears to be a good correlation between the predicted euphotic zone (water depth, based on measured Secchi depths) and the observed and documented high vegetation productivity (plant cover and biomass). This data appears to support a minimum effective Elevation of 111 feet NAVD88 (minimum depth of about 8 feet below the Normal Pool Elevation). The dredge feasibility study appears to recommend a dredge design depth of 9 feet. The Alternatives Analysis report appears to recommend a design dredge depth of 10 feet.
- **Watershed (Sediment) Management:** What are the practical details of a Watershed Management Plan. Specifically, it appears based on the 2012 analysis that much of the sediment source impacting the pond may be generated from a relatively small area (Nashoba Brook between Warner's Pond and Ice House Dam in Acton). Rather than ignoring watershed management because it seems like a daunting task due to the large watershed area and associated issue with nutrient loading, is it an alternative to focus on stream sediment and out-of-compliance stormwater management and work with Acton on a stream channel stabilization and stormwater compliance program for that small stretch of Nashoba Brook? This would benefit all alternatives.
- **History and Heritage**: Due to its role in the early Industrial Revolution, which is key to West Concord's history, how important is sustaining Warner's Pond for its history and heritage.

- **Community and Recreational Benefits**: Community and recreational benefits, including associated economic benefits for recreation and the value of an open water viewshed (currently available with the dam).
- **Verification of Cost Estimates**: Independent review of the cost estimates presented in the Alternatives Analysis report is warranted, for each of the alternatives.

The rationale for the questions and comments presented herein is based on publicly available information and presented in the attachments listed below, with some interpretation of that information. Future data (e.g., 30% dam removal design), hopefully, will provide answers to some of these questions. No verification of the information presented has been performed. Interpretation was performed solely for the purpose of developing questions and comments.

Attachments:
Attachment 1: The Warner’s Pond Wetland System
Attachment 2: Water Quality, Sedimentation and Vegetation Productivity of Warner’s Pond
Attachment 3: Warner’s Pond Dam Details
Attachment 4: Warner’s Pond and FEMA Flood Hazard Determination
Attachment 5: Warner’s Pond Wetland System – Fish and Wildlife
Attachment 6: Warner’s Pond Recreational and Community Benefits
Attachment 7: Warner’s Pond Alternatives

1. The Warner's Pond Wetland System

The Warner's Pond Wetland System is an approximately 86-acre ecologically complex group of wetlands (excluding connected wetlands) that are differentiated by their hydrologic regime, including forested, seasonally-flooded wetlands, scrub-shrub seasonally and semi-permanently flooded wetlands, emergent wetlands, a riverine wetland (stream), deep open water (Lacustrine, limnetic) wetlands and shallow open water (Lacustrine, littoral) wetlands. Of the 86-acre wetland system, about 42 acres are open water. The Warner's Pond and wetland system is mostly on Town-owned land dedicated for conservation. Although somewhat smaller, the Warner's Pond wetland system shares some common features with Great Meadows, a federally protected National Wildlife Refuge also located in part in Concord.

An important consideration that should be evaluated is that the presence and characteristics of much of the wetlands appear to be dependent upon maintaining the impounded water level. Based on the National Wetlands Inventory wetlands descriptions, about 80% of the 86 acres of wetlands are dependent ("created or modified") due to the presence of an elevated, impounded water level (specifically, the Normal Pool Elevation of 118.8 feet NAVD88). In addition, EA has stated that if the dam is removed the wetlands will transform due to areas becoming drier.

Regardless, the Alternatives Analyses descriptions of alternatives, schematics and scoring appear to imply that the extent of the existing wetlands will remain if the dam is removed.

Detailed analyses including surface water and groundwater modelling is required to confidently predict future wetland transformation. It is not clear, at this time, if the Town plans to perform a wetlands impact assessment if the Dam Removal Alternative is pursued further. However, at this time the currently available data provides some insights and questions at to the possible future of the wetlands should the dam be removed.

Questions:

The information presented in Attachment 1 and summarized in the comments below is provided solely as the basis for the following questions. It should not be considered as fact or a professional opinion nor should it be relied upon by the Task Force or the Town. It does, however, appear to support the following questions for the Task Force to consider and the NRC and consultants to evaluate.

1. *Will the Town's consultant be performing a wetlands impact analysis as part of the dam removal design? This question is asked, in particular, since permitting of a dam removal in Massachusetts may not require it by regulation.*
2. *If the Town will be performing a wetlands impact analysis, will it include: 1) observation wells to confirm groundwater elevations; 2) numerical groundwater modeling; 3) surface water modeling; and/or 4) coupled numerical groundwater/surface water modeling?*
3. *If the Town will not be performing this analysis, how will the Task Force and Town citizens be able to assess the impacts of dam removal on the existing +/- 86-acre wetland system.*
4. *Conceptual drawings and visual imagery presented in the EA Alternatives Analysis report appear to imply that the existing wetlands will remain. At the time of the Alternatives Analysis report, what was the technical basis supporting those presentations?*
5. *If a wetlands impact assessment is performed and determines the potential for substantial reduction of the existing wetlands, how will the Task Force consider that? Specifically, what will be the basis for valuing diminished wetlands (and associated habitat and wildlife) versus the benefits of a dam removal?*

6. *Great Meadows and the 86-acre Warner's Pond and wetland system have some similarities. However, Warner's Pond appears to be undervalued in the Town's deliberations as an ecological, recreational and community resource - certainly not considered as an opportunity for a conservation and wildlife refuge, even though it is remarkably popular for birding and other passive recreation – similar to Great Meadows. One difference may be simply that of perception. The wetlands and interior areas of Great Meadows interior are highly accessible, with trails and boardwalks. Warner's Pond wetlands are not (unless skating in the winter). In spite of this, the Town has invested in both dam restoration and the Gerow Recreation Area. If the Town were to manage the Warner's Pond and wetland System in a manner more similar to Great Meadows with more accessible trails and boardwalks, would that influence the Task Force? If dam removal is determined to diminish the existing wetlands (yet to be determined one way or the other) and the pond is reduced from about 40 acres of open water to a shallow 4.5-acre pond, would that reduce (increase or stay the same) the value of that opportunity in the future?*

Comments:

Attachment 1 summarizes publicly available data relating to wetlands and hydrology, including existing wetlands mapping, topography, geology, surface water hydrology, groundwater and historical maps (for the purpose of considering what the pre-colonial conditions might have been).

A review of the publicly available information, while certainly not conclusive, seems to imply that there may be substantial change (and/or loss) of the existing wetlands. Removal of the Warner's Pond dam may substantially modify the area hydrology (surface and groundwater), including the conditions necessary to maintain the existing 86-acre wetland system. Specifically:

The National Wetland Inventory indicates:

- The Warner's Pond Wetland System currently consists of about 86-acres of wetlands including:
    - forested/shrub wetland which is **persistent** and **seasonally flooded** requiring the presence of surface water for extended periods of more than a month during growing season. Surface water is absent by the end of the growing season but is absent by the end of the season but the substrate remains saturated at or near the ground surface.
    - scrub-shrub wetland which is **semi-permanently flooded** where surface water persists throughout the growing season, and otherwise the groundwater table is at or near ground surface
    - emergent wetland which is **semi-permanently flooded** where surface water persists throughout the growing season, and otherwise the groundwater table is at or near ground surface
    - Lake (lacustrine) habitat, including deepwater (limnetic) and shallow water **permanently flooded**
    - Riverine habitat (Fort Pond Brook) characterized by a low gradient. Some water flows all year, except during years of extreme drought. The substrate consists mainly of sand and mud. Oxygen deficits may sometimes occur. **Permanently flooded.**
- Most (about 80%) of the existing wetlands are indicated on the National Wetland Inventory to "*have been created or modified by a man-made barrier or dam that obstructs the inflow or outflow of water*".

- Topographic Effects: Topography can influence the presence of wetlands in several ways: 1) topographic depressions can be areas which collect surface water runoff (generally seasonally); and 2) in unconfined aquifers (which is the case here) the topography can influence groundwater elevation depth and flow. The area topography, including the pond bottom elevations consists of topographic highs to the west and northeast of the wetland system bordering a lower elevation area ranging from about 121 feet NAVD88 (outside of the pond open water areas). The bottom elevations within the pond range from 107 feet to 118 feet. The topography is overlain with the wetlands in the attached slides. It seems that the existing wetlands, at least in part, are present in areas that may not be consistent with wetlands in the absence of the impounded water level. While the pond area was (pre-dam) likely a low-lying depression with a steam floodplain and possibly a natural small pond, areas with ground surface elevations greater than about 117 to 118 feet NAVD88 may not be consistent with wetland maintenance in the absence of the impounded water level except locally as part of a seasonally flooded stream floodplain.
- Groundwater Effects: Groundwater can also influence the presence of wetlands when the water table is above or sufficiently close to the ground surface for a sufficient amount of time to support wetlands. In addition to topographic effects, geologic considerations include the permeability of the surficial geologic materials to support groundwater flow, storage and recharge. Nearly the entire area consists of coarse-grained glacial stratified drift, except along the Fort Pond Brook floodplain alluvium and an area of “swamp deposits” which likely (or may) represents shallow water sediment deposition of the last several hundred years – see topography and historic maps discussion. The pond sediment has been characterized and has sufficient fine-grained sediment to be considered low permeability. There is very little publicly available groundwater elevation depth and flow data; however, based on the limited available data it may be inferred that at times of “high” groundwater, groundwater at the pond is (optimistically) about Elevation 120 feet NAVD88 (indicating the potential for groundwater to discharge to the pond). Low groundwater levels may be about 4 feet lower at Elevation 114 to 116 feet NAVD88), indicating that the pond (Normal Pool Elevation 118.8 feet NAVD88) discharges and contributes to groundwater. A key uncertainty is the influence of the impounded water level (El 118.8 feet NAVD88) on the surrounding groundwater elevation. Notably, the hydrologic budget model performed by ESS (2012) assumed very little groundwater flow to the pond. Observations of elevated groundwater, very high-water levels in spring fed ponds (White Pond and Walden Pond), and low stream discharge (including discharge from Warner’s Pond) also appear to indicate only minimal groundwater input to stream channel (or Warner’s Pond) flow. Questions about groundwater are important because with the removal of the dam and loss of the impounded water level at 118.8 feet NAVD88, it has not been confirmed whether or not groundwater elevations relative to ground surface elevations will be sufficiently high for a sufficiently long enough period of time to support wetlands .
- Stream Flow Effects: Stream channel flow, with sufficient flooding of adjacent floodplains, can also influence the establishment and maintenance of wetlands. The seasonally flooded/saturated wetlands mapped adjacent to Fort Pond Brook is an example. A question, associated with the dam removal alternative, is whether or not the dam removal in conjunction with creation of a new stream channel will provide sufficient floodplain flooding to support the existing wetlands and the assumption that the current lacustrine areas will all convert to emergent wetlands. The 30% dam removal design, when available, should detail the new stream channel geometry, elevation, gradient and hydraulic discharge. A very preliminary estimate (guess) of what the new channel characteristics can be developed based on the available information as well as the documented discharge into and out of the Pond and a requirement to maintain flow in Nashoba

Brook downstream of the Pond. These channel characteristics along with known stream flow discharges do not appear to indicate periodic, seasonally flooding of the existing wetlands area, to the extent to maintain the existing wetlands including much of the current pond areas.

- Historic Map Information: The historic maps, in conjunction with the known current topography and the historic record of the dam, provide a picture of what early (pre-dam) conditions might have been relative to wetlands. The available maps appear to extend back to about the 1830s which do not completely represent a dam free environment (since the historic records indicates that an early dam ("2 logs high") was built in circa 1680s.
    - By the 1830s, it is likely a small dam had already been present. The Attachment 1 slides show the conjunction of the Fort Pond and Nashoba Brooks, and the Fort Pond Brook channel where the pond currently is. It is clear that in addition to the construction of the Pond, a section of the stream channel was relocated to the west sometime after 1830. This is also supported by the existing topography of the MCI farm fields and aerial imagery of the area during very high groundwater levels.
    - The 1830s map also likely indicates wetlands – specifically referred to as "meadowlands" areas that were seasonally frequently flooded. As shown on the slides, the meadowlands are shown in a limited area along the stream channel and the low-lying area to the northeast of the stream channel.
    - The next map is circa 1875, which appears to be a fairly accurate survey. A more substantial dam is in place, along with flooding of the pond, consistent with the historic record which indicates construction of a substantial dam by 1859 to 1860. The stream channel does not appear to have been relocated at this time. Wetlands are clearly shown the east and northeast of the stream channel. These wetlands are located in the area of the MCI farm fields south of Rt 2. The railroad tracks have also been constructed at this point (now the Bruce Freeman Rail Trail). The location of these wetlands relative to the current conditions appears to indicate that the MCI fields were originally low-lying seasonally flooded or wetland areas that were subsequently filled. The 1875 and 1830 maps are surprisingly consistent. The 1830 "meadowlands" are consistent with the 1875 wetlands, which is consistent the conclusions that the original stream channel was relocated and the former channel area (including the portions of meadowlands extending beneath Rt 2) were filled. Absent in these maps, however, are any wetland in areas that now constitute most of the existing wetlands. Further the wetlands that were present appear to be confined to smaller low-lying areas within the former stream floodplain.
    - The next historic map is an 1886 survey. This map indicates that the stream has been relocated to approximately its current location and the former channel area and the current MCI farm fields have been filled, including filling the former wetlands in this area. Although wetlands are clearly indicated on this map, no wetlands are present around the pond. The topography is generally consistent with current topography.
    - The 1886 survey also indicates pond "open water" across Laws Brook Road nearly to the railroad tracks (which are the current tracks for the commuter rail). These areas are currently seasonally-flooded freshwater forested/shrub wetland. Neither these wetlands nor pond surface water are indicated in the 1875 map. This possibly reflects the increase in dam height in the mid-1850s. It also indicates artificial flooding of low-lying areas to the west, southwest and south of the pond.

- Comparison of the current topography and the assumed former stream channel locations indicates that the relocation of the stream channel to the west, along with increasing the dam height (1859 to 1886) to about the current dam height and flooding of these areas to about Elevation 118 to 119 feet NAVD88, appears to have begun the process of depositing sediment along the western portion of the pond, which now (165 years later) has transformed to an extensive wetland system.
- This history also gives some insight to sedimentation within the pond including sedimentation rates and transition of formerly open water areas of the pond to emergent and other wetlands.

2. Flood Control

The Alternative Analysis Report indicates that the Dam Removal Alternative would have… “Potential long-term positive effect due to lowering water surface elevation and reducing the lateral extent of the 100-year floodplain upstream of the former dam location. Future modeling would confirm the scale of this benefit” and “Likely No Negative Effects”. Further the Dam Removal alternative was scored higher for this category (3 versus 2).

Questions:

The information presented in Attachment 4 and summarized above is provided solely as the basis for the following questions. It should not be considered as fact or a professional opinion nor should it be relied upon by the Task Force or the Town. It does, however, appear to support the following questions for the Task Force to consider and the NRC and consultants to evaluate.

3. *It may be that detailed analysis will indicate that flood risk is reduced with dam removal. However, given the complexity of flooding in the vicinity of Warner’s Pond, what was the technical basis for the conclusions and “Flood Control” score and why was the Dam Removal Alternative rated higher than the Dredging Alternative relative to flooding given that detailed analyses had not been performed at that time and there was no obvious basis for scoring Dam Removal higher?*
4. *Detailed hydrologic and hydraulic analysis including numerical model analysis will be required to evaluate the change in flood limits, depth and discharge due to dam removal and to support a FEMA map revision. It is assumed that the 30% dam removal design, results pending, will have performed this detailed hydrologic and hydraulic analysis. Is that correct?*
5. *Will the Dam Removal Alternative also require a FEMA Map Revision? Was the cost of a FEMA map revision considered in the Alternatives Analysis cost comparison?*
6. *Was the duration required for a FEMA map revision review (which will be substantial) considered in the project schedule comparisons?*
7. *Although it may not be required by FEMA at the time of the map revision request, consistent with Commonwealth policy will climate change-related effects on precipitation intensity also be included in the detailed hydrologic and hydraulic analyses?*

Comments:

It seems, based on review of available information at that time, that there was no technical basis provided for that score. In fact, the area flooding as described in the effective FEMA Flood Insurance Study (FIS) and Flood Insurance Rate Map (FIRM) is quite complex. Attachment 4 provides an overview of the information presented in the FEMA FIS and FIRM. The flood hazard at Warner’s Pond and adjacent areas during extreme flood events (>+/-10-year recurrence interval flood) is predicted by FEMA to be due to “backwater” flooding of the Assabet River which would result in reverse flow within the dam and dam embankment abutments. The effect of this backwater flooding is predicted by FEMA to extend northward to Rt 2. The Base Flood Elevation (BFE) in the pond and surrounding properties, controlled by the peak flood levels and discharge in the Assabet River, is Elevation 124 feet NAVD88. Considering both the predicted peak discharge from the north (Nashoba and Fort Pond Brooks (combined flow of about 1,820 cfs) and the “backwater” effects of the peak discharge in the Assabet (about 4,070 cfs at the confluence with Nashoba Brook), there is no basis for assuming (without detailed analysis) that the limits of the 100-year floodplain will be reduced. Further, there is no basis for assuming (without detailed analysis) that dam removal will not increase the flood hazard, in particular to properties located in the vicinity of the dam.

The dam is considered a flood protection structure. While the dam will have minor overtopping during the 100-year flood, which was assumably considered in the dam rehabilitation design, during the 100-year flood flow into the pond and draining from the pond appears to be mitigated by the dam. Further, the 2023 Phase I Dam Inspection Report page 3-5 indicates that breaching (i.e., removal) of the dam will result in a loss of flood attenuation capability.

Detailed hydrologic and hydraulic analysis including numerical model analysis, as noted in the Alternatives Analysis Report, will be required to evaluate the change in flood limits, depth and discharge due to dam removal. It may be (to be confirmed in the 30% design), that similar to the dredging alternative, some dredging, excavation and filling within the regulatory floodway will also be required for the dam removal (dam removal earthwork, concrete and masonry spillways and construction of new stream channel and channel banks)

While FEMA's review fees are waived for dam removal (as they are also for fish passageways), the hydrologic and hydraulic calculations along with the proposed map changes will require FEMA review. The cost of map revision request preparation, supporting calculations and documentation and FEMA review and the associated FEMA review and approval schedule does not appear to have been considered in the Alternatives Analysis.

3. Storm Damage Prevention

The Alternatives Analysis Report indicates that the Dam Removal Alternative would have… "Potential long-term positive effect due to lowering water surface elevation and reducing the lateral extent of the 100-year floodplain upstream of the former dam location. Future modeling would confirm the scale of this benefit" and "Likely No Negative Effects". Further the Dam Removal alternative was scored higher for this category (3 versus 2).

For the same reasons presented above, there was no technical basis provided for that conclusion or that score.

Questions:

The information presented in Attachment 4 and summarized above is provided solely as the basis for the following questions. It should not be considered as fact or a professional opinion nor should it be relied upon by the Task Force or the Town. It does, however, appear to support the following questions for the Task Force to consider and the NRC and consultants to evaluate.

1. *Given the complexity of flooding in the vicinity of Warner's Pond, what was the technical basis for the conclusions and "Storm Damage Prevention" score and why was the dam removal alternative rated higher than the dredging alternative relative to flooding given that detailed analyses had not been performed at that time?*

4. Water Quality/Pollution Prevention

The Alternatives Analysis Report indicates that the Dam Removal Alternative would have… "Potential significant long-term positive effect due to restoration of natural stream flow patterns which are expected to reduce water temperature and increase dissolved oxygen concentrations" and "Potential for short-term negative effects due to increased turbidity downstream of the dam. Future sediment transport modeling should confirm the potential for mobilizing arsenic-contaminated sediment."

The Report indicates that the Dredging Alternative would have… "Likely no significant positive effects. Dredging is anticipated to decrease water temperatures and increase dissolved oxygen concentrations within the dredge footprint; however, these benefits are likely to be offset by increased water temperatures and decreased dissolved oxygen concentrations within the fill footprints. Additionally, the reuse of dredged material within the pond basin will not result in a net removal of nutrients from the system, which would preclude any benefits that could be realized by removing and disposing sediment at an off-site location" and "Short-term negative effect due to temporary increase in suspended solids in Warner's Pond, which may be significant. Turbidity barriers would be used during construction to manage this effect. Likely no long-term negative effects."

Further the Dam Removal alternative was scored higher for this category (4 versus 2).

Questions:

The information presented in Attachment 2 and summarized in the comments below is provided solely as the basis for the following questions. It should not be considered as fact or a professional opinion nor should it be relied upon by the Task Force or the Town. It does, however, appear to support the following questions for the Task Force to consider and the NRC and consultants to evaluate.

1. *Given: a) the consistency of Pond and contributing and downstream tributary water quality, including nutrients; b) the observation that the available Pond water quality meets or exceeds Massachusetts standards; c) the observation that DO may be decreasing within the tributaries for unrelated reasons; d) the lack of evidence indicating that Warner's Pond water quality is adversely impacting the Assabet River; d) the likelihood that the principal factor contributing to the high Pond vegetation productivity appears to be shallow water depth and sedimentation; and e) water temperature increase is equally an issue for the shallow streams as well as the Pond, why (with the information available at the time) did the Alternatives Analysis Report score the Dam Removal Alternative twice as high as the dredging alternative?*
2. *The high turnover and flushing rate of Warner's Pond is highly unusual relative to typical ponds. As stated in the 2012 Watershed Management report, it is more appropriate to view the pond functioning as a large, wide river pool within a wetland system rather than a "pond". What are the beneficial implications of this high flushing rate on water quality within and downstream of Warner's Pond on water quality parameters*? *Why wasn't this considered in the Alternatives Analysis Report and scoring?*
3. *Was water quality testing performed by OARs and publicly available at the time considered as part of the Alternatives Analysis? If not, why not?*

Comments:

Detailed review of the available data introduces several questions and challenges to this score. Attachment 2 presents an overview of the Warner's Pond aquatic vegetation productivity issue, a description of water quality parameters including applicable Massachusetts Water Quality Standards, a discussion of nutrient loading, a discussion of light zonation, the implications of the high turnover rate of

Warner’s Pond and a comparison of the water quality within Warner’s Pond with the tributaries discharging to Warner’s Pond as well as Nashoba Brook and the Assabet River down gradient from Warner’s Pond.

- Review of the pond hydraulics, consistent with 2012 Watershed Management Plan findings, indicates that the predicted flushing rate of Warner’s Pond is such that water moves through Warner’s Pond very quickly (under normal flow 1 to 2 times a day) and in many regards, it is more appropriate to view the pond functioning as a large, wide river pool within a wetland system rather than a “pond”. This flushing rate results in high pond volumetric flow and rapid turnover of the pond water (i.e., in general, water entering the pond from Fort Pond and Nashoba Brooks discharges quickly).
- Clearly, there is a is high vegetation productivity issue in the Pond. And there appears to be adequate nutrients (phosphorous and nitrogen) in the contributing tributaries to support vegetation. However, the most recent, available water quality parameters appear to be relatively good (above quantitative Massachusetts Class B Inland Waters standards). In particular the measured dissolved oxygen, turbidity, pH, conductivity and temperature (indicators of eutrophication) exceed Massachusetts Class B Inland Waters standards and industry aquatic standards for warm water fisheries. Therefore, while pond eutrophication is happening describing the Pond as in an advanced state of eutrophication may be overstating the condition at this time.
- The high Pond turnover rate moves dissolved nutrients into and out of the Pond quickly. This may be why the Pond (unlike other Concord ponds with a very low turnover rate) does not experience algal blooms.
- Based on water quality testing performed for the 2012 Watershed Management Plan as well as water quality testing performed by OARs and made publicly available on their website (including a testing station downgradient of the Pond in Nashoba Brook, the Pond water quality parameter values appear to be generally consistent with (i.e., not worse than) those observed in other Upper Assabet tributaries, including tributaries flowing into Warner’s Pond and tributaries receiving Pond outlet flow.
- Discharge from Warner’s Pond does not appear to adversely affect water quality with the reaches of the Upper Assabet.
- Dissolved oxygen in Nashoba Brook (and likely other tributaries) appears to correlate with streamflow during low flow conditions indicating that during drought years with resultant low streamflow, dissolved oxygen may decrease. Lower Perennial wetlands, like this section of Nashoba Brook, may have oxygen deficits. Several of the low Nashoba Brook DO datapoints used in analyses performed by OARs are annual values associated with drought years and low flow conditions. Regardless, long term (1997 to 2023) dissolved oxygen readings (by OARs) in Nashoba Brook downgradient of the Pond appear to indicate a decline in dissolved oxygen of about 4% over that time period (about 0.2% per year). Over the last 10 years, that rate appears to have increased to about 1.1% per year.
- The observed decrease in dissolved oxygen in Nashoba Brook may indicate a similar decrease in Warner’s Pond values. Given the consistency between dissolved oxygen observed in both Pond input and outlet tributaries, it may also indicate a decrease in dissolved oxygen in the tributaries entering the Pond. It may also indicate normal oxygen deficits, in particular for low gradient shallow stream flow.
- The dam spillways and downslope channels, which create a “riffle” style flow may actually oxygenate the Pond discharge due to creating turbid flow and increased water surface area.

- The reduced flow velocity within the Pond may also be a pollution prevention measure by inducing settlement of suspended sediment, rather than discharging the sediment to downstream stream channels.
- Knowing that there are adequate nutrients present (upslope of the Pond, in the Pond and downgradient of the Pond) to support high vegetation productivity, the principal manageable issue associated with the vegetation in the Pond appears to be shallow depth. The shallow water depth (light zonation and photic zone) appears to be the major contributing factor to the high Pond productivity.

5. Recreation

The Alternatives Analysis Report indicates that the Dam Removal Alternative would have… "Long-term positive impacts through enhanced connectivity between Nashoba Brook and the Assabet River, which is expected to improve paddling and fishing opportunities. New recreational infrastructure will provide water access for active (e.g., paddling, fishing, etc.) and passive (e.g., wildlife viewing) recreation" and "Long-term negative effect on skating due to the reduction in the size of the open water area; however, a smaller pond is expected to remain following dam removal which could continue to support these uses. Most private property owners along the pond's shoreline would lose direct access to the water".

The Report indicates that the Dredging Alternative would have… "Long-term positive effect by improving navigability within the dredge footprint (through increased water depths and decreased cover/biovolume of aquatic plants) and installation of new recreational infrastructure" and "Long-term negative effect by decreasing navigability within the fill footprints. The southwestern cove would cease to be passible by small paddle craft, while water depths in the north fill area would decrease, which may increase aquatic plant growth and in turn impair recreational use in this area".

The Alternatives Analysis Report scored both the Dredging and the Dam Removal alternatives the same (3 versus 3).

Questions:

The information presented in Attachment 6 and summarized in the comments below is provided solely as the basis for the following questions. It should not be considered as fact or a professional opinion nor should it be relied upon by the Task Force or the Town. It does, however, appear to support the following questions for the Task Force to consider and the NRC and consultants to evaluate.

1. *Frankly it is really hard to understand the basis of the score for Recreation given in the Alternatives Analysis Report. What is the basis of that score, in particular since almost no recreational amenities have been included in the Dam Removal cost estimate?*
2. *What will be the range of depth in the new stream channel and what will be its navigation capacity throughout the year?*
3. *What will be the range of depth and associated aerial extent of the proposed 4.5-acre pond throughout the year?*
4. *Given the reduced flow to the new pond as well as shallow depth, how will eutrophication be managed so the new pond will be usable?*
5. *How will fishing be improved, given the current popularity of Warner's Pond for fishing?*
6. *How will birding and other passive recreation be improved given the current popularity of Warner's Pond for these activities, and the limited future access indicated in the Alternatives Analysis Dam Removal alternative and cost estimate.*

Comments:

Detailed review of the available data introduces several questions and challenges to this conclusion and score. Attachment 6 presents an overview Warner's Pond Recreational and Community Benefits.

- Dam Removal Alternative New Stream Channel. The anticipated water depths within the new stream channel, after dam removal, may be too shallow to be reasonably navigable – even by canoe or kayak for all or much of the year. Under August flow conditions, with combined total discharges of about 11 cfs, stream channels may be nearly dry.

- Dam Removal Alternative New Pond: With an anticipated new water level of about +/- 115 feet NAVD88 (to be confirmed by 30% design), the new 4.5-acre pond may be quite shallow (2 to 8 feet) and at times of low flow (August) may be even shallower. Further, the Alternatives Analysis Report score does not consider eutrophication of the new pond which likely happen given that it will have less flow than the current pond and be quite shallow.
- The Alternatives Analysis (and alternatives cost comparison) does not include any amenities to increase site access (e.g., boat launch, trails, boardwalks, etc. similar to those that exist at Great Meadows). And it is not clear how the new stream channel as well as wetlands areas will be accessible to boaters, paddlers, walkers, fisherman and birders. Also, should amenities comparable to those currently available at the Pond be included these would add significantly to the cost estimate (possibly $1M+/-), which in turn would have indicated that this alternative was not economically better than the Dredge and Filling Alternative.
- The Alternatives Analysis Report implies that wildlife and fisheries will be improved relative to the existing 86-acre wetland system; however, no basis for that conclusion is presented. In fact, a loss of existing wildlife may occur.
- In comparison, as presented in Attachment 6, the current 86-acres wetland system with about 40-acres of open water continues to be a significant Town recreational and community resource. The value of the Pond is such that Town policy has consistently been to invest in improvement, restoration and recreational enhancement of the Pond. Recent investments have included: 1) major restoration of the dam; 2) construction of Gerow Recreation Area; and 3) the Bruce Freeman Rail Trail.
- The decision to close the MCI Prison has opened up potential opportunities for further recreational and community benefits (e.g., a Pond circumference trail).
- Current recreational uses, even with the Pond's diminished condition, include: Fishing; Ice Skating; Pond Hockey; Boating: Paddling; Viewing; Boy Scouts/Girl Scouts; Birding and (potentially) swimming. Nothing in the Alternatives Analysis Report indicates comparable recreational and community benefits under the Dam Removal Alternative.
- The location of Warner's Pond, integral to Concord Junction and accessible to pedestrians and handicapped, makes the Warner's Pond and Wetland System unique and immensely valuable. Planning studies associated with evaluating opportunities with MCI closure (see examples in Attachment 6) show the Warner' Pond Wetland System at the center of everything proximate to Concord Junction.
- Further, the economic benefits of the existing and future (assuming no dam removal) Warner's Pond and Wetland System are significant and have not been considered. Professional planners are required to assess these values, including economic benefits. But, typical considerations: (https://recreationroundtable.org/):
    - According to a 2021 study "2021 Outdoor Participation Trends Report" by the Outdoor Foundation, 7.1 million more Americans participated in outdoor recreation in 2020 than in the previous year. The COVID-19 pandemic was the main driver of this trend, leading to outdoor activities becoming a safe way to socialize, improve physical and mental health, connect with family, and recover from screen fatigue. The study offers several key findings

about participation in outdoor activities, as well as the types of outdoor activities that people are undertaking.

- The United States Environmental Protection Agency (EPA) notes that “encouraging growth on Main Streets and in existing neighborhoods while promoting outdoor recreation can help foster community revitalization, protect air and water quality, create jobs, support economic growth and diversification, and offer new opportunities for people to connect with the natural world.”
- “Recreation Economic Values for Estimating Outdoor Recreation Economic Benefits From the National Forest System” (https://www.fs.usda.gov/pnw/pubs/pnw_gtr957.pdf) provide some general guidance for evaluating the economic benefits to the Town of maintaining the Pond and associated recreational benefits.
- Also… the findings of Active Living Research.org “The Economic Benefits of Open Space, Recreation Facilities and Walkable Community Design” indicate:
    - Open spaces such as parks and recreation areas can have a positive effect on nearby residential property values and can lead to proportionately higher property tax revenues for local governments (provided municipalities are not subject to caps on tax levies).
    - The economic impact parks and recreational areas have on home prices depends on how far the home is from the open space, the size of the open space and the characteristics of the surrounding neighborhood.
    - Open space in urban areas will increase the level of economic benefits to surrounding property owners more than open space in rural areas.
    - Open space, recreation areas and compact developments may provide fiscal benefits to municipal governments.
    - Compact, walkable developments can provide economic benefits to real estate developers through higher home sale prices, enhanced marketability and faster sales or leases than conventional development.

6. Fish and Shellfish Habitat

The Alternatives Analysis Report indicates that the Dam Removal Alternative would have… "Significant long-term positive effect on fish habitat through reconnection of aquatic habitat and restoration of fish passage in Nashoba Brook and "Significant short- to medium term negative effect on shellfish habitat through removal of impoundment. This effect may be moderated in the long-term as mussels recolonize the restored stream channel. No state-listed mussel species are known to occur in Warner's Pond, and a salvage and relocation effort could be undertaken immediately following dam removal to mitigate mortality rates of mussels".

The Report indicates that the Dredging Alternative would have… "Possible long-term positive effects due to increase in water depths within the dredge footprint which in turn would be expected in increase dissolved oxygen concentrations. Positive effect is likely to be limited due to the reduction in water depths within fill areas, the relatively limited scale of dredging, and the presence of deep water habitat elsewhere in Warner's Pond" and "Short- to medium-term negative effects. Short-term increases in suspended solids during dredging and filling operations may impair water quality and temporarily degrade habitat for fish and shellfish. Both dredging and filling are likely to result in direct mortality of shellfish, and area of filling in the southwest cove may become unsuitable for shellfish habitat due to significantly decreased water depths".

Further the Dam Removal alternative was scored higher for this category (4 versus 2).

Questions:

The information presented in Attachment 5 and summarized in the comments below is provided solely as the basis for the following questions. It should not be considered as fact or a professional opinion nor should it be relied upon by the Task Force or the Town. It does, however, appear to support the following questions for the Task Force to consider and the NRC and consultants to evaluate.

1. *The primary objective of dam removal is fisheries benefits. Has a detailed assessment of the actual, specific fisheries benefits, in consideration of the specific conditions presented at this site, been performed by a fisheries expert? If so, is it available? If not, will it be performed and made available? Specifically, which fish will benefit from the dam removal.*
2. *Assuming American shad make their way to the Assabet River, based on their desired habitat are they likely to migrate to Nashoba Brook and upstream tributaries within the Nashoba Brook sub-watershed, which are a much shallower with lower flows? Similar question for Blueback herring?*
3. *If not, how can the deliberations proceed without a clear understanding of the benefits?*
4. *Have the comparative benefits of the proposed +/- 4,700 lf channel and small 4.5-acre shallow pond versus the existing pond (assuming construction of a fish pass), been considered relative to pond spawning habitat? For example, alewife?*
5. *What will be the impacts to the existing fish present in the pond and wetlands if the dam is removed?*
6. *Given these unanswered questions, how was it assumed that the Dam Removal Alternative score is twice that of the Dredging Alternative? Was the score based solely on generic state and federal goals or on a detailed analysis of the site-specific fisheries benefits?*

Comments:

By dam removal, the Town is considering removing a major community resource. It appears that the principal benefit associated with a Dam Removal Alternative is fisheries, specifically improving aquatic connectivity with upstream areas and providing passage to diadromous fish for spawning. And it is noted that dam removal is consistent with federal and state policy (as is creating fish passage for conditions where the obstruction is not removed).

However, given the magnitude of the loss to the community of Warner's Pond and uncertainty about the adverse impacts to the remaining wetlands, it is essential that the actual site-specific benefits of dam removal be clearly and quantitatively documented. In particular:

- In general, there are clearly fisheries benefits associated the removal of obstructions and re-introducing diadromous fish to the larger, higher flow Concord and Assabet Rivers, but information has not been provided indicating the specific benefits of the removal of the Warner's Pond Dam and upstream areas relative to the specific target diadromous fish (documented in the Merrimack and Concord Rivers).
- Target species have not been identified (although review of the available publicly available information indicates which fish are targeted as likely candidates for the Assabet River).
- The Warner's Pond Dam is not on the Assabet River and does not obstruct flow within the Assabet River.
- No specific, detailed information has been provided as to the actual benefits of the dam removal relative to fisheries, either for the existing warm water fish within the Pond and tributaries and the specific target diadromous fish that are hoped will migrate to the Assabet River.
- The migratory timing and life history stage and preferred habitat of these targeted species relative to the site-specific conditions at Warner's Pond (and after dam removal) has not been documented or considered in the Alternatives Analysis.
- It has not been documented whether or not Nashoba Brook (between the dam and the Assabet River), the proposed stream channel and pond, and upstream tributaries within the upstream sub-watershed will meet minimum flow and depth threshold requirements for the migratory fish under consideration.
- The environmental attractors and stressors (flow volumes, flow velocity, water temperature, seasonal timing) have not been identified for Nashoba Brook (between the dam and the Assabet River), the proposed stream channel and pond, and upstream tributaries within the upstream sub-watershed.
- Should fish migrate to the Assabet River, can target fish return to the ocean in consideration of the stream and river flow conditions and existing obstructions including the Essex Dam? Assume so but should be confirmed.
- The details of the pond spawning habitat that will be available upon dam removal relative to that which currently exists within Warner's Pond have not been documented.
- Adverse impacts due to dam removal to the existing fish have not been documented.
- Obviously, removal of the Warner's Pond Dam will not address the numerous obstructions and dams that exist upstream of the pond (and that are not currently considered for removal).
- A naturalized fish passage has not been considered as a "hybrid" alternative.

7. Fish Passage

A Fish Passage was mentioned but not considered as an alternative in the Alternatives Analysis Report. The public presentation by the dam rehabilitation designer appears to have indicated that a future fish pass at the Auxiliary Spillway was an option. Information presented in Attachments 3 and 5 appears to indicate that it may be a viable and cost effective “hybrid” alternative, specifically a naturalized “rock ramp” at the Auxiliary Spillway, that could be considered and evaluated.

Questions:

The information presented in Attachments 3 and 5 and summarized above is provided solely as the basis for the following questions. It should not be considered as fact or a professional opinion nor should it be relied upon by the Task Force or the Town. It does, however, appear to support the following question for the Task Force to consider and the NRC and consultants to evaluate.

1. *Should a naturalized fish passage be considered and evaluated in detail as an alternative?*

8. Wildlife Habitat

The Alternatives Analysis Report indicates that the Dam Removal Alternative would have… "Very significant, long-term positive effects due to the removal of the impounding effects of the Warner's Pond dam and the re-establishment of approximately 35 acres of wildlife habitat" and "Short-term negative effects due to displacement during construction."

The Report indicates that the Dredging Alternative would have… "Long-term positive effect by creation of 3 acres of new emergent wetland habitat in the pond's southwestern cove and reduction in aquatic invasive plant growth within the dredge footprint" and "Short-term negative effects due to displacement during construction activities and increase in turbidity during dredging and filling operations".

Further the Dam Removal alternative was scored higher for this category (4 versus 3).

Warner's Pond itself is not classified as Priority or Estimated Habitats, but Priority Habitats and Estimated Habitats are located along Nashoba Brook and Fort Pond Brook upstream of the pond. No rare and endangered flora and fauna have been documented within Warner's Pond. The wood turtle is a listed species and has been identified in the area. In consideration of the wood turtle habitat, dam removal may benefit this species.

The effect on wildlife, positively or negatively, is very dependent upon what the conditions and habitat will be under each alternative. As shown in Attachment1 there is uncertainty as to what the post-dam removal habitat will be. As shown in Attachment 5, there is significant wildlife under the existing condition including a lot of associated recreational value (e.g., birding) that may be impacted.

Without evaluating habitat impacts, adverse or otherwise, it appears that was not possible to confidently predict and document for decision making purposes what the future habitat and wildlife there will be under the Dam Removal Alternative.

Questions:

The information presented in Attachment 5 and summarized above is provided solely as the basis for the following questions. It should not be considered as fact or a professional opinion nor should it be relied upon by the Task Force or the Town. It does, however, appear to support the following questions for the Task Force to consider and the NRC and consultants to evaluate.

1. *What is the technical basis and documentation that indicates what the environment and habitat will be for the Dam Removal Alternative? Specifically, it has not been determined what the post-dam site conditions will be including the presence and extent of wetlands.*
2. *There is substantial and diverse wildlife habitat present in the existing 86-acre wetland system ranging from shallow and deep open water to emergent wetlands to scrub-shrub to forested wetland. The Report has not demonstrated that the post-dam site conditions will provide more or "better" wildlife habitat.*
3. *In the absence of that information, what was the basis for the score?*

9. Educational/Scientific Value

The Alternatives Analysis Report indicates that the Dam Removal Alternative would have… "Significant long-term positive effect through opportunities to study the response of the system to dam removal" and "No negative effects".

The Report indicates that the Dredging Alternative would have… "Potential long-term positive effects by providing opportunity to study the impacts of the project to the environment and community" and "No negative effects".

Further the Dam Removal alternative was scored higher for this category (4 versus 3).

The Dam Removal Alternative will clearly benefit the knowledge around impoundment removal in Massachusetts, specifically successful access to upstream, shallower and lower flow sub-watersheds.

However, the existing 86-acre pond and wetlands system also has clear (if currently unrealized) educational and scientific value, similar to Great Meadows. It is currently unrealized in part due to the lack of public access to most of the wetland areas. This could be remedied with the construction of trails and boardwalks.

Questions:

The information presented in Attachment 5 and summarized above is provided solely as the basis for the following questions. It should not be considered as fact or a professional opinion nor should it be relied upon by the Task Force or the Town. It does, however, appear to support the following questions for the Task Force to consider and the NRC and consultants to evaluate.

1. *In consideration that both alternatives provide educational and scientific benefits, why were the scores not equal?*

10. Visual/Aesthetic

The Alternatives Analysis Report indicates that the Dam Removal Alternative would have the following visual/aesthetics impacts… "This alternative would result in significant, long-term changes in the visual quality of the system. These changes may be positive, negative, or neutral, depending upon personal preference. To the extent that the aesthetic quality of Warner's Pond is currently degraded by dense growths of aquatic invasive species to the water surface during the growing season, this alternative would benefit the visual quality of the system by re-establishing a native vegetative community within the existing impounded area. Based on the indicators of visual quality described in Section 2.4.5, the aesthetic value of the system following dam removal is expected to be high.

The Report indicates that the Dredging Alternative would have… "Long-term positive effect through expansion of emergent marsh community and reduction in invasive species growths at surface and "No negative effects".

The Report has not confirmed expectations for post-dam removal including wetland extent and character, stream channel water level and pond water level (and eutrophication). So, the visual effects of post-dam vistas are undetermined at this time (and the visual renderings while well done and highly effective may be misleading).

The Report also does not represent, in sight lines, the effect of having a dramatically lower water level in the proposed new pond at Gerow (water Elevation +/- 119 feet NAVD88 [current] vs Elevation +/- 114 to 116 feet NAVD88 [likely proposed]).

The Report does not consider the current values of having unobstructed views of open water, located within West Concord Village and accessible to all citizens at Gerow Recreational Area and the other pocket parks constructed by the Town solely for viewing purposes. Attachment 6 presents aerial images showing Warner's Pond relative to other key Concord Ponds, showing the comparable and significant surface water extent.

Also, the analysis of benefits including accessible open water viewsheds is not just personal preference, but a consideration of professional urban planners and landscape architects. Open water has, as documented, specific public benefits. As a typical example, reference… "Blue space: The importance of water for preference, affect, and restorativeness ratings of natural and built scenes - ScienceDirect; Landscape elements affect public perception of nature-based solutions managed by smart systems - ScienceDirect":

- Open water is critical for everyday aesthetic experiences.
- It is often associated with high landscape preference, aesthetic pleasure, and relaxation and restoration (Herzog, 1985, Kaplan and Kaplan, 1989, Völker et al., 2016, White et al., 2010).
- Studies of natural wetlands noted that absence of visible water (Dobbie, 2013) or presence of sediments (Cottet, Piégay, & Bornette, 2013) may significantly undermine aesthetic experiences.
- Aesthetic preferences for rivers have been reported to be greatest at medium water flow, with both high and low flows less preferred – possibly due to suspended debris and exposed channel beds (Brown and Daniel, 1991, Pflüger et al., 2010, Yamashita, 2002).

Questions:

The information presented in Attachment 6 and summarized above is provided solely as the basis for the following questions. It should not be considered as fact or a professional opinion nor should it be relied upon by the Task Force or the Town. It does, however, appear to support the following questions for the Task Force to consider and the NRC and consultants to evaluate.

1. *The Town has made significant investment in the Gerow Recreation Area as well as a pocket park for the purposes of visually observing the Pond. The open water of the Pond, situated proximate to West Concord Village and Concord Junction and pedestrian and handicap accessible, is a rare community resource and respite. How will these investments perform in the context of landscape vistas in a Dam Removal Alternative?*

11. Uniqueness/Heritage

The Alternatives Analysis Report indicates that the Dam Removal Alternative would have… "Long-term positive effects due to multiple benefits of dam removal, including but not limited to: re-establishing connection with Wild and Scenic River downstream of pond; enhancing habitat for rare species; re-establishing natural complex vegetative structure; providing rare scientific and educational opportunity to study the response of the system to dam removal; and improving water quality" and "Likely few if any negative effects based on a review of the considerations and qualifiers related to this function (USACE 1999). This alternative would change the nature of the Warner's Pond system, which has existed in its current state for approximately 160 years – and by extension, to a certain extent, the nature of West Concord. Whether this change is positive or negative is likely a matter of personal opinion and perspective."

The Report indicates that the Dredging Alternative would have… "No positive or negative effects."

Further the Dam Removal alternative was scored higher for this category (4 versus 2).

Questions:

1. Given the early Industrial Revolution legacy of West Concord, including Warner's Pond, why was this legacy not considered during the heritage value in the scoring?

Comments:

The Alternatives Analysis Report for this category is based on the 2019 USACE Highway Methodology Supplement which states… "This value relates to the effectiveness of the wetland or its associated waterbodies to produce certain special values. Special values may include such things as archaeological sites, unusual aesthetic quality, historical events, or unique plants, animals, or geologic features."

Warner's Pond Dam is part of the early industrial era legacy of Concord and the United States. Its purpose has evolved but, similar to the Bruce Freeman Rail Trail and other West Concord features for which there have been specific recognition of the importance of the historical legacy to Concord's history, the importance of Warner's Pond should be considered. The following indicates the integral role of Warner's Pond in West Concord history.

Information compiled from: "Park & Landscape Features: Recorded by A. Forbes for the Concord Historical Commission", March 10, 1988 Walking Tour of West Concord, Marian H. Wheeler, Concord Historical Commission Additional Town Documents. History of Warner's Pond (warnerspond.org)

- In the late 17th century, a Fulling Mill existing and in the early 19th century, a saw mill existed near the original dam at the Pail Factory bridge.
- 1819 – David Loring purchased the land and pond and had his Lead Pipe Works business there until 1854.
- 1830 – David Loring construction the home at 169/171 Commonwealth Avenue and lived there for several years before moving to another location. The Silvio family has owned this home.
- 1850's – Warner's Pond was and is still considered the most prominent geographical feature near Concord Junction. (West Concord Village).

- 1854 – The Pail Factory operated on the same site as David Loring's Lead Pipe Works. This was also the site for the Garnet Mill on the other side of Commonwealth Avenue, presently where Nashoba Bakery resides.
- By the late 1880, the pond became a center for recreation in all seasons of the year. "The Grove" behind "Commonwealth Row" (near the present boat landing off Commonwealth Avenue) was a picnic spot. The pond was full of small boats and Rev. Walter Campbell from the Union Church had a steam launch named the "Maude Blake" which was rented out for boating parties for many years. Sledding, ice skating and fishing, both in summer and winter were popular sports.
- Late 19th century ice houses were kept on the northeast corner of the pond to back up ice businesses. These burned sometime around 1895 and were never replaced.
- Henry Thoreau named the big island on Warner's "Myrica Island" because of the Sweet Gale he saw growing there.
- 1896 – West End Land Company purchased most of Ralph Warner's property, including the pond and the first project on the pond was to build a wooden bridge, no longer there, from the Commonwealth Avenue shore to the large Island, then named "Isle of Pines". Several camps had been built on this island.
- 1944 – West End Land Company transferred ownership of the large island (the Isle of Pines) in Warner's Pond, approximately 6.07 acres in size, to the Girl and Boy Scouts of America. Deed is signed by Burleigh L. Pratt and Harold Orendorff, Trustees.
- 1961 Town Meeting – Article 44 – Town voted to approve purchase of Warner's by Town of Concord.
- 1962, May 8th – Deed of Warner's Pond signed by Town Counsel, John J. Sheehan.

From VisitConcord.org…

- A Brief History of West Concord Industry
    - West Concord industries and the people whose entrepreneurship, innovation, labor, persistence, and resilience built them have profoundly shaped our village's economy, population, and culture throughout its history.
- Native American Manufacturing
    - The Concord area has been inhabited for more than 10,000 years by Native American people who established the village of Musketaquid here, according to the Concord Free Public Library's *Brief History of Concord*. Throughout this time they produced a wide variety of objects. For these millennia, Native people would "collect fresh-water clams, make tools, cut with axes, hunt game with spears, grind food with stone pestles, and cook with soapstone pots" as well as "make weirs to catch fish in brooks" and "make dug-out canoes."
- Beginnings of European Settlement in the 17th and 18th Centuries
    - West Concord began to be settled in the mid-17th century as part of the Second Division of land. Almost immediately, landowners began to build mills using the brooks and river. George Hayward built a sawmill in 1644 on Hayward's Pond that was later followed by a corn mill. Near the site of the Damon Mill, the Concord Ironworks was incorporated in 1658 by a group of investors. It dug and forged peat bog iron ore. Later a grist and fulling

    mill was operated on the same site run by Lot Conant and his descendants. Another fulling and saw mill was established by Ed Wright before 1700 along the Nashoba Brook.

- West Concord Industry in the 19th and Early 20th Centuries
    - West Concord really began to develop in the early 19th century as three villages grew up around mills and factories. Westvale (also known as Factory Village and Damondale) at the Damon Mill site was the first in the first half of the 19th century. In the mid-nineteenth century, Warnerville (also known as Concord Junction) grew up around the Warner Pail and Tub Factory and the junction of the railroads. Finally, Prison Village (also known as Reformatory), developed around housing for those employed in the Reformatory in the later 19th century. These three neighborhoods later merged to become West Concord.
    - West Concord's first railroad was the Fitchburg Railroad which had a station near the Damon Mill. The coming of the Framingham & Lowell, Middlesex Central, and the Acton, Nashua, and Boston branch of the Concord, New Haven and Montreal lines in the 1870s significantly contributed to the growth of industry due to the ability to move freight easily in and out of the village. At the height of railroad traffic, 120 trains came through Concord Junction each day.
    - The Loring Lead Works was established in 1819 by David Loring on Nashoba Brook near Warner's Pond. It first made lead pipe, but then turned to making sheet lead. In the 1830s, it used 300,000 pounds of lead annually.
    - By 1880, Warner's Pond was a popular site for recreation including ice skating, fishing, sledding, and boating. The "Maude Blake" steam launch steamed around the Pond. Summer camps operated on the island.

From a letter to the Concord Bridge…

> "Letter: Warner Pond's place in history
>
> June 2, 2023
>
> During present discussions about Warner's Pond, efforts should be made to ponder broader historical significance and issues of equity, which are closely tied together here.
>
> When Andrew Koh started serving on the Historical Commission, it understandably focused on houses and the first half of the town's history, but the commission increasingly made efforts to look beyond. When the circa 1829 Abiel Wheeler House was slated for demolition, it was originally considered insignificant compared to the 17th century Scotchford-Wheeler House. People highlighted the former's significance as a part of the greater Hubbardville fabric.
>
> Koh noted its role as the childhood home of Blanche Wheeler Williams, a pioneering Smith College graduate who co-founded the field of Aegean Bronze Age archaeology in the U.S. She features prominently in Koh's upcoming book, "The Cretan Collection in the Penn Museum." He continues to rely on experiences from Concord while serving as museum scientist for the Yale Peabody Museum as it undergoes transformational renovations sensitive to its original 1920s structure and surroundings.
>
> In much the same way, as the third owners of the early 20th-century Isaac Beharrell House where the old Reformatory neighborhood meets Warnersville, we see Warner's Pond as the beating heart of a historically diverse neighborhood. When our house was built, census records show reformatory wardens living near prison guards and Chinese workers living near train conductors.

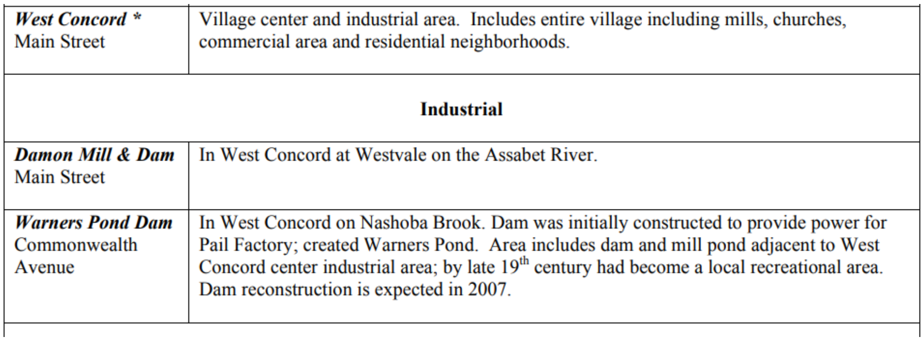
> Despite its pragmatic and manmade origins, the dam allowed a working-class neighborhood to enjoy aquatic activities and landscapes reserved for other parts of town. Please consider these issues of historical significance and equity when deliberating the future of the pond."

Massachusetts Heritage Landscape Inventory Program, "Freedom's Way Landscape Inventory" describes West Concord Village as:

"West Concord Village Concord has three village centers: Concord Center, Depot/Thoreau Street and West Concord. The town values each of these distinct areas and is working to preserve their unique character. While all three were identified by the community as heritage landscapes, West Concord was selected as a priority landscape because it is considered most vulnerable to change. West Concord is a mixed use village area between Route 2 and the Assabet River that reflects its late 19th and early 20th century development and has generally been considered secondary to other parts of Concord, but has recently been recognized as a vital and active part of the community with a distinct character of its own that is derived from the mix of buildings and uses, particularly its role as an incubator for small businesses.

West Concord developed as an industrial village in the 19th century, with mills along the Assabet River, Warner's Pond and Nashoba Brook that made it the industrial center of the community. Today it reflects its industrial heritage as well as the presence of MCI-Concord, the railroad and a diverse commercial center with many startup businesses and specialty stores. Our Lady's Church, industrial buildings and the West Concord Depot were institutions specifically mentioned by community residents. *Key issues are preserving the physical character of the area, as well as the unique mix of businesses, institutions and natural areas, including the Assabet River and Nashoba Brook."*

The inventory also lists Warner's Pond Dam:



West Concord * Main Street	Village center and industrial area. Includes entire village including mills, churches, commercial area and residential neighborhoods.
Industrial	
Damon Mill & Dam Main Street	In West Concord at Westvale on the Assabet River.
Warners Pond Dam Commonwealth Avenue	In West Concord on Nashoba Brook. Dam was initially constructed to provide power for Pail Factory; created Warners Pond. Area includes dam and mill pond adjacent to West Concord center industrial area; by late 19th century had become a local recreational area. Dam reconstruction is expected in 2007.

12. Construction Considerations

The Alternatives Analysis Report indicates that the Dam Removal Alternative would have the following construction considerations:

- Flood contingency/severe storm event planning for construction phases of project to ensure adequate capacity to route flows downstream of work area.
- Sediment management during and following dam removal.
- Potential for contaminated sediment upstream of dam that requires management and/or offsite disposal.
- Trucking of excess material from existing dam.
- Potential constraints to access main and auxiliary spillways and size of areas available for access and staging. It is likely that access areas will also require clearing of vegetation and mature trees.
- Coordination with neighboring property owners including construction scheduling, disturbances to property, landscaping replacement and management of homeowners' expectations.

The Alternatives Analysis Report indicates that the Dredging and Filling Alternative would have the following construction considerations:

- Potential for contaminated sediment in dredge area that requires management and/or off-site disposal.
- Potential for large debris in dredge area which may require additional management.
- Sediment stability in the dredge prism and ability to maintain designed side slopes.
- Stability of material in placement areas and dosage of polymer amendment prior to placement.
- Movement of dredge pipes within the relocation area.
- Settling times of amended material in placement area.
- Installation of underwater retaining structures (i.e., coir log placement).
- Feasibility of emergent wetland creation using existing submerged seed bed.
- Potential need for further invasive species management in fill areas.
- Potential access constraints to dredge and placement areas.
    - Feasibility of access with dredge barge and support equipment in shallow water areas.
    - Access will be required in the vicinity of property owners near the southern placement area.
- Coordination with neighboring property owners including construction scheduling, disturbances to property, and management of homeowner's expectations.

Further the Dam Removal alternative was scored higher for this category (4 versus 3).

Questions:

1. *Given what appears to be greater complexity of the Dam Removal Alternative construction compared to the Dredging and Filling Alternative, why was the Dam Removal Alternative scored higher than the Dredging Alternative?*
2. *Will dredging be required as part of the Dam Removal Alternative? If so, how will this be evaluated relative to construction considerations?*

Comments:

The Dredging and Filling Alternative includes: 1) sediment controls including temporary turbidity curtains; 2) hydraulic dredging of about 14,000 cy of sediment; 3) in-pond flocculent treatment of sediment; 4) in-pond fill placement of 14,000 cy using hydraulic fill placement. This requires a single construction operation, with limited equipment and with no off-site materials management.

The Dam Removal Alternative appears to have complicated construction activities at a very busy intersection with little to no laydown area. The photographs of the dam reconstruction in 2007/2008 give an idea of the level of activity that may be similar to dam removal. Also noted is that a temporary dam failed during the dam reconstruction. The Dam Removal Alternative involves: 1) development of a large construction laydown area at the busy intersection of Commonwealth and Laws Brook Roads (an area with almost no space); 2) extensive sedimentation and erosion controls, including management of suspended sediment from downstream movement; 3) flood control including use of temporary dams; 4) demolition of the dam structures including concrete and masonry spillway, sluiceway and retaining wall structures; 5) excavation of about 2,000 cy of dam embankment fill; 5. sediment (behind spillways) excavation and off-site disposal off-site disposal; 6) off-site disposal of embankment fill and concrete and masonry construction debris ; and 7) vegetation planting. Although not mentioned, rip-rap stabilization of the side banks (along private property) may be required to provide stable banks during a 100-year recurrence interval flood. Both in-water and conventional construction is required. Extensive water and sediment management is required.

The Dredging and Filling Alternative has more materials management (in cy) but appears to be a simpler operation with no (or minimal) off-site materials management.

Also, the Dam Removal Alternative has not indicated if, in addition to demolition of the dam structures and earthwork associated with dam embankment removal, whether there will also be dredging or earthwork to create the new stream channel.

Construction costs are discussed separately.

13. Regulatory Feasibility

From the Report… "The Town previously received permits to hydraulically dredge approximately 35,000 cy of sediment from a 6.3-acre area of Warner's Pond, of which approximately 4,500 cy would be relocated to another area within the pond basin to form an approximately 1-acre emergent wetland shelf and the remaining 30,500 cy would be removed, dewatered, and transported to an off-site location. It is anticipated that the Dredging and Filling Alternative evaluated herein will be viewed as a significant change to the previously-permitted dredging project, and therefore will likely require a new set of permits and approvals." And… "the primary concern of regulatory agencies for the Dredging and Filling Alternative is likely to be related to the filling of a relatively large portion of the pond with dredged sediment. Specific concerns may include the impact of filling on mussels and other benthic organisms, the physical stability of the fill area side slopes, the potential challenges with establishing a native emergent marsh community in the southwestern fill area, and significant temporary increases in suspended solids during construction. Additionally, unlike the previously-permitted dredging project, the Dredging and Filling Alternative would not result in a net removal of nutrient-rich sediments from the system. This may cause increased regulatory agency scrutiny of the ecological benefits of the project compared to the No Action Alternative, especially because a relatively deep, weed-free area already exists in the pond's northern cove."

If the original dredge contract was to be re-bid, there would be no additional regulatory considerations since according to the NRC the permits are still active.

In general, the EA conclusions appear reasonable but may overstate the issues associated with supplemental permitting of the Dredging and Filling Alternative.

The Dam Removal Alternative, while possibly a preferable alternative to regulators in general, will also have significant permitting issues, in particular relative to downstream sediment management. Eutrophication within the new 4.5-acre pond and (possibly) the proposed stream will also be considerations.

14. Property Owners and Stakeholders

In the Alternatives Analysis Report, primary property owners and stakeholders included: Town of Concord; Residents of Concord; residential property owners along the Pond shoreline; the Boy Scouts of America and the Massachusetts Department of Correction. The Report concludes… "The Dam Removal Alternative would likely result in a net positive long-term effect on the Town of Concord by (1) eliminating the long-term financial burden associated with inspecting, maintaining, and repairing the dam, (2) eliminating the public safety liability associated with the dam, and (3) eliminating the long-term financial burden associated with management of the pond (e.g., aquatic plant management)."

Questions:

Relative to the criteria presented above:

1. *The maintenance and inspections costs are available. Why were these costs not explicitly stated since they are not relatively high?*
2. *Relative to cost, the Town's dam inspection consultants appear to have indicated that a reduction in the Dam Hazard Potential to Low (which would extend the inspection schedule) is feasible. Why has this option not been pursued by the Town?*
3. *Certain specific public safety liabilities appear to have been identified in the Phase I Dam Inspection. Have specific costs been identified? A dam failure risk appears to have been considered in the Town's consultant's suggestion that a reduction of the Dam Hazard Potential be considered.*
4. *For either alternative, the implications to the Town's federal flood insurance rate and properties located within FEMA mapped flood hazard areas does not appear to have been considered.*
5. *For either alternative, the long-term effects of climate change on both the future dam capabilities and performance (assuming that the dam remains) and future FEMA map revisions under either alternative, does not appear to have been considered.*
6. *The relative long-term economic benefits of maintaining Warner's Pond do not appear to have been considered, including the economic benefits associated with recreational uses and cultural benefits? These include the long-term benefits focused on having this unique resource proximate to Concord Junction (which is an evolving development)? Why have these not been professionally determined and considered, including a benefit/cost analysis?*

Comments:

The Alternatives Analysis for this criterion appears to focus on (and possibly overstates) economic burdens and ignores benefits values, including cultural, recreational and economic benefits to the residents of Concord associated with having an 86-acre refuge with over 40-acres of open, surface water. It also seems to ignore that, for the last 40-years, the position of the Town was consistently to maintain this resource. And that the Town has made continued investment (e.g., Gerow Recreational Area) designed based on the presence of the Pond. It also ignores the future value of this resource as West Concord, including Concord Junction, evolves. Conversely, it also does not consider certain stakeholder issues (possibly liabilities) associated with climate change and flooding risk.

15. Project Costs

An independent, line-item review of the cost estimates presented in the Alternatives Analysis report is warranted, for each of the alternatives.

Attachment 1
The Warner’s Pond Wetlands System

Introduction

Warner's Pond is an 86-acre ecologically complex wetland system including forested seasonally-flooded wetlands, scrub-shrub seasonally and semi-permanently flooded wetlands, emergent wetlands, a riverine wetland (stream) and deep open water (Lacustrine, limnetic) wetlands and shallow open water (Lacustrine, littoral) wetlands. Of the 86-acre wetland system, about 42 acres are open water.

Based on the National Wetlands Inventory, about 80% of the 86 acres of wetlands is dependent (either their presence or characteristics) on the presence of an elevated, impounded water level (Normal Pool Elevation of 118.8 feet NAVD88). The Great Meadows National Wildlife Pond in Concord is another example of a large wetland complex controlled by a regulated water level, the two ponds (62 acres) being drained and refiled seasonally.

Removal of the Warner's Pond dam will substantially modify the area hydrology (surface and groundwater), including the conditions necessary to maintain the existing 86-acre wetland system. Detailed analysis including both surface water and groundwater modeling is required for a confident evaluation of what the post-dam removal conditions will be. However, it appears clear that dam removal will impact (adversely or otherwise) the existing wetland system.

The Town, as of this date, has not performed these types of analyses. In addition, the Town and their consultants have made general statements relative to dam removal that imply that the existing wetlands will not be affected other than the open water converting to emergent or scrub-shrub wetlands. However, the available data appears to challenge those statements and at a minimum demonstrates that more extensive analyses should be performed to evaluate the effect of dam removal on the existing wetlands.

This attachment presents details about the existing wetlands (including mapped wetlands, area topography, area surficial geology. And sediment characteristics. Available data is presented in summary form in the following slides:

1. Description of the current wetlands as mapped by the National Wetland Inventory.
2. An overview of the area topography and geology
3. Sediment characteristics
4. A review of historical maps relative to conditions prior to and subsequent to about 1830

Introduction cont.

This attachment also presents the details of Warner’s Pond hydrology and hydraulics. This information is relevant to understanding: 1) the causes of the observed pond eutrophication; 2) why algal blooms are unlikely; and 3) future pond alternatives including dredging and the effects of dam removal.

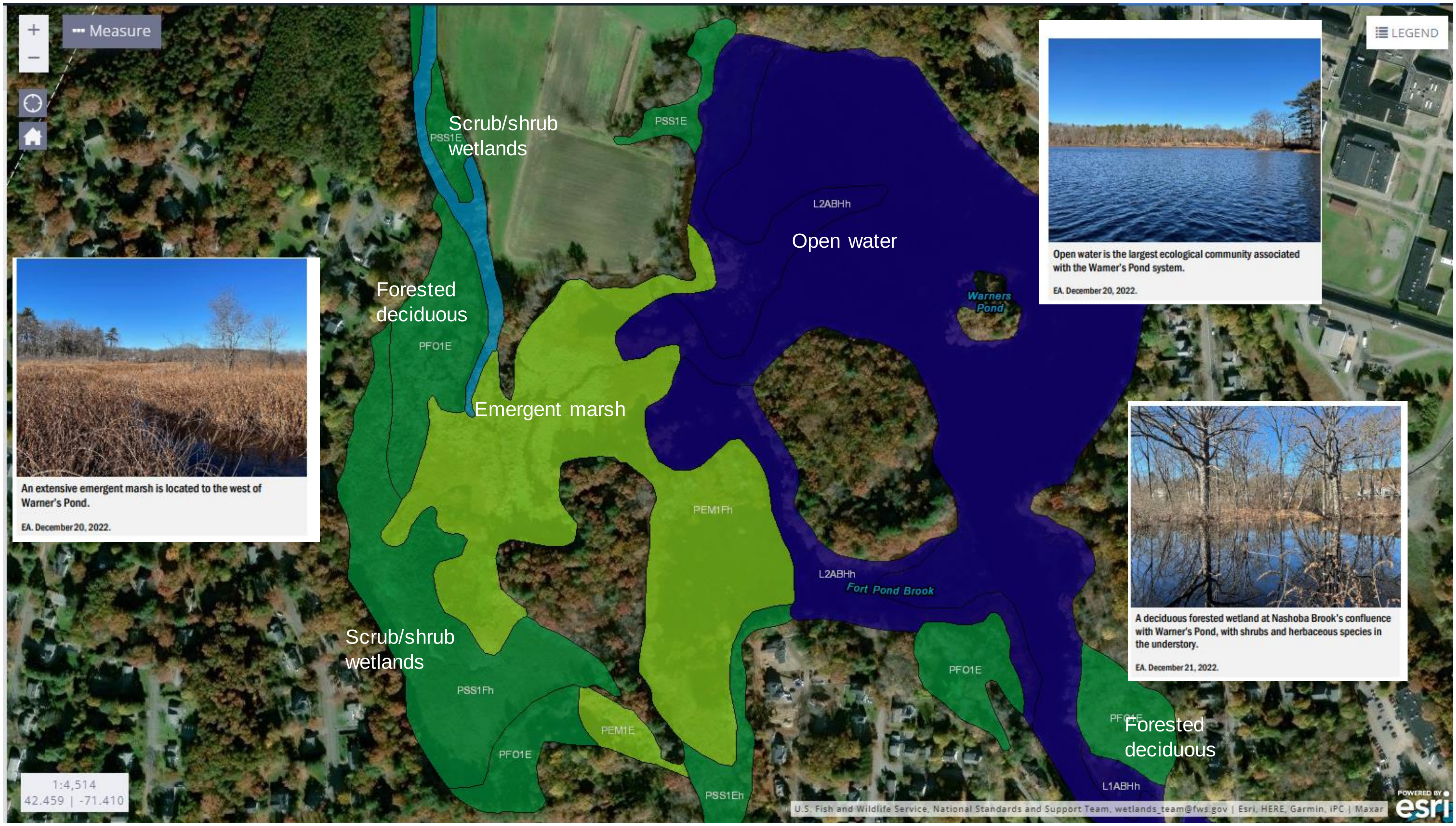
The information presented in this attachment is primarily based on the 2012 “Warner’s Pond Watershed Management Plan”, prepared by ESS. Additional data was collected from public sources including the USGS.

As presented in this attachment, the predicted flushing rate of Warner’s Pond indicates that water moves through Warner’s Pond very quickly and in many regards, it is more appropriate to view the pond functioning as a large, wide pool within a river system within a larger wetlands system rather than a “pond”.

Mapped Wetlands

The National Wetlands Inventory, developed and maintained by the U.S. Fish and Wildlife Service, presents maps and geospatial data on wetlands and deepwater habitats. The following images and data were developed using the U.S. Fish and Wildlife Service Wetlands Mapper webviewer: https://fwsprimary.wim.usgs.gov/wetlands/apps/wetlands-mapper/

The wetlands present within the 86-acre Warner's Pond Wetland System are summarized in the following slides along with definitions of the wetland classification descriptors.



Open water is the largest ecological community associated with the Warner's Pond system.

EA. December 20, 2022.

An extensive emergent marsh is located to the west of Warner's Pond.

EA. December 20, 2022.

A deciduous forested wetland at Nashoba Brook's confluence with Warner's Pond, with shrubs and herbaceous species in the understory.

EA. December 21, 2022.

U.S. Fish and Wildlife Service, National Standards and Support Team, wetlands_team@fws.gov | Esri, HERE, Garmin, iPC | Maxar

Mapped Wetlands

The wetland areas by descriptor present within the 86-acre Warner's Pond Wetland System are summarized below with their wetland areas. **Bold** indicates wetlands that are created or modified by the dam's impounded water level – about 69 acres (80%) of the approximately 86 acres total mapped wetlands.

PFO1E: 3.52 acres PFO1E: 1.71 acres PFO1E: 1.98 acres PFO1E: 1.92 acres	Freshwater Forested/Shrub Wetland habitat: **P** indicates the Palustrine System includes all nontidal wetlands dominated by trees, shrubs, persistent emergents, emergent mosses or lichens. **FO:** indicates Forested, characterized by woody vegetation that is 6m tall or taller. **E** indicates Seasonally Flooded/Saturated. Surface water is present for extended periods generally more than a month during growing season but is absent by the end of season in most years. When surface water is absent the substrate remains saturated at or near the surface. **1**: indicates Broad-Leafed Deciduous, woody trees or shrubs with wide flat leave that shed during cold or dry season
PSS1E: 0.78 acre PSS1E: 0.87 acre PSS1E: 0.71 acre PSS1E: 0.94 acre **PSS1Fh: 8.03 acres** **PSS1Eh: 1.49 acres**	Freshwater Forested/Shrub Wetland habitat. **P** indicates the Palustrine System includes all nontidal wetlands dominated by trees, shrubs, persistent emergents, emergent mosses or lichens. **SS:** indicates Scrub-Shrub, areas dominated by woody vegetation less than 6 m tall including shrubs, young trees, and tress or shrubs that are small or stunted due to environmental conditions. **1**: indicates Broad-Leafed Deciduous, woody trees or shrubs with wide flat leave that shed during cold or dry season. **F**: indicates semi-permanently flooded, surface water persists throughout the growing season in most years. When surface water is absent the water table is usually at or near the land surface. **E** indicates Seasonally Flooded/Saturated. Surface water is present for extended periods generally more than a month during growing season but is absent by the end of season in most years. When surface water is absent the substrate remains saturated at or near the surface. **h**: a special modifier indicating that these wetlands have been created or modified by a man-made barrier or dam that obstructs the inflow or outflow of water.
PEM1E: 0.84 acre **PEMF1h: 17.88 acres**	Freshwater Emergent Wetland habitat. **P** indicates the Palustrine System includes all nontidal wetlands dominated by trees, shrubs, persistent emergents, emergent mosses or lichens. **EM**: indicates emergent wetlands, characterized by erect, rooted herabaceous hydrophytes, excluding mosses and linchens. This vegetation is present for most of the growing season in most years. These wetlands are dominated by perennial plants. **Persistent (1)**: indicates dominated by species that normally remain standing at least until the beginning of the next growing season. **F**: indicates semi-permanently flooded, surface water persists throughout the growing season in most years. When surface water is absent the water table is usually at or near the land surface. **E** indicates Seasonally Flooded/Saturated. Surface water is present for extended periods generally more than a month during growing season but is absent by the end of season in most years. When surface water is absent the substrate remains saturated at or near the surface. **h**: a special modifier indicating that these wetlands have been created or modified by a man-made barrier or dam that obstructs the inflow or outflow of water.

Mapped Wetlands

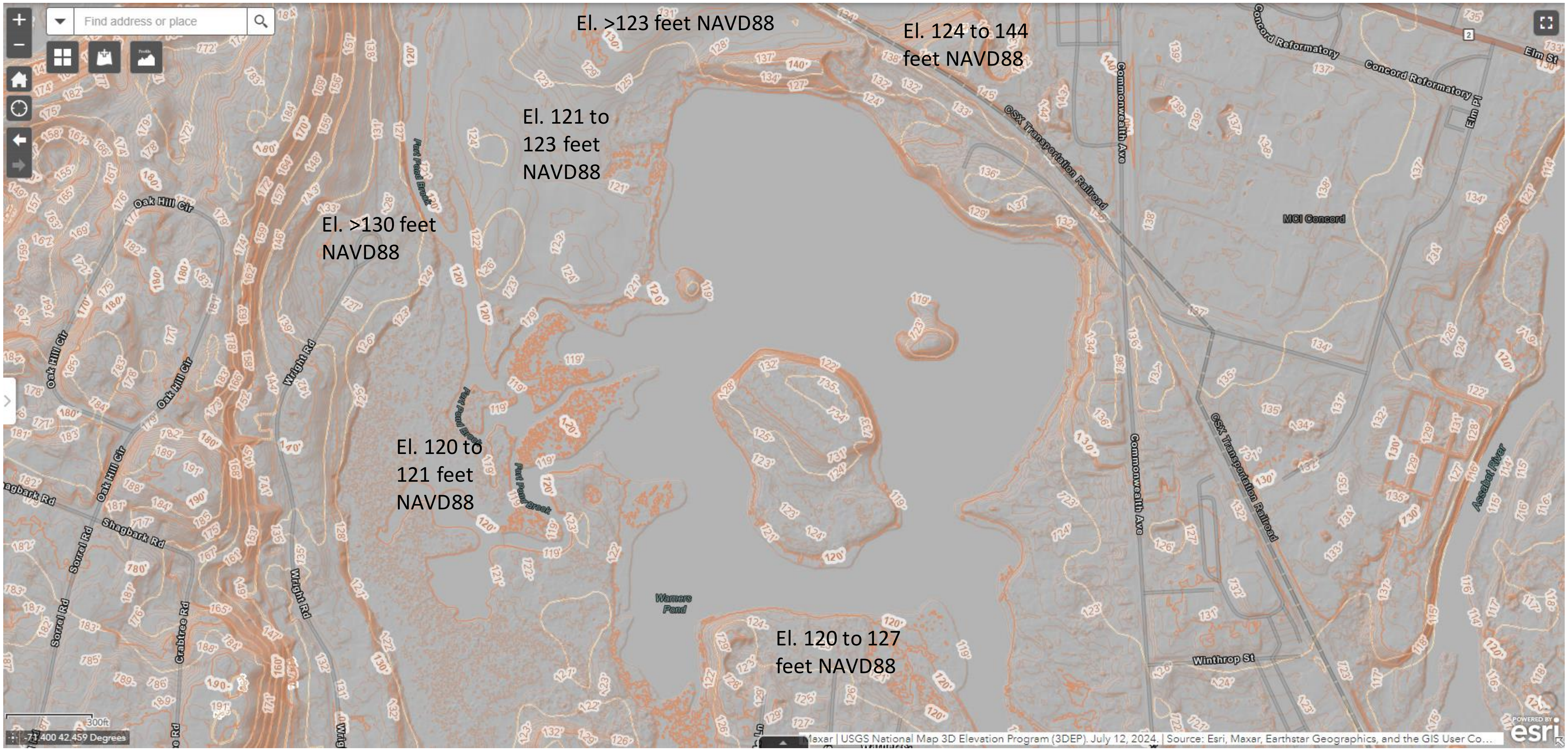
The wetland areas by descriptor present within the 86-acre Warner's Pond Wetland System are summarized below with their wetland areas. **Bold** indicates wetlands that are created or modified by the dam's impounded water level – about 69 acres (80%) of the approximately 86 acres total mapped wetlands.

L1UBHh: 31.42 acres **L2ABHh: 4.31 acres** **L2ABHh: 5.23 acres** **L1ABHh: 0.61 acre**	Lake habitat. **L**: indicates Lacustrine. **Limnetic (1)**: indicates all deepwater habitats (i.e., areas >2.5m deep below low water) in the Lacustrine System. **Littoral (2)**: This Subsystem includes all wetland habitats in the Lacustrine System. It extends from the shoreward boundary of the System to a depth of 2.5 m (8.2 ft) below low water, or to the maximum extent of nonpersistent emergents if these grow at depths greater than 2.5 m. **UB**: indicate unconsolidated bottom including all wetlands and deepwater habitats with at least 25% cover of particles smaller than stones (<6 to 7 cm) and a vegetative cover less than 30%. **AB**: Aquatic Bed indicating wetlands and deepwater habitats dominated by plants that grow principally on pr below the surface of the water for most of the growing season in most years. **H**: indicates permanently flooded including water covers the substrate throughout the year in all years. **h**: a special modifier indicating that these wetlands have been created or modified by a man-made barrier or dam that obstructs the inflow or outflow of water.
R2UBH: 3.48 acre	Riverine habitat. **R**: indicates Riverine system. **Lower Perennial (2)**: This Subsystem is characterized by a low gradient. Some water flows all year, except during years of extreme drought. The substrate consists mainly of sand and mud. Oxygen deficits may sometimes occur. The fauna is composed mostly of species that reach their maximum abundance in still water, and true planktonic organisms are common. The gradient is lower than that of the Upper Perennial Subsystem and the floodplain is well developed. **UB**: indicate unconsolidated bottom including all wetlands and deepwater habitats with at least 25% cover of particles smaller than stones (<6 to 7 cm) and a vegetative cover less than 30%. **H**: indicates permanently flooded including water covers the substrate throughout the year in all years.

Topography and Geology

The topography within and adjacent to the 86-acre wetlands complex consists of topographic highs to the west and northeast of the wetland system bordering a lower elevation area that ranges from about 121 feet to 120 feet NAVD88 (outside of the surface water areas).

Hydrologically, surface water enters the low-lying areas in the vicinity of Warner's Pond (now an emergent wetland) via Fort Pond Brook. Based on streamflow data discharging downgradient of Warner's Pond, the flow entering the low-lying areas in the vicinity of Warner's Pond ranges from greater than 500 cfs to 2 cfs, with a 50% exceedance flow (median) of about 60 cf/s).



Maxar | USGS National Map 3D Elevation Program (3DEP). July 12, 2024. | Source: Esri, Maxar, Earthstar Geographics, and the GIS User Co…

Warners Pond Topography and Bathymetry

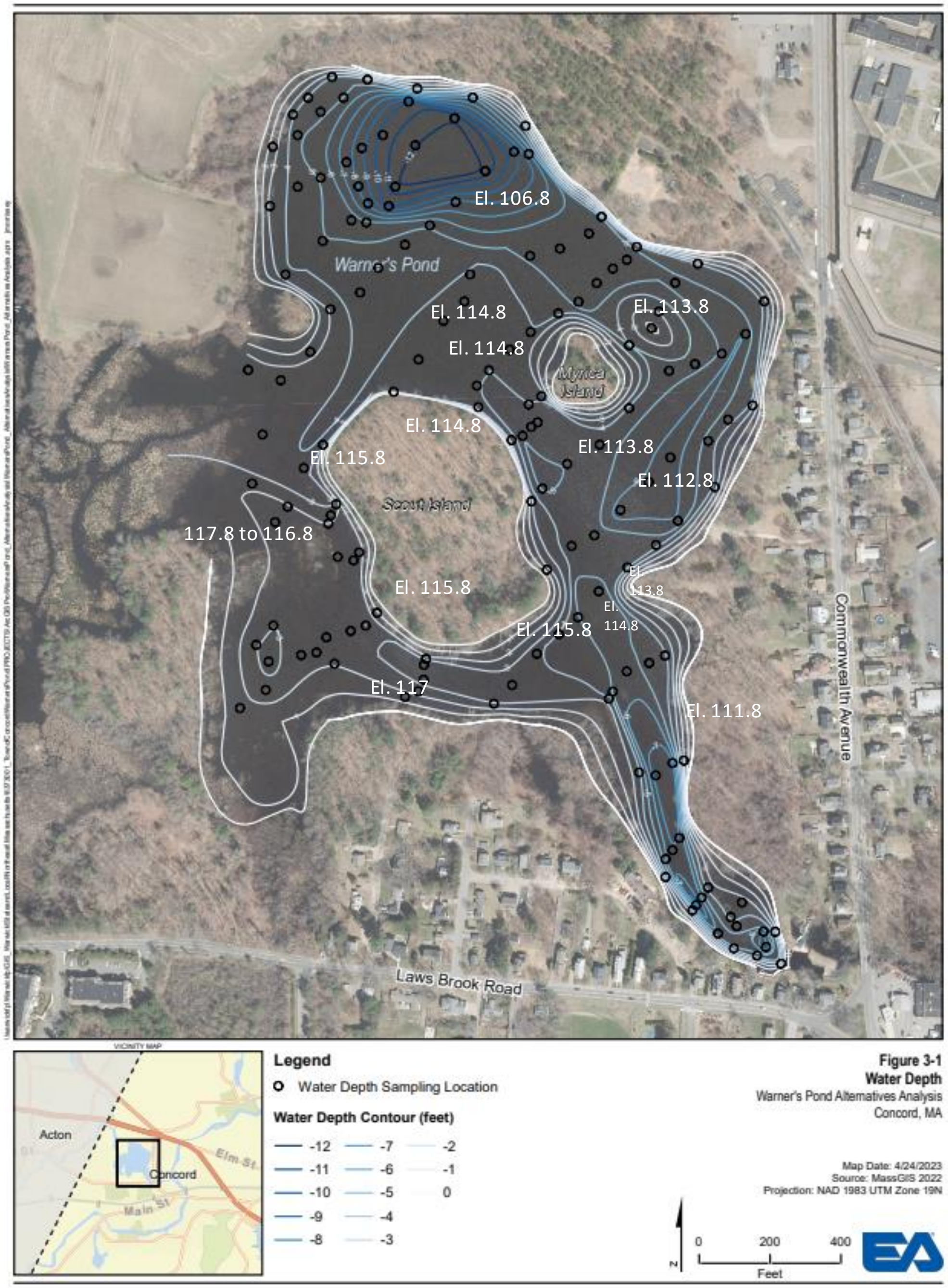
Using depth measurements provided by Town consultants and assuming a Normal Pool Elevation of 118.8 feet NAVD88, the image to the right presents estimated Pond bottom elevations relative to NAVD88.

Pond bathymetric features include:

- Bottom elevation around 117 to 118 feet NAVD88 along western shore where the tributary flow enters the Pond. Adjacent wetland bank elevations range from about 118 to 119 feet NAVD88
- A deeper hole, possibly representing a pre-dam pond with a bottom elevation of about 106 to 107 feet NAVD88
- Topographic highs up to Elevation 130 to 134 feet NAVD88, representing islands above the impounded water level.
- Higher Pond bottom elevations south of the main island (Scout Island).
- Lower Pond elevations at about 111 to 112 feet NAVD88 at the northeast side of the Pond.
- Lower channel elevations at about 111 to 112 feet NAVD88 at the southeast end of the Pond (discharging to the dam), rising to 113 feet to 114 feet between the dam and the bridge.

These estimated elevations are important in understanding plant vegetation and wetland issues as well as dredging.

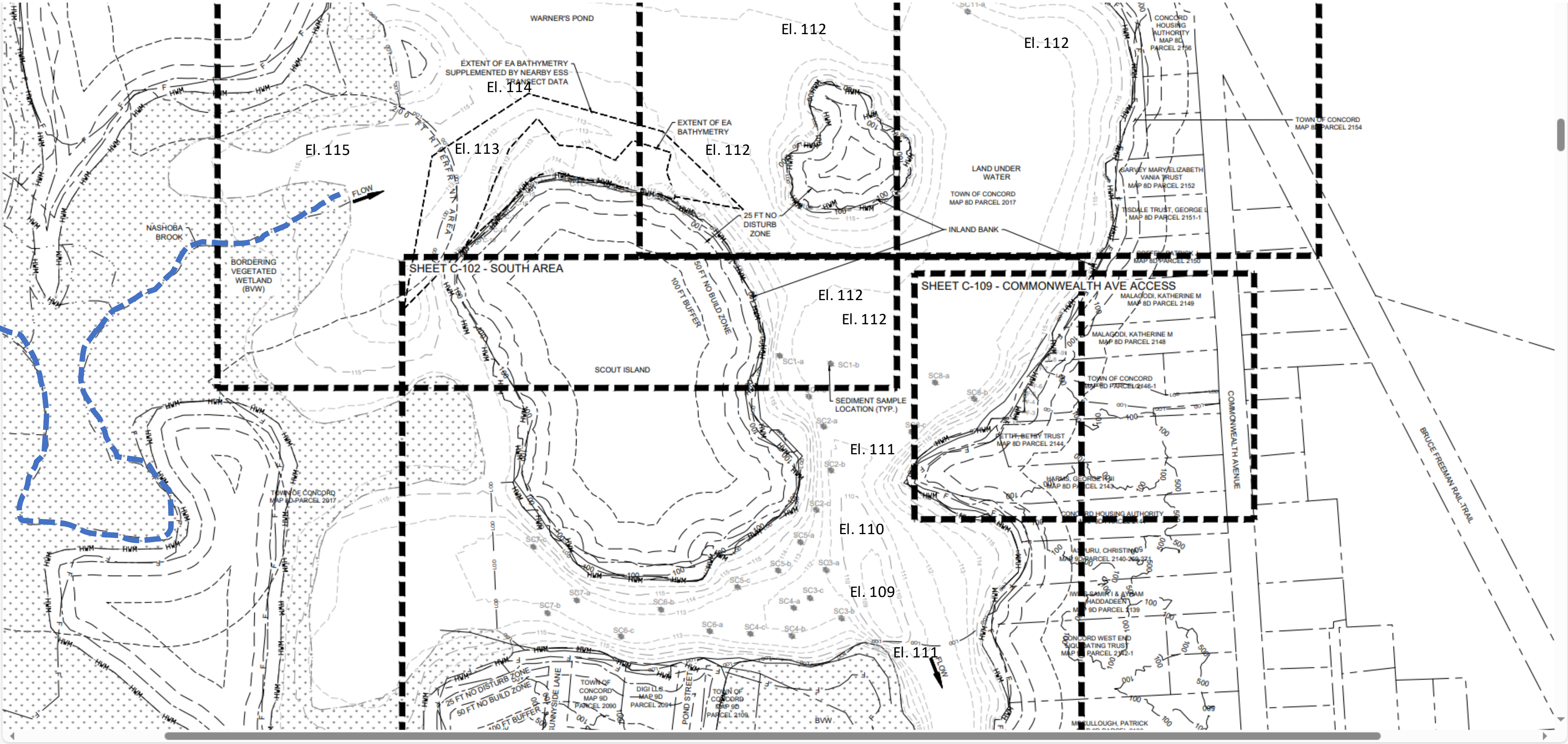
Note: detailed bottom elevations are presented on the Dredging Construction Plans.



Topography and Geology

The bottom elevations within the surface water area was developed based on bathymetric surveys (note that detailed bathymetric data is presented on the dredge bid construction plans.)

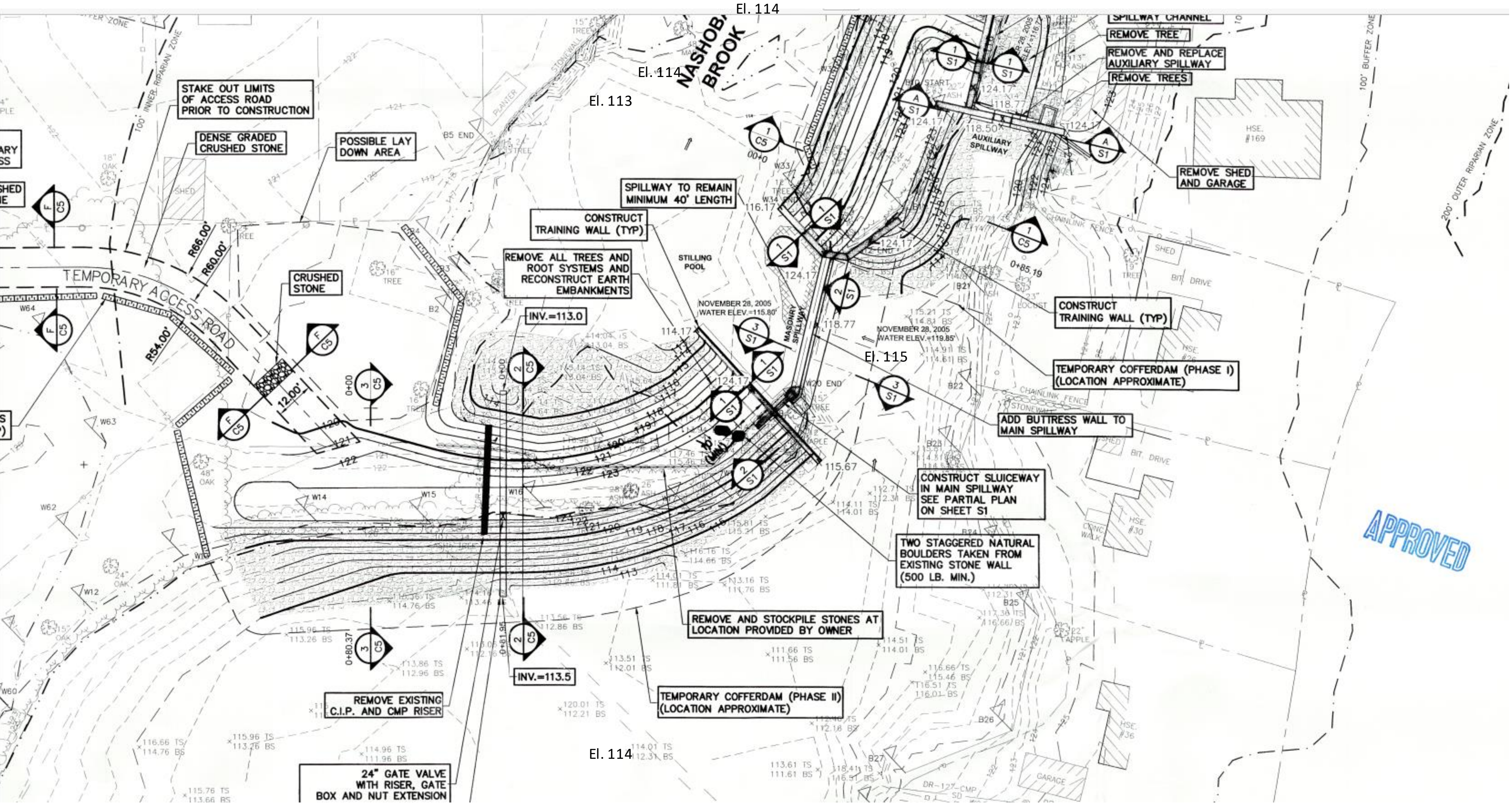
Detailed bottom elevations along the flow line are shown below.



Topography and Geology

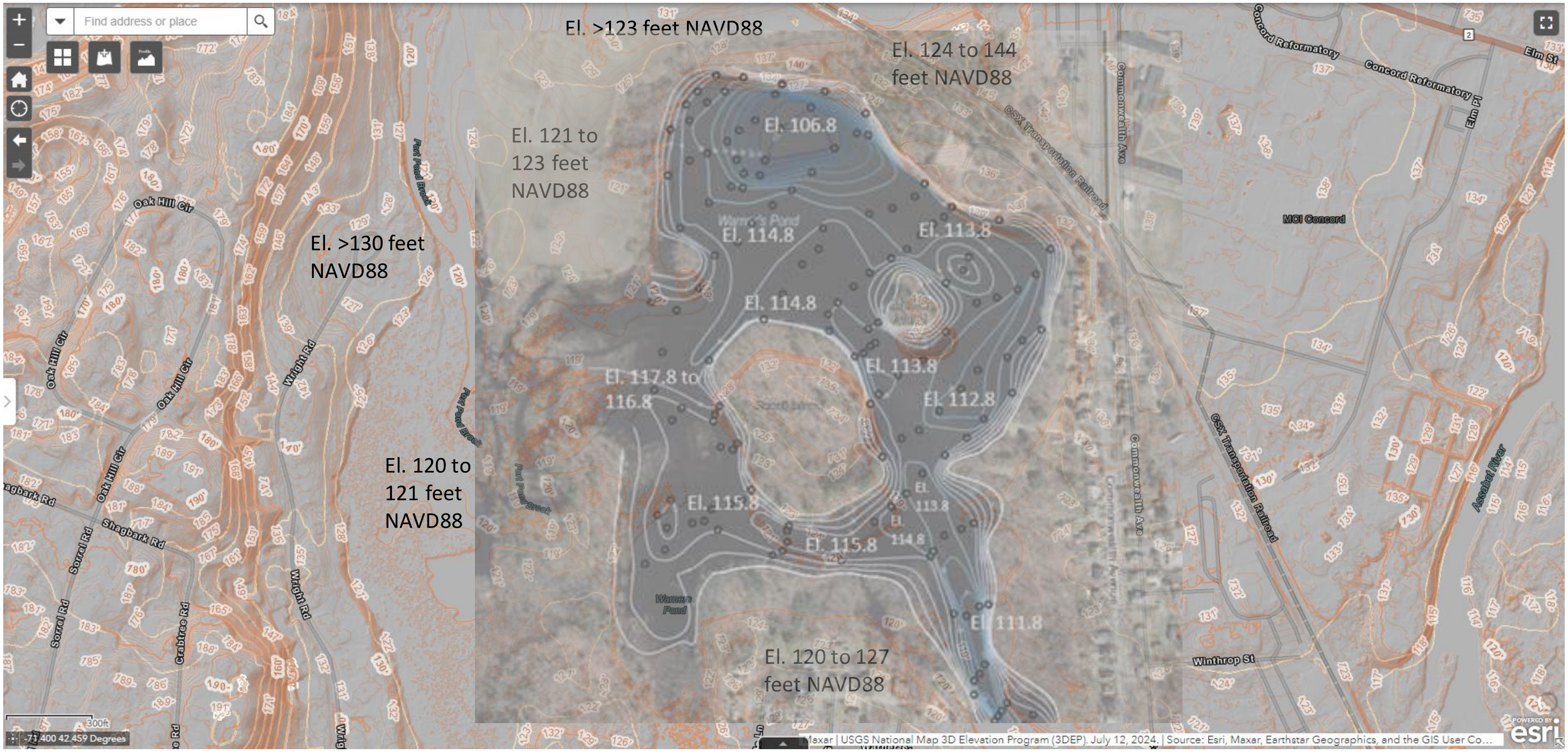
The bottom elevations within the surface water area was developed based on bathymetric surveys (note that detailed bathymetric data is presented on the dredge bid construction plans.)

Detailed bottom elevations along the flow line are shown below at the connection to Nashoba Brook. Slides 9 and 10 indicate that at the upstream end of the Pond, Nashoba Brook enters the emergent wetlands at a topographic grade of about 119 feet, enters the Pond at about 115 feet, flows along grades of 114 feet to 112 feet to 109 feet and then grades rise to 114 feet to 115 feet at the dam then to about 113 feet at the stilling pond and then up to 114 feet at the downstream connection to Nashoba Brook.



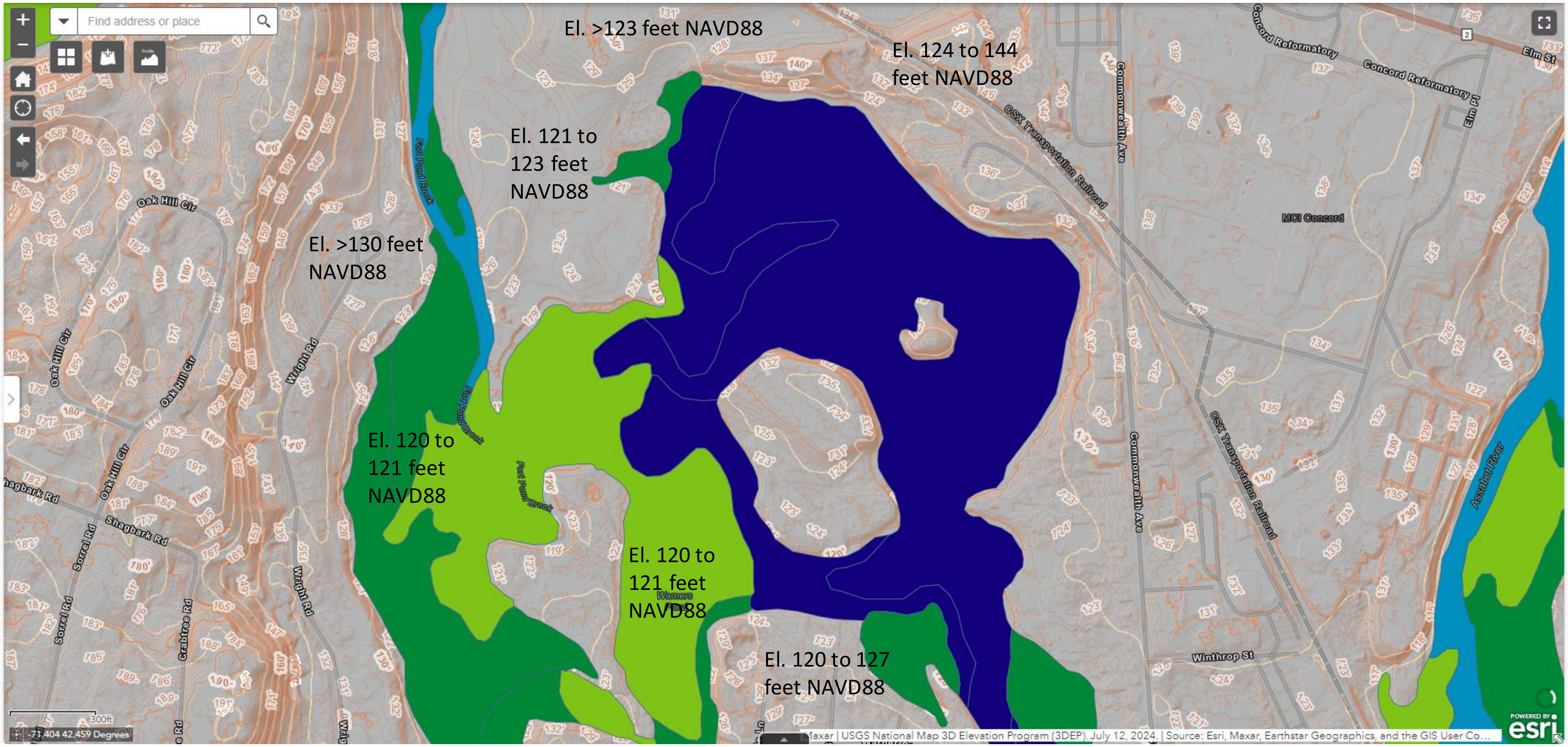
Topography and Geology

The bottom elevations within the surface water area was developed based on bathymetric surveys (note that detailed bathymetric data is presented on the dredge bid construction plans.) The following pond elevations combined with area topography in feet, NAVD88.



Topography and Geology

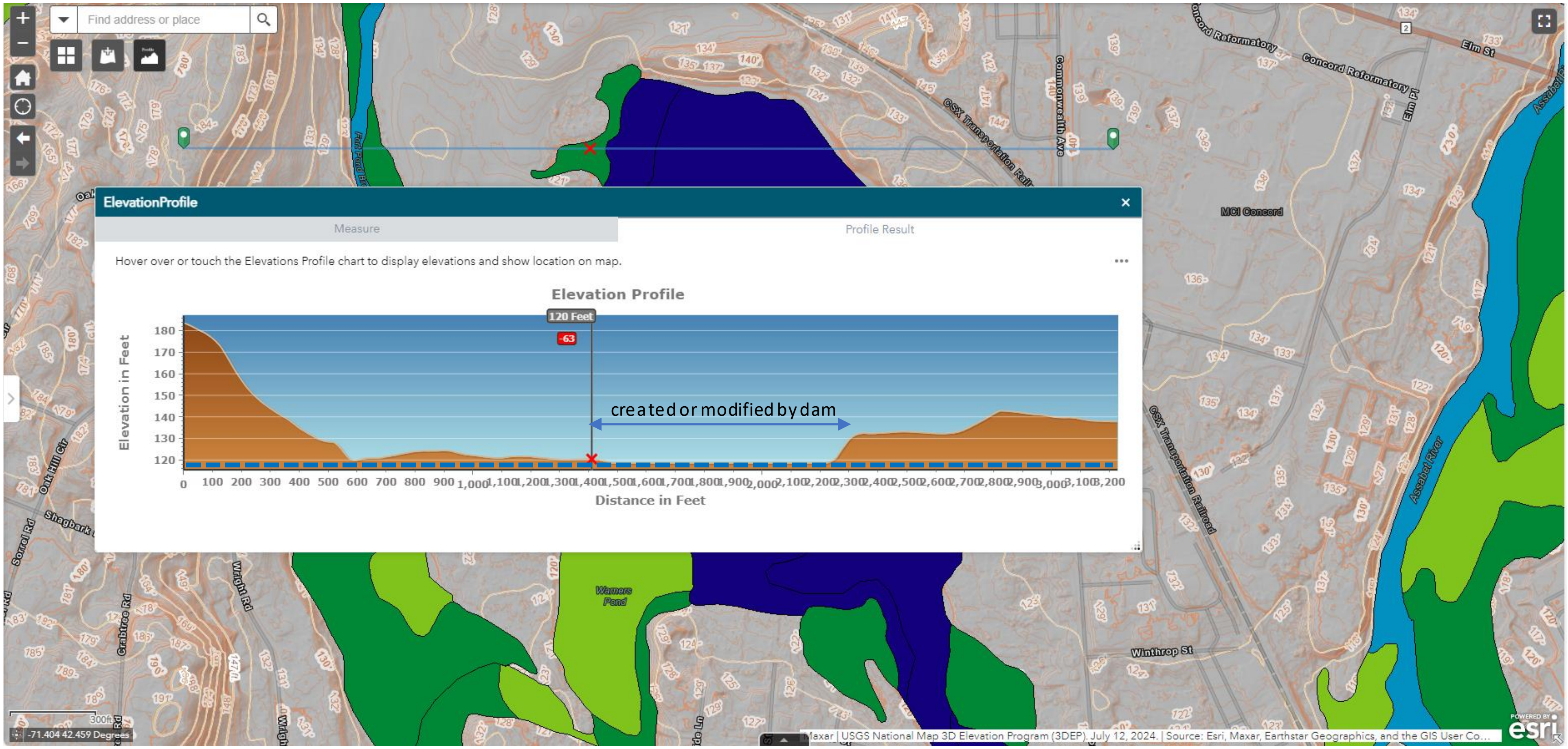
The mapped wetlands limits are overlain with the area topography. The limits of the surface water reflect topographic elevations below the Normal Pool Elevation of 118.8 feet NAVD88. The wetlands adjacent to the Fort Pond Brook south of Rt 2 are either fringe floodplain wetlands adjacent to the stream channel or larger, hydraulically connected low-lying areas. Most of the wetlands are in low-lying areas with grades of 120 feet to 121 feet NAVD88.



Maxar | USGS National Map 3D Elevation Program (3DEP), July 12, 2024. | Source: Esri, Maxar, Earthstar Geographics, and the GIS User Co...

Topography and Geology

The topography, relative to the wetlands are also indicated using profiles (USGS3DEP tool). The Normal Pool Elevation 118.8 feet NAVD88 is shown for reference. The limits of wetlands that are indicated to have been created or modified by the dam and impounded water level are also shown..



Hover over or touch the Elevations Profile chart to display elevations and show location on map.

Maxar | USGS National Map 3D Elevation Program (3DEP). July 12, 2024. | Source: Esri, Maxar, Earthstar Geographics, and the GIS User Co...

Topography and Geology

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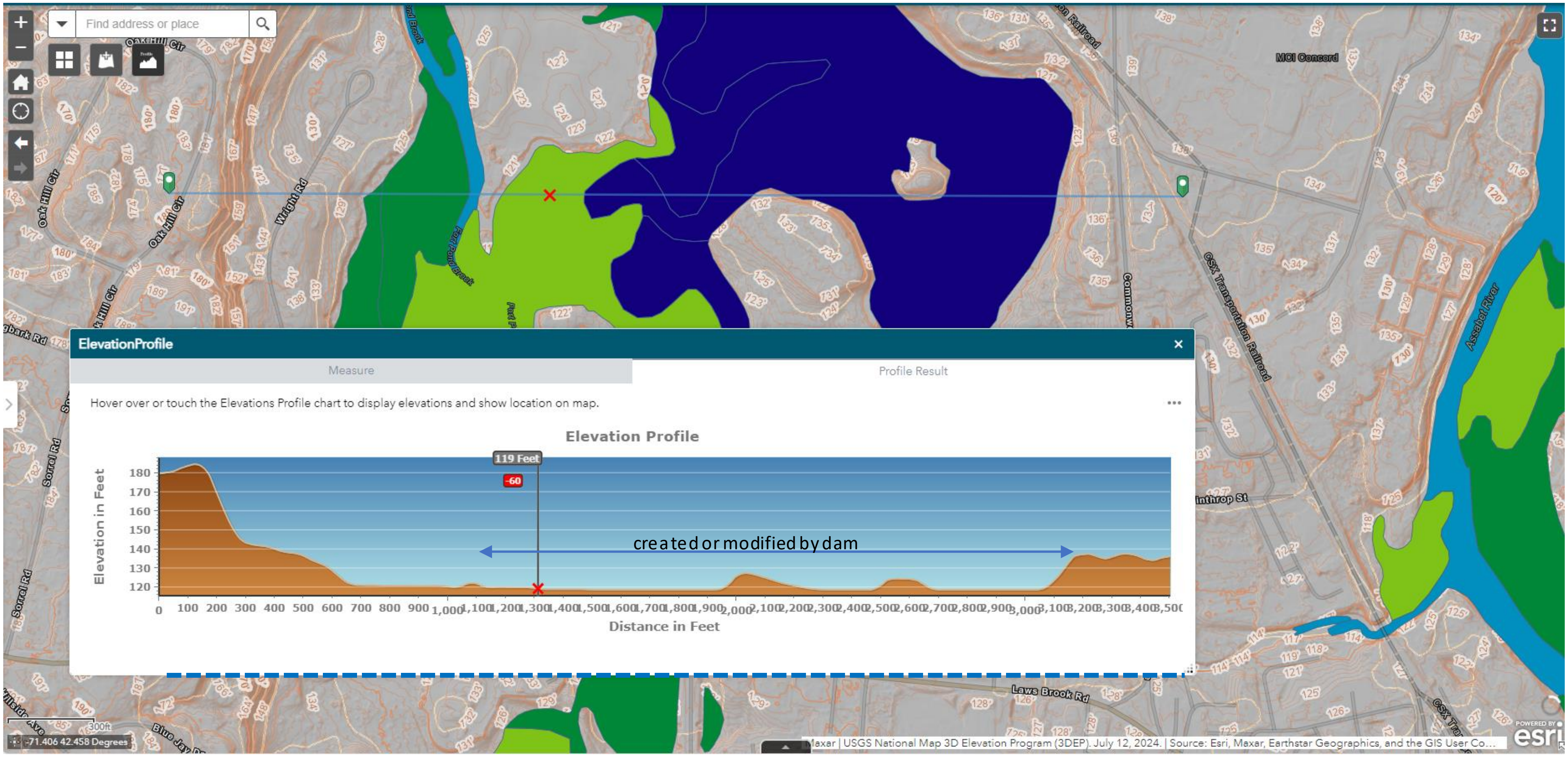

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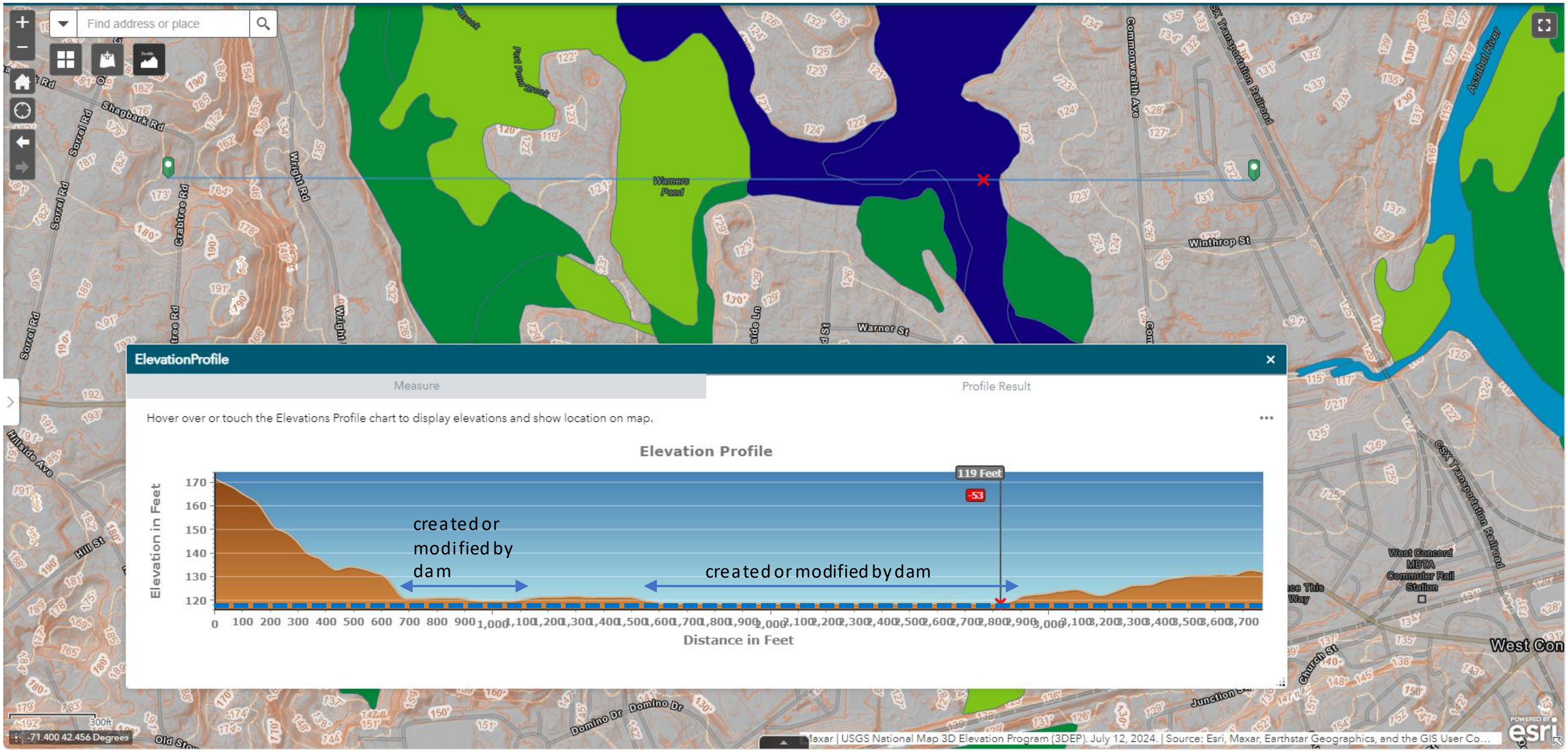


ElevationProfile

Hover over or touch the Elevations Profile chart to display elevations and show location on map.

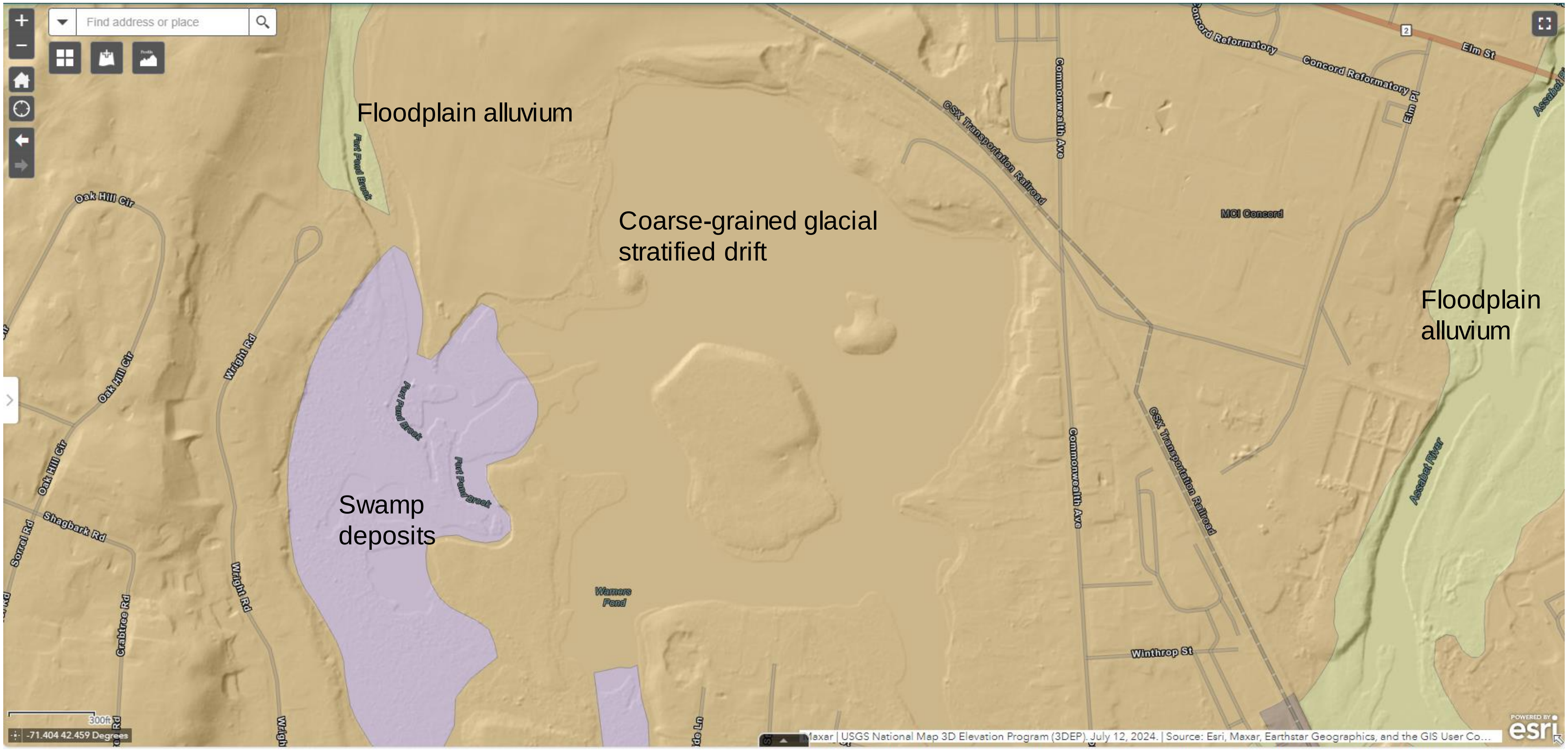
created or modified by dam

created or modified by dam

Maxar | USGS National Map 3D Elevation Program (3DEP). July 12, 2024. | Source: Esri, Maxar, Earthstar Geographics, and the GIS User Co...

Topography and Geology

The surficial geology is mapped based on MassGIS geologic data. The majority of the area consists of permeable, coarse-grained (sand) glacial stratified drift. The Fort Pond Brook stream floodplain consists of alluvium deposits. The low-lying area to the west of the pond consists of fine-grained “swamp” deposits, likely representing deposition of sediment over the last 100 to 200 years.



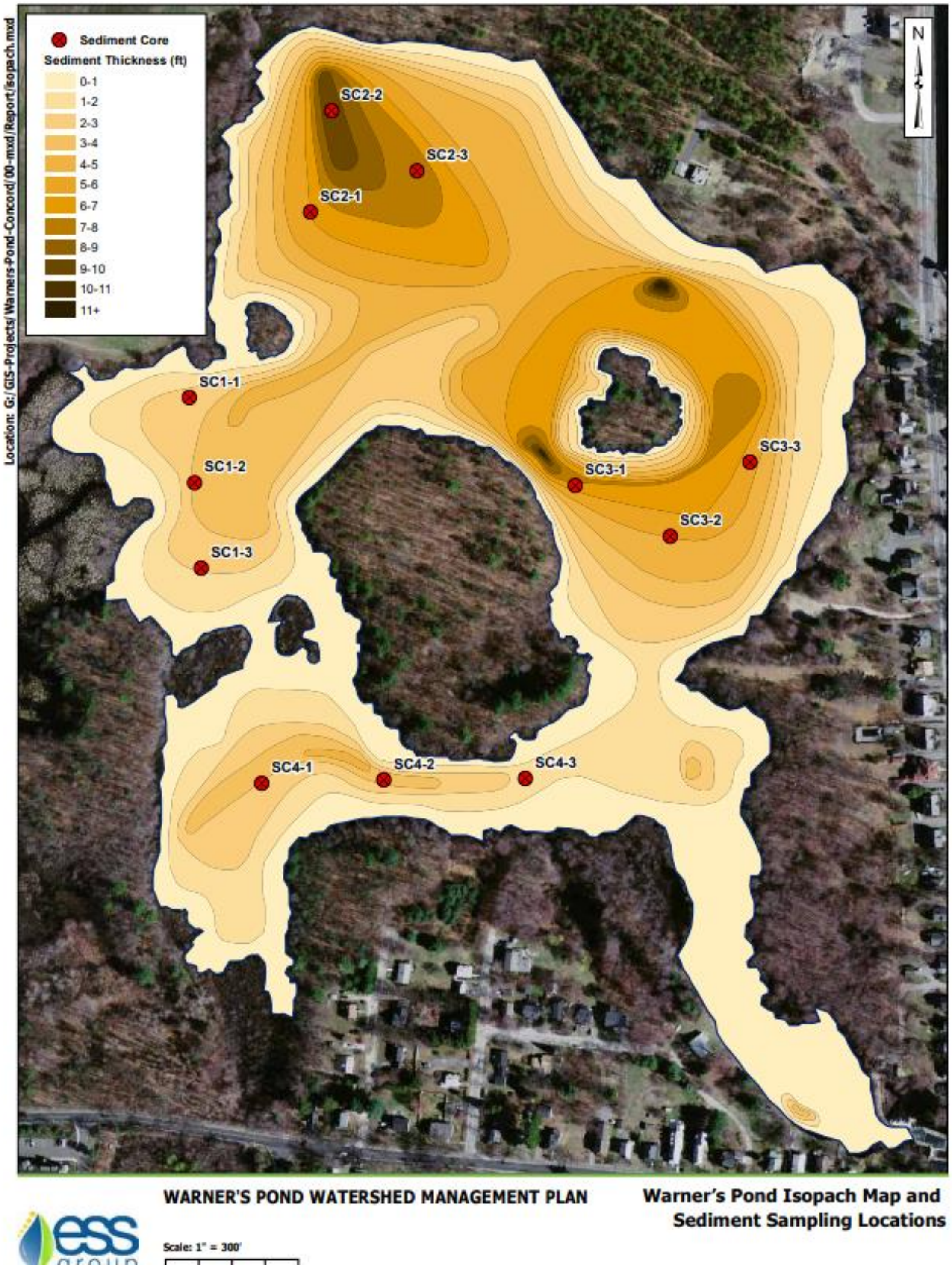
Warner’s Pond Sediment

Sediment cores were also obtained by the Town consultants and Isopach Maps were developed. As described in reports by the Town’s consultants, the isopach map represents the thickness of sediment above either bedrock or the natural glacio-alluvial sand.

The sediment thicknesses range for 0 to about 11 feet and are typically on the order of 2 to 4 feet. The average sediment thickness was 2.8 feet

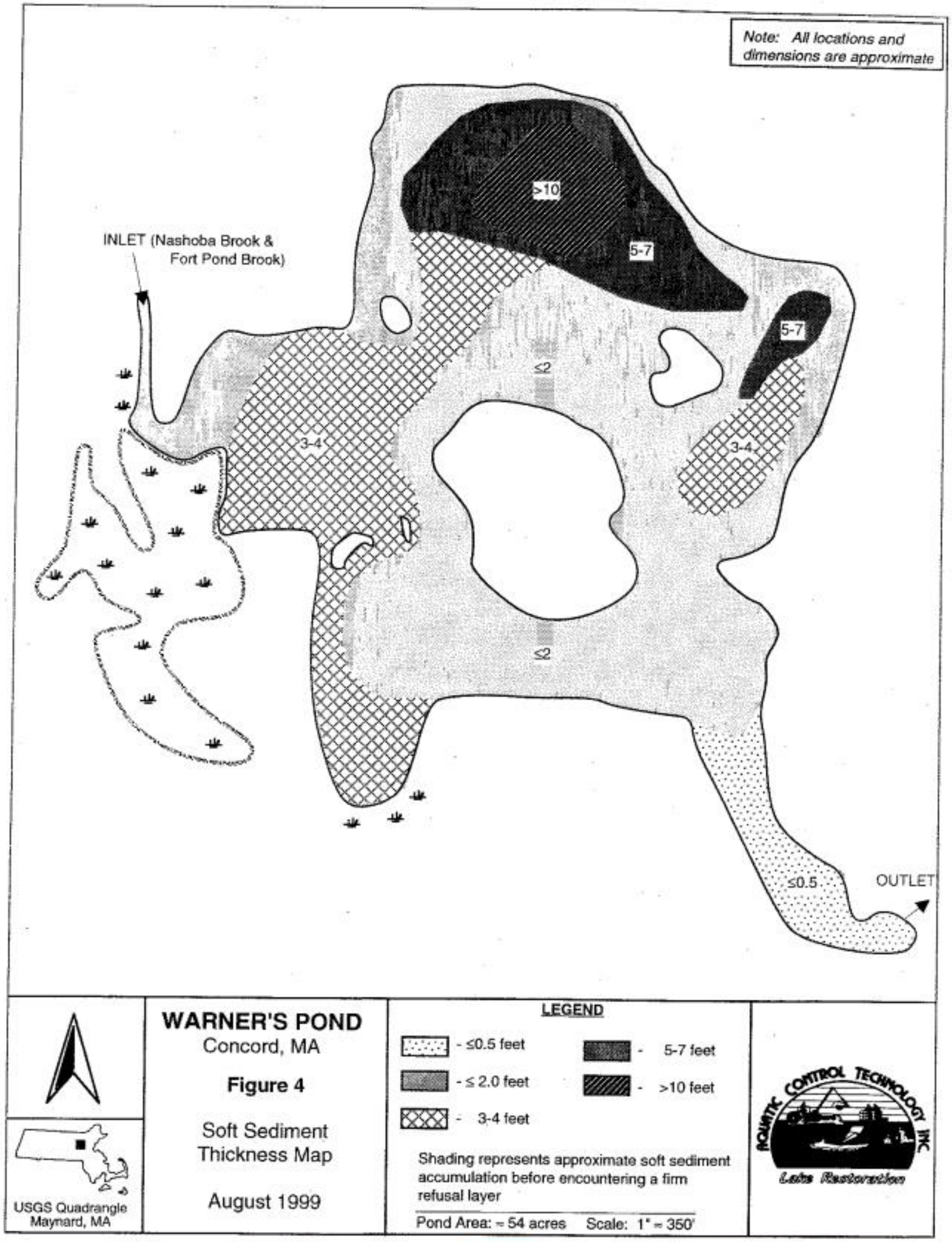
As expected, the thickest deposits are in the deeper hole at the north end of the Pond.

Sedimentation has likely been going on for a long time, in particular along the original (pre-dam) stream channel and over several hundred years representing a range of dam impoundments up to the current configuration. Development, primarily along Nashoba Brook between the Pond and the Ice House Pond dam in Action, destabilized stream banks and poor compliance with MA stormwater regulations has likely significantly increased sedimentation rates in recent time.



Warner’s Pond Sediment

Sediment cores were also obtained by the Town consultants and Isopach Maps were developed in 1999 as well,

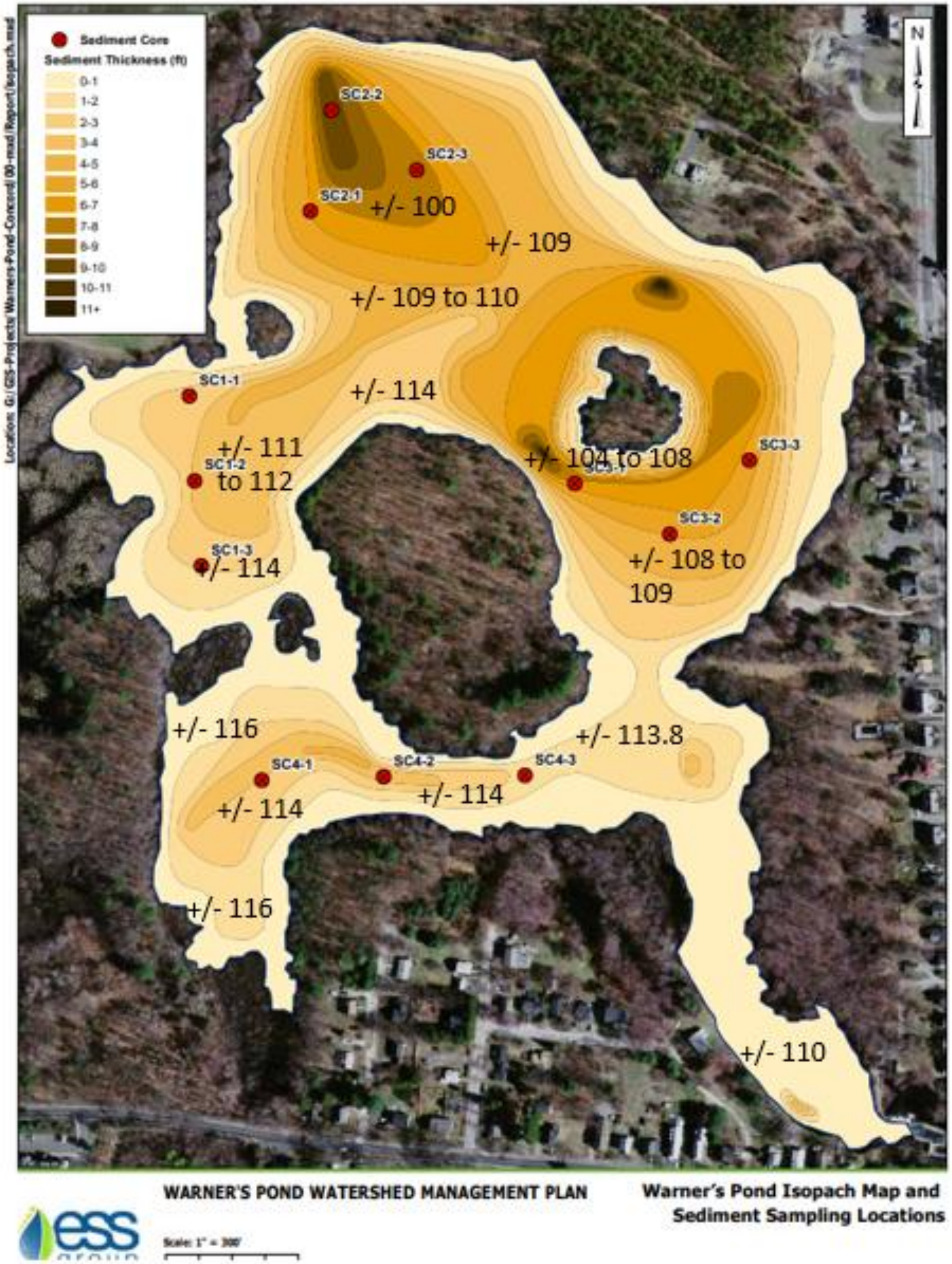


Warner’s Pond Sub-Sediment Elevation

Using the approximately estimated pond bottom elevations and sediment core data (isopach map) developed by Town consultants, the elevation of the pre-sedimentation bottom was estimated.

Although unconfirmed, it appears that the thickest sediment deposits may occur in areas where the elevation of the underlying bedrock or sand deposits was the lowest and were likely areas where flow velocities were lower than the primary pond flow resulting in settlement of suspended solids.

Pre-sedimentation elevations are shown in feet NAVD88.



Warner’s Pond Sediment

In 2011, a total of four sediment samples (SC1, SC2, SC3, SC4) was composited from three individual sediment cores (SC1-1, SC1-2, SC1-3, etc.) and submitted to the laboratory for gradation (grain size distribution) analysis. The majority of the sediment cores collected consisted of a dark brown, organic muck mixed with silt. A few of the sediment cores were dark, brown, organic mucks mixed with greater percentages of sand and clay. Gradation data is presented below.

Table 6. Results of Sieve Analysis for Sediment Sample, Warner's Pond

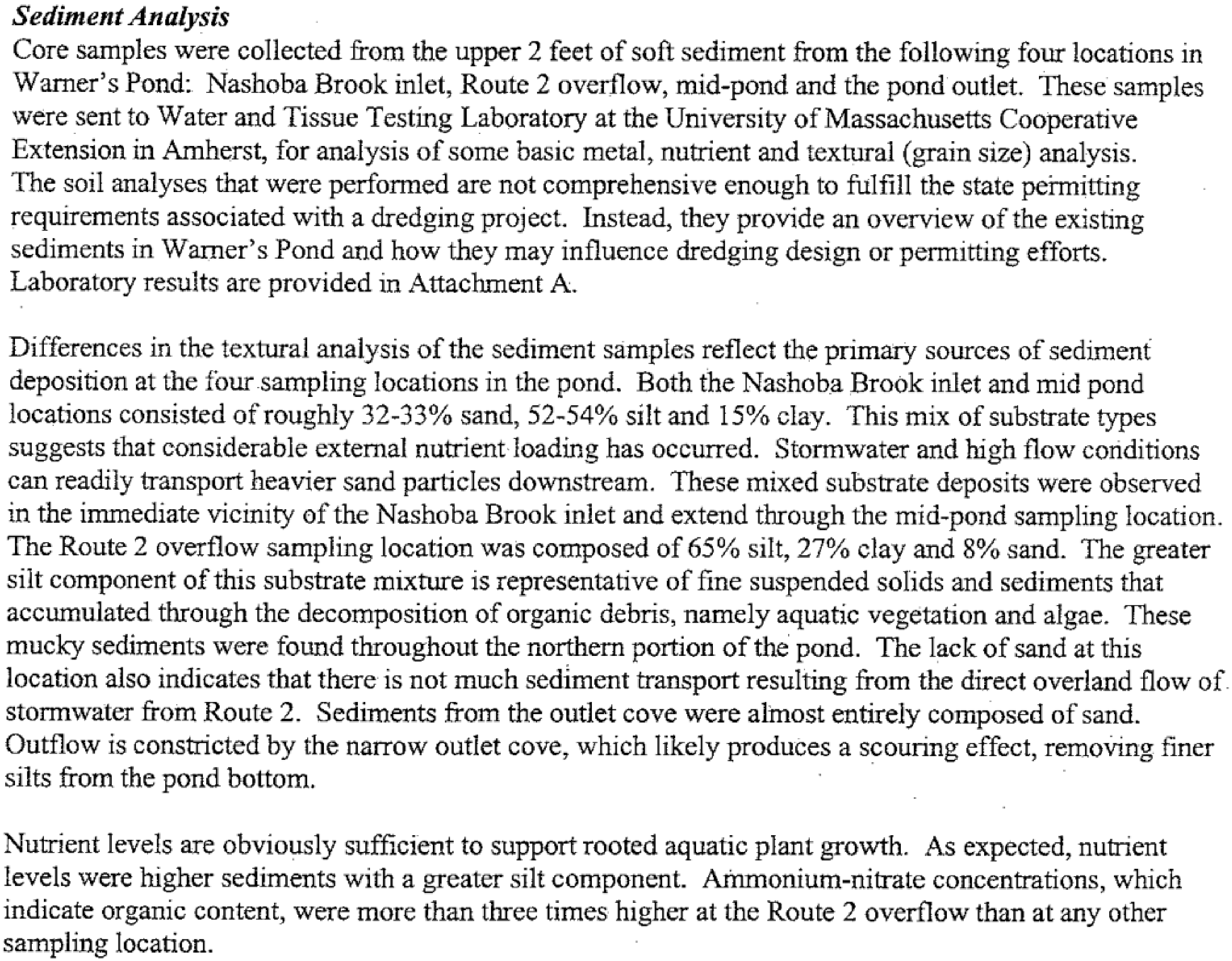
Sample ID	Sieve Analysis ASTM C 136, ASTM C 117							
	Percent Passing #4 (% by Wt.)	Percent Passing #10 (% by Wt.)	Percent Passing #20 (% by Wt.)	Percent Passing #40 (% by Wt.)	Percent Passing #60 (% by Wt.)	Percent Passing #80 (% by Wt.)	Percent Passing #100 (% by Wt.)	Percent Passing #200 (% by Wt.)
SC-1	99.7	92.0	77.2	65.8	59.1	53.3	49.4	15.9
SC-2	99.1	86.1	62.4	46.4	37.0	31.9	29.8	17.1
SC-3	99.8	91.2	66.8	47.1	36.6	31.0	28.2	14.2
SC-4	99.7	82.6	55.9	42.3	34.1	29.0	26.1	11.1

Table 5. Unified Soil Classification System for Warner's Pond Sediments

Sample ID	Fines (Clay or Silt)	Fine Sand	Medium Sand	Coarse Sand	Fine Gravel
SC-1	15.9	49.9	26.2	7.7	0.3
SC-2	17.1	29.3	39.7	13.0	0.9
SC-3	14.2	32.9	44.1	8.6	0.2
SC-4	11.1	31.2	40.3	17.1	0.3

Warner’s Pond Sediment Chemical Characteristics

In 1999, a total of four sediment samples were collected and tested:



Sediment Analysis

Core samples were collected from the upper 2 feet of soft sediment from the following four locations in Warner’s Pond: Nashoba Brook inlet, Route 2 overflow, mid-pond and the pond outlet. These samples were sent to Water and Tissue Testing Laboratory at the University of Massachusetts Cooperative Extension in Amherst, for analysis of some basic metal, nutrient and textural (grain size) analysis. The soil analyses that were performed are not comprehensive enough to fulfill the state permitting requirements associated with a dredging project. Instead, they provide an overview of the existing sediments in Warner’s Pond and how they may influence dredging design or permitting efforts. Laboratory results are provided in Attachment A.

Differences in the textural analysis of the sediment samples reflect the primary sources of sediment deposition at the four sampling locations in the pond. Both the Nashoba Brook inlet and mid pond locations consisted of roughly 32-33% sand, 52-54% silt and 15% clay. This mix of substrate types suggests that considerable external nutrient loading has occurred. Stormwater and high flow conditions can readily transport heavier sand particles downstream. These mixed substrate deposits were observed in the immediate vicinity of the Nashoba Brook inlet and extend through the mid-pond sampling location. The Route 2 overflow sampling location was composed of 65% silt, 27% clay and 8% sand. The greater silt component of this substrate mixture is representative of fine suspended solids and sediments that accumulated through the decomposition of organic debris, namely aquatic vegetation and algae. These mucky sediments were found throughout the northern portion of the pond. The lack of sand at this location also indicates that there is not much sediment transport resulting from the direct overland flow of stormwater from Route 2. Sediments from the outlet cove were almost entirely composed of sand. Outflow is constricted by the narrow outlet cove, which likely produces a scouring effect, removing finer silts from the pond bottom.

Nutrient levels are obviously sufficient to support rooted aquatic plant growth. As expected, nutrient levels were higher sediments with a greater silt component. Ammonium-nitrate concentrations, which indicate organic content, were more than three times higher at the Route 2 overflow than at any other sampling location.

Warner's Pond Sediment Chemical Characteristics

In 2011, a total of four sediment samples (SC1, SC2, SC3, SC4) was composited from three individual sediment cores (SC1-1, SC1-2, SC1-3, etc.) and submitted to the laboratory for chemical analysis. Volatile organic compounds (VOCs) were sampled from individual cores prior to compositing, in order to avoid sample loss through volatilization. Bulk physical and chemical analysis was conducted on the four composite samples. Sediment samples were analyzed for the following parameters: arsenic, cadmium, chromium, copper, lead, mercury, nickel, zinc, polychlorinated biphenyls (PCBs), volatile organic compounds (VOCs), polynuclear aromatic hydrocarbons (PAHs), extractable petroleum hydrocarbons (EPH), percent ash and ASTM grain size analysis per American Society for Testing and Materials (ASTM) standards. Based on the results of the initial round of sampling, an additional composite sample was collected from the pond at SC-2 on September 2, 2011 to re-test the total chromium and hexavalent chromium levels.

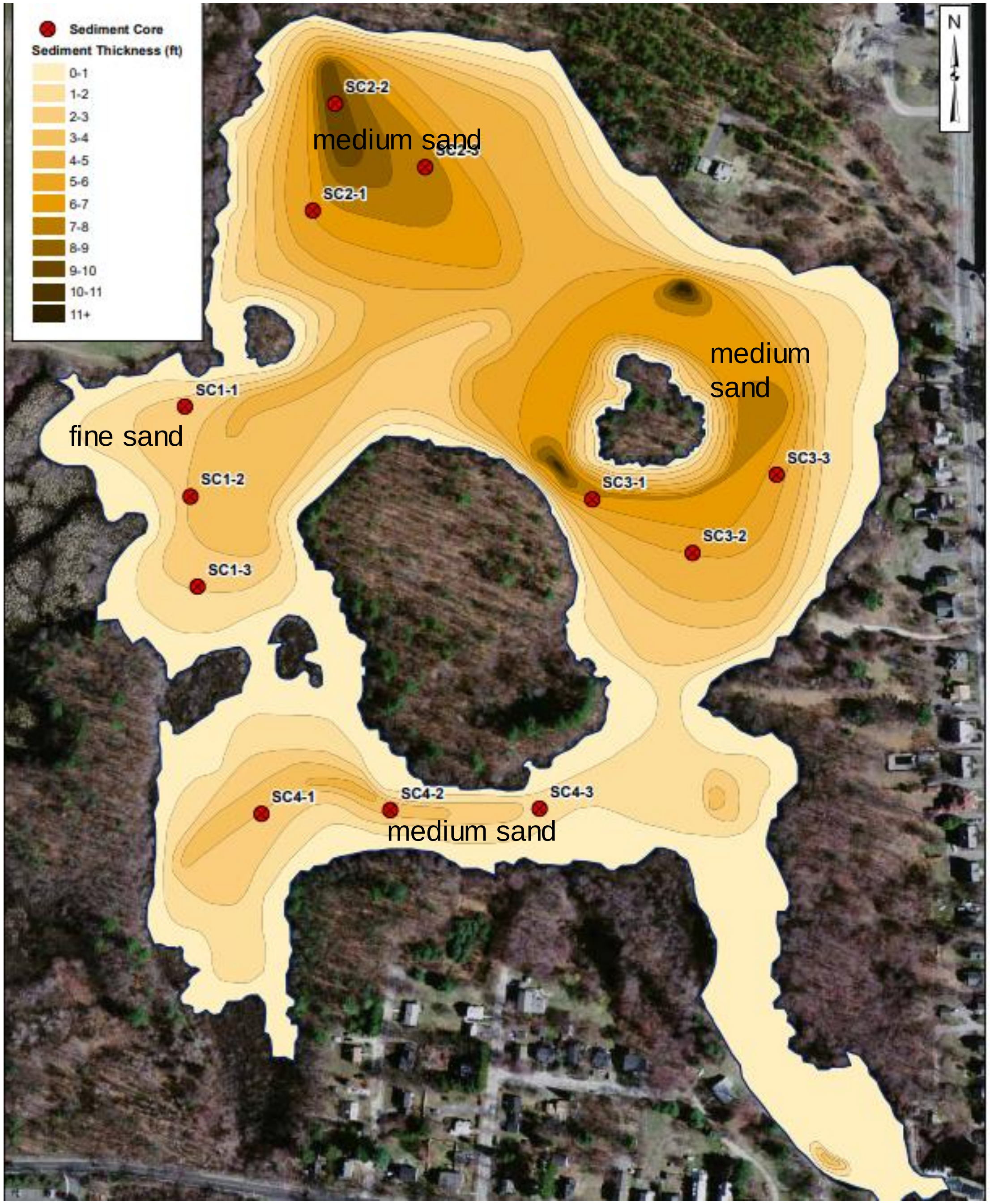
Results: Sediments collected from the northern basin (composite sample SC-2) on February 17, 2011 exceeded the MCP Method 1 Soil Standards for chromium. Chromium occurs in two valence states, trivalent and hexavalent. Trivalent chromium is an essential element and is considered much less toxic than hexavalent chromium, both for acute and chronic exposure. Sediments from this area were re-sampled on September 2, 2011 and analyzed for hexavalent chromium to determine whether the observed exceedance was due to this valence state or the less toxic trivalent state. The results of the re-sampling effort indicate that the hexavalent chromium was not detected and that dredging is a feasible option (Attachment F 2012 ESS Report).

Warner’s Pond Sediment Distribution

The north (SC-2), east (SC-3), and southern (SC-4) basins of Warner’s Pond have “medium sand” as the dominant grain size in the sediments. The western basin (SC-1) near the pond inlet was primarily “fine sand” according to the Unified Soil Classification System.

Each of the samples, as composited, are “well-graded” indicating a wide distribution of gradation from fines (silt and clay) to fine to coarse sand to fine gravel. However, as shown of the following slides showing representative sediment cores, there is sediment stratification with gradation and color differentiation indicating seasonal changes, different flow velocities, climatological change and changes to the pond configuration. Coarser grained suspended sediment will have higher sedimentation rates than fines.

Overall, the percentage of fines in the sediment indicate that the sediment is relatively low permeability.

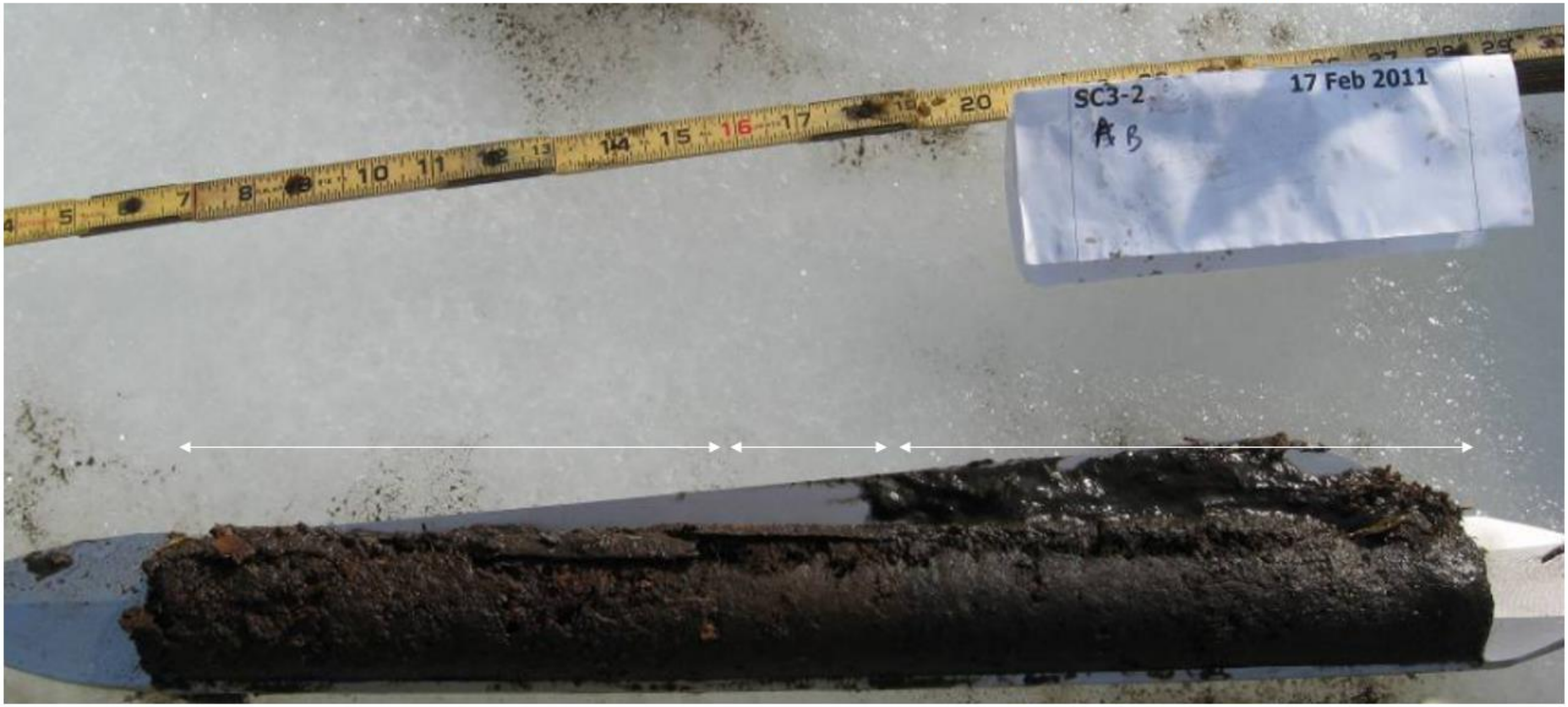


Warner’s Pond Sediment

Sample ID	Fines (Clay or Silt)	Fine Sand	Medium Sand	Coarse Sand	Fine Gravel
SC-1	15.9	49.9	26.2	7.7	0.3

Warner's Pond Sediment

Sample ID	Fines (Clay or Silt)	Fine Sand	Medium Sand	Coarse Sand	Fine Gravel
SC-3	14.2	32.9	44.1	8.6	0.2



Warner’s Pond Sediment

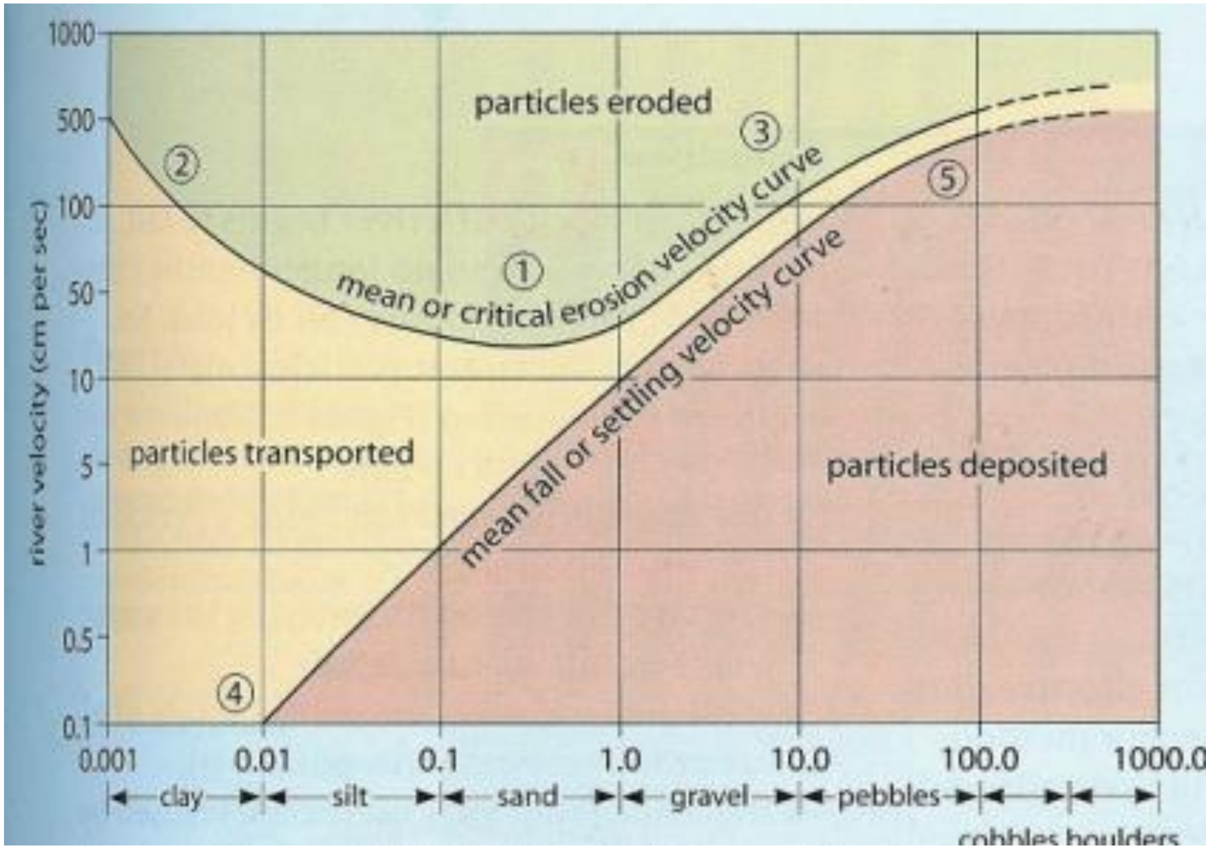
Sample ID	Fines (Clay or Silt)	Fine Sand	Medium Sand	Coarse Sand	Fine Gravel
SC-3	14.2	32.9	44.1	8.6	0.2

Warner's Pond Hydraulics and Sedimentation

There is a relationship between: 1) suspended sediment in water entering the Pond; 2) flow velocities within the Pond; and 3) sediment grain size distribution. The plot to the right indicates this relationship in general terms.

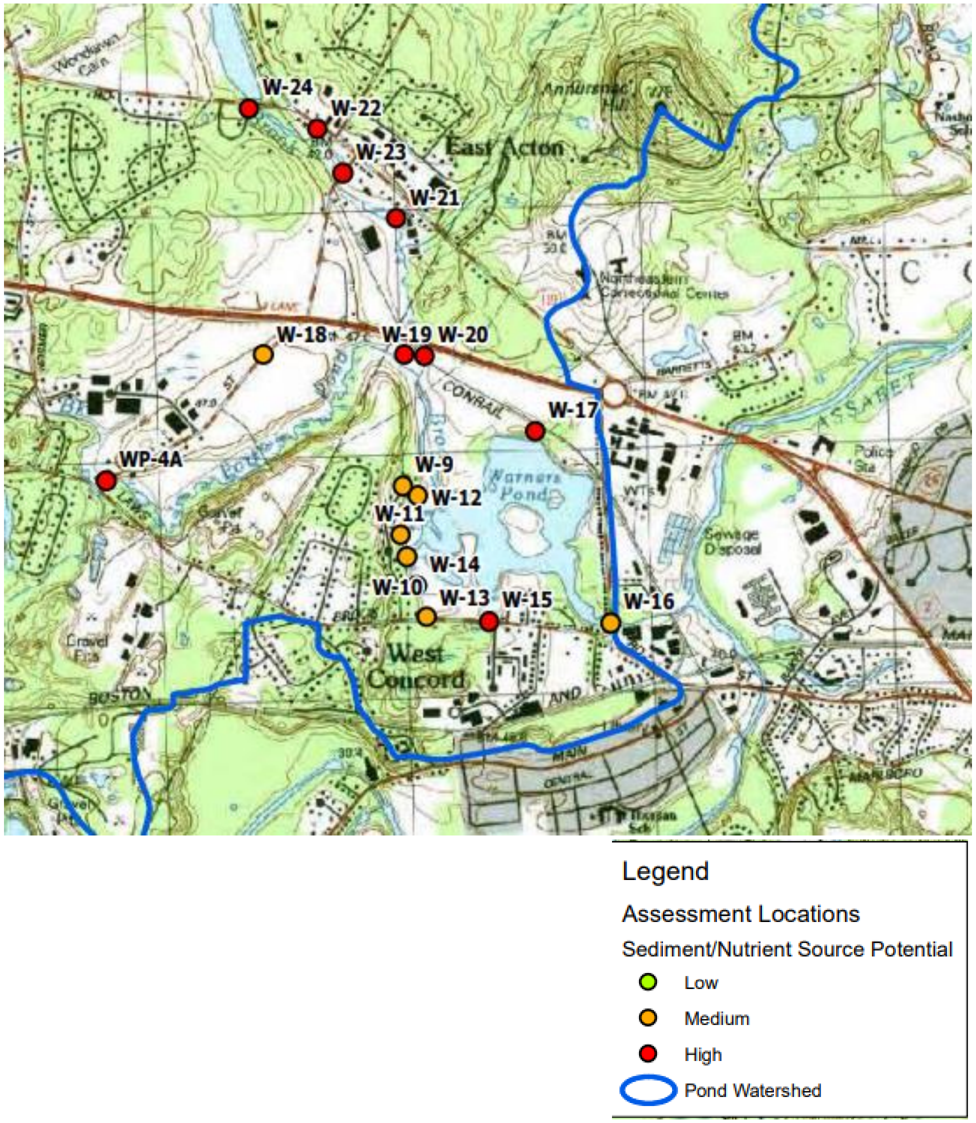
As shown on this plot, very low velocities are required for fines (silt) to be deposited (0.1 to 1 cm/s: 0.003 to 0.03 fps). Fine to medium sand is deposited at velocities of 0.03 fps to 0.3 fps). Coarse sand is deposited at velocities of 0.3 fps to 1 fps). Coarser material (fine gravel) is deposited at velocities of about 1.5 fps.

The sediment gradation data collected at representative sample locations is generally consistent with the predicted flow velocities within the pond.



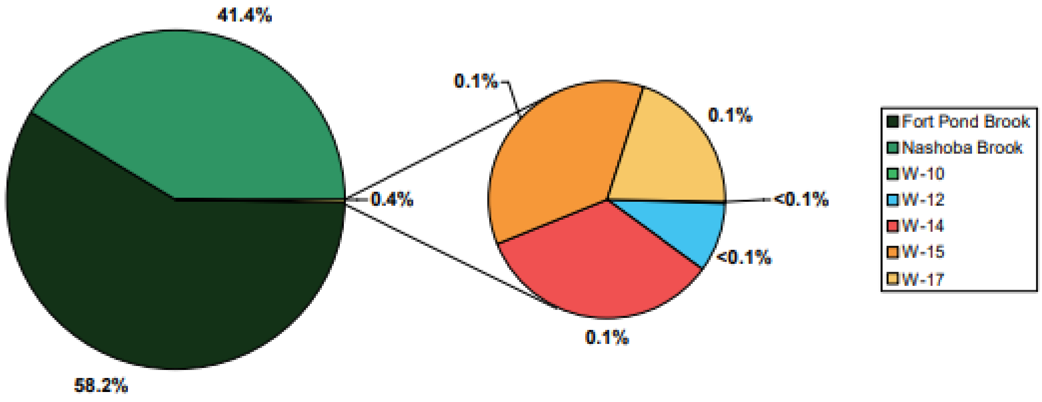
Warner’s Pond Sediment Sources

- The primary sediment loading hotspot occurs along the reach of Nashoba Brook from downstream of Concord Road to the point at which Nashoba Brook turns south from Route 119/2A.
- Numerous commercial and light industrial businesses line Nashoba Brook along Route 119/2A with little to no vegetative buffer along the banks of the brook. A dam just downstream of Concord Road in Acton impounds Nashoba Brook to form Ice House Pond. Although there are additional sources of sediment and nutrients from commercial development upstream of Ice House Pond, most of these upstream sediments are likely trapped behind the dam and do not reach Warner’s Pond.
- Development along Fort Pond Brook, the other major tributary to Warner’s Pond, is generally lighter. Drainage from commercial and residential development in West Acton and South Acton likely contributes sediment to Fort Pond Brook. Fort Pond Brook runs alongside the large impervious parking area of the Acton MBTA commuter rail parking lot, which is another potential sediment source. Another large impervious area associated with a facility at the corner of Hosmer Road and Route 2 is another potential sediment source to Coles Brook, which discharges to Fort Pond Brook.



Warner's Pond Hydraulics and Sedimentation

ESS (2012) estimated relative contribution of the main tributaries (+/- 99%) and nearby outfalls (+/- 1%) to sedimentation. The total sediment load was estimated to be 108 to 162 cy/year. Approximately 68 to 98 cy/year is estimated to leave the Pond, indicating that the estimated net depositional load is 43 to 64 cy/yr.



Assuming a Pond area of 49 acres (2,130,000 sf),:

- an average sediment thickness of 2.8 feet and a sedimentation rate of 64 cy/yr (1,728 cf/yr) indicates annual sedimentation of 0.01 in/yr and that several thousand years would be required to achieve the observed sediment thicknesses.
- assuming 4 feet sediment thickness concentrated over a third of the Pond area only increases the sediment rate to about 0.03 in/yr.
- Sedimentation rates likely increased in recent time (e.g., current configuration of the Pond) Considering the thickness of the coarser fractions of the sediment cores estimated sediment rates to about 0.13 to 0.3 in/yr were possible.

Furthermore, a large sediment load would be expected to move into the pond with every storm or high-water flow and the streambed upstream of the pond is essentially a sandy-bottomed channel feeding the pond with new sediment each year.

Based on the site history, it is possible that much of the sediment was deposited episodically. For example, the site history indicates periods of significant earthwork (e.g., stream relocation; land filling; railroad construction; real estate development) that could have resulted in large sediment deposits.

Looking at an aerial photograph circa 1940 versus current conditions in the western area of the Pond (open water in the 1940s and now mostly emergent wetlands) indicates possible sedimentation rates within this area of about 0.4 in/yr.

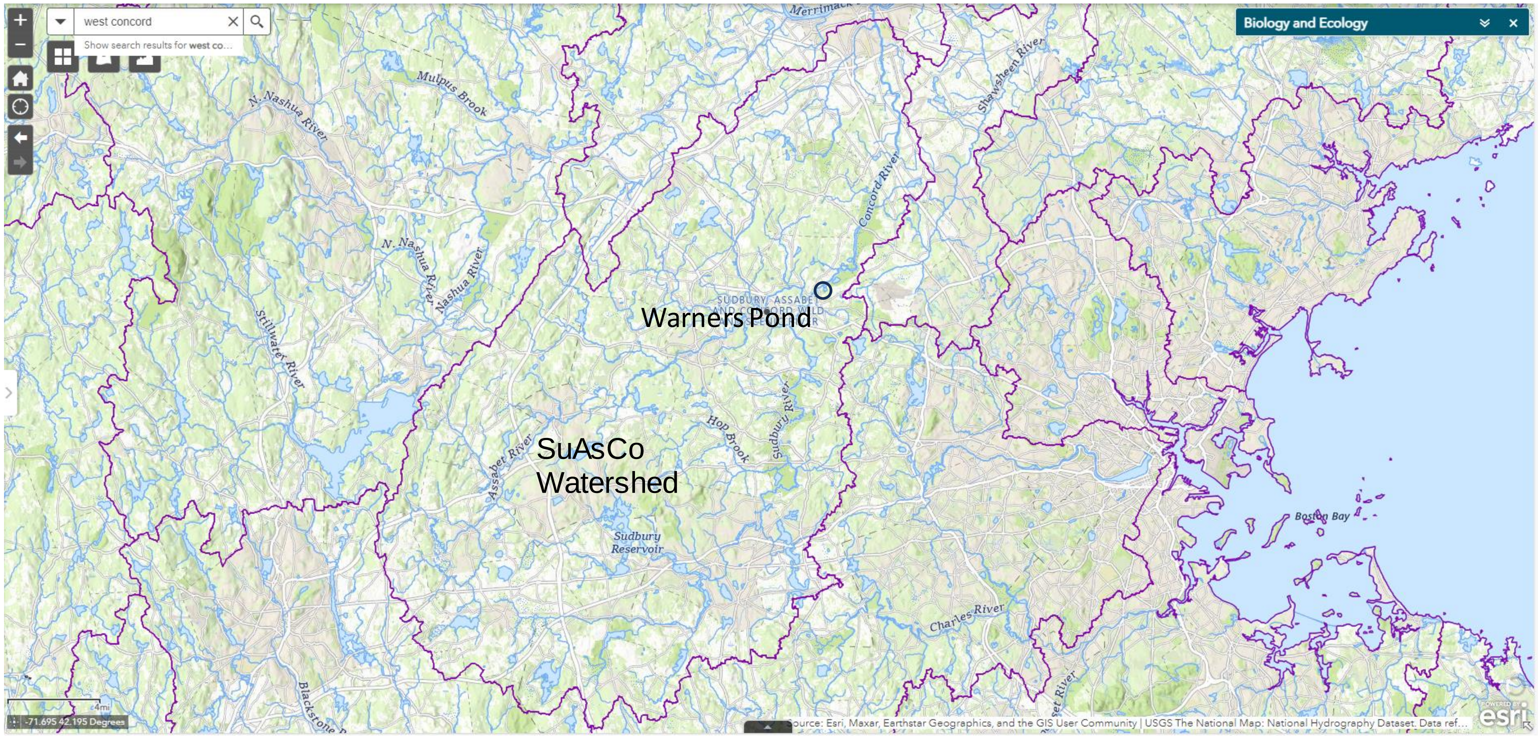
Hydrologic and Hydrographic Setting

Context - Massachusetts has 3,000 dams on 8,000 miles of rivers. Like Warner’s Pond, most of these dams were constructed over the last 200 years as part of the early Industrial Revolution. The presence of these dams over several hundred years has become an integral component of the hydrology, hydrography and geohydrology of within watersheds and sub-watersheds.

Hydrologic and Hydrographic Setting

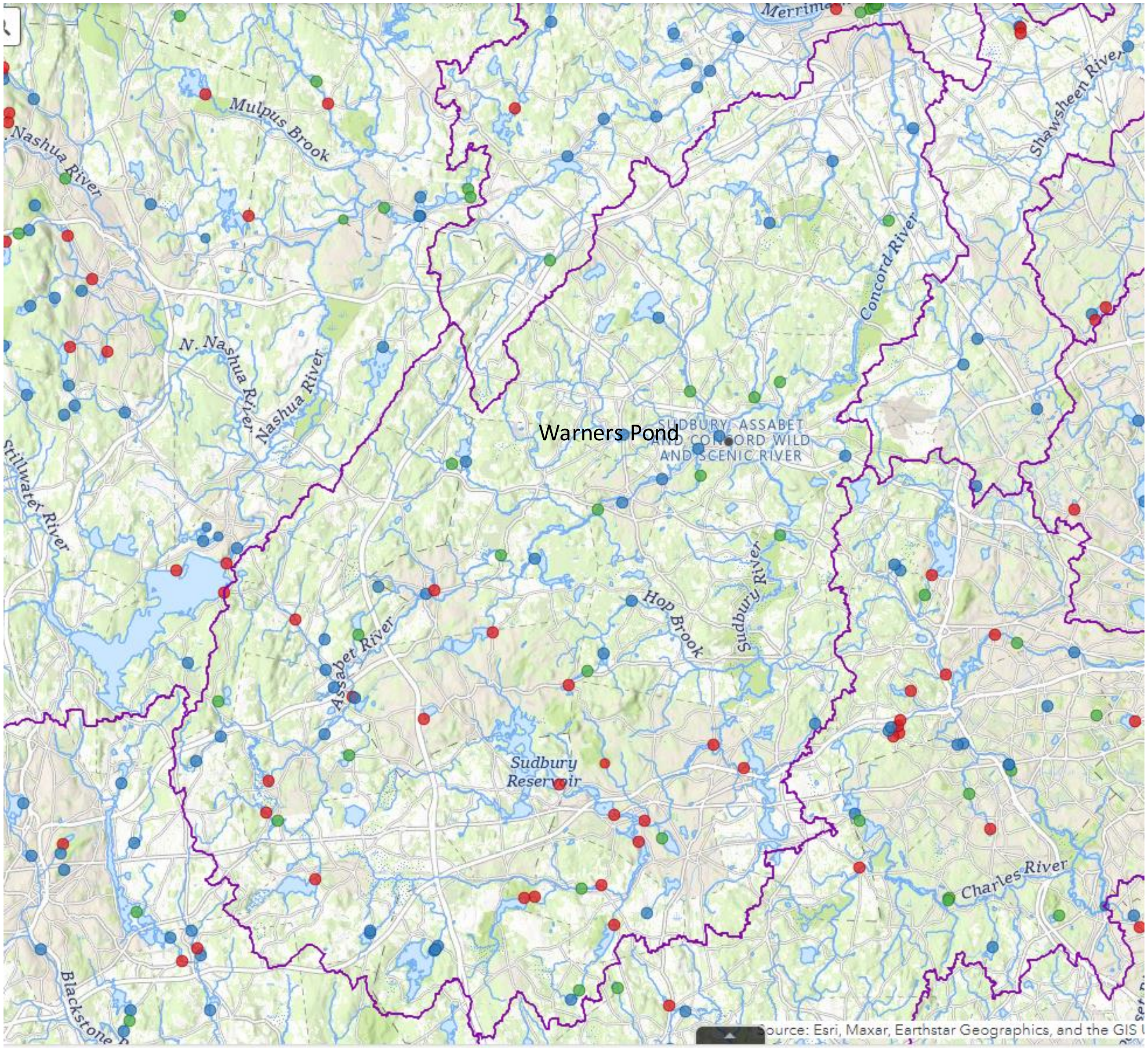
Watersheds are land areas that based on topographic relief channel rainfall and snowmelt to creeks, streams, and rivers, and eventually to outflow points such as reservoirs, bays, and the ocean. The size of a watershed (also called a drainage basin or catchment) is defined on several scales—referred to as its Hydrologic Unit Codes (HUC)—based on the geography that is most relevant to its specific area. Watersheds are delineated by USGS using a nationwide system based on surface hydrologic features, dividing the country into 19,000 watersheds and 105,000 subwatersheds.

Concord (including Warner's Pond) is located within a major Massachusetts watershed – the Sudbury, Assabet, and Concord (SuAsCo) watershed. Thirty-six towns are part of the SuAsCo Watershed, and are all connected by the Sudbury, Assabet, and Concord River system. The watershed covers approximately 377 square miles and includes a variety of upland habitats, wetland habitats, historic sites, scenic sites and recreational areas.



Hydrologic and Hydrographic Setting

Of the 3,000 dams in Massachusetts, about 50 of the dams are located within the Sudbury, Assabet, and Concord (SuAsCo) watershed, including Warner’s Pond. Dots indicate dam locations.



Hydrologic and Hydrographic Setting

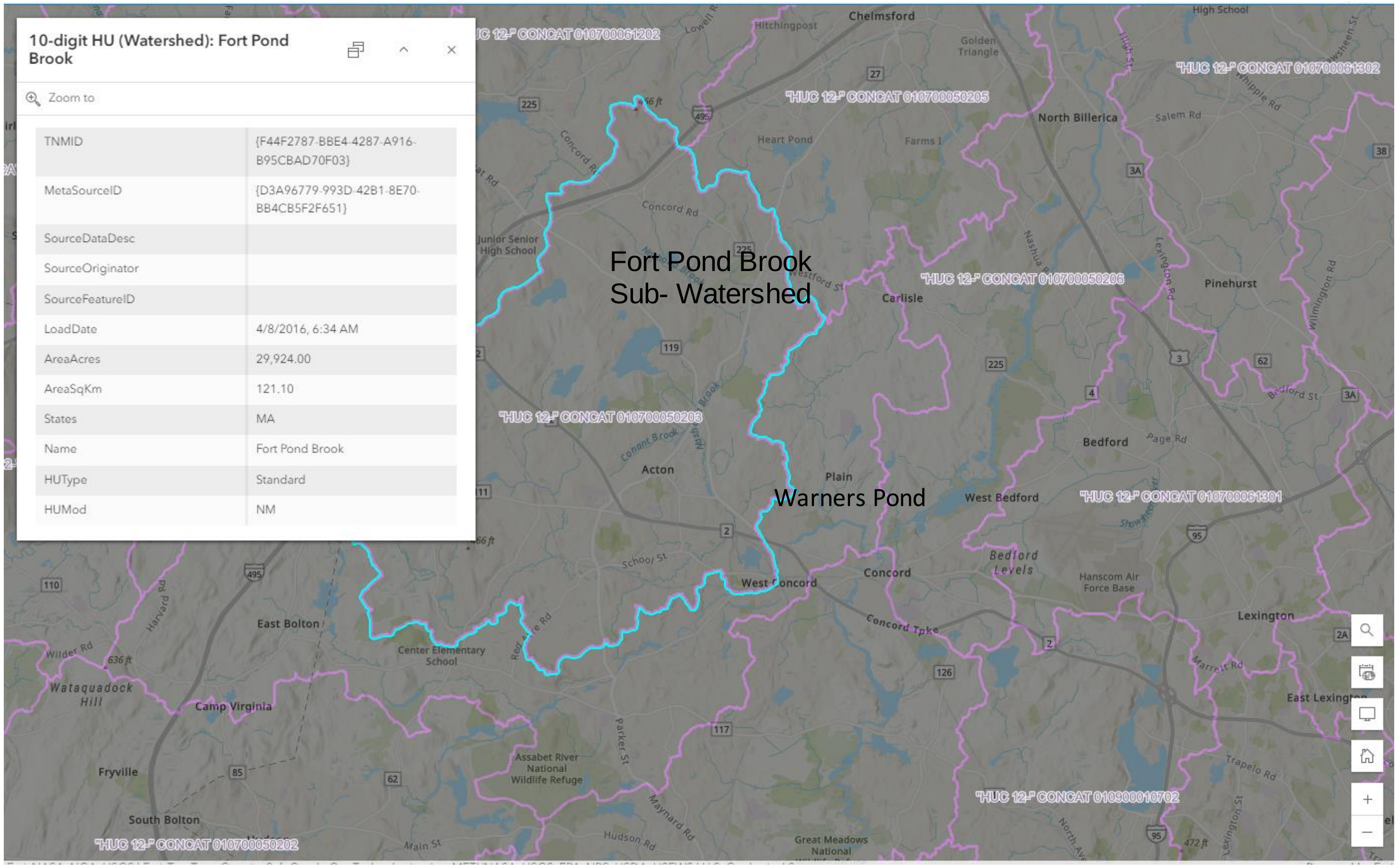
In April 1999 Congress designated 29 miles of the Sudbury, Assabet, and Concord Rivers as Wild and Scenic for their outstanding ecology, history, scenery, recreation values, and place in American literature. The designated reach includes: the 14.9-mile segment of the Sudbury River beginning at the Danforth Street Bridge in Framingham, downstream to the Route 2 bridge in Concord, and the 1.7-mile segment of the Sudbury River from the Route 2 bridge downstream to its confluence with the Assabet River at Egg Rock; the 4.4-mile segment of the Assabet River beginning 1,000 feet downstream from the Damonmill Dam in West Concord, to its confluence with the Sudbury River at Egg Rock in Concord; and the 8-mile segment of the Concord River from Egg Rock at the confluence of the Sudbury and Assabet Rivers downstream to the Route 3 bridge in Billerica.

Hydrologic and Hydrographic Setting

The SuAsCo Watershed is subdivided into a series of smaller sub-watersheds. Warner's Pond is located at the southeast end of the HUC 10 Fort Pond Brook sub-watershed. The Fort Pond Brook watershed is about 46.8 sq. mi. in extent (29,924 acres). The principal tributaries within the Fort Pond Brook watershed are: Nashoba Brook and Fort Pond Brook.

The Fort Pond subwatershed includes portions of the towns of Concord, Acton, Boxborough, Carlisle, Littleton, Stowe and Westford.

Note: Fort Pond Brook watershed is the name utilized by the USGS. Also referred to as the Nashoba Brook and Fort Pond Brook Watershed or the Nashoba Brook Watershed.



10-digit HU (Watershed): Fort Pond Brook

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SourceDataDesc	
SourceOriginator	
SourceFeatureID	
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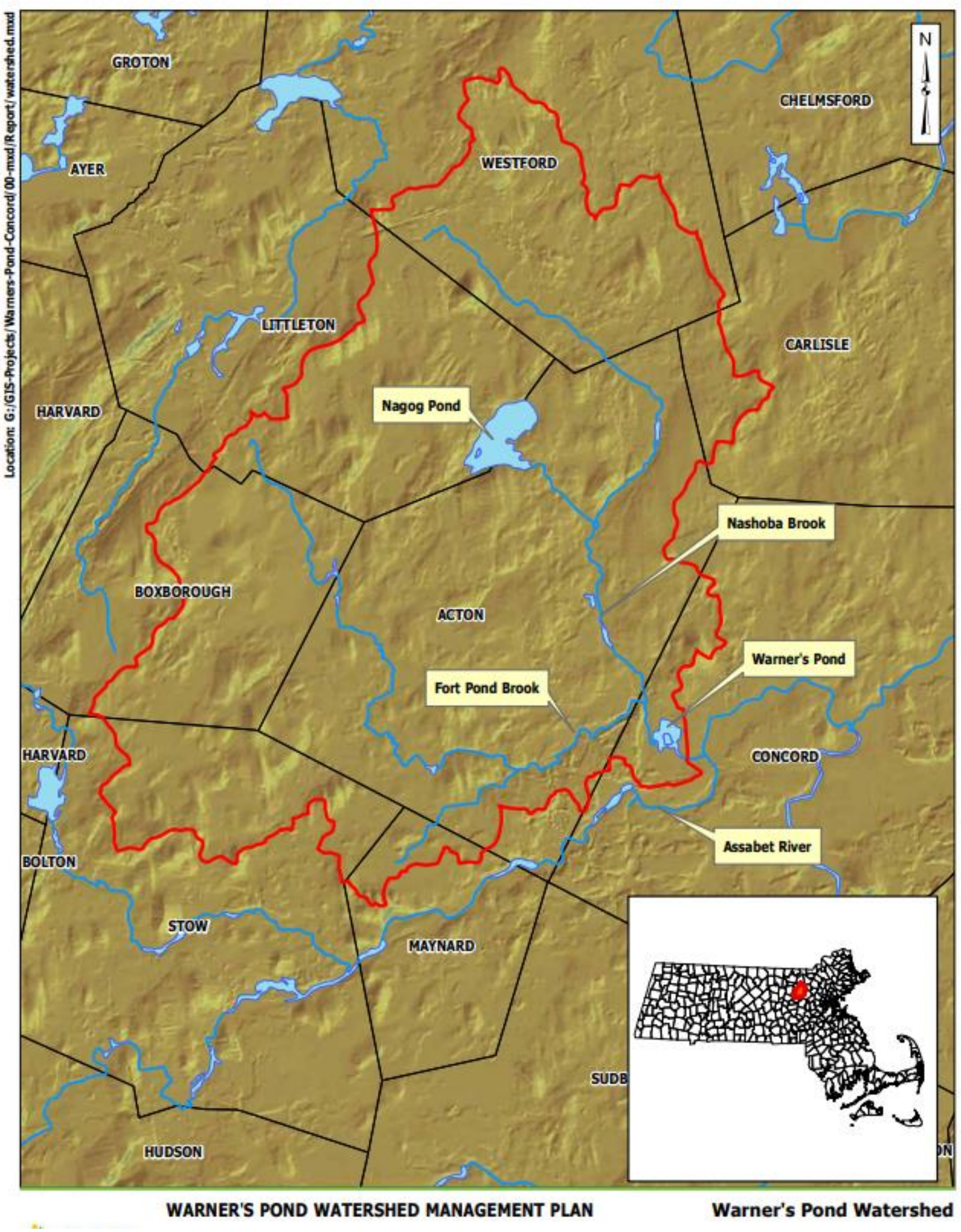
AreaAcres	29,924.00
AreaSqKm	121.10
States	MA
Name	Fort Pond Brook
HUType	Standard
HUMod	NM

Hydrologic and Hydrographic Setting

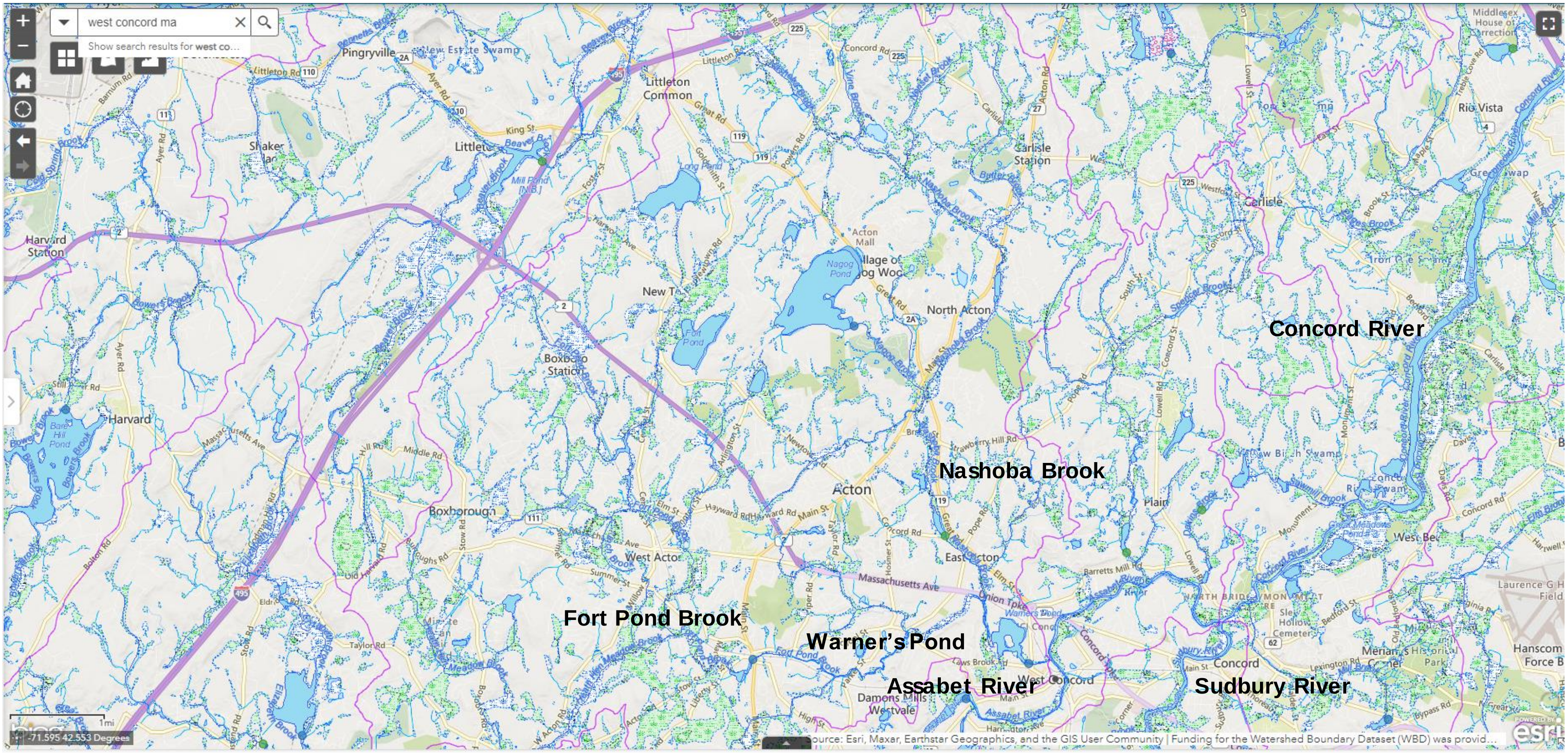


Within the Fort Pond Brook sub-watershed, the tributaries that are hydraulically connecting and discharging to Warner's Pond are: 1) Nashoba Brook; and 2) Fort Pond Brook.

Given the size of the pond's watershed and the volume of water contained in the streams feeding the pond, the water entering Warner's Pond flushes through the pond rapidly. Water leaves the pond via its outlet at the southeast corner of the pond.

Hydrologic and Hydrographic Setting

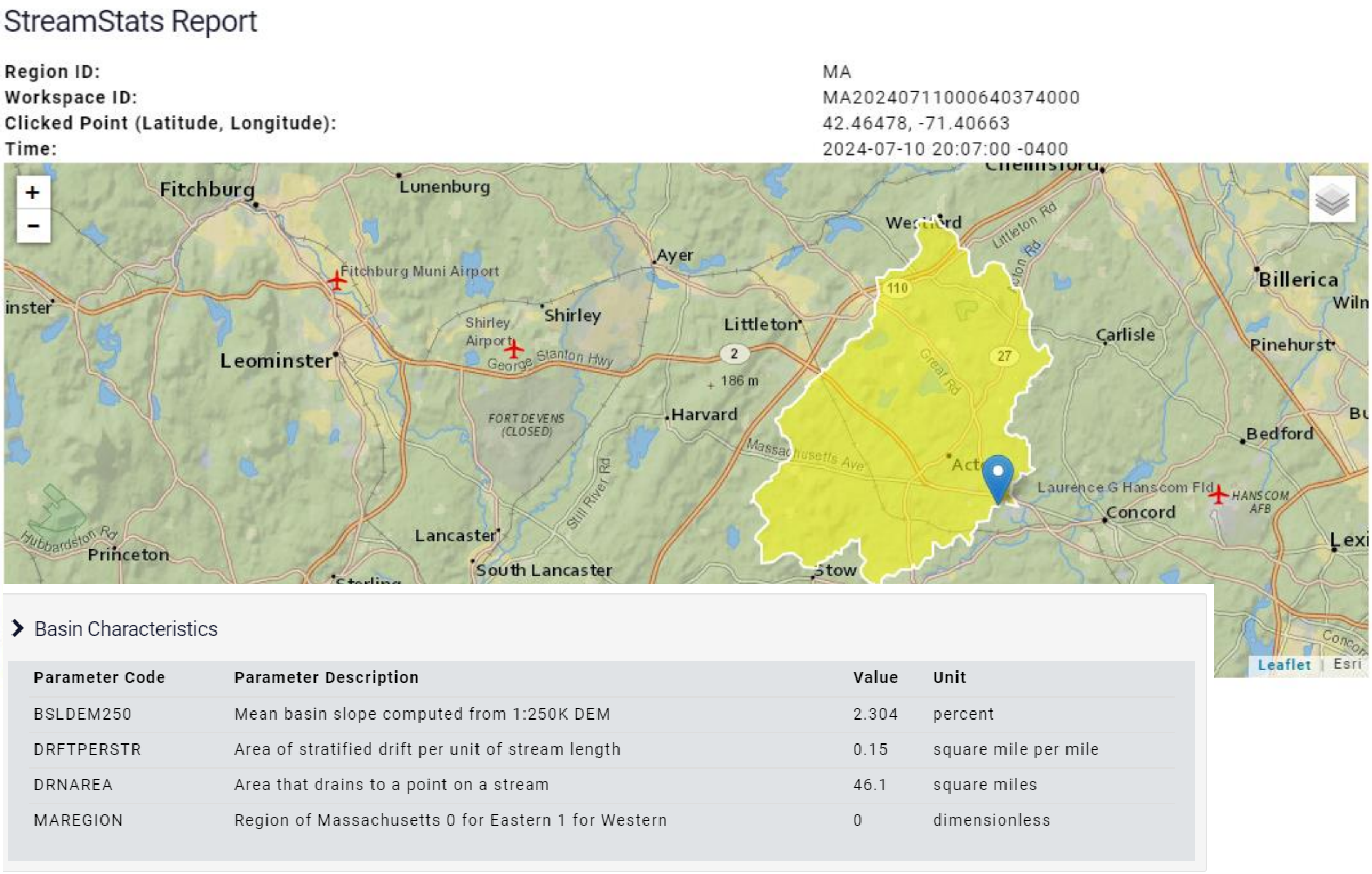
Warner’s Pond discharges via the dam to Nashoba Brook (at the Commonwealth Avenue bridge), which in turn discharges to the Assabet River. The Assabet flows to the north and both the Assabet and the Sudbury Rivers connect to the Concord River. The Concord River flows north and connects with the Merrimack River, which in turn discharges to the Atlantic Ocean.



Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community | Funding for the Watershed Boundary Dataset (WBD) was provid...

Hydrology

StreamStats provides a hydrologic overview of the Fort Pond Brook sub-watershed.



StreamStats Report

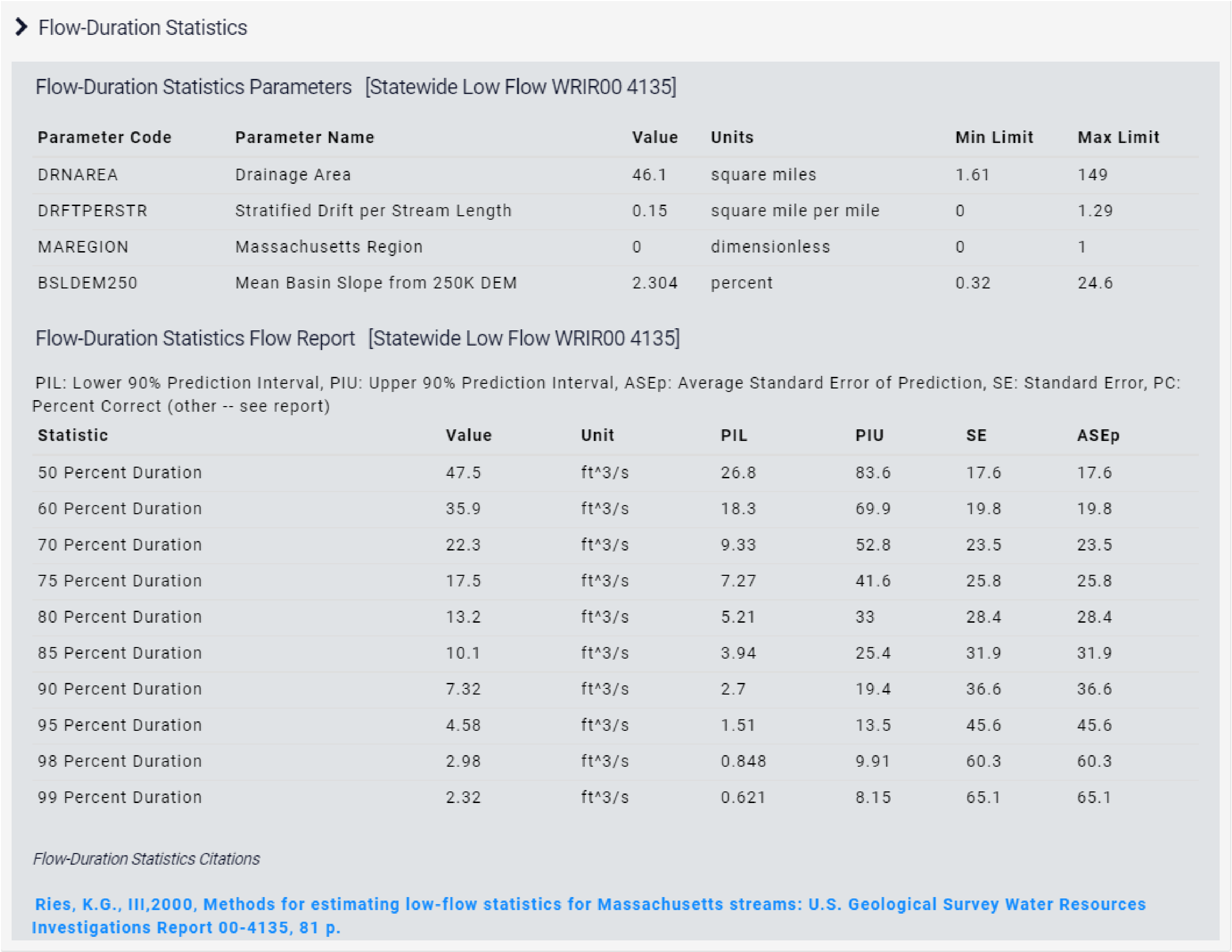
Region ID:	MA
Workspace ID:	MA20240711000640374000
Clicked Point (Latitude, Longitude):	42.46478, -71.40663
Time:	2024-07-10 20:07:00 -0400

Basin Characteristics

Parameter Code	Parameter Description	Value	Unit
BSLDEM250	Mean basin slope computed from 1:250K DEM	2.304	percent
DRFTPERSTR	Area of stratified drift per unit of stream length	0.15	square mile per mile
DRNAREA	Area that drains to a point on a stream	46.1	square miles
MAREGION	Region of Massachusetts 0 for Eastern 1 for Western	0	dimensionless

Hydrology

StreamStats provides a hydrologic overview of the Fort Pond Brook sub-watershed.



Flow-Duration Statistics

Flow-Duration Statistics Parameters [Statewide Low Flow WRIR00 4135]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	46.1	square miles	1.61	149
DRFTPERSTR	Stratified Drift per Stream Length	0.15	square mile per mile	0	1.29
MAREGION	Massachusetts Region	0	dimensionless	0	1
BSLDEM250	Mean Basin Slope from 250K DEM	2.304	percent	0.32	24.6

Flow-Duration Statistics Flow Report [Statewide Low Flow WRIR00 4135]

PIL: Lower 90% Prediction Interval, PIU: Upper 90% Prediction Interval, ASEp: Average Standard Error of Prediction, SE: Standard Error, PC: Percent Correct (other -- see report)

Statistic	Value	Unit	PIL	PIU	SE	ASEp
50 Percent Duration	47.5	ft^3/s	26.8	83.6	17.6	17.6
60 Percent Duration	35.9	ft^3/s	18.3	69.9	19.8	19.8
70 Percent Duration	22.3	ft^3/s	9.33	52.8	23.5	23.5
75 Percent Duration	17.5	ft^3/s	7.27	41.6	25.8	25.8
80 Percent Duration	13.2	ft^3/s	5.21	33	28.4	28.4
85 Percent Duration	10.1	ft^3/s	3.94	25.4	31.9	31.9
90 Percent Duration	7.32	ft^3/s	2.7	19.4	36.6	36.6
95 Percent Duration	4.58	ft^3/s	1.51	13.5	45.6	45.6
98 Percent Duration	2.98	ft^3/s	0.848	9.91	60.3	60.3
99 Percent Duration	2.32	ft^3/s	0.621	8.15	65.1	65.1

Flow-Duration Statistics Citations

Ries, K.G., III,2000, Methods for estimating low-flow statistics for Massachusetts streams: U.S. Geological Survey Water Resources Investigations Report 00-4135, 81 p.

Hydrology

StreamStats provides a hydrologic overview of the Fort Pond Brook sub-watershed.

August Flow-Duration Statistics

August Flow-Duration Statistics Parameters [Statewide Low Flow WRIR00 4135]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	46.1	square miles	1.61	149
BSLDEM250	Mean Basin Slope from 250K DEM	2.304	percent	0.32	24.6
DRFTPERSTR	Stratified Drift per Stream Length	0.15	square mile per mile	0	1.29
MAREGION	Massachusetts Region	0	dimensionless	0	1

August Flow-Duration Statistics Flow Report [Statewide Low Flow WRIR00 4135]

PIL: Lower 90% Prediction Interval, PIU: Upper 90% Prediction Interval, ASEp: Average Standard Error of Prediction, SE: Standard Error, PC: Percent Correct (other -- see report)

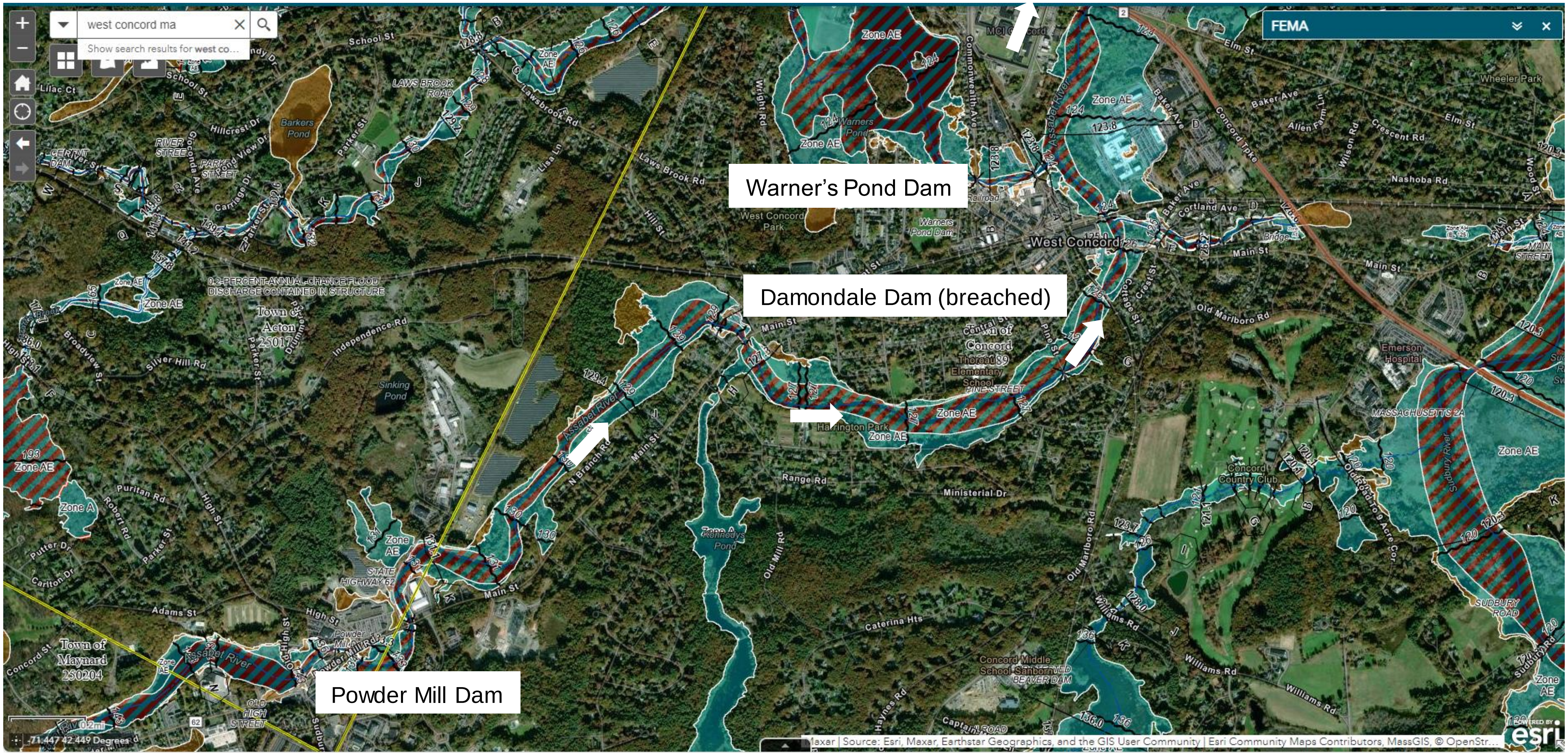
Statistic	Value	Unit	PIL	PIU	SE	ASEp
August 50 Percent Duration	10.8	ft^3/s	4.2	27.3	33.2	33.2

August Flow-Duration Statistics Citations

Ries, K.G., III,2000, Methods for estimating low-flow statistics for Massachusetts streams: U.S. Geological Survey Water Resources Investigations Report 00-4135, 81 p.

Assabet River Floodplain

Existing dams affect flooding along the key tributaries and the Assabet River, as shown on the FEMA Flood Profiles. The image below is the Assabet River upgradient from Warner's Pond. The white arrows are added to the FEMA map to indicate river flow direction within the Assabet. Warner's Pond dam is not on the Assabet, but is shown here for reference.

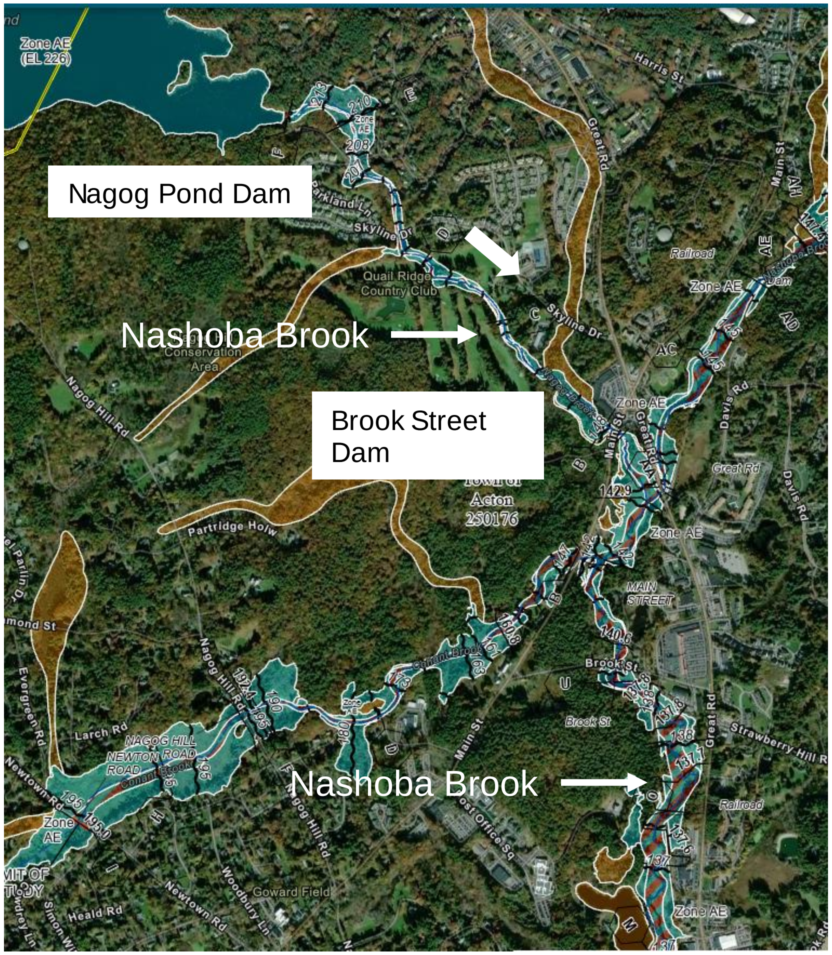


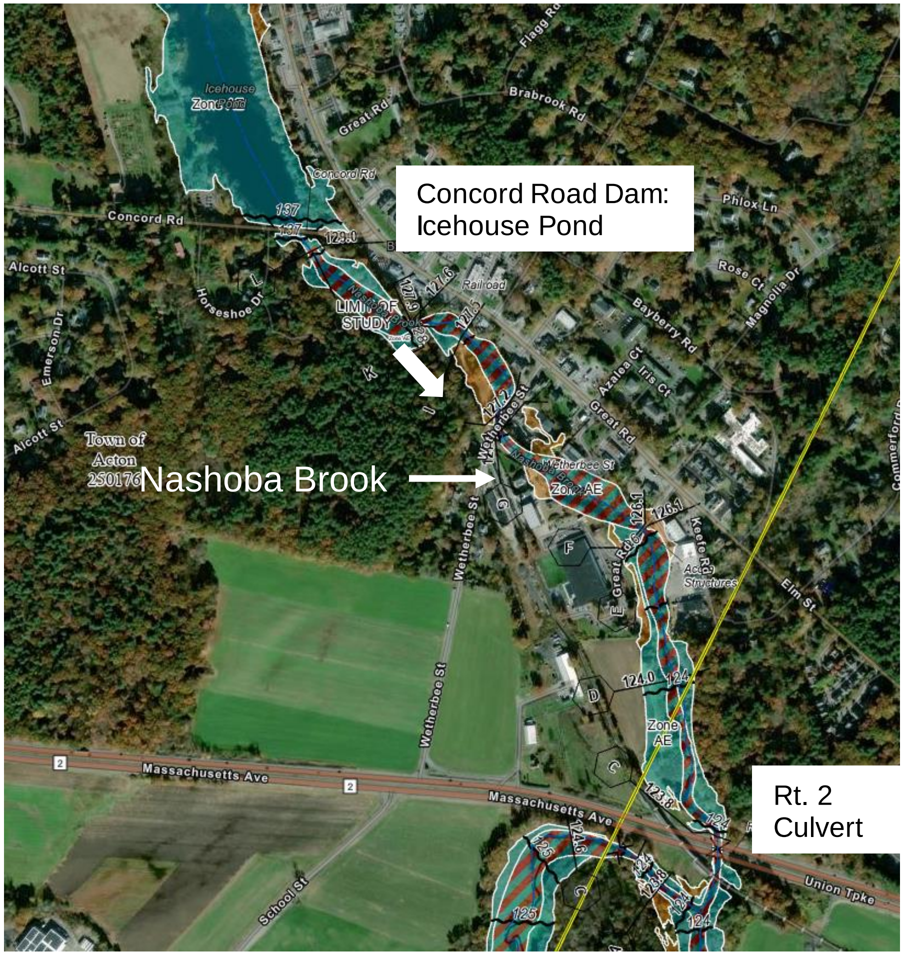
Assabet River Floodplain

The image below is the Assabet River downgradient of Warner’s Pond. The white arrows are added to the FEMA map to indicate river flow direction within the Assabet.

Hydrology: Nashoba Brook and Floodplain

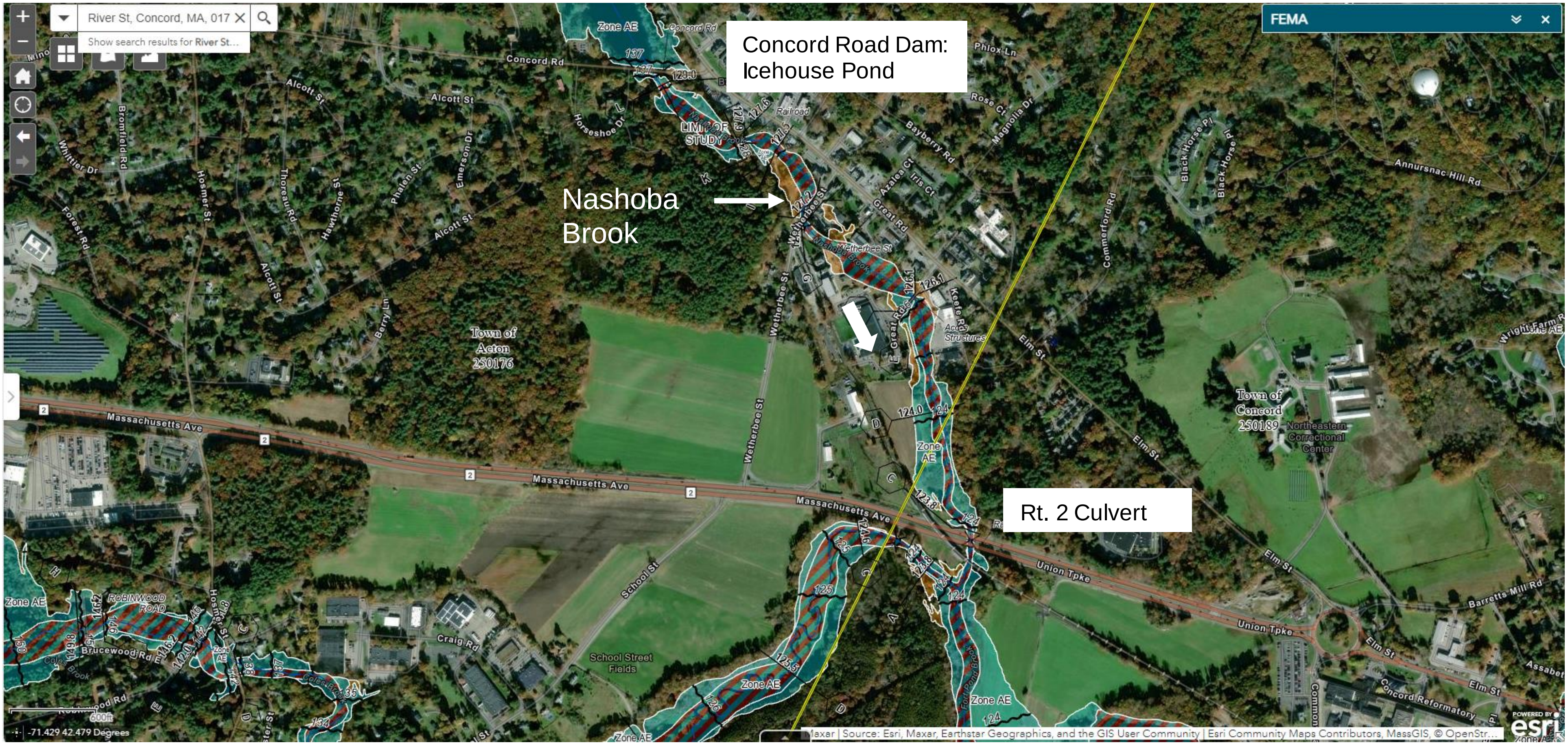
Existing dams affect flooding along Nashoba Brook. The white arrows are added to the FEMA map to indicate river flow direction within Nashoba Brook. The images below show Nashoba Brook upstream of Warner's Pond.





Hydrology: Nashoba Brook and Floodplain

Existing dams affect flooding along Nashoba Brook. The white arrows are added to the FEMA map to indicate river flow direction within Nashoba Brook. The image below show Nashoba Brook upstream of Warner’s Pond.



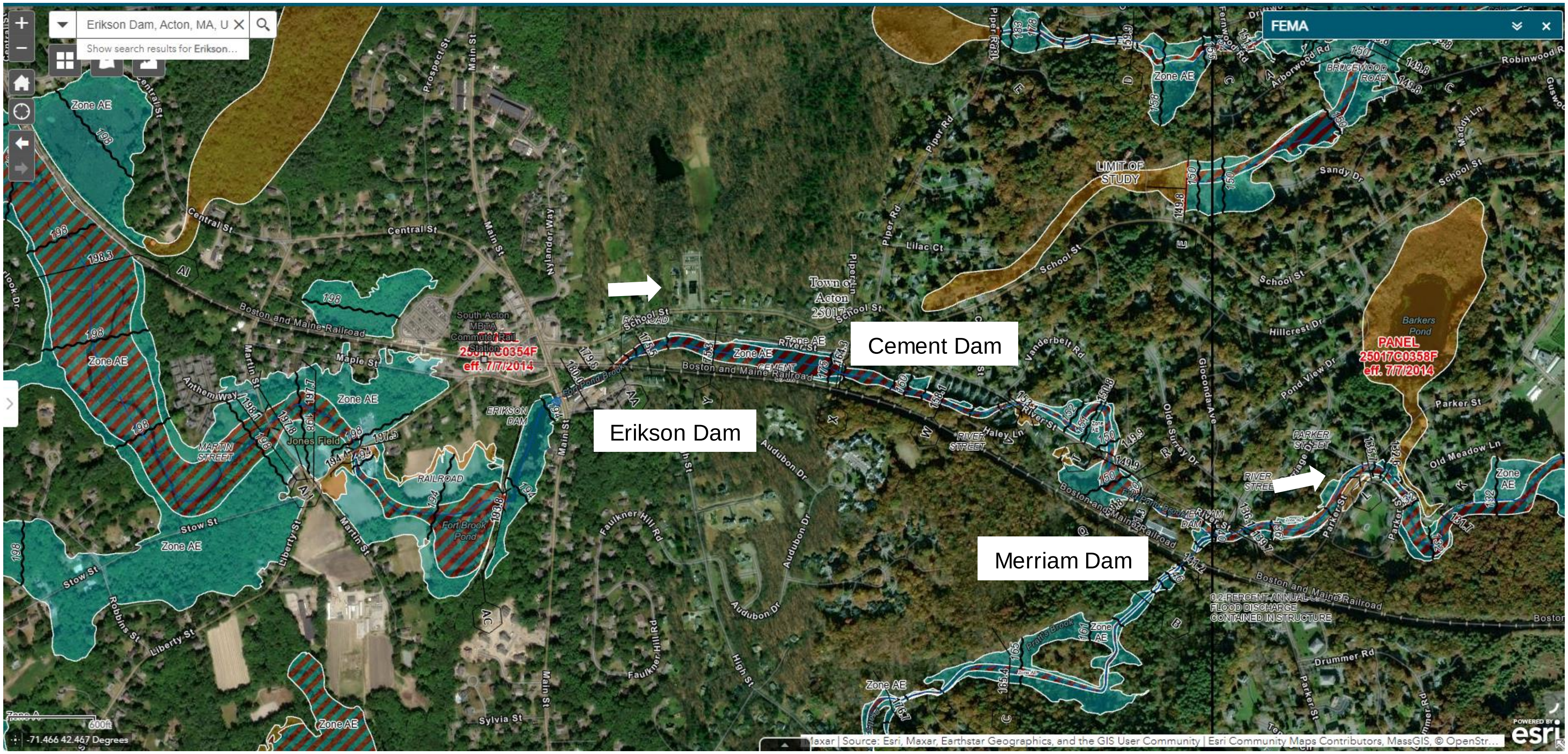
Concord Road Dam: Icehouse Pond

Nashoba Brook

Rt. 2 Culvert

Hydrology: Fort Pond Brook and Floodplain

Existing dams affect flooding along Fort Pond Brook. The white arrows are added to the FEMA map to indicate river flow direction. The image below shows Fort Pond Brook upstream of Warner's Pond.

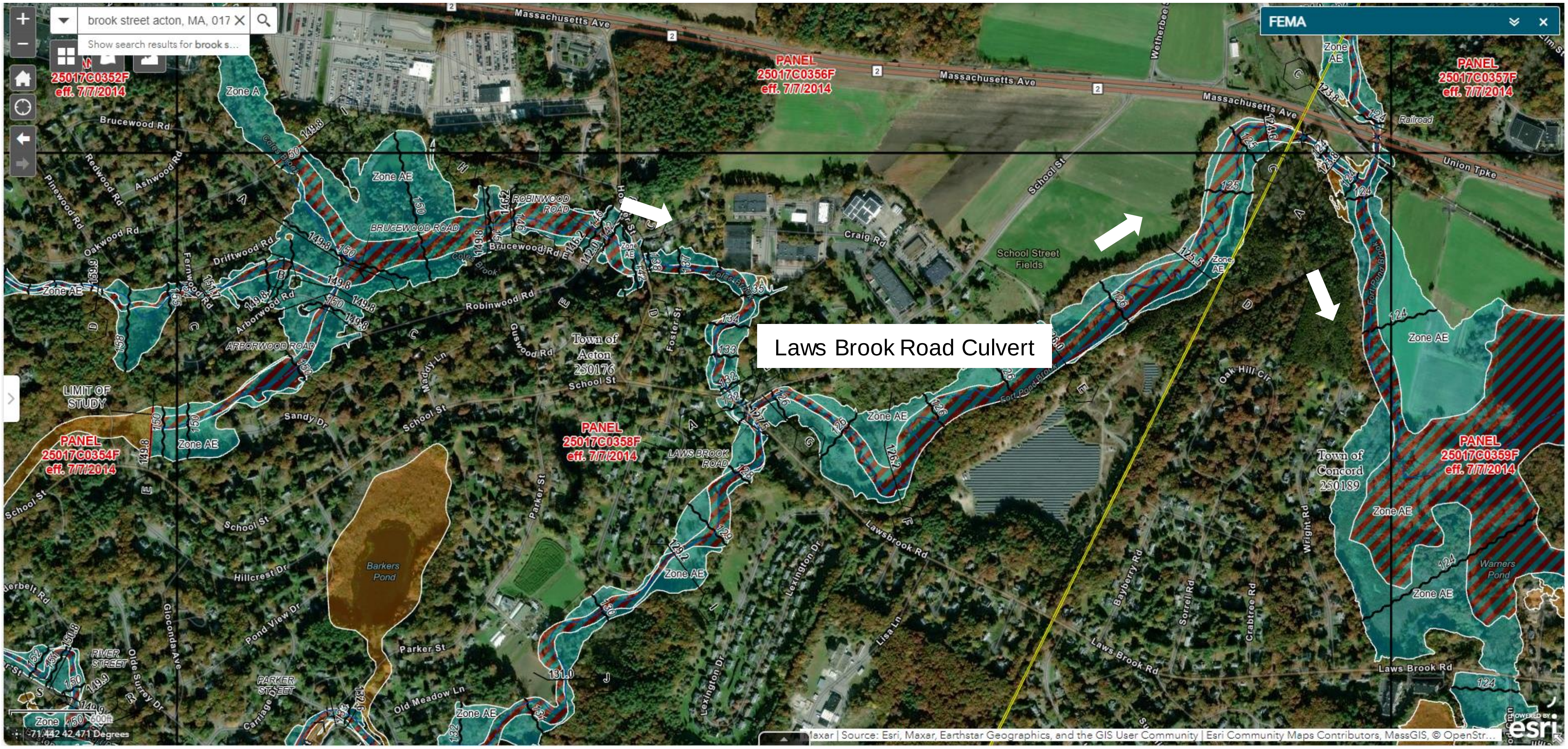


Hydrology: Fort Pond Brook and Floodplain

Existing dams affect flooding along Fort Pond Brook. The white arrows are added to the FEMA map to indicate river flow direction. The image below shows Fort Pond Brook upstream of Warner’s Pond.

Hydrology: Fort Pond Brook and Floodplain

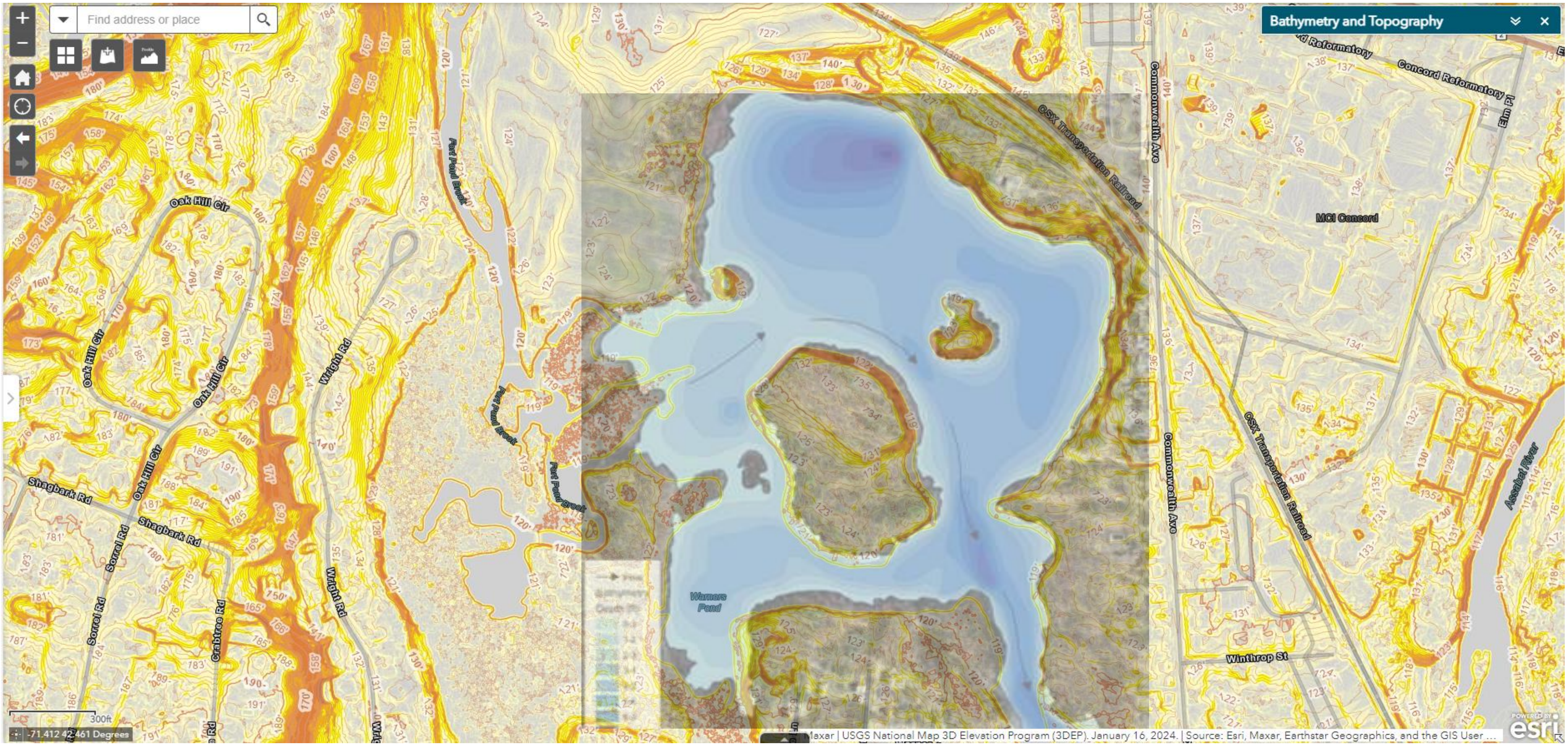
Existing dams affect flooding along Fort Pond Brook. The white arrows are added to the FEMA map to indicate river flow direction. The image below shows Fort Pond Brook upstream of Warner's Pond.



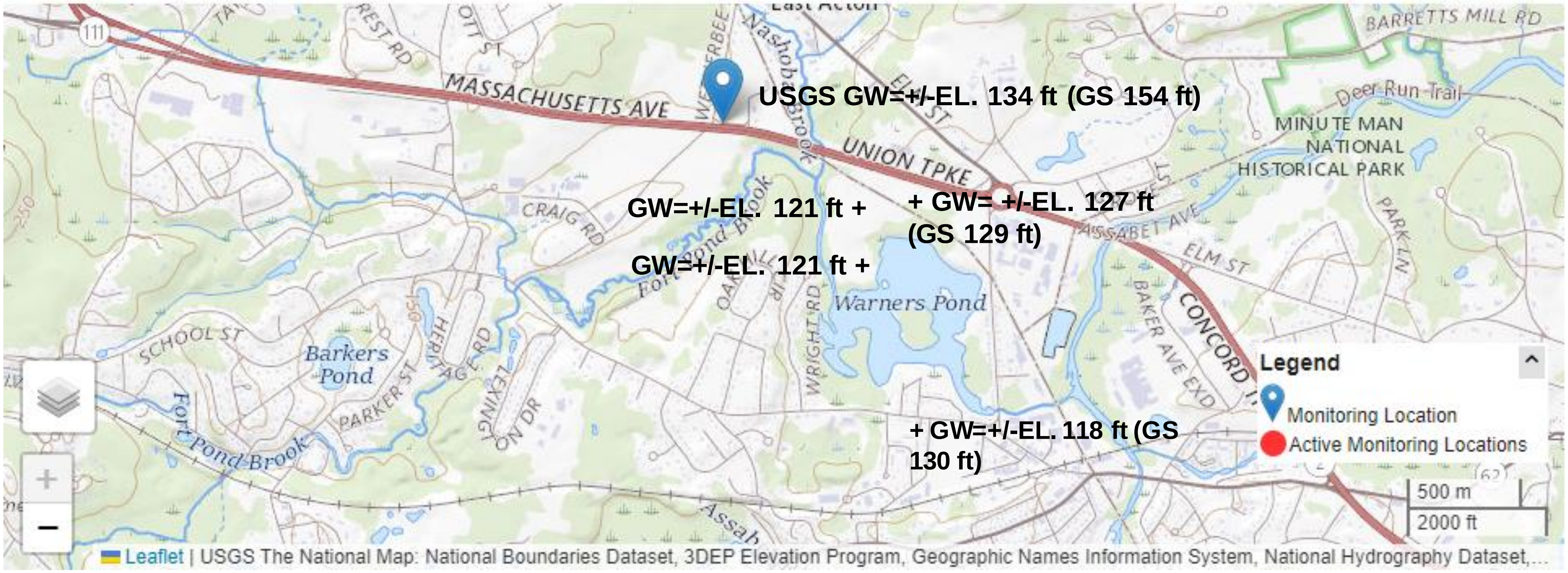
Laws Brook Road Culvert

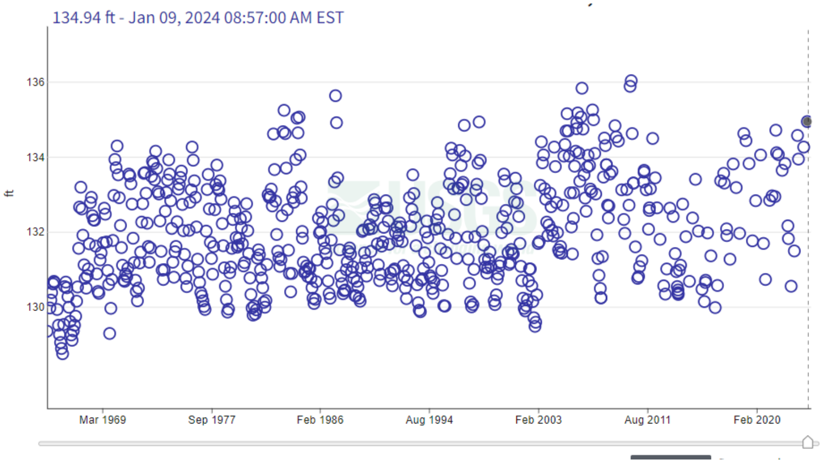
Hydrology

The image below combines the area topography and pond depth, indicating the combined flows of Nashoba Brook and Fort Pond Brook discharging into the pond through a broad delta of emergent wetlands on the western shore, and principal flow direction through the pond and discharging via the dam. Mixing within the pond likely occurs.



Geohydrology



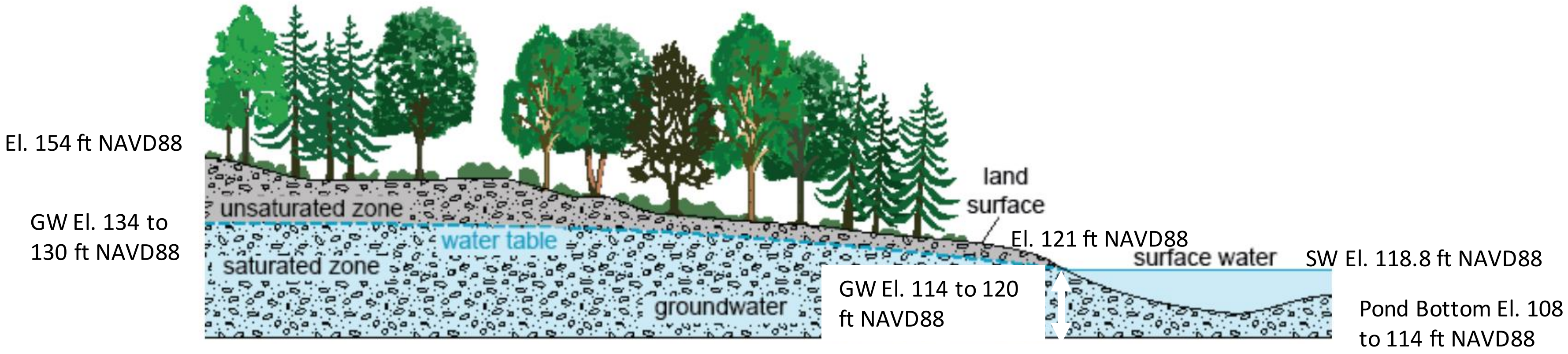


There are limited data points (including only one USGS well) where groundwater depth and elevation are documented. See image above (representing high groundwater elevations) and USGS groundwater elevation measurements (left). Although highly approximate and based on very limited data, it may be inferred that **at times of "high" groundwater, groundwater at the pond is about Elevation 120 feet NAVD88** (indicating the potential for groundwater to discharge to the pond). **Low groundwater levels may be about 4 feet lower at Elevation 114 to 116 feet NAVD88),** indicating that the pond (Normal Pool Elevation 118.8 feet NAVD88) discharges and contributes to groundwater .

Ma-Acw 158 Acton, MA - USGS Water Data for the Nation

Massachusetts Elevation Finder (arcgis.com)

Geohydrology



The limited groundwater elevation data shown on the previous slide are shown conceptually in cross-section, above. The uncertainty with this interpretation is the influence of the impounded water level (El 118.8 feet NAVD88) on the surrounding groundwater elevation. It may be that, similar to other surface water including rivers and streams, during periods of high groundwater elevation, groundwater contributes to recharge of the pond and surrounding wetlands and during periods of low groundwater elevation, the impounded water levels maintain vicinity groundwater elevations.

The hydrologic model by ESS (2012) assumed very little groundwater inflow to the pond. This may indicate that groundwater contribution to wetlands (if the dam is removed) may also be limited. This assumption is consistent with recent observations. Stream gage data during July 2024 indicated low stream flow conditions (e.g., downgradient of Warner’s Pond, Nashoba Brook and Assabet River), the observed groundwater data at the 158 Acton USGS station indicates high groundwater levels. The high groundwater USGS readings are supported by very high water levels observed at spring fed ponds (Walden Pond and White’s Pond). This appears to indicate limited hydraulic contribution of groundwater to streamflow (and water levels within Warner’s Pond).

Warner’s Pond Hydraulics

The “hydraulics” of the Pond describe how water flows through the Pond and dam and refer to parameters such as flow volumes and flow rates (velocities). There are some discrepancies in hydraulic data assumptions and analyses performed by the Town’s consultants; however, the basics are relatively consistent. Some background data... The first table indicates “normal” and flood water levels (from the dam design) and the second table by Town consulting ecologists presents pond geometry as well as input to a flow model. (Note significant differences in assumed Pond normal pool storage volume and area between the two tables.)

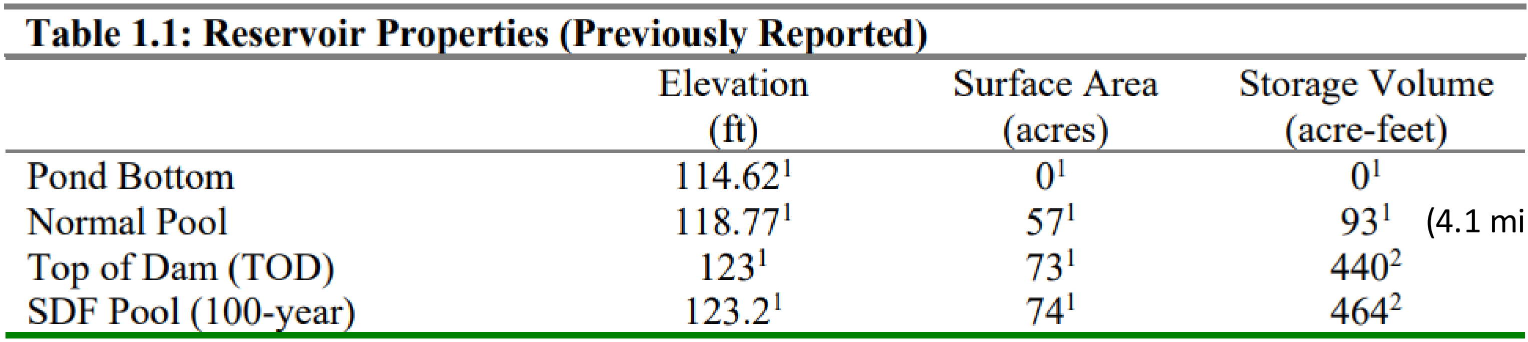


Table 1.1: Reservoir Properties (Previously Reported)

	Elevation (ft)	Surface Area (acres)	Storage Volume (acre-feet)
Pond Bottom	114.62[1]	0[1]	0[1]
Normal Pool	118.77[1]	57[1]	93[1] (4.1 million cubic feet)
Top of Dam (TOD)	123[1]	73[1]	440[2]
SDF Pool (100-year)	123.2[1]	74[1]	464[2]

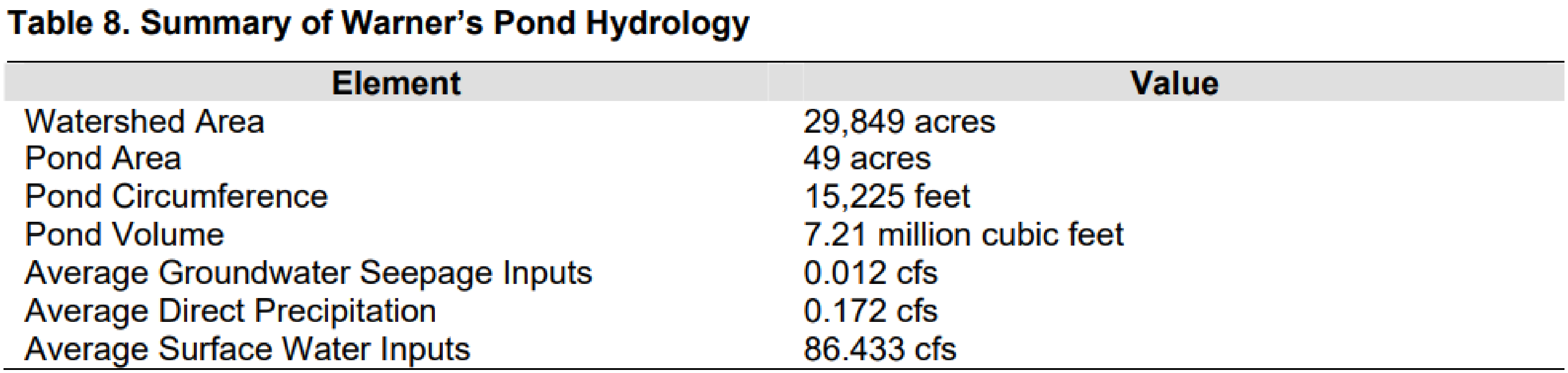


Table 8. Summary of Warner’s Pond Hydrology

Element	Value
Watershed Area	29,849 acres
Pond Area	49 acres
Pond Circumference	15,225 feet
Pond Volume	7.21 million cubic feet
Average Groundwater Seepage Inputs	0.012 cfs
Average Direct Precipitation	0.172 cfs
Average Surface Water Inputs	86.433 cfs

Warner’s Pond Hydraulics

From the 2012 ESS study:

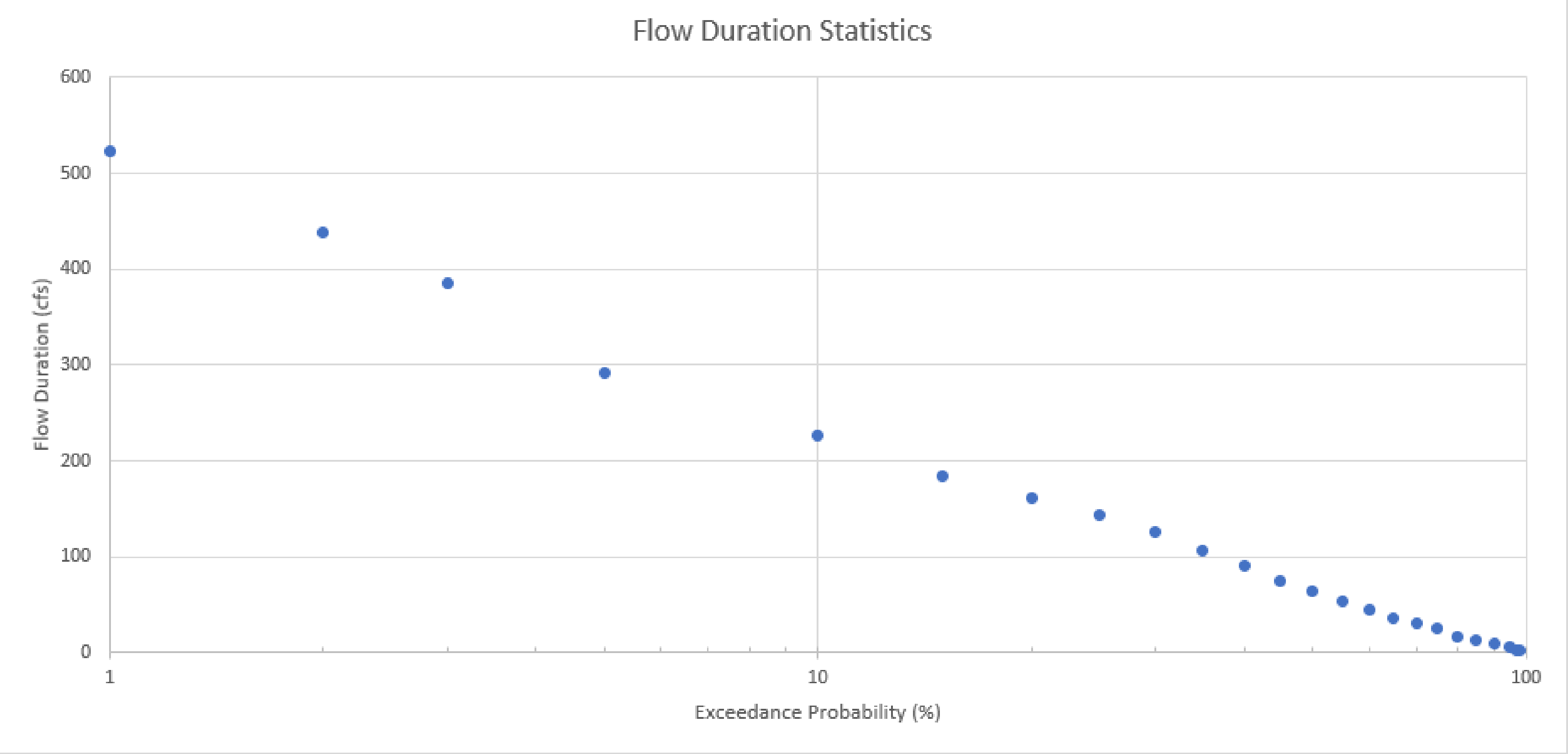
- A hydrologic budget for Warner’s Pond was performed by ESS using: a) general pond characteristics including acreage, circumference, volume, and watershed size; b) streamflow inputs from the two tributaries to the pond (Nashoba Brook and Fort Pond Brook) using the online streamflow modeling application, Streamstats; c) an estimate of the rate of groundwater movement into the pond, based on averages obtained for southern New England ponds of similar morphometry; and d) data on average precipitation were collected from local weather stations and regional estimates, including the 30-year normals for Boston and Worcester (www.wunderground.com).
- Based on total pond volume (7.2 million cubic feet) and the estimated flow through the system, average detention time was calculated to be 0.949 days (0.0026 years). The flow rate was estimated as about 86.5 cfs (almost entirely from water flow from the two tributaries).
- Since detention time represents the duration of time necessary to exchange the volume of water in the pond one time this means that the water entering Warner’s Pond is retained for less than a day’s time, on average.
- Flushing rate is the inverse of detention time and represents the number of times per year the pond volume is replaced; for Warner’s Pond the flushing rate is nearly 379 times per year. This is an extremely high flushing rate but is not unexpected given the large watershed to pond area ratio (approximately 612:1).
- The flushing rate indicates that water moves through Warner’s Pond very quickly and in many regards, it is more appropriate to view the pond functioning as a large, wide pool within a river system rather than a pond.

Warner’s Pond Hydraulics

The flow rate used by ESS for the hydrologic budget was estimated as about 86.5 cfs (almost entirely from water flow from the two tributaries). For comparison, StreamStats (USGS gage located at the SE end of Pond at dam) indicates that 86.5 cfs is about the 40% exceedance flow duration stream flow. The 50% exceedance flow duration stream flow is 64 cfs.

Note: assuming a storage volume of 93 acre-feet = 4.1x10-06 cf and the assumed flow rate of 86.5 cfs, the predicted detention time is 0.54 day – much higher flushing rate than indicated in 2012 report. Conversely, assuming a storage volume of 93 acre-feet and an assumed flow rate of 64 cfs, the predicted detention time is 0.74 day.

Regardless, the range of estimated detention times (0.95 to 0.54 day), water moves through Warner’s Pond very quickly and in many regards, it is more appropriate to view the pond functioning as a large, wide pool within a river system rather than a pond.

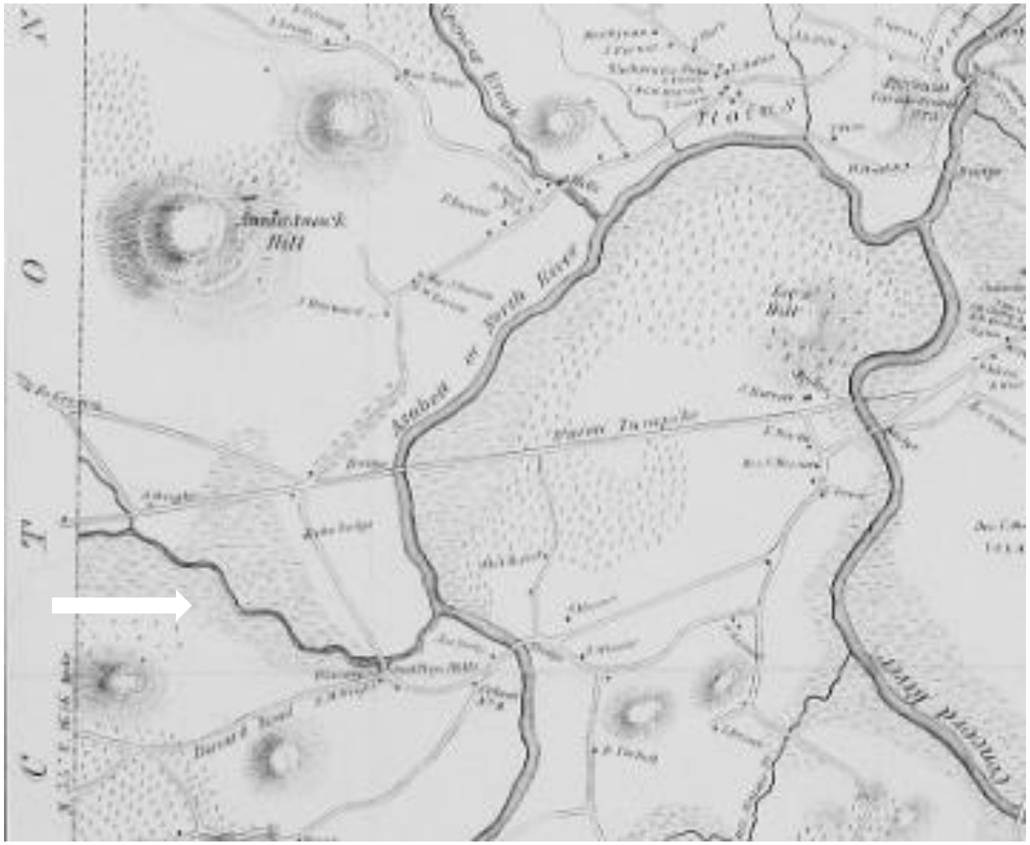


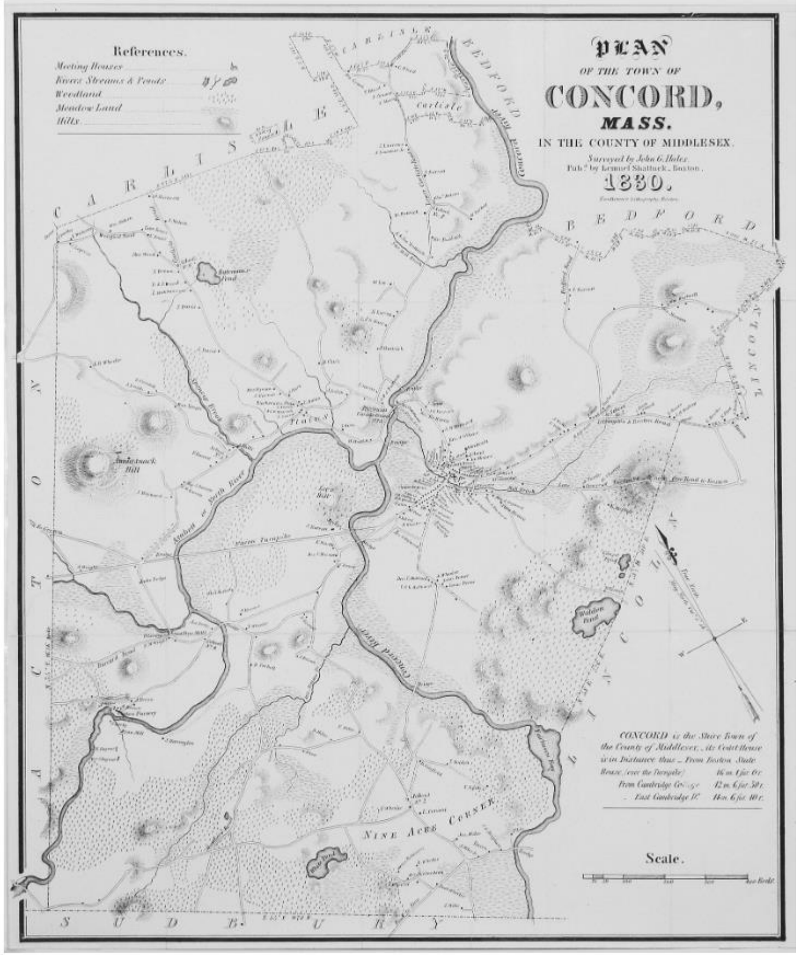
Note: the following slides show historic maps copied from various websites images. Portions of these images are being used, without permission of the owners, for the sole purpose of submitting comments and questions to the Task Force. Reproduction of these images is prohibited. Referenced websites are indicated.

Pre-Dam Wetlands Based on Historical Maps

1830:

Prior to the construction of a dam at Warner's Pond, the Nashoba Brook and Fort Pond Brook tributaries apparently connected and discharged directly to the Assabet River via the stream channel shown below. "Meadowland" is shown along the stream channel and with the low-lying area to the north and east of the channel – current location of the MCI fields north and south of Rt 2. The current elevation within this area, if reflective of 1830, indicates that it would have been wet but likely collected is too high for wetlands.

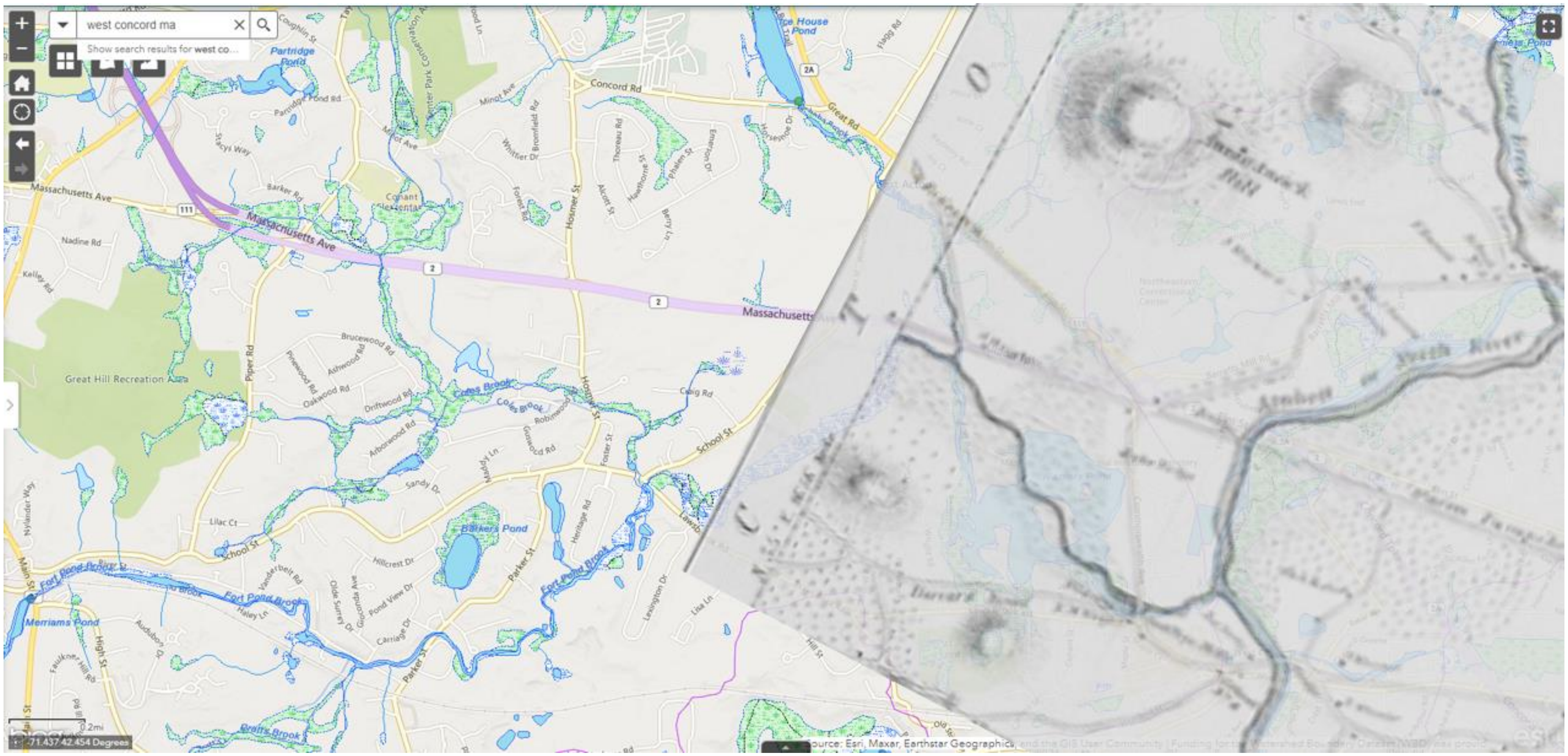




Pre-Dam Wetlands Based on Historical Maps

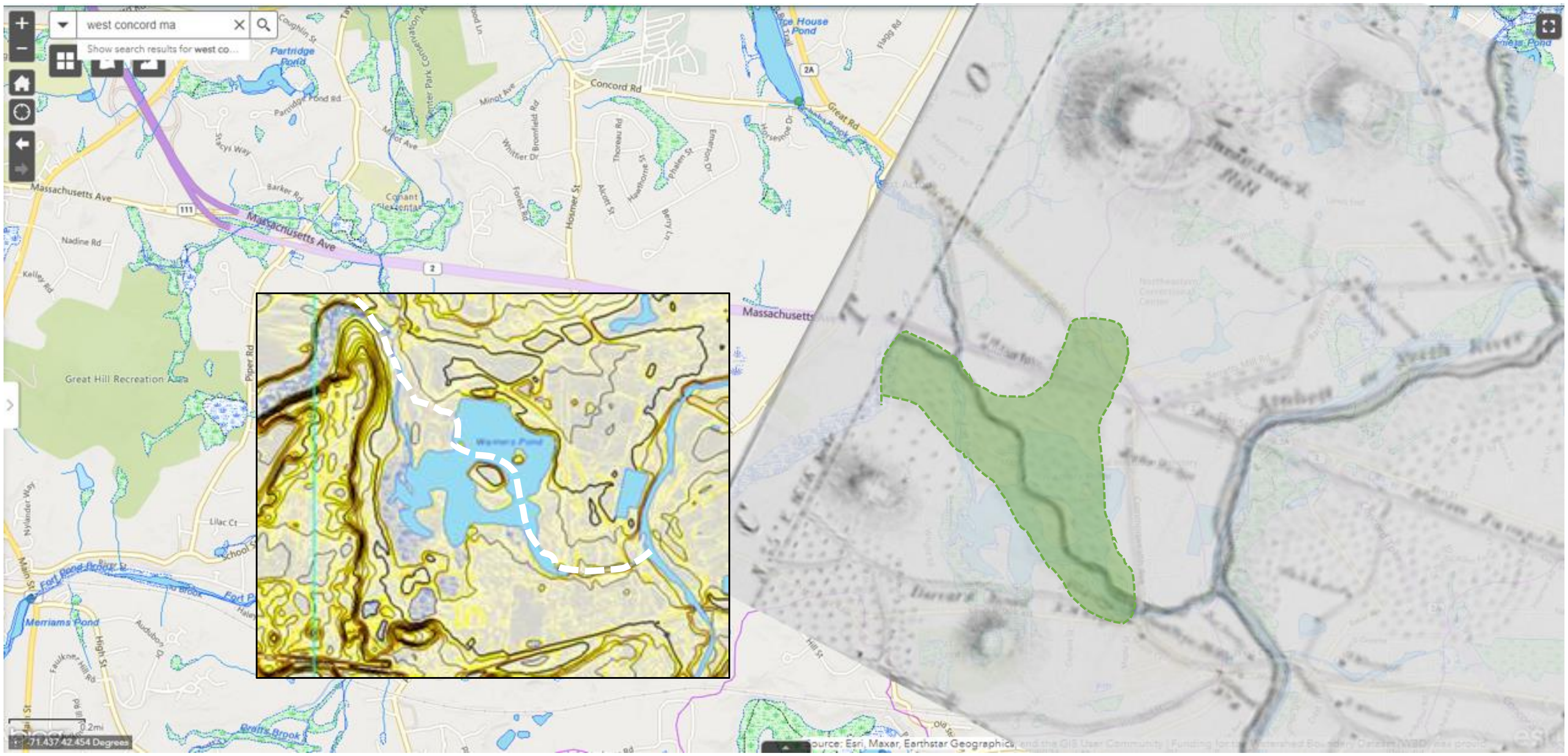
1830:

The location of the former Fort Pond Channel relative to current site conditions was developed by overlaying current and **1830** hydrographic features. This approximation indicates that the location of the channel was north of the pond and was likely relocated. A significant dam does not appear to be present at this time. Since the historical record indicates that Edward Wright built a dam ("2 logs high") in the 1680s, a very low dam may have existed at this time. It is unknown what height the dam would be, but Elevation 115 to 117 feet NAVD88 seems reasonable based on the existing grades.



Pre-Dam Wetlands Based on Historical Maps

1830:
The low dam built starting in the 1680s may have resulted in saturation of low-lying areas, with some wetlands by the 1800s. Assuming the mapped areas of “meadowlands” is indicative of saturated low-lying areas indicating wetlands, the limits of these areas are more clearly indicated below (shaded in green). A comparison of these areas to the area topography indicates that these are low-lying areas (around 120 feet to 125 feet NAVD88 that are adjacent to the stream. The meadowlands may have been present, in part, due to the low dam. Wetlands are not present in the areas southwest of the former stream channel, where extensive wetlands currently are present .



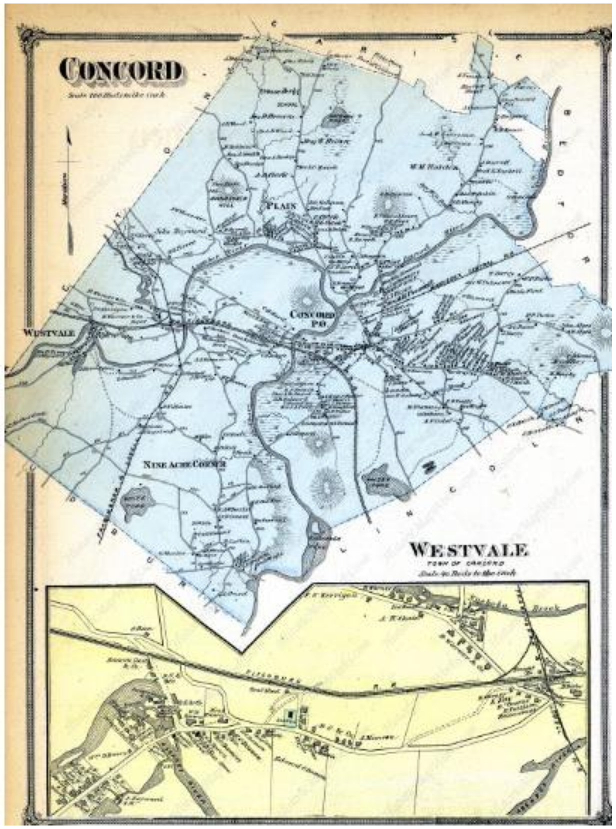
Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community

Pre-Dam Wetlands Based on Historical Maps

1875:

An approximation of the former Nashoba Brook river channel is based on an **1875** topographic survey. This survey appears to indicate that the stream has not yet been relocated to its current location and the area around the former channel area (the current MCI farm fields) have not yet been filled. A substantial dam, to higher elevation, has been constructed by 1875 (likely around 1859 to 1860). This image shows the wetlands present at that time. At this time, no wetlands are shown to the west and south of the stream channel and pond. Wetlands are clearly delineated to the north and east of the stream channel – current location of the MCI fields south of Rt 2 and consistent with the location of wetlands shown in the 1830 historical map. The railroad is also present (current Bruce Freeman Rail Trail). The area of the MCI farm fields shown as wetlands in this image were subsequently filled and the stream channel relocated.

[Concord, Atlas: Middlesex County 1875, Massachusetts Historical Map (historicmapworks.com)](https://historicmapworks.com)



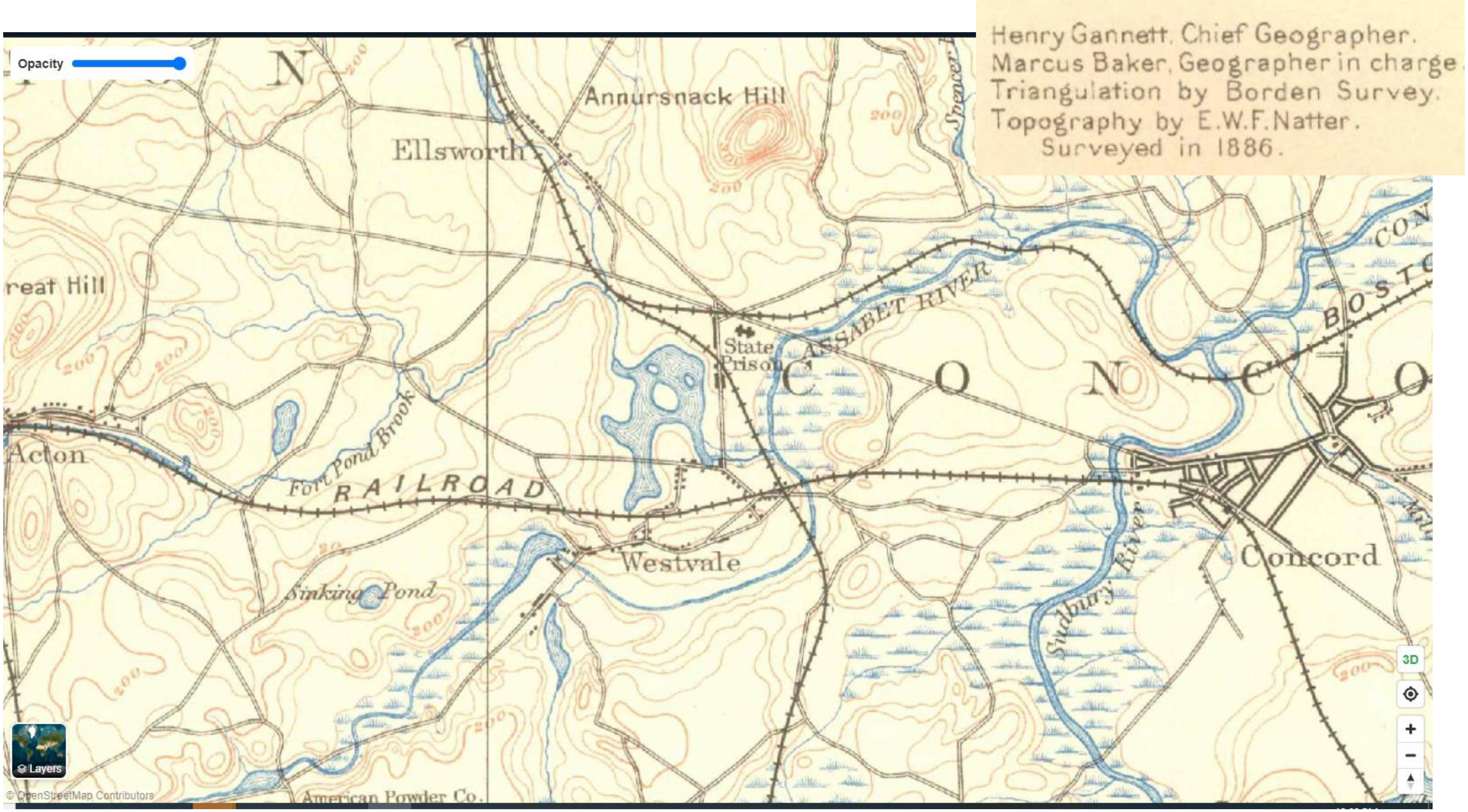
From **Middlesex County 1875**, Massachusetts
Published by F. W. Beers in 1875

Pre-Dam Wetlands Based on Historical Maps

The assumption that the location of the original channel north of the pond was relocated to the west of the pond is supported by current aerial photographs, which indicate (saturated dark areas) the original channel location (which is also generally consistent with the 1830 map). The dark areas between the Bruce Freeman Rail Trail and Rt 2 indicate former wetlands that were filed. This also is consistent with the location of former wetlands indicated on te historical maps and surveys.

Pre-Dam Wetlands Based on Historical Maps

1886:
An approximation of the former Nashoba Brook river channel is based on an **1886** topographic survey. This survey appears to indicate that the stream has been relocated to approximately its current location and the former channel area (the current MCI farm fields) have been filled, including filling the former wetlands in this area. Although wetlands are clearly indicated on this map, wetlands are indicated to no longer present around the pond. The topography is generally consistent with current topography.



Henry Gannett, Chief Geographer.
Marcus Baker, Geographer in charge.
Triangulation by Borden Survey.
Topography by E.W.F. Natter.
Surveyed in 1886.

Pre-Dam Wetlands Based on Historical Maps

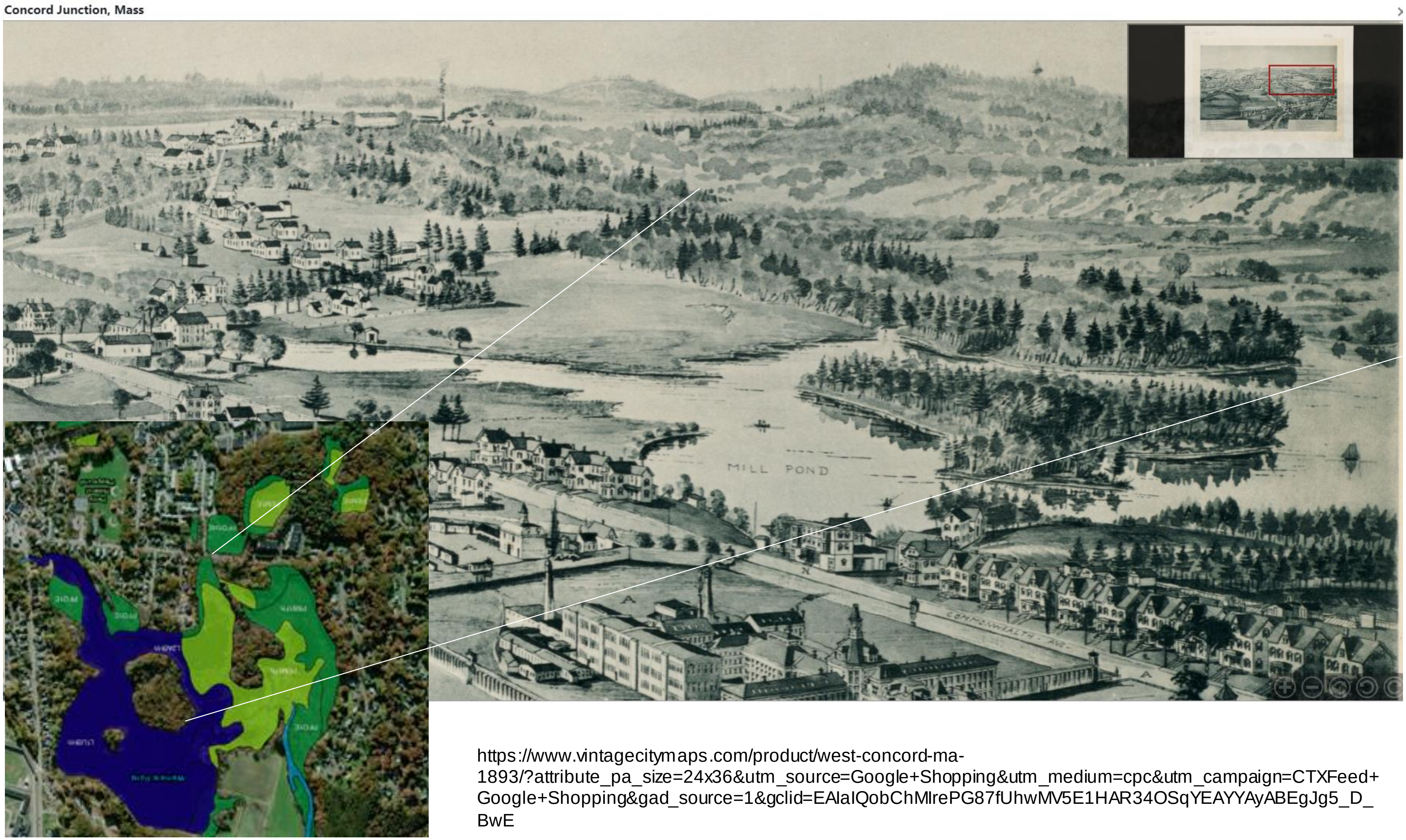
1886:

This survey map, which appears reasonably accurate when overlain with current features, also indicates pond open water across Laws Brook Road nearly to the railroad tracks (which are the current tracks for the commuter rail). These areas are currently seasonally-flooded freshwater forested/shrub wetland. Neither these wetlands nor pond surface water are indicated in the 1875 map. This possibly reflects the increase in dam height in the mid-1850s. It also indicates artificial flooding of low-lying areas to the west, southwest and south of the pond. Flooding of these areas and relocation of the stream channel further the west of the pond (due to filing of the MCI fields) also began the process of depositing sediment along the western portion of the pond, which has now transformed to wetlands. Historic and current pond images shown side by side.

Pre-Dam Wetlands Based on Historical Maps

1890s:

This excerpt from the 1893 birds-eye view of Concord Junction created by George Norris shows portions of Warner’s Pond quite clearly. The wetlands currently existing to the west of the pond (between the pond and the topographically high ridge) are partially indicated with the image appearing to show some flooded areas. However, the wetlands appear much less extensive than current.



https://www.vintagecitymaps.com/product/west-concord-ma-1893/?attribute_pa_size=24x36&utm_source=Google+Shopping&utm_medium=cpc&utm_campaign=CTXFeed+Google+Shopping&gad_source=1&gclid=EAIaIQobChMIrePG87fUhwMV5E1HAR34OSqYEAYYAyABEgJg5_D_BwE

Pre-Dam Wetlands Based on Historical Maps

1907 to 1910:

This excerpt from a 1907 to 1910 Town Map shows the limits of Warner's Pond surface water at that time.

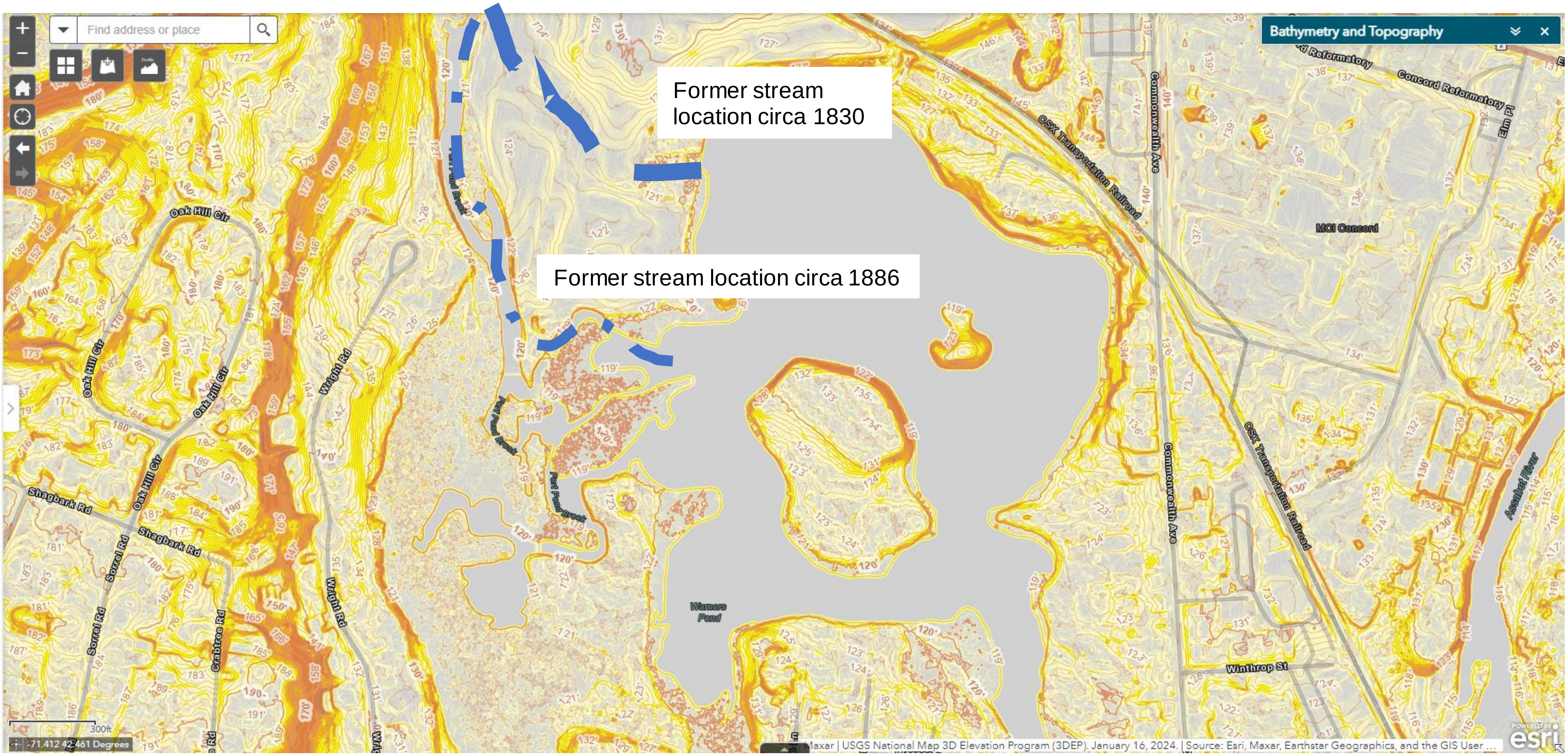
Pre-Dam Wetlands Based on Historical Maps

1940s:
This aerial photo from the 1940s (left) compared to current (right) shows much more surface water in the western portions of the Pond (where emergent wetland are now present, indicating significant sedimentation in this area over the last 80 years. Similar to the 1893 image, the area farther to the west (along the ridge) appears much drier than current although that may be an artifact of the image.

https://www.mapsonline.net/concordma/index.html#x=-7951013.836845,5229443.326944,-7946427.615148,5231638.50285

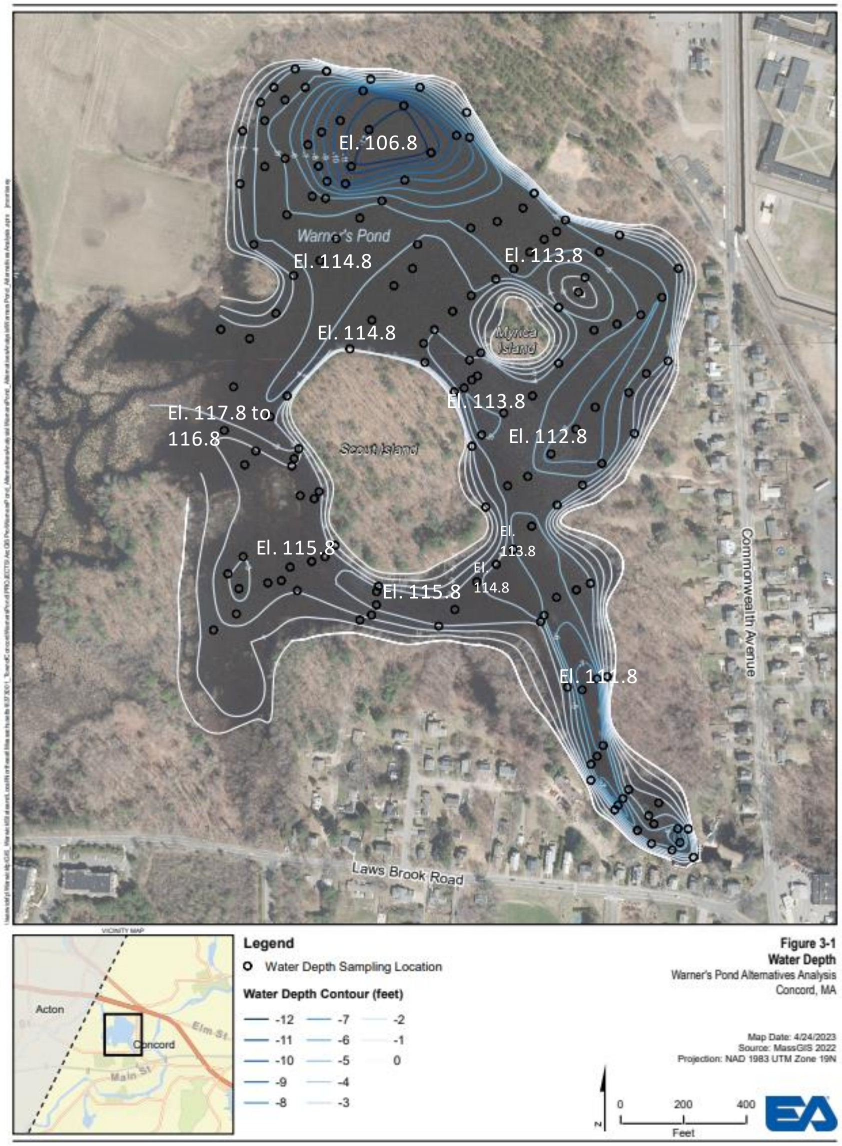
Pre-Dam Wetlands Based on Historical Maps

The former channel locations are shown below relative to the current topography.



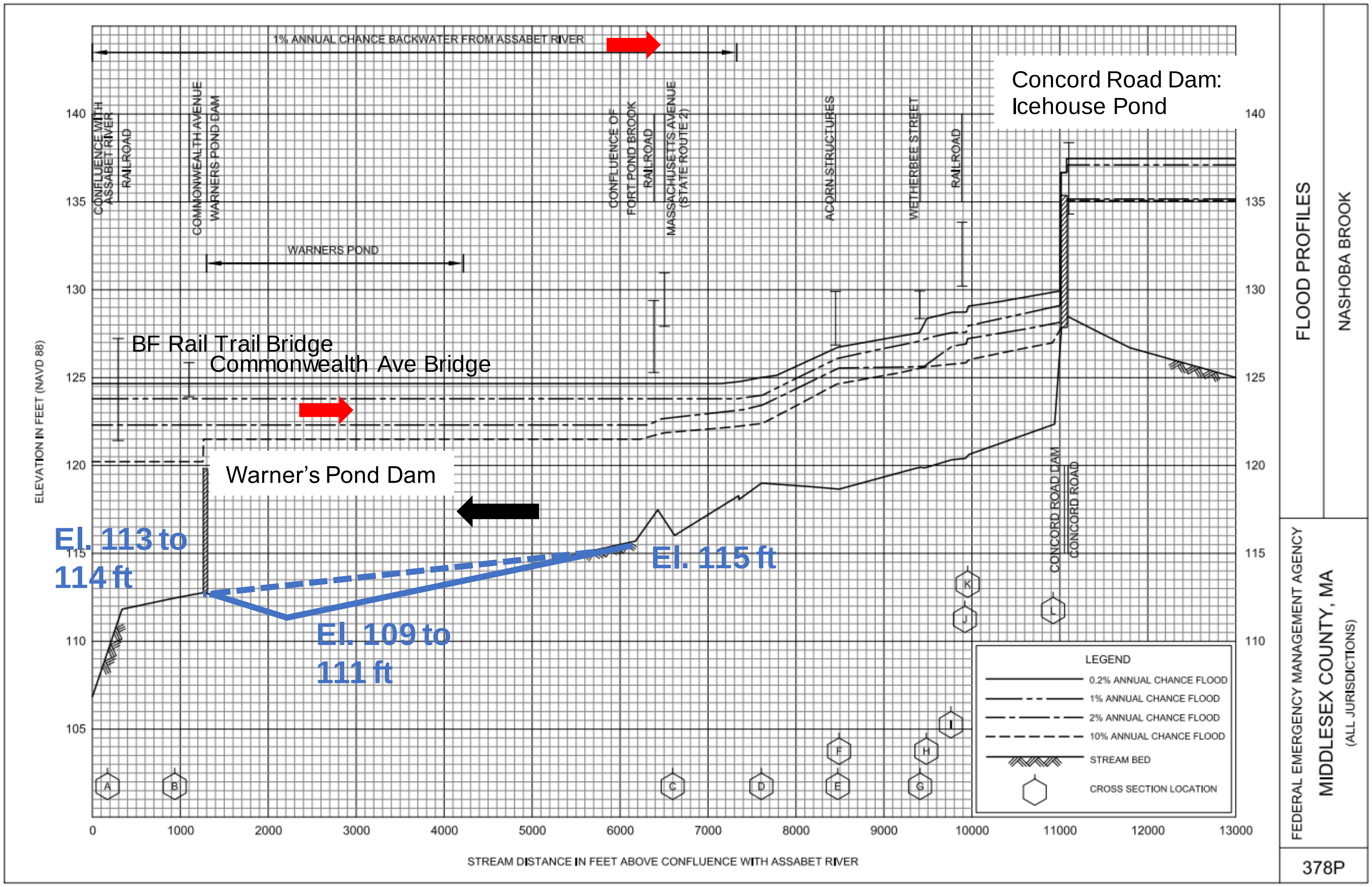
Future of Wetlands if the Dam is Removed

The dam removal alternative includes creation of a new, approximately 4,700 lf new stream channel. Details are not available at this date. However, although very approximate and preliminary, it may be that the new stream channel will have a relatively flat gradient, with an upstream (where it connects to the Fort Pond Brook) thalweg elevation of about 115 feet NAVD88 to a downstream (near the dam) thalweg elevation of about 111 feet NAVD88, rising to about 113 feet to 114 feet before the bridge at Commonwealth Avenue. Based on Nashoba Brook discharge, the channel width will likely be at least 80 feet, about 3 feet deep.



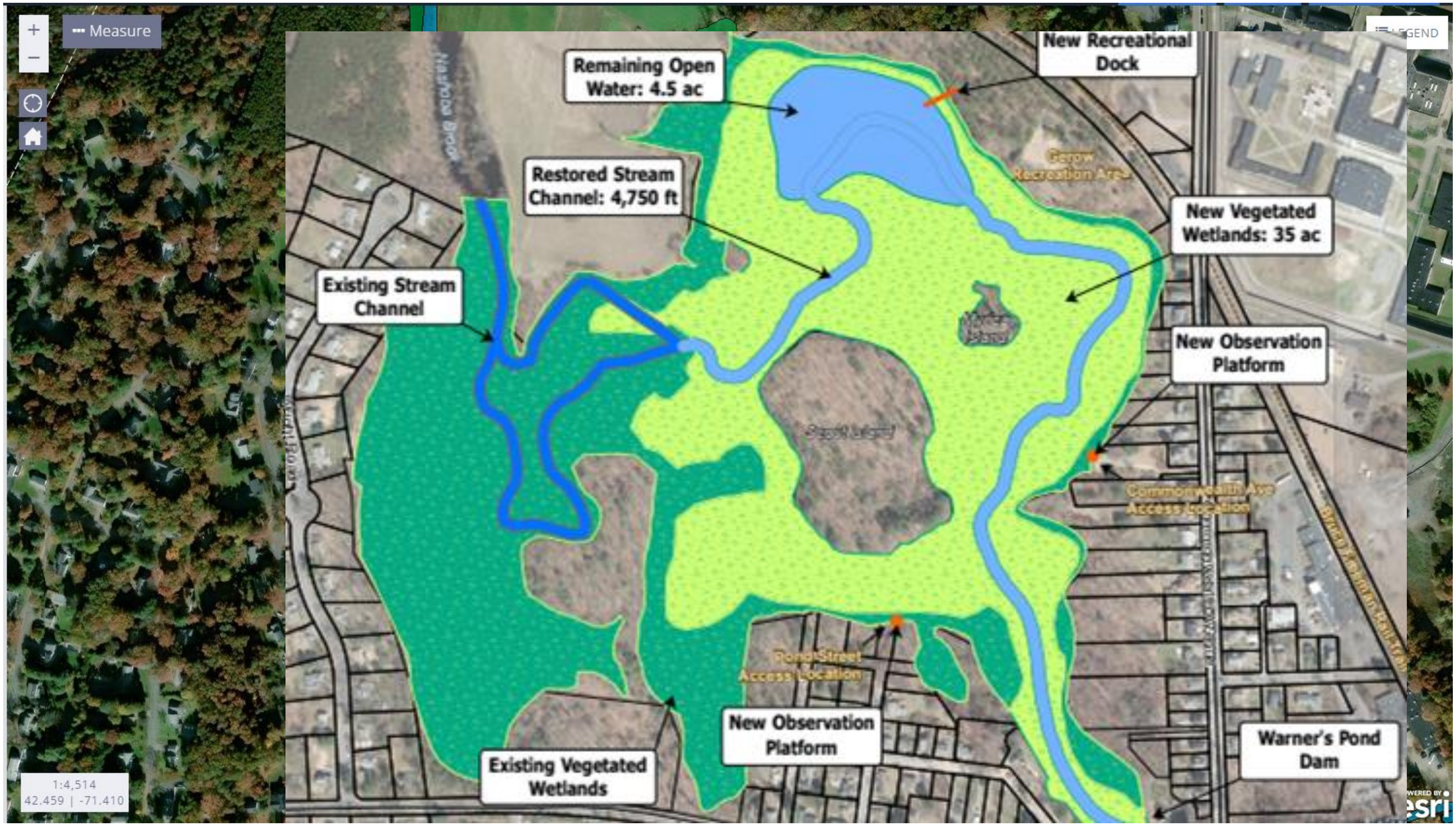
Dam Removal New Stream Channel Gradient Relative to FEMA Nashoba Brook Flood

The dashed blue line indicates the likely gradient of a new stream channel, with the dam removal alternative.



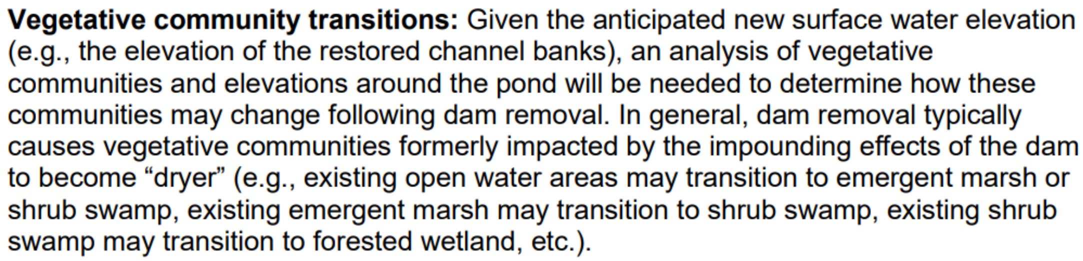
Future of Wetlands if the Dam is Removed

The image below shows the proposed new stream channel, pond and wetlands as presented in the EA Alternatives Analysis Report. However, the report does state that wetlands transition should be expected and that detailed analyses are required to evaluate and predict those transitions.



Future of Wetlands if the Dam is Removed

From EA Alternatives Analysis Report…



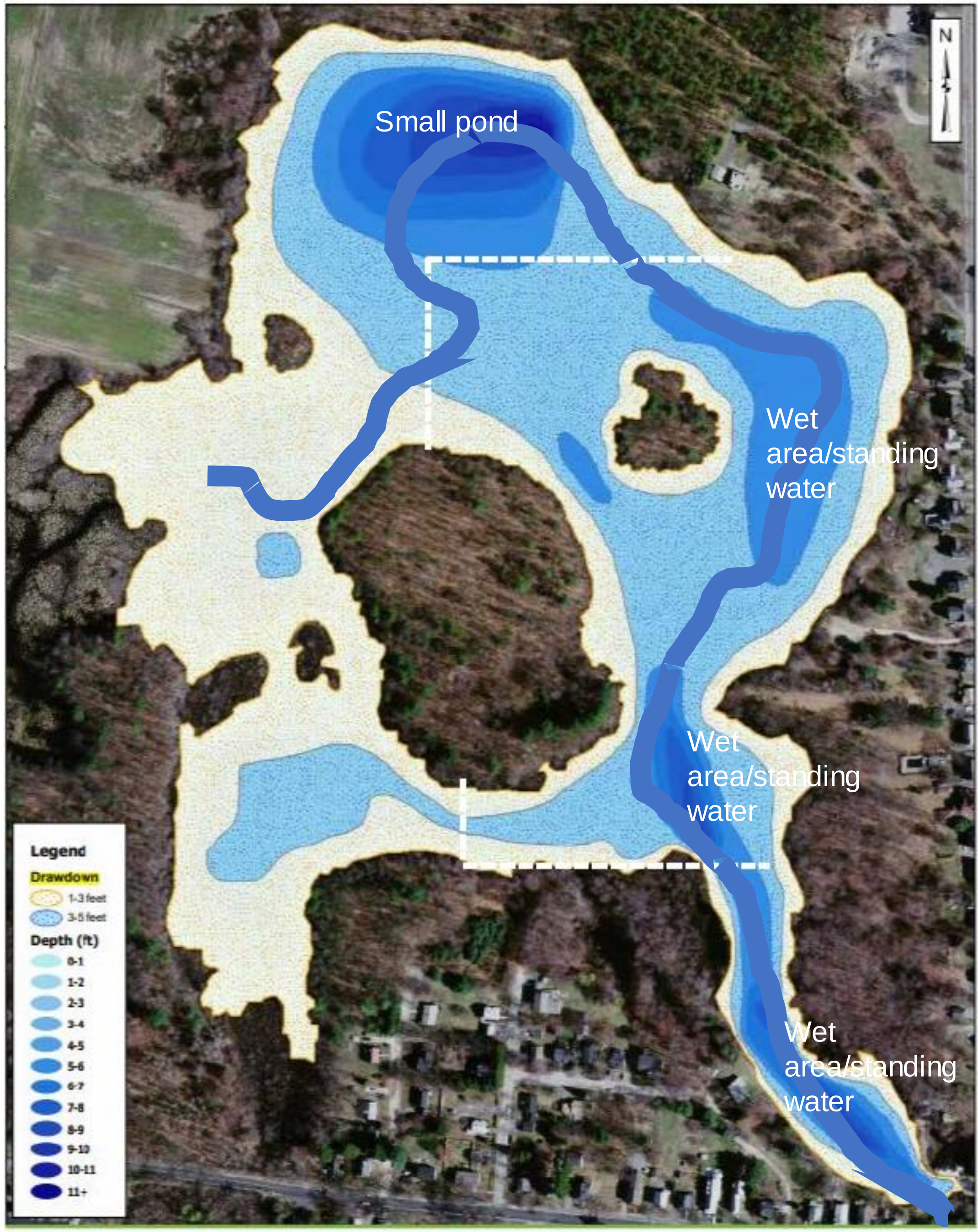
Vegetative community transitions: Given the anticipated new surface water elevation (e.g., the elevation of the restored channel banks), an analysis of vegetative communities and elevations around the pond will be needed to determine how these communities may change following dam removal. In general, dam removal typically causes vegetative communities formerly impacted by the impounding effects of the dam to become "dryer" (e.g., existing open water areas may transition to emergent marsh or shrub swamp, existing emergent marsh may transition to shrub swamp, existing shrub swamp may transition to forested wetland, etc.).

Review of historical maps and surveys and the area topography, hydrology and geology indicate:

1. Based on assumed new channel dimensions and flow, the stream discharge **may not be adequate to maintain wetlands beyond the adjacent frequently-flooded floodplains**. This should be evaluated by the Town.
2. **The historical maps do not indicate an extensive wetland system (pre-dam) in this area**. Wetlands were located along the former stream floodplain and few low-lying areas (current MCI fields). The historic re-location of the stream channel to the west, along with flooding of low-lying areas to the west and southwest areas of pond created the sedimentation and hydrologic conditions for wetlands in these areas, and it appears that over the last 160 years these areas have transformed from shallow open water and low-lying dry areas to Forested and Emergent wetlands. **This would indicate a potential scenario (1) where much of the wetlands disappear and convert to woodlands in the years following the dam removal.**
3. Based on very limited available data, groundwater elevations in the pond area are estimated to range from about 118 feet to 120 feet NAVD88 (high groundwater) to about 114 feet to 116 feet NAVD88 (low groundwater). The limited groundwater elevation data is shown conceptually in section on the previous slide. The uncertainty with this interpretation is the influence of the impounded water level (El 118.8 feet NAVD88) on the surrounding groundwater elevation. **It may be that similar to other surface water including rivers and streams, at periods of high groundwater elevation, groundwater contributes to recharge of the Pond and surrounding wetlands and during periods of low groundwater elevation, the impounded water levels maintain vicinity groundwater elevations. However current observations do not indicate significant groundwater contribution to the pond or streams. This has implications for the area whether groundwater can support wetlands should the dam be removed.**
4. Based on topographic and available groundwater data **another, more optimistic, scenario (2) appears feasible where: 1) the pond area (about 40 acres) will partially convert from surface water to Semi-Permanently flooded Emergent wetland and/or Seasonally Flooded wetlands; 2) the existing Emergent wetland (about 19 acres) will convert to a Seasonally Flooded Forested Shrub wetlands or diminish (convert to woodlands); and 3) the existing Forested wetlands (about 9 acres) will diminish (areas outside stream floodplain) and convert to woodland.**

Future of Wetlands if the Dam is Removed

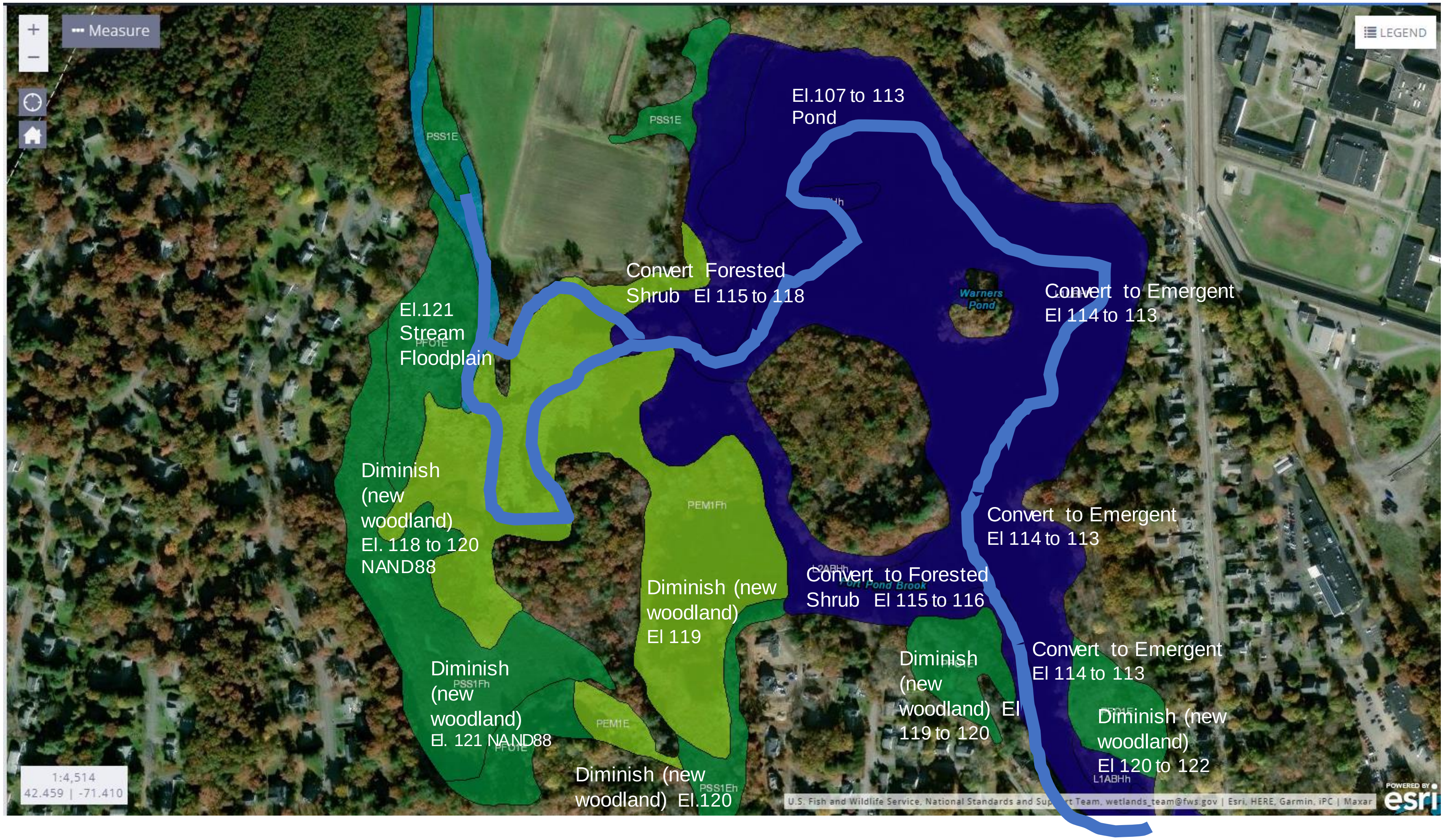
If water levels lower to +-115 feet NAVD88 (about 4 feet below the current Normal Pool Elevation of 118.8 feet NAVD88) during typical flow (+/- 64 cfs), water will be present in shaded areas of darker blue, and lower during dry periods. Proposed new stream channel shown. The lighter blue shaded areas are likely typical of relatively frequent floodplain conditions (+/- 116 feet NAVD88).



Future of Wetlands if the Dam is Removed

Scenario 1:

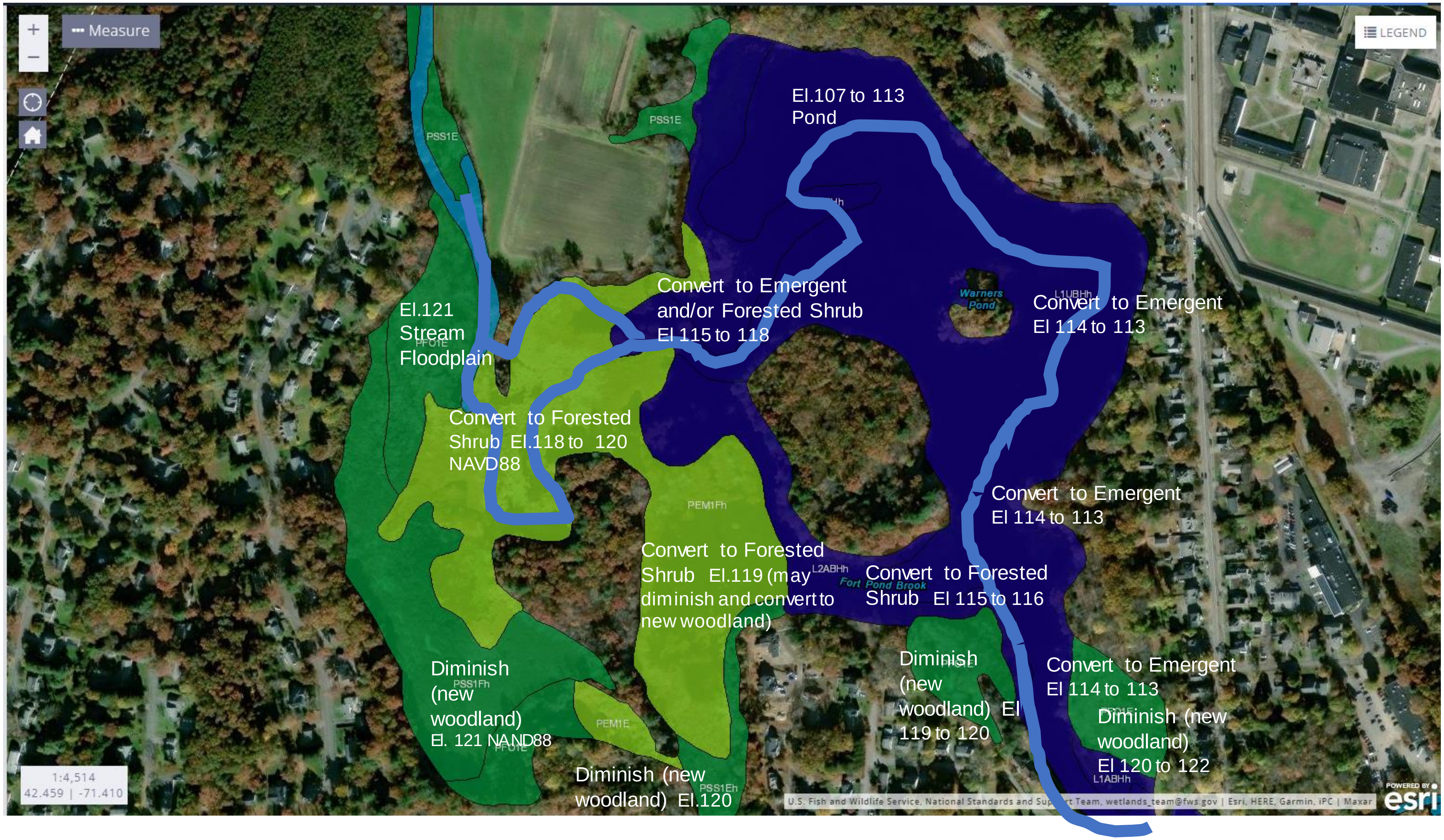
- Only a small portion of the deeper, former pond convers to Emergent Wetlands (Elevation 113 to 114 feet NAVD88)
- About half of the existing wetlands convert to woodland
- The remainder of existing wetlands converts to Forested Shrub.
- About 4 acres will be a very shallow pond (Bottom at El 107 to 113 feet NAVD88)



Future of Wetlands if the Dam is Removed

Scenario 2:

- About 14 acres wetland likely convert to woodland (areas at ≥121 feet NAVD88 and outside stream floodplain)
- About 18 acres convert from Emergent to Forested Shrub (areas at 118 to 120 feet in stream floodplain)
- About 38 acres convert form Lake to Emergent (areas ≤ 114 feet NAVD88 and/or Forested Shrub (areas 115 to 118 feet NAVD88)
- About 4 acres will be a shallow pond (El 107 to 113 feet NAVD88)



Attachment 2

Water Quality, Sedimentation and Productivity of Warner's Pond

Introduction

This attachment presents:

- summary of the Warner’s Pond aquatic vegetation productivity issue
- a brief description of water quality parameters, applicable Massachusetts Water Quality Standards, and the results of Warner’s Pond and tributary water quality testing.
- a comparison of Warner’s Pond water quality to quantitative Massachusetts Water Quality Standards
- a discussion of nutrient loading and vegetation productivity
- a discussion of water depth, light zonation and vegetation productivity
- an overview of aquatic vegetation species and coverage, including biomass, within Warner’s Pond
- a review of the key factors (root causes) contributing to the observed high pond productivity, and the implications of the Pond’s high turnover rate
- a comparison of Warner’s Pond water quality to area main streams and tributaries, including whether there are indications of adverse effects to these water bodies due to Warner’s Pond

Relevance

The high productivity of Warner’s Pond, which has resulted in excessive biomass and plant coverage, and the presence of invasive species are the reasons for which pond mitigation alternatives are currently being considered. This chapter looks at the root causes of this high productivity and the unusual flow characteristics of Warner’s Pond as the basis for understanding Pond processes and to inform the benefits of different mitigation approaches and alternatives. This chapter also looks at the basis of past public statements about the adverse affects of Warner’s Pond on downstream water quality and whether the available information supports those statements.

Summary of Findings

- ✓ Warner’s Pond has excessive aquatic vegetation (biomass and pond cover) due to high aquatic vegetation productivity, with the potential for eutrophication over time. Nutrients (phosphorous and nitrates) entering into and within the Pond are adequate to cause this level of productivity (in fact typical, natural background levels may be adequate if other conditions like photosynthesis are available).
- ✓ While the overall number of different plant species observed in the Pond was relatively high, nearly all of the aquatic plant cover within the Pond was determined to consist of: Fanwort (invasive) or Coontail (native). This includes southwestern portions of the Pond dominated by Water Lily species, where fanwort and variable Watermilfoil were also present as subdominant species. The majority of the other species observed was found at a few limited locations along the shorelines of the southeastern outlet of the pond.
- ✓ Although there is high vegetation productivity in the Pond, based on the available water test data it appears that the current water quality parameters are relatively good (above quantitative Massachusetts Class B Inland Waters standards). In particular, measured dissolved oxygen, turbidity, pH, conductivity and temperature (indicators of eutrophication) appear to exceed (are better than) Massachusetts Class B Inland Waters standards and industry aquatic standards for warm water fisheries.
- ✓ Similar to the Upper Assabet and contributing tributaries, Warner’s Pond waters are consistent with warm water fisheries.
- ✓ The measured Pond water quality parameter values are also generally consistent with (i.e., not worse than) those observed in other Upper Assabet tributaries, including tributaries flowing into Warner’s Pond and tributaries receiving Pond outlet flow.
- ✓ Dissolved oxygen in Nashoba Brook (and likely other tributaries) appears to correlate with streamflow during low flow conditions indicating that during drought years with resultant low stream flows, dissolved oxygen may decrease. Mean summer streamflow appears to be marginally increasing. This low flow relationship with dissolved oxygen is a factor in the National Wetland Inventory wetland characerization for these streams.
- ✓ Long term (1997 to 2023) dissolved oxygen readings in Nashoba Brook, however, do appear to indicate a decline in dissolved oxygen under typical flow conditions of about 4% over that time period (about 0.2% per year). Over the last 10 years, that rate appears to have increased to about 1.1% per year (indicating the mean summer values may be below the 5 mg/l standard in about 17 years. It is not clear whether or not this is specific to this stretch of Nashoba Brook or is indicative of a wider spread condition.
- ✓ Discharge from Warner’s Pond does not appear to adversely affect water quality with the reaches of the Upper Assabet.

Summary of Findings

- ✓ The observed decrease in dissolved oxygen may indicate a similar decrease in Warner’s Pond values. Given the consistency between dissolved oxygen observed in both Pond input and outlet tributaries, it may also indicate a decrease in dissolved oxygen in the tributaries entering the Pond.
- ✓ Given the necessary presence of nutrients (phosphorous and nitrogen) in the water and sediment, the shallow water depth (light zonation and photic zone) appears to be the major contributing factor to the high Pond productivity. Consistently, the areas of greatest biovolume coincide with the shallowest pond depths. Areas where bottom elevations are less than about 113 feet NAVD88 show much less biovolume, and little to no biovolume is present where bottom elevations are less than about 111 feet NAVD88 (about 8 feet below the Normal Pool Elevation of 118.8 feet NAVD88). The observed Secchi Depth at Warner’s Pond (September 2011) was 1.25 meters (4.1 feet), indicating a current pond photic zone of about 8 to 14 feet (Elevations 110.8 feet to 104.8 feet NAVD88, respectively).
- ✓ Atypical to most other ponds including impoundments, the Pond has a **very high** turnover rate, ranging from 0.5 to 1 pond volumes per day during normal flow and one pond volume every 2 to 4 days during August low flow conditions. This very high turnover rate means that nutrients in the water flow through the Pond quickly reducing the likelihood of build-up and algal blooms.
- ✓ The Pond’s spillway flow, with a rocky “riffle” stream channels may also oxygenate the discharging waters.

Issues

Since at least the 1980s, Warner's Pond has indicated: 1) excessively high vegetation productivity with potential for eutrophication (a process where waterbodies receiving excessive nutrients experience excessive plant growth and associated water quality effects); and 2) shallow water depths with on-going sediment deposition, leading to decreased recreational use as well as diminished ecological value from the establishment of several non-native invasive plants. Invasive native and non-native species of plants dominate the Pond today, and open water areas and habitats are dwindling. The increased aquatic vegetation is also impairing the pond's ability to serve the community with regard to recreational opportunities. Water quality remains good at this point in time.

The observed high productivity at Warner's Pond is due to several factors:

- **Shallowness of the Pond**. The Pond is on average only 3 to 4 feet deep, allowing sunlight to penetrate to depth and support plant growth. The shallow depth is due to: 1) the original, shallow Pond bathymetry; and 2) sedimentation over the last several hundred years, which further reduces pond depth.
- **Nutrients:** The presence of nutrients, in particular phosphates and nitrogen, from stormwater runoff within the watershed. Excessive nutrients foster plant growth and algal blooms.

In addition:

- **Invasive Species:** Non-native species, such as Fanwort, are established in the Pond and aggressively dominating pond vegetation.

Pond Flow, Retention Time and High Turnover Rate: Given the size of the pond's watershed and the volume of water contained in the streams feeding the pond, the water entering the pond flushes through the pond relatively rapidly. The very high flushing rate of Warner's Pond is hydrologically and hydraulically atypical relative to other natural ponds and dammed impoundments. **The predicted flushing rate of Warner's Pond indicates that it is more appropriate to view the Pond functioning as a large, wide pool within a river system rather than a pond. The Pond's high flow rate has positive implications for water quality within the Pond as well as downstream of the Pond.**

Pond Water Quality Parameters - Dissolved Oxygen

Oxygen depletion occurs when the demands for oxygen are greater than what is being produced. Oxygen depletion can occur for different reasons. Situations typically associated with oxygen depletion are:

- Hot, cloudy, and still (windless) days;
- Pond stratification followed by turnovers (the mixing of stratified layers, which develop during the summer in ponds 8 ft deep or greater);
- A sudden algal bloom die-off (from natural causes or after a chemical application); and
- Organic waste decomposition (oxygen depletion will occur in the presence of excessive organic matter from waste products, such as uneaten feed).

Whenever DO levels fall below 3 to 4 ppm, oxygen stress will occur. Lack of adequate dissolved oxygen is the leading cause of fish kills. Normal oxygen content in a healthy pond will range from 5 to 10 ppm. Warmwater fish (e.g., bass, bluegill) require about 5 ppm (mg/l) and coldwater fish (e.g., trout, salmon) require about 6.5 ppm (mg/l) to maintain good health. **Dissolved oxygen levels of less than 3 ppm (mg/l) will kill warmwater fish** and levels less than 5 ppm will kill coldwater fish. Fish exposed to low, nonlethal levels of DO over prolonged periods will be chronically stressed, stop eating, and be more susceptible to disease. Low oxygen concentrations also increase the activity of anaerobic bacteria, which create methane and hydrogen sulfide gases during anaerobic decomposition. Ponds with oxygen-poor bottoms and accumulated organic matter can release these gases when the bottom sediment is disturbed. Hydrogen sulfide has a rotten egg smell and is very toxic to fish.

The Massachusetts Class B Inland Waters water quality dissolved oxygen standard for warm water fisheries is $\geq$ 5 mg/l (ppm) and 60% saturation.

Pond Water Quality Parameters - Temperature

Warm water fisheries means a stream, reach, lake or impoundment where water temperature, habitat and other characteristics are suitable for support and propagation of warm water fish and other aquatic life or serving as a spawning or nursery area for warm water fish species. Examples of warm water fish species include large mouth bass and bluegills.

The Massachusetts Class B Inland Waters water quality standard for temperature shall not exceed 83°F (28.3°C) in warm water fisheries with less than 2.8 °C deviation.

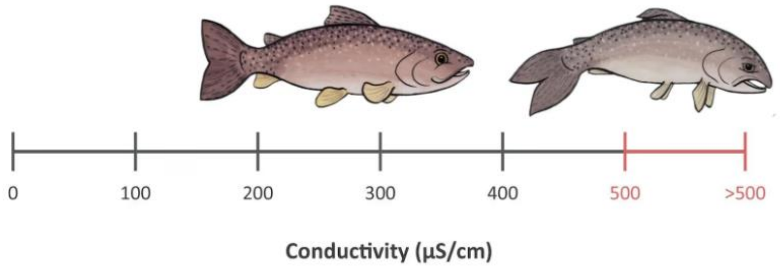
Pond Water Quality Parameters - pH

The term pH refers to the concentration of hydrogen ions and is a measure of whether a substance is an acid, a base, or neutral. The scale of pH values ranges from 0 to 14. Seven (7) represents neutral conditions, values less than 7 indicate more acidic conditions, and values above 7 indicate more alkaline or basic conditions. The pH of freshwater ponds can fluctuate considerably both daily and seasonally; the magnitude of this fluctuation will depend on how well-buffered the freshwater system is. These fluctuations are due to photosynthesis and respiration by plants and animals, which results in the highest pH typically occurring at dusk and the lowest at dawn. This is because during the night respiration increases concentrations of carbon, which interacts with water to produce carbonic acid (H_2CO_3), lowering the pH. During the day, carbon dioxide concentrations decrease because of photosynthesis, driving pH values up.

The Massachusetts Class B Inland Waters water quality temperature standard for pH shall be in the range of 6.5 through 8.3 (alkaline or basic conditions).

Pond Water Quality Parameters – Conductivity (Specific Conductance)

Specific conductance is an indirect measure of the collective concentration of dissolved ions in solution and is defined as the electrical conductance of 1 cubic centimeter (cm³) of a solution at 25 degrees Celsius (°C). Conductivity ranges tell a lot about the quality of water because it is a direct measurement of how many pollutants and contaminants are in the water and an indirect measurement of salinity. Conductivity often fluctuates seasonally. As water gets warmer, conductivity goes up. Additionally, if ponds or lakes do not receive enough rain or stream water, conductivity increases. This is because evaporation takes water away but does not take salts away. When ice forms on a lake in winter, the water below may also become saltier because salts are not incorporated into the ice. When the snow and ice melts in the spring, conductivity usually goes down because the meltwater dilutes the concentration of salts.



Conductivity is an indirect measure of the saltiness of the water. Fish and bugs that live in freshwater cannot tolerate large increases in saltiness because they are not adapted to saline (salty) water, like marine fish are.

Studies of inland fresh waters indicate that streams supporting good mixed fisheries have a conductivity range between 150 and 500 µhos/cm. Conductivity outside this range could indicate that the water is not suitable for certain species of fish or macroinvertebrates. Industrial waters can range as high as 10,000 µmhos/cm.

Pond Water Quality Parameters - Nutrients

The observed high productivity and potential eutrophication of Warner's Pond reflects a pond ecosystem with shallow depth and light zonation and excessive nutrients relative to its depth and hydraulic capacity.

Various nutrients are required to maintain a healthy pond ecosystem. Important nutrients for ponds include potassium, iron, magnesium and manganese. The two most important nutrients in pond management are nitrogen and phosphorus. Too little nitrogen or phosphorus can limit the growth of plants. Conversely, too much nitrogen or phosphorus can cause excessive growth of algae and plants.

Nutrients likely enter Warner's Pond in a number of ways, including leaching from sediments, decomposition of dead plant and animals, and fecal matter from livestock, waterfowl and on-site septic systems. However, most nutrients probably come from runoff from surrounding land. Runoff occurs when rainwater or excessive irrigation within the watershed collects nutrients and discharges them directly to the Pond, tributaries or stormwater outlets.

Some of the nutrients are dissolved in the water; others are attached to sediment as it moves into a pond. For example, phosphorus in water comes in two forms: dissolved and particulate. Dissolved phosphorus enters the aquatic environment from fertilizers, crop residues, or human or animal wastes, and is the form that is readily available to aquatic plants and algae.

Particulate phosphorus is bound to soil and sediment particles and minerals that contain aluminum, iron, or calcium, as well as to organic matter, and enters aquatic systems primarily through soil erosion and surface runoff, as suspended sediment. While it may not be as readily available to aquatic plants, particulate phosphorus can accumulate in sediments and can be a source of slow release of phosphorus into the water for years. Total phosphorous, which measures all forms of phosphorous, was measured in the Warner's Pond Water Quality testing as well as testing by OARs.

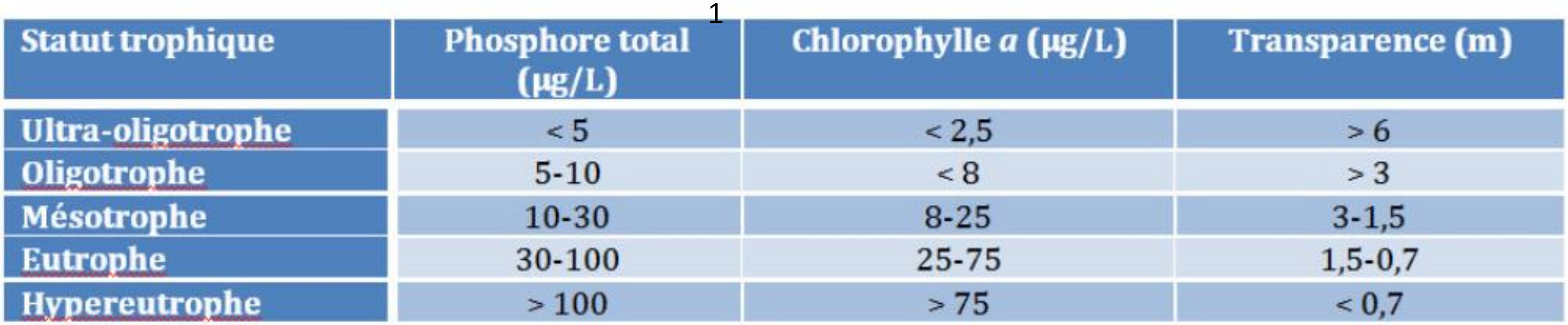
Once these nutrients enter a pond, they will contribute to plant and algae growth. The natural levels of phosphate usually range from 0.005 to 0.05 mg/l (ppm). The natural background levels of total phosphorus are generally less than 0.03 mg/l.

The increasing concentration of available phosphorus allows plants to assimilate more nitrogen before the phosphorus is depleted. Thus, if sufficient phosphorus is available, elevated concentrations of nitrates will lead to algal blooms. Although levels of 0.08 to 0.10 ppm phosphate may trigger periodic blooms, long-term eutrophication will usually be prevented if total phosphorus levels are below 0.5 ppm and 0.05 ppm, respectively. In general, total phosphorus readings exceeding 0.020 mg/l (ppm) are considered eutrophic, or highly productive. Readings below 0.010 mg/l (ppm) are considered oligotrophic, or highly unproductive. Ponds and lakes in the intermediate range are considered mesotrophic.

Understanding Water Quality Parameters to Better Manage Your Pond | New Mexico State University - BE BOLD. Shape the Future. (nmsu.edu)

Pond Water Quality Parameters - Nutrients

[1]



Statut trophique	Phosphore total (µg/L)	Chlorophylle *a* (µg/L)	Transparence (m)
Ultra-oligotrophe	< 5	< 2,5	> 6
Oligotrophe	5-10	< 8	> 3
Mésotrophe	10-30	8-25	3-1,5
Eutrophe	30-100	25-75	1,5-0,7
Hypereutrophe	> 100	> 75	< 0,7

These threshold values make it possible to prioritize water bodies. **Oligotrophic** refers to a nutrient-poor environment with reference to its phosphorus concentration. A **hypereutrophic** environment is, on the contrary, the ultimate stage of degradation. The term mesotrophic refers to a transitional environment between ultra-oligotrophic and hypereutrophic. In rivers, attention to eutrophication problems is more recent. Rivers are considered as **self-purifying** systems, capable of digesting and discharging far downstream disturbances at a given point in the hydrographic network.

Eutrophic conditions can occur with total phosphorous values on 0.03 mg/l to 1 mg/l and possibly as low as 0.01 mg/l dependent upon pond hydrology, hydraulics and depth.

Note 1: 1 ug/l (ppb) = 1000 mg/l (ppm) 30ug/l = 0.03 mg/l; 100 ug/l = 0.1 mg/l

Phosphorus and eutrophication - Encyclopedia of the Environment (encyclopedie-environnement.org)

Pond Water Quality Parameters – Secchi Depths and Turbidity

Turbidity and Secchi Depths are measures of water clarity. Turbidity describes the amount of light scattered or blocked by particles floating in the water. In rivers and lakes, these particles can come from algae and other plant material, soils, silt and clay, and other substances in the water like salts, minerals and metals. The measurement of water clarity using a Secchi disk is known as Secchi Depth Transparency. This is a direct measure of how deep sunlight penetrates the water column and an indirect measure of the amount of suspended material (algae, microscopic organisms, and sediment) in the water column.

Oligotrophic waterbodies are clear to great depths and have low nutrient, or productivity levels. At the other end of the spectrum are eutrophic lakes, having low water clarity and high productivity levels. Mesotrophic lakes occupy the middle range.

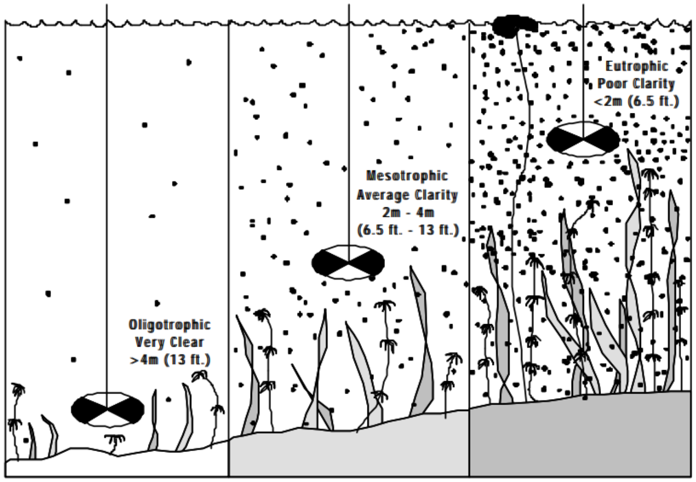
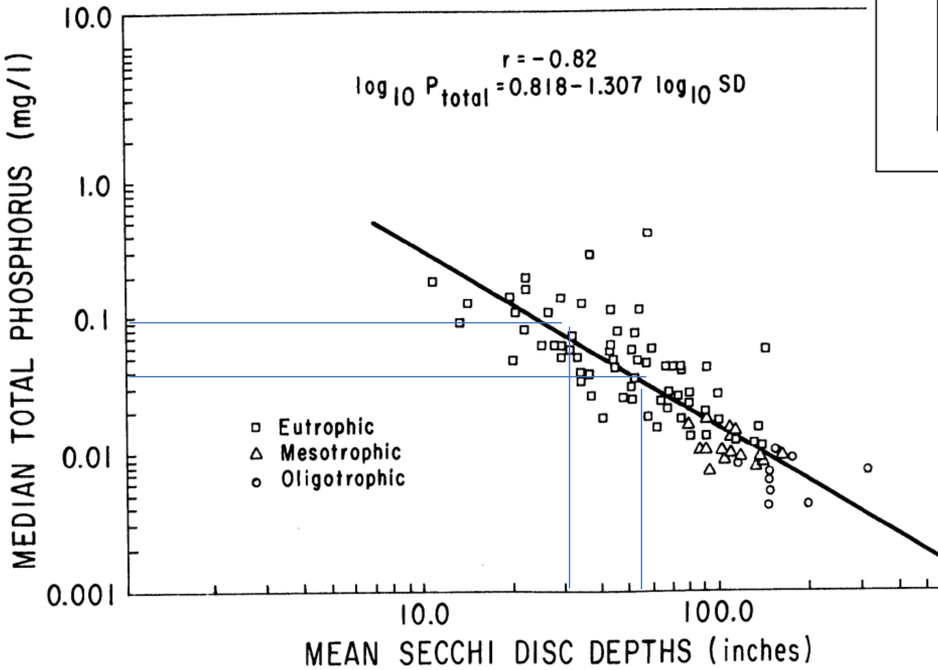


Figure 1:
Water Clarity and Secchi Depth Measurements
This diagram illustrates how Secchi depth measurements are influenced by algae, suspended sediments, and aquatic plants. Ranges of Secchi depth measurements are correlated with the appropriate trophic status.



Massachusetts Water Quality Standards

Warner’s Pond is a Massachusetts Class B Inland Water. Class B Inland Waters are designated as a habitat for fish, other aquatic life, and wildlife, including for their reproduction, migration, growth and other critical functions, and for primary and secondary contact recreation:

a. Dissolved Oxygen (DO): Shall not be less than 6.0 mg/l in cold water fisheries and not less than 5.0 mg/l in warm water fisheries. Where natural background conditions are lower, DO shall not be less than natural background conditions. Natural seasonal and daily variations that are necessary to protect existing and designated uses shall be maintained.

b. Temperature shall not exceed 83°F (28.3°C) in warm water fisheries. The rise in temperature due to a discharge shall not exceed 3°F (1.7°0C) in rivers and streams designated as cold water fisheries nor 5°F (2.8°C) in rivers and streams designated as warm water fisheries (based on the minimum expected flow for the month); in lakes and ponds the rise shall not exceed 3°F (1.7°0C) in the epilimnion (based on the monthly average of maximum daily temperature);

c. pH. Shall be in the range of 6.5 through 8.3 standard units and not more than 0.5 units outside of the natural background range. There shall be no change from natural background conditions that would impair any use assigned to this Class.

d. Solids. These waters shall be free from floating, suspended and settleable solids in concentrations and combinations that would impair any use assigned to this Class, that would cause aesthetically objectionable conditions, or that would impair the benthic biota or degrade the chemical composition of the bottom.

e. Color and Turbidity. These waters shall be free from color and turbidity in concentrations or combinations that are aesthetically objectionable or would impair any use assigned to this Class. 7.

f. Oil and Grease. These waters shall be free from oil, grease and petrochemicals that produce a visible film on the surface of the water, impart an oily taste to the water or an oily or other undesirable taste to the edible portions of aquatic life, coat the banks or bottom of the water course, or are deleterious or become toxic to aquatic life. 8. Taste and Odor. None in such concentrations or combinations that are aesthetically objectionable, that would impair any use assigned to this Class, or that would cause tainting or undesirable flavors in the edible portions of aquatic life.

Note: In waters where flows are regulated by dams or similar structures, the lowest flow condition at which aquatic life criteria must be applied is the flow equaled or exceeded 99% of the time on a yearly basis, or another equivalent flow agreed upon by the Department and the federal, state or private entity controlling the flow.

Massachusetts Water Quality Standards

In addition:

a. At bathing beaches as defined by the Massachusetts Department of Public Health in 105 CMR 445.010: where E. coli is the chosen indicator, the geometric mean of the five most recent samples taken during the same bathing season shall not exceed 126 colonies per 100 ml and no single sample taken during the bathing season shall exceed 235 colonies per 100 ml; alternatively, where enterococci are the chosen indicator, the geometric mean of the five most recent samples taken during the same bathing season shall not exceed 33 colonies per 100 ml and no single sample taken during the bathing season shall exceed 61 colonies per 100 ml;

b. Additional Minimum Criteria Applicable to all Surface Waters.

   (a) Aesthetics. All surface waters shall be free from pollutants in concentrations or combinations that settle to form objectionable deposits; float as debris, scum or other matter to form nuisances; produce objectionable odor, color, taste or turbidity; or produce undesirable or nuisance species of aquatic life.

   (b) Bottom Pollutants or Alterations. All surface waters shall be free from pollutants in concentrations or combinations or from alterations that adversely affect the physical or chemical nature of the bottom, interfere with the propagation of fish or shellfish, or adversely affect populations of non-mobile or sessile benthic organisms.

   (c) Nutrients. Unless naturally occurring, all surface waters shall be free from nutrients in concentrations that would cause or contribute to impairment of existing or designated uses and shall not exceed the site-specific criteria developed in a TMDL or as otherwise established by the Department pursuant to 314 CMR 4.00. Any existing point source discharge containing nutrients in concentrations that would cause or contribute to cultural eutrophication, including the excessive growth of aquatic plants or algae, in any surface water shall be provided with the most appropriate treatment as determined by the Department, including, where necessary, highest and best practical treatment (HBPT) for POTWs and BAT for non POTWs, to remove such nutrients to ensure protection of existing and designated uses. Human activities that result in the nonpoint source discharge of nutrients to any surface water may be required to be provided with cost effective and reasonable best management practices for nonpoint source control.

Massachusetts Waterbody Categories

Category 4a waters listed alphabetically by major watershed "TMDL is completed"

Waterbody	AU_ID	Description	Size	Units	Impairment	ATTAINS Action ID
Quabbin Reservoir	MA36129	Petersham/Pelham/Ware/Hardwick/Shutesbury/Belchertown/New Salem.	24,010.00	Acres	(Non-Native Aquatic Plants*)	
					Mercury in Fish Tissue	33880
Quacumquasit Pond	MA36131	Brookfield/East Brookfield/Sturbridge. (also known as South Pond)	223.00	Acres	(Eurasian Water Milfoil, Myriophyllum Spicatum*)	
					(Fanwort*)	
					(Non-Native Aquatic Plants*)	
					Mercury in Fish Tissue	33880
Spectacle Pond	MA36142	Wilbraham.	9.00	Acres	Nutrient/Eutrophication Biological Indicators	3631
Sugden Reservoir	MA36150	Spencer.	85.00	Acres	Nutrient/Eutrophication Biological Indicators	3633
Wickaboag Pond	MA36166	West Brookfield.	316.00	Acres	Turbidity	1332
Concord (SuAsCo)						
Ashland Reservoir	MA82003	Ashland.	168.00	Acres	(Non-Native Aquatic Plants*)	
					Mercury in Fish Tissue	42396
Boons Pond	MA82011	Stow/Hudson.	174.00	Acres	(Fanwort*)	
					(Non-Native Aquatic Plants*)	
					Algae	2353
					Mercury in Fish Tissue	33880
Nutting Lake	MA82124	[West Basin] Billerica.	51.00	Acres	Mercury in Fish Tissue	33880
Sudbury Reservoir	MA82106	Southborough/Marlborough.	1,181.00	Acres	(Eurasian Water Milfoil, Myriophyllum Spicatum*)	
					(Water Chestnut*)	
					Mercury in Fish Tissue	33880
Walden Pond	MA82109	Concord.	63.00	Acres	Mercury in Fish Tissue	33880
Warners Pond	MA82110	Concord.	59.00	Acres	(Water Chestnut*)	
					Mercury in Fish Tissue	33880

Water Quality Testing

Water quality and nutrient testing was performed in 1999.

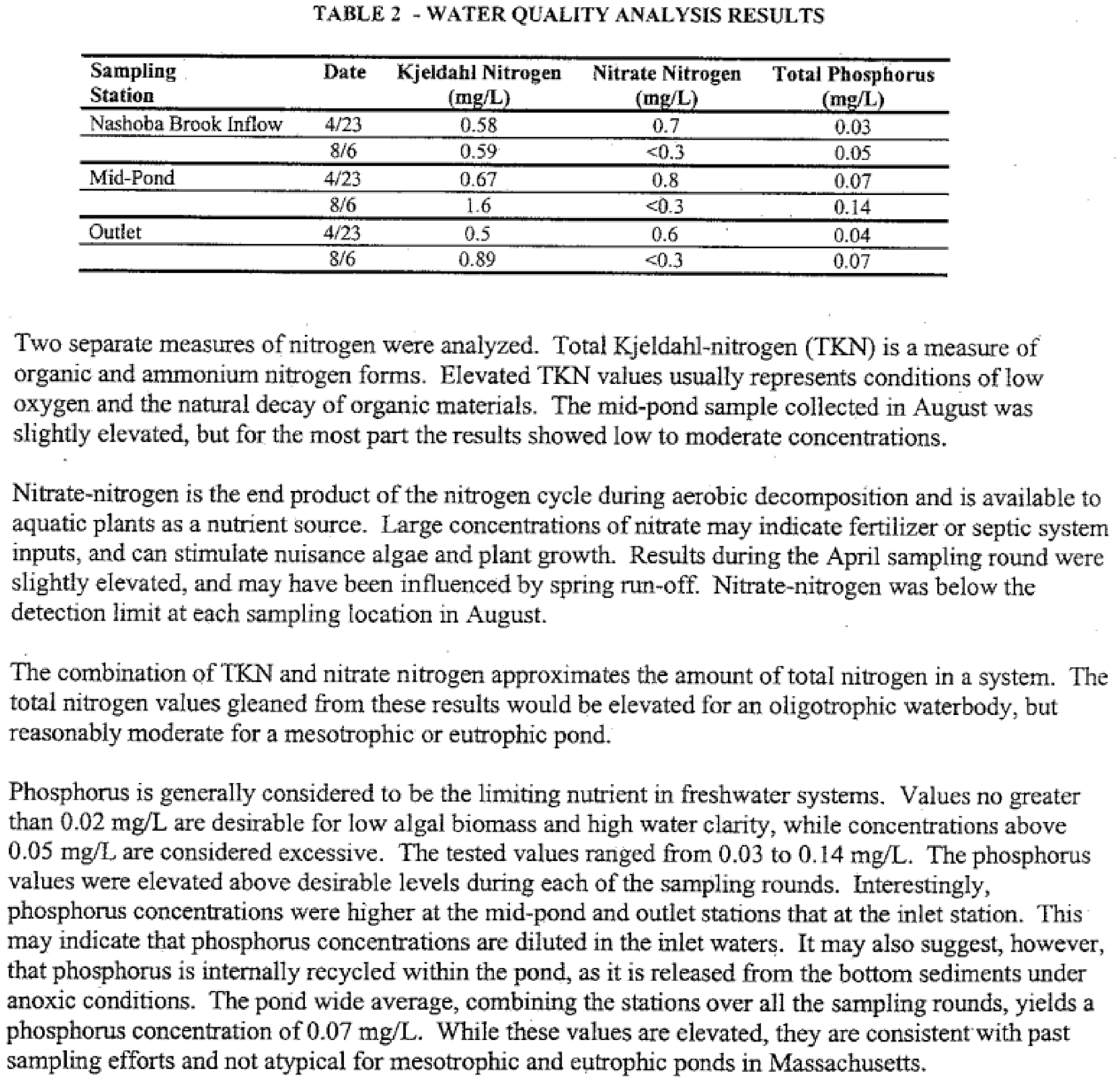


TABLE 2 - WATER QUALITY ANALYSIS RESULTS

Sampling Station	Date	Kjeldahl Nitrogen (mg/L)	Nitrate Nitrogen (mg/L)	Total Phosphorus (mg/L)
Nashoba Brook Inflow	4/23	0.58	0.7	0.03
	8/6	0.59	<0.3	0.05
Mid-Pond	4/23	0.67	0.8	0.07
	8/6	1.6	<0.3	0.14
Outlet	4/23	0.5	0.6	0.04
	8/6	0.89	<0.3	0.07

Two separate measures of nitrogen were analyzed. Total Kjeldahl-nitrogen (TKN) is a measure of organic and ammonium nitrogen forms. Elevated TKN values usually represents conditions of low oxygen and the natural decay of organic materials. The mid-pond sample collected in August was slightly elevated, but for the most part the results showed low to moderate concentrations.

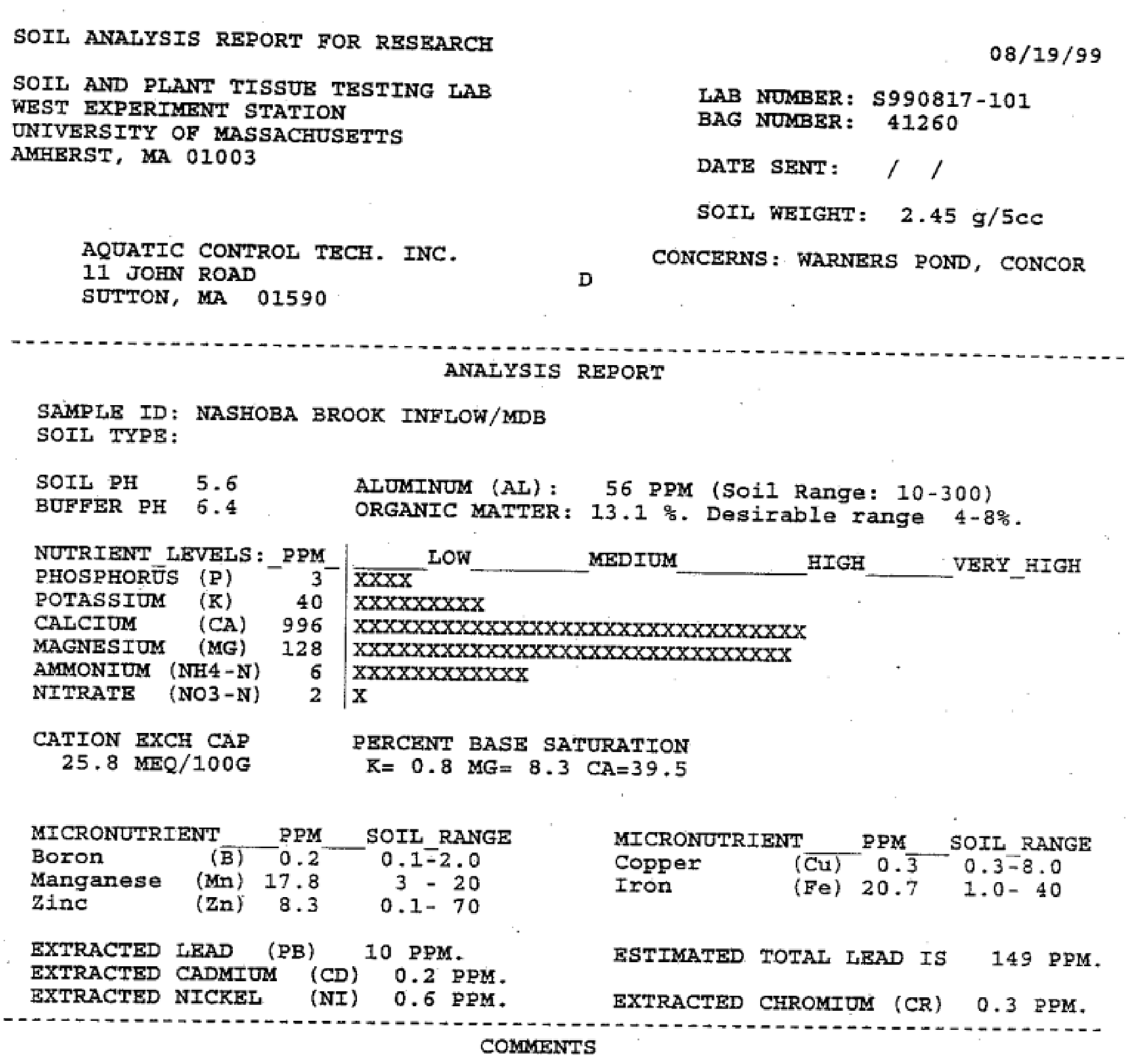
Nitrate-nitrogen is the end product of the nitrogen cycle during aerobic decomposition and is available to aquatic plants as a nutrient source. Large concentrations of nitrate may indicate fertilizer or septic system inputs, and can stimulate nuisance algae and plant growth. Results during the April sampling round were slightly elevated, and may have been influenced by spring run-off. Nitrate-nitrogen was below the detection limit at each sampling location in August.

The combination of TKN and nitrate nitrogen approximates the amount of total nitrogen in a system. The total nitrogen values gleaned from these results would be elevated for an oligotrophic waterbody, but reasonably moderate for a mesotrophic or eutrophic pond.

Phosphorus is generally considered to be the limiting nutrient in freshwater systems. Values no greater than 0.02 mg/L are desirable for low algal biomass and high water clarity, while concentrations above 0.05 mg/L are considered excessive. The tested values ranged from 0.03 to 0.14 mg/L. The phosphorus values were elevated above desirable levels during each of the sampling rounds. Interestingly, phosphorus concentrations were higher at the mid-pond and outlet stations that at the inlet station. This may indicate that phosphorus concentrations are diluted in the inlet waters. It may also suggest, however, that phosphorus is internally recycled within the pond, as it is released from the bottom sediments under anoxic conditions. The pond wide average, combining the stations over all the sampling rounds, yields a phosphorus concentration of 0.07 mg/L. While these values are elevated, they are consistent with past sampling efforts and not atypical for mesotrophic and eutrophic ponds in Massachusetts.

Sediment Nutrient Testing

Sediment nutrient testing was performed in 1999.



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SOIL ANALYSIS REPORT FOR RESEARCH
                                                                08/19/99
SOIL AND PLANT TISSUE TESTING LAB
WEST EXPERIMENT STATION                       LAB NUMBER: S990817-101
UNIVERSITY OF MASSACHUSETTS                   BAG NUMBER:  41260
AMHERST, MA 01003
                                              DATE SENT:    /  /

                                              SOIL WEIGHT:  2.45 g/5cc

   AQUATIC CONTROL TECH. INC.               CONCERNS: WARNERS POND, CONCOR
   11 JOHN ROAD                           D
   SUTTON, MA  01590

------------------------------------------------------------------------------
                             ANALYSIS REPORT

 SAMPLE ID: NASHOBA BROOK INFLOW/MDB
 SOIL TYPE:

 SOIL PH     5.6        ALUMINUM (AL):   56 PPM (Soil Range: 10-300)
 BUFFER PH   6.4        ORGANIC MATTER: 13.1 %. Desirable range  4-8%.

 NUTRIENT_LEVELS:_PPM_|_____LOW________MEDIUM_________HIGH______VERY_HIGH
 PHOSPHORUS  (P)     3 |XXXX
 POTASSIUM   (K)    40 |XXXXXXXXX
 CALCIUM     (CA)  996 |XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
 MAGNESIUM   (MG)  128 |XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
 AMMONIUM (NH4-N)    6 |XXXXXXXXXXXXX
 NITRATE  (NO3-N)    2 |X

 CATION EXCH CAP        PERCENT BASE SATURATION
   25.8 MEQ/100G         K= 0.8 MG= 8.3 CA=39.5

 MICRONUTRIENT____PPM___SOIL_RANGE       MICRONUTRIENT____PPM___SOIL_RANGE
 Boron        (B)  0.2    0.1-2.0        Copper       (Cu)  0.3   0.3-8.0
 Manganese   (Mn) 17.8     3 - 20        Iron         (Fe) 20.7   1.0- 40
 Zinc        (Zn)  8.3    0.1- 70

 EXTRACTED LEAD  (PB)   10 PPM.          ESTIMATED TOTAL LEAD IS   149 PPM.
 EXTRACTED CADMIUM  (CD)  0.2 PPM.
 EXTRACTED NICKEL   (NI)  0.6 PPM.       EXTRACTED CHROMIUM (CR)  0.3 PPM.
------------------------------------------------------------------------------
                                COMMENTS
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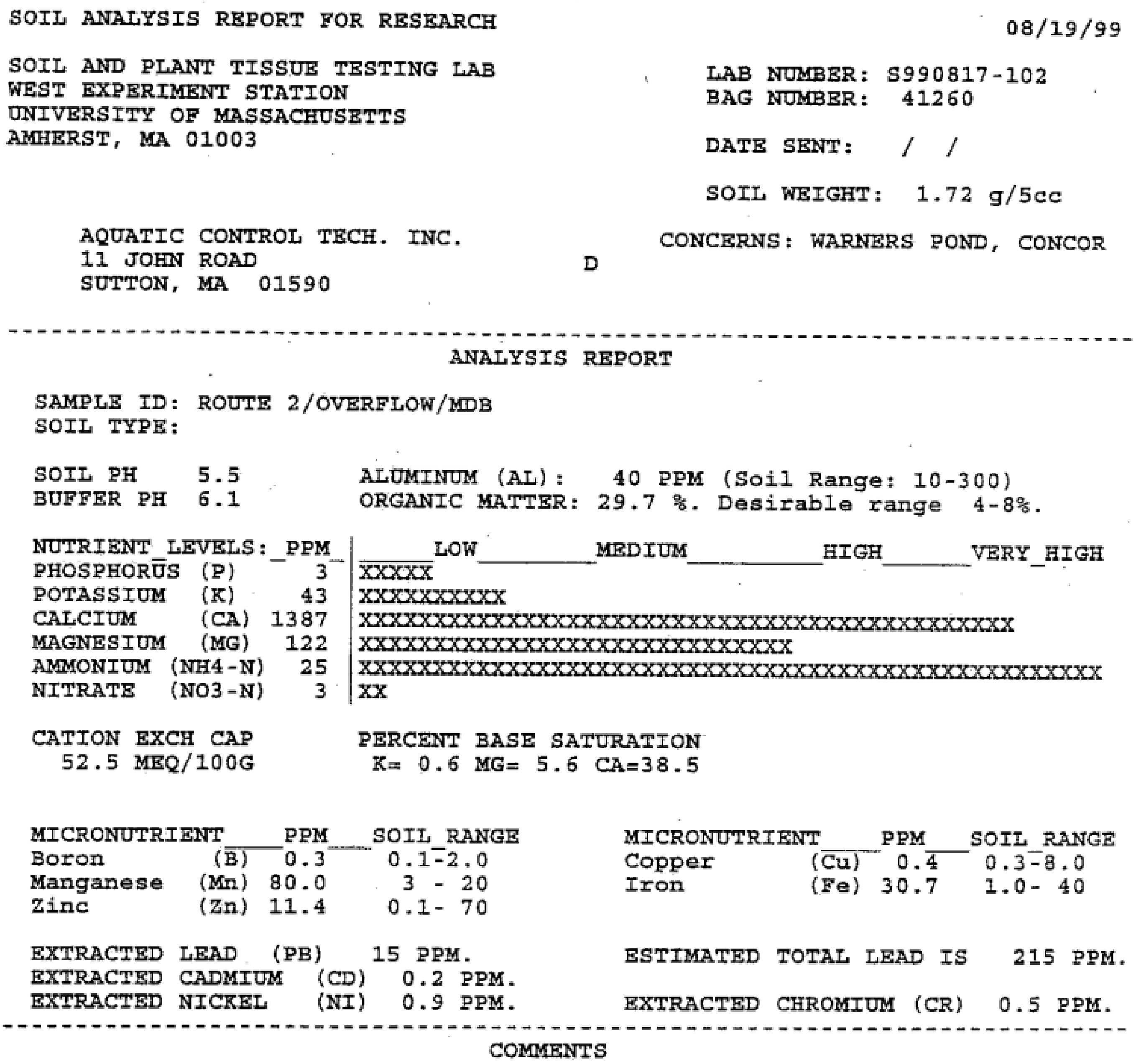
Sediment Nutrient Testing

Sediment nutrient testing was performed in 1999.



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SOIL ANALYSIS REPORT FOR RESEARCH                                    08/19/99

SOIL AND PLANT TISSUE TESTING LAB                       LAB NUMBER: S990817-102
WEST EXPERIMENT STATION                                 BAG NUMBER:  41260
UNIVERSITY OF MASSACHUSETTS
AMHERST, MA 01003                                       DATE SENT:   /  /

                                                        SOIL WEIGHT:  1.72 g/5cc

    AQUATIC CONTROL TECH. INC.                      CONCERNS: WARNERS POND, CONCOR
    11 JOHN ROAD                                D
    SUTTON, MA  01590

------------------------------------------------------------------------------
                                ANALYSIS REPORT

 SAMPLE ID: ROUTE 2/OVERFLOW/MDB
 SOIL TYPE:

 SOIL PH    5.5         ALUMINUM (AL):   40 PPM (Soil Range: 10-300)
 BUFFER PH  6.1         ORGANIC MATTER: 29.7 %. Desirable range  4-8%.

 NUTRIENT_LEVELS:_PPM  |_____LOW_________MEDIUM__________HIGH______VERY_HIGH
 PHOSPHORUS  (P)     3 |XXXXX
 POTASSIUM   (K)    43 |XXXXXXXXXX
 CALCIUM     (CA) 1387 |XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
 MAGNESIUM   (MG)  122 |XXXXXXXXXXXXXXXXXXXXXXXXXXXXX
 AMMONIUM (NH4-N)   25 |XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
 NITRATE  (NO3-N)    3 |XX

 CATION EXCH CAP        PERCENT BASE SATURATION
   52.5 MEQ/100G         K= 0.6 MG= 5.6 CA=38.5


 MICRONUTRIENT____PPM___SOIL_RANGE        MICRONUTRIENT____PPM___SOIL_RANGE
 Boron         (B)  0.3    0.1-2.0        Copper       (Cu)  0.4   0.3-8.0
 Manganese    (Mn) 80.0     3 - 20        Iron         (Fe) 30.7   1.0- 40
 Zinc         (Zn) 11.4    0.1- 70

 EXTRACTED LEAD  (PB)   15 PPM.           ESTIMATED TOTAL LEAD IS   215 PPM.
 EXTRACTED CADMIUM  (CD)  0.2 PPM.
 EXTRACTED NICKEL   (NI)  0.9 PPM.        EXTRACTED CHROMIUM (CR)  0.5 PPM.
------------------------------------------------------------------------------
                                  COMMENTS
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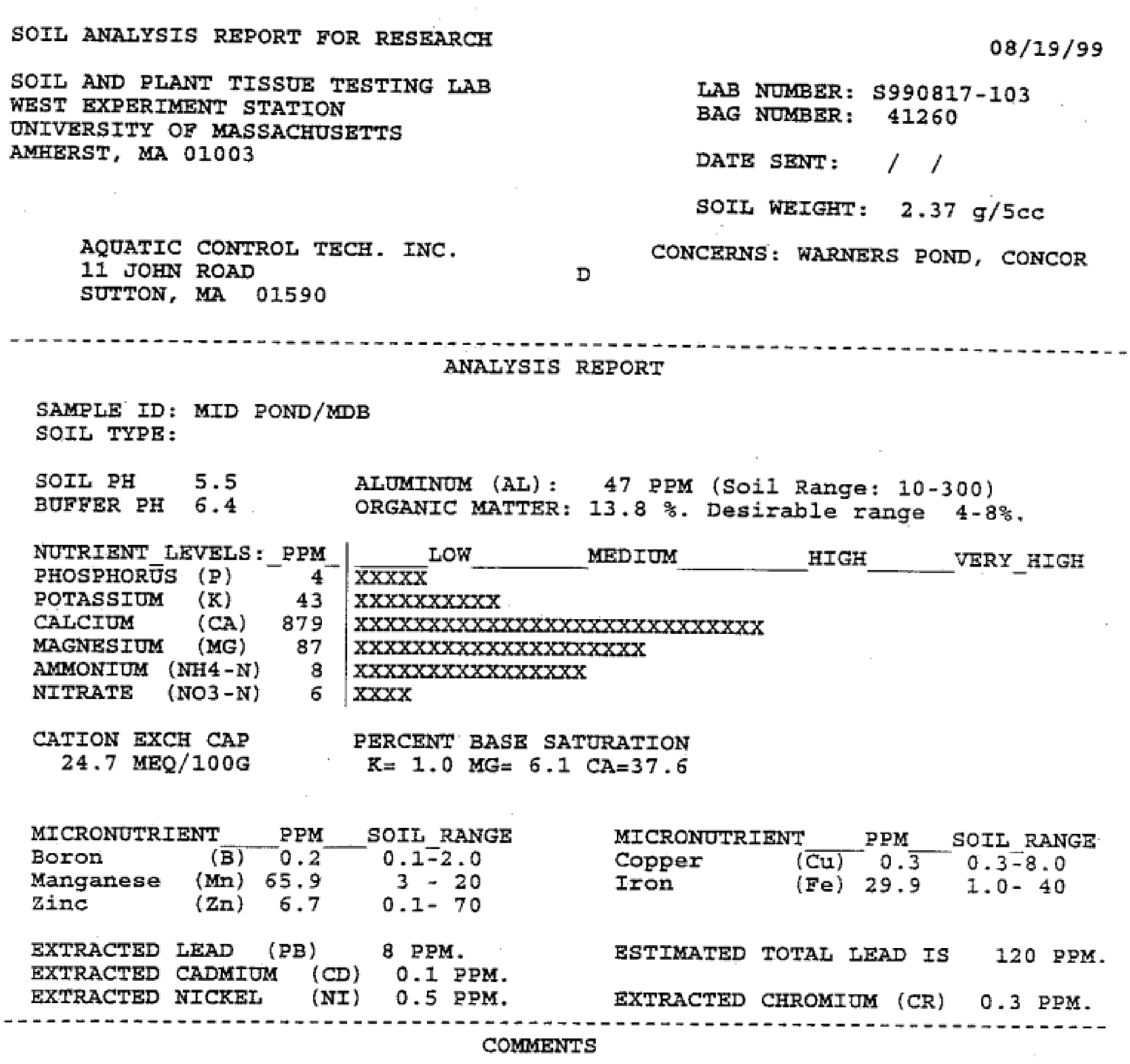
Sediment Nutrient Testing

Sediment nutrient testing was performed in 1999.



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SOIL ANALYSIS REPORT FOR RESEARCH
                                                                08/19/99

SOIL AND PLANT TISSUE TESTING LAB                 LAB NUMBER: S990817-103
WEST EXPERIMENT STATION                           BAG NUMBER:  41260
UNIVERSITY OF MASSACHUSETTS
AMHERST, MA 01003                                 DATE SENT:    /  /

                                                  SOIL WEIGHT:  2.37 g/5cc

   AQUATIC CONTROL TECH. INC.                   CONCERNS: WARNERS POND, CONCOR
   11 JOHN ROAD                           D
   SUTTON, MA  01590

----------------------------------------------------------------------------
                              ANALYSIS REPORT

 SAMPLE ID: MID POND/MDB
 SOIL TYPE:

 SOIL PH    5.5          ALUMINUM (AL):   47 PPM (Soil Range: 10-300)
 BUFFER PH  6.4          ORGANIC MATTER: 13.8 %. Desirable range  4-8%.

 NUTRIENT_LEVELS:_PPM_|_____LOW_________MEDIUM_________HIGH______VERY_HIGH
 PHOSPHORUS (P)     4 |XXXXX
 POTASSIUM  (K)    43 |XXXXXXXXXX
 CALCIUM    (CA)  879 |XXXXXXXXXXXXXXXXXXXXXXXXXXXX
 MAGNESIUM  (MG)   87 |XXXXXXXXXXXXXXXXXXXX
 AMMONIUM (NH4-N)   8 |XXXXXXXXXXXXXXXX
 NITRATE  (NO3-N)   6 |XXXX

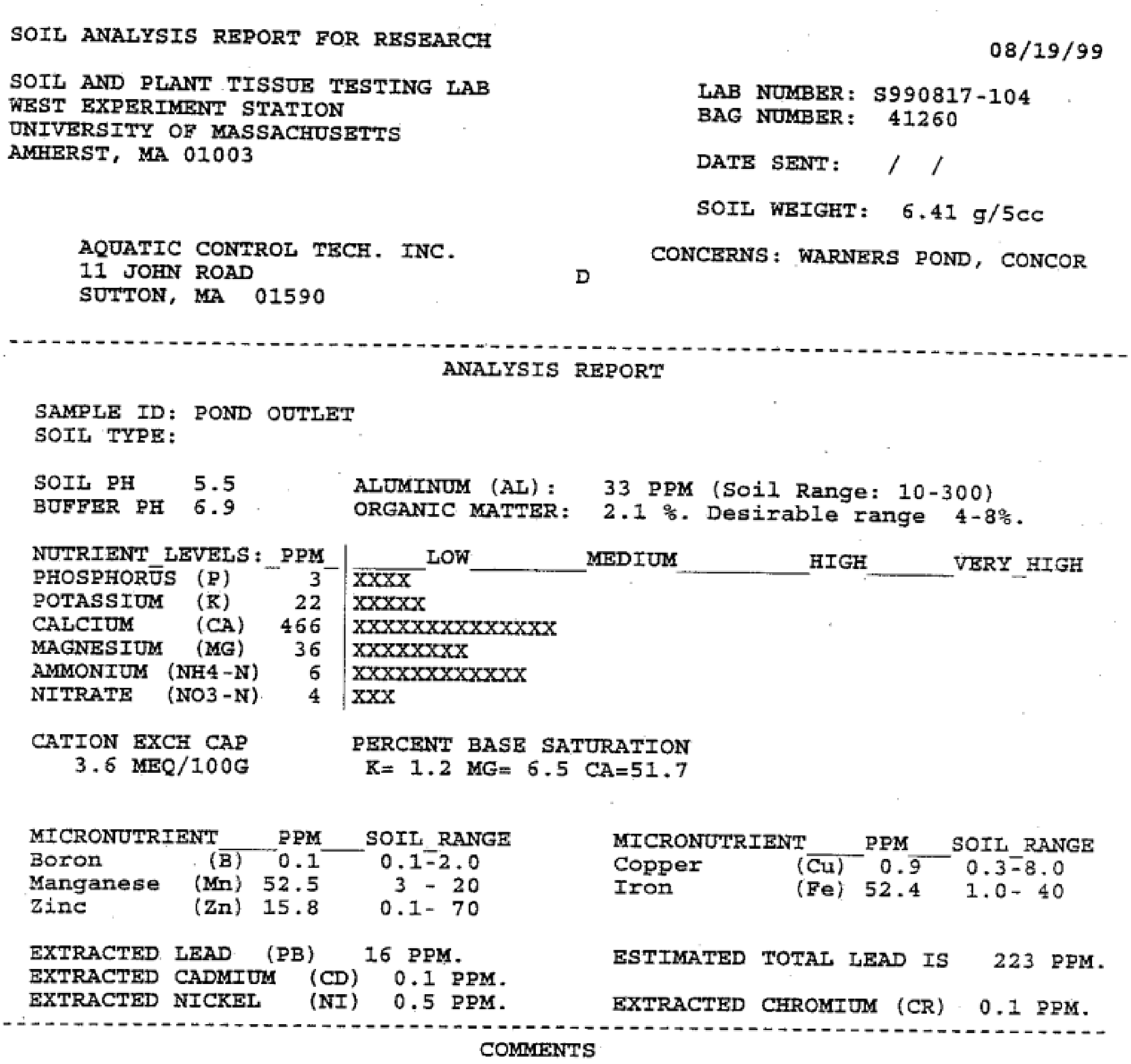
 CATION EXCH CAP         PERCENT BASE SATURATION
   24.7 MEQ/100G          K= 1.0 MG= 6.1 CA=37.6

 MICRONUTRIENT____PPM___SOIL_RANGE       MICRONUTRIENT____PPM___SOIL_RANGE
 Boron        (B)   0.2    0.1-2.0       Copper       (Cu)   0.3   0.3-8.0
 Manganese   (Mn) 65.9      3 - 20       Iron         (Fe) 29.9    1.0- 40
 Zinc        (Zn)   6.7    0.1- 70

 EXTRACTED LEAD   (PB)     8 PPM.        ESTIMATED TOTAL LEAD IS    120 PPM.
 EXTRACTED CADMIUM   (CD)  0.1 PPM.
 EXTRACTED NICKEL    (NI)  0.5 PPM.      EXTRACTED CHROMIUM (CR)  0.3 PPM.
----------------------------------------------------------------------------
                                 COMMENTS
```

Sediment Nutrient Testing

Sediment nutrient testing was performed in 1999.



SOIL ANALYSIS REPORT FOR RESEARCH

08/19/99

SOIL AND PLANT TISSUE TESTING LAB
WEST EXPERIMENT STATION
UNIVERSITY OF MASSACHUSETTS
AMHERST, MA 01003

LAB NUMBER: S990817-104
BAG NUMBER: 41260

DATE SENT: / /

SOIL WEIGHT: 6.41 g/5cc

AQUATIC CONTROL TECH. INC.
11 JOHN ROAD
SUTTON, MA 01590

CONCERNS: WARNERS POND, CONCOR
D

ANALYSIS REPORT

SAMPLE ID: POND OUTLET
SOIL TYPE:

SOIL PH 5.5
BUFFER PH 6.9

ALUMINUM (AL): 33 PPM (Soil Range: 10-300)
ORGANIC MATTER: 2.1 %. Desirable range 4-8%.

NUTRIENT LEVELS:	PPM	LOW	MEDIUM	HIGH	VERY HIGH
PHOSPHORUS (P)	3	XXXX			
POTASSIUM (K)	22	XXXXX			
CALCIUM (CA)	466	XXXXXXXXXXXXXX			
MAGNESIUM (MG)	36	XXXXXXXX			
AMMONIUM (NH4-N)	6	XXXXXXXXXXXX			
NITRATE (NO3-N)	4	XXX			

CATION EXCH CAP
3.6 MEQ/100G

PERCENT BASE SATURATION
K= 1.2 MG= 6.5 CA=51.7

MICRONUTRIENT		PPM	SOIL RANGE
Boron	(B)	0.1	0.1-2.0
Manganese	(Mn)	52.5	3 - 20
Zinc	(Zn)	15.8	0.1- 70

MICRONUTRIENT		PPM	SOIL RANGE
Copper	(Cu)	0.9	0.3-8.0
Iron	(Fe)	52.4	1.0- 40

EXTRACTED LEAD (PB) 16 PPM.
EXTRACTED CADMIUM (CD) 0.1 PPM.
EXTRACTED NICKEL (NI) 0.5 PPM.

ESTIMATED TOTAL LEAD IS 223 PPM.

EXTRACTED CHROMIUM (CR) 0.1 PPM.

COMMENTS

Water Quality Testing

Water quality and nutrient testing was performed in 2011 including the Pond and the results are summarized in the table to the right (note tributary and river sampling is independently performed by OARS on a periodic basis). Samples were collected in 2011 during both dry and wet weather conditions from:

- Tributaries (Nashoba, Fort Pond, Coles Brooks)
- Tributary inlets to the Pond
- Warner's Pond outlet
- Warner's Pond surface and bottom
- Stormwater culverts (Wright Road, Laws Brook Road and Route 2)

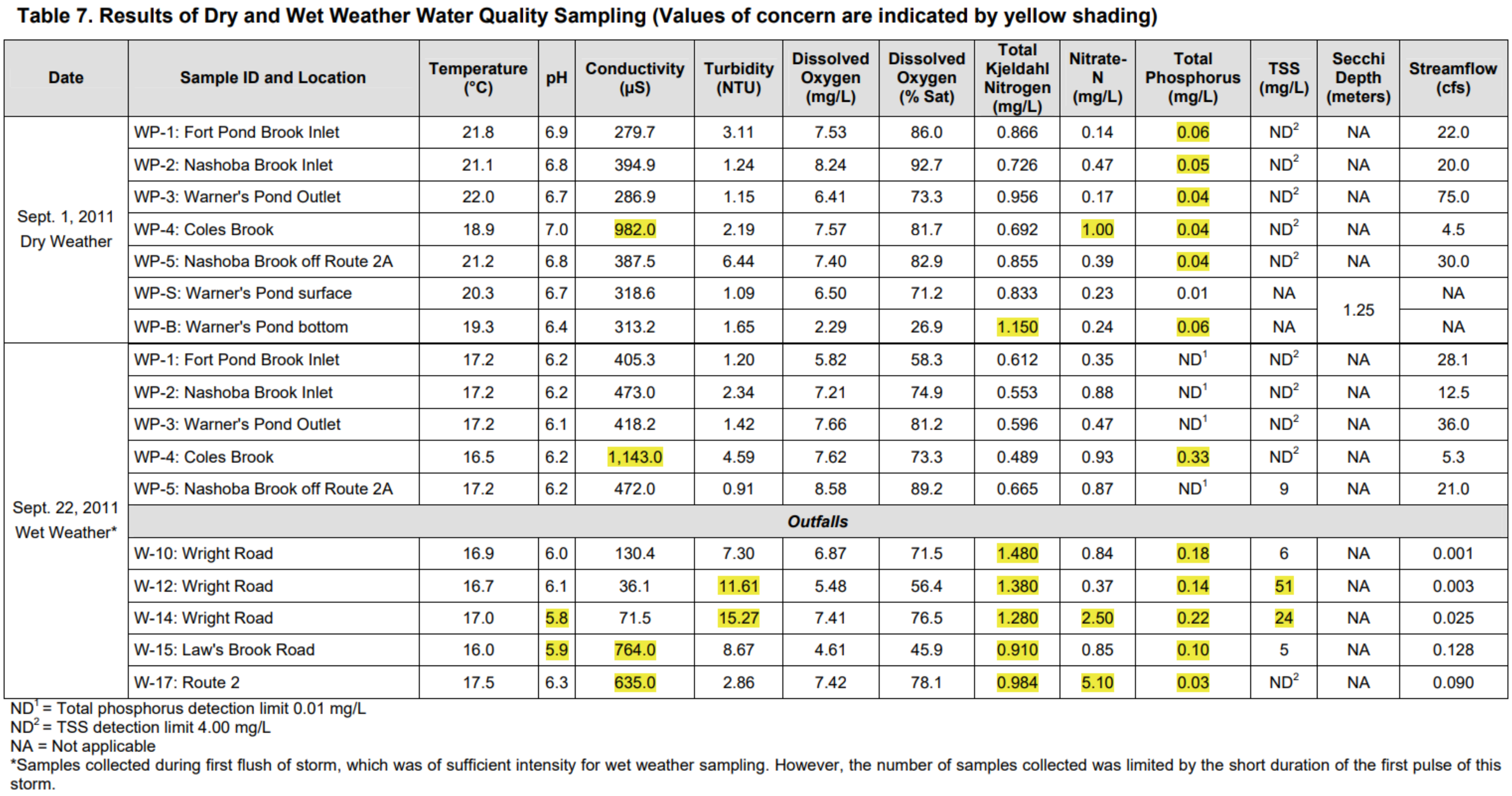


Table 7. Results of Dry and Wet Weather Water Quality Sampling (Values of concern are indicated by yellow shading)

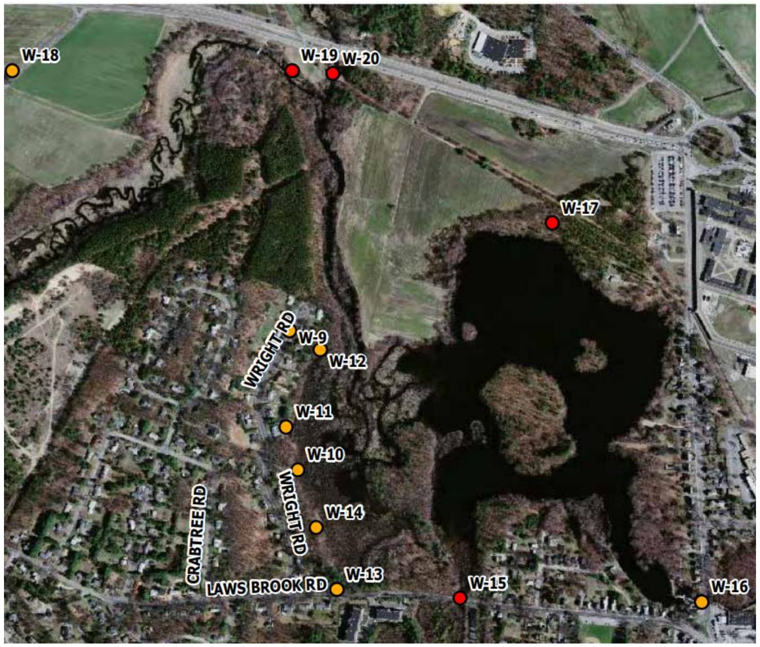
Date	Sample ID and Location	Temperature (°C)	pH	Conductivity (µS)	Turbidity (NTU)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (% Sat)	Total Kjeldahl Nitrogen (mg/L)	Nitrate-N (mg/L)	Total Phosphorus (mg/L)	TSS (mg/L)	Secchi Depth (meters)	Streamflow (cfs)
Sept. 1, 2011 Dry Weather	WP-1: Fort Pond Brook Inlet	21.8	6.9	279.7	3.11	7.53	86.0	0.866	0.14	0.06	ND^2	NA	22.0
	WP-2: Nashoba Brook Inlet	21.1	6.8	394.9	1.24	8.24	92.7	0.726	0.47	0.05	ND^2	NA	20.0
	WP-3: Warner's Pond Outlet	22.0	6.7	286.9	1.15	6.41	73.3	0.956	0.17	0.04	ND^2	NA	75.0
	WP-4: Coles Brook	18.9	7.0	982.0	2.19	7.57	81.7	0.692	1.00	0.04	ND^2	NA	4.5
	WP-5: Nashoba Brook off Route 2A	21.2	6.8	387.5	6.44	7.40	82.9	0.855	0.39	0.04	ND^2	NA	30.0
	WP-S: Warner's Pond surface	20.3	6.7	318.6	1.09	6.50	71.2	0.833	0.23	0.01	NA	1.25	NA
	WP-B: Warner's Pond bottom	19.3	6.4	313.2	1.65	2.29	26.9	1.150	0.24	0.06	NA		NA
Sept. 22, 2011 Wet Weather*	WP-1: Fort Pond Brook Inlet	17.2	6.2	405.3	1.20	5.82	58.3	0.612	0.35	ND^1	ND^2	NA	28.1
	WP-2: Nashoba Brook Inlet	17.2	6.2	473.0	2.34	7.21	74.9	0.553	0.88	ND^1	ND^2	NA	12.5
	WP-3: Warner's Pond Outlet	17.2	6.1	418.2	1.42	7.66	81.2	0.596	0.47	ND^1	ND^2	NA	36.0
	WP-4: Coles Brook	16.5	6.2	1,143.0	4.59	7.62	73.3	0.489	0.93	0.33	ND^2	NA	5.3
	WP-5: Nashoba Brook off Route 2A	17.2	6.2	472.0	0.91	8.58	89.2	0.665	0.87	ND^1	9	NA	21.0
	Outfalls												
	W-10: Wright Road	16.9	6.0	130.4	7.30	6.87	71.5	1.480	0.84	0.18	6	NA	0.001
	W-12: Wright Road	16.7	6.1	36.1	11.61	5.48	56.4	1.380	0.37	0.14	51	NA	0.003
	W-14: Wright Road	17.0	5.8	71.5	15.27	7.41	76.5	1.280	2.50	0.22	24	NA	0.025
	W-15: Law's Brook Road	16.0	5.9	764.0	8.67	4.61	45.9	0.910	0.85	0.10	5	NA	0.128
	W-17: Route 2	17.5	6.3	635.0	2.86	7.42	78.1	0.984	5.10	0.03	ND^2	NA	0.090

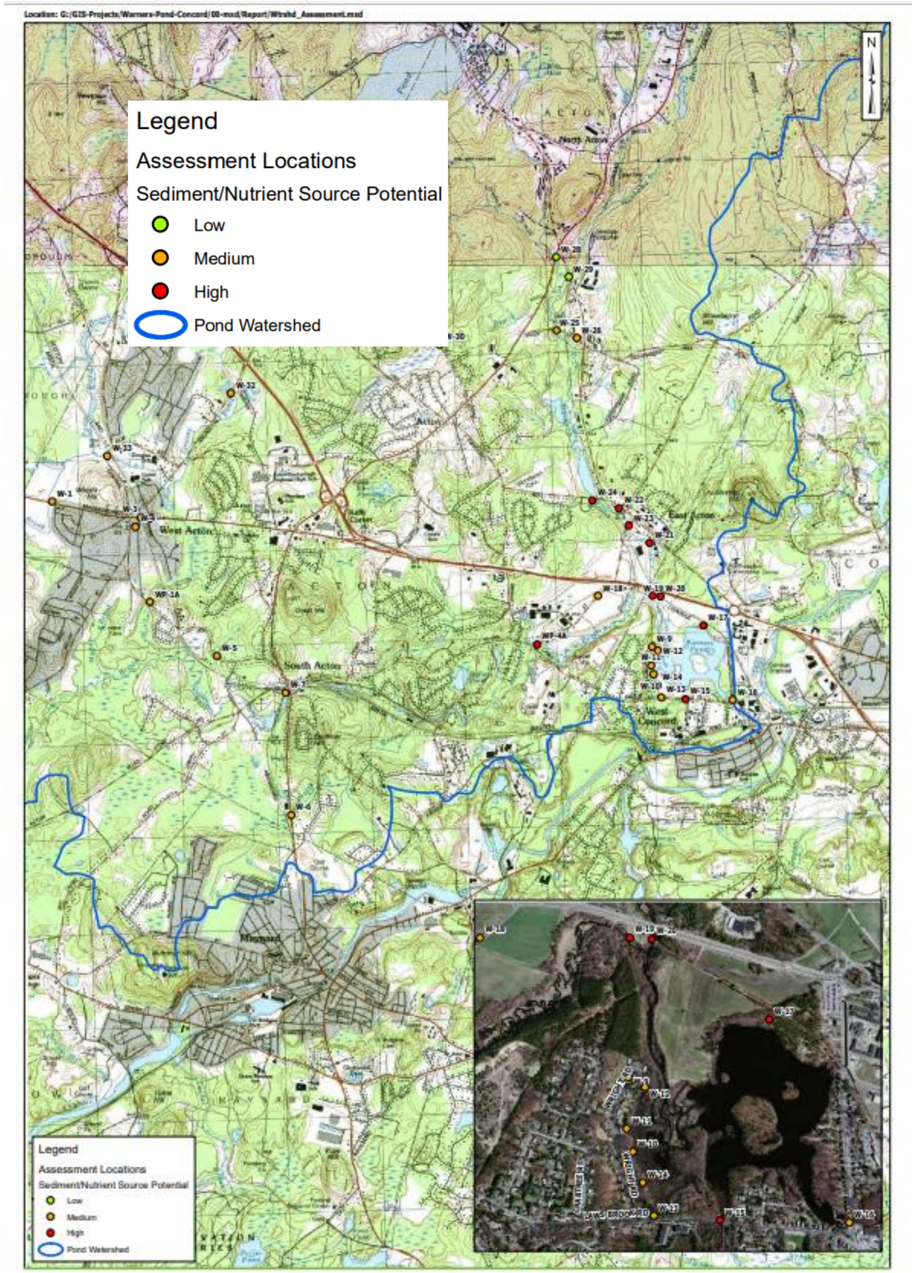
ND^1 = Total phosphorus detection limit 0.01 mg/L
ND^2 = TSS detection limit 4.00 mg/L
NA = Not applicable
*Samples collected during first flush of storm, which was of sufficient intensity for wet weather sampling. However, the number of samples collected was limited by the short duration of the first pulse of this storm.

Lake & Pond Manual_extended.indd (lmpa.org)   All about Phosphorus - SNEP Network

Water Quality Testing

The water quality sampling locations are shown here. In addition, samples were collected and tested from the pond water surface and near bottom. The color coding represents the sediment and/or nutrient source potential. The sources of high nutrient concentrations and sediment load are located along Nashoba Brook between the Pond and Ice House Dam in Acton. Management measures required by the Commonwealth under current regulations would eliminate or mitigate these sources, if enforced.





Comparison to Massachusetts Water Quality Standards

Warner's Pond is a Massachusetts Class B Inland Water. Comparison of the water quality results (Warner's Pond surface, bottom and outlet) indicates the following:

- Dissolved Oxygen: DO ranged from 7.66, 6.41, 6.5, and 2.19 mg/l at the outlet (wet), outlet (dry), surface and bottom respectively. These values indicate that at the date of testing pond water DO meets and exceeds Massachusetts standard of 5 mg/l.
- Temperature: Temperature ranged from 17.2, 22, 20.3 and 19.3 degrees Celsius at the outlet (wet), outlet (dry), surface and bottom respectively. Warner's Pond is a warm water fisheries pond. These values indicate that at the date of testing (September 11, 2011), the pond temperature meets and is less than Massachusetts standard of 28 degrees Celsius.
- pH: pH ranged from 6.1, 6.7, 6.7 and 6.4 at the outlet (wet), outlet (dry), surface and bottom respectively. These values indicate that at the date of testing (September 11, 2011), the pond pH meets and is less than Massachusetts standard range of 6.5 to 8.3.
- Solids: Total Suspended Sediments (TSS) were tested at the outlet and were ND (detection limit of 4 mg/l) for both wet and dry conditions.
- Color and Turbidity: Turbidity ranged from 1.42, 1.15, 1.09 and 1.65 NTUs at the outlet (wet), outlet (dry), surface and bottom respectively. Massachusetts does not have quantitative standards for turbidity; however, turbidity values less than 10 NTU are considered low, a value of 50 NTU would be considered moderately turbid, and very high turbidity values can be more than 100 NTU. Measured turbidity values at Warner's Pond are low consistent with the observed low TSS values. However, Secchi depths were measured at 1.25 meters, possible a result of high biomass in the water column (not particulate matter) and indicative of borderline eutrophic conditions. Observed Secchi depths correlate to total phosphorous median values of around 0.04 mg/l (consistet with measured values of total phosphorous).

In summary, water quality testing indicates that the Pond water quality meets or exceeds quantitative Massachusetts Class B Inland Water Standards. Nutrient results are presented in the following slides.

Warner’s Pond Ecosystem: Nutrients

The total phosphorous values measured in the 2011 water quality testing at **high levels** (i.e., falling within the range of eutrophic and highly productive to plant growth of approximately $\geq$ 0.03 mg/l) at the following locations and conditions:

- Warner’s Pond outlet (dry conditions): 0.04 mg/l
- Warner’s Pond inlet tributaries, including Coles, Nashoba and Fort Pond Brooks (dry conditions): 0.33, 0.05, 0.06 mg/l
- Warner’s Pond bottom (dry conditions): 0.06 mg/l
- Stormwater outfalls (measured during wet conditions):
  - Wright Road: 0.14 to 0.22mg/l
  - Laws Brook Road: 0.10 mg/l
  - Rt 2: 0.03mg/l

Total phosphorous values measured in the 2012 water quality testing at **low levels** (<0.03 mg/l):

- Warner’s Pond surface water: 0.01 mg/l
- Warner’s Pond outlet (wet conditions): ND
- Warner’s Pond inlet tributaries, except Coles (wet conditions): ND

Comparatively, total phosphorous levels were low and within or marginally above the typical range of natural background levels. Levels within the Pond are similar or lower than the contributing, upstream tributaries. The low pond surface water values may reflect the extremely short detention time and rapid flow and flushing rate within the Pond. The short detention time and high flushing rate also likely explains why, unlike other Concord ponds, Warner’s Pond does not experience algal blooms. What is less certain, in particular in light of the very high pond flushing rate, is the relative contribution of dissolved nutrients relative to particulate phosphorous bound up in the sediment. Laboratory results indicate that the soft sediment at Warner’s Pond contains significant phosphorous (an average of 147 mg/kg [ppm} of total phosphorus.) – source of this data is unknow, The 1999 sediment testing (ACT) indicated sediment phosphorous of 3 to 4 ppm. The phosphorous may be stratified in the sediment column, with higher value in sediment deposited since the 1940s.

Warner’s Pond Ecosystem: Nutrient Load

Although the total phosphorous values measured in the water quality tests is relatively low, the critical phosphorous concentration at Warner’s Pond was approximately determined by ESS by mass balance modeling and is a function of pond depth and hydraulics as well as pond concentrations and pond loading input concentrations.

Estimation of Nutrient Load:

- A calculation of the minimum nutrient load was made by multiplying the volume of the pond by its flushing rate and the average concentration of the nutrient observed during this study. The minimum phosphorus and nitrogen loads delivered to Warner’s Pond were determined to be 24.99 g/m2 /yr (4,930 kg/yr) and 504.58 g/m2 /yr (99,547 kg/yr), respectively, based on the in-pond nutrient concentrations observed during the study.
- The actual load of phosphorus or nitrogen will exceed the estimated minimum load as a consequence of loss processes that reduce the in-pond concentration over time. A more detailed and realistic estimate of nutrient loading was obtained by using a combination of actual field data and in-pond modeling theory, e.g., Vollenweider, 1975 and Reckhow, 1977). Based on this approach, the predicted phosphorus load necessary to achieve the values found in Warner’s Pond ranges between 22.80 g/m2/yr (4,498 kg/yr) using the Vollenweider (1975) model and 27.96 g/m2/yr (5,516 kg/yr) using the Reckhow (1977) model. The average predicted phosphorus load for all models was 24.99 g/m2/yr (4,930 kg/yr). The nitrogen load necessary to achieve the observed in-pond concentrations was estimated to be 529.35 g/m2/yr (104,434 kg/yr) (Bachmann 1980).

Permissible and Critical Nutrient Concentrations:

- Vollenweider (1968) established criteria for calculating the phosphorus load below which no productivity problems were expected (permissible load) and above which productivity problems were almost certain to persist (critical load). The modeling results indicate that the permissible level is 393 kg/yr and the critical level of 785 kg/yr.
- In consideration of the Pond hydraulics, the associated phosphorous concentrations for the permissible and critical loads are 0.0051 mg/l and 0.0101 mg/l, respectively. These values are within the range of typical, naturally occurring values and well below (by a factor of 4 to 5) the observed levels within the main tributaries contributing to Warner’s Pond. The single measured value at the Pond’s water surface (0.01 mg/l) is at about the predicted critical level.

Aquatic Plant Species in Warner's Pond

The following information is based on a 2011 aquatic vegetation survey by ESS (and an earlier 1980s survey). This survey followed a partial herbicide treatment of the Pond and to a certain extent may reflect the effects of that treatment. Overall, however, it provides a reasonable overview of invasive and non-invasive aquatic plant species that dominate the Pond vegetation.

The table to the right summarizes the observed species.

While the overall number of different plant species observed was relatively high, nearly all of the aquatic plant cover within the Pond was determined to consist of: Fanwort or Coontail. This includes southwestern portions of the Pond dominated by Water Lily species, where fanwort and variable Watermilfoil were also present as subdominant species. The majority of the other species observed was found at a few limited locations along the shorelines of the southeastern outlet of the pond.

Regardless, observed vegetation as well as nutrient load modeling by ESS indicates that nutrient loads are adequate to create highly productive conditions where other necessary conditions (specifically light) are present.

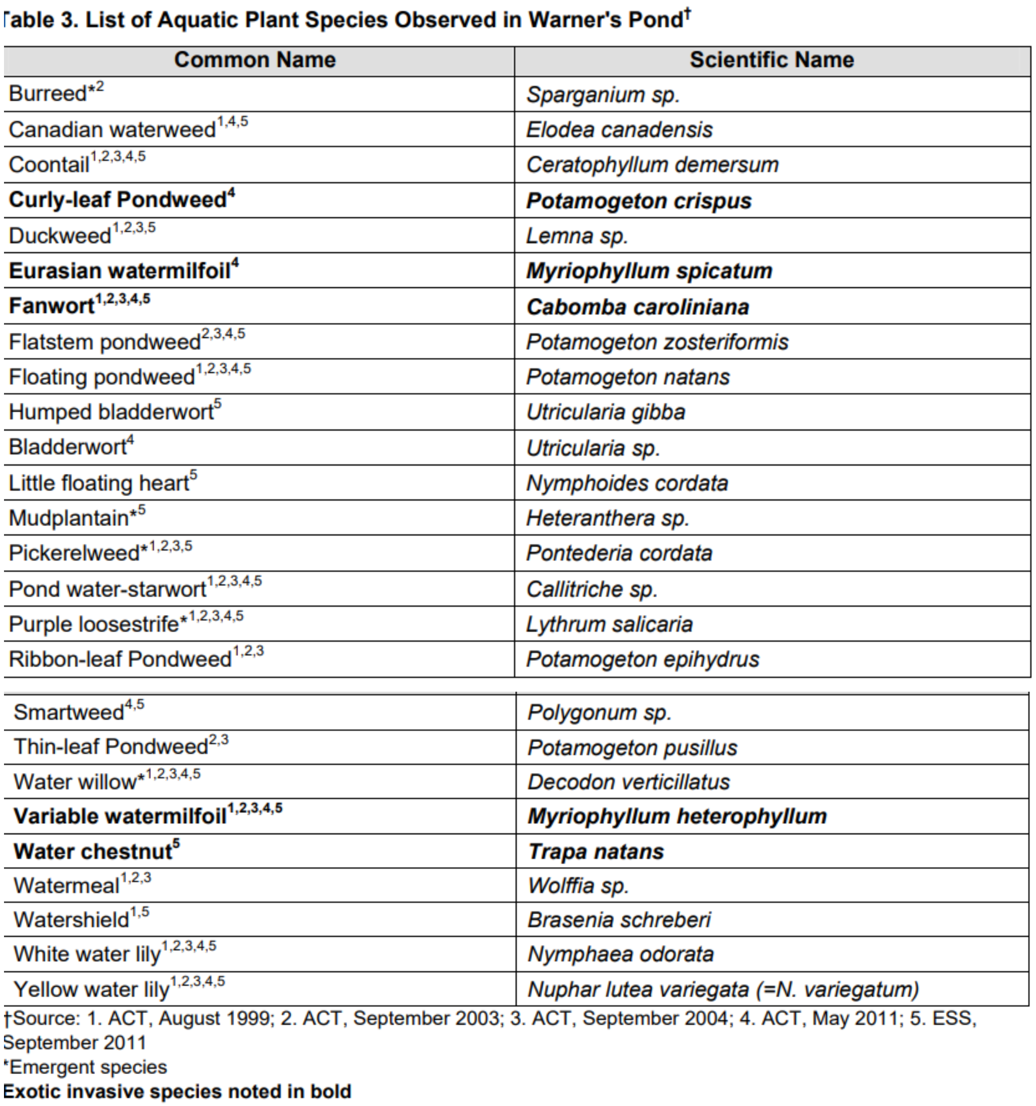


Table 3. List of Aquatic Plant Species Observed in Warner's Pond†

Common Name	Scientific Name
Burreed*[2]	*Sparganium sp.*
Canadian waterweed[1,4,5]	*Elodea canadensis*
Coontail[1,2,3,4,5]	*Ceratophyllum demersum*
Curly-leaf Pondweed[4]	***Potamogeton crispus***
Duckweed[1,2,3,5]	*Lemna sp.*
Eurasian watermilfoil[4]	***Myriophyllum spicatum***
Fanwort[1,2,3,4,5]	***Cabomba caroliniana***
Flatstem pondweed[2,3,4,5]	*Potamogeton zosteriformis*
Floating pondweed[1,2,3,4,5]	*Potamogeton natans*
Humped bladderwort[5]	*Utricularia gibba*
Bladderwort[4]	*Utricularia sp.*
Little floating heart[5]	*Nymphoides cordata*
Mudplantain*[5]	*Heteranthera sp.*
Pickerelweed*[1,2,3,5]	*Pontederia cordata*
Pond water-starwort[1,2,3,4,5]	*Callitriche sp.*
Purple loosestrife*[1,2,3,4,5]	*Lythrum salicaria*
Ribbon-leaf Pondweed[1,2,3]	*Potamogeton epihydrus*
Smartweed[4,5]	*Polygonum sp.*
Thin-leaf Pondweed[2,3]	*Potamogeton pusillus*
Water willow*[1,2,3,4,5]	*Decodon verticillatus*
Variable watermilfoil[1,2,3,4,5]	***Myriophyllum heterophyllum***
Water chestnut[5]	***Trapa natans***
Watermeal[1,2,3]	*Wolffia sp.*
Watershield[1,5]	*Brasenia schreberi*
White water lily[1,2,3,4,5]	*Nymphaea odorata*
Yellow water lily[1,2,3,4,5]	*Nuphar lutea variegata (=N. variegatum)*

†Source: 1. ACT, August 1999; 2. ACT, September 2003; 3. ACT, September 2004; 4. ACT, May 2011; 5. ESS, September 2011

*Emergent species

Exotic invasive species noted in bold

Aquatic Plant Species in Warner's Pond

The plan to the right presents the predominant aquatic plant species type and degree of plant coverage. The darker shades of green represent greater surface coverage with vegetation.

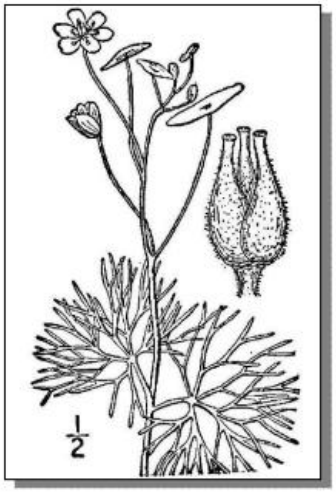
On the lower left and following slides, descriptions of the dominant aquatic plant species are presented from the 2011 Warner's Pond Field Guide.

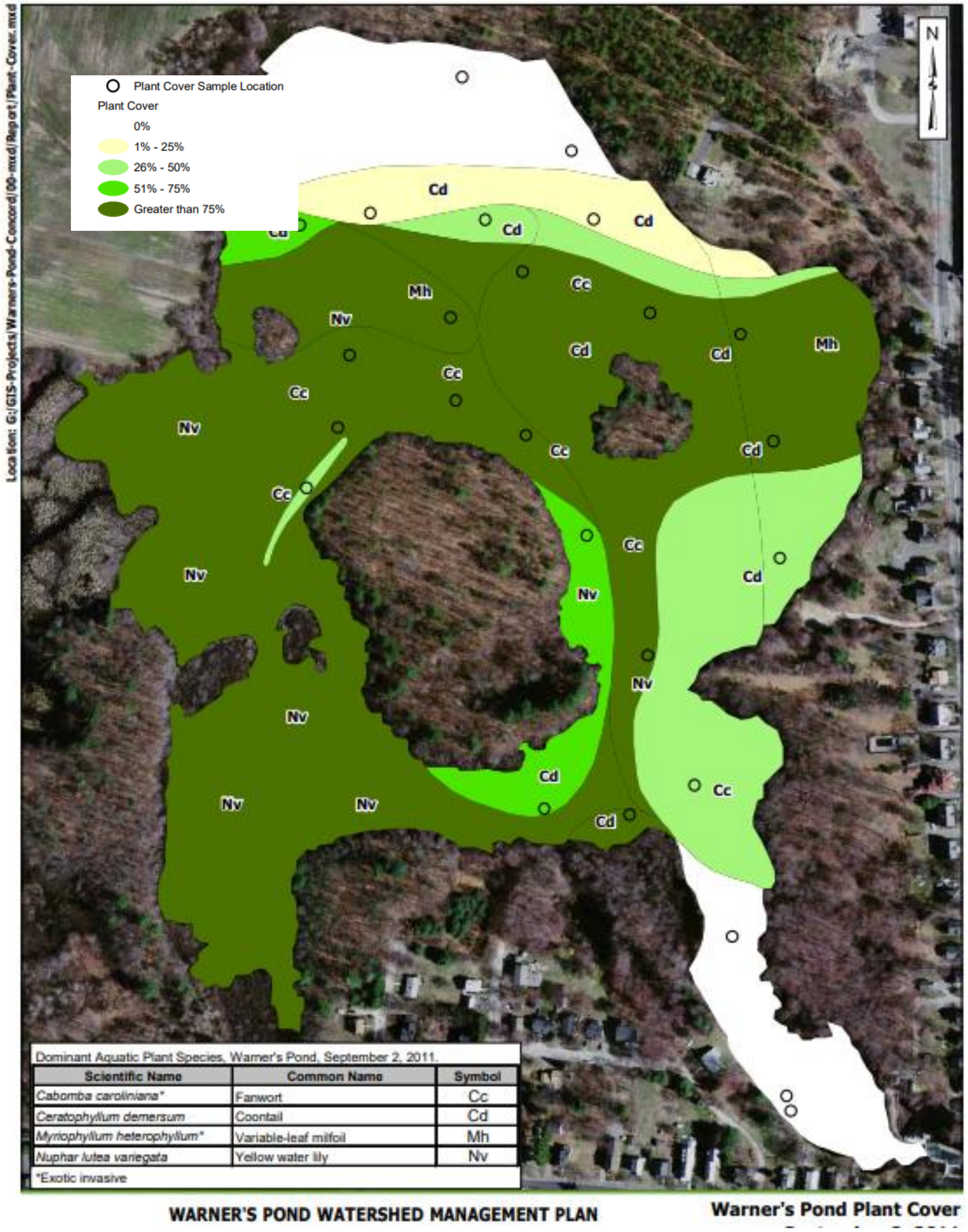
Fanwort (Cc)

Cabomba caroliniana - Fanwort

Exotic Invasive

Key Features: Finely dissected, fanlike leaves arranged oppositely on submersed stems. Small, white flowers with small floating leaves emerge in late summer but submersed leaves will remain obvious.
Habitat: Ponds, lakes and other sluggish waters. Can form dense, extensive monocultures.
Similar Species: *Ranunculus* sp.*





Dominant Aquatic Plant Species, Warner's Pond, September 2, 2011.

Scientific Name	Common Name	Symbol
*Cabomba caroliniana**	Fanwort	Cc
Ceratophyllum demersum	Coontail	Cd
*Myriophyllum heterophyllum**	Variable-leaf milfoil	Mh
Nuphar lutea variegata	Yellow water lily	Nv

*Exotic invasive

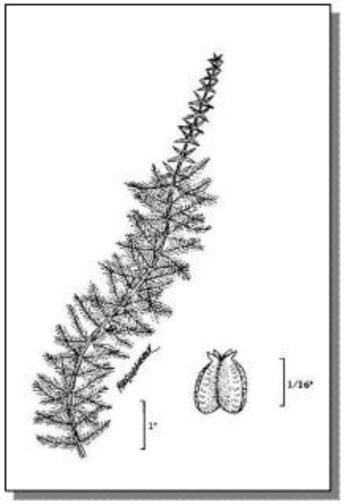
Aquatic Plant Species in Warner's Pond

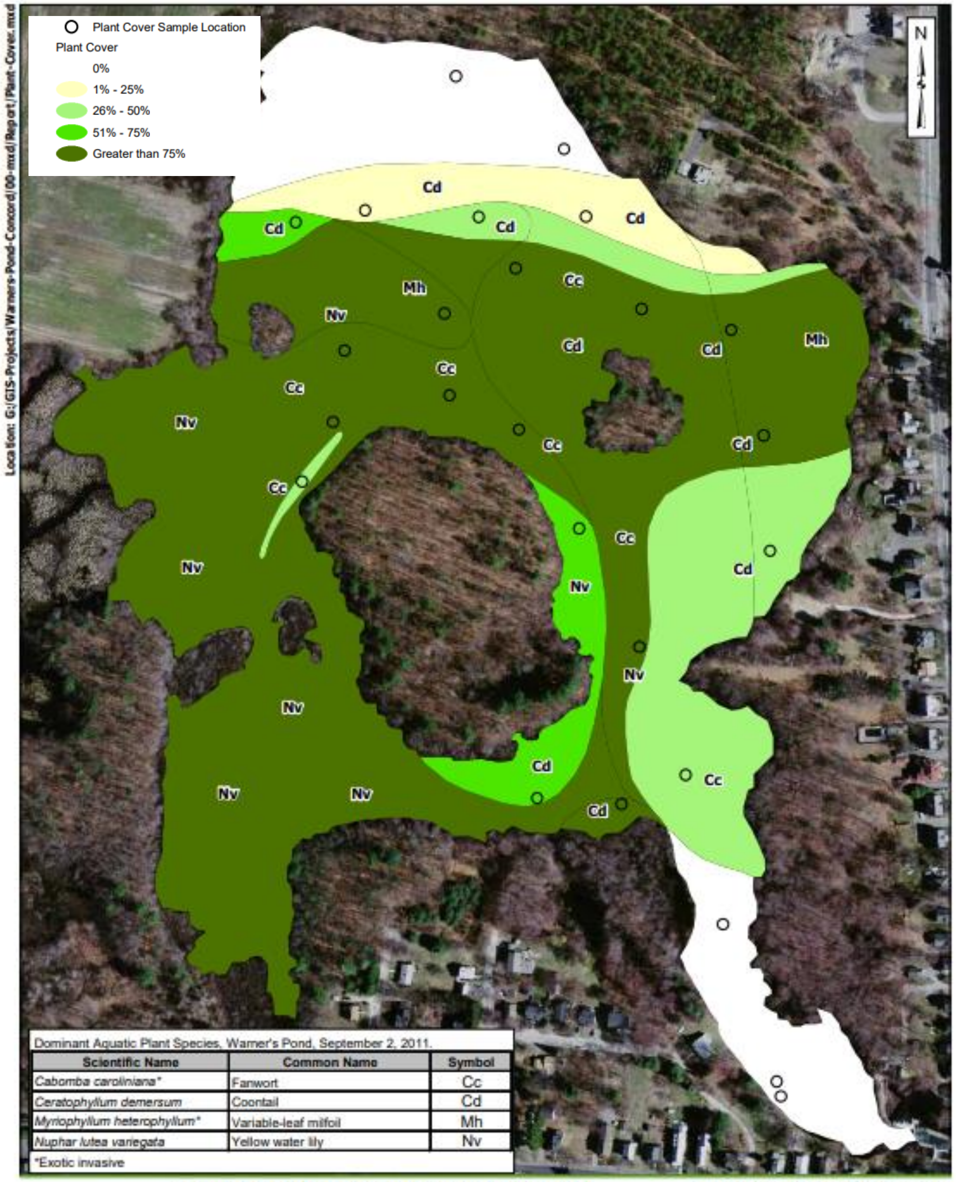
Milfoil (Mh)

Myriophyllum heterophyllum – Variable-leaf Milfoil

Nonindigenous Transplant with Invasive Potential

Key Features: Finely dissected, feathery leaves arranged in whorls of 4-6 on submersed stems. Emergent stems form comblike or serrated bracts that are larger than the flowers and look very different from the submersed leaves in August and September. Stems can grow more than 10' long.
Habitat: Shallow edges and quiet waters of protected coves and stream outlets. Can form dense, extensive monocultures.
Similar Species: *Myriophyllum spp.*





○ Plant Cover Sample Location
Plant Cover
0%
🟨 1% - 25%
🟩 26% - 50%
🟩 51% - 75%
🟩 Greater than 75%

Dominant Aquatic Plant Species, Warner's Pond, September 2, 2011.

Scientific Name	Common Name	Symbol
*Cabomba caroliniana**	Fanwort	Cc
Ceratophyllum demersum	Coontail	Cd
*Myriophyllum heterophyllum**	Variable-leaf milfoil	Mh
Nuphar lutea variegata	Yellow water lily	Nv

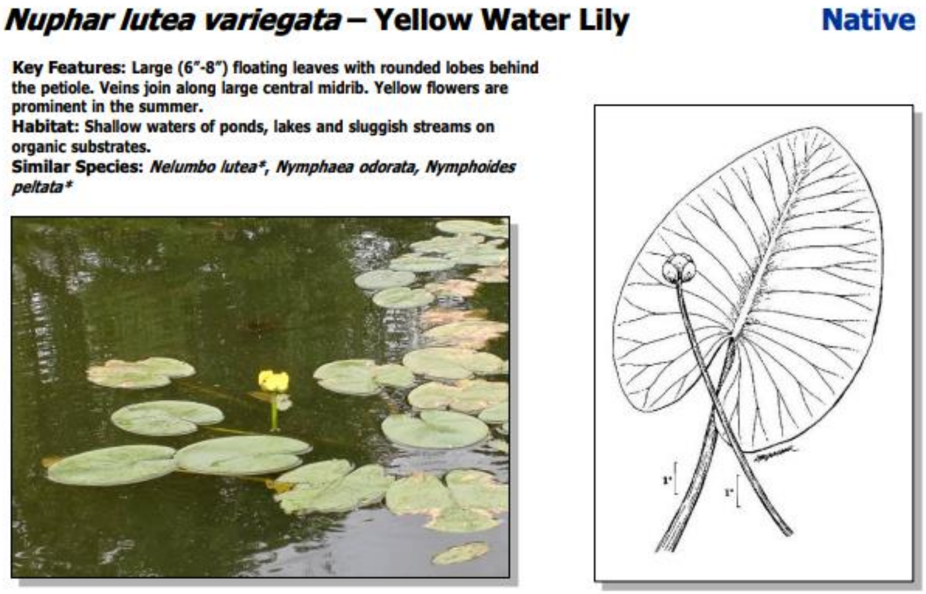
*Exotic invasive

WARNER'S POND WATERSHED MANAGEMENT PLAN

Warner's Pond Plant Cover

Aquatic Plant Species in Warner's Pond

Yellow Water Lilly (Nv)



Nuphar lutea variegata **– Yellow Water Lily** **Native**

Key Features: Large (6"-8") floating leaves with rounded lobes behind the petiole. Veins join along large central midrib. Yellow flowers are prominent in the summer.
Habitat: Shallow waters of ponds, lakes and sluggish streams on organic substrates.
Similar Species: *Nelumbo lutea*, Nymphaea odorata, Nymphoides peltata**

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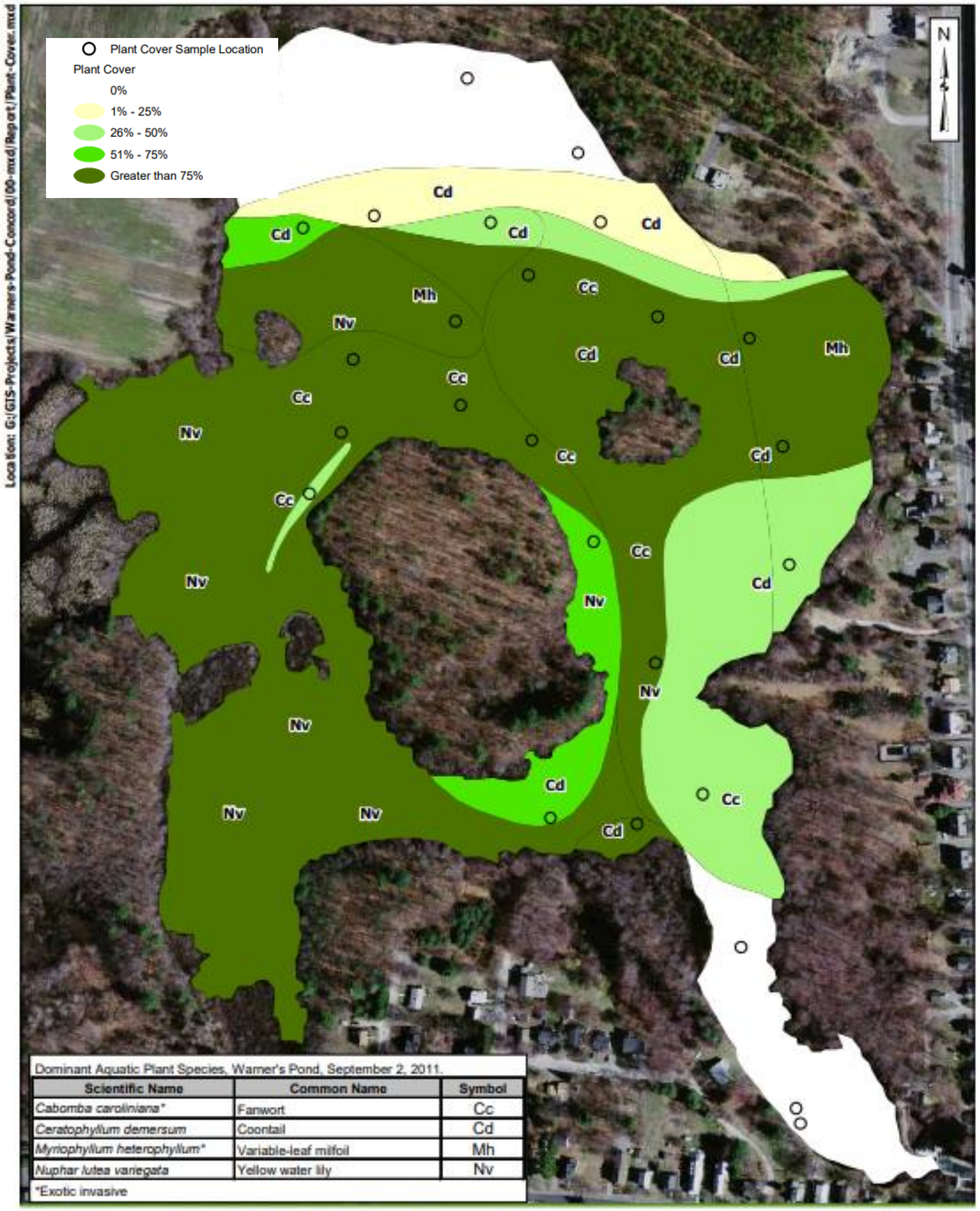


Dominant Aquatic Plant Species, Warner's Pond, September 2, 2011.

Scientific Name	Common Name	Symbol
*Cabomba caroliniana**	Fanwort	Cc
Ceratophyllum demersum	Coontail	Cd
*Myriophyllum heterophyllum**	Variable-leaf milfoil	Mh
Nuphar lutea variegata	Yellow water lily	Nv

*Exotic invasive

WARNER'S POND WATERSHED MANAGEMENT PLAN

Warner's Pond Plant Cover

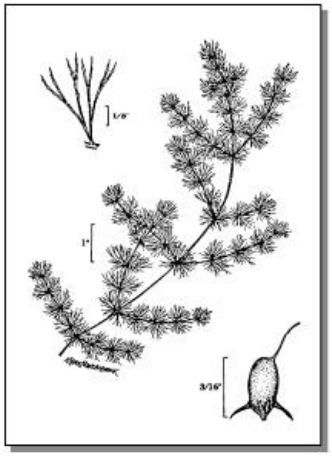
Aquatic Plant Species in Warner's Pond

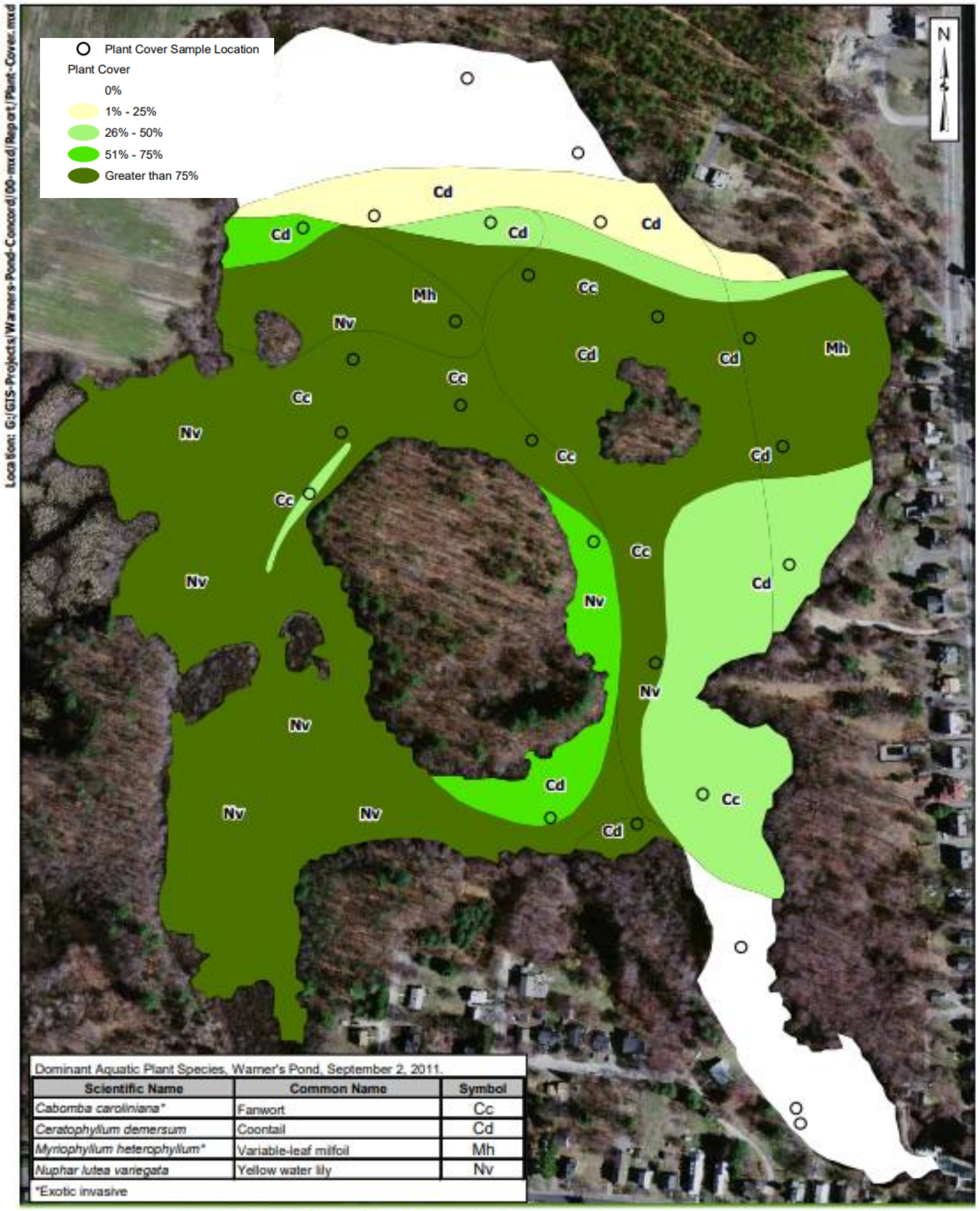
Coontail (Cd)

Ceratophyllum demersum - Coontail

Native

Key Features: Finely dissected, whorled leaves are branched. Leaves often cluster together near the stem tips giving them a look reminiscent of a raccoon tail. Plants are rootless.
Habitat: Ponds, lakes and other sluggish waters. Can grow to nuisance levels.
Similar Species: *Myriophyllum* spp.





Dominant Aquatic Plant Species, Warner's Pond, September 2, 2011.

Scientific Name	Common Name	Symbol
*Cabomba caroliniana**	Fanwort	Cc
Ceratophyllum demersum	Coontail	Cd
*Myriophyllum heterophyllum**	Variable-leaf milfoil	Mh
Nuphar lutea variegata	Yellow water lily	Nv

*Exotic invasive

WARNER'S POND WATERSHED MANAGEMENT PLAN

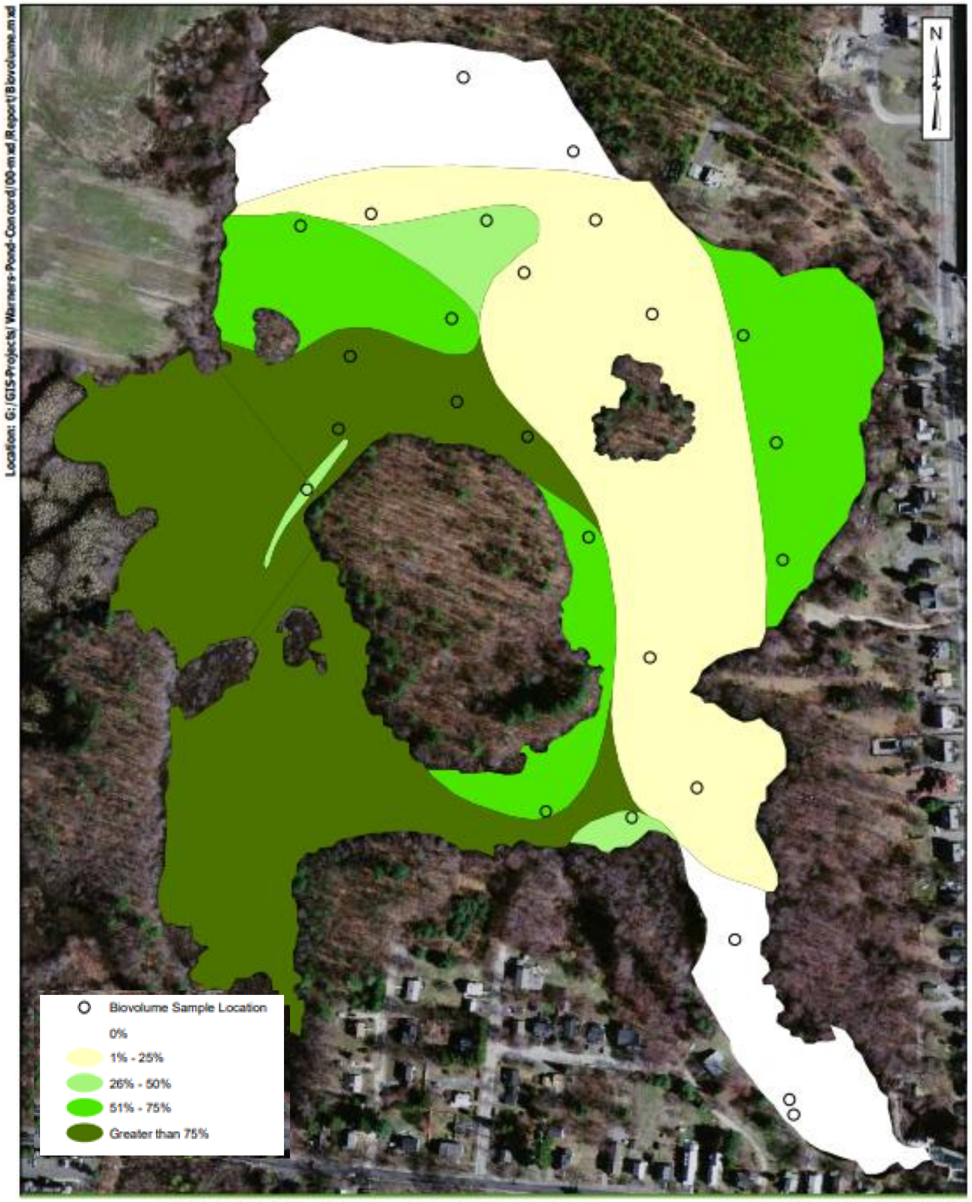
Warner's Pond Plant Cover

Aquatic Plant Species in Warner's Pond

The plan to the right presents the aquatic plant coverage in terms of biovolume. Biovolume is the percentage of the water column that is occupied by plants.

Biovolume was observed during the 2011 survey to be greatest in the western and southwestern areas of the pond. Lower biovolume was observed in the northern and eastern portions of the pond.

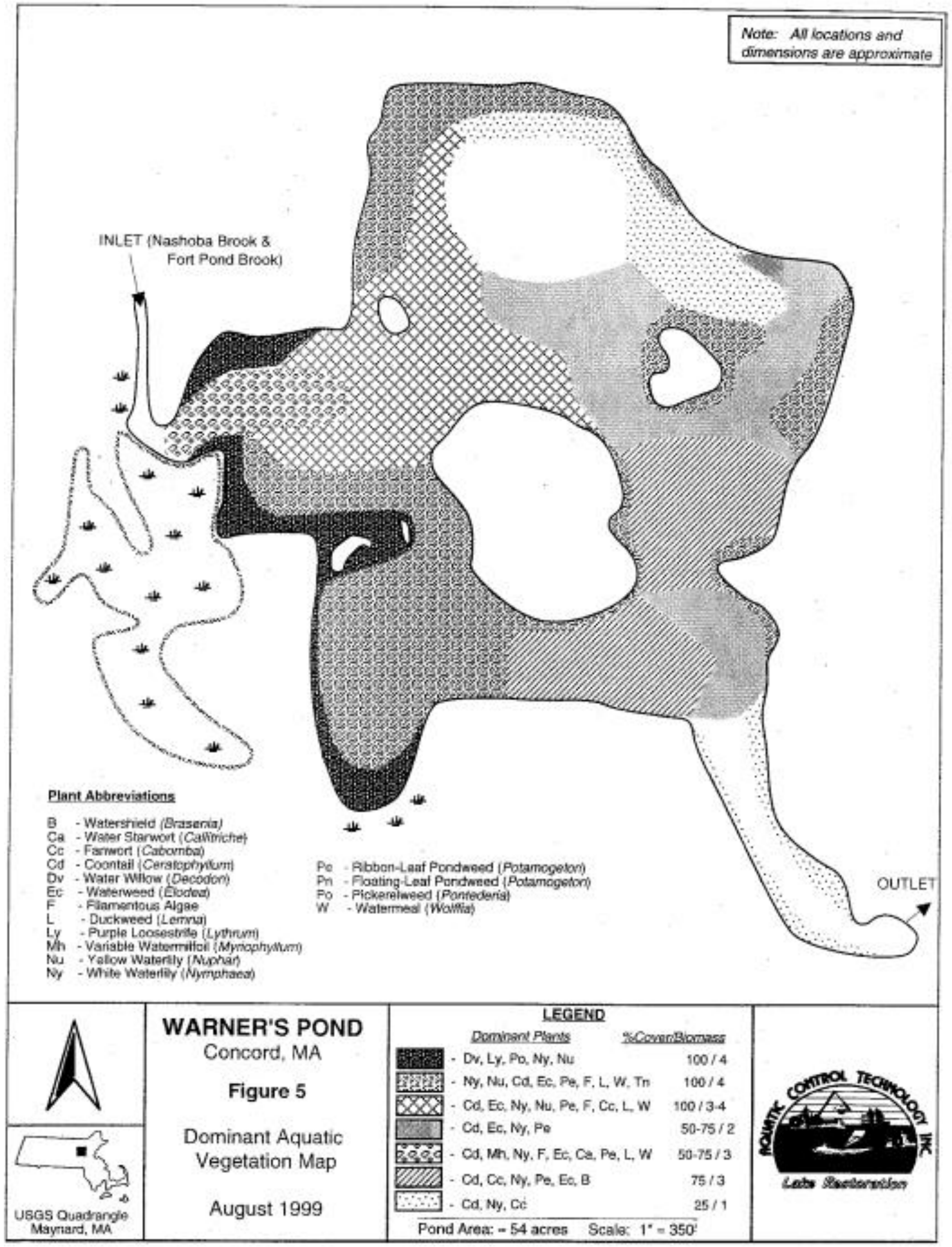
The distribution of biovolume may, in part, be a function of the prior herbicide treatment, but is more likely a function of pond water depth.



WARNER'S POND WATERSHED MANAGEMENT PLAN

Warner's Pond Biovolume

Aquatic Plant Species in Warner's Pond: Transition 1999 to 2011



Plant Abbreviations

B	- Watershield *(Brasenia)*
Ca	- Water Starwort *(Callitriche)*
Cc	- Fanwort *(Cabomba)*
Cd	- Coontail *(Ceratophyllum)*
Dv	- Water Willow *(Decodon)*
Ec	- Waterweed *(Elodea)*
F	- Filamentous Algae
L	- Duckweed *(Lemna)*
Ly	- Purple Loosestrife *(Lythrum)*
Mh	- Variable Watermilfoil *(Myriophyllum)*
Nu	- Yellow Waterlily *(Nuphar)*
Ny	- White Waterlily *(Nymphaea)*
Pe	- Ribbon-Leaf Pondweed *(Potamogeton)*
Pn	- Floating-Leaf Pondweed *(Potamogeton)*
Po	- Pickerelweed *(Pontederia)*
W	- Watermeal *(Wolffia)*

WARNER'S POND
Concord, MA

Figure 5

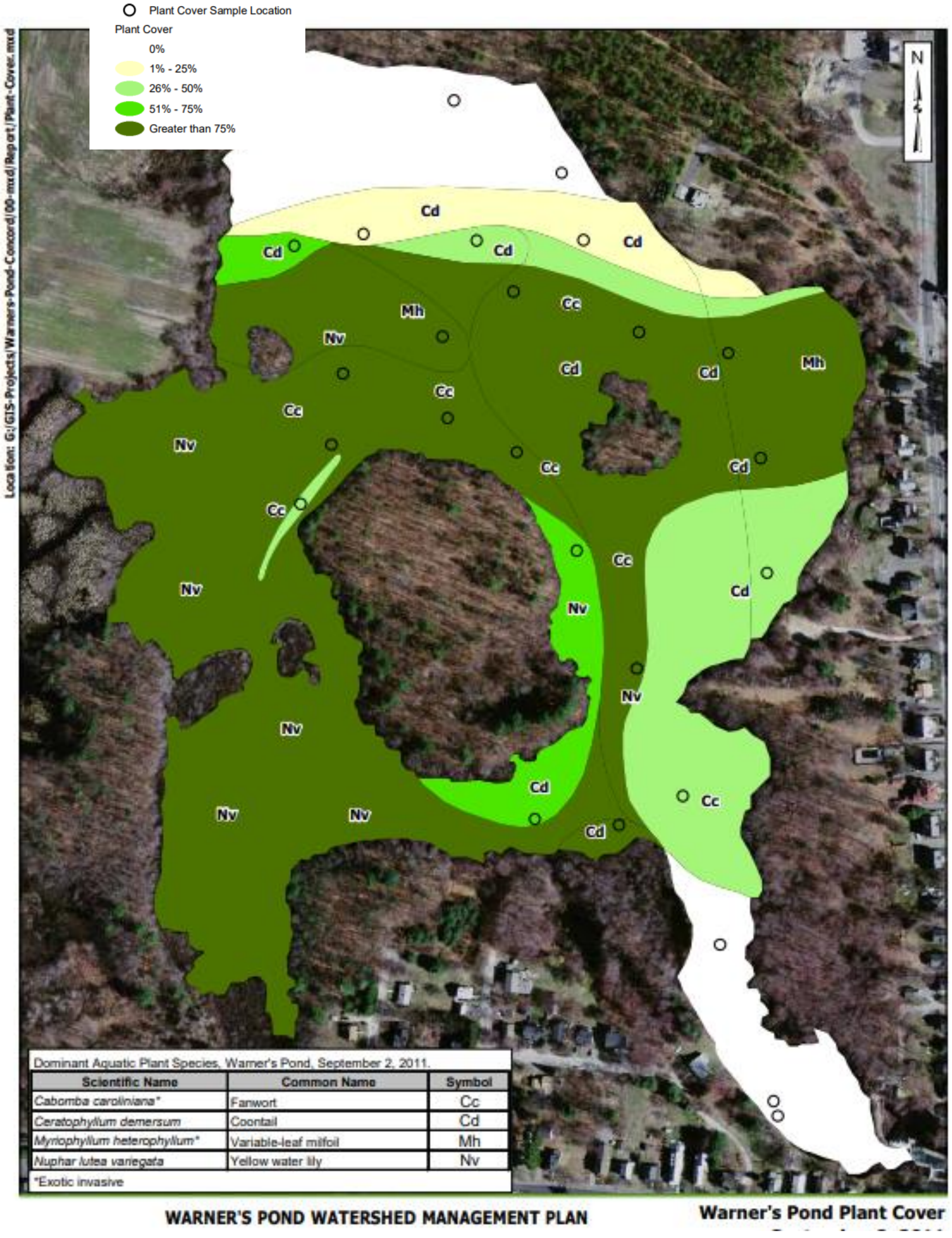
Dominant Aquatic Vegetation Map

August 1999

LEGEND

	Dominant Plants	*%Cover/Biomass*
▩	- Dv, Ly, Po, Ny, Nu	100 / 4
▦	- Ny, Nu, Cd, Ec, Pe, F, L, W, Tn	100 / 4
▧	- Cd, Ec, Ny, Nu, Pe, F, Cc, L, W	100 / 3-4
▒	- Cd, Ec, Ny, Pe	50-75 / 2
▤	- Cd, Mh, Ny, F, Ec, Ca, Pe, L, W	50-75 / 3
▨	- Cd, Cc, Ny, Pe, Ec, B	75 / 3
░	- Cd, Ny, Cc	25 / 1

Pond Area: ≈ 54 acres Scale: 1" = 350'



Dominant Aquatic Plant Species, Warner's Pond, September 2, 2011.

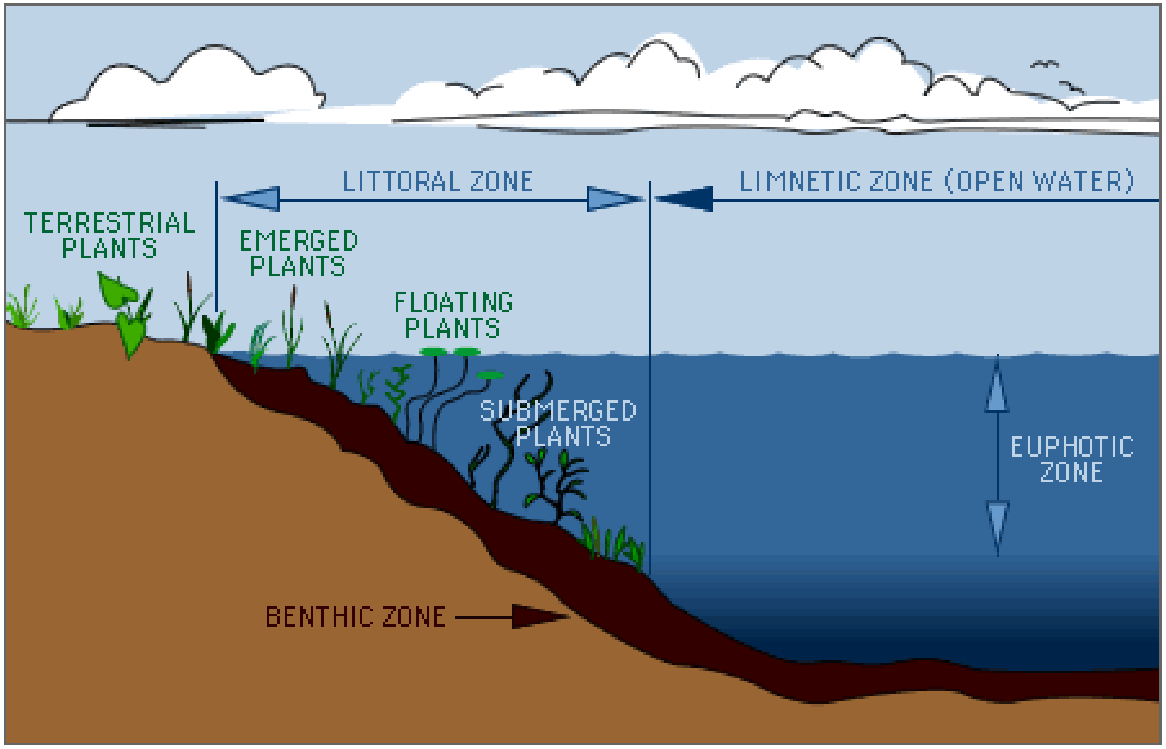
Scientific Name	Common Name	Symbol
*Cabomba caroliniana**	Fanwort	Cc
Ceratophyllum demersum	Coontail	Cd
*Myriophyllum heterophyllum**	Variable-leaf milfoil	Mh
Nuphar lutea variegata	Yellow water lily	Nv

*Exotic invasive

WARNER'S POND WATERSHED MANAGEMENT PLAN

Warner's Pond Plant Cover

Light Zonation and Pond Depth



Given the presence of adequate nutrients (either dissolved or particulate in sediment) for eutrophic conditions, the next key factor to the productivity of aquatic plant species is light zonation.

Light is critical for photosynthesis in plants. Photosynthesis is the process by which plants convert carbon dioxide and light to energy and release oxygen.

Photosynthesis can only occur in the littoral zone where rooted plants (macrophytes) receive adequate sunlight for growth. Light levels of about 1% or less of surface values usually define this depth. Light levels influence zonation in aquatic ecosystems by determining the distribution and abundance of photosynthetic organisms.

The uppermost layer, down to 1% light level, is where light penetration is highest, is known as the euphotic or photic zone. The dysphotic zone is where light levels are insufficient for photosynthesis.

Light Zonation and Pond Depth

The Secchi Depth is related to the depth of the photic zone; the depth at which there is 1% of the incident light can be estimated as 2 to 3.5 times the Secchi Depth *(https://www.gfredlee.com/Nutrients/Secchi_Depth.pdf*). The observed Secchi Depth at Warner's Pond (September, 2011) was 1.25 meters (4.1 feet; 49 inches), indicating a current pond photic zone of about 8 to 14 feet. Correlations of Secchi Depth and Mean Total Phospohorous indicates a Secchi Depth of about 100 inches (about 8 feet) associated with a concentration of 0.01 mg/l and a Secchi Depth of 49 inches (observed at the Pond) of about 0.04 mg/l.

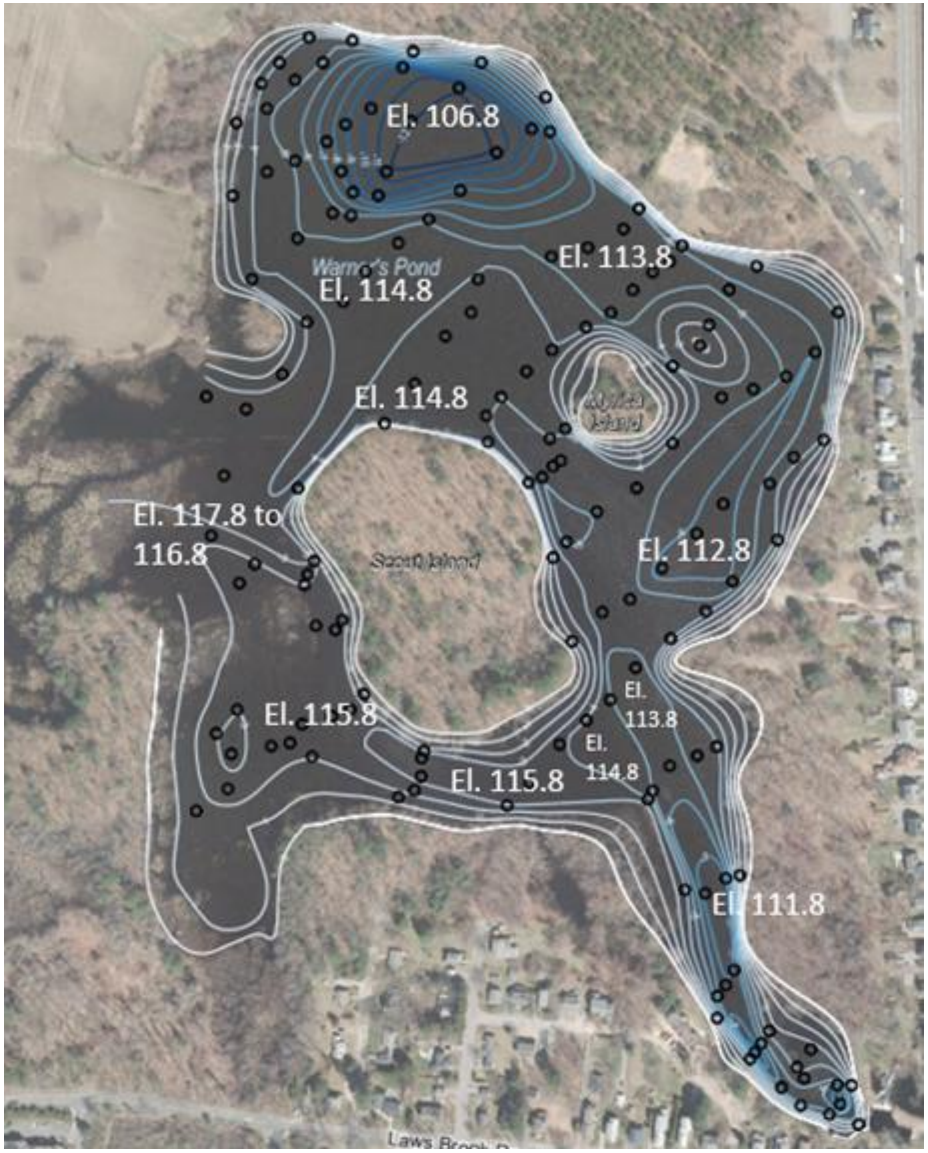
In very shallow ponds like Warner's Pond, the littoral zone can extend across the entire water body. Assuming a Normal Pool Elevation of 118.8 feet NAVD88 and an assumed photic zone of 8 feet, the littoral zone would be expected to extend to pond areas where the bottom elevation is at about 110.8 feet NAVD88.

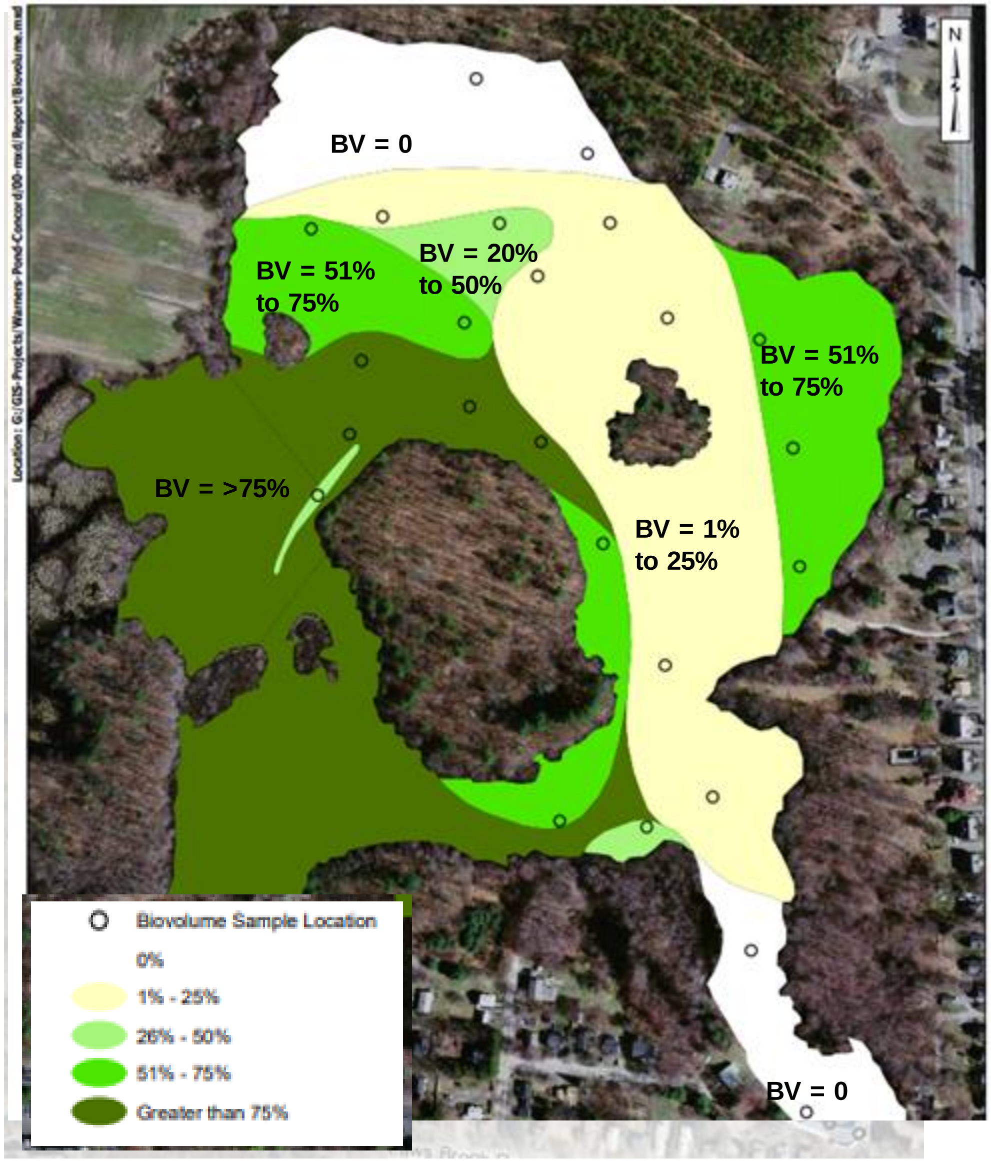
The following slide (left) shows the approximate, inferred bottom elevations throughout the Pond. The following slide (right) overlays the biovolume plan with the pond bottom elevation. Consistently, the areas of greatest biovolume coincide with the shallowest pond depths, and areas where bottom elevations are less than about 113 feet NAVD88 show much less biovolume, and little to no biovolume where bottom elevations are less than about 111 feet NAVD88 (about 8 feet below Normal Pool Elevation). A 14-foot water depth (upper end of estimated photic zone) would be about Elevation 105 feet NAVD88.

Possible Pond management goals based on observed conditions (preliminary): Improvement to achieve better to optimum littoral zone plant coverage: 1) reduce littoral zone to pond margins, and about 30% of pond area; 2) within this littoral zone maintain 65% to 100% plant coverage; 3) less than 15% to no invasive species; 4) maintain 5 or more native species; 5) no single native species constitutes more than 30% of plant coverage; and 6) all aquatic plant coverage (submerged, emerged and floating) is greater than 30% and less than 85% of pond area. It appears that this could likely be achieved by dredging to about Elevation 111 feet NAVD88 (or lower) over 15% to 30% of the Pond area. Reference Littoral Zone Scorecard Littoral Zone Scorecard (ufl.edu)

Light Zonation and Existing Pond Depth

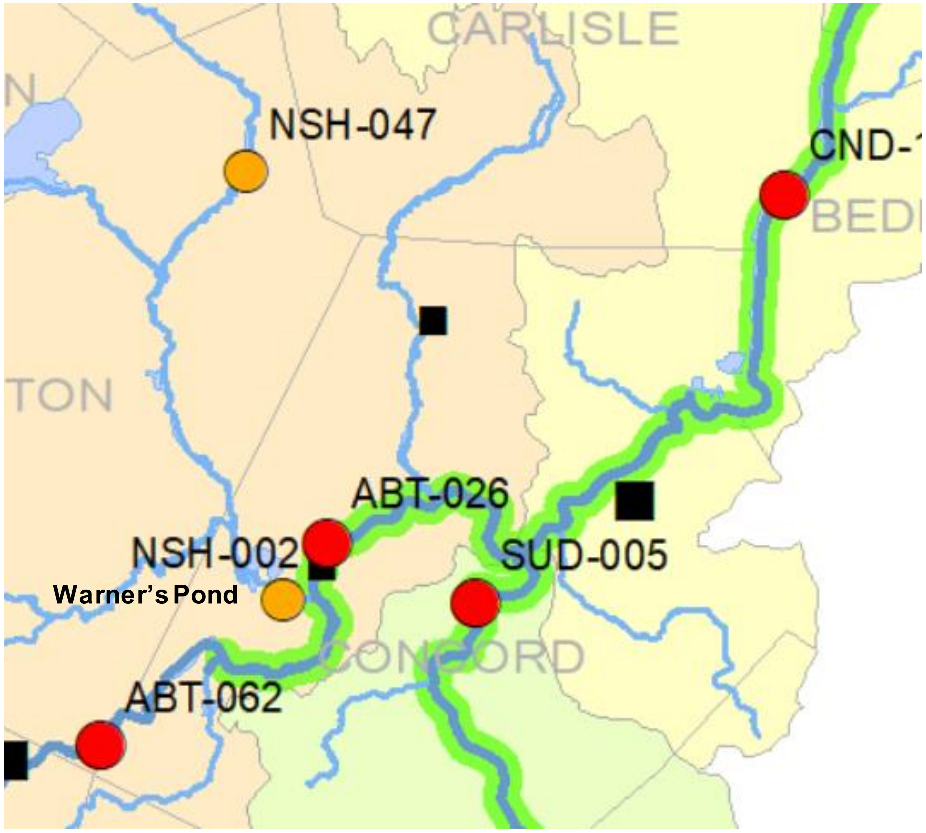
The depth versus biovolume at Warner’s Pond matches well with that predicted in the literature.

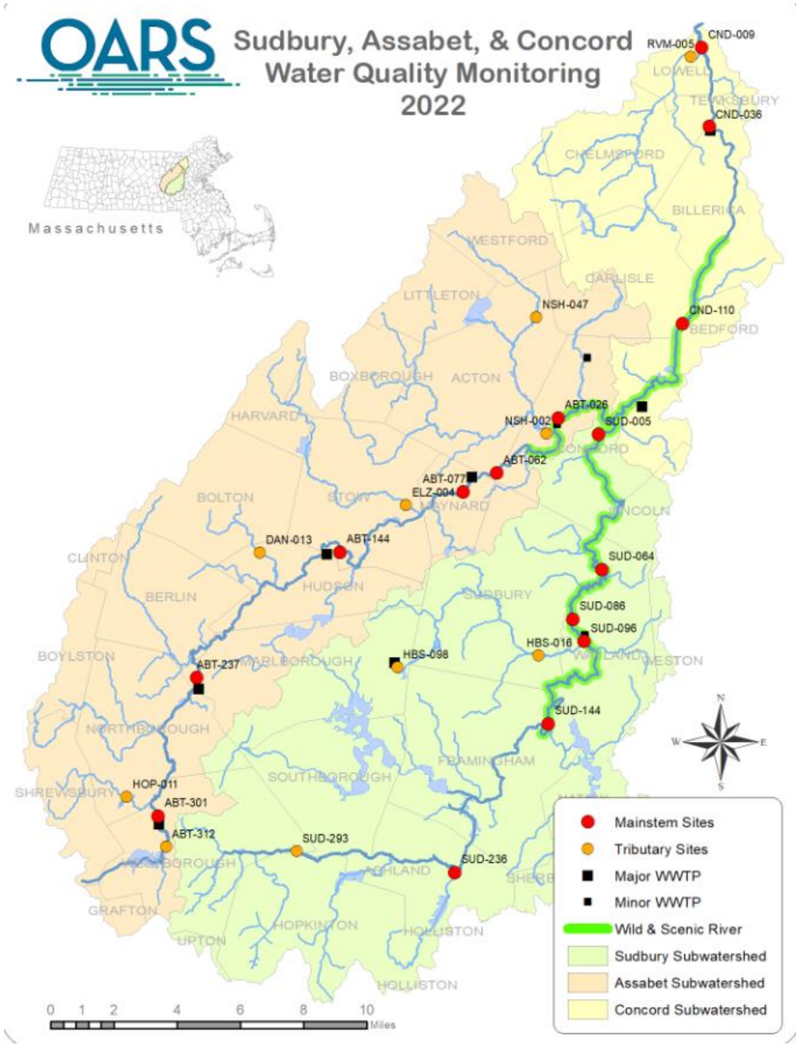




Comparison of Warner’s Pond Water Quality to Area Water Bodies

OARs sampling locations. The following uses data sources including publicly available OARS water quality reports and USGS streamflow data.





Comparison of Warner’s Pond Water Quality to Area Water Bodies: Phosphorous

Warner’s Pond water quality testing in September of 2011 indicated total phosphorous values of 0.01 mg/l (pond surface) to ND to 0.04 mg/l (pond outlet).

Warner’s Pond 2011 total phospohorus concentrations are consistent with those recently (2023) observed in the Upper Assabet and tributaries including OARs sample locations NSH-002 (adjacent to and downgradient of pond outlet) and NSH-047 (Nashoba Brook in Acton (contributing tributary to Warner’s Pond), and do not indicate a relatively degraded condition. The values are less than a referenced standard of 0.05 mg/l (reference condition of 50 percentile June through September; EPA)

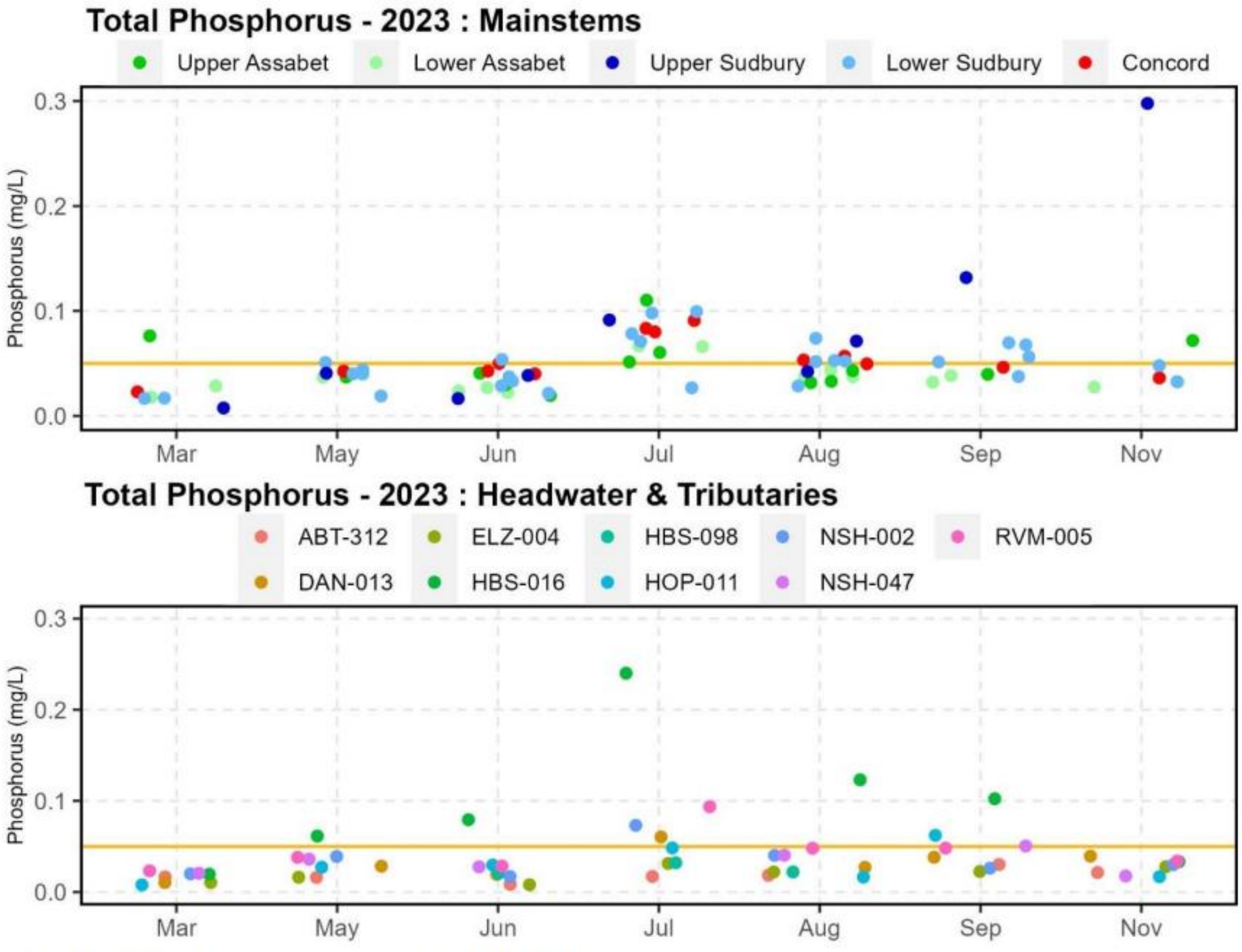


Figure 28: TP concentration by month and site (2023)

Comparison of Warner’s Pond Water Quality to Area Water Bodies: Dissolved Oxygen

Warner’s Pond water quality testing in September of 2011 indicated DO concentrations of 7.66, 6.41, 6.50 and 2.29 mg/l at the outlet (wet), outlet (dry), surface and bottom respectively.

Warner’s Pond 2011 DO concentrations are consistent with those recently (2023) observed in the Upper Assabet and tributaries including OARs sample locations NSH-002 (adjacent to and downgradient of pond outlet) and NSH-047 (Nashoba Brook in Acton (contributing tributary to Warner’s Pond), and do not indicate a relatively degraded condition.

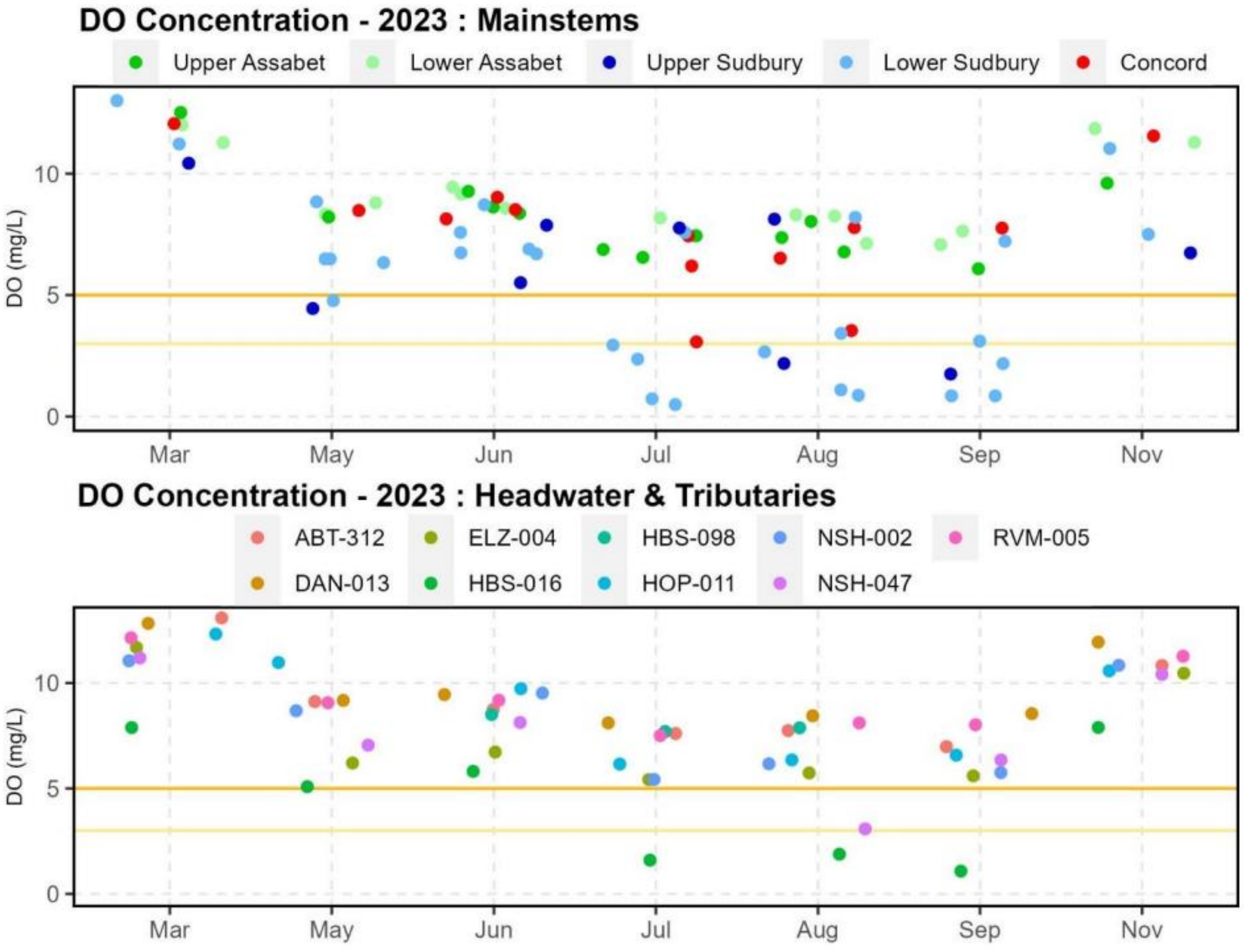


Figure 20: Dissolved Oxygen by month and site (2023)

Comparison of Warner’s Pond Water Quality to Area Water Bodies: pH

Warner’s Pond water quality testing in September of 2011 indicated pH values of 6.1 to 6.7 total phosphorous values of 0.10 mg/l (pond surface) to ND to 0.04mg/l (pond outlet).

Warner’s Pond 2011 pH values are consistent with those recently (2023) observed in the Upper Assabet and tributaries including OARs sample locations NSH-002 (adjacent to and downgradient of pond outlet) and NSH-047 (Nashoba Brook in Acton (contributing tributary to Warner’s Pond), and do not indicate a relatively degraded condition.

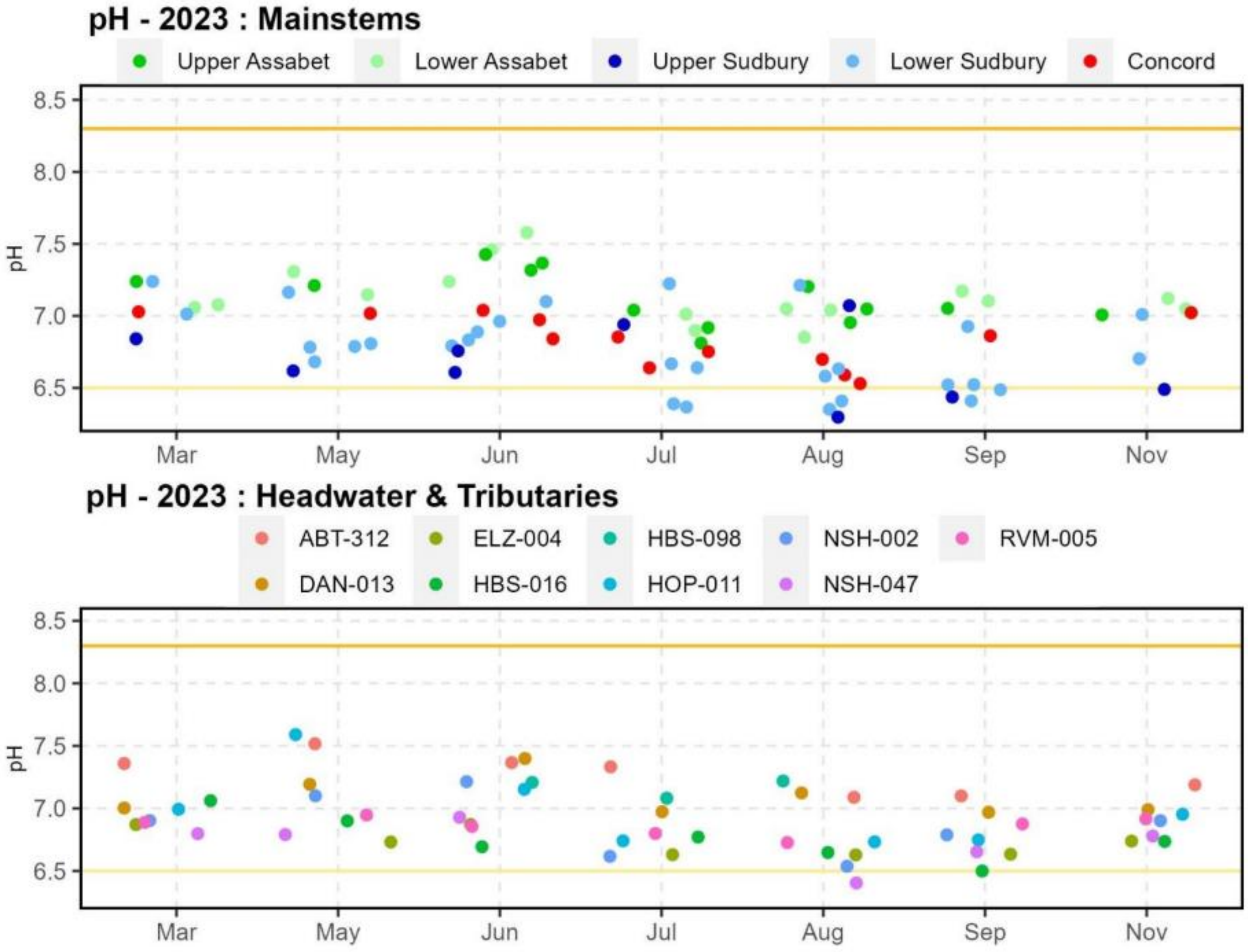


Figure 24: pH by month and site (2023)

Comparison of Warner's Pond Water Quality to Area Water Bodies: Specific Conductance

Warner's Pond water quality testing in September of 2011 indicated specific conductance values that ranged from 418.2, 266.9, 318.6 and 313.2 uS/cm at the outlet (wet), outlet (dry), surface and bottom respectively.

Warner's Pond 2011 specific conductance concentrations are consistent with those recently (2023) observed in the Upper Assabet and tributaries including OARs sample locations NSH-002 (adjacent to and downgradient of pond outlet) and NSH -047 (Nashoba Brook in Acton (contributing tributary to Warner's Pond), and do not indicate a relatively degraded condition.

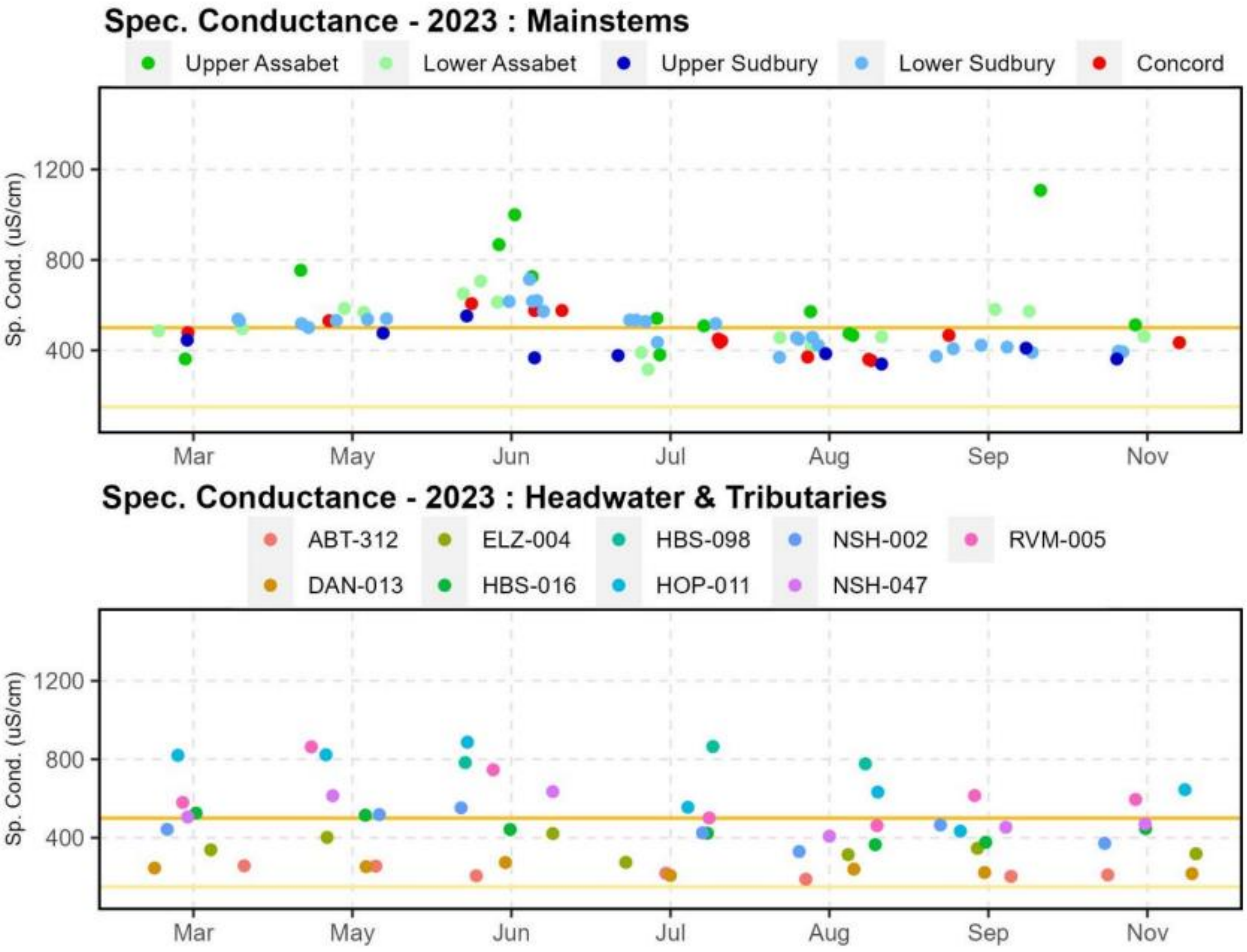


Figure 15: Specific conductance by month and site (2023)

Comparison of Warner’s Pond Water Quality to Area Water Bodies: Temperature

Warner’s Pond water quality testing in September of 2011 indicated water temperatures that ranged from 17.2, 22.0, 20.3 and 19.3 degrees Celsius at the outlet (wet), outlet (dry), surface and bottom respectively.

Warner’s Pond 2011 water temperature is consistent with that recently (2023) observed in the Upper Assabet and tributaries including OARs sample locations NSH-002 (adjacent to and downgradient of pond outlet) and NSH -047 (Nashoba Brook in Acton (contributing tributary to Warner’s Pond), and do not indicate a relatively degraded condition.

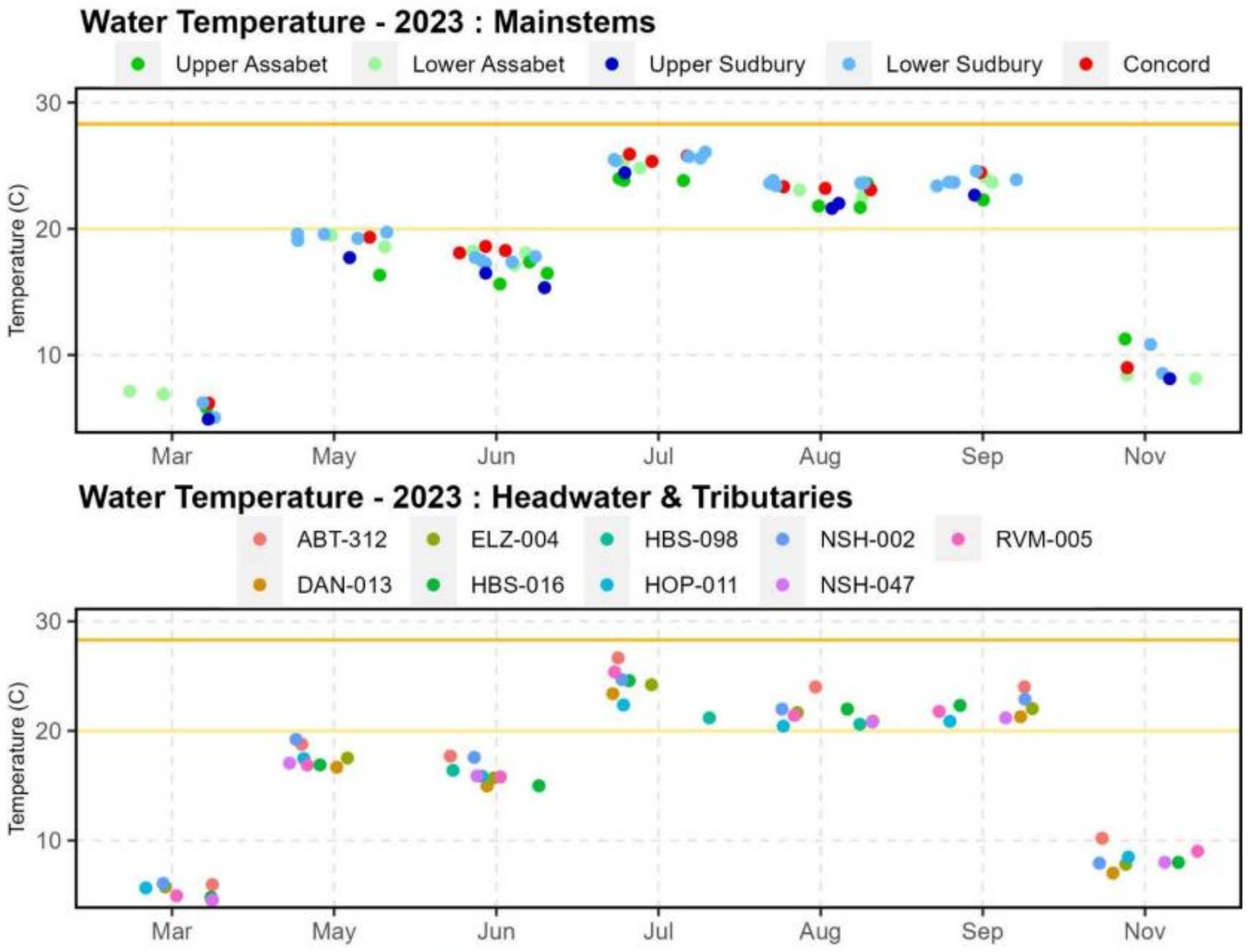


Figure 11: Water temperature by month and site (2023)

Effects of Warner’s Pond on Downstream Water Quality: Dissolved Oxygen

OARs: Nashoba Brook at NSH-002: “The median summer dissolved oxygen level is below the MassDEP Class B Water Quality Standard of 5 mg/L. The data show a year-on-year steady decline in dissolved oxygen below the dam from more than 7 mg/L in 2009 to less than 5 mg/L in 2022. [OARS Water Quality Report (oars3rivers.org)]

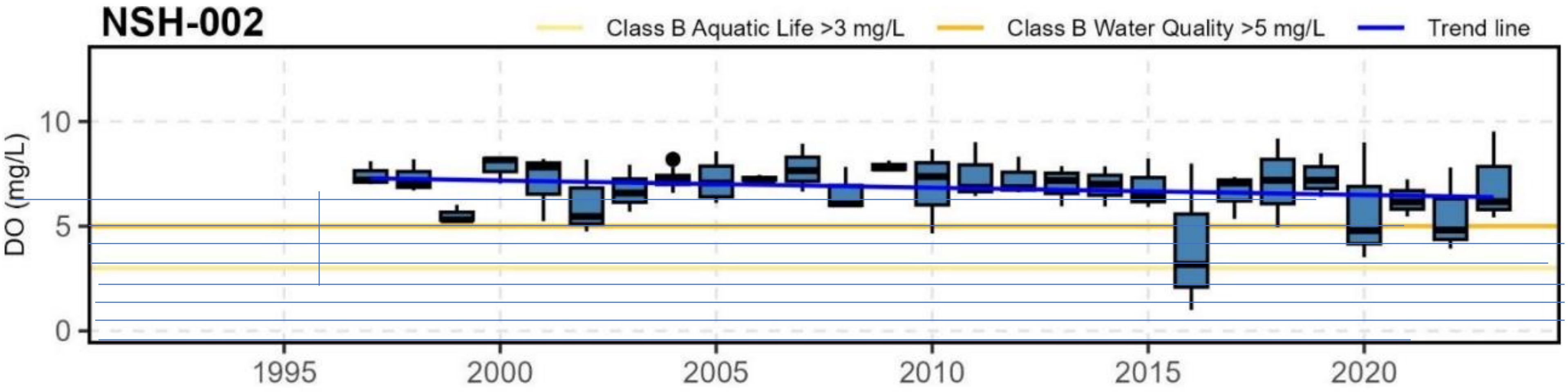


Figure 22: Dissolved Oxygen by year for selected sites (June/July/August)

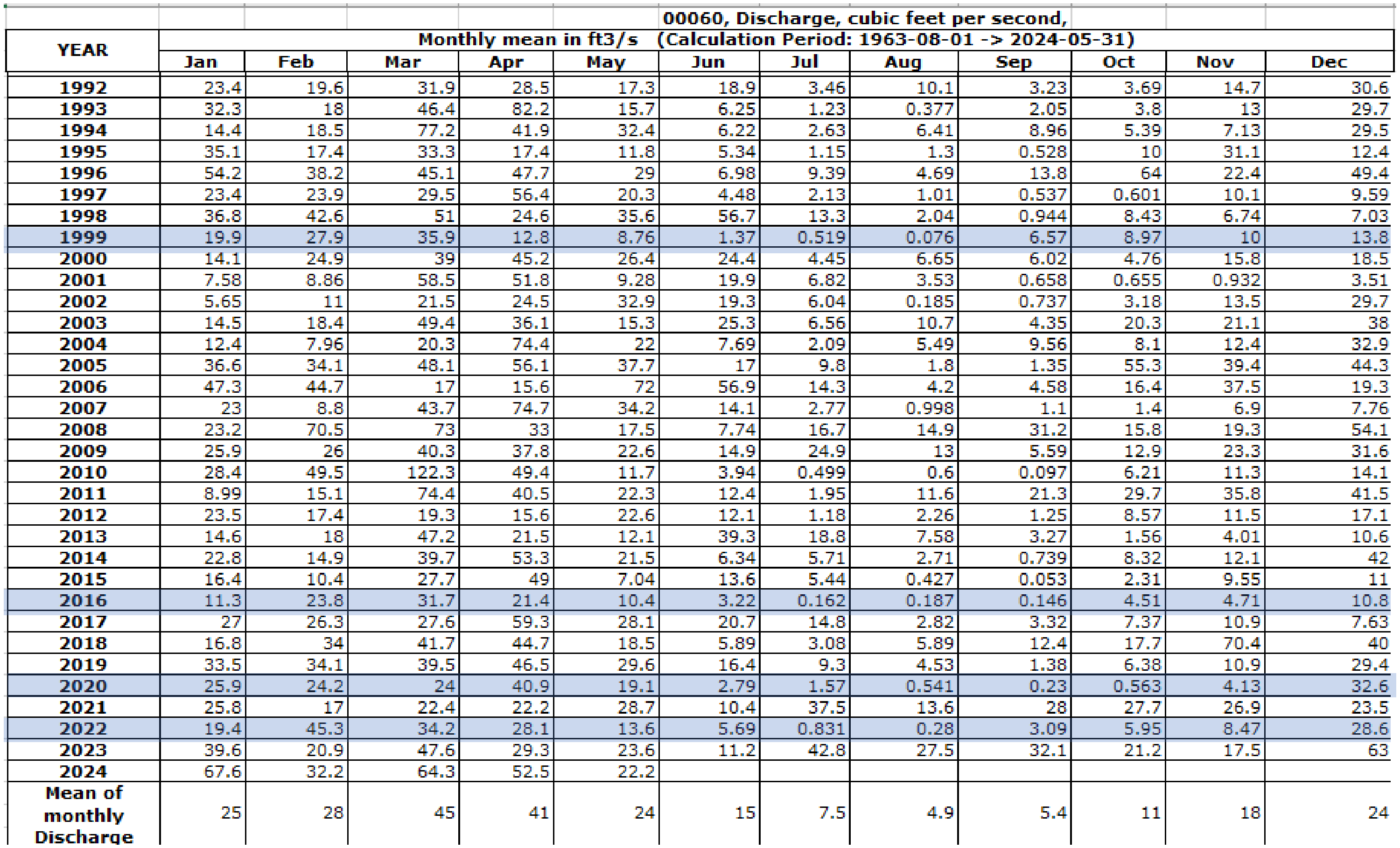
Effects of Warner’s Pond on Downstream Water Quality: Dissolved Oxygen

Data Interpretation: The conclusion by OARs is that the trend line indicates consistently decreasing DO, with the implication that it is due to the water quality within Warner’s Pond. Additional considerations:

1. Very low readings (2016, 2020 and 2022) in the previous slide appear to be due, in part, to the fact that there was very low to no flow within this section of Nashoba Brook at these times due to drought conditions:
   - 1999: The Northeast region (which includes the states from Delaware, Maryland, and Pennsylvania northeastward to Maine) has suffered from unusually dry conditions during the last five months, with April-August 1999 ranking as the driest such period this century. Eleven of the last 14 months have been drier than normal. Other 1999 statistics include: second driest summer and sixth driest September-August.
   - 2016: From 2016-2017, Massachusetts experienced a drought with rapid decline in conditions from month to month; what scientists refer to as "flash drought." This was the most significant drought in Massachusetts since the 1960s, with record low streamflow and groundwater levels (reported by the U.S. Geological Survey) and below average precipitation in the mid-30s inches each year, compared to the typical 44 yearly inches measured by the National Weather Service.
   - 2020: In 2020, Massachusetts had another significant drought that lasted most of the year, setting the stage for the dry conditions we saw in 2021. Climate change exacerbated this string of drought events and will make them even more common in the future.
   - 2022: August 2022 also was a Critical Level 3 Drought.
2. Streamflow data for this section of Nashoba Brook (NHS-02) is not available; however, streamflow for Nashoba Brook in Acton (NHS-047, north of Warner’s Pond) is available and relevant as an indicator of flow conditions within the tributaries. NHS-07 indicated low to no flow conditions during these drought conditions. The following slide, generated from USGS gage shows stream flow (cfs) for Nashoba Brook in Acton (north of Warner’s Pond) for the period of 1992 to current with low flows highlighted. Consistent with the literature, analysis of the OAR’s Nashoba Brook data indicates that low flow has been correlated with reduced DO.
3. For years with typical (e.g., mean) streamflow, such as the graphs presented here for 2023, Nashoba Brook water quality parameters are as good or better at the sample location downstream of Warner’s Pond (NSH-002) as the upgradient (NHS-047). See following slides.

Effects of Warner's Pond on Downstream Water Quality

MA Drought Years (shaded)

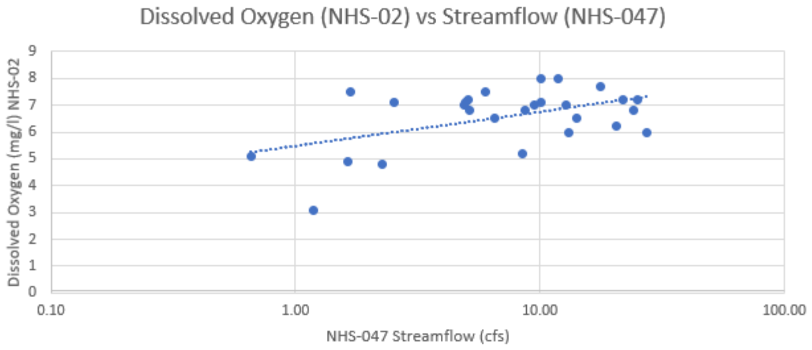


00060, Discharge, cubic feet per second,

Monthly mean in ft3/s (Calculation Period: 1963-08-01 -> 2024-05-31)

YEAR	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1992	23.4	19.6	31.9	28.5	17.3	18.9	3.46	10.1	3.23	3.69	14.7	30.6
1993	32.3	18	46.4	82.2	15.7	6.25	1.23	0.377	2.05	3.8	13	29.7
1994	14.4	18.5	77.2	41.9	32.4	6.22	2.63	6.41	8.96	5.39	7.13	29.5
1995	35.1	17.4	33.3	17.4	11.8	5.34	1.15	1.3	0.528	10	31.1	12.4
1996	54.2	38.2	45.1	47.7	29	6.98	9.39	4.69	13.8	64	22.4	49.4
1997	23.4	23.9	29.5	56.4	20.3	4.48	2.13	1.01	0.537	0.601	10.1	9.59
1998	36.8	42.6	51	24.6	35.6	56.7	13.3	2.04	0.944	8.43	6.74	7.03
1999	19.9	27.9	35.9	12.8	8.76	1.37	0.519	0.076	6.57	8.97	10	13.8
2000	14.1	24.9	39	45.2	26.4	24.4	4.45	6.65	6.02	4.76	15.8	18.5
2001	7.58	8.86	58.5	51.8	9.28	19.9	6.82	3.53	0.658	0.655	0.932	3.51
2002	5.65	11	21.5	24.5	32.9	19.3	6.04	0.185	0.737	3.18	13.5	29.7
2003	14.5	18.4	49.4	36.1	15.3	25.3	6.56	10.7	4.35	20.3	21.1	38
2004	12.4	7.96	20.3	74.4	22	7.69	2.09	5.49	9.56	8.1	12.4	32.9
2005	36.6	34.1	48.1	56.1	37.7	17	9.8	1.8	1.35	55.3	39.4	44.3
2006	47.3	44.7	17	15.6	72	56.9	14.3	4.2	4.58	16.4	37.5	19.3
2007	23	8.8	43.7	74.7	34.2	14.1	2.77	0.998	1.1	1.4	6.9	7.76
2008	23.2	70.5	73	33	17.5	7.74	16.7	14.9	31.2	15.8	19.3	54.1
2009	25.9	26	40.3	37.8	22.6	14.9	24.9	13	5.59	12.9	23.3	31.6
2010	28.4	49.5	122.3	49.4	11.7	3.94	0.499	0.6	0.097	6.21	11.3	14.1
2011	8.99	15.1	74.4	40.5	22.3	12.4	1.95	11.6	21.3	29.7	35.8	41.5
2012	23.5	17.4	19.3	15.6	22.6	12.1	1.18	2.26	1.25	8.57	11.5	17.1
2013	14.6	18	47.2	21.5	12.1	39.3	18.8	7.58	3.27	1.56	4.01	10.6
2014	22.8	14.9	39.7	53.3	21.5	6.34	5.71	2.71	0.739	8.32	12.1	42
2015	16.4	10.4	27.7	49	7.04	13.6	5.44	0.427	0.053	2.31	9.55	11
2016	11.3	23.8	31.7	21.4	10.4	3.22	0.162	0.187	0.146	4.51	4.71	10.8
2017	27	26.3	27.6	59.3	28.1	20.7	14.8	2.82	3.32	7.37	10.9	7.63
2018	16.8	34	41.7	44.7	18.5	5.89	3.08	5.89	12.4	17.7	70.4	40
2019	33.5	34.1	39.5	46.5	29.6	16.4	9.3	4.53	1.38	6.38	10.9	29.4
2020	25.9	24.2	24	40.9	19.1	2.79	1.57	0.541	0.23	0.563	4.13	32.6
2021	25.8	17	22.4	22.2	28.7	10.4	37.5	13.6	28	27.7	26.9	23.5
2022	19.4	45.3	34.2	28.1	13.6	5.69	0.831	0.28	3.09	5.95	8.47	28.6
2023	39.6	20.9	47.6	29.3	23.6	11.2	42.8	27.5	32.1	21.2	17.5	63
2024	67.6	32.2	64.3	52.5	22.2							
Mean of monthly Discharge	25	28	45	41	24	15	7.5	4.9	5.4	11	18	24

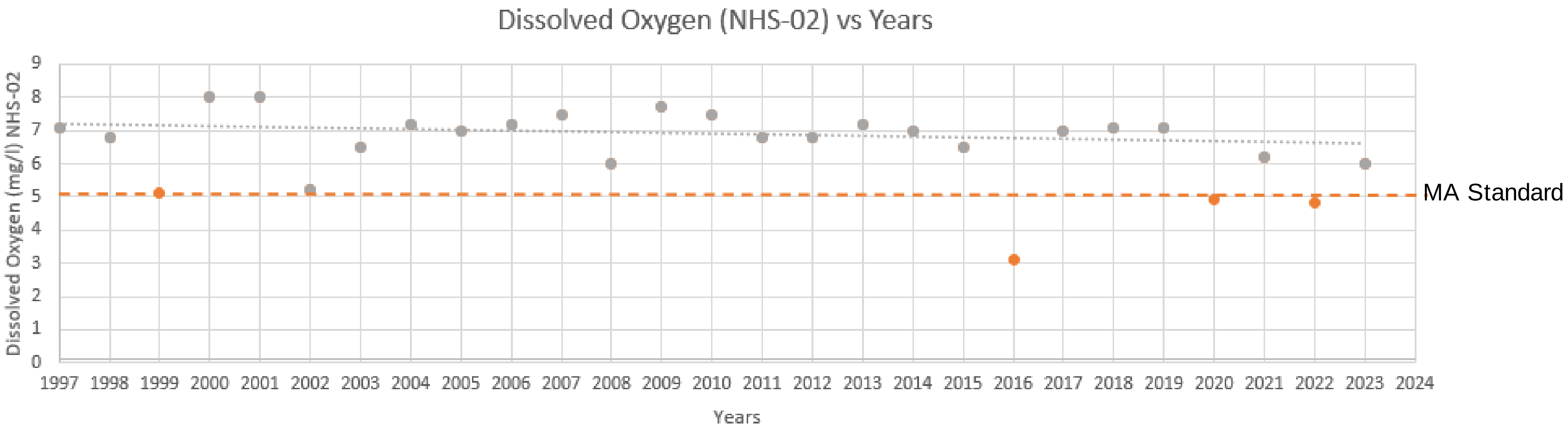
Low flow appears to be correlated with low DO during low flow conditions. This graph compares mean summer DO readings (1997 to 2023) obtained from NHS-02 to mean summer streamflow (flow data for NHS-047, which is used here as analog for representative flow). A logarithmic trend line indicates a reasonable correlation of DO to streamflow, indicating that DO likely decreases during low flow conditions in Nashoba Brook.

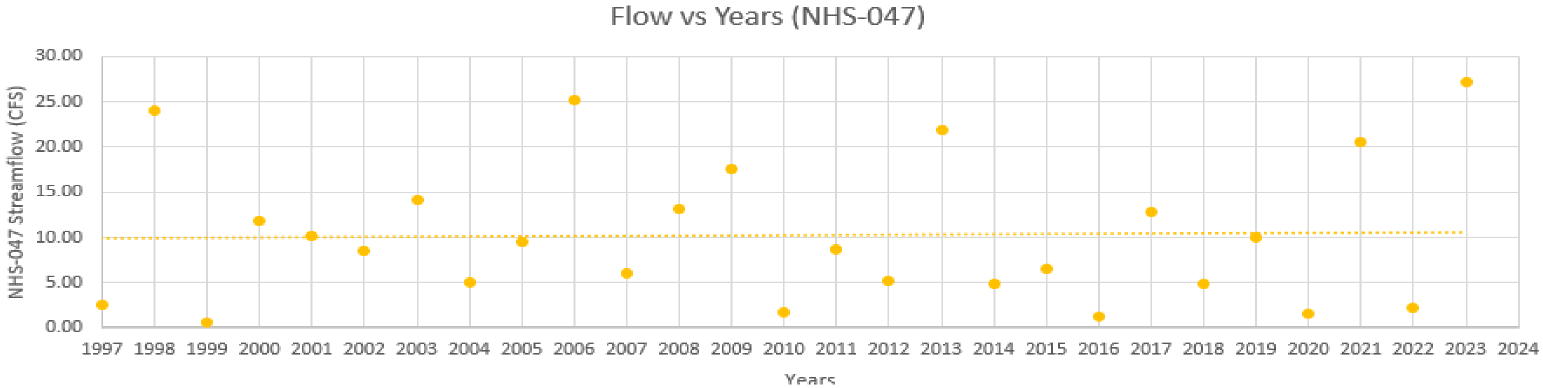


Effects of Warner’s Pond on Downstream Water Quality

Although DO appears to correlate with streamflow, in particular at low flow conditions, which significantly influence DO trend analysis when drought years are included, some long-term decrease of DO in Nashoba Brook (NHS-02) does appear to be occurring as noted by OARs.

The upper graph compares NHS-02 mean summer DO readings (1997 to 2023) with the very low flow drought years removed. A linear trend line indicates some decrease in DO over time in Nashoba Brook. This reduction, over the long-term, does not appear to be due to a long-term reduction in mean summer streamflow (in fact, mean summer streamflow appears to be steady to marginally increasing – bottom graph).





Effects of Warner's Pond on Downstream Water Quality

The trend line indicates an approximately 4% reduction in mean summer DO over the 27 years represented, corresponding to an average reduction of about 0.2% per year. The rate of decrease in Nashoba Brook is relatively low; however, based on trends over the last 10 years (excluding drought years), the rate appears to be increasing to about 1.1% per year. At this rate, mean summer DO will be at 5 mg/l (standard) in about 17 years.

Comparison:

There is insufficient data available for a conclusion about the relationship between Pond DO and downstream DO. The limited available data appear to indicate that during higher flow, pond outlet DO >pond input, with the reverse at lower flows. The following shows a comparison based on very limited data.

The NHS-02 mean Summer 2011 DO measurement was about 7 mg/l.

For comparison, the September 2011 Pond water quality tests indicate:

- Dry weather inlet DO: 7.9 mg/l
- Dry weather pond surface DO: 6.5 mg/l
- Dry weather pond outlet DO: 6.41 mg/l

- Wet weather inlet DO: 6.5 mg/l
- Wet weather pond outlet DO: 7.66 mg/l

- Dry and wet weather pond outlet DO combined average: 7.03 mg/l
- Dry and wet weather inlet DO combined average: 7.20 mg/l

The 2011 outlet and Pond surface dry weather DO data show good agreement. The Pond outlet average shows good agreement with NHS-02.

The wet weather Pond outlet versus inlet indicates an increase in DO at the outlet.

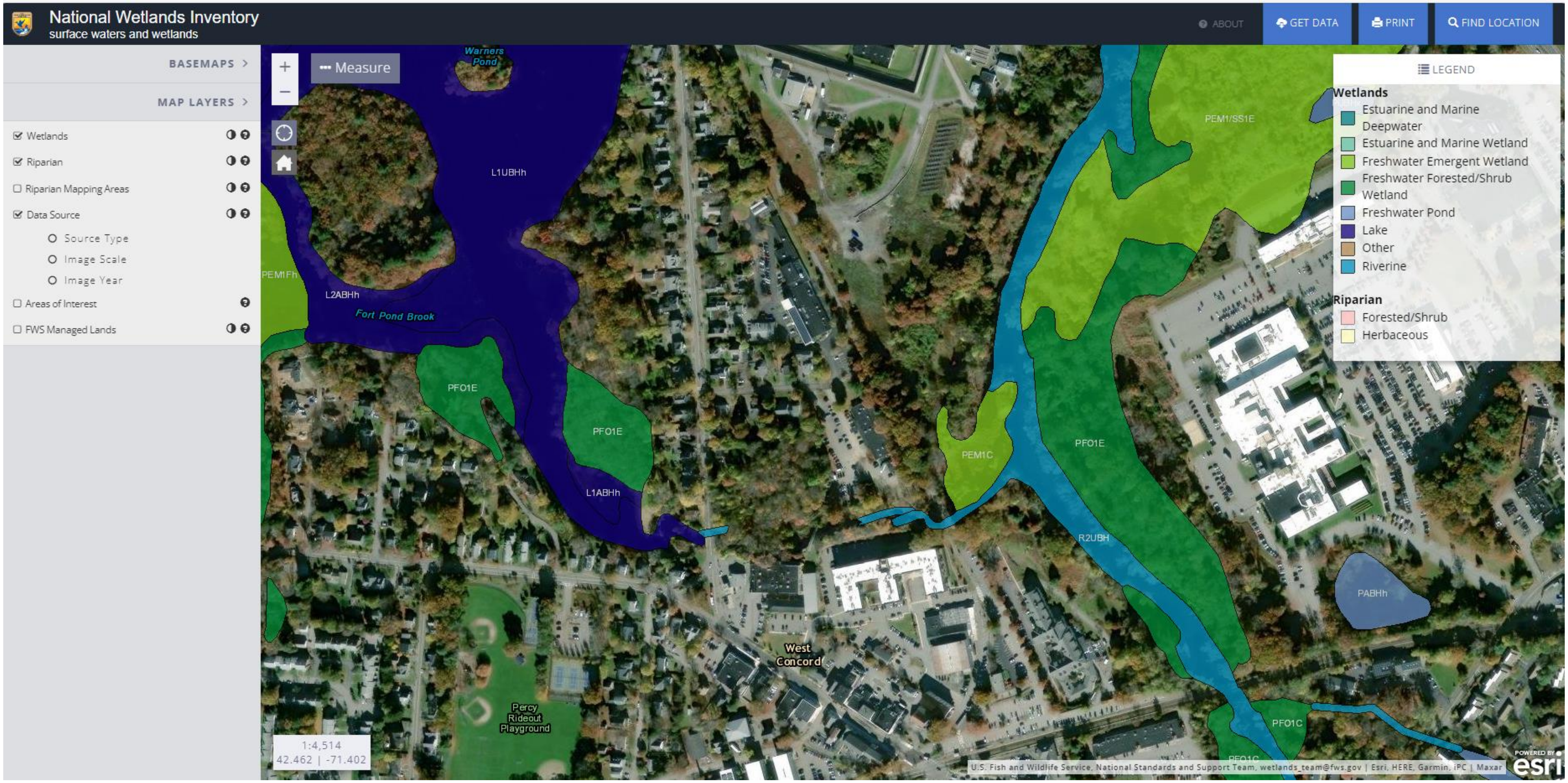
Flow at the dam spillways and channel may oxygenate Pond water discharging to Nashoba Brook.

As a shallow, low gradient stream channel, oxygen deficits and low DO should be expected in Nashoba Brook regardless.

Additional data, in particular Pond data, is required to understand the effect of the Pond on downstream water quality. Regardless, it is not expected that the Pond will affect the Upper Assabet water quality.

Effects of Warner's Pond on Downstream Water Quality

However, given the shallow, water and low gradient oxygen deficits and low DO would be expected along this section of Nashoba Brook. See the National Wetlands Inventory Classification below.



Subsystem **Lower Perennial (2)** : **This Subsystem is characterized by a low gradient**. There is no tidal influence, and some water flows all year, except during years of extreme drought. The substrate consists mainly of sand and mud. **Oxygen deficits may sometimes occur**. The fauna is composed mostly of species that reach their maximum abundance in still water, and true planktonic organisms are common. The gradient is lower than that of the Upper Perennial Subsystem and the floodplain is well developed.

Comparison of Warner's Pond Water Quality to Area Water Bodies

For years with typical (e.g., mean) streamflow, such as the graphs presented here for 2023, Nashoba Brook water quality parameters are as good as or better at sample location downstream of Warner's Pond (NSH-002) than upgradient (NHS-047). For example, NSH-02 has slightly higher DO, lower conductivity and similar phosphorous as NSH-047.

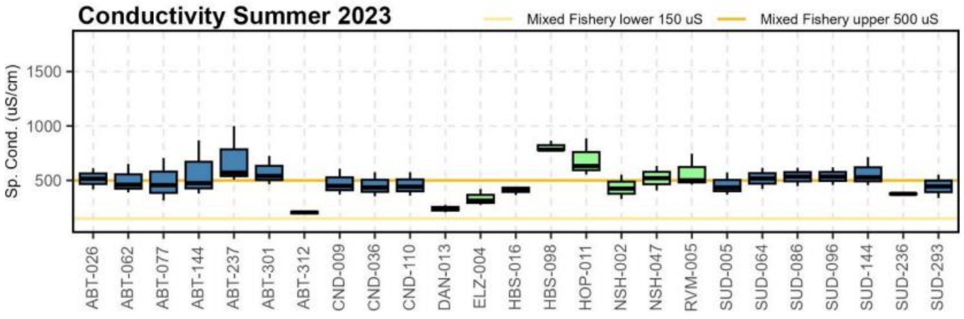


Figure 14: Specific conductance by site, summer (Jun-Aug 2023)

The tributary sites in this by-site chart are grouped together and colored green, from DAN-013 to RVM-005. Mainstem sites are grouped by river and listed in river mile sequence.

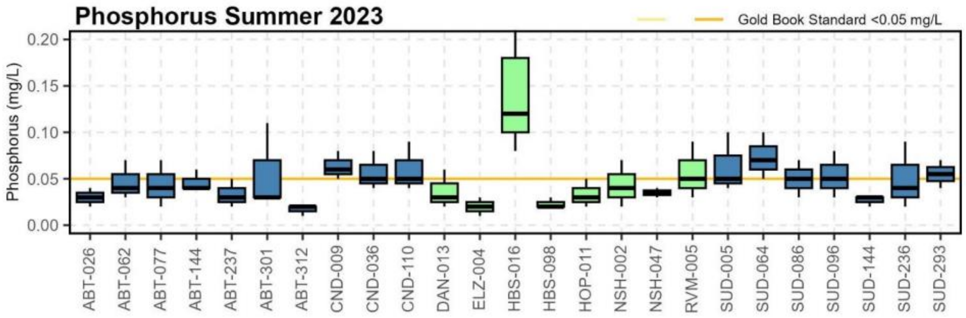


Figure 27: TP concentration by site, summer (Jun-Aug 2023)

The tributary sites in this by-site chart are grouped together and colored green, from DAN-013 to RVM-005. Mainstem sites are grouped by river and listed in river mile sequence.

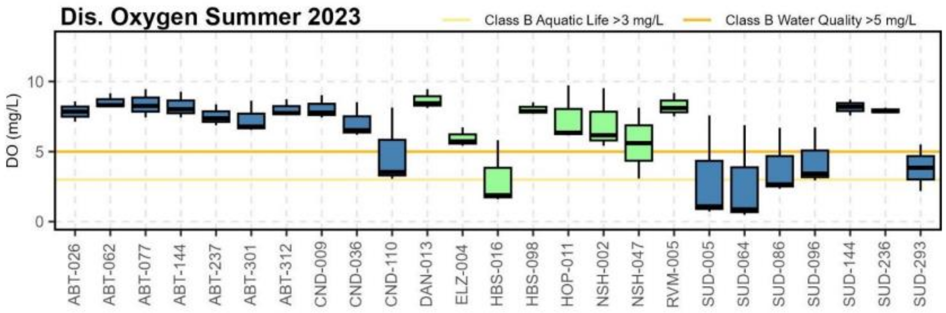


Figure 19: Dissolved Oxygen concentration by site, summer (Jun-Aug 2023)

The tributary sites in this by-site chart are grouped together and colored green, from DAN-013 to RVM-005. Mainstem sites are grouped by river and listed in river mile sequence.

Comparison of Warner's Pond Water Quality to Area Water Bodies

The limited available data appear to indicate that during higher flow, pond outlet DO may exceed pond input, with the reverse at lower flows. The graph below shows 2023 data for NH-047 (Nashoba Brook pond input tributary) in purple and NHS-02 (Nashoba Brook pond outlet) in blue. 2023 mean summer streamflow was relatively high and NHS-02 DO values (outlet) appear higher than NHS-047 (inlet).

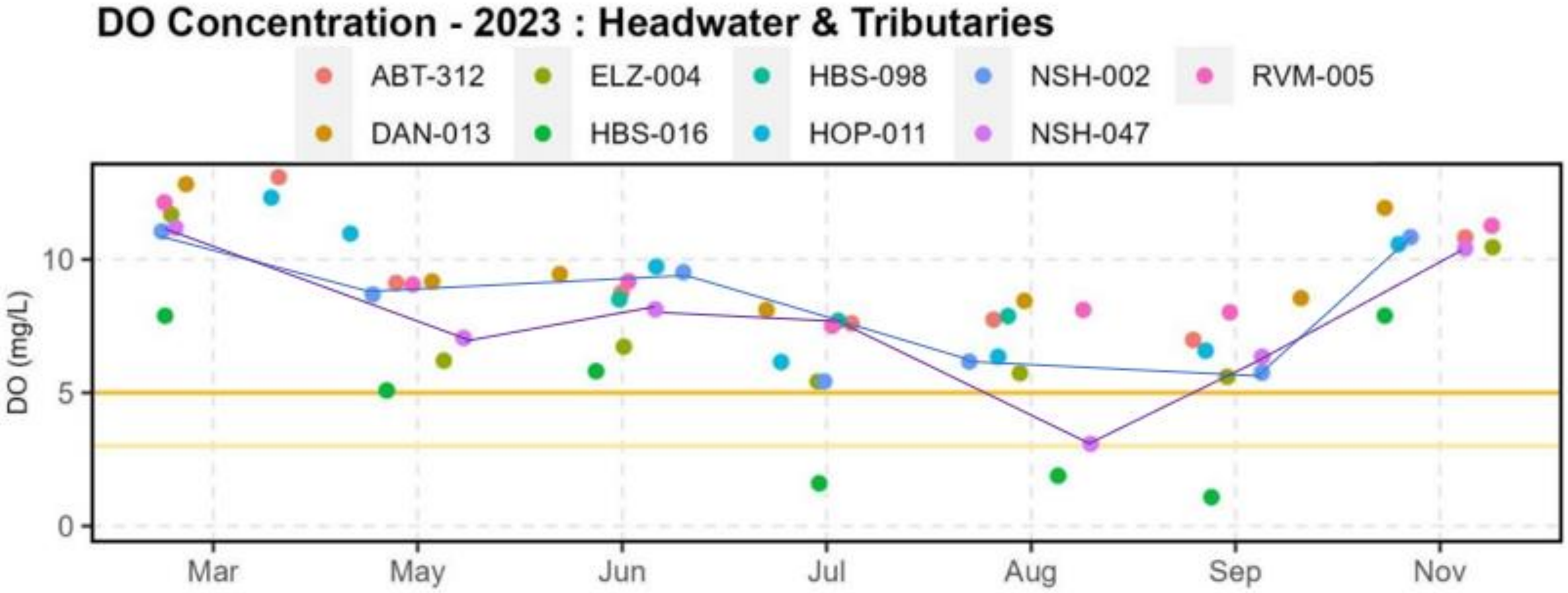


Figure 20: Dissolved Oxygen by month and site (2023)

Effects of Warner’s Pond on Downstream Water Quality

The available data appear to indicate that water discharging from either Warner’s Pond or Nashoba Brook does not have any adverse effect on water quality within the Upper Assabet. And no adverse effect would be expected given the significant difference difference in streamflow.

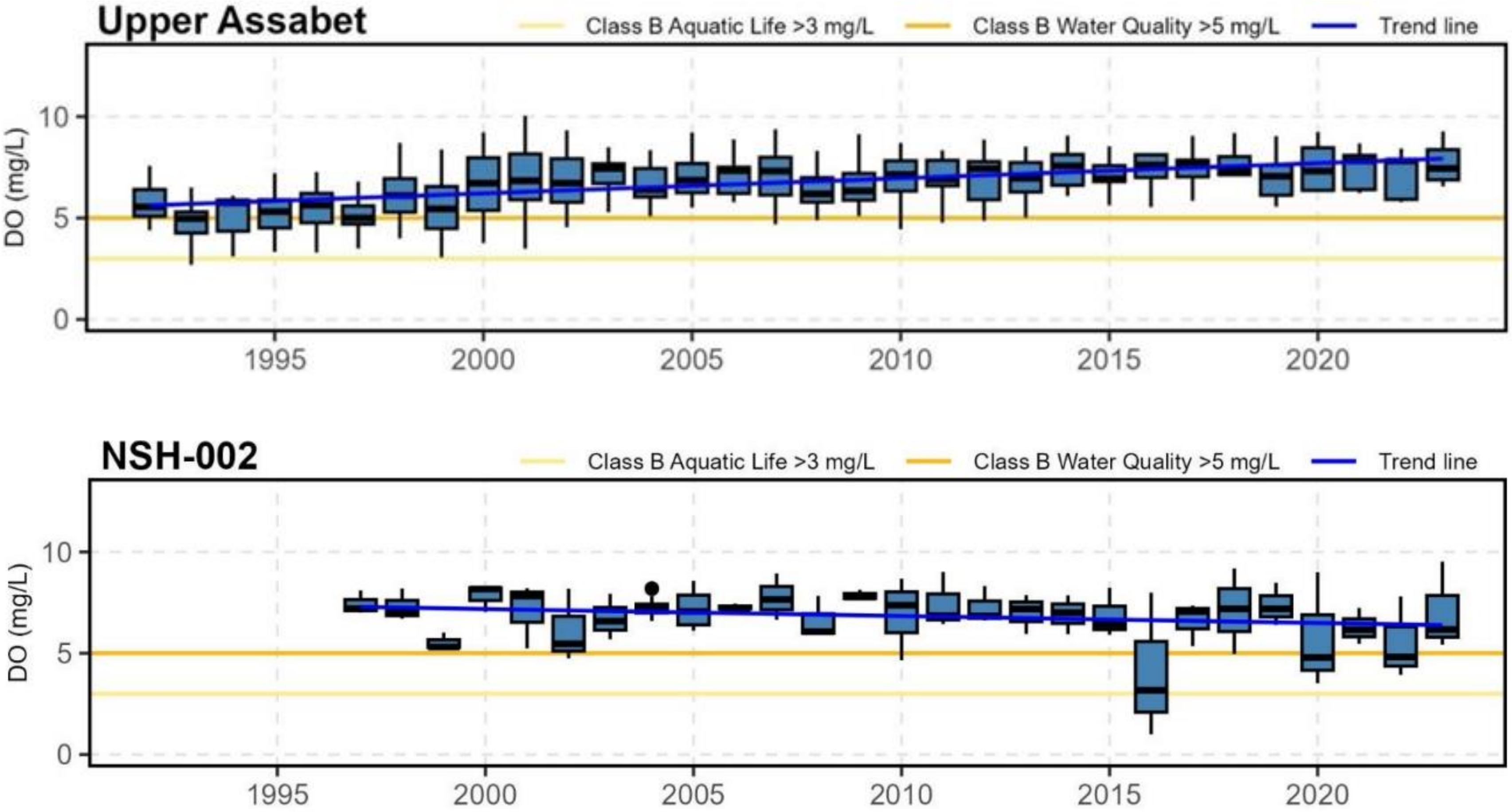
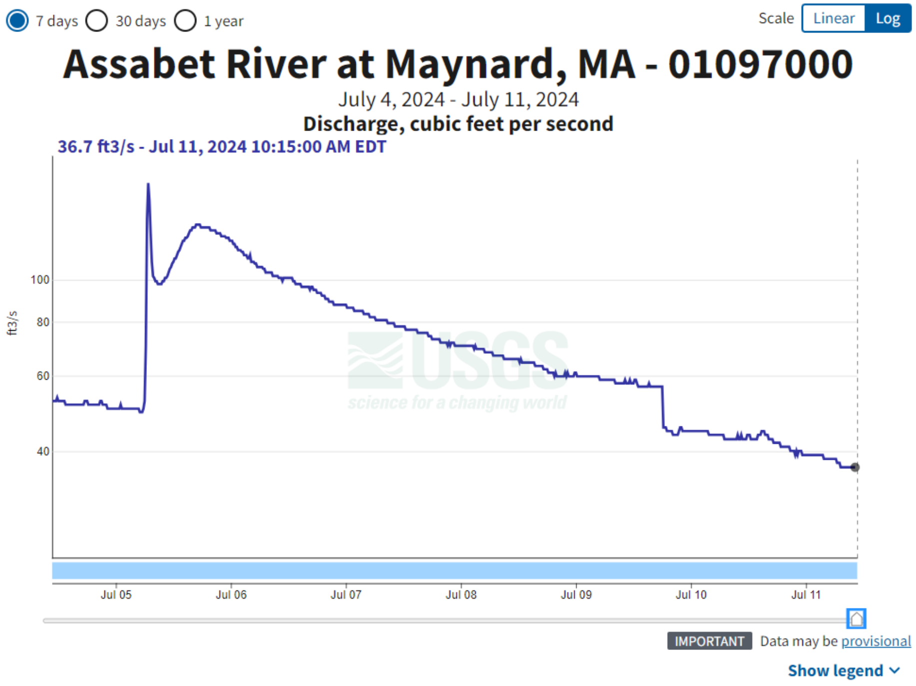


Figure 22: Dissolved Oxygen by year for selected sites (June/July/August)

Effects of Warner’s Pond on Downstream Water Quality

The following slides present photographs of Nashoba Brook and Assabet River during low flow conditions on July 11, 2024. For comparison to the previous log graph of DO vs streamflow, the flow at NHS-047 on this date was 0.84 cfs.



● 7 days ○ 30 days ○ 1 year

Scale: Linear **Log**

Assabet River at Maynard, MA - 01097000

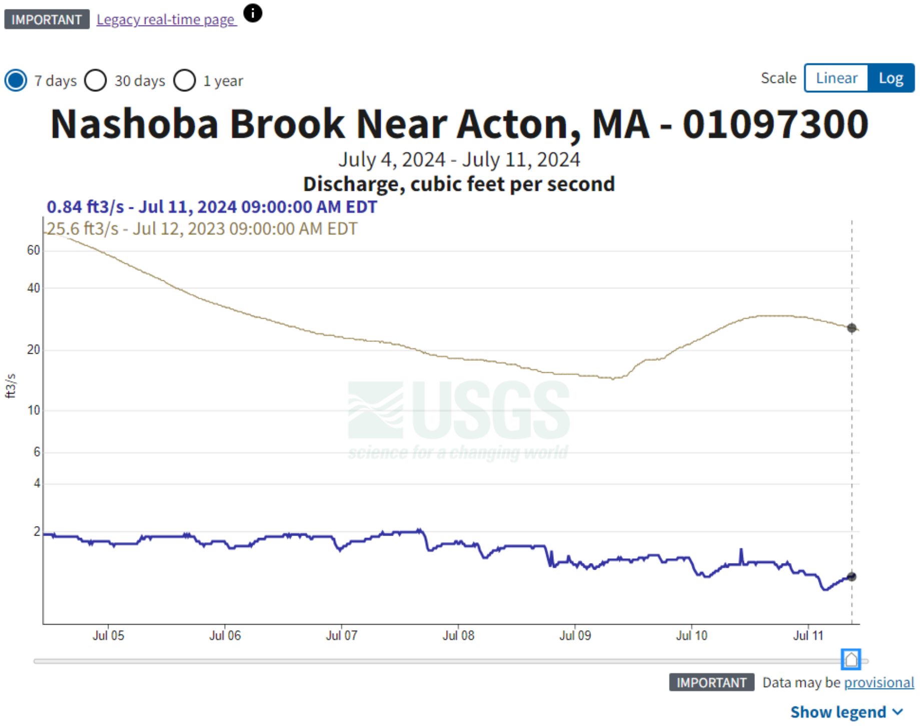
July 4, 2024 - July 11, 2024

Discharge, cubic feet per second

36.7 ft3/s - Jul 11, 2024 10:15:00 AM EDT

IMPORTANT Data may be provisional

Show legend



IMPORTANT Legacy real-time page

● 7 days ○ 30 days ○ 1 year

Scale: Linear **Log**

Nashoba Brook Near Acton, MA - 01097300

July 4, 2024 - July 11, 2024

Discharge, cubic feet per second

0.84 ft3/s - Jul 11, 2024 09:00:00 AM EDT

25.6 ft3/s - Jul 12, 2023 09:00:00 AM EDT

IMPORTANT Data may be provisional

Show legend

Comparison of Warner's Pond Water Quality to Area Water Bodies

Images from Warner's Pond Dam during low flow
conditions (07-11-2024)

Comparison of Warner’s Pond Water Quality to Area Water Bodies

Images from Nashoba Brook east of
Commonwealth Avenue Bridge during low flow
conditions (07-11-2024). Thalweg depth was about
1 to 1.5 feet or less.

Comparison of Warner’s Pond Water Quality to Area Water Bodies

Image from Commonwealth Avenue Bridge during low flow conditions (07-11-2024). Thalweg depth was about 1 to 1.5 feet or less.

Comparison of Warner's Pond Water Quality to Area Water Bodies

Images from Nashoba Brook east of Commonwealth Avenue Bridge from timber pedestrian bridge during low flow conditions (07-11-2024)

Comparison of Warner’s Pond Water Quality to Area Water Bodies

Images from Nashoba Brook east of Commonwealth Avenue Bridge from Bruce Freeman Rail Trail bridge during low flow conditions (07-11-2024)

Comparison of Warner’s Pond Water Quality to Area Water Bodies

Images from Nashoba Brook east of Commonwealth Avenue Bridge from Bruce Freeman Rail Trail bridge during low flow conditions (07-11-2024)

Comparison of Warner's Pond Water Quality to Area Water Bodies

Images from Assabet River east of Commonwealth Avenue Bridge from Main Street Bridge during low flow conditions (07-11-2024)

Comparison of Warner’s Pond Water Quality to Area Water Bodies

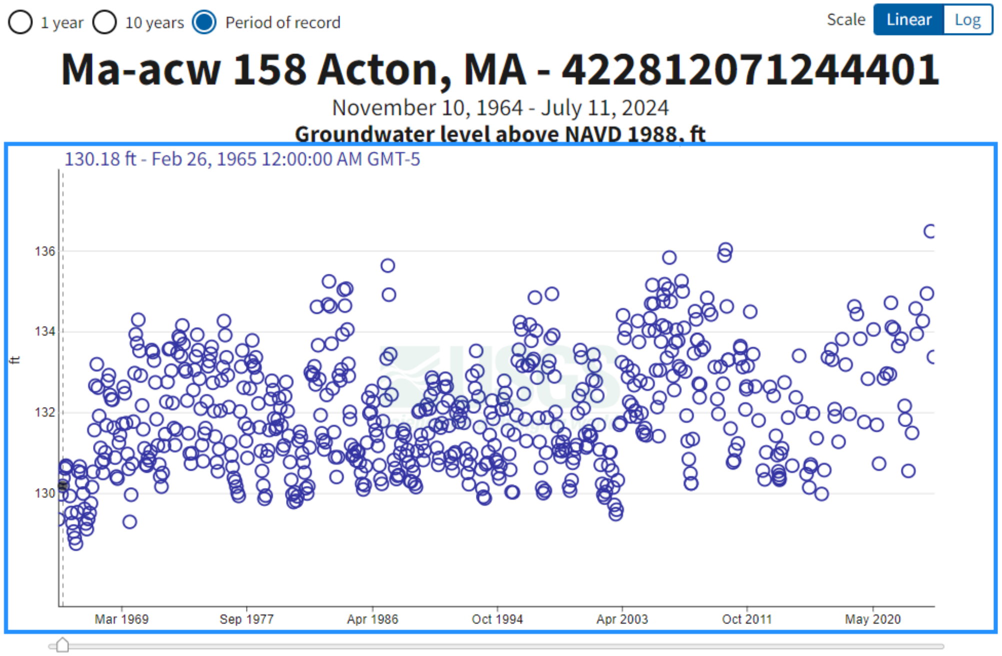
Images from Assabet River from Bruce Freeman Rail Trail during low flow conditions (07-11-2024)

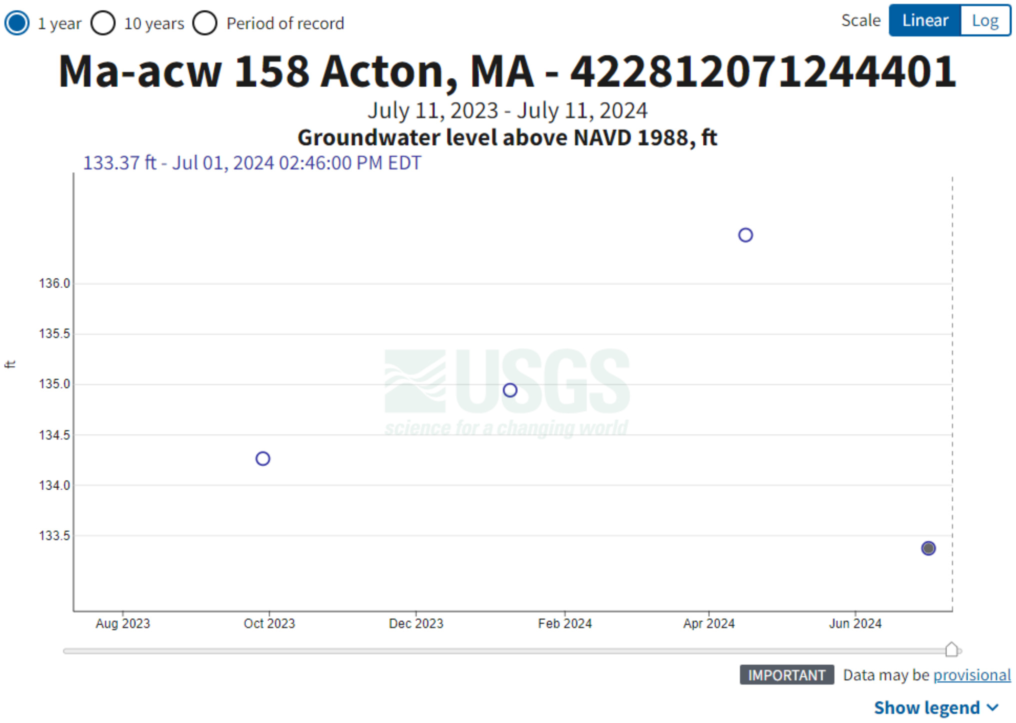
Comparison of Warner’s Pond Water Quality to Area Water Bodies

Images from Assabet River from Bruce Freeman Rail Trail
during low flow conditions (07-11-2024)

Contribution of Groundwater to Streamflow and Warner's Pond

As an additional point of interest, while the previous information shows fairly low stream flow conditions (e.g., Nashoba Brook and Assabet River) on July 11, 2024 the observed groundwater data at the 158 Acton USGS station indicates fairly high groundwater levels. The high groundwater USGS readings are supported by very high water levels observed at spring fed ponds (Walden Pond and White's Pond). This appears to support an assumption of limited hydraulic contribution of groundwater to streamflow (and water levels within Warner's Pond).





Attachment 3
Warner’s Pond Dam Details

Introduction:

This attachment presents the details of the dam rehabilitation design and construction during 2006 – 2008. It also reviews the results of the 2023 Phase I dam inspection report. As such it represents the current condition of the dam layout, components and condition.

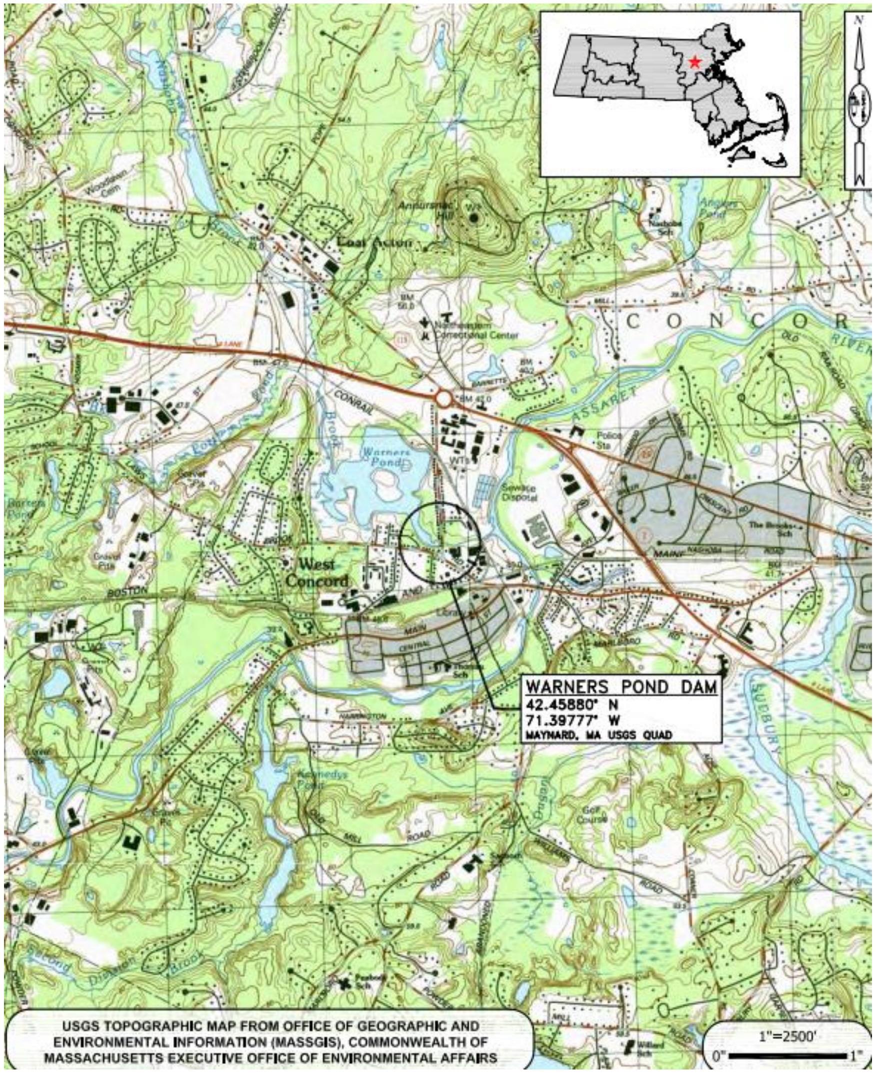
It also considers the addition of a naturalized fish passageway in the future as an alternative.

The information presented here is based on available data, including:

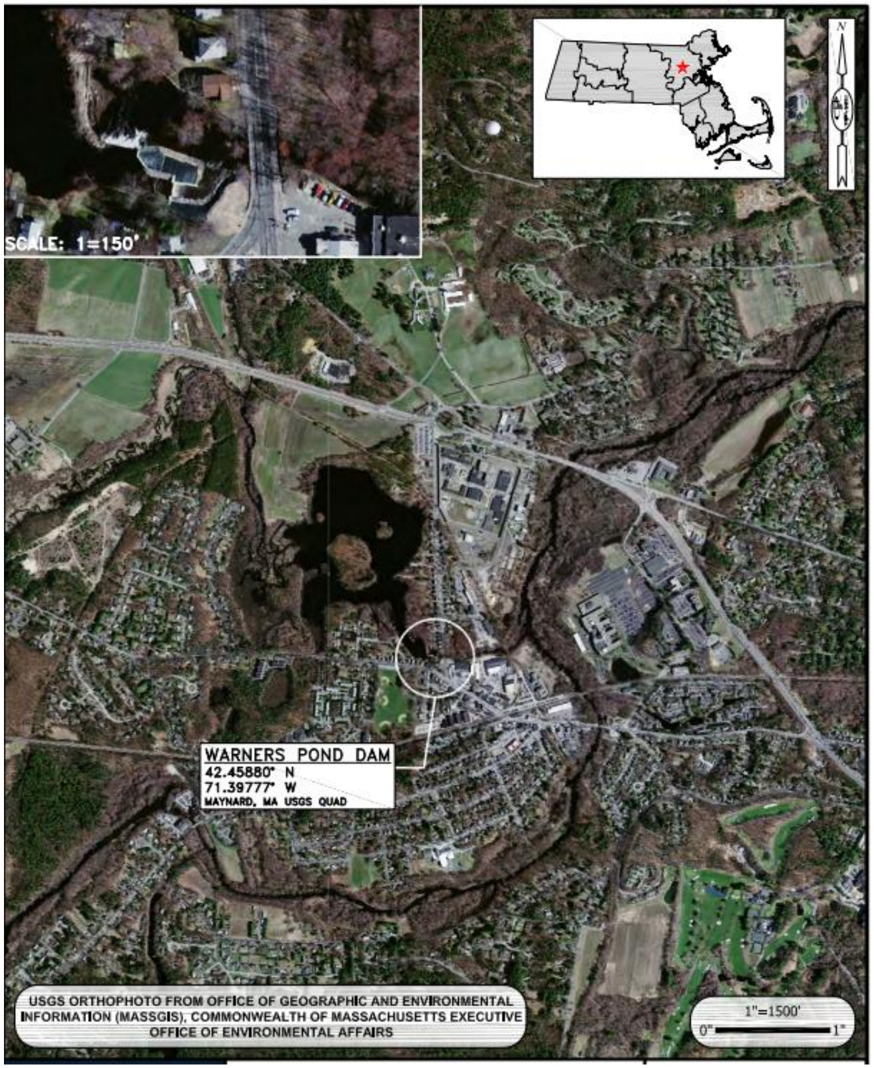
- Phase I Dam Inspection field observation of the dam features.
- Google Earth aerial imagery and measurement tools.
- A March 2006 presentation to the Town by GZA GeoEnvironmental, Inc. of proposed dam improvements.
- Dam Rehabilitation Construction Plans
- 2023 Annual Town Report (Public Works)

Warners Pond Dam Location

Warners Pond is an approximately 320 feet long earthen dam located at the SE corner of the Warners Pond.



USGS TOPOGRAPHIC MAP FROM OFFICE OF GEOGRAPHIC AND ENVIRONMENTAL INFORMATION (MASSGIS), COMMONWEALTH OF MASSACHUSETTS EXECUTIVE OFFICE OF ENVIRONMENTAL AFFAIRS



USGS ORTHOPHOTO FROM OFFICE OF GEOGRAPHIC AND ENVIRONMENTAL INFORMATION (MASSGIS), COMMONWEALTH OF MASSACHUSETTS EXECUTIVE OFFICE OF ENVIRONMENTAL AFFAIRS

Images taken from 2018 Phase I Inspection Report by Pare Corporation

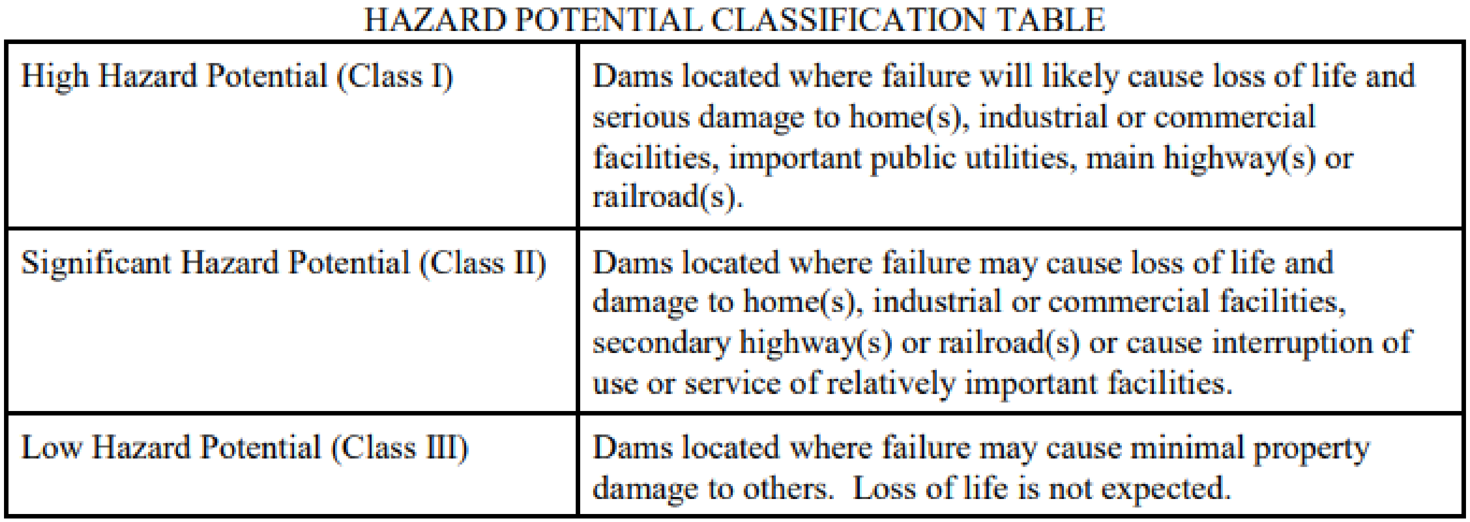
Warners Pond Dam Features

The Dam rehabilitation was designed and constructed between +/- 2006 and 2008, with 2011 Record Drawings. **The principal features include earthen low permeability dam, earthen dam embankments, main and auxiliary spillways, a sluiceway, an outlet pipe and a stilling pool.** The median annual flow through the dam is about 49 cfs and the median August flow is about 11 cfs. The Dam maintains the pond water "Normal Pool Elevation" at 118.8 feet NAVD88 and the 100-year flood at 123.2 feet NAVD88.

Reference 2011 Town presentation slides

Warners Pond Dam Hazard Potential Classification

Dams in Massachusetts are classified for purposes of establishing inspection schedules and adherence to design criteria, in accordance with their potential for damage to life or property in the area downstream from the dam in the event of failure of the dam or appurtenant facilities. See Hazard Potential Classification Table below.



HAZARD POTENTIAL CLASSIFICATION TABLE

High Hazard Potential (Class I)	Dams located where failure will likely cause loss of life and serious damage to home(s), industrial or commercial facilities, important public utilities, main highway(s) or railroad(s).
Significant Hazard Potential (Class II)	Dams located where failure may cause loss of life and damage to home(s), industrial or commercial facilities, secondary highway(s) or railroad(s) or cause interruption of use or service of relatively important facilities.
Low Hazard Potential (Class III)	Dams located where failure may cause minimal property damage to others. Loss of life is not expected.

Warner's Pond is currently classified as a Class II Significant Hazard Dam. **As noted in the 2018 and 2023 Phase I Dam Inspection Reports the dam may warrant reclassification to Low Hazard Potential due to the limited anticipated impacts between the Dam and the Assabet River. It has been recommended (see 2018 and 2023 Phase I Dam Inspection/Evaluation Reports) that a hazard classification review be performed by the Town to determine if reclassification to Low Hazard is warranted.** This would lower the dam's hazard potential classification, extend the required inspection schedule for every 5 years to 10 years and reduce the hazard design basis from the 100-year flood recurrence interval flood to the 50-year recurrence interval flood – reflecting the determination that the dam risk is lower than the current classification.

The Dam is owned by the Town of Concord with maintenance responsibility by the Department of Public Works. As noted in the above referenced Phase I Dam Inspection Report, an Operations and Maintenance Manual does not appear to be available for the Dam.

Warners Pond Dam Reservoir

The following table provides a summary of the general characteristics of the Dam’s impoundment storage capacity and pool elevations.

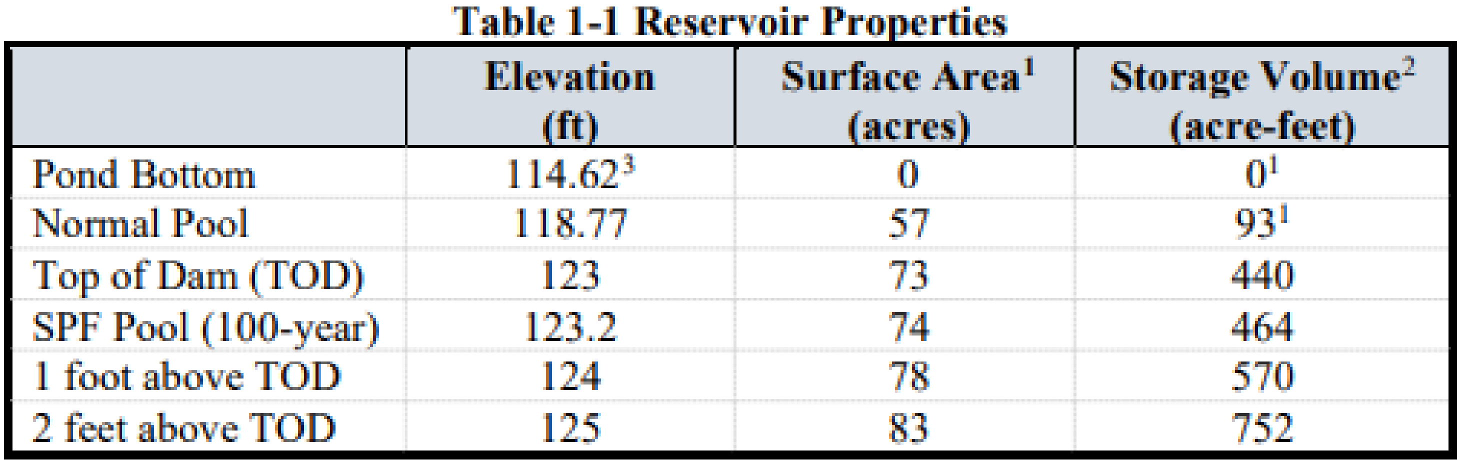
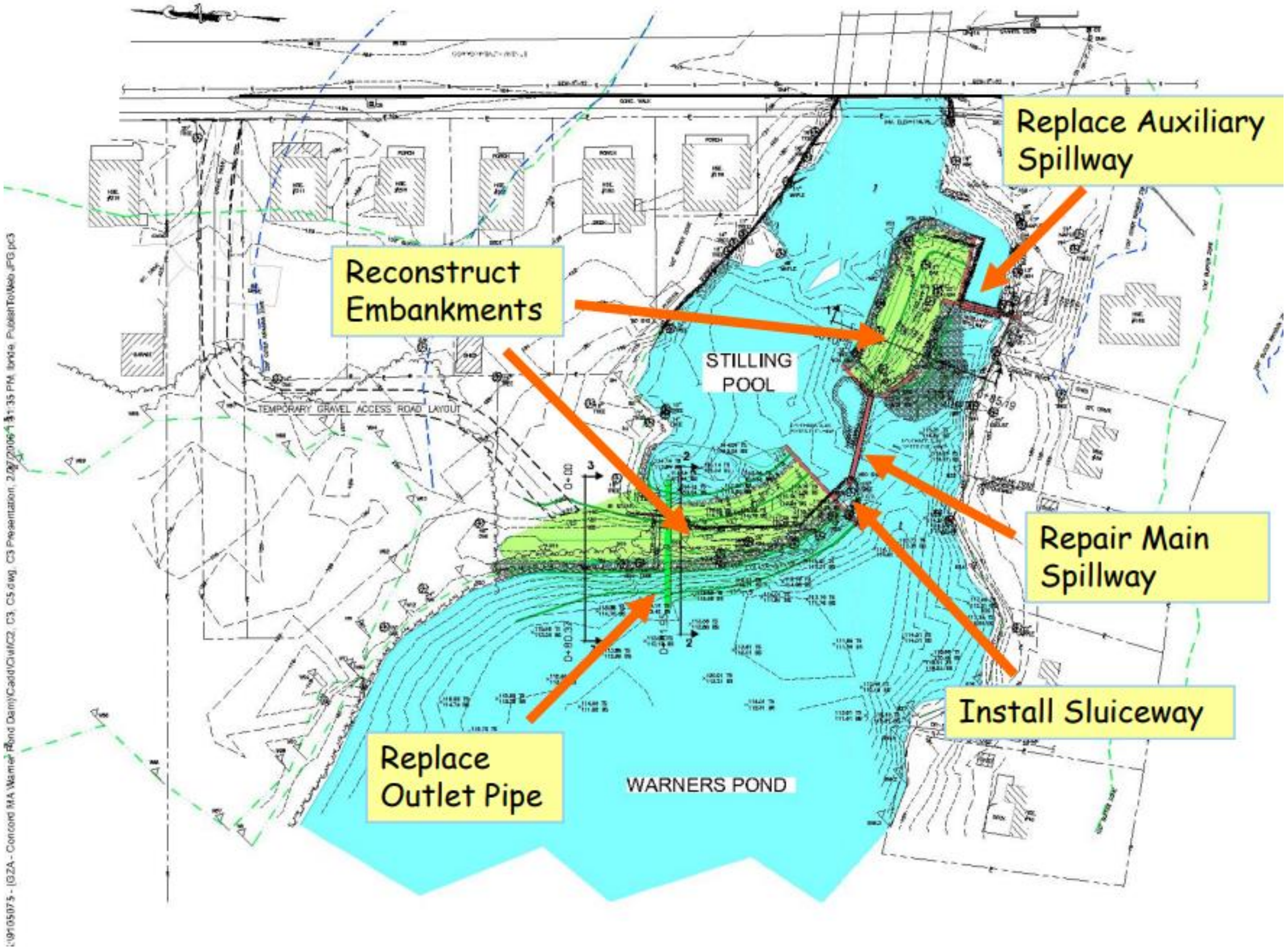


Table 1-1 Reservoir Properties

	Elevation (ft)	Surface Area[1] (acres)	Storage Volume[2] (acre-feet)
Pond Bottom	114.62[3]	0	0[1]
Normal Pool	118.77	57	93[1]
Top of Dam (TOD)	123	73	440
SPF Pool (100-year)	123.2	74	464
1 foot above TOD	124	78	570
2 feet above TOD	125	83	752

Elevations reference NAVD88. Table is from the 2023 Phase I Dam Inspection Report.

Warners Pond Dam Reconstruction

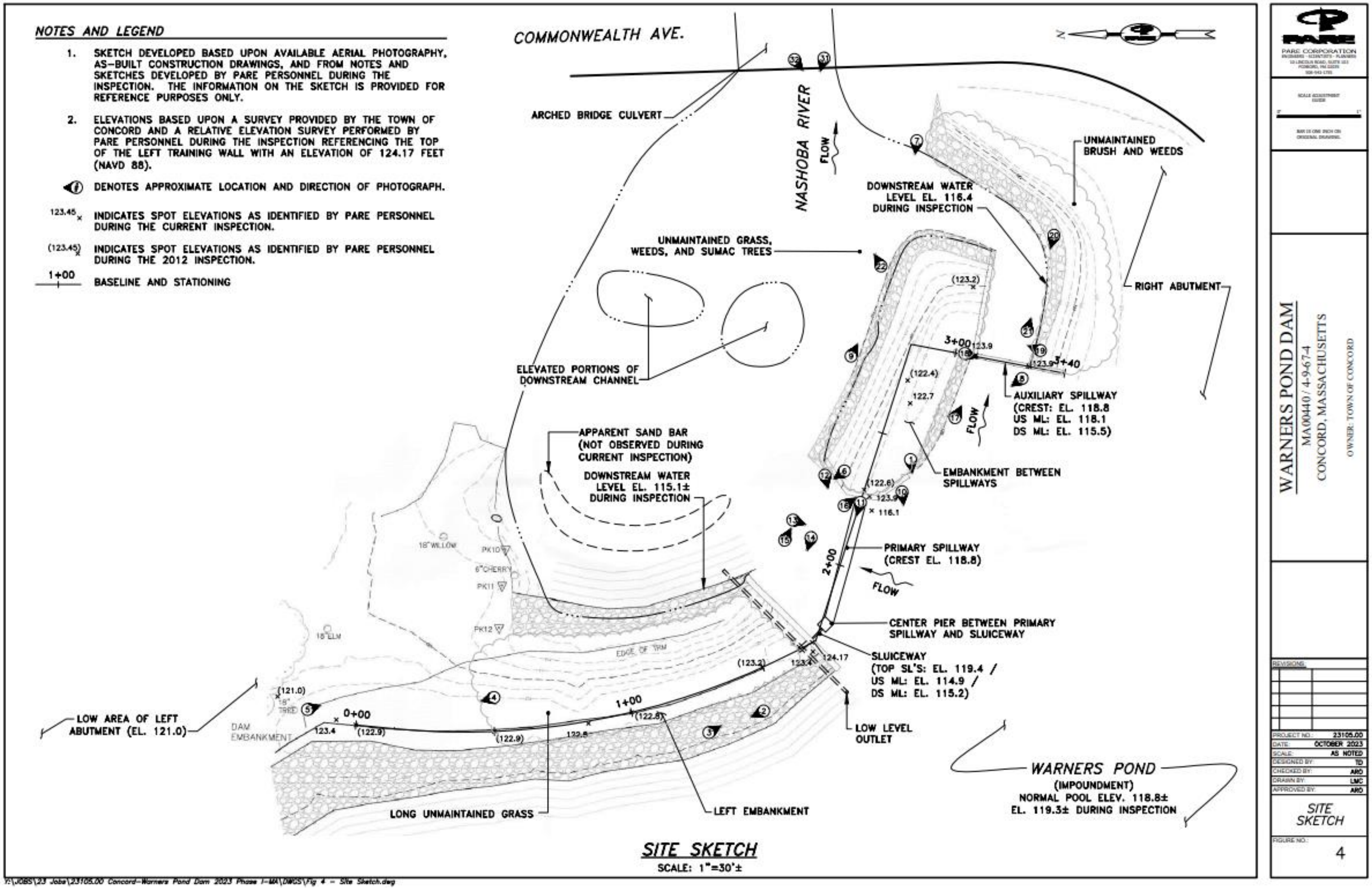


Dam Reconstruction Goals and Benefits:

1. Improve Dam Safety (the previous spillway had inadequate capacity to pass 100-year flood event)
2. Improve flood protection from Assabet River “backwater” flooding
3. Preserve the Pond and associated recreational, cultural and ecological resources
4. Add Functional Water Controls:
   - Allow for seasonal drawdowns
   - Allow for emergence drawdown
5. Improve water quality in auxiliary spillway area
6. Enhance view of pond from Commonwealth Avenue

Reference 2006 Town presentation slides

Dam Features and Elevation (2023 Phase I Dam Inspection report



Main Dam Embankment

The main dam embankment is about 200 feet long. It is an earthen dam constructed of low-permeability earthen fill and a base key. The crest width is about 10 feet and the crest elevation is at about 123 feet NAVD88. The pondside side 2H:1V slope is protected with about 24-inch thick rip-rap layer over 1.5" crushed stone bedding. The downgradient side is protected with a rock toe and a 2.5H:1V vegetated slope. A turf reinforcement mat is present along the crest and downgradient side slope.

Secondary Dam Embankment

The secondary dam embankment is about 90 feet long. It is an earthen dam constructed of low-permeability earthen fill and a base key. The crest width is about 10 feet and the crest elevation is at about 123 feet NAVD88. The pondside side 2H:1V slope is protected with about 24-inch thick rip-rap layer over 1.5” crushed stone bedding. The downgradient side is protected with a rock toe and a 2.5H:1V vegetated slope (using a vegetation mat). Portions of the secondary dam embankment are supported with reinforced concrete retaining walls that form the auxiliary spillway.

Main Spillway

Main Spillway and Sluiceway

The Warners Pond Dam has a Main Spillway consisting of: 1) a 40-feet wide stone masonry spillway structure with reinforced concrete buttress; 2) reinforced concrete “training” walls with natural stone veneer and cap for retainage of the adjacent embankments; 3) reconstructed low-permeability earthen embankments; and 4) a sluiceway with reinforced concrete walls with natural stone veneer and cap and stoplog guide and hoist. The elevation of the main spillway crest is 118.8 feet NAVD88. The elevation of the tops of walls (capstone) is 124.17 feet. The elevation of the embankment crests are about 123 feet NAVD88.

Main Spillway Sluiceway

The sluiceway is approximately 5-feet wide. Sluiceway timber stop logs consisting of 12” high plates with two lifting points each. Stop logs extend vertically to Elevation 119 feet NAVD88. Removal of stop logs reduces sluiceway crest elevation to about 115 feet NAVD88.

Sluiceway concrete wall top at
Elevation 115 feet NAVD88

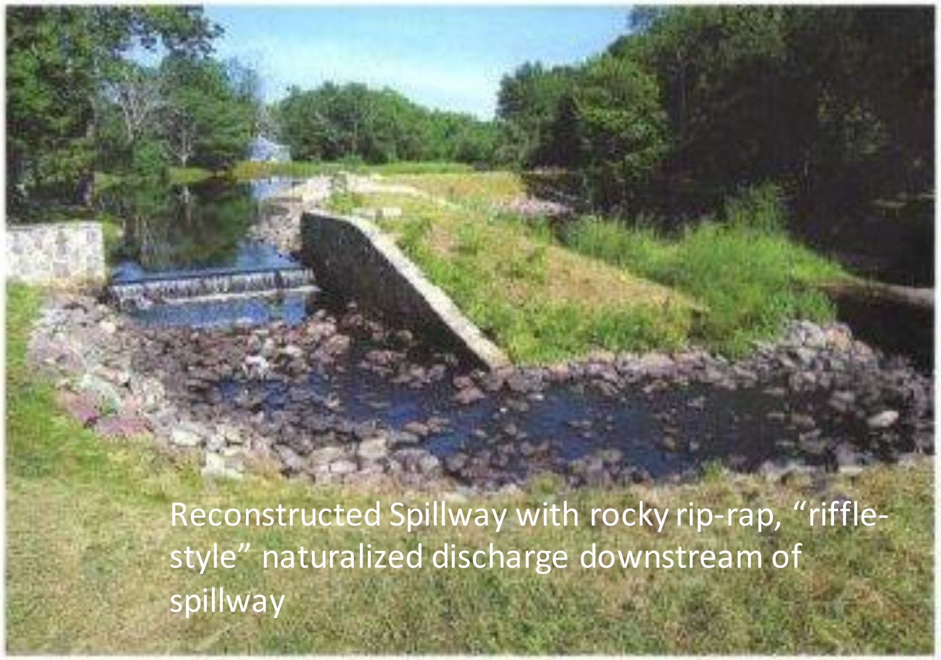
Pipe and Gate Valve

In addition to the sluiceway, the Warners Pond Dam also has a buried ductile ion pipe (with a concrete cradle) and gate valve for use as low level outlet. Specifically, the purpose is to allow lowering of the Pond water level. The pipe is 24-inch diameter with a 24-inch diameter gate valve with riser. The invert elevation of the 24-inch diameter pipe at the downgradient location is assumed to be at about Elevation 113 feet NAVD88 (at outlet).


Gate box for valve access

Auxiliary (Secondary) Spillway

The Warners Pond Dam has an auxiliary spillway consisting of: 1) a reinforced concrete spillway structure; 2) reinforced concrete "training" walls with natural stone veneer and cap for retainage of the adjacent embankments; 3) a naturalized rip-rap secondary channel for downgradient spillway discharge; 4) reconstructed low-permeability earthen embankments; and 5) stabilized, vegetated side slopes (above the rip-rap slopes). The elevation of the auxiliary spillway crest is 118.8 feet NAVD88. The elevation of the top of wall (capstone) is 124.17 feet. The elevation of the embankment crests are about 123 feet NAVD88. The width of the spillway (between the walls) is 18 feet. The total width including stabilized side slopes is about 40 feet.

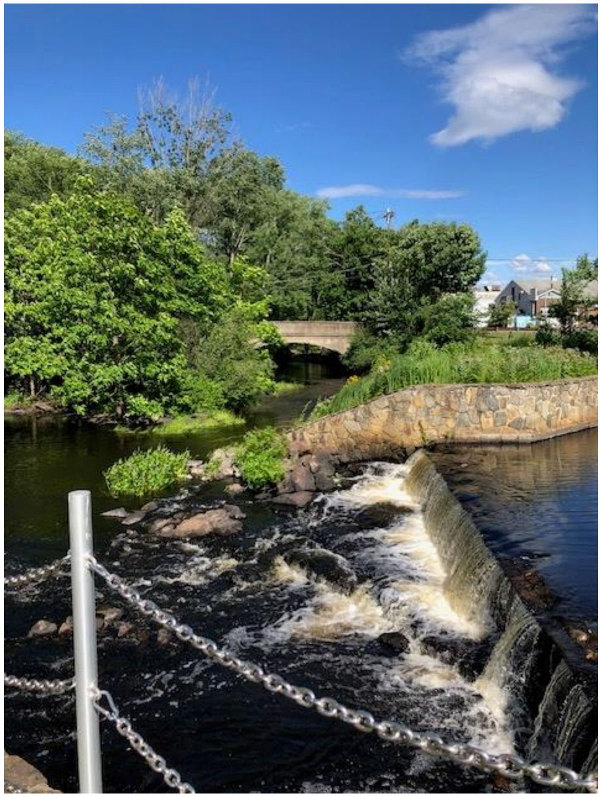

Reconstructed Spillway with rocky rip-rap, "riffle-style" naturalized discharge downstream of spillway

Stilling Pool

The Warners Pond Dam spillways discharge to a Stilling Pool. The Stilling Pool is an area of somewhat deeper water, with a bottom mudline elevation of about 112 to 113 feet NAVD88. The elevation of the spillways is at 118.8 feet NAVD88. The spillway channels immediately downgradient of the spillways are at about Elevation 116 to 117 feet NAVD88 and water levels at the Stilling Pool areas are typically at about 116 feet NAVD88. In addition to ecological value, the area of deeper water reduces flow velocities.

Spillway Channels

The Warners Pond spillway channels are constructed with relatively flat slopes and using natural stone and bedrock and stone rip-rap to create naturalized “riffle-type” spillway channels. This type of spillway channel construction dissipates energy by increasing the undulation of the channel bed and increasing the roughness of the channel. In conjunction with the Stilling Pool, these channels provide complex microhabitats and opportunities for future fish passageways. The “riffle” flow also likely oxygenates the water by increasing turbulent flow and water surface area.



Warners Pond 2023 Phase I Dam Inspection Findings and 2023 Town Annual Report

Owners of dams are required to hire a qualified engineer to inspect and report results every 2 years for High Hazard Potential dams, every 5 years for Significant Hazard Potential dams and every 10 years for Low Hazard Potential dams.

According to the 2023 Annual Town Report (Public Works)…

> *"Warner's Pond Dam is categorized as an Intermediate-sized, Significant (Class II) hazard potential dam. It underwent an inspection in June to assess its current condition, following the guidelines outlined in 302 CMR 10.04. The dam was determined to be in a* ***satisfactory*** *condition, a rating that remains unchanged from the previous inspection conducted in 2018. The assessment noted a significant overgrowth of woody plants, grass, and brush vegetation which were removed in November, and the report was submitted to the Office of Dam Safety. In addition, the Engineering Division revised the Emergency Action Plan (EAP) for Warners Pond Dam and distributed it to all designated responders as part of the EAP."*

A Satisfactory rating is the highest rating and indicates that "No existing or potential dam safety deficiencies are recognized. Acceptable performance is expected under all loading conditions (static, hydrologic, seismic) in accordance with the minimum applicable state or federal regulatory criteria or tolerable risk guidelines."

Key findings of the 2023 Phase I Inspection report (ratings based on 1 to 5, with 5 being the best):

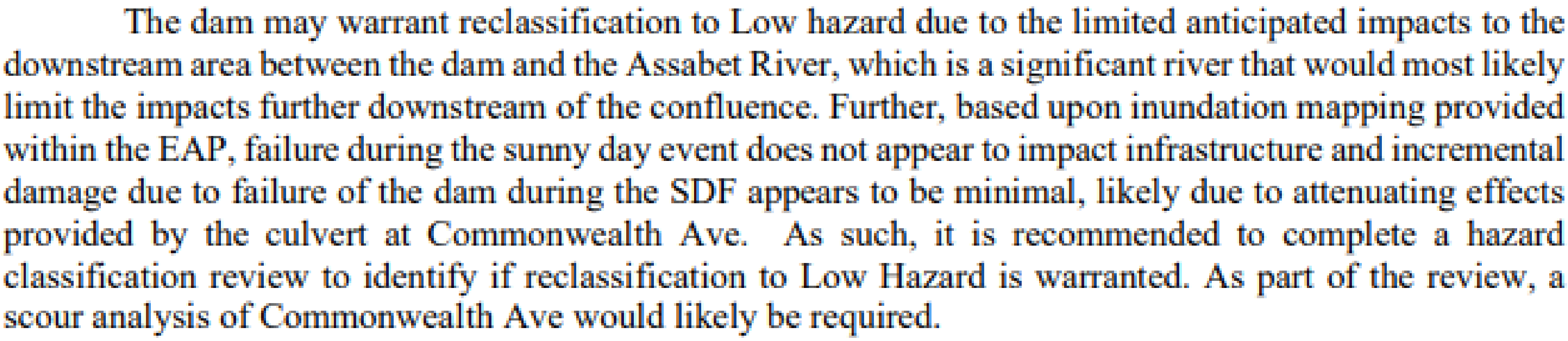
- **Overall Condition: Satisfactory -** minor operational and maintenance deficiencies.
- Level of Maintenance: Fair (less than Adequate) (3 out of 5)
- Emergency Action Plan: Available (4 out of 5)
- No or minor seepage observed (positive finding) (5 out of 5)
- Embankment Condition: unmaintained grass, rodent activity and maintainable erosion (consistent with the Fair maintenance rating) (4 out of 5)
- Concrete condition: minor spalling and surface cracking (4 out of 5)
- Low-level outlet discharge capacity: operatable gate but needs maintenance (4 out of 5)
- Low-level outlet physical condition: operable but needs maintenance (4 out of 5)
- Spillway design capacity: 90% to 100% of Spillway Design Flood (3 out of 5) – discussed in following slide

Warners Pond 2023 Phase I Dam Inspection - Hazard Potential

Additional findings and recommendations of the 2023 Phase I Dam Inspection Report:

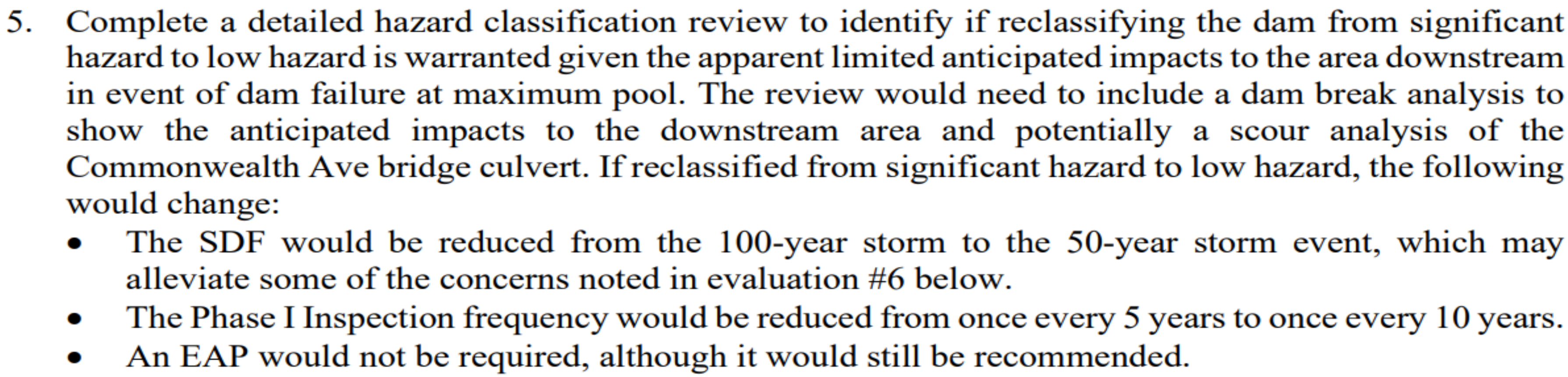
Hazard Potential Re-Classification:

The 2018 and 2023 Phase I reports indicate that a lowering of the hazard potential classification is warranted:



The dam may warrant reclassification to Low hazard due to the limited anticipated impacts to the downstream area between the dam and the Assabet River, which is a significant river that would most likely limit the impacts further downstream of the confluence. Further, based upon inundation mapping provided within the EAP, failure during the sunny day event does not appear to impact infrastructure and incremental damage due to failure of the dam during the SDF appears to be minimal, likely due to attenuating effects provided by the culvert at Commonwealth Ave. As such, it is recommended to complete a hazard classification review to identify if reclassification to Low Hazard is warranted. As part of the review, a scour analysis of Commonwealth Ave would likely be required.

The 2023 Phase I report recommends:



5. Complete a detailed hazard classification review to identify if reclassifying the dam from significant hazard to low hazard is warranted given the apparent limited anticipated impacts to the area downstream in event of dam failure at maximum pool. The review would need to include a dam break analysis to show the anticipated impacts to the downstream area and potentially a scour analysis of the Commonwealth Ave bridge culvert. If reclassified from significant hazard to low hazard, the following would change:
    - The SDF would be reduced from the 100-year storm to the 50-year storm event, which may alleviate some of the concerns noted in evaluation #6 below.
    - The Phase I Inspection frequency would be reduced from once every 5 years to once every 10 years.
    - An EAP would not be required, although it would still be recommended.

Warners Pond 2023 Phase I Dam Inspection Spillway Capacity Considerations

Additional findings and recommendations of the 2023 Phase I Dam Inspection Report:

Spillway Capacity:

As presented in the 2023 Phase I Dam Inspection Report, the rehabilitated dam was designed to a Spillway Design Flood (SDF) of the 100-year recurrence interval flood, with peak inflow and outflow of 3,200 cfs and 6.8- inch precipitation intensity. The associated peak WSEL (flood water level) was 123.2 feet NAVD88 with about 0.2-foot overtopping at the dam embankments. The distribution of flow during the SDF (excerpted from 2023 Phase I Dam Inspection Report. The “Left Embankment” refers to alower-lying wooded area west of the Main dam embankment, which is indicated to be at a lower elevation (121 feet NAVD88). This is discussed in more detail in the Attachment on Flooding.

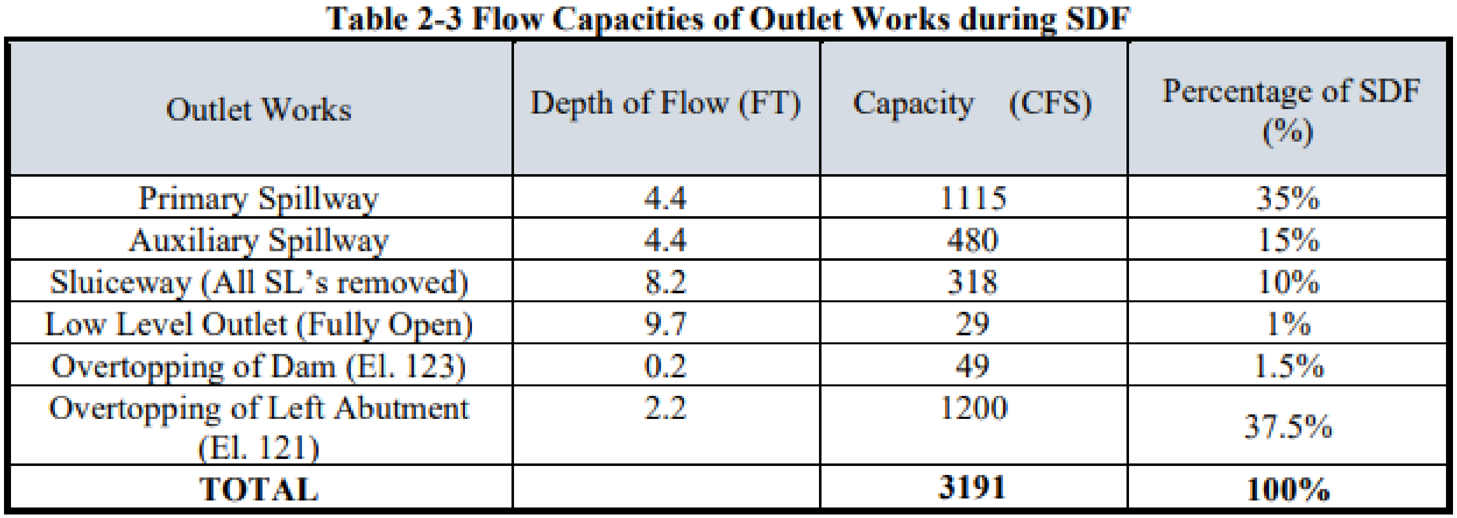


Table 2-3 Flow Capacities of Outlet Works during SDF

Outlet Works	Depth of Flow (FT)	Capacity (CFS)	Percentage of SDF (%)
Primary Spillway	4.4	1115	35%
Auxiliary Spillway	4.4	480	15%
Sluiceway (All SL’s removed)	8.2	318	10%
Low Level Outlet (Fully Open)	9.7	29	1%
Overtopping of Dam (El. 123)	0.2	49	1.5%
Overtopping of Left Abutment (El. 121)	2.2	1200	37.5%
TOTAL		**3191**	**100%**

Warners Pond 2023 Phase I Dam Inspection – Public Safety and Town Employee Safety

Additional findings and recommendations of the 2023 Phase I Dam Inspection Report relative to safety (potentially reflective of Town liability).

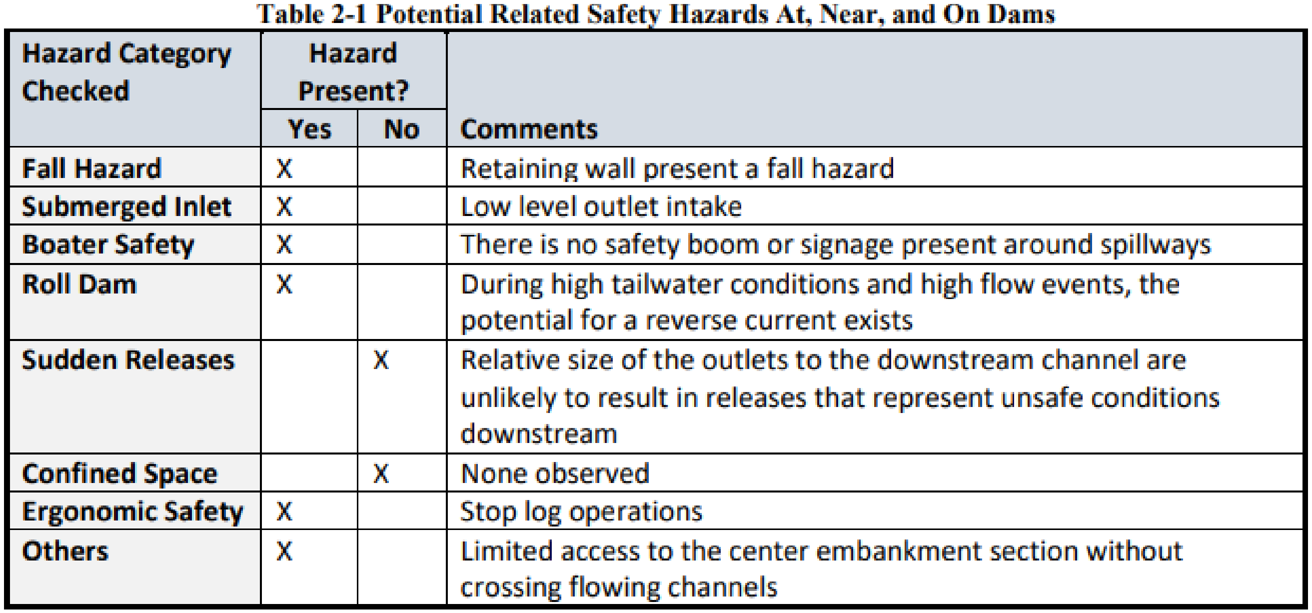
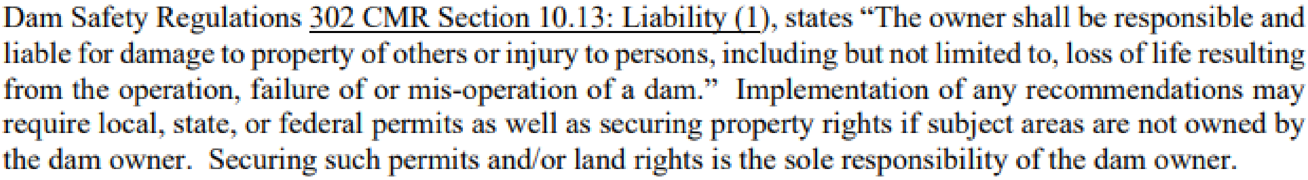


Table 2-1 Potential Related Safety Hazards At, Near, and On Dams

Hazard Category Checked	Hazard Present?		Comments
	Yes	No	
Fall Hazard	X		Retaining wall present a fall hazard
Submerged Inlet	X		Low level outlet intake
Boater Safety	X		There is no safety boom or signage present around spillways
Roll Dam	X		During high tailwater conditions and high flow events, the potential for a reverse current exists
Sudden Releases		X	Relative size of the outlets to the downstream channel are unlikely to result in releases that represent unsafe conditions downstream
Confined Space		X	None observed
Ergonomic Safety	X		Stop log operations
Others	X		Limited access to the center embankment section without crossing flowing channels

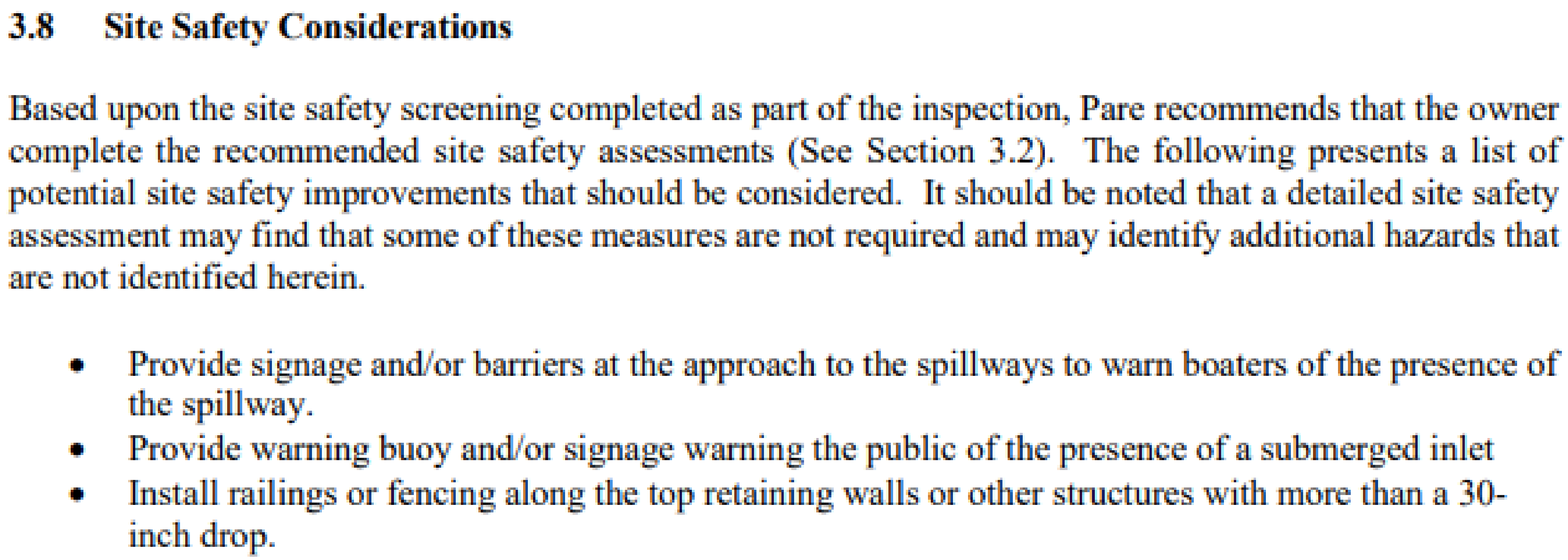


Dam Safety Regulations 302 CMR Section 10.13: Liability (1), states "The owner shall be responsible and liable for damage to property of others or injury to persons, including but not limited to, loss of life resulting from the operation, failure of or mis-operation of a dam." Implementation of any recommendations may require local, state, or federal permits as well as securing property rights if subject areas are not owned by the dam owner. Securing such permits and/or land rights is the sole responsibility of the dam owner.

- A primary safety issue is the potential for a sudden release from the dam resulting in unsafe downstream conditions. This hazard is rated as No Hazard Present. In fact, a lowering of the Dam Hazard Potential to Low has been recommended for consideration.
- Stop log and access hazards are the purview of the Town DPW and assumed covered under DPW Health & Safety Plans.
- Reverse currents are predicted under extreme flood flow conditions (backwater flooding from the Assabet) – see Flooding Attachment. These conditions were< presumably, know and considered at the time of the dam rehabilitation design.
- Fall hazards, boater safety and submerged inlet hazards are all relevant to the recreational use of the pond and mitigation measures are recommended (next slide).

Warners Pond 2023 Phase I Dam Inspection – Public Safety and Town Employee Safety Recommendations

Improvements to dam safety relative to recreational use and Town DPW dam maintenance have been recommended in the 2023 Phase I Dam Inspection report:

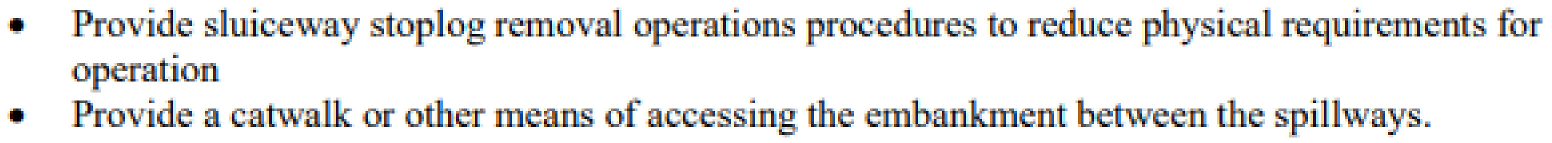


3.8 Site Safety Considerations

Based upon the site safety screening completed as part of the inspection, Pare recommends that the owner complete the recommended site safety assessments (See Section 3.2). The following presents a list of potential site safety improvements that should be considered. It should be noted that a detailed site safety assessment may find that some of these measures are not required and may identify additional hazards that are not identified herein.

- Provide signage and/or barriers at the approach to the spillways to warn boaters of the presence of the spillway.
- Provide warning buoy and/or signage warning the public of the presence of a submerged inlet
- Install railings or fencing along the top retaining walls or other structures with more than a 30-inch drop.

DPW Procedures:



- Provide sluiceway stoplog removal operations procedures to reduce physical requirements for operation
- Provide a catwalk or other means of accessing the embankment between the spillways.

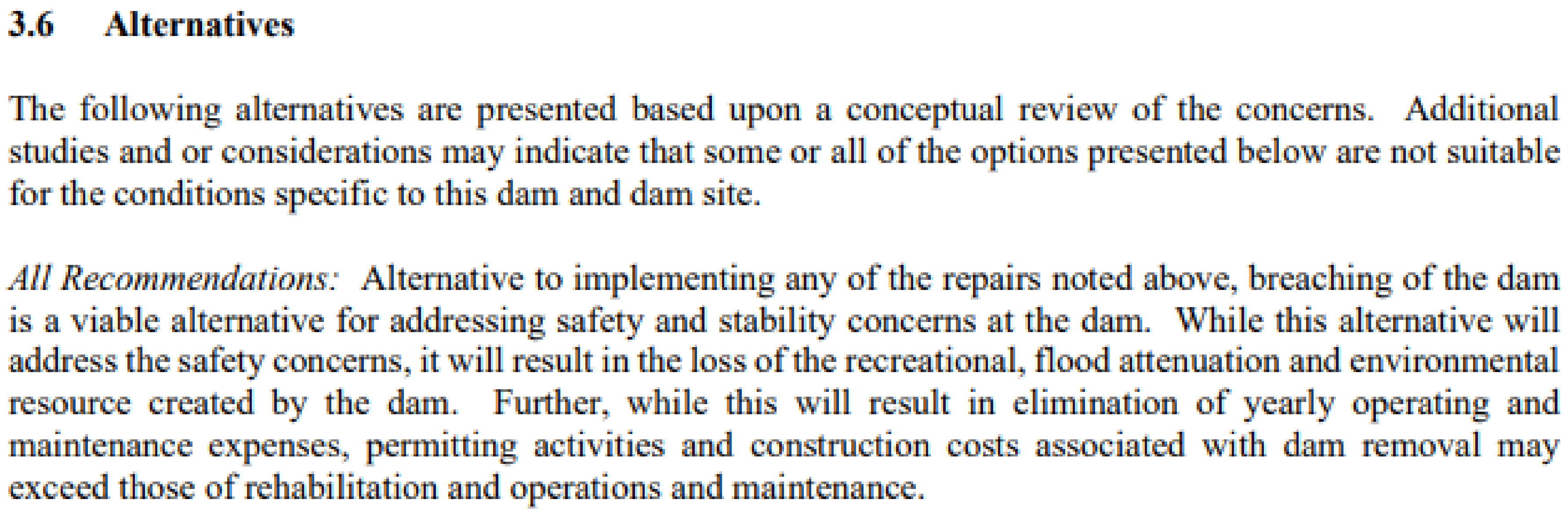
Warners Pond 2023 Phase I Dam Inspection - Costs

Estimated repair costs to mitigate observed deficiencies: **$41,000 to $118,000:**

- Studies and Analyses: $26,000 to $42,000
- Yearly Inspection and Maintenance: $5,000 to $11,000
- Recommended Repairs (Minor): $10,000 to $20,000
- Engineering and Design” $5,000
- Permitting: $5,000
- 30% Contingency: $10,000

Warners Pond 2023 Phase I Dam Inspection – Alternatives Assessment

The 2023 Phase I Dam Inspection report includes an alternatives assessment, specifically the alternative of dam removal or dam breaching:



3.6 Alternatives

The following alternatives are presented based upon a conceptual review of the concerns. Additional studies and or considerations may indicate that some or all of the options presented below are not suitable for the conditions specific to this dam and dam site.

All Recommendations: Alternative to implementing any of the repairs noted above, breaching of the dam is a viable alternative for addressing safety and stability concerns at the dam. While this alternative will address the safety concerns, it will result in the loss of the recreational, flood attenuation and environmental resource created by the dam. Further, while this will result in elimination of yearly operating and maintenance expenses, permitting activities and construction costs associated with dam removal may exceed those of rehabilitation and operations and maintenance.

Alternative: Construction of a naturalized fish passageway

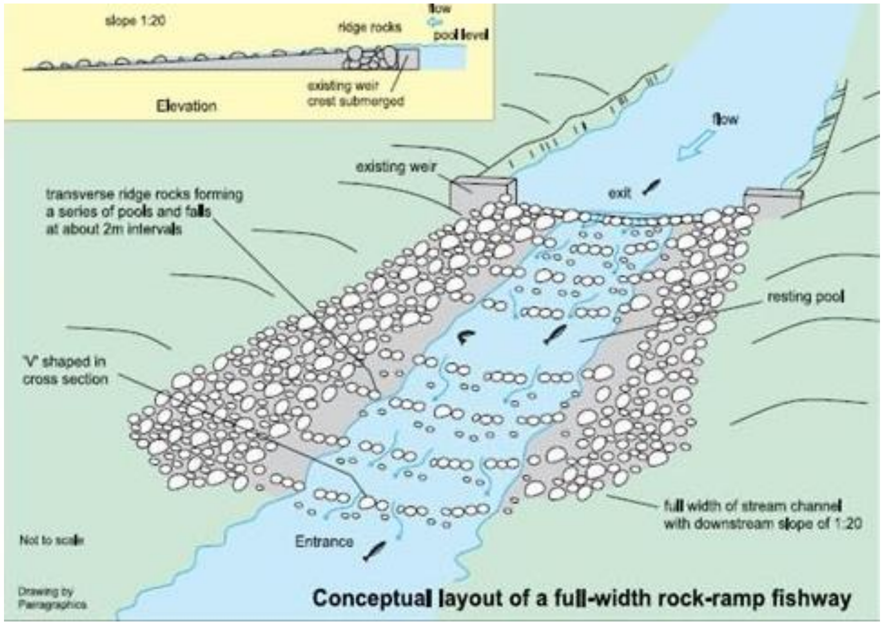
Fish Passageway

A fish ladder was considered during the 2006 dam reconstruction design. However, due to other area fish obstructions it was decided not to pursue a fish passageway at that time. It was noted by the Engineer at that time that the Auxiliary Spillway could be retrofitted to include a fish passageway into the pond in the future.

The low elevation and flat grade of the auxiliary spillway, along with the existing rock and rip-rap channel, indicates that an alternative (and low cost) approach to conventional fish ladders may be possible. Specifically, a naturalized channel as shown below mimics natural river channels by providing a gradually sloping, open channel with a coarse streambed consisting of gravel and boulders to mimic a series of riffles and pools. This would simply be an enhancement of the existing spillway and could provide a “hybrid” approach alternative to dam removal.

See **Attachment 5** for additional detail.

Naturalized fish passageway:



Additional Dam Photographs

Additional images of the Dam

Additional images of the Dam

Additional images of the Dam

Additional images of the Dam

Additional images of the Dam

Additional images of the Dam

Additional images of the Dam

Additional images of the Dam

Additional images of the Dam

Additional images of the Dam

Additional images of the Dam Reconstruction

Additional images of the Dam Reconstruction

Attachment 4

Warner’s Pond and FEMA Flood Hazard Determination

Introduction

This attachment presents information presented in the effective FEMA Flood Insurance Study (FIS) and Flood Insurance Rate Map (FIRM) for flood data in the vicinity of Warner's Pond.

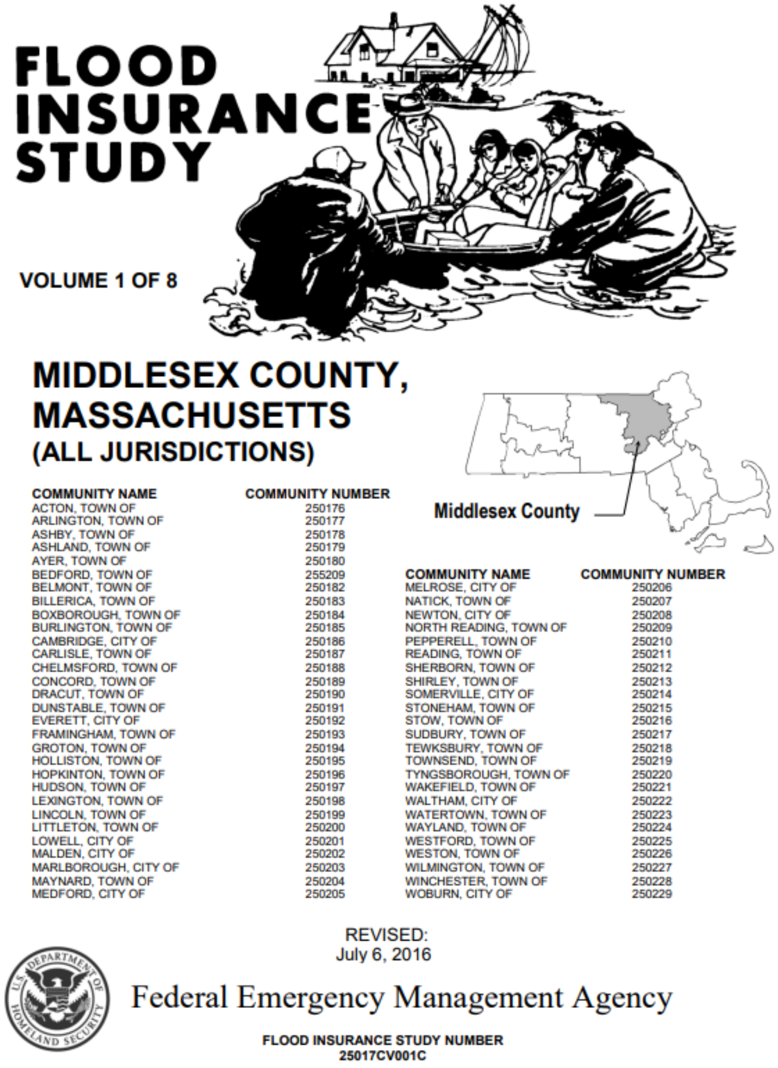
As presented herein, extreme flooding in the area (the 100-year and 500-year annual recurrence interval floods evaluated by FEMA under the National Flood Insurance Program [NFP]), is complex. The flood hazard as presented by FEMA indicates that flood events greater than about the 10-year recurrence interval flood have the potential to result in "backwater" flooding from peak flooding of the Assabet River.

The information summarized here includes:

- Definition of floodway and floodplain in riverine flooding
- The FEMA mapped flood zones (limits of 100-year and 500-year floodplains, and regulated floodways.
- A topographic plan showing the low-lying area within the "Left Abutment" discussed in the 2023 Phase I Dam Inspection Report.
- The FEMA determined Base Flood Elevations (BFE) that are reflective of the 100-year recurrence interval flood
- FEMA determined flood profiles and floodway data showing predicted peak flood elevations along sections of the relevant tributaries including Nashoba Brook and Fort Pond Brook and the Assabet River.
- The locations of dams along these tributaries and Assabet River, which also affect flooding and streamflow.
- Considerations of climate change effects on the flood hazard (ResilientMass Climate & Hazards Viewer).
- NOAA Atlas 14 current precipitation intensity data.
- Consideration of climate change related increase in precipitation frequency and intensity based on MA guidance.

Extensive, detailed numerical analyses are typically required to evaluate the effects of dam removal alternative of the flood hazard including changes to the FEMA FIS and FIRM. A Letter of Map Revision (LOMR) and associated documentation may also be required by the Town, along with FEMA review and approval, if dam removal is planned to be implemented. Massachusetts climate predictions indicate a predicted increase in precipitation depth. Municipalities can evaluate these effects for both the dam and removed dam conditions, consistent with FEMA guidance for Future Conditions. MA provides state guidance for consideration of climate change including precipitation.

FEMA Resources



FLOOD INSURANCE STUDY

VOLUME 1 OF 8

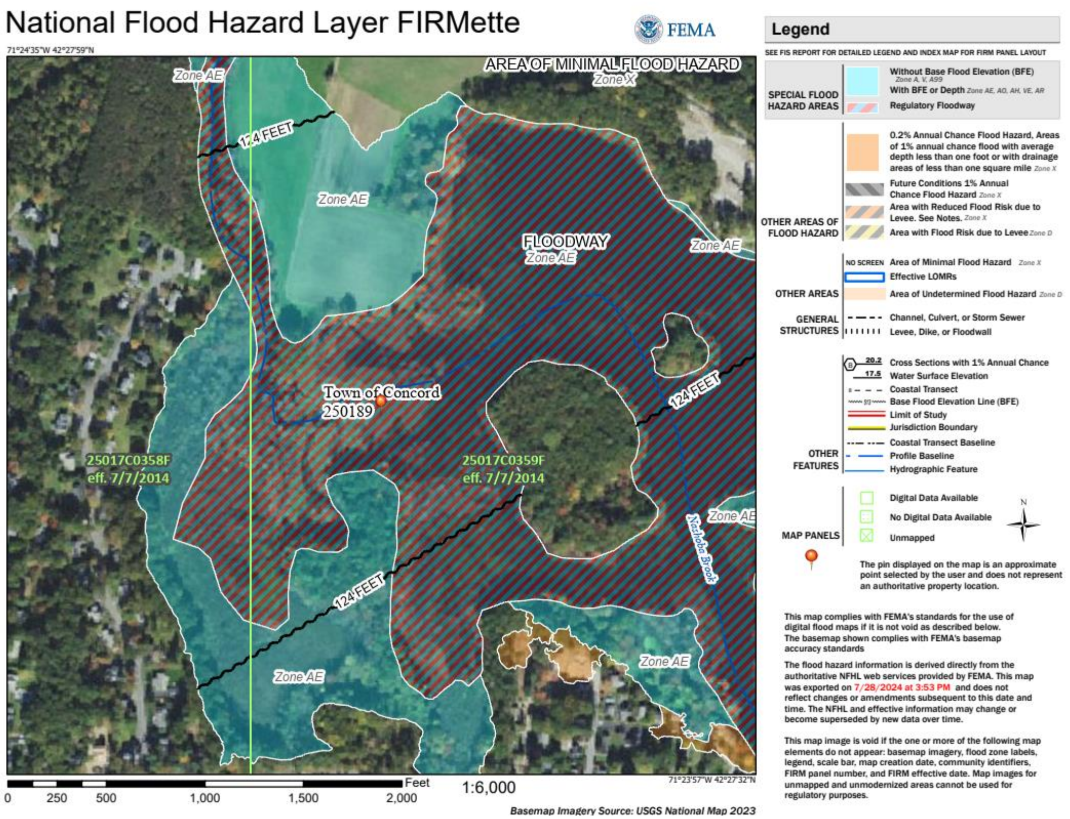
MIDDLESEX COUNTY, MASSACHUSETTS
(ALL JURISDICTIONS)

COMMUNITY NAME	COMMUNITY NUMBER
ACTON, TOWN OF	250176
ARLINGTON, TOWN OF	250177
ASHBY, TOWN OF	250178
ASHLAND, TOWN OF	250179
AYER, TOWN OF	250180
BEDFORD, TOWN OF	255209
BELMONT, TOWN OF	250182
BILLERICA, TOWN OF	250183
BOXBOROUGH, TOWN OF	250184
BURLINGTON, TOWN OF	250185
CAMBRIDGE, CITY OF	250186
CARLISLE, TOWN OF	250187
CHELMSFORD, TOWN OF	250188
CONCORD, TOWN OF	250189
DRACUT, TOWN OF	250190
DUNSTABLE, TOWN OF	250191
EVERETT, CITY OF	250192
FRAMINGHAM, TOWN OF	250193
GROTON, TOWN OF	250194
HOLLISTON, TOWN OF	250195
HOPKINTON, TOWN OF	250196
HUDSON, TOWN OF	250197
LEXINGTON, TOWN OF	250198
LINCOLN, TOWN OF	250199
LITTLETON, TOWN OF	250200
LOWELL, CITY OF	250201
MALDEN, CITY OF	250202
MARLBOROUGH, CITY OF	250203
MAYNARD, TOWN OF	250204
MEDFORD, CITY OF	250205
MELROSE, CITY OF	250206
NATICK, TOWN OF	250207
NEWTON, CITY OF	250208
NORTH READING, TOWN OF	250209
PEPPERELL, TOWN OF	250210
READING, TOWN OF	250211
SHERBORN, TOWN OF	250212
SHIRLEY, TOWN OF	250213
SOMERVILLE, CITY OF	250214
STONEHAM, TOWN OF	250215
STOW, TOWN OF	250216
SUDBURY, TOWN OF	250217
TEWKSBURY, TOWN OF	250218
TOWNSEND, TOWN OF	250219
TYNGSBOROUGH, TOWN OF	250220
WAKEFIELD, TOWN OF	250221
WALTHAM, CITY OF	250222
WATERTOWN, TOWN OF	250223
WAYLAND, TOWN OF	250224
WESTFORD, TOWN OF	250225
WESTON, TOWN OF	250226
WILMINGTON, TOWN OF	250227
WINCHESTER, TOWN OF	250228
WOBURN, CITY OF	250229

REVISED:
July 6, 2016

Federal Emergency Management Agency

FLOOD INSURANCE STUDY NUMBER
25017CV001C



National Flood Hazard Layer FIRMette

Basemap Imagery Source: USGS National Map 2023

Legend

SEE FIS REPORT FOR DETAILED LEGEND AND INDEX MAP FOR FIRM PANEL LAYOUT

SPECIAL FLOOD HAZARD AREAS	🟦	Without Base Flood Elevation (BFE) *Zone A, V, A99*
		With BFE or Depth *Zone AE, AO, AH, VE, AR*
	▨	Regulatory Floodway
OTHER AREAS OF FLOOD HAZARD	🟧	0.2% Annual Chance Flood Hazard, Areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile *Zone X*
	▨	Future Conditions 1% Annual Chance Flood Hazard *Zone X*
	▨	Area with Reduced Flood Risk due to Levee. See Notes. *Zone X*
	▨	Area with Flood Risk due to Levee *Zone D*
OTHER AREAS	NO SCREEN	Area of Minimal Flood Hazard *Zone X*
	☐	Effective LOMRs
	🟧	Area of Undetermined Flood Hazard *Zone D*
GENERAL STRUCTURES	– — – –	Channel, Culvert, or Storm Sewer
	׀׀׀׀׀׀׀	Levee, Dike, or Floodwall
OTHER FEATURES	(B) 20.2 / 17.5	Cross Sections with 1% Annual Chance Water Surface Elevation
	– – –	Coastal Transect
	~~ 513 ~~~	Base Flood Elevation Line (BFE)
	—	Limit of Study
	—	Jurisdiction Boundary
	–·– –·–	Coastal Transect Baseline
	– —	Profile Baseline
	—	Hydrographic Feature
MAP PANELS	☐	Digital Data Available
	☐	No Digital Data Available
	☒	Unmapped

The pin displayed on the map is an approximate point selected by the user and does not represent an authoritative property location.

This map complies with FEMA's standards for the use of digital flood maps if it is not void as described below. The basemap shown complies with FEMA's basemap accuracy standards

The flood hazard information is derived directly from the authoritative NFHL web services provided by FEMA. This map was exported on 7/28/2024 at 3:53 PM and does not reflect changes or amendments subsequent to this date and time. The NFHL and effective information may change or become superseded by new data over time.

This map image is void if the one or more of the following map elements do not appear: basemap imagery, flood zone labels, legend, scale bar, map creation date, community identifiers, FIRM panel number, and FIRM effective date. Map images for unmapped and unmodernized areas cannot be used for regulatory purposes.

FEMA Resources

FEMA's National Flood Hazard Layer (NFHL) Viewer

with Web AppBuilder for ArcGIS

Find address or place

NFHL Print Tool

Input

Output

To print NFHL FIRMette or Full FIRM:

1) Click the pin tool, and click on the map to place the pin.

2) Choose to create a print-size FIRMette or full-size FIRM.

3) Press "Execute" - The process may take up to 1 minute.*

Size*: FIRMETTE

File Format*

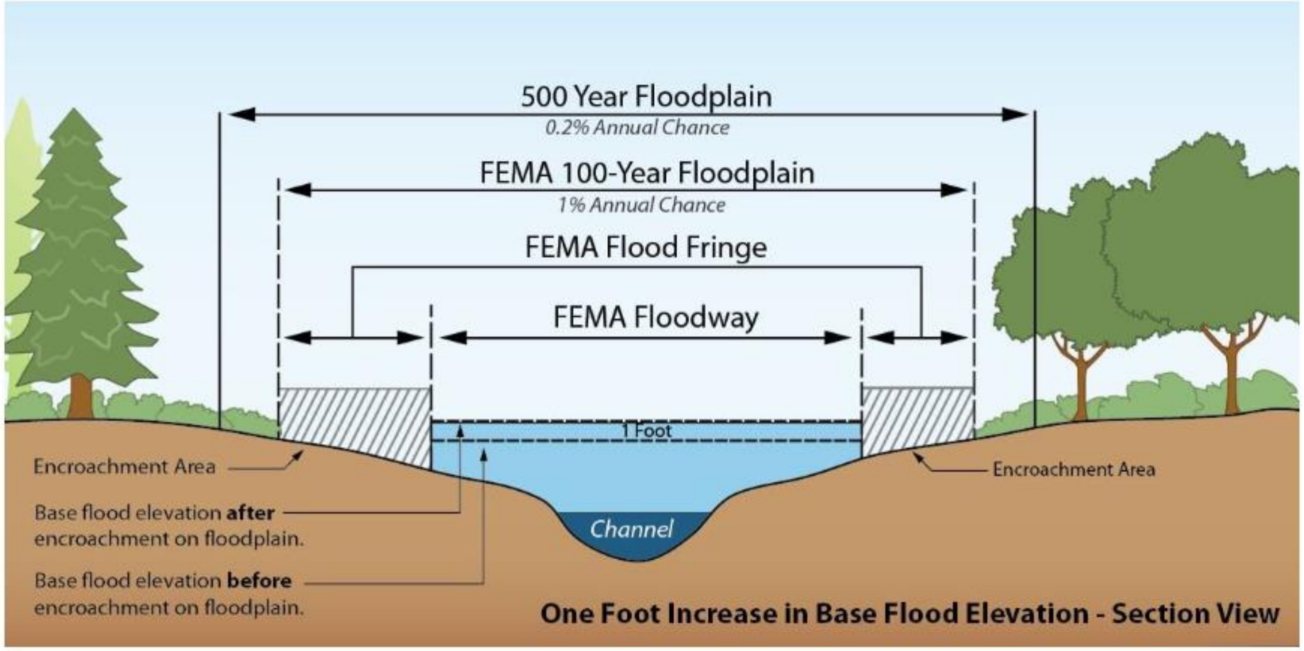
Definition of FEMA Riverine Floodway and Floodplain

Flood Hazard Boundaries

- ═ Limit Lines
- SFHA / Flood Zone Boundary
- ●─ Flowage Easement Boundary

Flood Hazard Zones

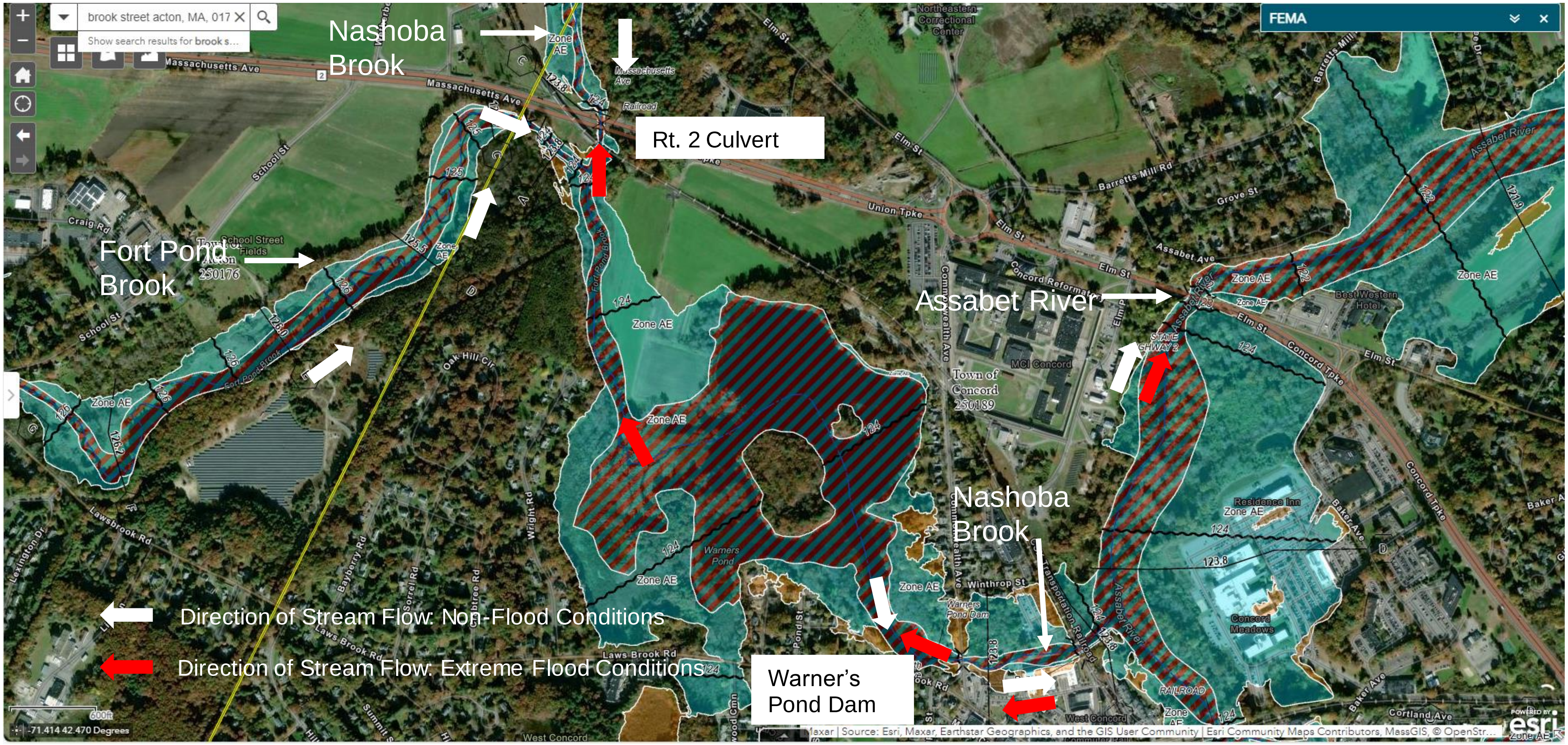
- 🟦 1% Annual Chance Flood Hazard
- ▨ Regulatory Floodway
- ◈ Special Floodway
- 🟨 Area of Undetermined Flood Hazard
- 🟧 0.2% Annual Chance Flood Hazard
- ▨ Future Conditions 1% Annual Chance Flood Hazard
- ▨ Area with Reduced Risk Due to Levee
- ▨ Area with Risk Due to Levee



A FEMA Floodway is defined as the channel of the river or stream and any adjacent land area that will allow floodwaters to pass without increasing the water surface elevation by more than one foot. Earthen fill is sometimes placed in a Special Flood Hazard Area (SFHA) to reduce flood risk to the filled area. The placement of fill is considered development and will require a permit under applicable Federal, state and local laws, ordinances, and regulations. Fill is prohibited within the floodway unless it has been demonstrated that it will not result in any increase in flood levels. Some communities limit the use of fill in the flood fringe to protect storage capacity or require compensatory storage.

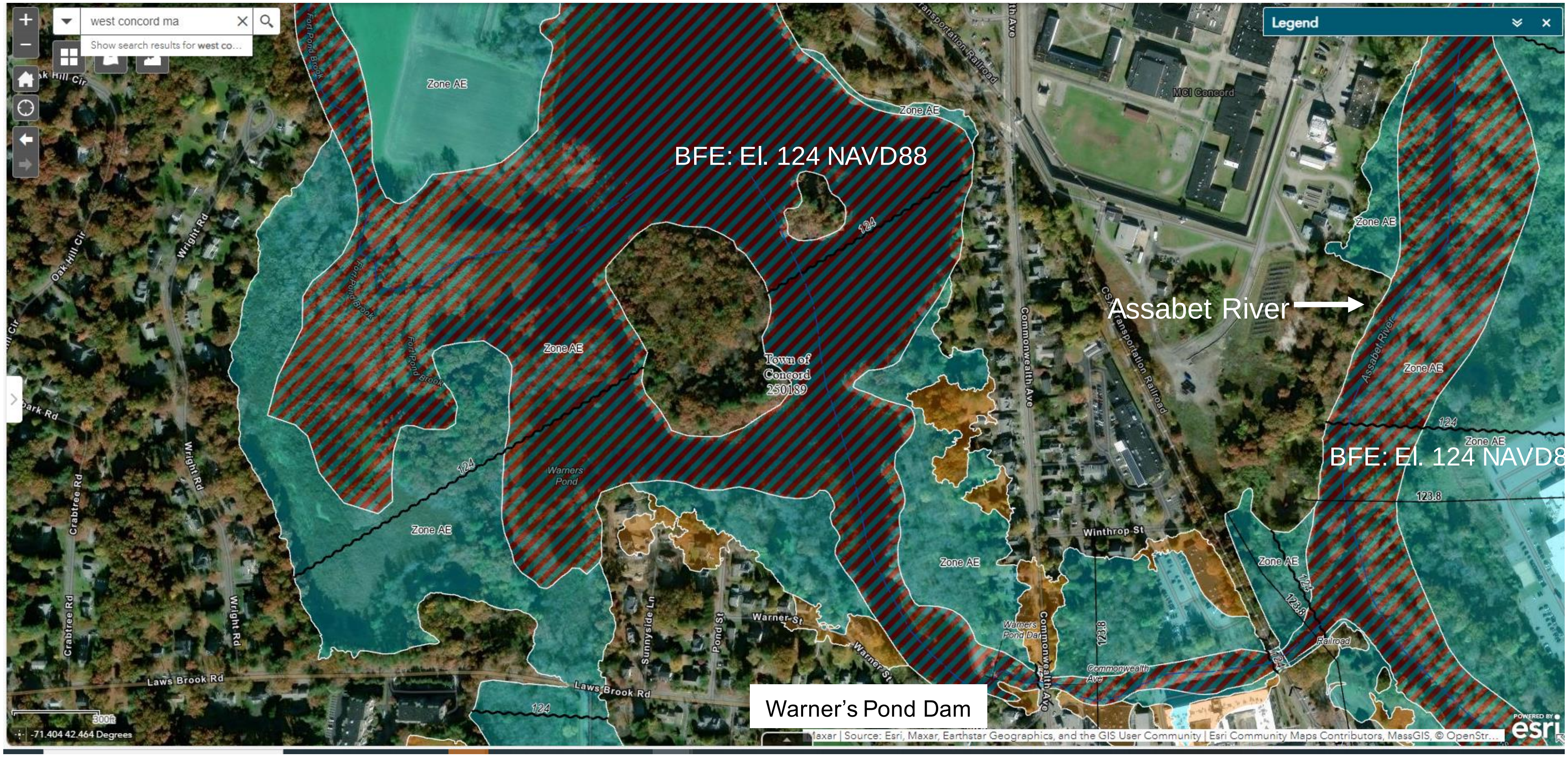
FEMA Flood Hazard Zones

Note: The red arrows are not part of the FEMA FIS or FIRM but have been added here to illustrate the “backwater” flow from the Assabet River during peak flood. The red inclined lines indicate the FEMA regulated floodway limits. Green shaded areas reflect the limits of the 100-year floodplain. The yellow (gold) shaded areas reflect additional flood inundation due to the 500-year flood event.



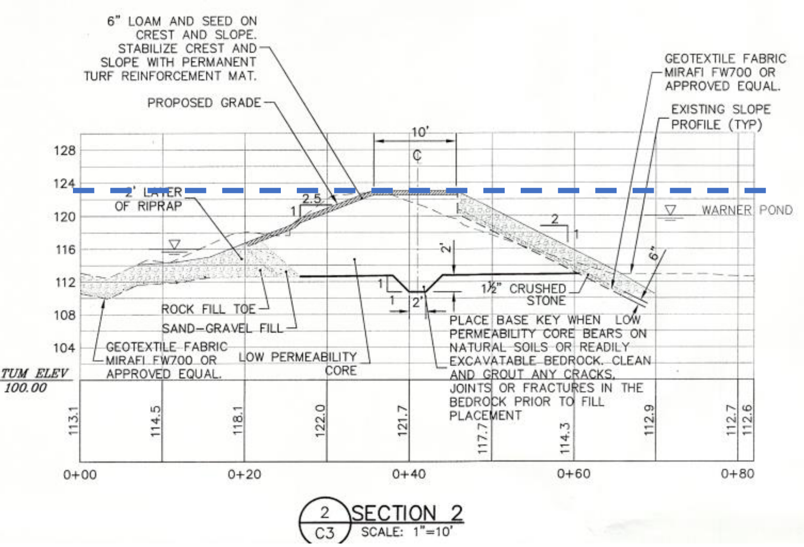
FEMA Flood Hazard Zones

The FEMA Base Flood Elevation (BFE) associated with the 100-year flood is Elevation 124 feet NAVD88, as indicated on the FEMA Firm. The FEMA flood profiles, with greater resolution, indicate a slightly lower 100-year peak flood elevation (123.8 feet NAVD88).



FEMA 100-year Peak Flood

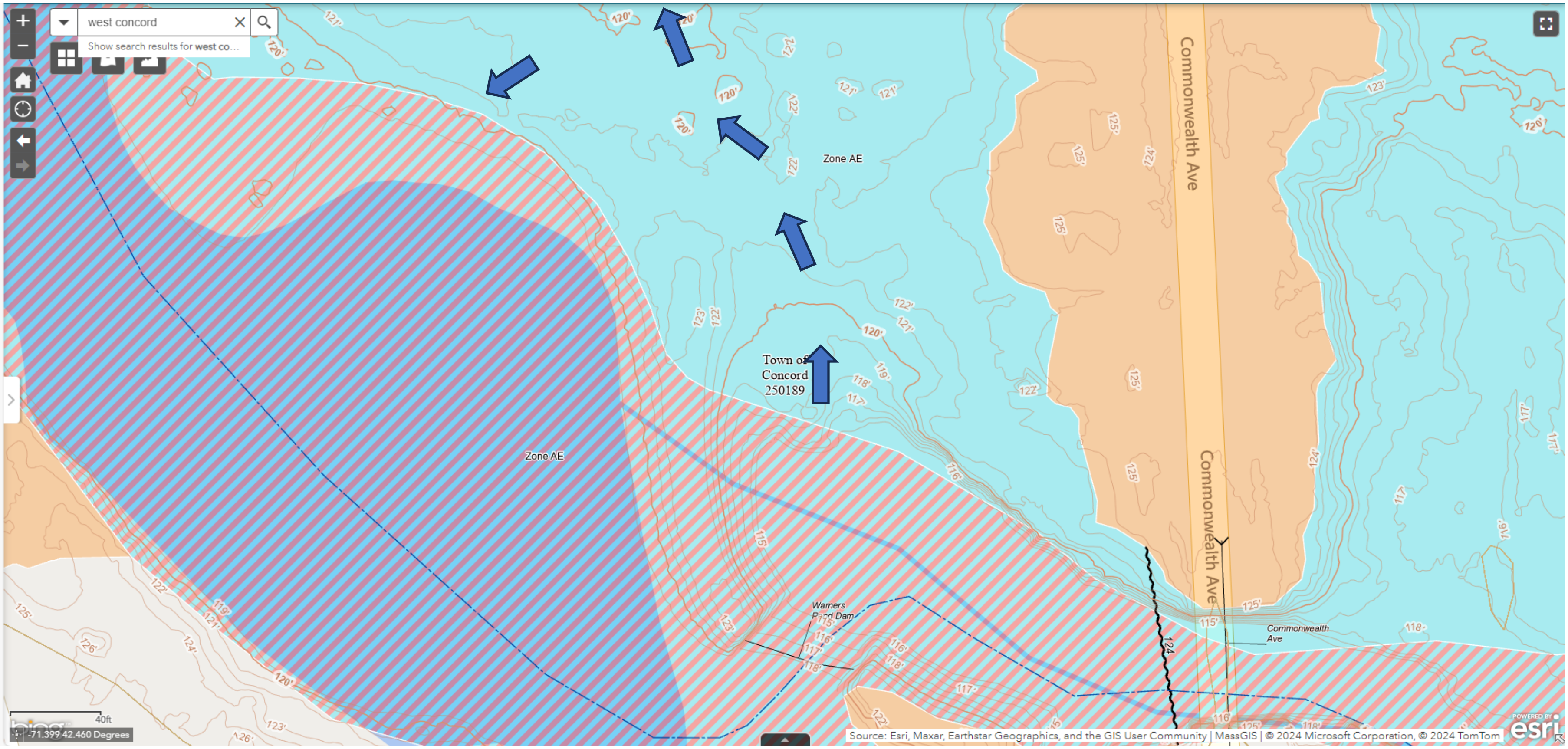
Peak flood elevations will exceed the top of the dam embankments as well as the dam abutment areas.



FEMA 10%: +/- 120.2 ft NAVD88
FEMA 2%: +/- 122.4 ft NAVD88
FEMA 1% BFA: 123.8 ft NAVD88
FEMA 0.2%: +/- 124.5 ft NAVD88
Embankment Crest: 123 ft NAVD88
Left Abutment area: +/- 121 ft NAVD88
Spillway: 118.8 ft NAVD88

FEMA 100-year Peak Flood - Left Embankment Area

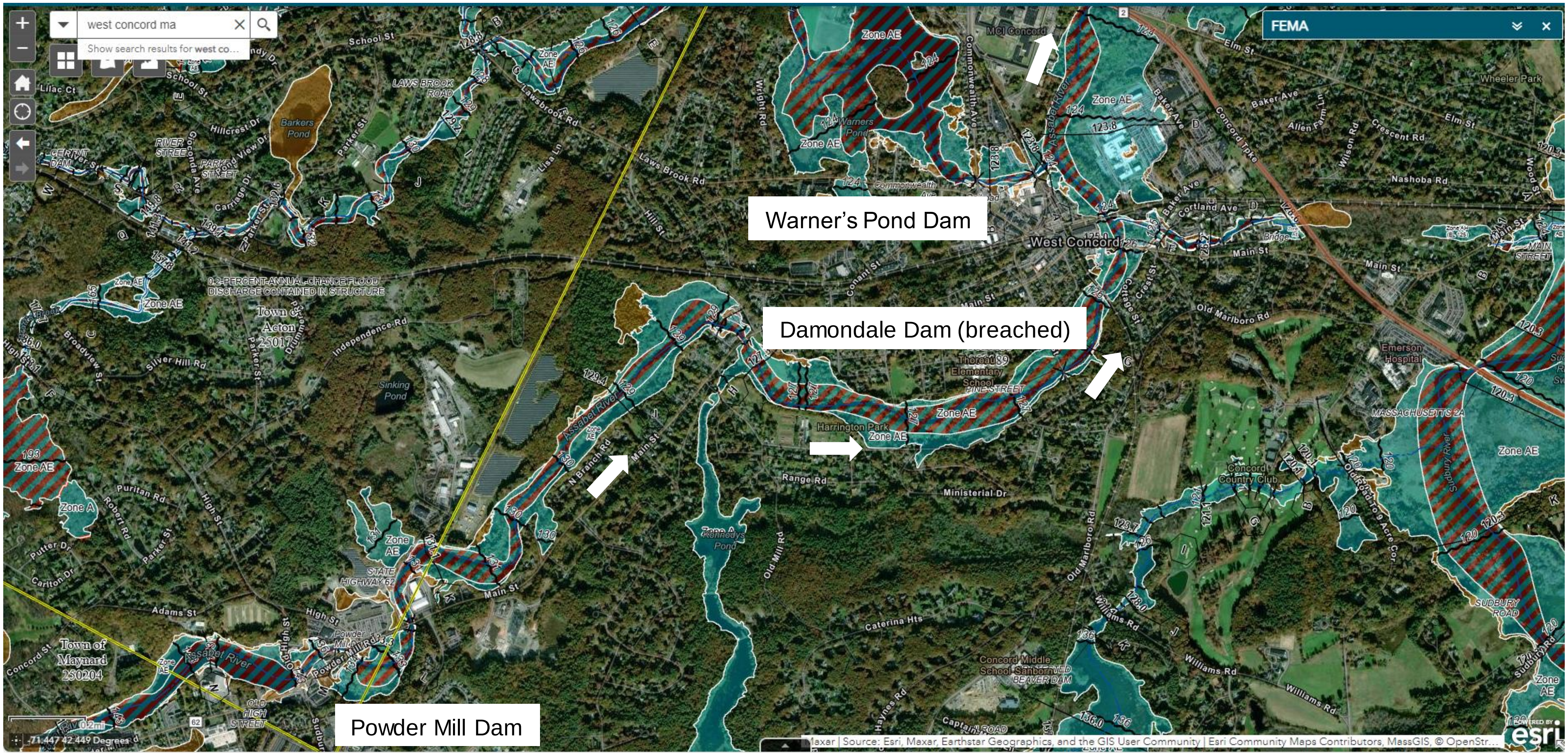
This illustration (blue arrows and topographic contour lines added to the FEMA map) indicates the likely flood pathway, in particular during floodwater rising above Elevation 121 feet NAVD88. As shown by the FEMA flood zones, this area floods but is outside of the regulated floodway. Information presented in the 2023 Phase I Dam Inspection Report indicates that about 37.5% of the total Spillway Design Flood (SDF) capacity is via this area. The blue arrows assume the condition of “backwater” flooding from the Assabet River peak flood.



Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community | MassGIS | © 2024 Microsoft Corporation, © 2024 TomTom

Assabet River Floodplain

Existing dams affect flooding along the key tributaries and the Assabet River, as shown on the FEMA Flood Profiles. The image below is the Assabet River downgradient from Warner's Pond. The white arrows are added to the FEMA map to indicate river flow direction within the Assabet. Warner's Pond Dam is not on the Assabet but is shown here for reference.



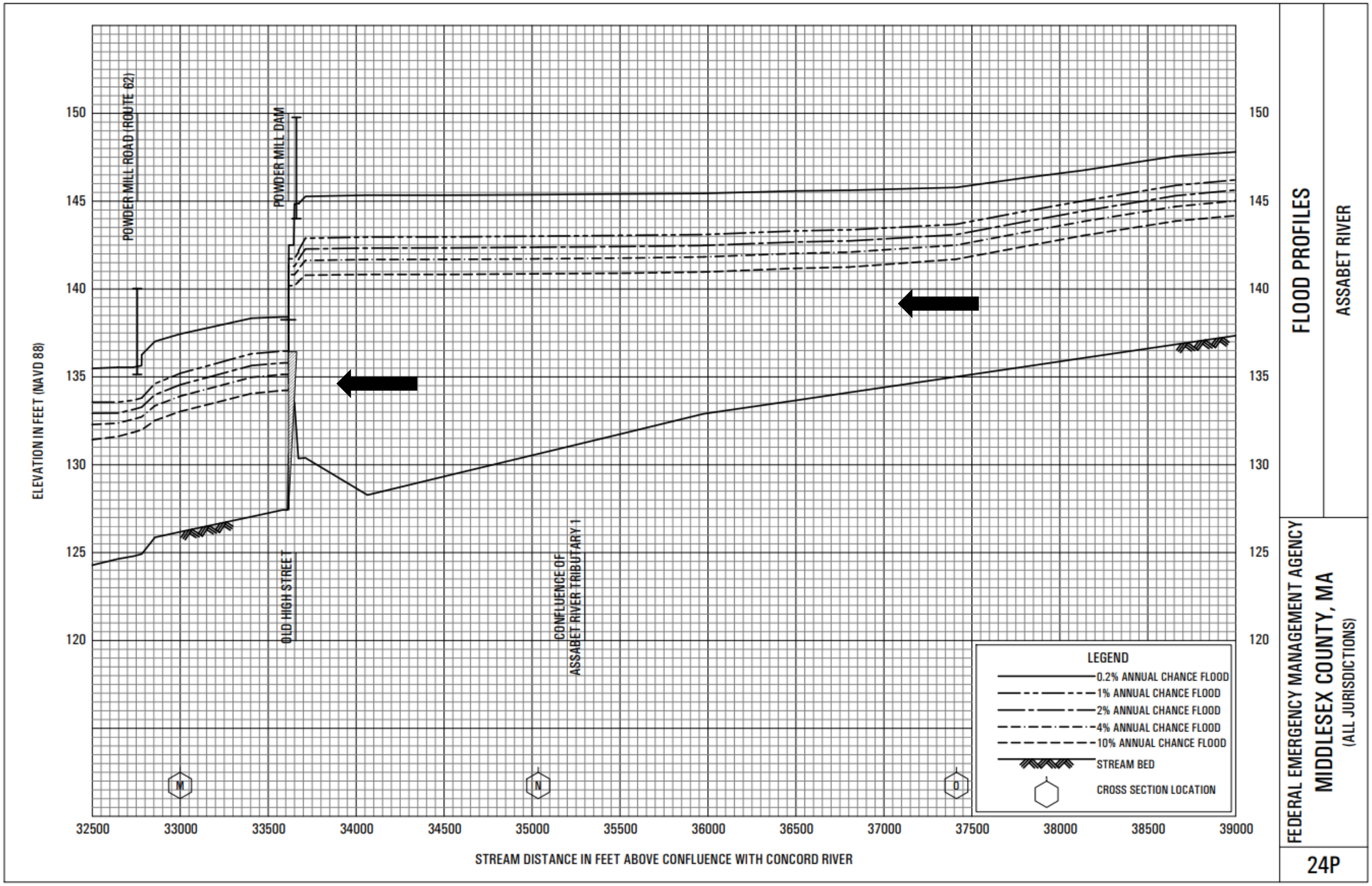
Assabet River Floodplain

Existing dams affect flooding along the key tributaries and the Assabet River, as shown on the FEMA Flood Profiles. The image below is the Assabet River upgradient form Warner's Pond. The white arrows are added to the FEMA map to indicate river flow direction within the Assabet.

Warner' Pond Dam

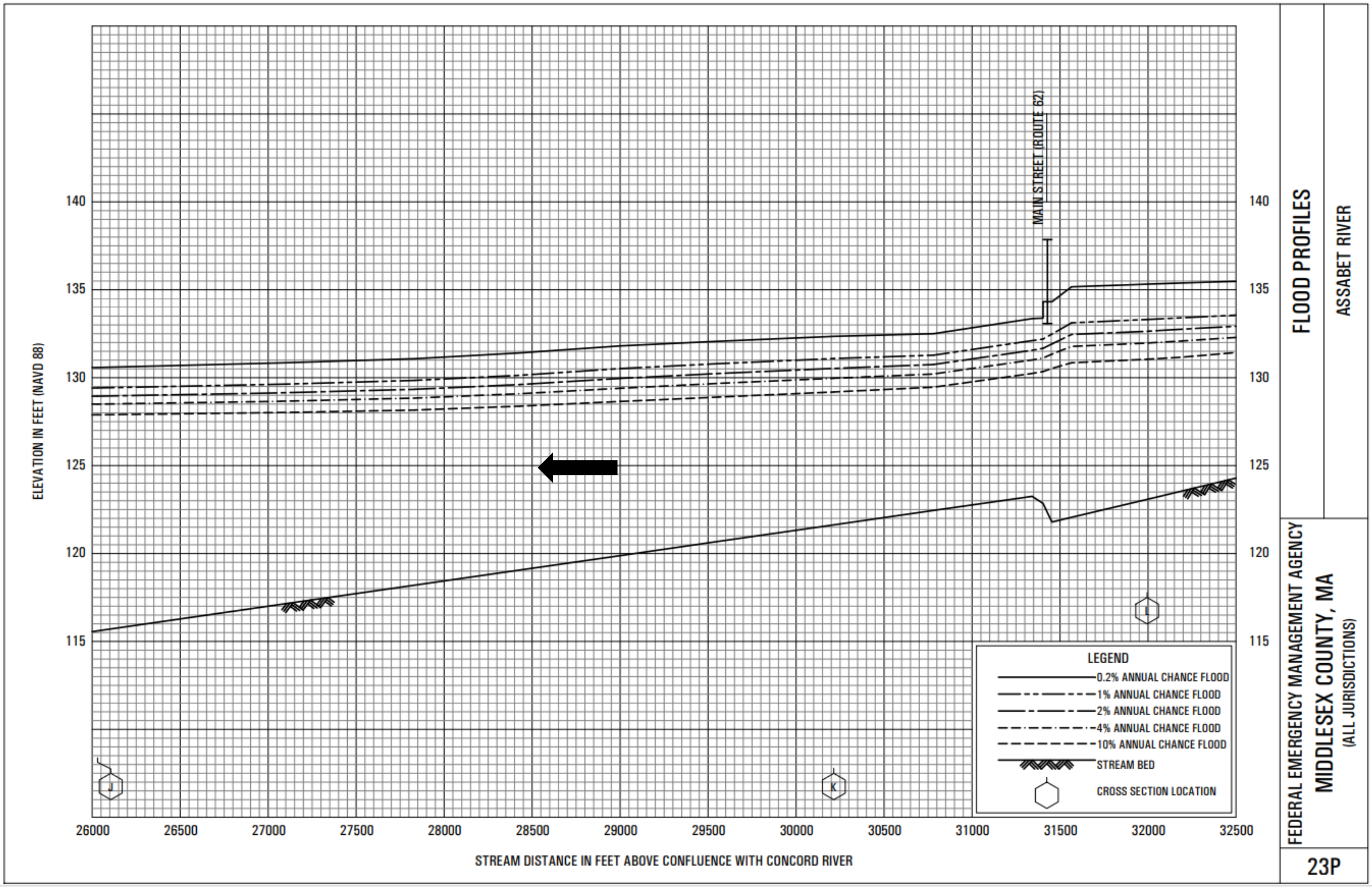
FEMA Flood Profiles: Assabet River

Flood profile lines show flood elevations associated with different recurrence interval flood events. The stream distance indicates distance from the confluence of the Assabet and Concord Rivers. Arrows have been added to show flow direction.



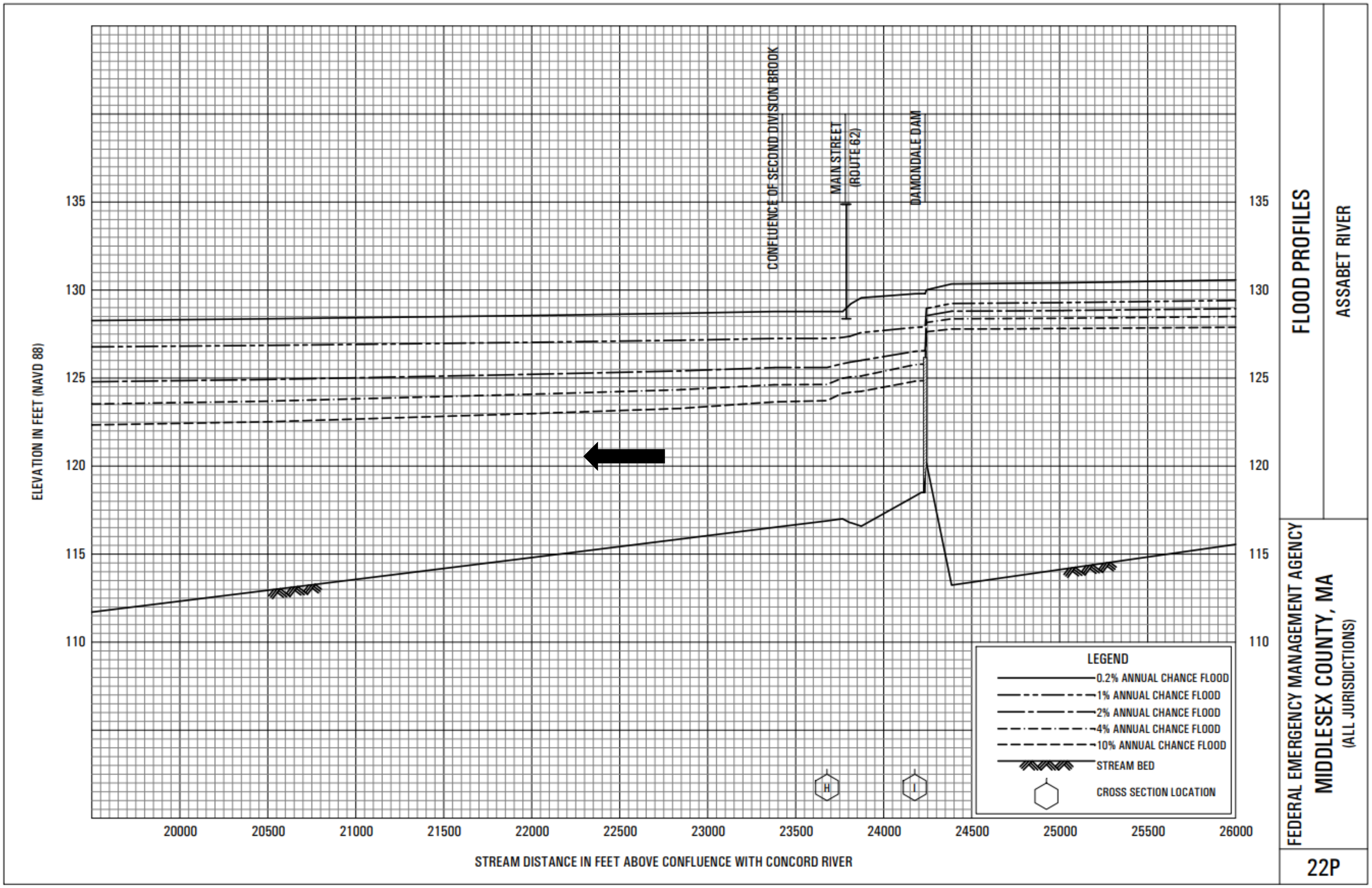
FEMA Flood Profiles: Assabet River

The stream distance indicates distance from the confluence of the Assabet and Concord Rivers. Arrows have been added to show flow direction.



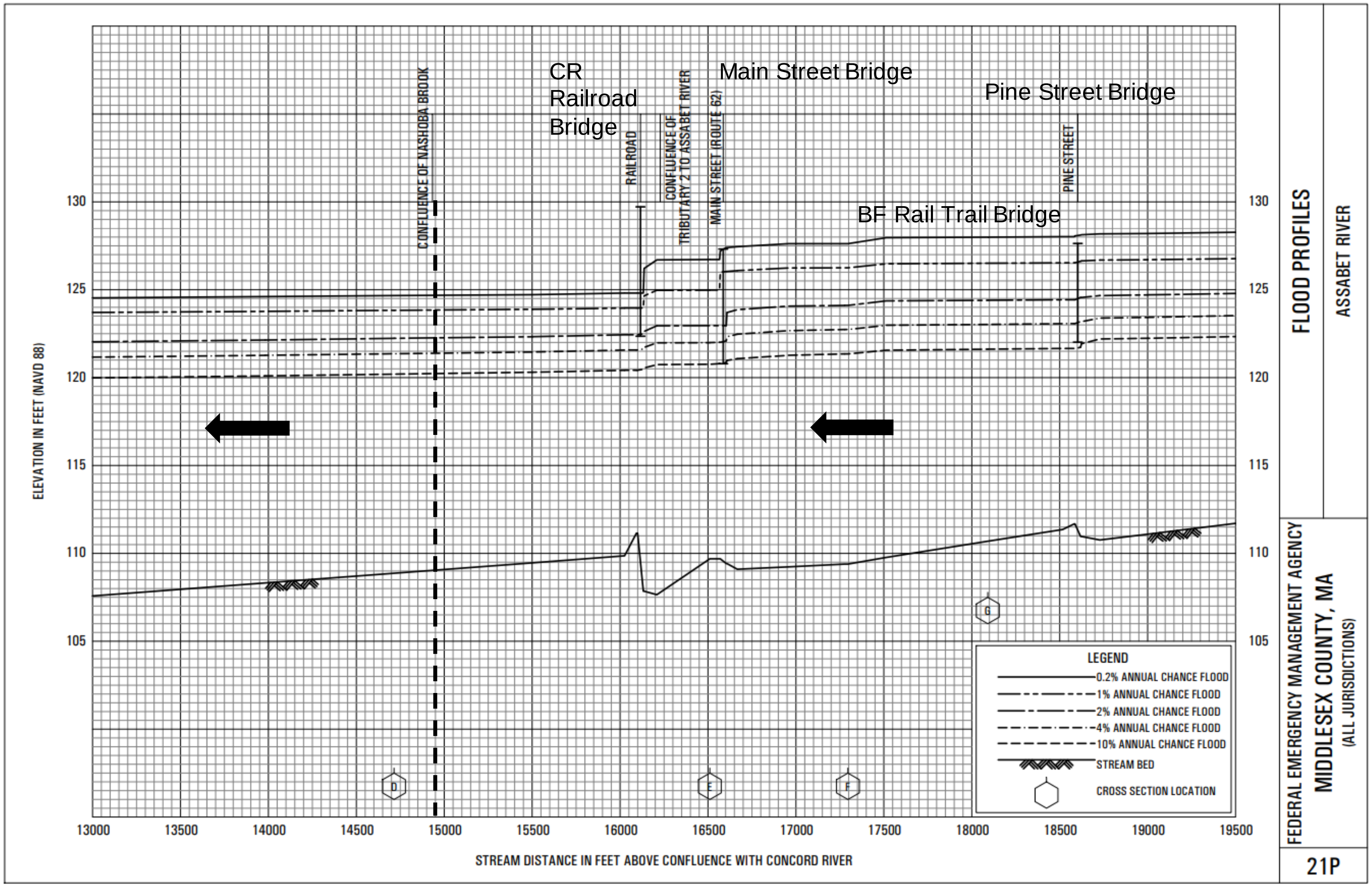
FEMA Flood Profiles: Assabet River

The stream distance indicates distance from the confluence of the Assabet and Concord Rivers. Arrows have been added to show flow direction.



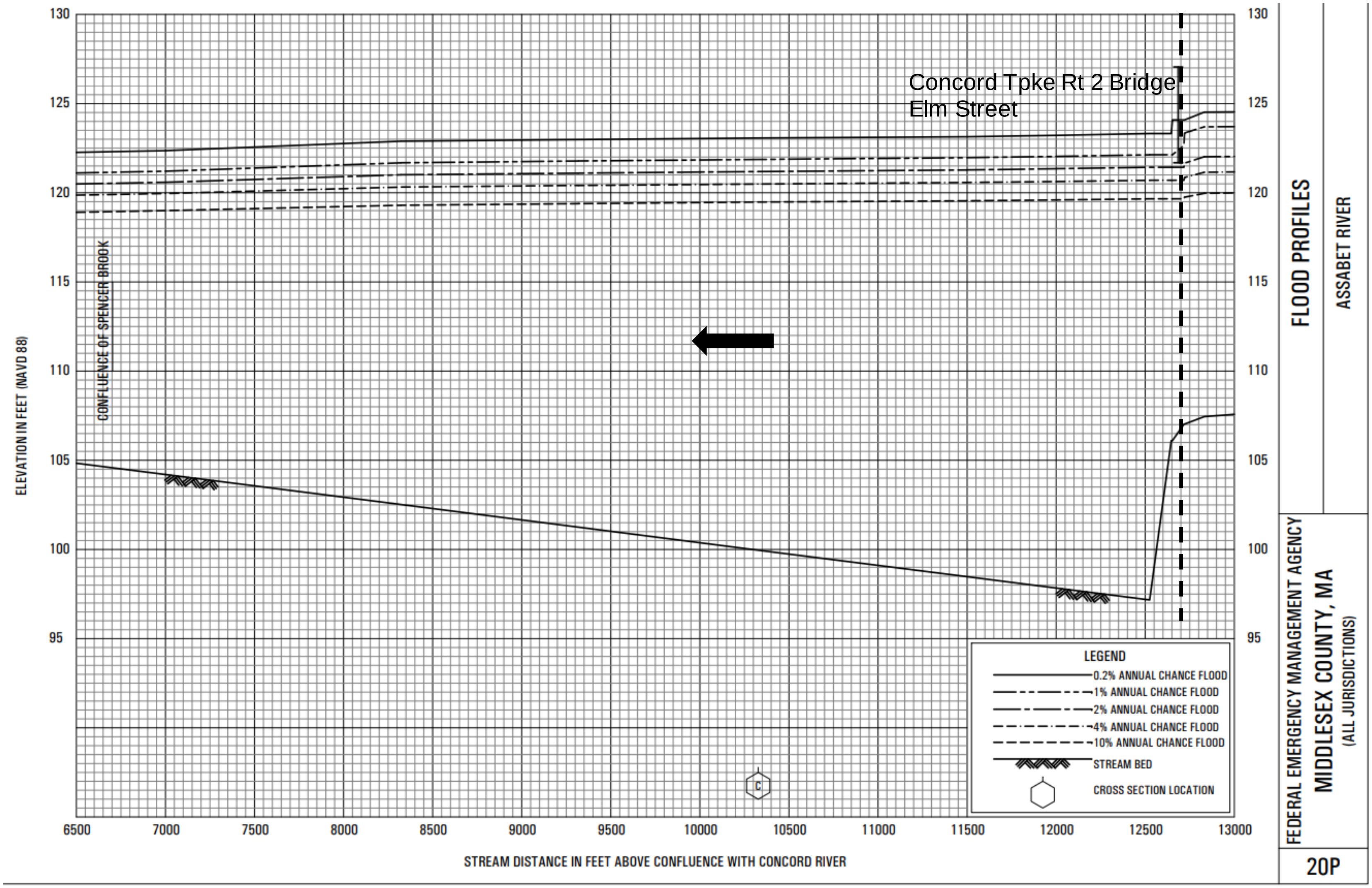
FEMA Flood Profiles: Assabet River

The stream distance indicates distance from the confluence of the Assabet and Concord Rivers. Arrows have been added to show flow direction.



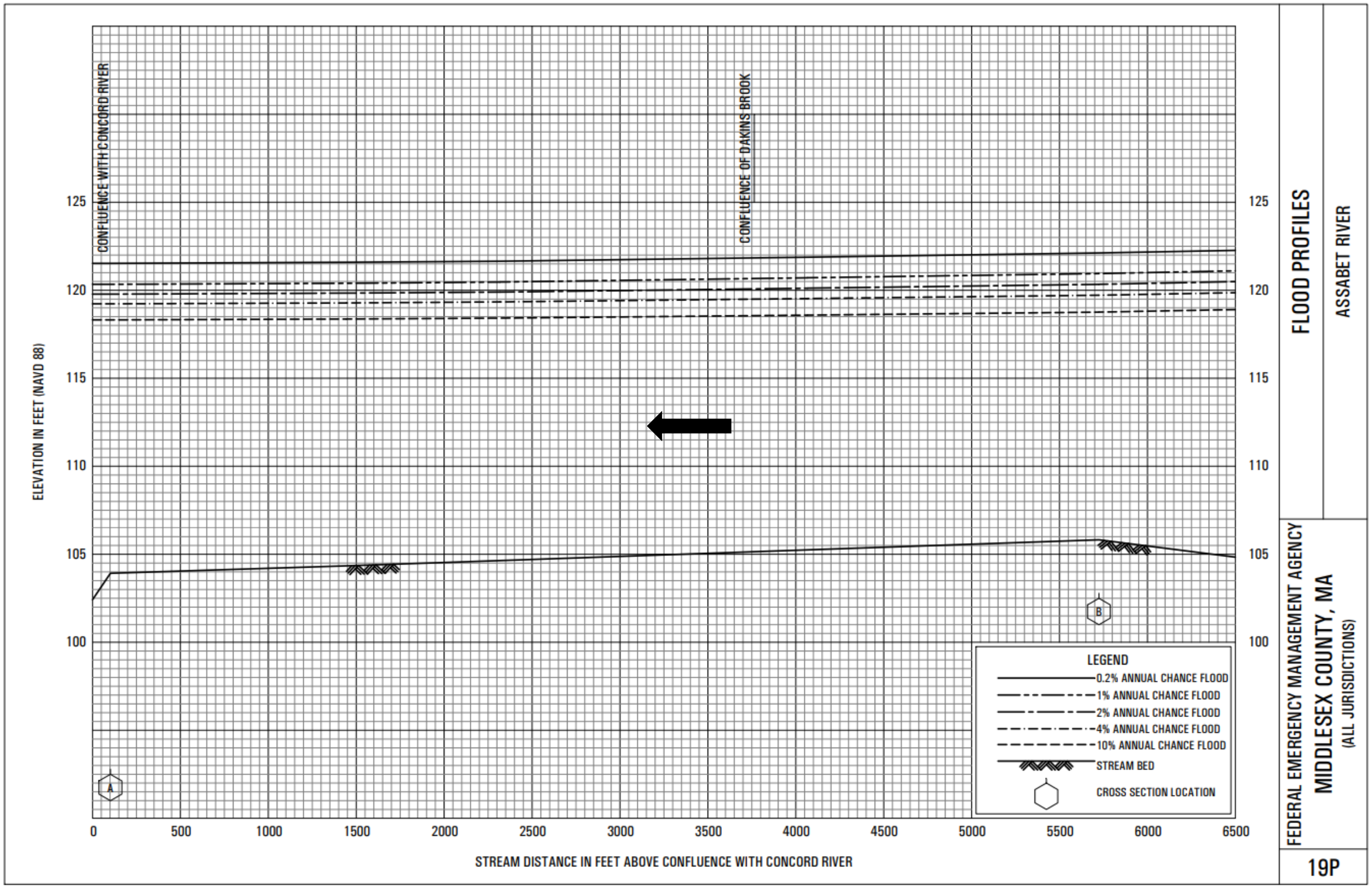
FEMA Flood Profiles: Assabet River

The stream distance indicates distance from the confluence of the Assabet and Concord Rivers. Arrows have been added to show flow direction.



FEMA Flood Profiles: Assabet River

The stream distance indicates distance from the confluence of the Assabet and Concord Rivers. Arrows have been added to show flow direction.



FEMA Flood Discharge: Assabet River

At confluence with Nashoba Brook

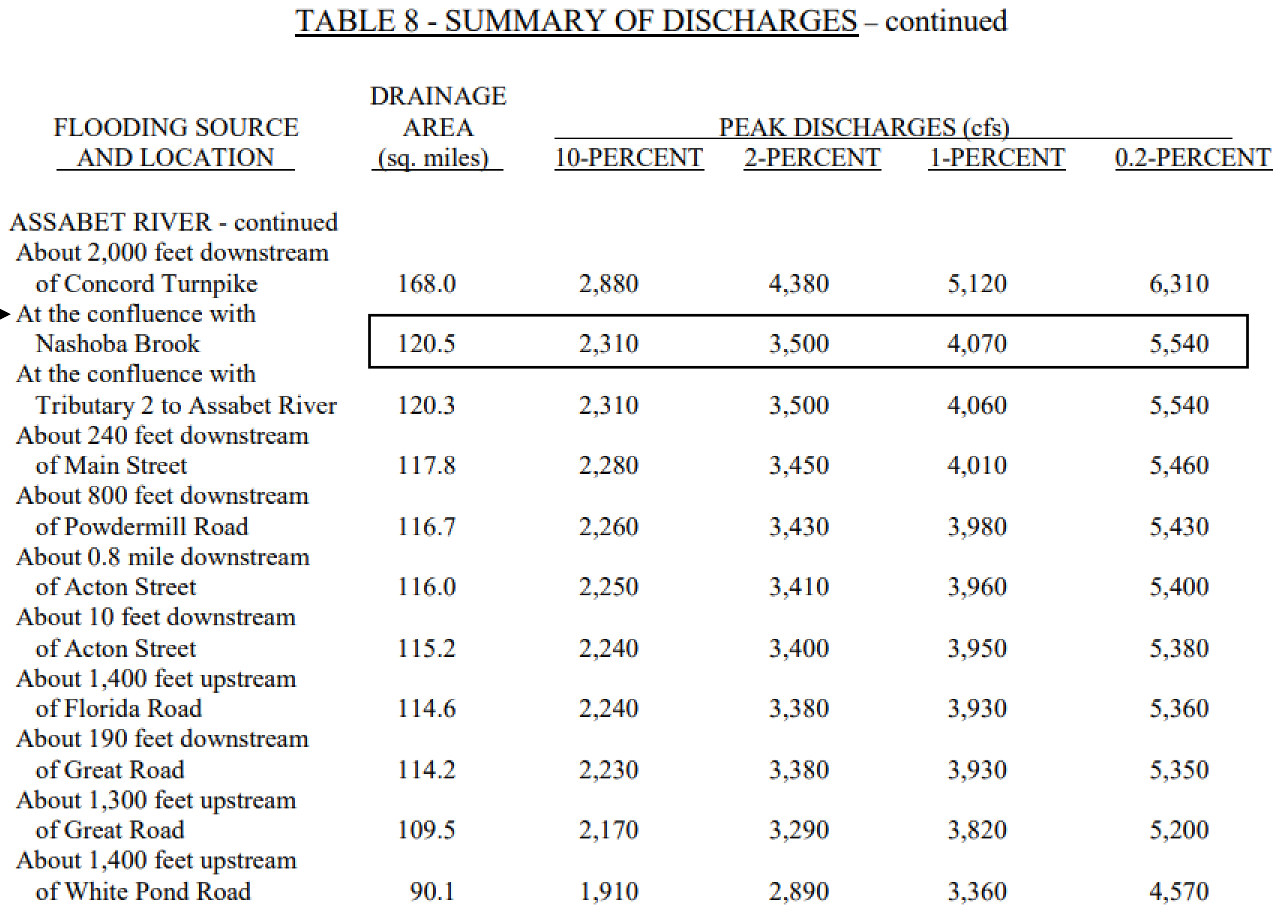


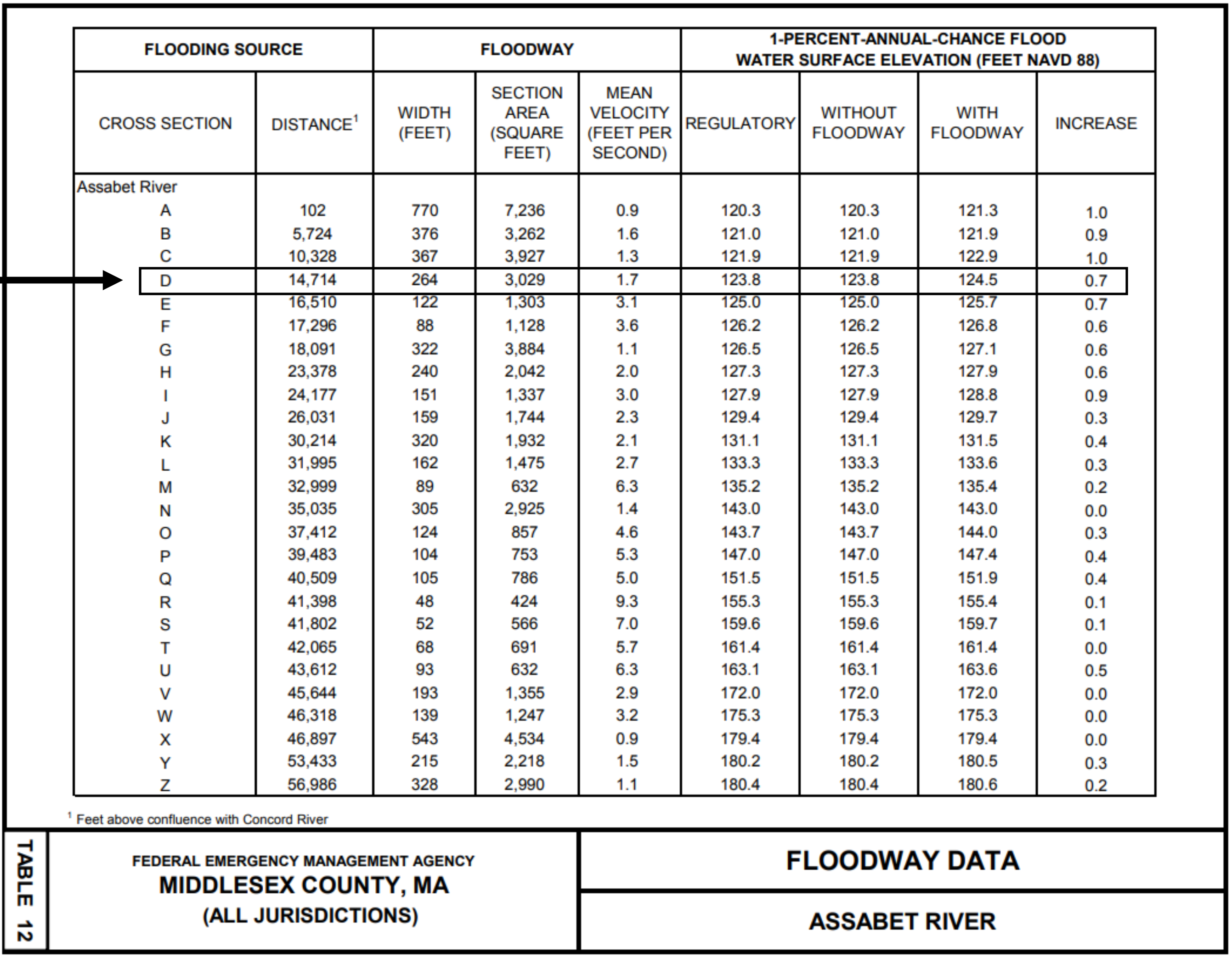
TABLE 8 - SUMMARY OF DISCHARGES – continued

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs)			
		10-PERCENT	2-PERCENT	1-PERCENT	0.2-PERCENT
ASSABET RIVER - continued					
About 2,000 feet downstream of Concord Turnpike	168.0	2,880	4,380	5,120	6,310
At the confluence with Nashoba Brook	120.5	2,310	3,500	4,070	5,540
At the confluence with Tributary 2 to Assabet River	120.3	2,310	3,500	4,060	5,540
About 240 feet downstream of Main Street	117.8	2,280	3,450	4,010	5,460
About 800 feet downstream of Powdermill Road	116.7	2,260	3,430	3,980	5,430
About 0.8 mile downstream of Acton Street	116.0	2,250	3,410	3,960	5,400
About 10 feet downstream of Acton Street	115.2	2,240	3,400	3,950	5,380
About 1,400 feet upstream of Florida Road	114.6	2,240	3,380	3,930	5,360
About 190 feet downstream of Great Road	114.2	2,230	3,380	3,930	5,350
About 1,300 feet upstream of Great Road	109.5	2,170	3,290	3,820	5,200
About 1,400 feet upstream of White Pond Road	90.1	1,910	2,890	3,360	4,570

This FEMA FIS table indicates that the 100-year peak discharge within the Assabet River at the location where it connects with Nashoba Brook (downstream form Warner's Pond) is 4,070 cfs).

FEMA Flood Discharge: Assabet River

Nashoba Brook



FLOODING SOURCE		FLOODWAY			1-PERCENT-ANNUAL-CHANCE FLOOD WATER SURFACE ELEVATION (FEET NAVD 88)			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Assabet River								
A	102	770	7,236	0.9	120.3	120.3	121.3	1.0
B	5,724	376	3,262	1.6	121.0	121.0	121.9	0.9
C	10,328	367	3,927	1.3	121.9	121.9	122.9	1.0
D	14,714	264	3,029	1.7	123.8	123.8	124.5	0.7
E	16,510	122	1,303	3.1	125.0	125.0	125.7	0.7
F	17,296	88	1,128	3.6	126.2	126.2	126.8	0.6
G	18,091	322	3,884	1.1	126.5	126.5	127.1	0.6
H	23,378	240	2,042	2.0	127.3	127.3	127.9	0.6
I	24,177	151	1,337	3.0	127.9	127.9	128.8	0.9
J	26,031	159	1,744	2.3	129.4	129.4	129.7	0.3
K	30,214	320	1,932	2.1	131.1	131.1	131.5	0.4
L	31,995	162	1,475	2.7	133.3	133.3	133.6	0.3
M	32,999	89	632	6.3	135.2	135.2	135.4	0.2
N	35,035	305	2,925	1.4	143.0	143.0	143.0	0.0
O	37,412	124	857	4.6	143.7	143.7	144.0	0.3
P	39,483	104	753	5.3	147.0	147.0	147.4	0.4
Q	40,509	105	786	5.0	151.5	151.5	151.9	0.4
R	41,398	48	424	9.3	155.3	155.3	155.4	0.1
S	41,802	52	566	7.0	159.6	159.6	159.7	0.1
T	42,065	68	691	5.7	161.4	161.4	161.4	0.0
U	43,612	93	632	6.3	163.1	163.1	163.6	0.5
V	45,644	193	1,355	2.9	172.0	172.0	172.0	0.0
W	46,318	139	1,247	3.2	175.3	175.3	175.3	0.0
X	46,897	543	4,534	0.9	179.4	179.4	179.4	0.0
Y	53,433	215	2,218	1.5	180.2	180.2	180.5	0.3
Z	56,986	328	2,990	1.1	180.4	180.4	180.6	0.2

[1] Feet above confluence with Concord River

TABLE 12

FEDERAL EMERGENCY MANAGEMENT AGENCY
MIDDLESEX COUNTY, MA
(ALL JURISDICTIONS)

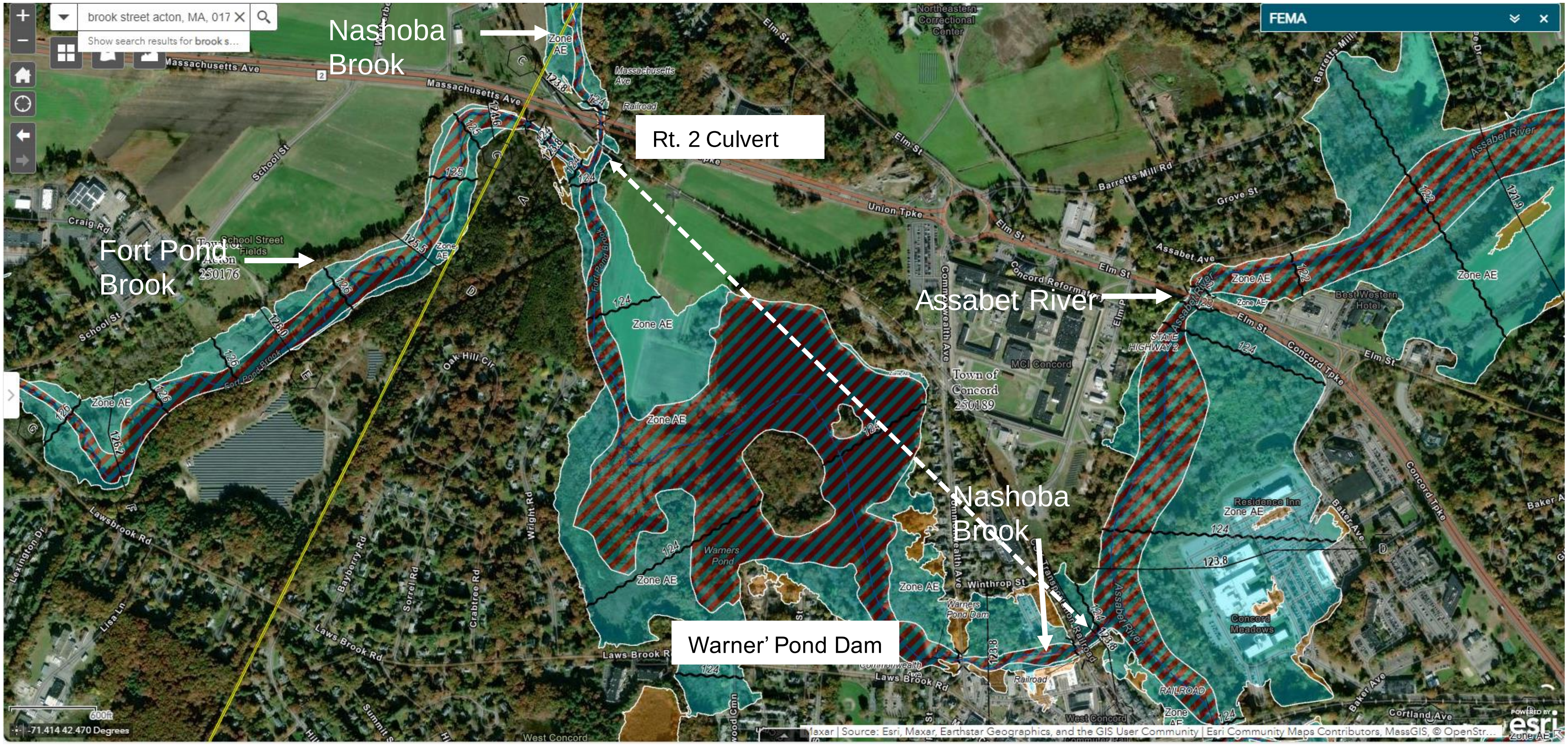
FLOODWAY DATA

ASSABET RIVER

This FEMA FIS table indicates that the 100-year peak water level elevation within the Assabet River at the location where it connects with Nashoba Brook (downstream form Warner's Pond) is 123.8 feet NAVD88), controlling flooding within Nashoba Brook and Warner's Pond up to about Rt. 2.

FEMA Flood Discharge: Assabet River

This image indicates the approximate extent (dashed white arrow) of the effect of “backwater” from the 100-year peak water level elevation within the Assabet River, including all of Warner’s Pond floodplain.



Nashoba Brook

Rt. 2 Culvert

Fort Pond Brook

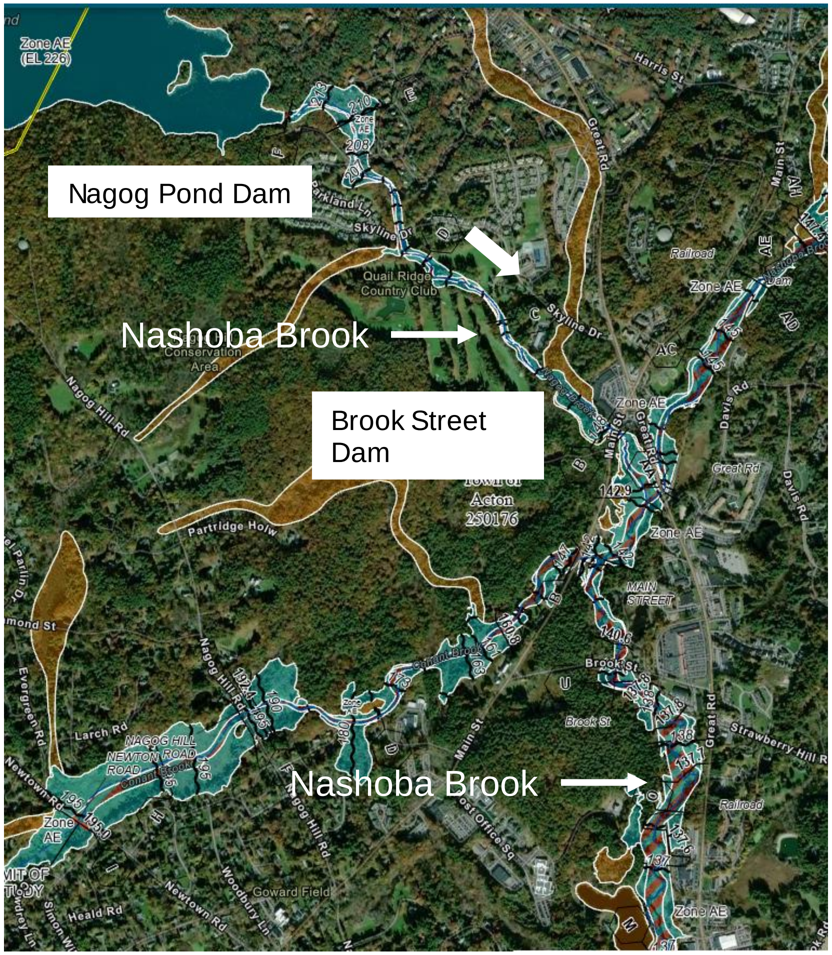
Assabet River

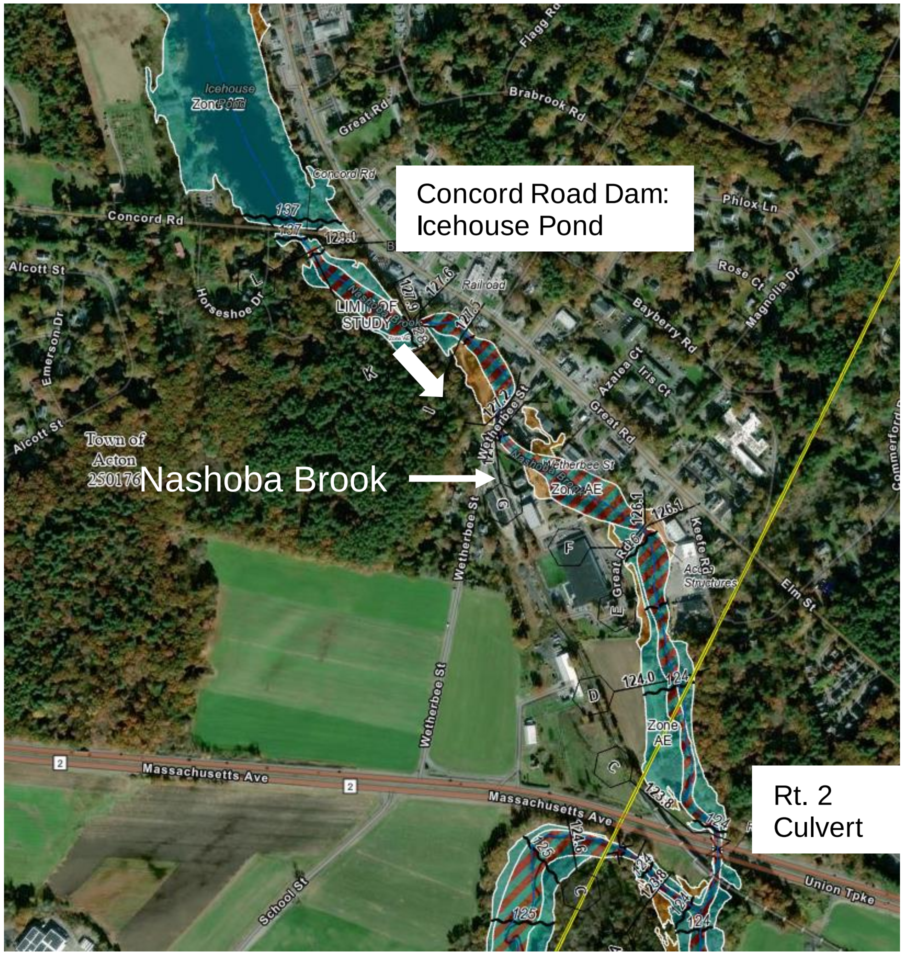
Nashoba Brook

Warner’ Pond Dam

Nashoba Brook Floodplain

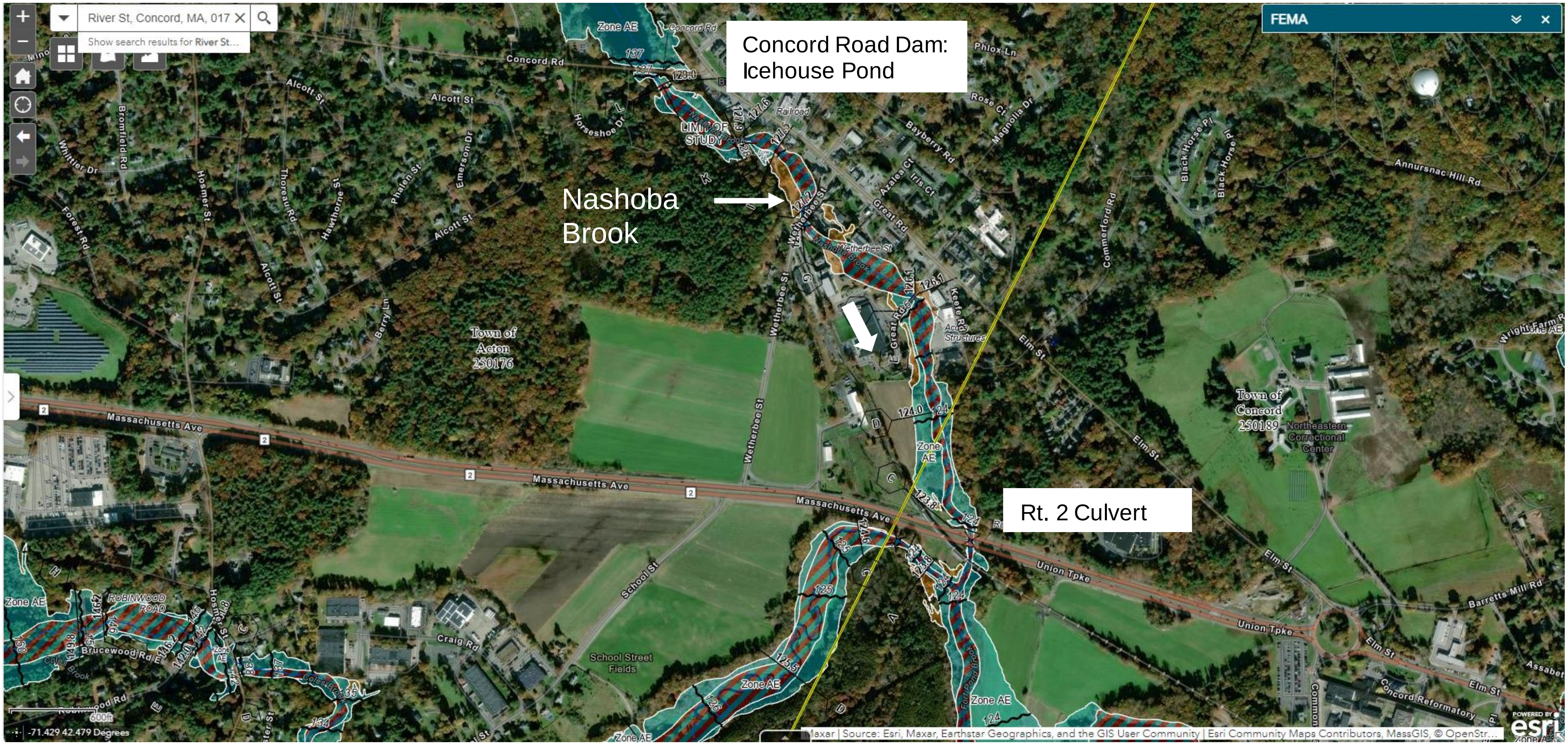
Existing dams affect flooding along Nashoba Brook. The white arrows are added to the FEMA map to indicate river flow direction within Nashoba Brook.





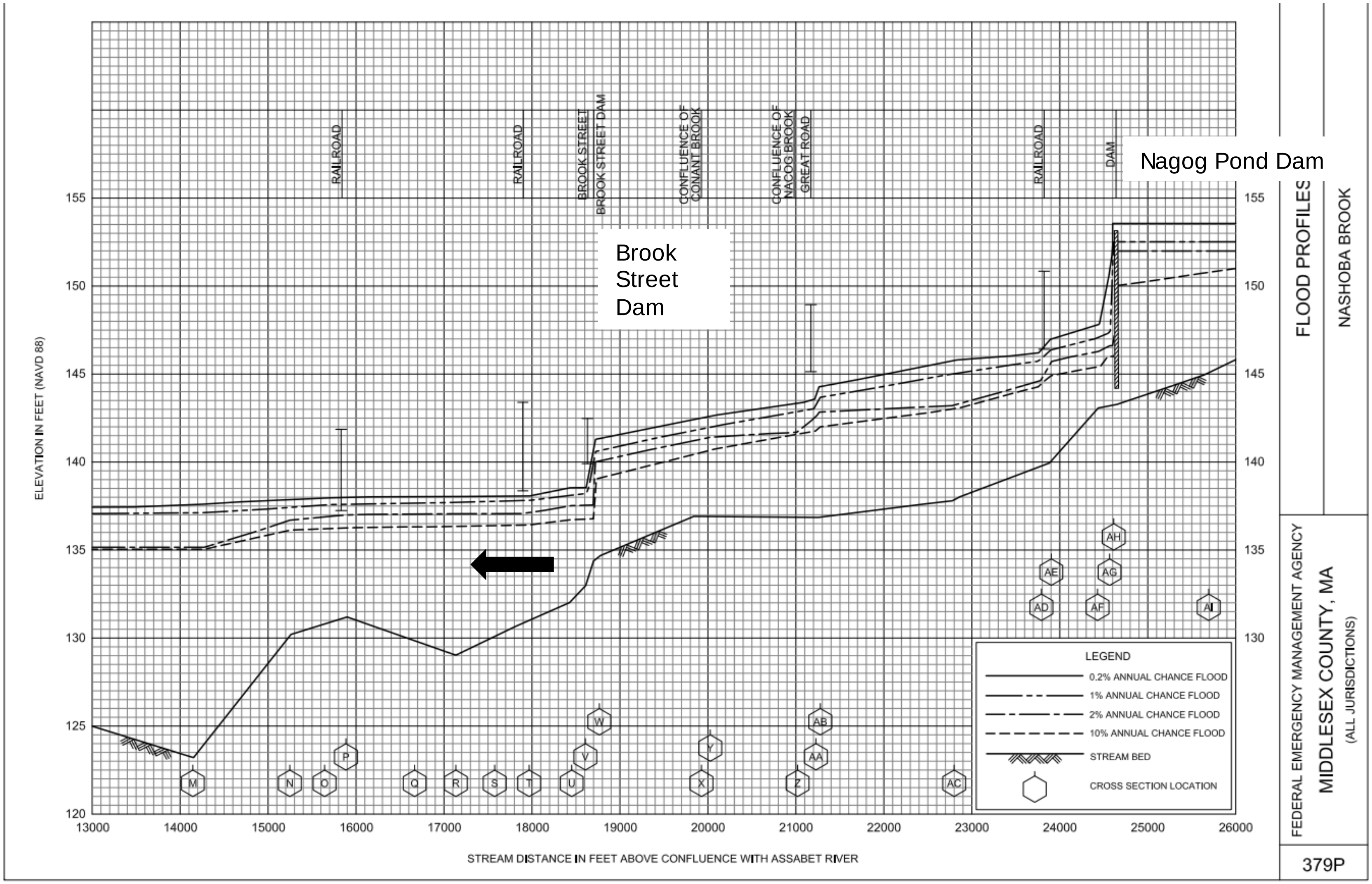
Nashoba Brook Floodplain

Existing dams affect flooding along Nashoba Brook. The white arrows are added to the FEMA map to indicate river flow direction within Nashoba Brook.



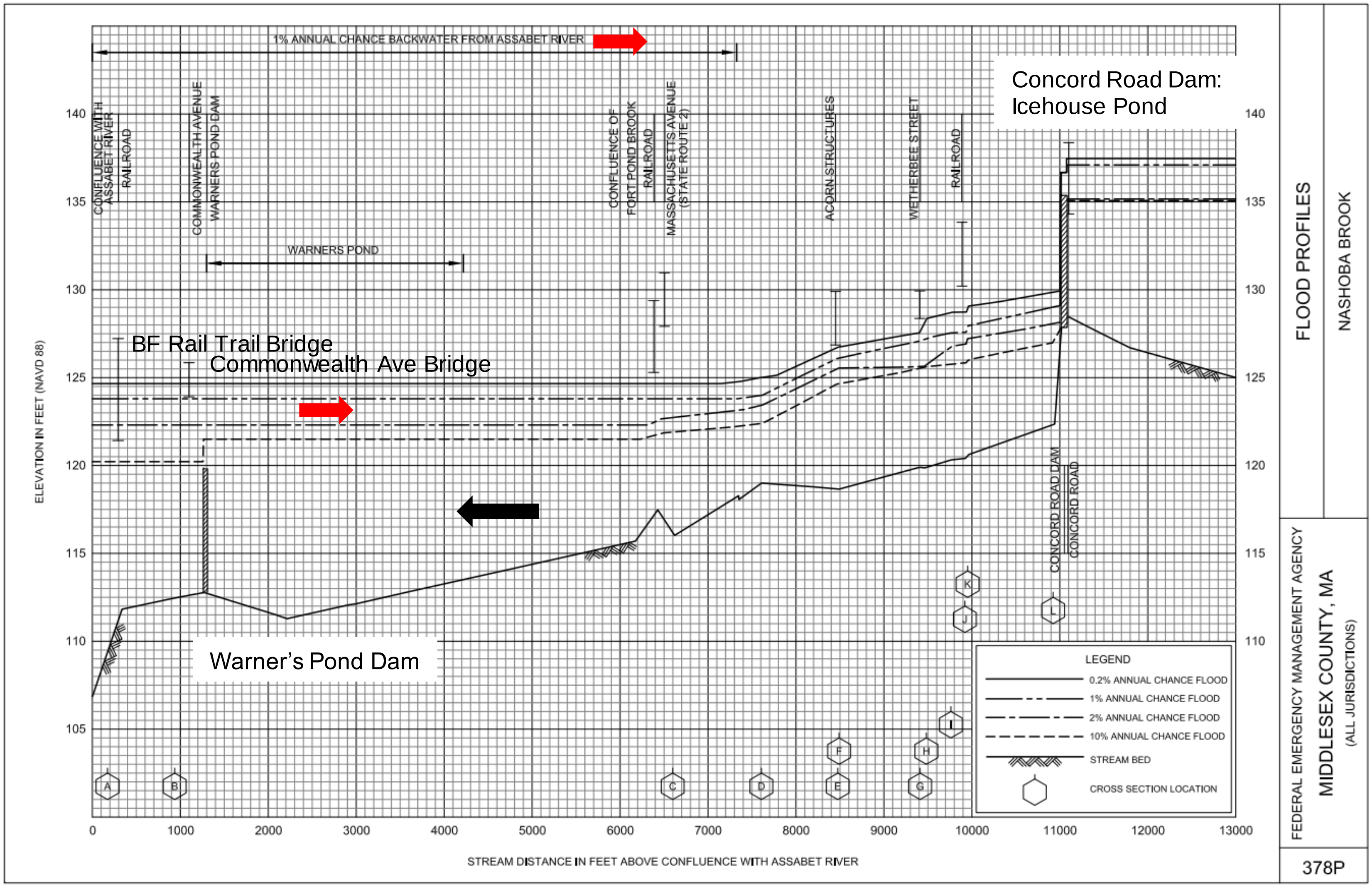
FEMA Flood Profiles: Nashoba Brook

The stream distance indicates distance from the confluence of Nashoba Brook with the Assabet River. Arrows have been added to show flow direction.



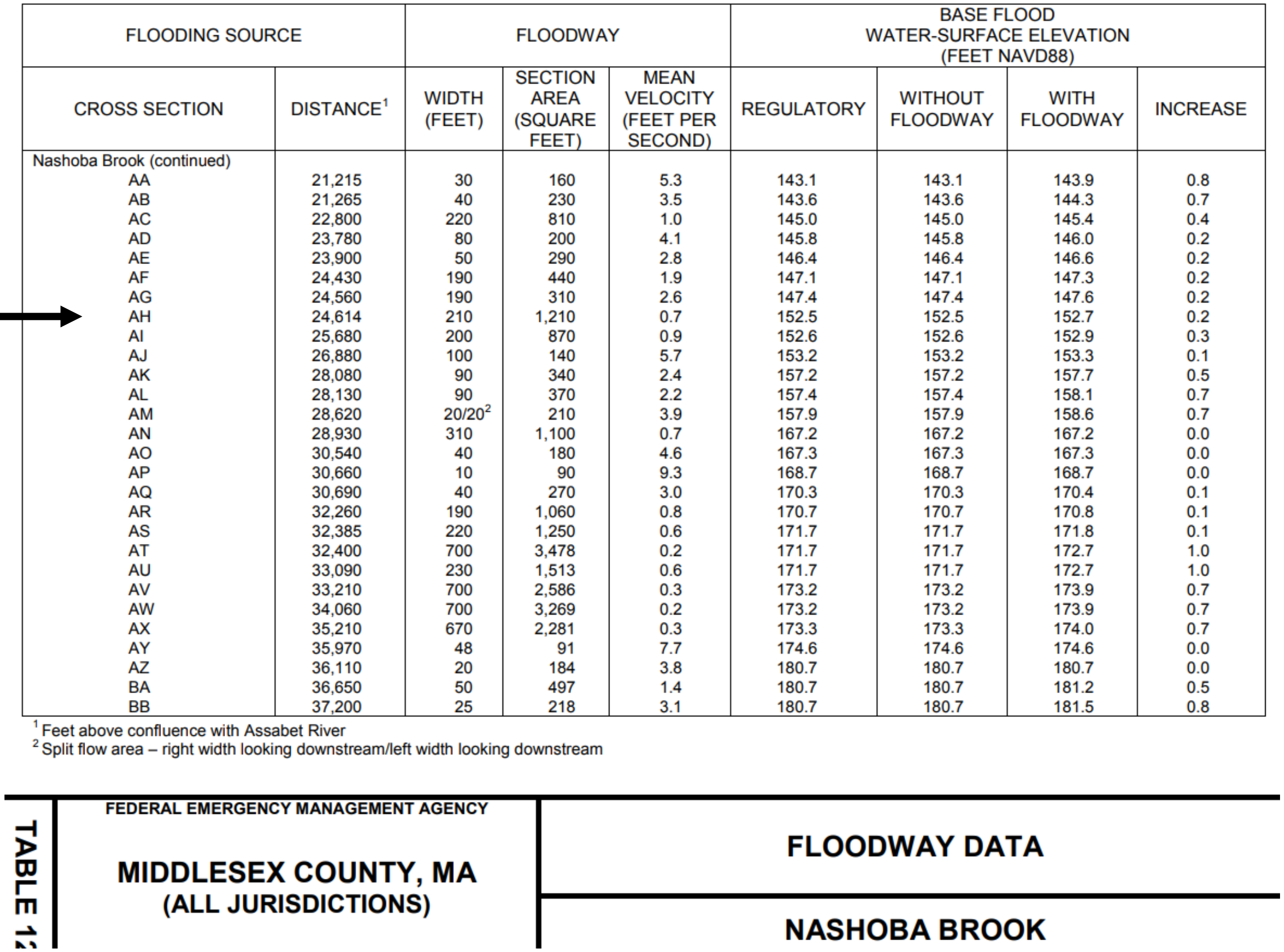
FEMA Flood Profiles: Nashoba Brook

The stream distance indicates distance from the confluence of Nashoba Brook with the Assabet River. Arrows have been added to show flow direction.



FEMA Flood Discharge: Nashoba Brook

Nagog Pond →



FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION (FEET NAVD88)			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Nashoba Brook (continued)								
AA	21,215	30	160	5.3	143.1	143.1	143.9	0.8
AB	21,265	40	230	3.5	143.6	143.6	144.3	0.7
AC	22,800	220	810	1.0	145.0	145.0	145.4	0.4
AD	23,780	80	200	4.1	145.8	145.8	146.0	0.2
AE	23,900	50	290	2.8	146.4	146.4	146.6	0.2
AF	24,430	190	440	1.9	147.1	147.1	147.3	0.2
AG	24,560	190	310	2.6	147.4	147.4	147.6	0.2
AH	24,614	210	1,210	0.7	152.5	152.5	152.7	0.2
AI	25,680	200	870	0.9	152.6	152.6	152.9	0.3
AJ	26,880	100	140	5.7	153.2	153.2	153.3	0.1
AK	28,080	90	340	2.4	157.2	157.2	157.7	0.5
AL	28,130	90	370	2.2	157.4	157.4	158.1	0.7
AM	28,620	20/20[2]	210	3.9	157.9	157.9	158.6	0.7
AN	28,930	310	1,100	0.7	167.2	167.2	167.2	0.0
AO	30,540	40	180	4.6	167.3	167.3	167.3	0.0
AP	30,660	10	90	9.3	168.7	168.7	168.7	0.0
AQ	30,690	40	270	3.0	170.3	170.3	170.4	0.1
AR	32,260	190	1,060	0.8	170.7	170.7	170.8	0.1
AS	32,385	220	1,250	0.6	171.7	171.7	171.8	0.1
AT	32,400	700	3,478	0.2	171.7	171.7	172.7	1.0
AU	33,090	230	1,513	0.6	171.7	171.7	172.7	1.0
AV	33,210	700	2,586	0.3	173.2	173.2	173.9	0.7
AW	34,060	700	3,269	0.2	173.2	173.2	173.9	0.7
AX	35,210	670	2,281	0.3	173.3	173.3	174.0	0.7
AY	35,970	48	91	7.7	174.6	174.6	174.6	0.0
AZ	36,110	20	184	3.8	180.7	180.7	180.7	0.0
BA	36,650	50	497	1.4	180.7	180.7	181.2	0.5
BB	37,200	25	218	3.1	180.7	180.7	181.5	0.8

[1] Feet above confluence with Assabet River

[2] Split flow area – right width looking downstream/left width looking downstream

TABLE 1

FEDERAL EMERGENCY MANAGEMENT AGENCY

MIDDLESEX COUNTY, MA
(ALL JURISDICTIONS)

FLOODWAY DATA

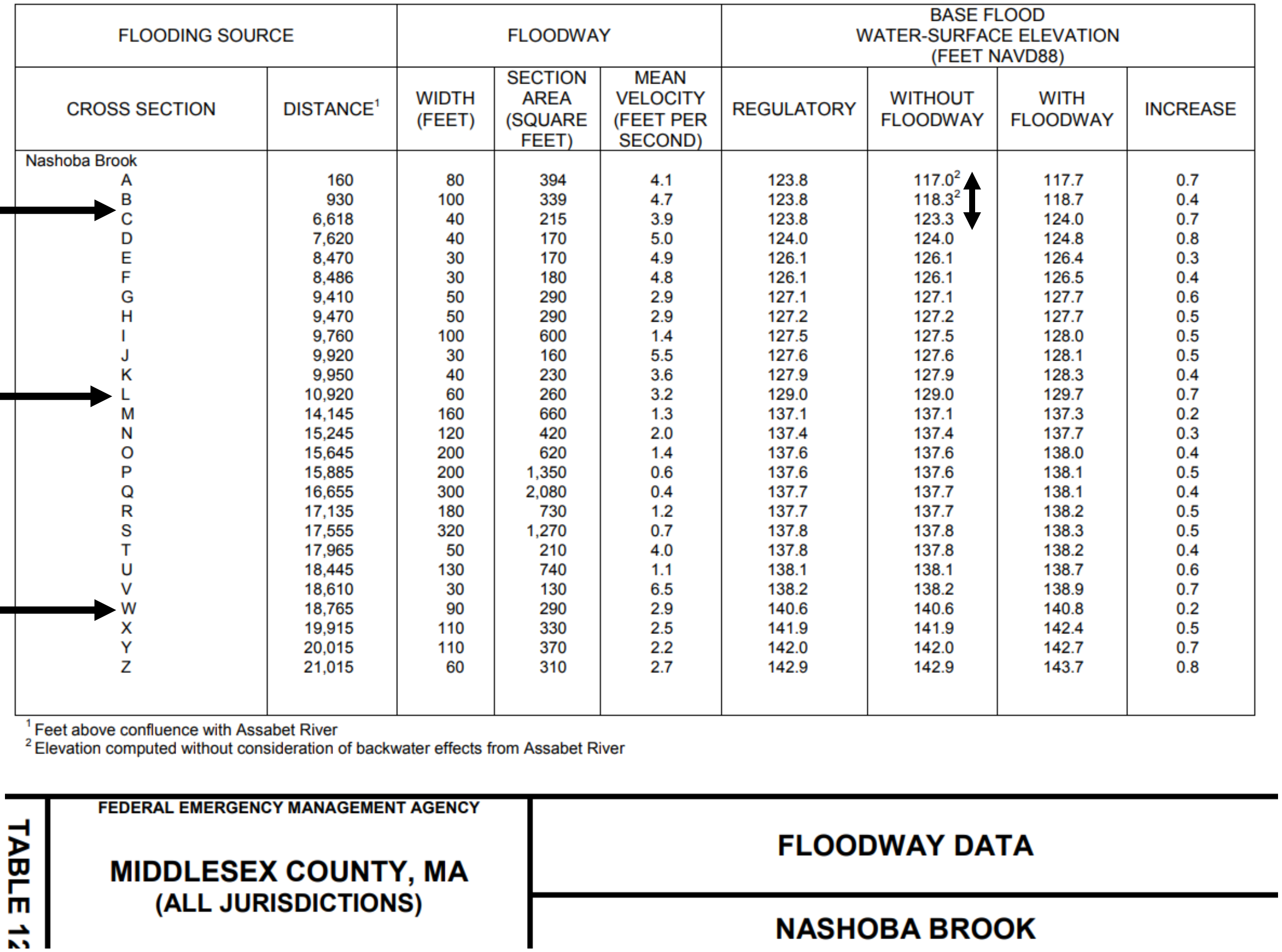
NASHOBA BROOK

FEMA Flood Discharge: Nashoba Brook

Warner’s Pond Dam

Concord Road Dam:
Icehouse Pond

Brook Street Dam



FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION (FEET NAVD88)			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Nashoba Brook								
A	160	80	394	4.1	123.8	117.0[2]	117.7	0.7
B	930	100	339	4.7	123.8	118.3[2]	118.7	0.4
C	6,618	40	215	3.9	123.8	123.3	124.0	0.7
D	7,620	40	170	5.0	124.0	124.0	124.8	0.8
E	8,470	30	170	4.9	126.1	126.1	126.4	0.3
F	8,486	30	180	4.8	126.1	126.1	126.5	0.4
G	9,410	50	290	2.9	127.1	127.1	127.7	0.6
H	9,470	50	290	2.9	127.2	127.2	127.7	0.5
I	9,760	100	600	1.4	127.5	127.5	128.0	0.5
J	9,920	30	160	5.5	127.6	127.6	128.1	0.5
K	9,950	40	230	3.6	127.9	127.9	128.3	0.4
L	10,920	60	260	3.2	129.0	129.0	129.7	0.7
M	14,145	160	660	1.3	137.1	137.1	137.3	0.2
N	15,245	120	420	2.0	137.4	137.4	137.7	0.3
O	15,645	200	620	1.4	137.6	137.6	138.0	0.4
P	15,885	200	1,350	0.6	137.6	137.6	138.1	0.5
Q	16,655	300	2,080	0.4	137.7	137.7	138.1	0.4
R	17,135	180	730	1.2	137.7	137.7	138.2	0.5
S	17,555	320	1,270	0.7	137.8	137.8	138.3	0.5
T	17,965	50	210	4.0	137.8	137.8	138.2	0.4
U	18,445	130	740	1.1	138.1	138.1	138.7	0.6
V	18,610	30	130	6.5	138.2	138.2	138.9	0.7
W	18,765	90	290	2.9	140.6	140.6	140.8	0.2
X	19,915	110	330	2.5	141.9	141.9	142.4	0.5
Y	20,015	110	370	2.2	142.0	142.0	142.7	0.7
Z	21,015	60	310	2.7	142.9	142.9	143.7	0.8

[1] Feet above confluence with Assabet River
[2] Elevation computed without consideration of backwater effects from Assabet River

TABLE 1

FEDERAL EMERGENCY MANAGEMENT AGENCY

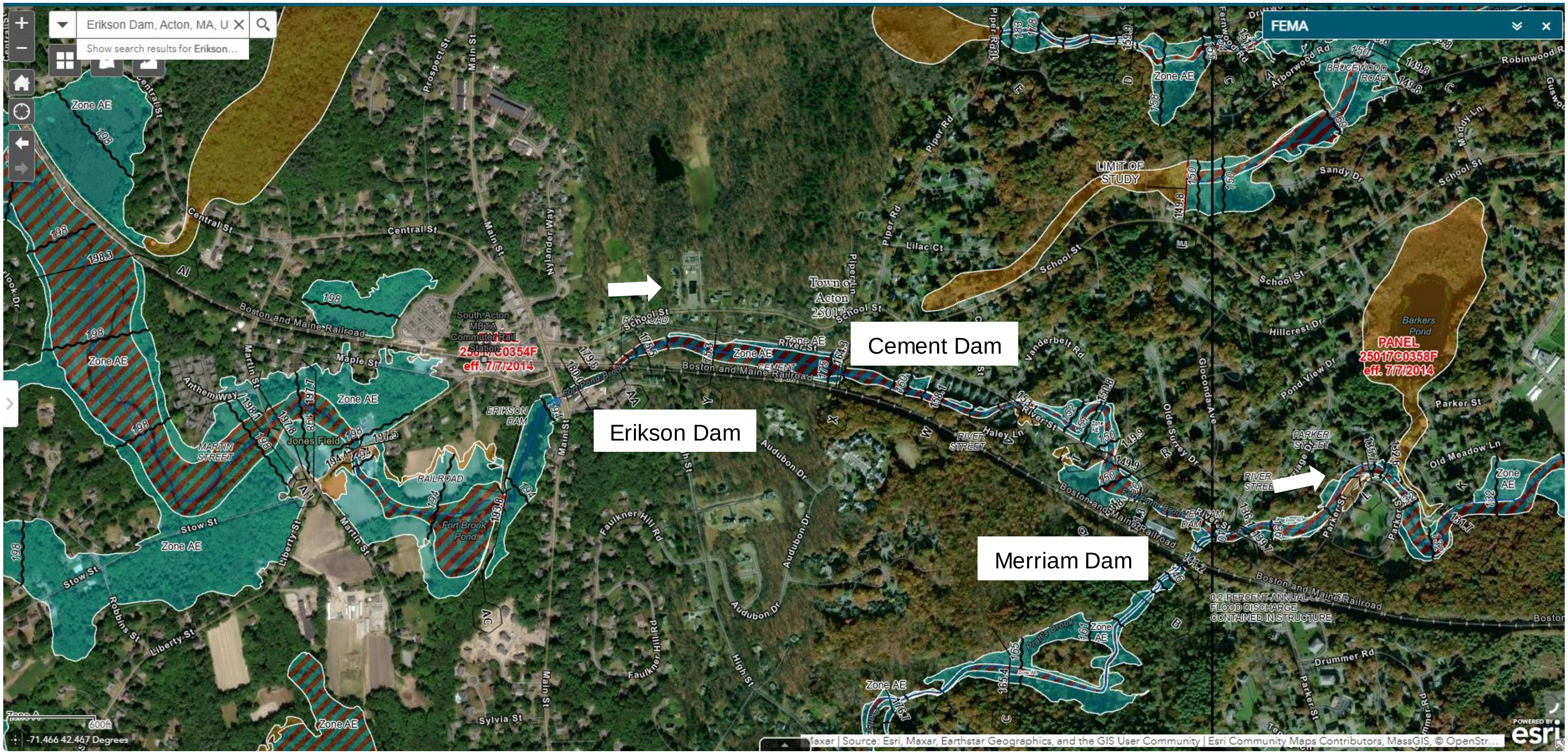
MIDDLESEX COUNTY, MA
(ALL JURISDICTIONS)

FLOODWAY DATA

NASHOBA BROOK

Fort Pond Brook Floodplain

Existing dams affect flooding along Nashoba Brook. The white arrows are added to the FEMA map to indicate river flow direction.

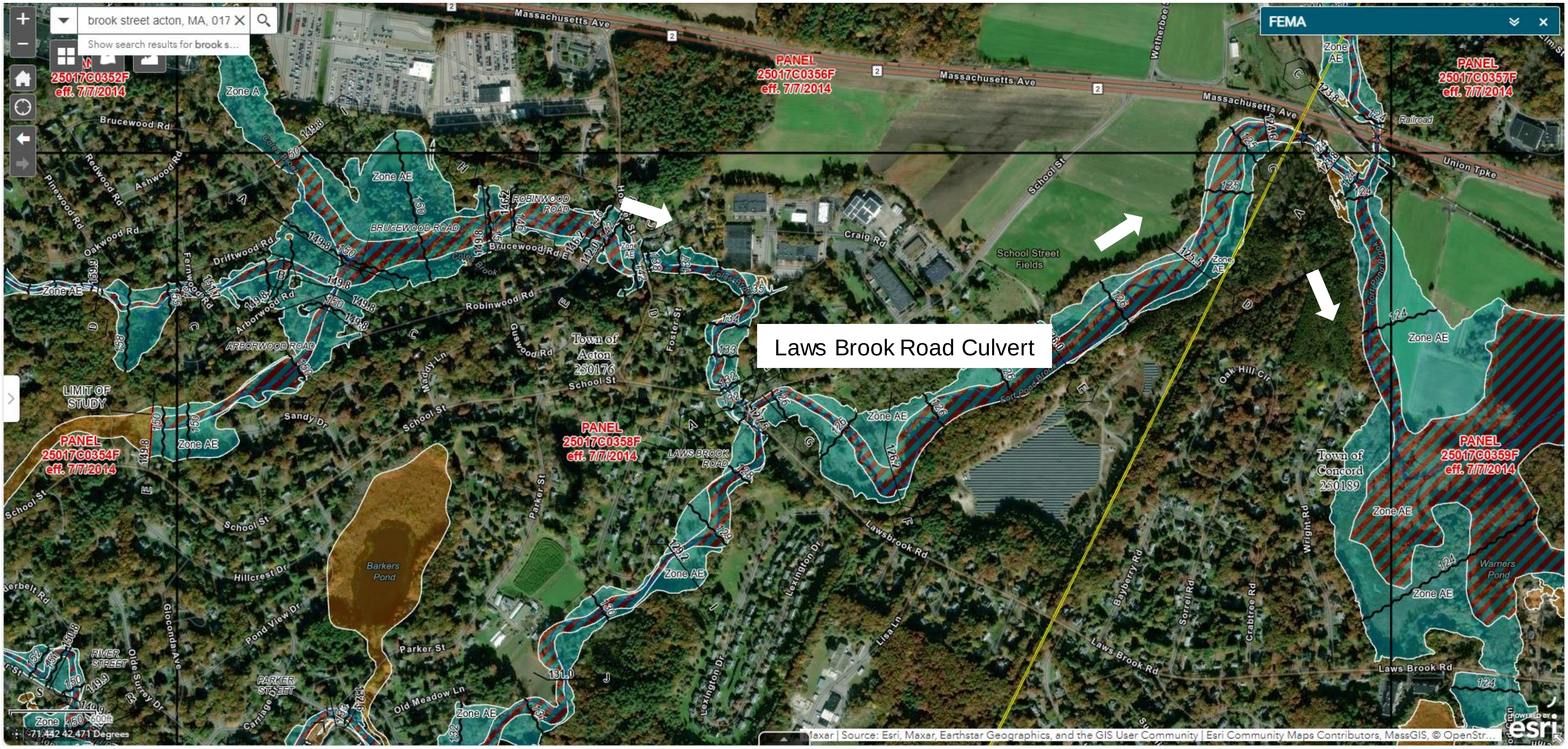


Fort Pond Brook Floodplain

Existing dams affect flooding along Nashoba Brook. The white arrows are added to the FEMA map to indicate river flow direction.

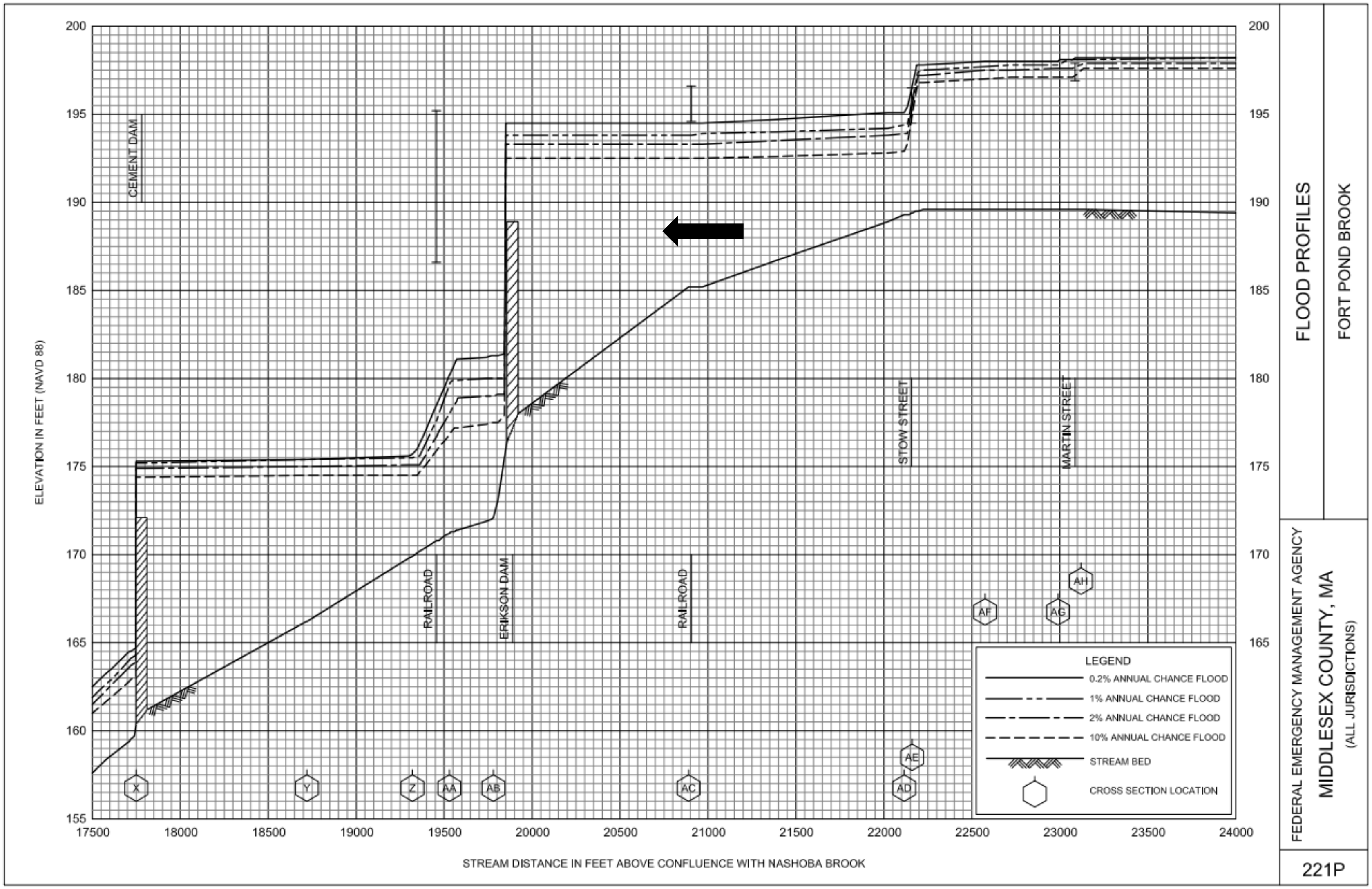
Fort Pond Brook Floodplain

Existing dams affect flooding along Nashoba Brook. The white arrows are added to the FEMA map to indicate river flow direction.


Laws Brook Road Culvert

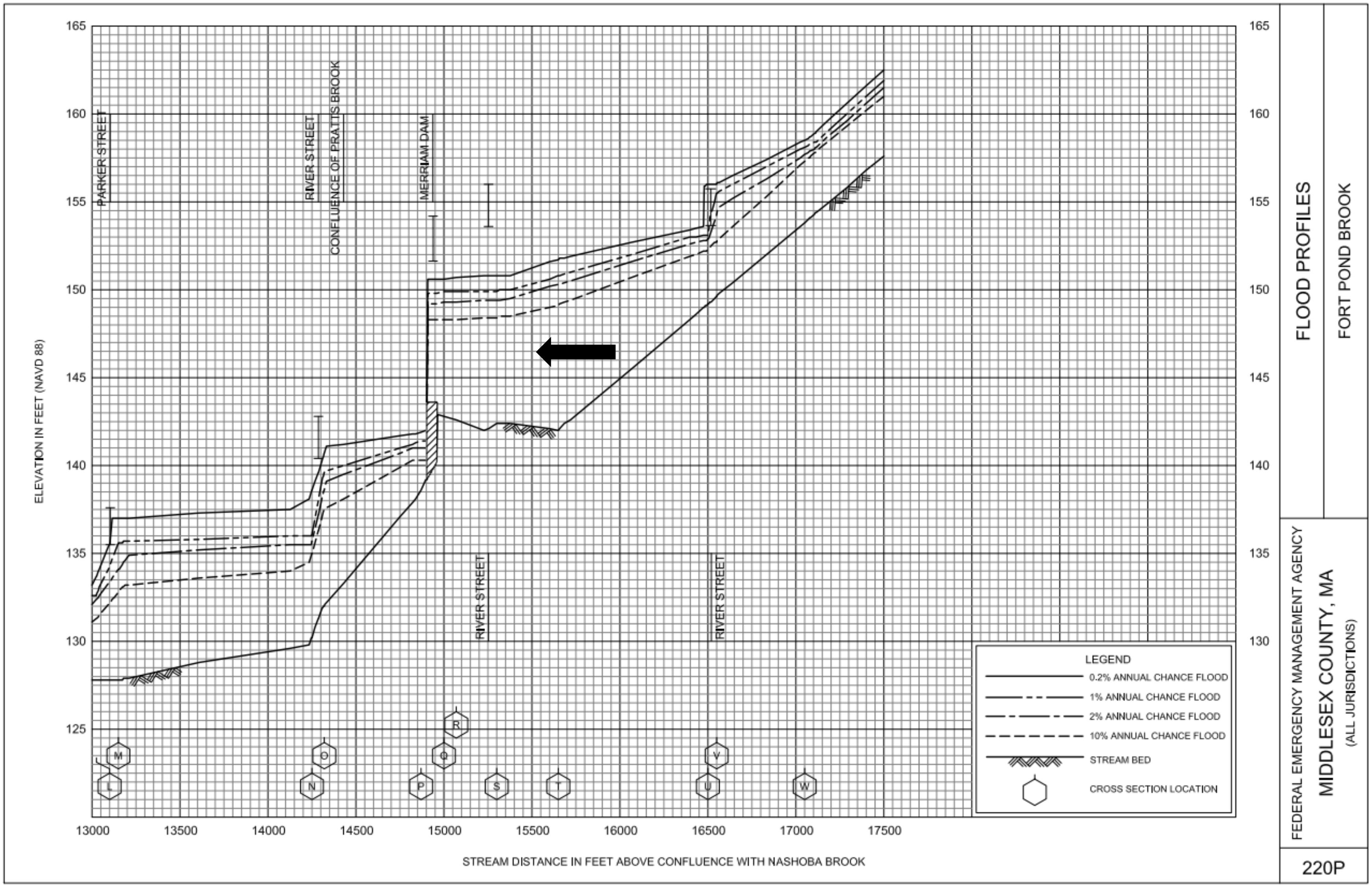
FEMA Flood Profiles: Fort Pond Brook

The stream distance indicates distance from the confluence of Nashoba Brook with Nashoba Brook. Arrows have been added to show flow direction.



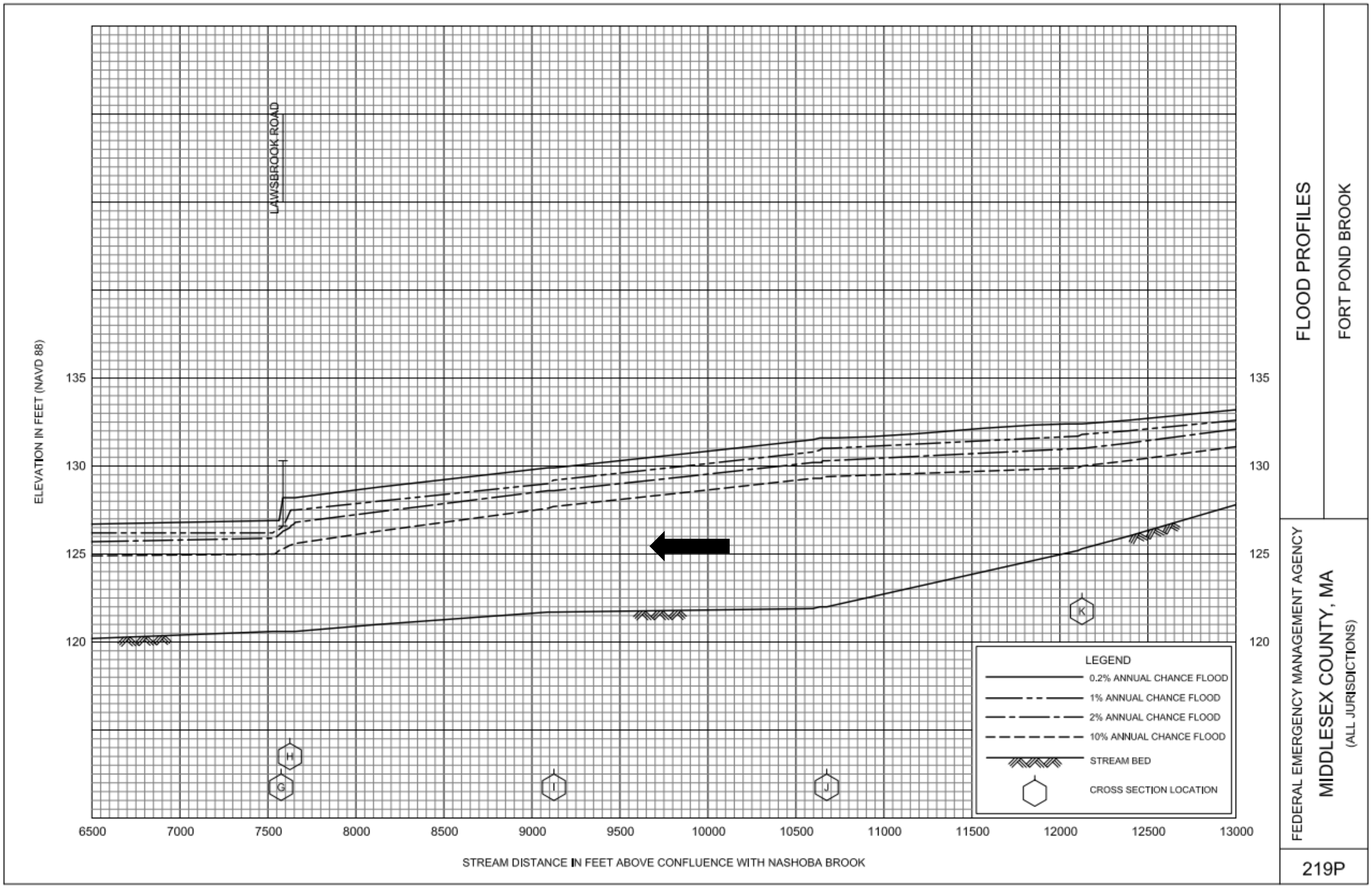
FEMA Flood Profiles: Fort Pond Brook

The stream distance indicates distance from the confluence of Nashoba Brook with Nashoba Brook. Arrows have been added to show flow direction.



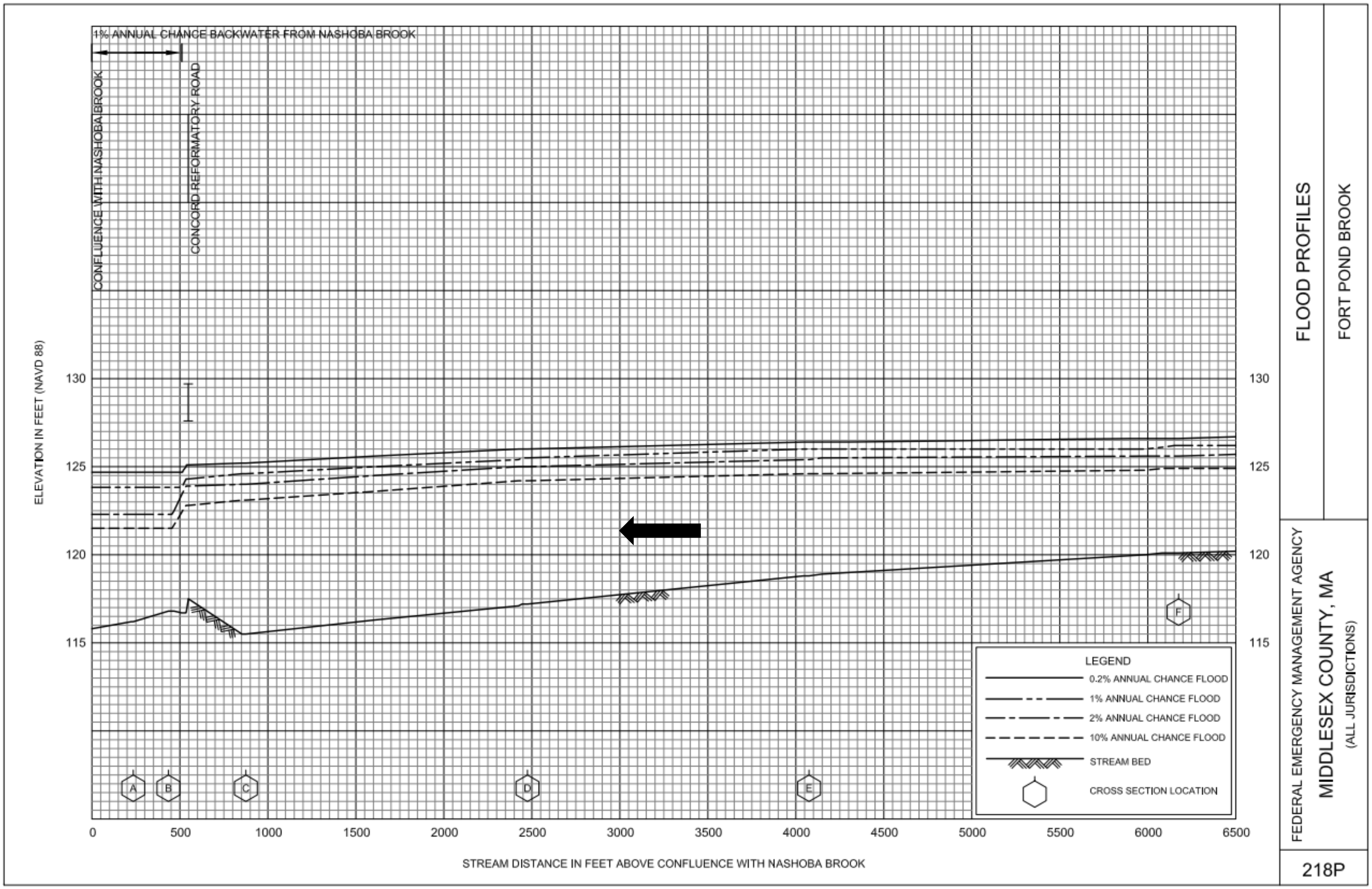
FEMA Flood Profiles: Fort Pond Brook

The stream distance indicates distance from the confluence of Nashoba Brook with Nashoba Brook. Arrows have been added to show flow direction.



FEMA Flood Profiles: Fort Pond Brook

The stream distance indicates distance from the confluence of Nashoba Brook with Nashoba Brook. Arrows have been added to show flow direction.



FEMA Flood Discharge: Fort Pond Brook and Nashoba Brook

At confluence with Nashoba Brook

At confluence with Fort Pond Brook

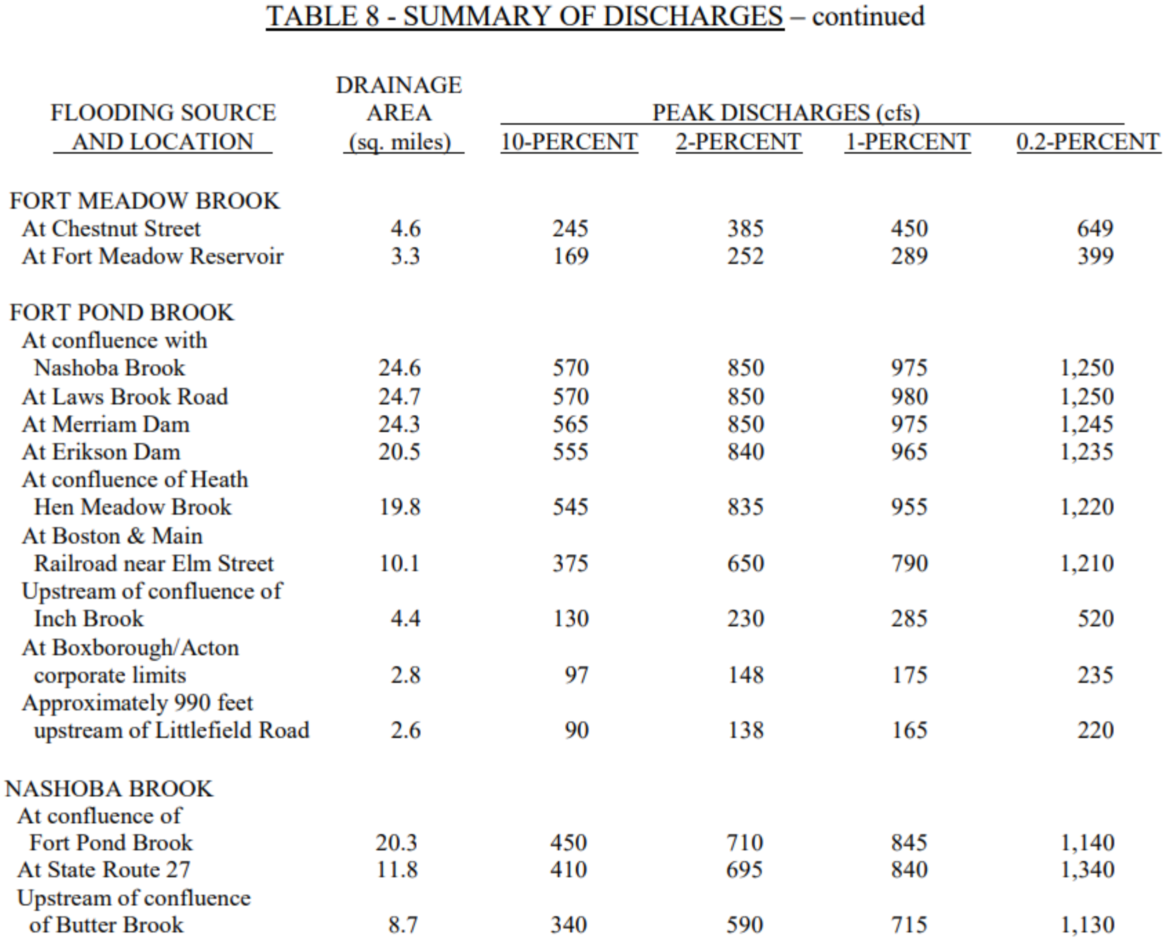


TABLE 8 - SUMMARY OF DISCHARGES – continued

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) 10-PERCENT	2-PERCENT	1-PERCENT	0.2-PERCENT
FORT MEADOW BROOK					
At Chestnut Street	4.6	245	385	450	649
At Fort Meadow Reservoir	3.3	169	252	289	399
FORT POND BROOK					
At confluence with Nashoba Brook	24.6	570	850	975	1,250
At Laws Brook Road	24.7	570	850	980	1,250
At Merriam Dam	24.3	565	850	975	1,245
At Erikson Dam	20.5	555	840	965	1,235
At confluence of Heath Hen Meadow Brook	19.8	545	835	955	1,220
At Boston & Main Railroad near Elm Street	10.1	375	650	790	1,210
Upstream of confluence of Inch Brook	4.4	130	230	285	520
At Boxborough/Acton corporate limits	2.8	97	148	175	235
Approximately 990 feet upstream of Littlefield Road	2.6	90	138	165	220
NASHOBA BROOK					
At confluence of Fort Pond Brook	20.3	450	710	845	1,140
At State Route 27	11.8	410	695	840	1,340
Upstream of confluence of Butter Brook	8.7	340	590	715	1,130

This FEMA FIS table indicates that the 100-year combined peak discharge within Nashoba and Fort Pond Brooks discharging to Warner’s Pond is about is 1,820 cfs.

Climate Change Considerations

Precipitation intensity and frequency may increase in the future due to climate change. This increase will increase the flood hazard relative to that currently indicated. As shown below, the Commonwealth of Massachusetts recommend an assumption of precipitation increase for dams be considered for the 100-year and 50-year recurrence interval floods.

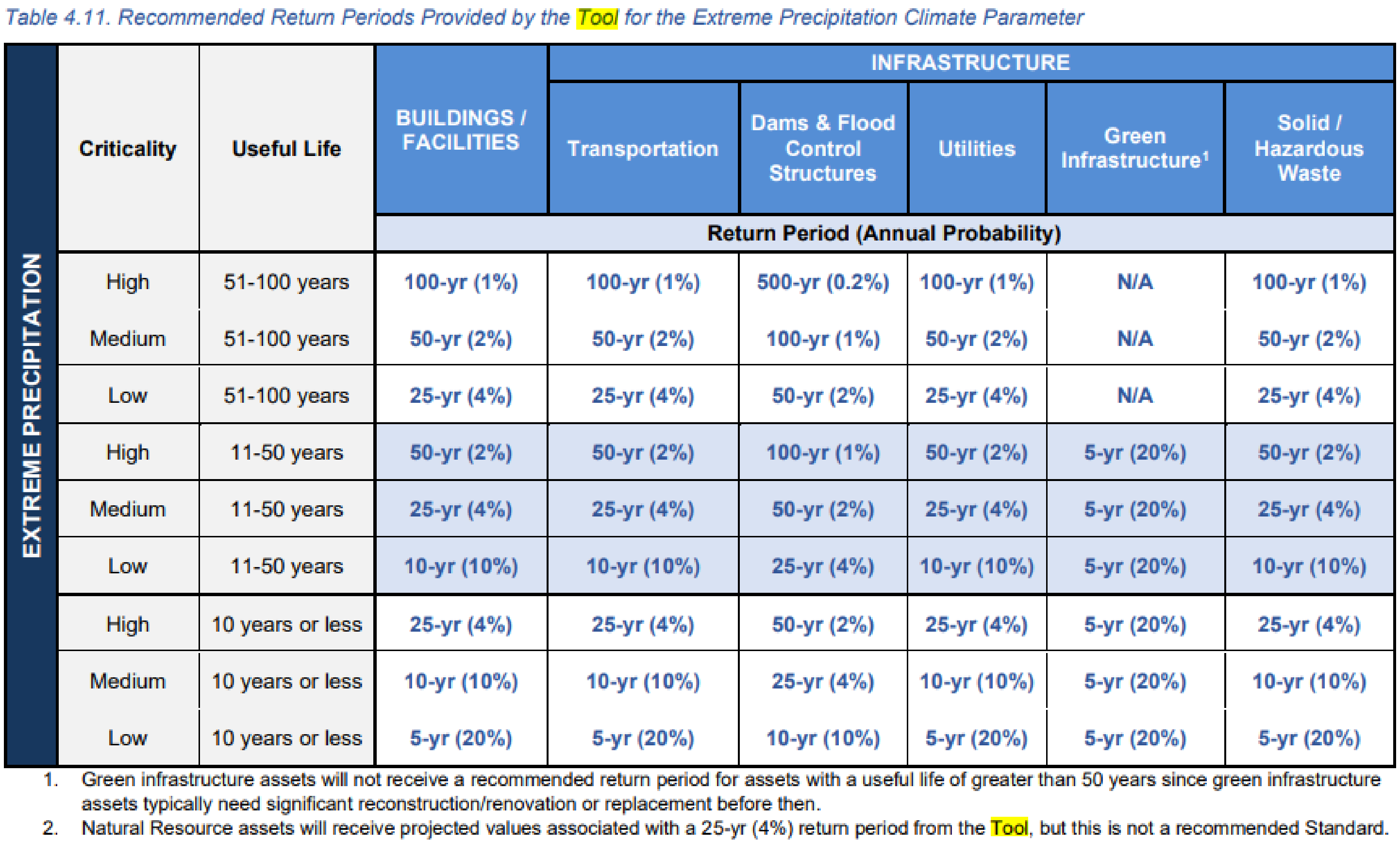


Table 4.11. Recommended Return Periods Provided by the Tool for the Extreme Precipitation Climate Parameter

	Criticality	Useful Life	BUILDINGS / FACILITIES	INFRASTRUCTURE				
				Transportation	Dams & Flood Control Structures	Utilities	Green Infrastructure[1]	Solid / Hazardous Waste
			Return Period (Annual Probability)					
EXTREME PRECIPITATION	High	51-100 years	100-yr (1%)	100-yr (1%)	500-yr (0.2%)	100-yr (1%)	N/A	100-yr (1%)
	Medium	51-100 years	50-yr (2%)	50-yr (2%)	100-yr (1%)	50-yr (2%)	N/A	50-yr (2%)
	Low	51-100 years	25-yr (4%)	25-yr (4%)	50-yr (2%)	25-yr (4%)	N/A	25-yr (4%)
	High	11-50 years	50-yr (2%)	50-yr (2%)	100-yr (1%)	50-yr (2%)	5-yr (20%)	50-yr (2%)
	Medium	11-50 years	25-yr (4%)	25-yr (4%)	50-yr (2%)	25-yr (4%)	5-yr (20%)	25-yr (4%)
	Low	11-50 years	10-yr (10%)	10-yr (10%)	25-yr (4%)	10-yr (10%)	5-yr (20%)	10-yr (10%)
	High	10 years or less	25-yr (4%)	25-yr (4%)	50-yr (2%)	25-yr (4%)	5-yr (20%)	25-yr (4%)
	Medium	10 years or less	10-yr (10%)	10-yr (10%)	25-yr (4%)	10-yr (10%)	5-yr (20%)	10-yr (10%)
	Low	10 years or less	5-yr (20%)	5-yr (20%)	10-yr (10%)	5-yr (20%)	5-yr (20%)	5-yr (20%)

1. Green infrastructure assets will not receive a recommended return period for assets with a useful life of greater than 50 years since green infrastructure assets typically need significant reconstruction/renovation or replacement before then.
2. Natural Resource assets will receive projected values associated with a 25-yr (4%) return period from the Tool, but this is not a recommended Standard.

[UserGuide_V1.2.pdf (eea-nescaum-dataservices-assets-prd.s3.amazonaws.com)]()

[ResilientMass Climate Hub (arcgis.com)]()

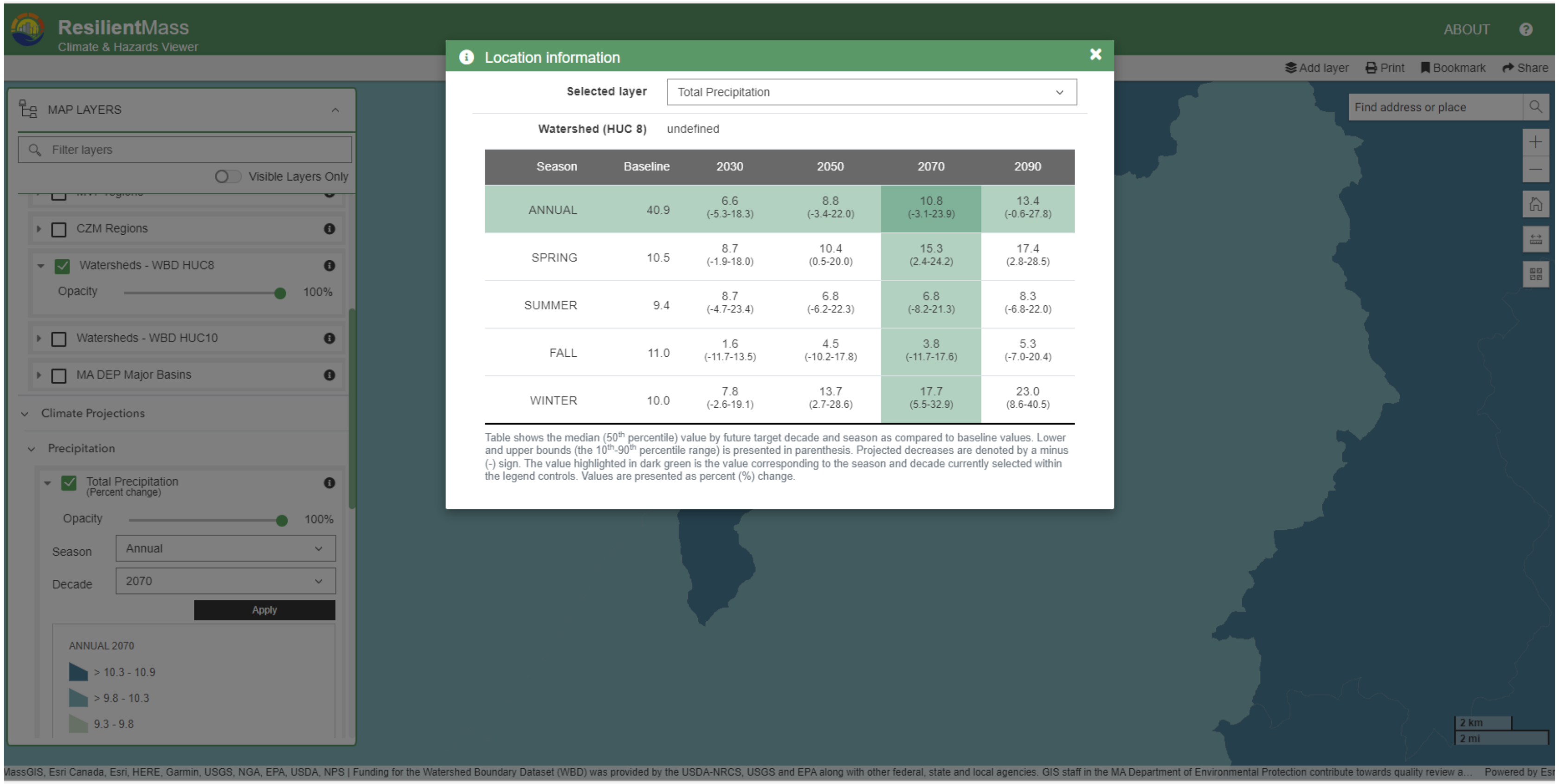
[V1.2_SECTION_4.pdf (eea-nescaum-dataservices-assets-prd.s3.amazonaws.com)]()

Climate Change Considerations

Led by the Executive Office of Energy and Environmental Affairs (EEA), the Massachusetts Climate and Hydrologic Risk Project (Phase 1) has developed new climate change projections for the Commonwealth. These new temperature and precipitation projections are downscaled for Massachusetts at the HUC8 watershed scale using Global Climate Models and a Stochastic Weather Generator and reflect a warming scenario linked to the Representation Concentration Pathway (RCP) 8.5, a comparatively high greenhouse gas emissions scenario.

The ResilientMass Climate & Hazards Viewer indicates 2070 total precipitation percentage change generally within the sub-watershed:

- Annual 10.8% (-3.1 to 23.9)
- Spring 15.3% (2.4 to 24.2)
- Summer 6.8% (-8.22 to 21.3)
- Fall 4.2% (-11.7 to 17.6)
- Winter 17.7 (5.5-32.9)



Opacity 100%

Season: Annual

Decade: 2070

Location information

Selected layer Total Precipitation

Watershed (HUC 8) undefined

Season	Baseline	2030	2050	2070	2090
ANNUAL	40.9	6.6 (-5.3-18.3)	8.8 (-3.4-22.0)	10.8 (-3.1-23.9)	13.4 (-0.6-27.8)
SPRING	10.5	8.7 (-1.9-18.0)	10.4 (0.5-20.0)	15.3 (2.4-24.2)	17.4 (2.8-28.5)
SUMMER	9.4	8.7 (-4.7-23.4)	6.8 (-6.2-22.3)	6.8 (-8.2-21.3)	8.3 (-6.8-22.0)
FALL	11.0	1.6 (-11.7-13.5)	4.5 (-10.2-17.8)	3.8 (-11.7-17.6)	5.3 (-7.0-20.4)
WINTER	10.0	7.8 (-2.6-19.1)	13.7 (2.7-28.6)	17.7 (5.5-32.9)	23.0 (8.6-40.5)

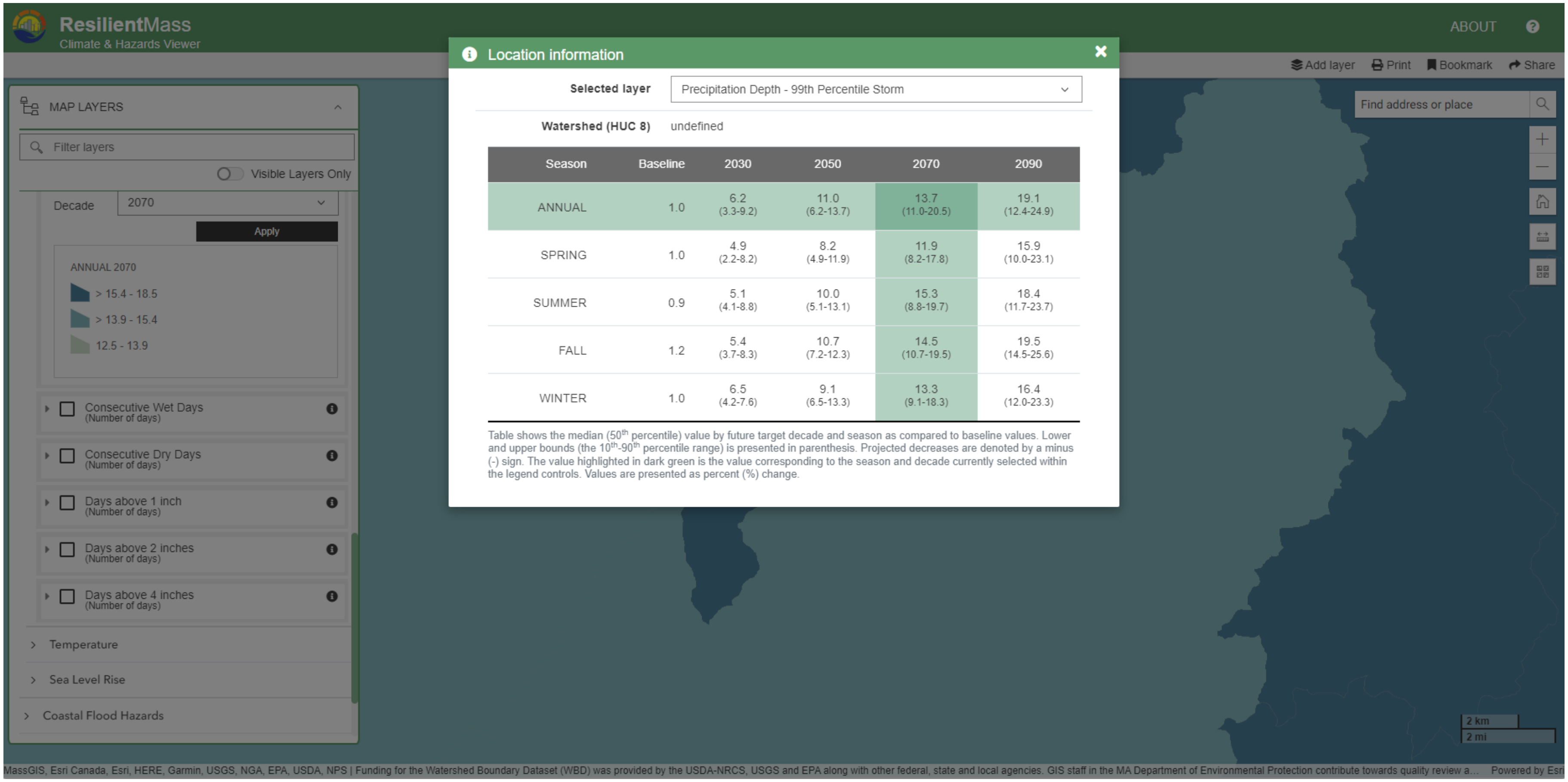
Table shows the median (50th percentile) value by future target decade and season as compared to baseline values. Lower and upper bounds (the 10th-90th percentile range) is presented in parenthesis. Projected decreases are denoted by a minus (-) sign. The value highlighted in dark green is the value corresponding to the season and decade currently selected within the legend controls. Values are presented as percent (%) change.

assGIS, Esri Canada, Esri, HERE, Garmin, USGS, NGA, EPA, USDA, NPS | Funding for the Watershed Boundary Dataset (WBD) was provided by the USDA-NRCS, USGS and EPA along with other federal, state and local agencies. GIS staff in the MA Department of Environmental Protection contribute towards quality review a… Powered by Es

Climate Change Considerations

The ResilientMass Climate & Hazards Viewer indicates 2070 99th percentile storm precipitation depth percentage change generally within the sub watershed:

- Annual 13.7% (11.0 to 20.5)
- Spring 11.9% (8.2 to 17.8)
- Summer 6.8% (8.8 to 19.7)
- Fall 14.5% (10.7 to 19.5)
- Winter 13.3 (9.1 to 18.3)



Location information

Selected layer Precipitation Depth - 99th Percentile Storm

Watershed (HUC 8) undefined

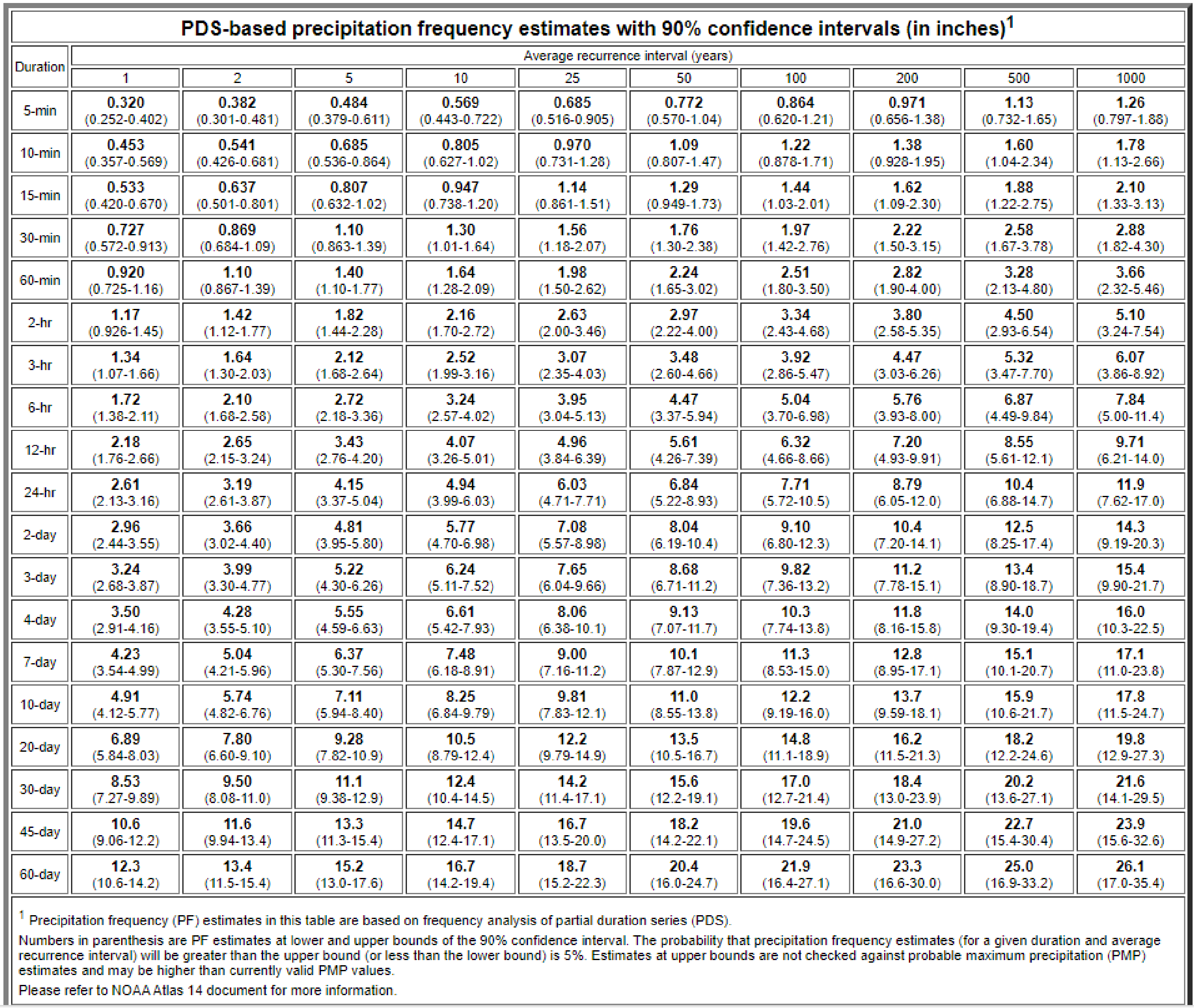
Season	Baseline	2030	2050	2070	2090
ANNUAL	1.0	6.2 (3.3-9.2)	11.0 (6.2-13.7)	13.7 (11.0-20.5)	19.1 (12.4-24.9)
SPRING	1.0	4.9 (2.2-8.2)	8.2 (4.9-11.9)	11.9 (8.2-17.8)	15.9 (10.0-23.1)
SUMMER	0.9	5.1 (4.1-8.8)	10.0 (5.1-13.1)	15.3 (8.8-19.7)	18.4 (11.7-23.7)
FALL	1.2	5.4 (3.7-8.3)	10.7 (7.2-12.3)	14.5 (10.7-19.5)	19.5 (14.5-25.6)
WINTER	1.0	6.5 (4.2-7.6)	9.1 (6.5-13.3)	13.3 (9.1-18.3)	16.4 (12.0-23.3)

Table shows the median (50th percentile) value by future target decade and season as compared to baseline values. Lower and upper bounds (the 10th-90th percentile range) is presented in parenthesis. Projected decreases are denoted by a minus (-) sign. The value highlighted in dark green is the value corresponding to the season and decade currently selected within the legend controls. Values are presented as percent (%) change.

MassGIS, Esri Canada, Esri, HERE, Garmin, USGS, NGA, EPA, USDA, NPS | Funding for the Watershed Boundary Dataset (WBD) was provided by the USDA-NRCS, USGS and EPA along with other federal, state and local agencies. GIS staff in the MA Department of Environmental Protection contribute towards quality review a...

Climate Change Considerations

For comparison, the NOAA Atlas 14 indicates the predicted precipitation intensity (90th% precipitation depth) upgradient from West Concord (Westford). The statistical range (upper and lower bounds represent the 5% and 95% statistical bounds:



PDS-based precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	**0.320** (0.252-0.402)	**0.382** (0.301-0.481)	**0.484** (0.379-0.611)	**0.569** (0.443-0.722)	**0.685** (0.516-0.905)	**0.772** (0.570-1.04)	**0.864** (0.620-1.21)	**0.971** (0.656-1.38)	**1.13** (0.732-1.65)	**1.26** (0.797-1.88)
10-min	**0.453** (0.357-0.569)	**0.541** (0.426-0.681)	**0.685** (0.536-0.864)	**0.805** (0.627-1.02)	**0.970** (0.731-1.28)	**1.09** (0.807-1.47)	**1.22** (0.878-1.71)	**1.38** (0.928-1.95)	**1.60** (1.04-2.34)	**1.78** (1.13-2.66)
15-min	**0.533** (0.420-0.670)	**0.637** (0.501-0.801)	**0.807** (0.632-1.02)	**0.947** (0.738-1.20)	**1.14** (0.861-1.51)	**1.29** (0.949-1.73)	**1.44** (1.03-2.01)	**1.62** (1.09-2.30)	**1.88** (1.22-2.75)	**2.10** (1.33-3.13)
30-min	**0.727** (0.572-0.913)	**0.869** (0.684-1.09)	**1.10** (0.863-1.39)	**1.30** (1.01-1.64)	**1.56** (1.18-2.07)	**1.76** (1.30-2.38)	**1.97** (1.42-2.76)	**2.22** (1.50-3.15)	**2.58** (1.67-3.78)	**2.88** (1.82-4.30)
60-min	**0.920** (0.725-1.16)	**1.10** (0.867-1.39)	**1.40** (1.10-1.77)	**1.64** (1.28-2.09)	**1.98** (1.50-2.62)	**2.24** (1.65-3.02)	**2.51** (1.80-3.50)	**2.82** (1.90-4.00)	**3.28** (2.13-4.80)	**3.66** (2.32-5.46)
2-hr	**1.17** (0.926-1.45)	**1.42** (1.12-1.77)	**1.82** (1.44-2.28)	**2.16** (1.70-2.72)	**2.63** (2.00-3.46)	**2.97** (2.22-4.00)	**3.34** (2.43-4.68)	**3.80** (2.58-5.35)	**4.50** (2.93-6.54)	**5.10** (3.24-7.54)
3-hr	**1.34** (1.07-1.66)	**1.64** (1.30-2.03)	**2.12** (1.68-2.64)	**2.52** (1.99-3.16)	**3.07** (2.35-4.03)	**3.48** (2.60-4.66)	**3.92** (2.86-5.47)	**4.47** (3.03-6.26)	**5.32** (3.47-7.70)	**6.07** (3.86-8.92)
6-hr	**1.72** (1.38-2.11)	**2.10** (1.68-2.58)	**2.72** (2.18-3.36)	**3.24** (2.57-4.02)	**3.95** (3.04-5.13)	**4.47** (3.37-5.94)	**5.04** (3.70-6.98)	**5.76** (3.93-8.00)	**6.87** (4.49-9.84)	**7.84** (5.00-11.4)
12-hr	**2.18** (1.76-2.66)	**2.65** (2.15-3.24)	**3.43** (2.76-4.20)	**4.07** (3.26-5.01)	**4.96** (3.84-6.39)	**5.61** (4.26-7.39)	**6.32** (4.66-8.66)	**7.20** (4.93-9.91)	**8.55** (5.61-12.1)	**9.71** (6.21-14.0)
24-hr	**2.61** (2.13-3.16)	**3.19** (2.61-3.87)	**4.15** (3.37-5.04)	**4.94** (3.99-6.03)	**6.03** (4.71-7.71)	**6.84** (5.22-8.93)	**7.71** (5.72-10.5)	**8.79** (6.05-12.0)	**10.4** (6.88-14.7)	**11.9** (7.62-17.0)
2-day	**2.96** (2.44-3.55)	**3.66** (3.02-4.40)	**4.81** (3.95-5.80)	**5.77** (4.70-6.98)	**7.08** (5.57-8.98)	**8.04** (6.19-10.4)	**9.10** (6.80-12.3)	**10.4** (7.20-14.1)	**12.5** (8.25-17.4)	**14.3** (9.19-20.3)
3-day	**3.24** (2.68-3.87)	**3.99** (3.30-4.77)	**5.22** (4.30-6.26)	**6.24** (5.11-7.52)	**7.65** (6.04-9.66)	**8.68** (6.71-11.2)	**9.82** (7.36-13.2)	**11.2** (7.78-15.1)	**13.4** (8.90-18.7)	**15.4** (9.90-21.7)
4-day	**3.50** (2.91-4.16)	**4.28** (3.55-5.10)	**5.55** (4.59-6.63)	**6.61** (5.42-7.93)	**8.06** (6.38-10.1)	**9.13** (7.07-11.7)	**10.3** (7.74-13.8)	**11.8** (8.16-15.8)	**14.0** (9.30-19.4)	**16.0** (10.3-22.5)
7-day	**4.23** (3.54-4.99)	**5.04** (4.21-5.96)	**6.37** (5.30-7.56)	**7.48** (6.18-8.91)	**9.00** (7.16-11.2)	**10.1** (7.87-12.9)	**11.3** (8.53-15.0)	**12.8** (8.95-17.1)	**15.1** (10.1-20.7)	**17.1** (11.0-23.8)
10-day	**4.91** (4.12-5.77)	**5.74** (4.82-6.76)	**7.11** (5.94-8.40)	**8.25** (6.84-9.79)	**9.81** (7.83-12.1)	**11.0** (8.55-13.8)	**12.2** (9.19-16.0)	**13.7** (9.59-18.1)	**15.9** (10.6-21.7)	**17.8** (11.5-24.7)
20-day	**6.89** (5.84-8.03)	**7.80** (6.60-9.10)	**9.28** (7.82-10.9)	**10.5** (8.79-12.4)	**12.2** (9.79-14.9)	**13.5** (10.5-16.7)	**14.8** (11.1-18.9)	**16.2** (11.5-21.3)	**18.2** (12.2-24.6)	**19.8** (12.9-27.3)
30-day	**8.53** (7.27-9.89)	**9.50** (8.08-11.0)	**11.1** (9.38-12.9)	**12.4** (10.4-14.5)	**14.2** (11.4-17.1)	**15.6** (12.2-19.1)	**17.0** (12.7-21.4)	**18.4** (13.0-23.9)	**20.2** (13.6-27.1)	**21.6** (14.1-29.5)
45-day	**10.6** (9.06-12.2)	**11.6** (9.94-13.4)	**13.3** (11.3-15.4)	**14.7** (12.4-17.1)	**16.7** (13.5-20.0)	**18.2** (14.2-22.1)	**19.6** (14.7-24.5)	**21.0** (14.9-27.2)	**22.7** (15.4-30.4)	**23.9** (15.6-32.6)
60-day	**12.3** (10.6-14.2)	**13.4** (11.5-15.4)	**15.2** (13.0-17.6)	**16.7** (14.2-19.4)	**18.7** (15.2-22.3)	**20.4** (16.0-24.7)	**21.9** (16.4-27.1)	**23.3** (16.6-30.0)	**25.0** (16.9-33.2)	**26.1** (17.0-35.4)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

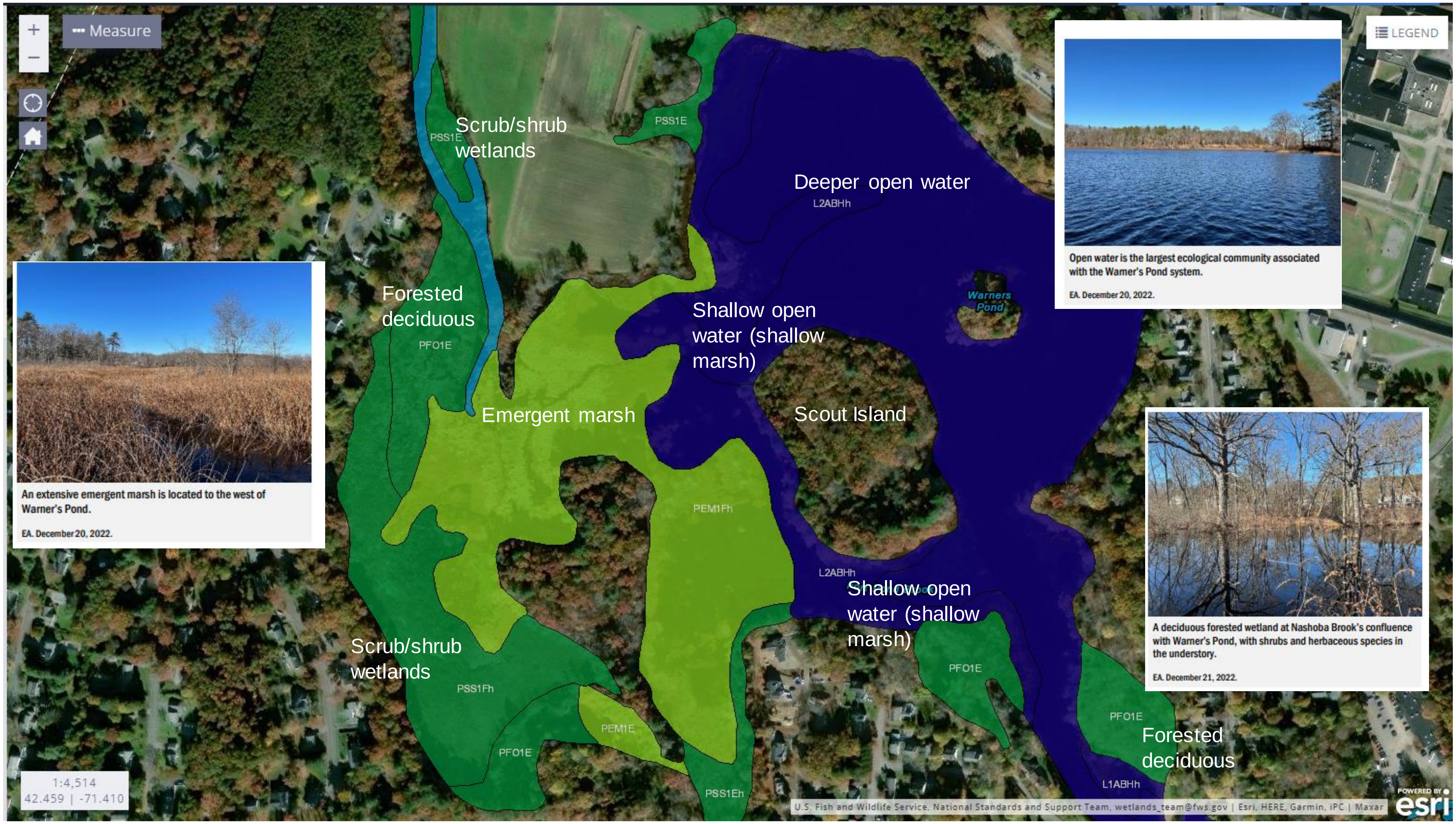
Attachment 5

Warner’s Pond Wetland System Fish and Wildlife

Habitat

Warner's Pond is an approximately 86-acre, ecologically complex, integrated area of wetlands, upland islands and open water, with about 42 acres of open water and approximately 43 acres of connected adjacent wetland habitat – all located within the heart of West Concord. Based on several Town studies, the Warner's Pond habitat can be divided into the following primary habitat types:

- A large emergent marsh at the inlet and western portions of the pond which, since the 1980, has advanced to southern portions of the pond and along the shoreline of Scout Island
- Shallow marsh north and west of Scout Island.
- Open water along the eastern side and in the north
- Areas of deciduous forested wetland
- Mixed upland forest habitat on the islands



An extensive emergent marsh is located to the west of Warner's Pond.

EA. December 20, 2022.

Open water is the largest ecological community associated with the Warner's Pond system.

EA. December 20, 2022.

A deciduous forested wetland at Nashoba Brook's confluence with Warner's Pond, with shrubs and herbaceous species in the understory.

EA. December 21, 2022.

Habitat

A “Wildlife and Habitat Assessment” was performed for the Town in 1999 by New England Environmental, Inc.. The assessment was updated in 2012 by EES (presented in the Watershed Management Report). The following summarizes the findings of these assessments. As indicate in the EES report, the locations and descriptions of ecological communities in 2012 were general the same as those observed in 1999. The most significant difference is that the scrub/shrub emergent wetlands (which formerly been limited to the tributary pond inlet and western shoreline) has expanded to other areas of the Pond. These emergent wetlands consist primarily of water willow (decodon verticillatus) now are present at the southern pond shoreline and areas bordering Scout Island.

Attachment 1 presents a summary of the aquatic plant species in Warner’s Pond and not repeated here.

Emergent Wetland Habitat:	This large wetland area is a result of sedimentation, shallow water and maintenance of the impounded water level (118.8 feet NAVD88). The area is dominated by Yellow Water Lilly, a native but invasive species that expands in areas of shallow pond fringes and accumulating sediment and organic debris. Small birds including Goldfinch, Chimney Swift, Least Flycatcher, Eastern Kingbird and Song Sparrow have been observed here. Water depths are minimal over much of this area.
Shallow Open Water/Shallow Marsh:	Areas of shallow water (1 to 3 feet) located to the north, west and south of Scout Island. These areas are dominated by Coontail, a native species and Fanwort, an exotic invasive species. In general these areas are used by a wide variety of wildlife, is a warm water fish habitat and possible feeding area for migratory waterfowl. Waterfowl and wading species have been observed in these areas including Wood Duck, Mallard Duck, Canada Goose, Great Blue Heron, Little Green Heron, Spotted Sandpiper, and Belted Kingfisher. Dragonflies and damselfies use the area, as do painted turtles and green frogs. Wood ducks, mallard ducks and Canada Goose have been observed nesting on the adjacent island. have been observed
Open Water:	The deeper open water habitat in the northeast portion of the pond, with depths greater than 6 feet, are used by Canada Goose, Mallard Duck, Belted Kingfisher and Double-Crested Cormorant. The cooler, deeper water allow fish to escape the warm shallow oxygen water of the marsh habitats.
Upland Habitat:	The upland areas of the islands are forested with deciduous trees and dens shrub understory, including Pin Oak, White Birch, Red maple, White Oak, Tupelo, Pitch Pine and White Pine. Shrubs include Sweet Pepperbush, Swamp Azalea, Alder, Highbush Blueberry, Black Huckleberry, Lowbush Blueberry, Sheep Laurel, European Buckthorn, Spreading Dogbane and Nannyberry. Wildlife includes beaver, chipmunks and squirrels. Birds observed include Downy Woodpecker, Morning Dove, Catbird, Yellow-shafted Flicker, Cedar Wax Wing and Black-capped Chickadee.

Warner-Pond-Wildlife-and-Habitat-Assessment-November-1999-PDF
(concordma.gov)

Habitat and Wildlife

Per ESS, 2012… *“Despite the presence of aquatic invasive species, Warner’s Pond provides habitat for birds, warm-water fisheries, reptiles, amphibians, invertebrates and aquatic mammals. The pond is fringed by the extensive scrub-shrub/emergent wetland system near the inlet and along the southern shoreline. These wetlands provide ideal habitat for a variety of waterbirds and likely offer an important feeding area for migratory waterfowl (NEE, 1999). The dense vegetation within the wetlands and shallow water provide foraging, cover, and nesting habitat for avian species.”*

Habitat and Wildlife

Reptiles and Amphibians

Reptiles and amphibians were not directly observed by ESS at Warner's Pond. However, NEE (1999) reported painted turtle (Chrysemys picta) and green frog (Rana clamitans) observations. Appropriate breeding, foraging, and overwintering habitat is readily available for both species and they are likely to be common at Warner's Pond.

Macronvertebrates

Aquatic macroinvertebrates, including the terrestrial stages of some species, were observed at Warner's Pond by NEE (1999) and ESS. In addition to several dragonfly and damselfly (Odonata) species, other aquatic worms, insects, crustaceans, snails, and native eastern elliptio freshwater mussels (Elliptio complanata) were observed and an important part of the pond community. No rare aquatic macroinvertebrate species were observed.

Mammals

Although not observed by ESS, the scrub-shrub/emergent and shallow marsh wetlands on the eastern and southern sides of the pond may also provide habitat for muskrats (Ondatra zibethicus), beavers (Castor canadensis), and mink (Mustela vison). Muskrats may forage to some extent on freshwater mussels in Warner's Pond, as evidenced by the presence of empty mussel valves along portions of the pond shoreline.

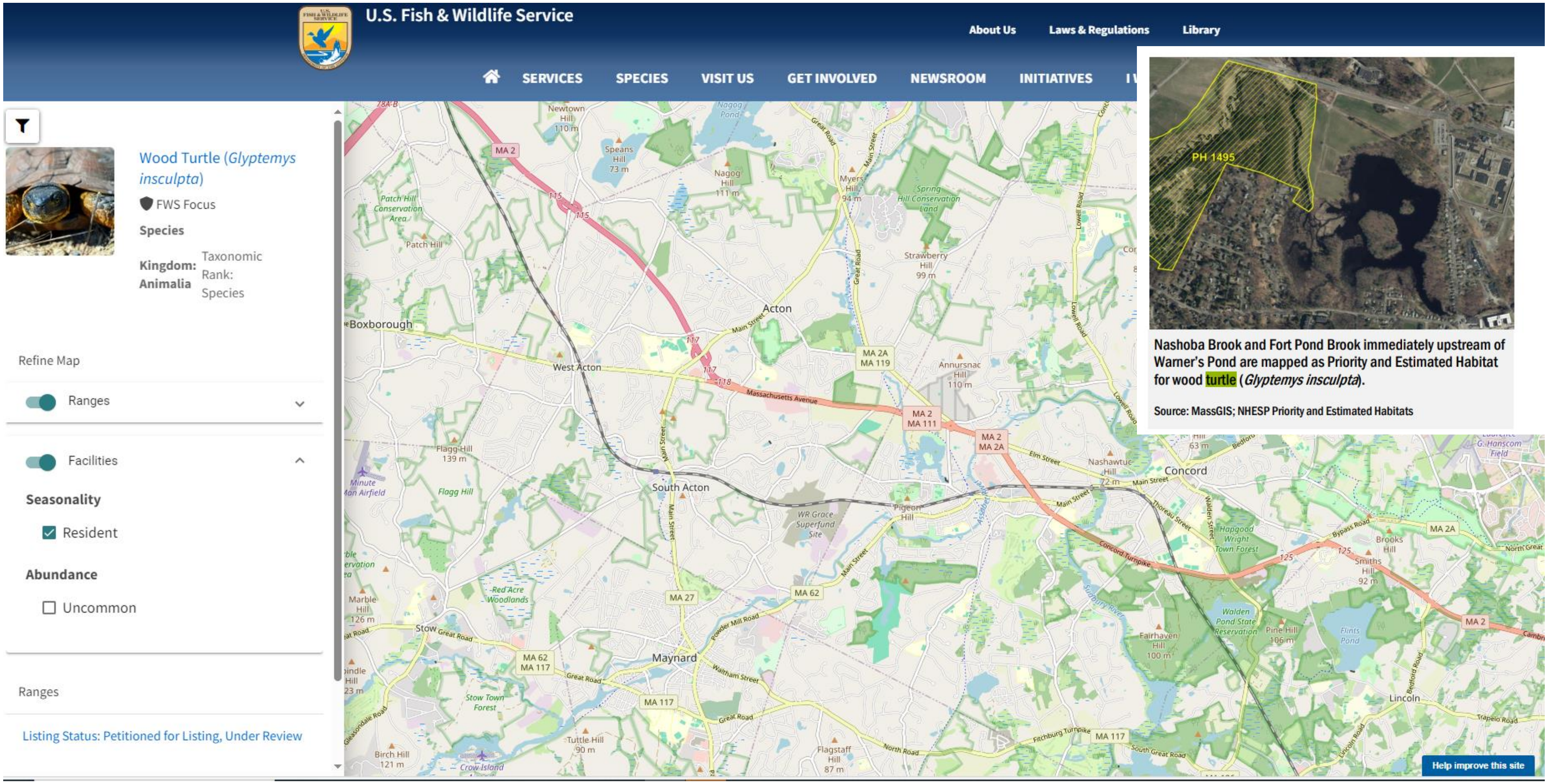
Warner's Pond provides valuable wildlife habitat through the diversity of wetland and open water habitats that occur within the pond. The mix of water depths, variety of water flow regimes, and extensive scrub-shrub/emergent wetland system that border the pond are ecological assets. However, the excessive sediment and nutrient load to the pond have fostered the aggressive expansion of aquatic and emergent plant species that will continue to encroach upon areas of open water habitat.

Habitat and Wildlife

Rare and Endangered Species

No rare and endangered flora and fauna have been documented within Warner’s Pond.

Warner’s Pond itself is not classified as Priority or Estimated Habitats, but Priority Habitats (PH 1495) and Estimated Habitats (EH 1043) are located along Nashoba Brook and Fort Pond Brook upstream of the pond. One state-listed species is associated with these habitat areas: wood turtle (Glyptemys insculpta), a Special Concern species in Massachusetts.



Wood Turtle (*Glyptemys insculpta*)

FWS Focus

Species

Kingdom: Animalia

Taxonomic Rank: Species

Seasonality

☑ Resident

Abundance

☐ Uncommon

Listing Status: Petitioned for Listing, Under Review

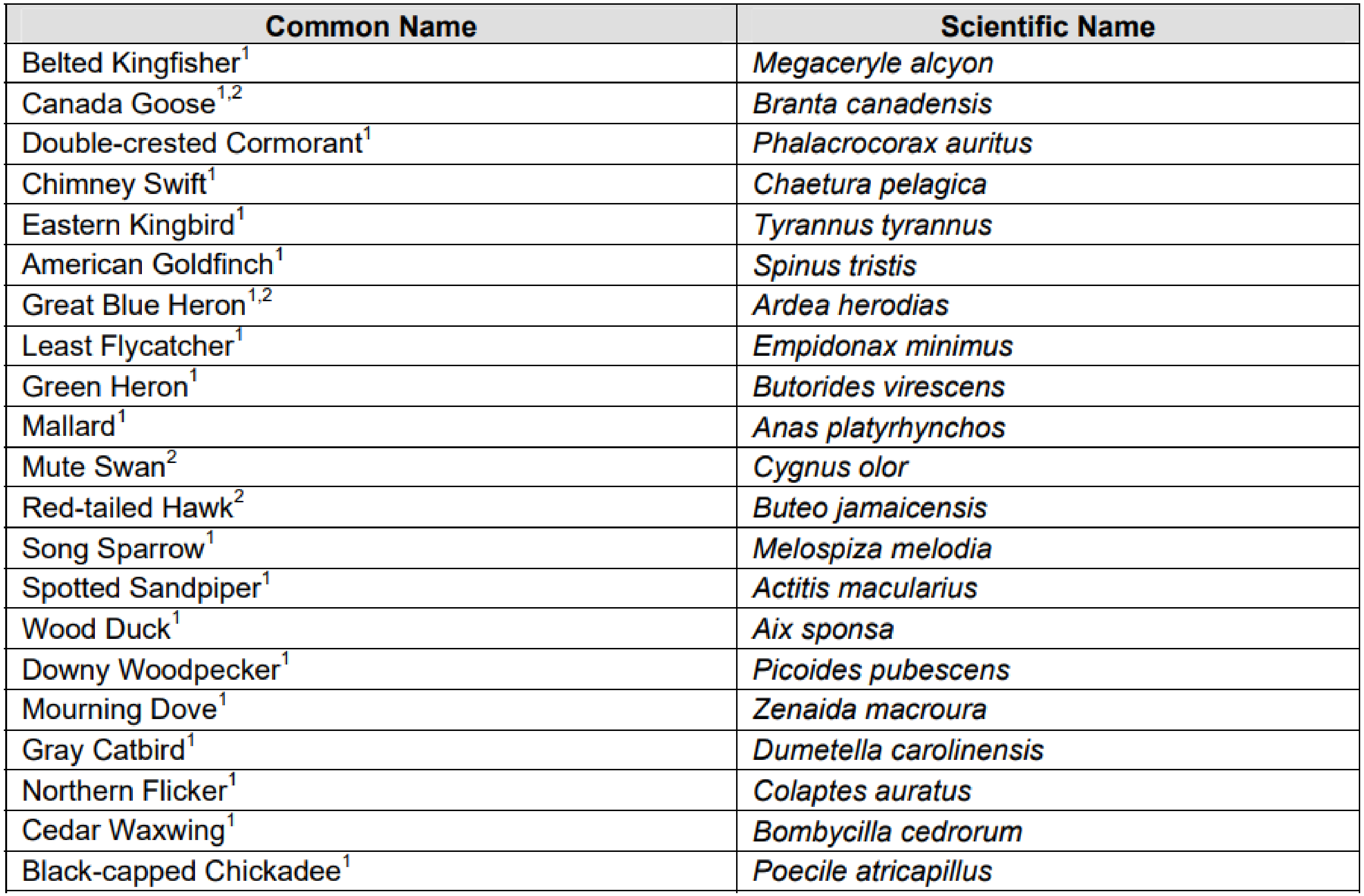
Nashoba Brook and Fort Pond Brook immediately upstream of Warner’s Pond are mapped as Priority and Estimated Habitat for wood turtle (*Glyptemys insculpta*).

Source: MassGIS; NHESP Priority and Estimated Habitats

Habitat and Wildlife

The Warner's Pond Wetlands System is a very popular birding area due to its rich and diverse habitat and is considered a "birding hotspot".

Table 4. List of Avian Species Observed using Warner's Pond and its Shoreline Habitats

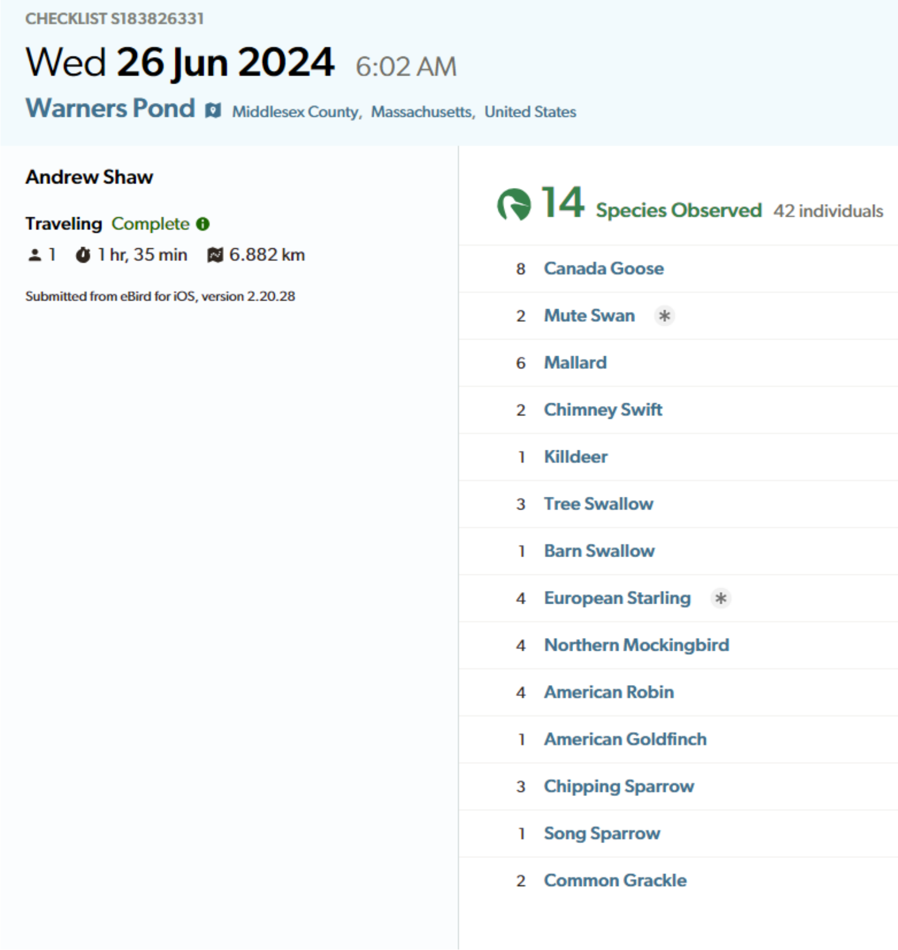


Common Name	Scientific Name
Belted Kingfisher[1]	*Megaceryle alcyon*
Canada Goose[1,2]	*Branta canadensis*
Double-crested Cormorant[1]	*Phalacrocorax auritus*
Chimney Swift[1]	*Chaetura pelagica*
Eastern Kingbird[1]	*Tyrannus tyrannus*
American Goldfinch[1]	*Spinus tristis*
Great Blue Heron[1,2]	*Ardea herodias*
Least Flycatcher[1]	*Empidonax minimus*
Green Heron[1]	*Butorides virescens*
Mallard[1]	*Anas platyrhynchos*
Mute Swan[2]	*Cygnus olor*
Red-tailed Hawk[2]	*Buteo jamaicensis*
Song Sparrow[1]	*Melospiza melodia*
Spotted Sandpiper[1]	*Actitis macularius*
Wood Duck[1]	*Aix sponsa*
Downy Woodpecker[1]	*Picoides pubescens*
Mourning Dove[1]	*Zenaida macroura*
Gray Catbird[1]	*Dumetella carolinensis*
Northern Flicker[1]	*Colaptes auratus*
Cedar Waxwing[1]	*Bombycilla cedrorum*
Black-capped Chickadee[1]	*Poecile atricapillus*

Source: 1. NEE, April to August 1999; 2. ESS, September 2012

Habitat and Wildlife

Some recent siting (from eBird)…



CHECKLIST S183826331

Wed **26 Jun 2024** 6:02 AM

Warners Pond Middlesex County, Massachusetts, United States

Andrew Shaw

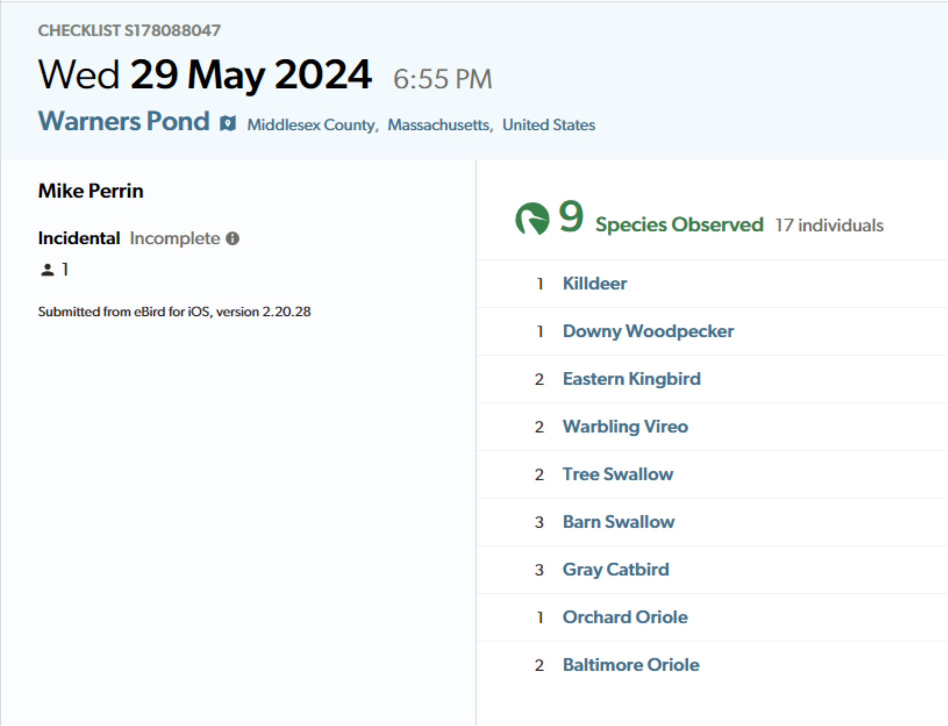
Traveling Complete

1 1 hr, 35 min 6.882 km

Submitted from eBird for iOS, version 2.20.28

14 Species Observed 42 individuals

8	Canada Goose
2	Mute Swan *
6	Mallard
2	Chimney Swift
1	Killdeer
3	Tree Swallow
1	Barn Swallow
4	European Starling *
4	Northern Mockingbird
4	American Robin
1	American Goldfinch
3	Chipping Sparrow
1	Song Sparrow
2	Common Grackle



CHECKLIST S178088047

Wed **29 May 2024** 6:55 PM

Warners Pond Middlesex County, Massachusetts, United States

Mike Perrin

Incidental Incomplete

1

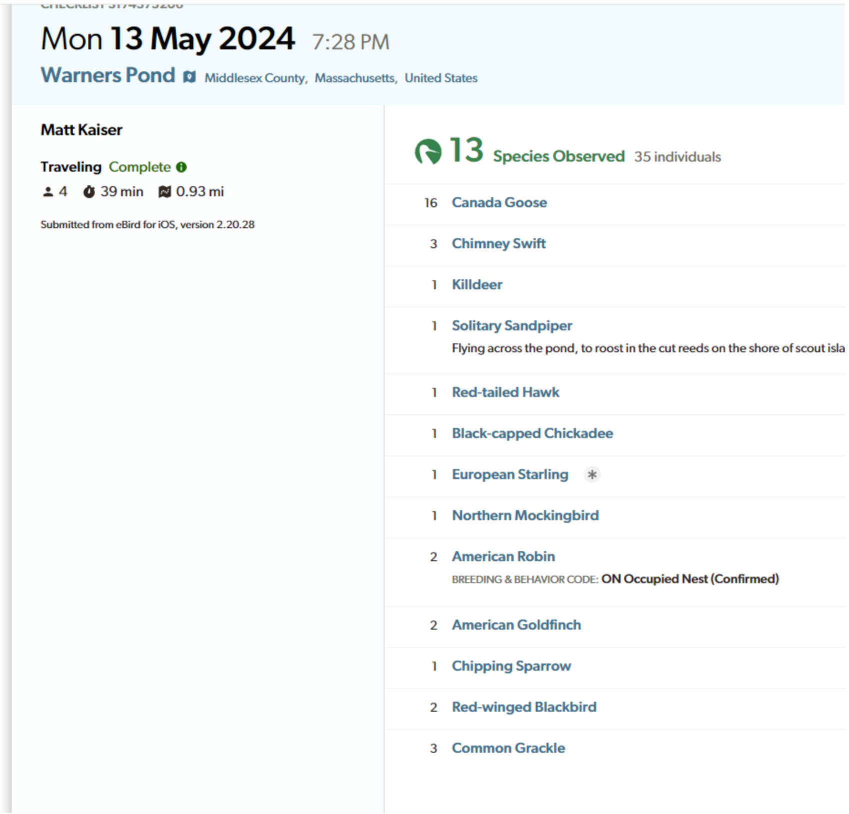
Submitted from eBird for iOS, version 2.20.28

9 Species Observed 17 individuals

1	Killdeer
1	Downy Woodpecker
2	Eastern Kingbird
2	Warbling Vireo
2	Tree Swallow
3	Barn Swallow
3	Gray Catbird
1	Orchard Oriole
2	Baltimore Oriole

Habitat and Wildlife

Some recent siting (from eBird)…



Mon **13 May 2024** 7:28 PM

Warners Pond Middlesex County, Massachusetts, United States

Matt Kaiser

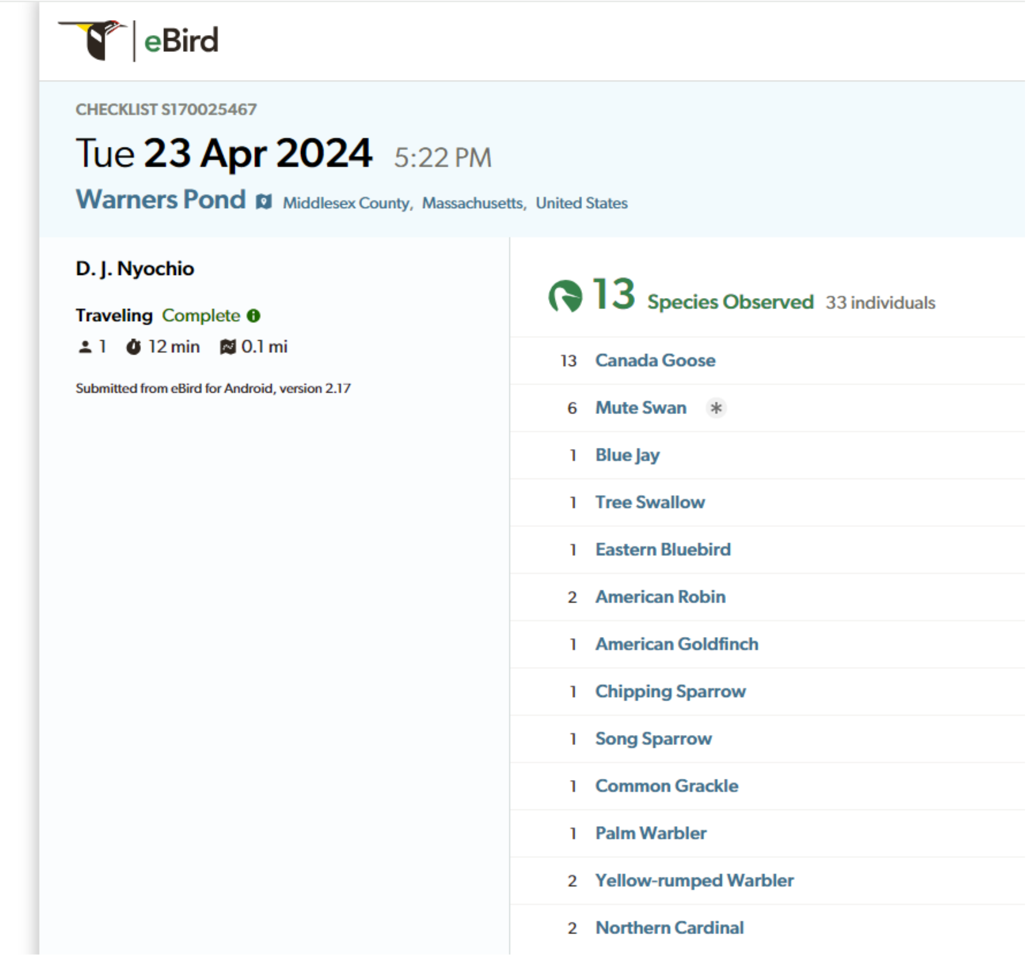
Traveling Complete

4 · 39 min · 0.93 mi

Submitted from eBird for iOS, version 2.20.28

13 Species Observed 35 individuals

16	Canada Goose
3	Chimney Swift
1	Killdeer
1	Solitary Sandpiper Flying across the pond, to roost in the cut reeds on the shore of scout isla
1	Red-tailed Hawk
1	Black-capped Chickadee
1	European Starling *
1	Northern Mockingbird
2	American Robin BREEDING & BEHAVIOR CODE: **ON Occupied Nest (Confirmed)**
2	American Goldfinch
1	Chipping Sparrow
2	Red-winged Blackbird
3	Common Grackle



eBird

CHECKLIST S170025467

Tue **23 Apr 2024** 5:22 PM

Warners Pond Middlesex County, Massachusetts, United States

D. J. Nyochio

Traveling Complete

1 · 12 min · 0.1 mi

Submitted from eBird for Android, version 2.17

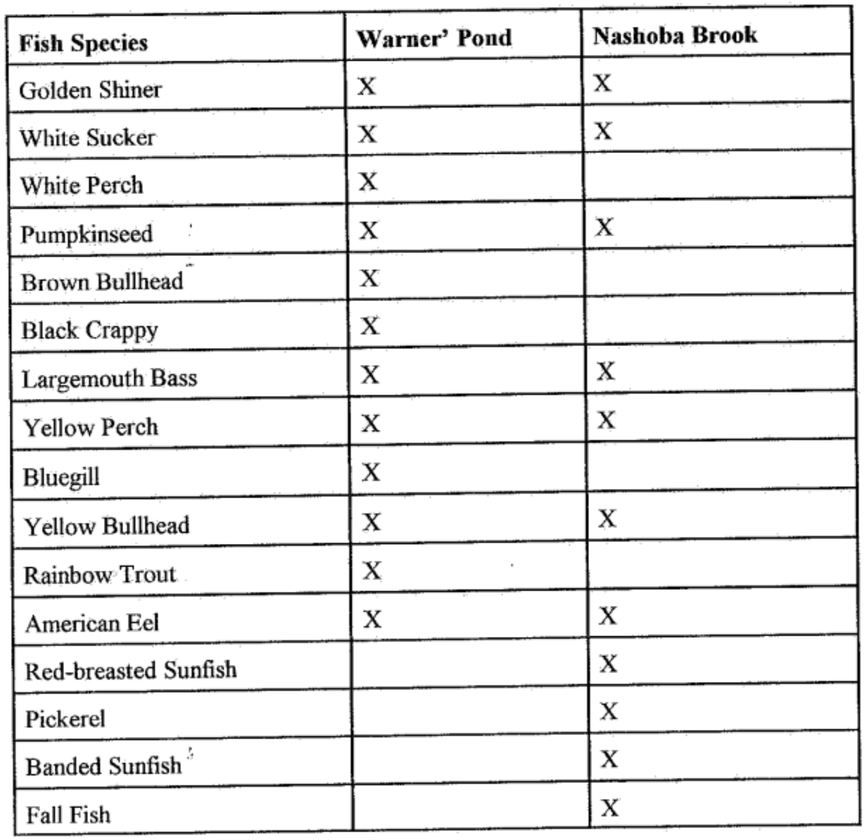
13 Species Observed 33 individuals

13	Canada Goose
6	Mute Swan *
1	Blue Jay
1	Tree Swallow
1	Eastern Bluebird
2	American Robin
1	American Goldfinch
1	Chipping Sparrow
1	Song Sparrow
1	Common Grackle
1	Palm Warbler
2	Yellow-rumped Warbler
2	Northern Cardinal

Fish

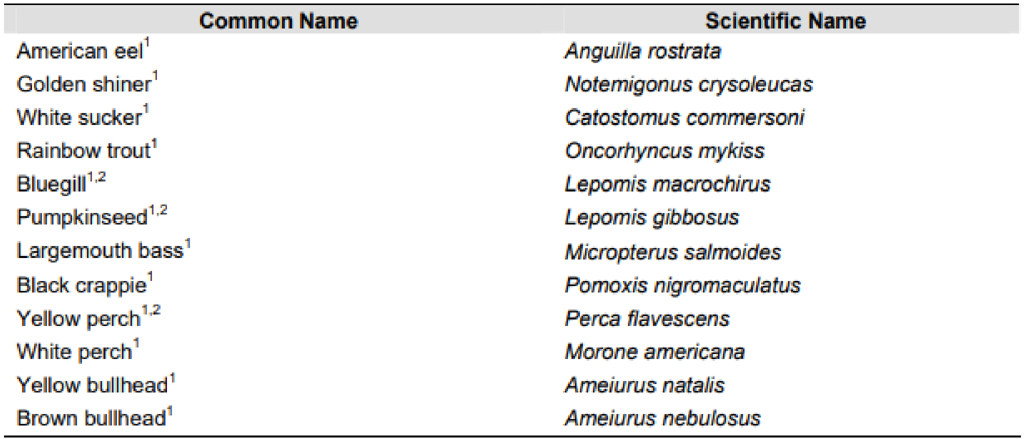
The Massachusetts Department of Fisheries and Wildlife have conducted fish inventories (1983) of Warner's Pond and the Nashoba and Fort Pond Brook areas upstream of the Pond. In 1999, NEC prepared a fish inventory. See Table 1, below. At that time, it was thought that the Pond had been stocked with rainbow trout; however, the water is too warm now for rainbow trout. ESS, in 2011, indicated that the fish community remained similar to 1999. Also, no rare or endangered flora or fauna have been observed. The observed fish indicate that warm-water species are dominant within Warner's Pond fisheries communities. Additionally, red-breasted sunfish (Lepomis auritus), pickerel (presumably the redfin pickerel) Esox americanus americanus), banded sunfish (Enneacanthus obesus), and fallfish (Semotilus corporalis) were also observed by MassWildlife in Nashoba Brook and may occur on a transient basis within or at the margins of Warner's Pond. Many of these fish are native (Golden Shiner, White Sucker, Pumpkinseed, Chain Pickerel). Largemouth Bass and Black Crappie are non-native.

Table 1. Fish Species from Warner's Pond and vicinity



Fish Species	Warner' Pond	Nashoba Brook
Golden Shiner	X	X
White Sucker	X	X
White Perch	X	
Pumpkinseed	X	X
Brown Bullhead	X	
Black Crappy	X	
Largemouth Bass	X	X
Yellow Perch	X	X
Bluegill	X	
Yellow Bullhead	X	X
Rainbow Trout	X	
American Eel	X	X
Red-breasted Sunfish		X
Pickerel		X
Banded Sunfish		X
Fall Fish		X

Table 2. Fish Species Observed in Warner's Pond



Common Name	Scientific Name
American eel[1]	*Anguilla rostrata*
Golden shiner[1]	*Notemigonus crysoleucas*
White sucker[1]	*Catostomus commersoni*
Rainbow trout[1]	*Oncorhyncus mykiss*
Bluegill[1,2]	*Lepomis macrochirus*
Pumpkinseed[1,2]	*Lepomis gibbosus*
Largemouth bass[1]	*Micropterus salmoides*
Black crappie[1]	*Pomoxis nigromaculatus*
Yellow perch[1,2]	*Perca flavescens*
White perch[1]	*Morone americana*
Yellow bullhead[1]	*Ameiurus natalis*
Brown bullhead[1]	*Ameiurus nebulosus*

†Source: 1. MassWildlife, 1983; 2. ESS, September 2012

The report prepared by the Organization for the Assabet River in 1997 includes plant map results, chlorophyll *a*, and Secchi depth data. The report indicates that the pond was considered eutrophic based on sedimentation levels and excessive aquatic plant growth in the pond.

Note: See this link for fish descriptions and pictures…
Freshwater Fish of Massachusetts · iNaturalist

Fish

Common freshwater fishes. Checkmark indicates observed in Warner's Pond:

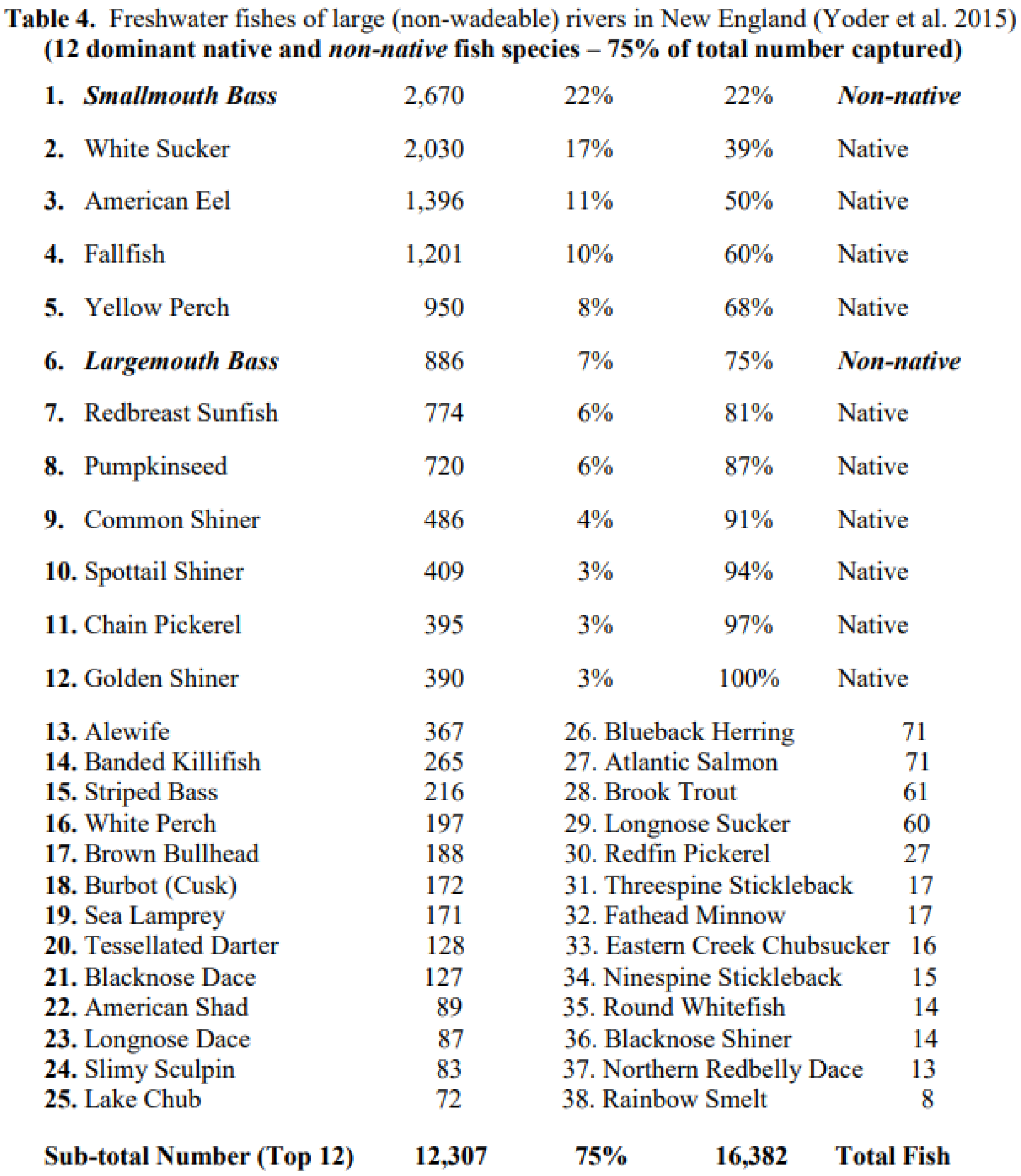


Table 4. Freshwater fishes of large (non-wadeable) rivers in New England (Yoder et al. 2015)
(12 dominant native and *non-native* fish species – 75% of total number captured)

	1. ***Smallmouth Bass***	2,670	22%	22%	***Non-native***
✓	**2.** White Sucker	2,030	17%	39%	Native
✓	**3.** American Eel	1,396	11%	50%	Native
✓	**4.** Fallfish	1,201	10%	60%	Native
✓	**5.** Yellow Perch	950	8%	68%	Native
✓	**6.** ***Largemouth Bass***	886	7%	75%	***Non-native***
✓	**7.** Redbreast Sunfish	774	6%	81%	Native
✓	**8.** Pumpkinseed	720	6%	87%	Native
✓	**9.** Common Shiner	486	4%	91%	Native
	10. Spottail Shiner	409	3%	94%	Native
✓	**11.** Chain Pickerel	395	3%	97%	Native
✓	**12.** Golden Shiner	390	3%	100%	Native

13. Alewife	367	26. Blueback Herring	71
14. Banded Killifish	265	27. Atlantic Salmon	71
15. Striped Bass	216	28. Brook Trout	61
16. White Perch	197	29. Longnose Sucker	60
17. Brown Bullhead	188	30. Redfin Pickerel	27
18. Burbot (Cusk)	172	31. Threespine Stickleback	17
19. Sea Lamprey	171	32. Fathead Minnow	17
20. Tessellated Darter	128	33. Eastern Creek Chubsucker	16
21. Blacknose Dace	127	34. Ninespine Stickleback	15
22. American Shad	89	35. Round Whitefish	14
23. Longnose Dace	87	36. Blacknose Shiner	14
24. Slimy Sculpin	83	37. Northern Redbelly Dace	13
25. Lake Chub	72	38. Rainbow Smelt	8

Sub-total Number (Top 12) **12,307** **75%** **16,382** **Total Fish**

ED_NE-FISH_Distribution-Biogeography_Halliwell_July 27 2019_Distribute.pdf (conservationgateway.org)

Fish

Common freshwater sport fishes observed in Warner's Pond:

Table 5. Dominant freshwater sport fishes in Northeastern LAKES (EMAP-SW 1994).
(US-EPA Region 1, New England and US-EPA Region 2, New York and New Jersey)

✓ **1.** Brown Bullhead
✓ **2.** Pumpkinseed
✓ **3.** ***Largemouth Bass***
✓ **4.** Yellow Perch
5. White Sucker
✓ **6.** Chain Pickerel
7. ***Bluegill***
✓ **8.** ***Yellow Bullhead***
✓ **9.** White Perch
10. ***Smallmouth Bass***
11. American Eel ✓
12. Redbreast Sunfish
13. Rainbow Smelt (landlocked)
14. ***Black Crappie*** ✓
15. Brook Trout
16. ***Brown Trout***
17. ***Rainbow Trout/Salmon***
18. ***Rock Bass***
19. Alewife (landlocked)
20. Atlantic Salmon (landlocked)

ED_NE-FISH_Distribution-Biogeography_Halliwell
July 27 2019 Distribute.pdf
(conservationgateway.org)

Fish

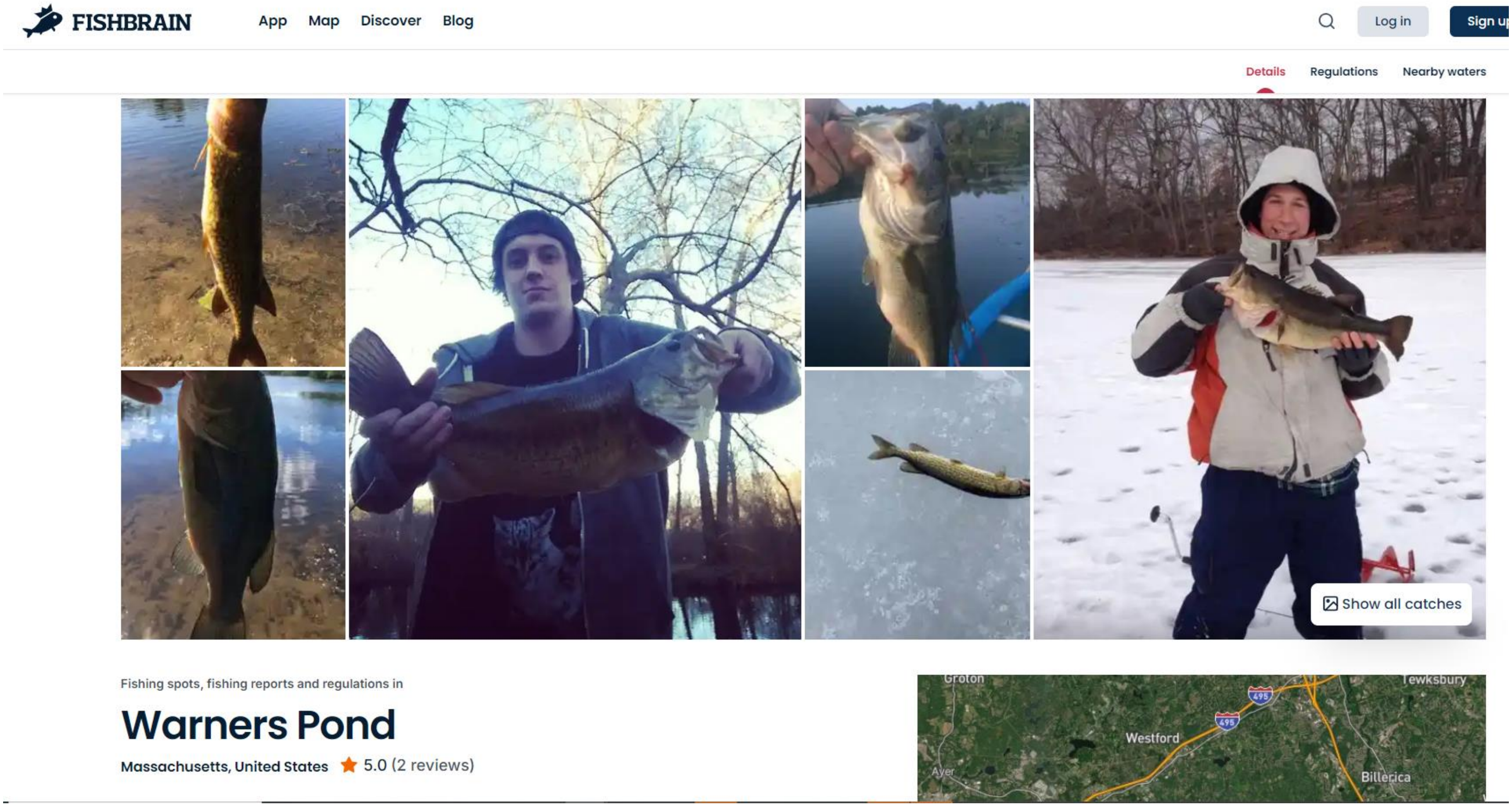
The fish observed in Warner’s Pond and Nashoba Brook are generally consistent with the results of prior fish sampling (USACE) in the Concord River watershed:

“*The top seven most abundantly expected species, comprising approximately 83% of the total, include* ***fallfish*** *(37.3%),* ***common shiner*** *(18.7%),* ***white sucker*** *(9.3%),* ***redbreast sunfish*** *(6.2%),* ***American eel*** *(4.1%),* ***tessellated darter*** *(3.7%), and* ***brook trout*** *(3.4%). The remaining species have expected proportions between 1.4% and 2.9% and represent almost 17% of the fauna. The species includes fluvial specialists such as fallfish, tessellated darter, brook trout and the creek chubsucker as well as fluvial dependents such as common shiner and white sucker, and macrohabitat generalists such as redbreast sunfish, American eel, bridle shiner, yellow perch, pumpkinseed, chain pickerel, brown bullhead, redfin pickerel and golden shiner.”*

Microsoft Word - Cover for Report August 2010.docx (army.mil)

Fish

Warner’s Pond continues to be a popular fishing spot (FishBrain)…



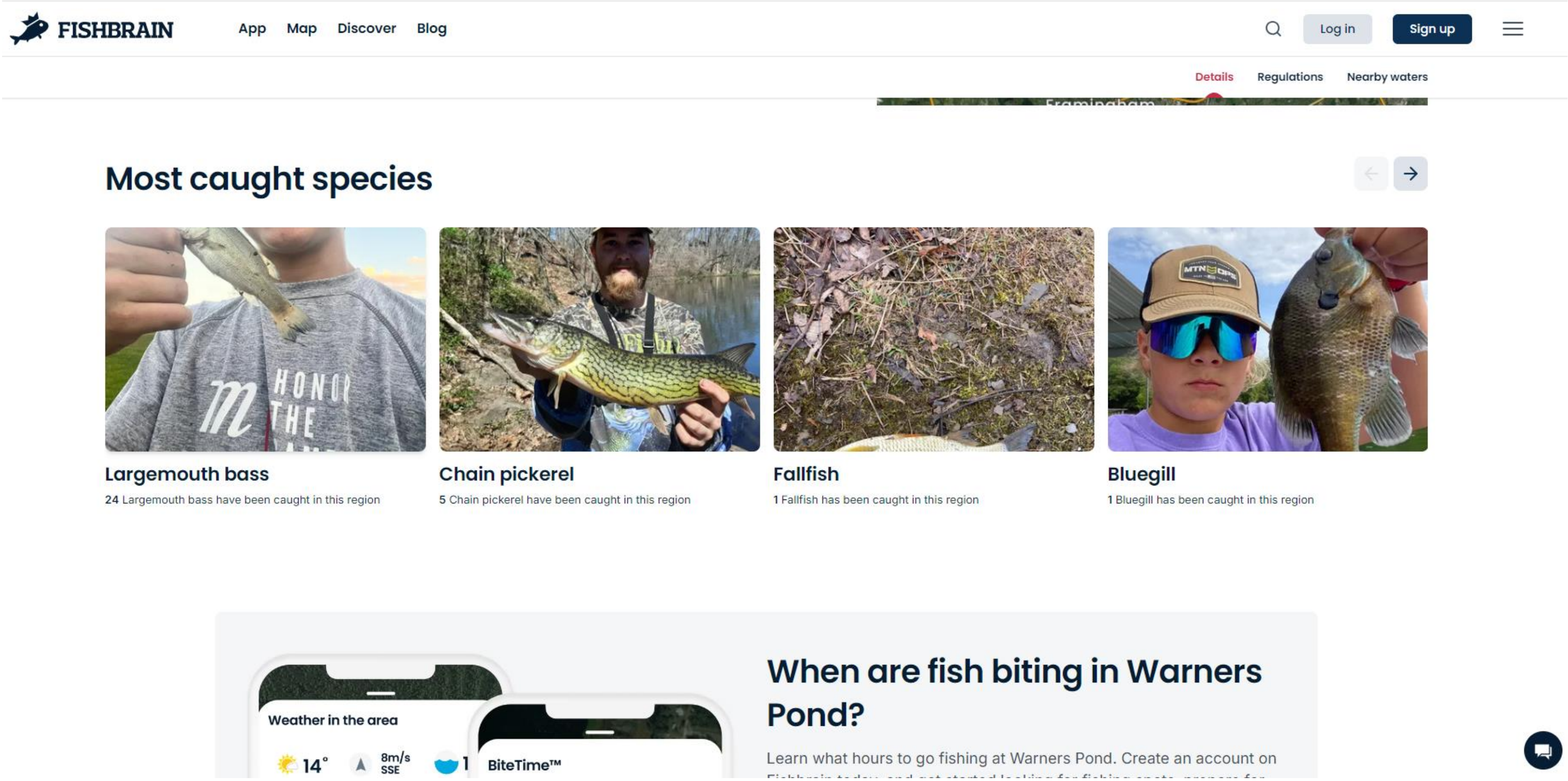
Fishing spots, fishing reports and regulations in

Warners Pond

Massachusetts, United States ★ 5.0 (2 reviews)

Fish

Warner’s Pond continues to be a popular fishing spot…



Most caught species

Largemouth bass

24 Largemouth bass have been caught in this region

Chain pickerel

5 Chain pickerel have been caught in this region

Fallfish

1 Fallfish has been caught in this region

Bluegill

1 Bluegill has been caught in this region

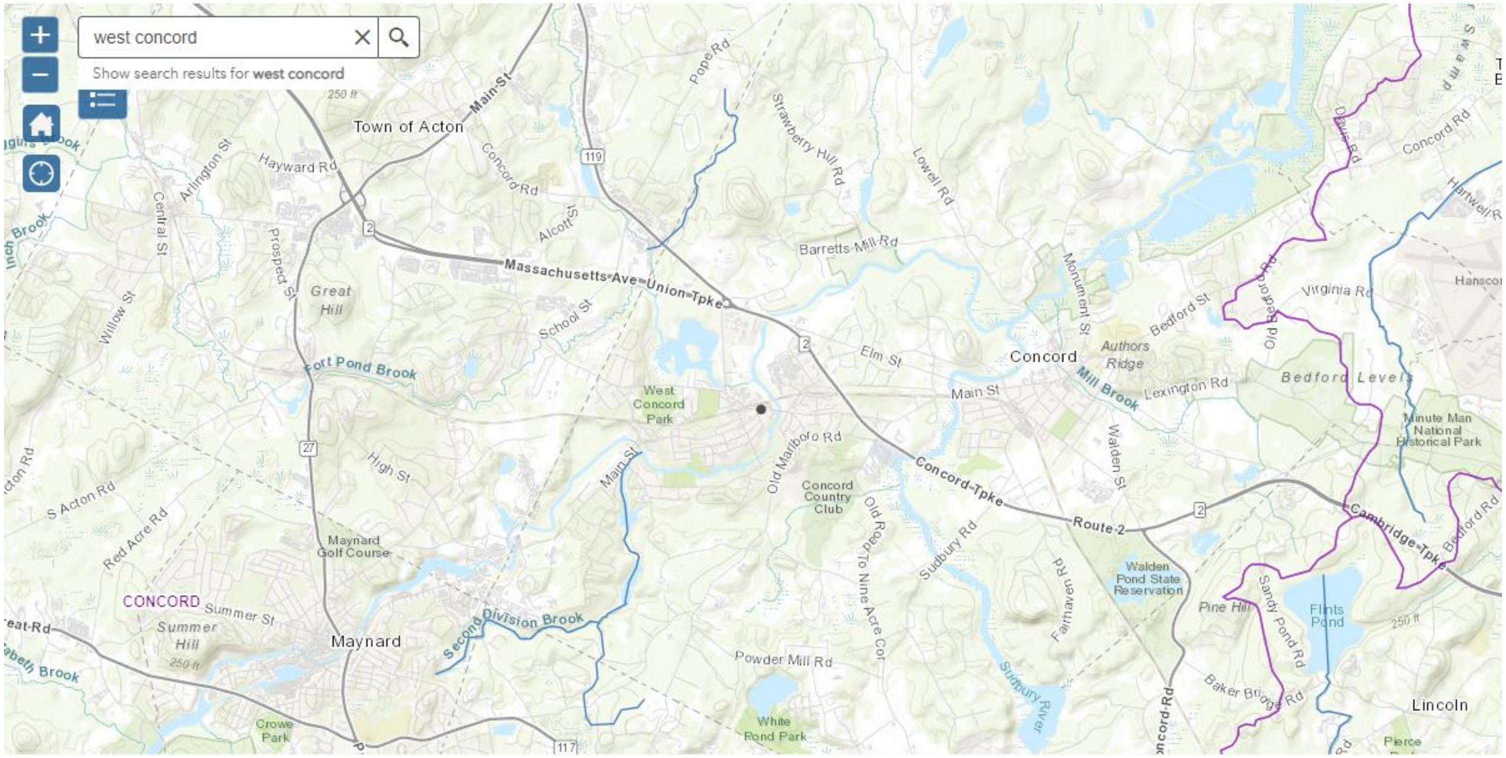
When are fish biting in Warners Pond?

Learn what hours to go fishing at Warners Pond. Create an account on

Fish

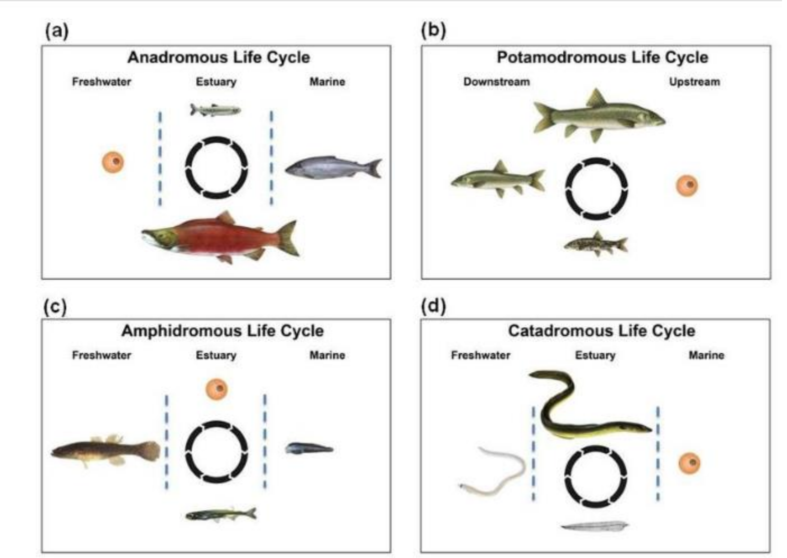
There are several considerations to think about relative to fish relative to Warner's Pond, the Assabet River, Nashoba Brook and the tributaries and Fort Pond and Nashoba Brooks watershed upstream of the Pond.

1. Water Temperature. Warm Water versus Coldwater Fish Resources. Warm water fisheries are waters in which the maximum mean monthly temperature generally exceeds 68 degrees F and are not capable of sustain a year-round population of coldwater stenothermal aquatic life. Climate change is warming all Massachusetts water bodies. That is a fact and it is going to increase. Is there any chance of the waterbodies noted above to be a coldwater fisheries? Not likely. Concord is considered to be in the Northeastern Coastal region, a warm water fish community. Currently mapped coldwater fisheries water bodies near West Concord are shown below. There is a section of Nashoba Brook upstream of the Pond which is mapped as Coldwater Fisheries Resource; however, temperature measurements in the Pond and tributaries and, in particular, the Assabet River indicative that these are warm water fish resources and the observed fish are warm water fish. The low gradient shallow flow in Fort Pond and Nashoba Brook makes them susceptible to warming. Warming is demonstrated by the loss of rainbow trout in the Pond. Warming will continue. Massachusetts warm-water fish streams and lakes support fish species such as smallmouth bass (Micropterus dolomieui), largemouth bass (Micropterus salmoides), and chain pickerel (Esox niger). Warm-water streams and lakes can also contain stocked trout or salmon but these fish may not survive year-round. Note that these have been documented in Warner's Pond.

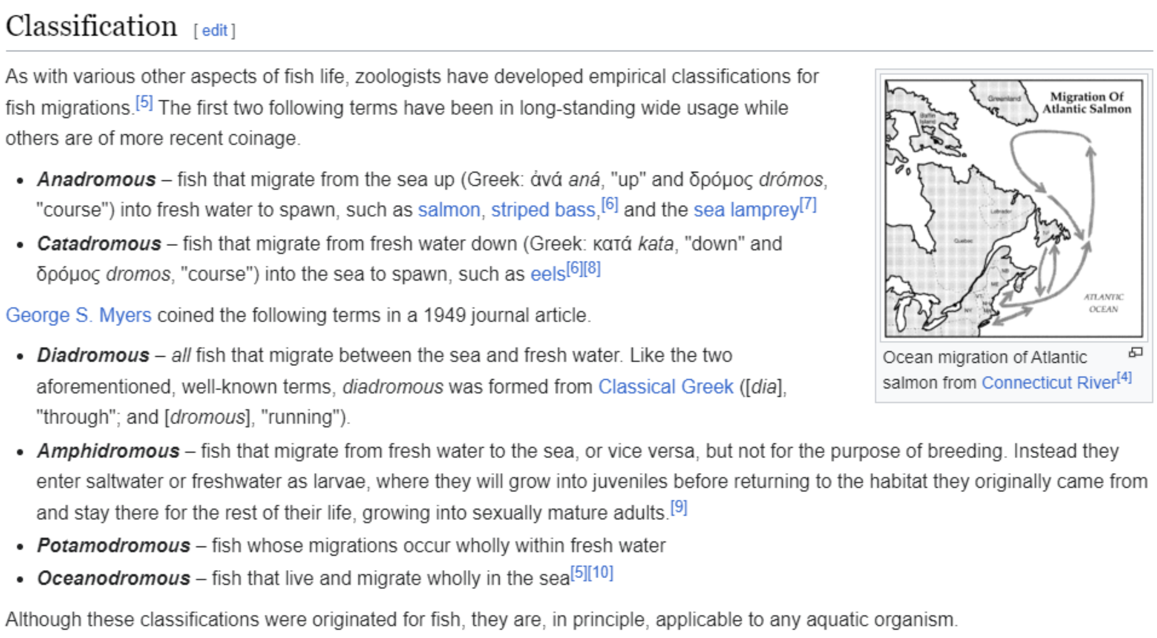


Migratory Fish

2. Migratory versus Non-Migratory Fish. Certain Massachusetts fish have life cycles that occur wholly within fresh water. Other fish migrate from the sea to freshwater to spawn. Other fish migrate from freshwater to the ocean to spawn. The table and image below show the different classifications:



1 Different types of fish migration. (a) Anadromous species: reproduction takes place in freshwater, then fish migrate to the sea as juveniles where they grow into adults before migrating back into freshwater to spawn (e.g. Sockeye salmon, Oncorhynchus nerka); (b) Potamodromous species: migration occurs exclusively in freshwater generally fish are born in upstream habitats and then migrate downstream as juveniles to grow into adults befor migrating back upstream to spawn (e.g. Iberian barbel, Luciobarbus bocagei); (c) Amphidromous species: reproduction occurs in freshwater/estuaries then larvae migrate/drift into the sea before migrating back into freshwater to grow into adults and spawn (e.g. Smelt, Retropina retropina); (d) Catadromous species: reproduction takes place in the sea, then fish migrate as juveniles into freshwater where they grow into adults before migrating back to the sea to spawn (e.g. eels, Anguilla anguilla) (adapted from: www.thefisheriesblog.com).



Classification [edit]

As with various other aspects of fish life, zoologists have developed empirical classifications for fish migrations.[5] The first two following terms have been in long-standing wide usage while others are of more recent coinage.

- ***Anadromous*** – fish that migrate from the sea up (Greek: ἀνά *ana*, "up" and δρόμος *drómos*, "course") into fresh water to spawn, such as salmon, striped bass,[6] and the sea lamprey[7]
- ***Catadromous*** – fish that migrate from fresh water down (Greek: κατά *kata*, "down" and δρόμος *dromos*, "course") into the sea to spawn, such as eels[6][8]

George S. Myers coined the following terms in a 1949 journal article.

- ***Diadromous*** – *all* fish that migrate between the sea and fresh water. Like the two aforementioned, well-known terms, *diadromous* was formed from Classical Greek ([*dia*], "through"; and [*dromous*], "running").
- ***Amphidromous*** – fish that migrate from fresh water to the sea, or vice versa, but not for the purpose of breeding. Instead they enter saltwater or freshwater as larvae, where they will grow into juveniles before returning to the habitat they originally came from and stay there for the rest of their life, growing into sexually mature adults.[9]
- ***Potamodromous*** – fish whose migrations occur wholly within fresh water
- ***Oceanodromous*** – fish that live and migrate wholly in the sea[5][10]

Although these classifications were originated for fish, they are, in principle, applicable to any aquatic organism.

Ocean migration of Atlantic salmon from Connecticut River[4]

The fish documented to exist on Warner's Pond and Nashoba Brook are very common fresh warm water species in New England. The American Eel, observed in Warner's Pond is catadromous; however, other Warner's Pond fish are non migratory, with their life history in freshwater pond, lakes and streams.

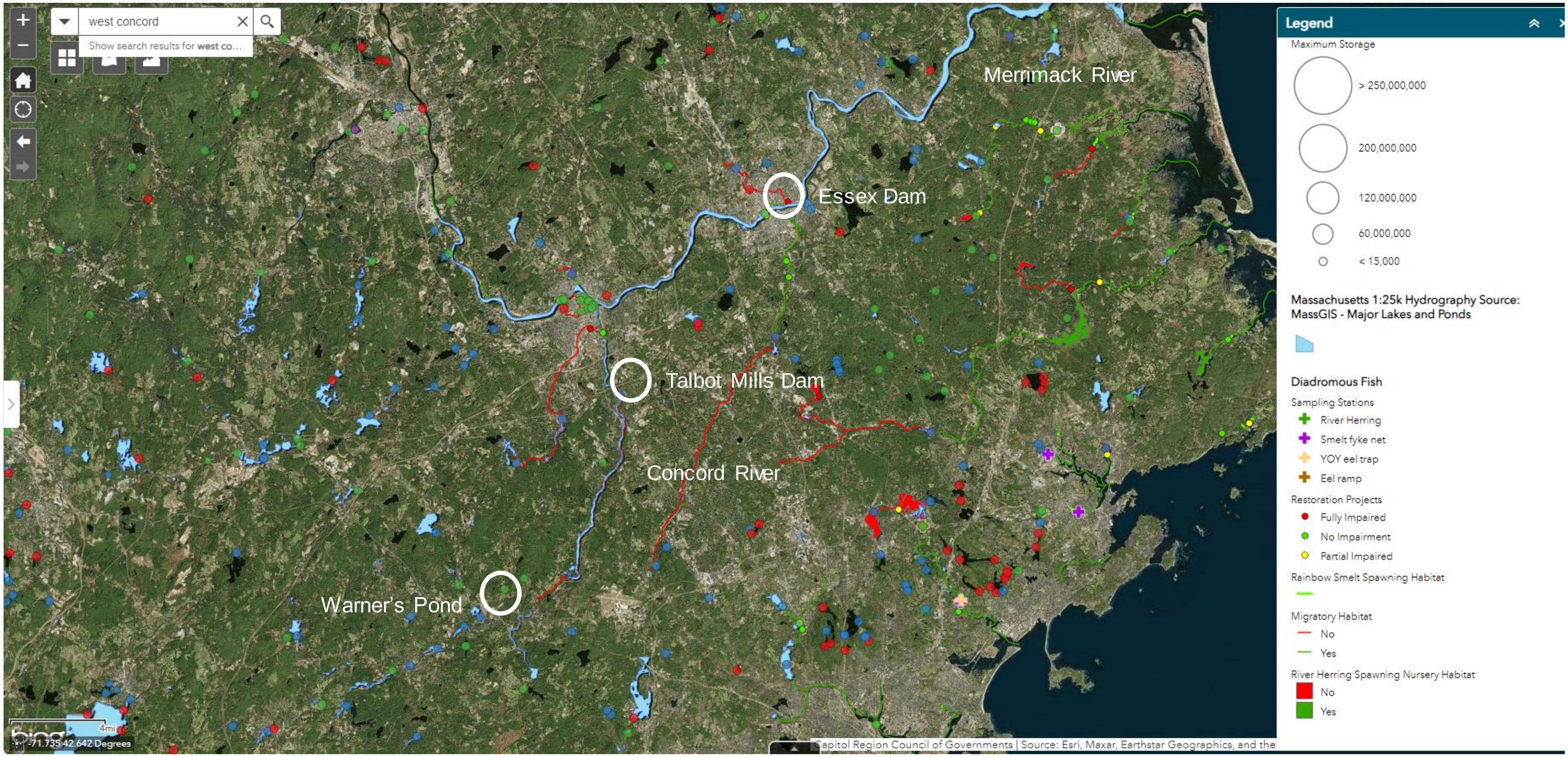
However, before the industrial revolution, the free-flowing Assabet River and its tributaries were home to abundant migratory fish populations. Diadromous fish **Blueback herring, alewife, American shad, American eel, and sea lamprey** would migrate up and down these rivers and streams every year. These annual cycles played a critical role in the freshwater food web and nutrient cycles, and abundant hatchling fish returning to the sea served as food for birds, mammals, and larger fish.

The primary objective of the Dam Removal Alternative is to remove obstructions to migratory pathways from the Atlantic Ocean via the Merrimack river and to the Concord and Assabet Rivers and connected tributaries. For this to be successful, existing obstructions (dams, culverts, etc.) would need to be removed from the Merrimack, Concord and Assabet Rivers. More uncertain is, if obstructions are removed, are the climatological and hydrological conditions conducive for spawning for these species.

Fish… removing obstructions for migratory fish

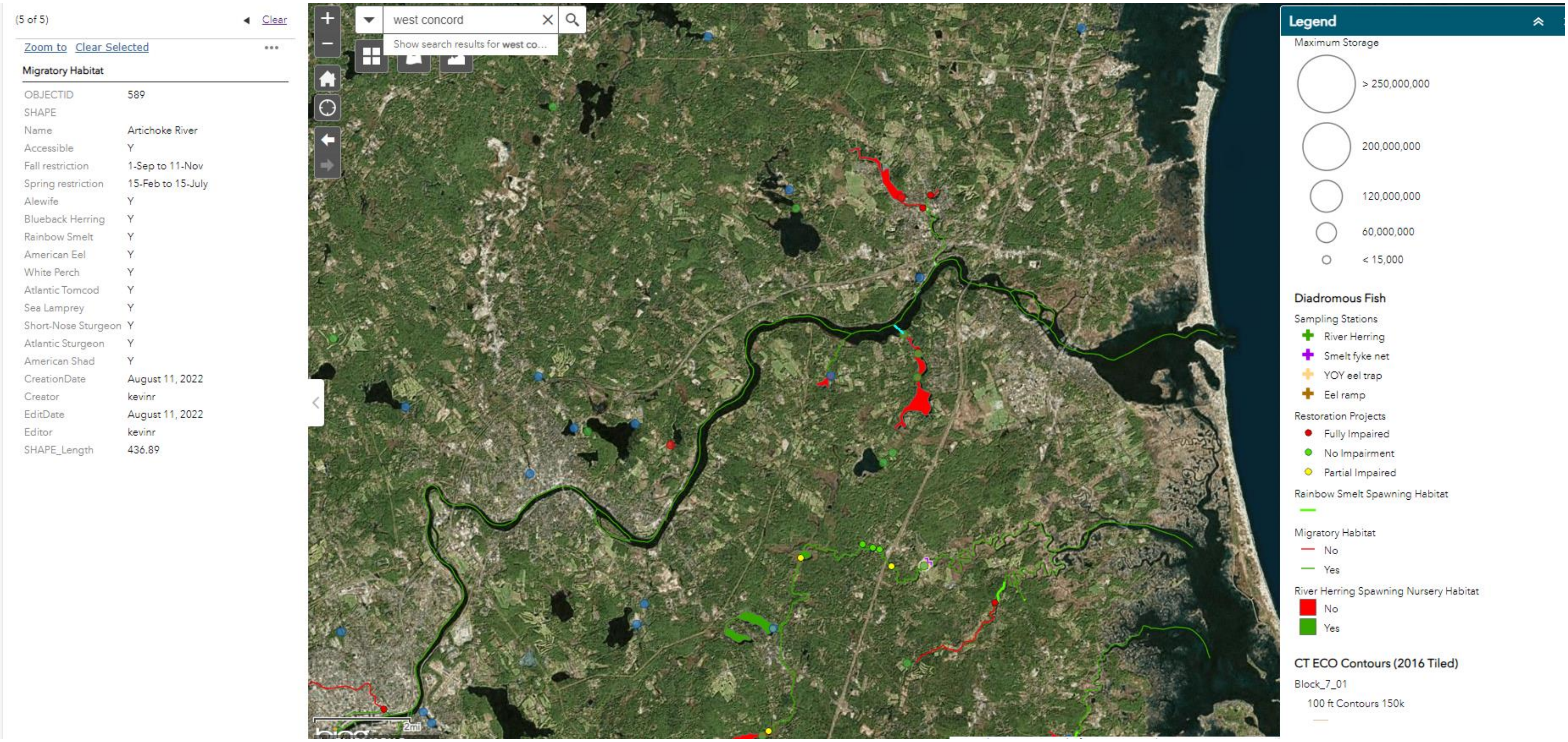
An objective, supported by the Commonwealth, has been to remove obstructions to historically migratory fish. In general terms - this is being done opportunistically that is, removing or bypassing (fish passageway) obstructions (in particular dams) as the opportunity arises even though there may not be a near-term benefit. Where dam removal is not feasible, fish passageways are constructed as an alternative.

The Essex Dam has fish ladders for fish bypassing the dam. Talbot Mills Dam on the Concord River in Billerica is now the only dam blocking fish passage between the Assabet River and the ocean. Removal of that dam is currently in the permitting process and is slated for completion in 2024 or 2025.



Fish… removing obstructions for migratory fish

Looking at the trip from the Atlantic to Warner’s Pond… currently obstruction removal has resulted in observations of **Alewife, Blueback Herring, Rainbow Smelt, American Eel, White Perch, Atlantic Tomcod, Sea Lamprey, Short-nose Sturgeon, and American Shad** over this stretch form the ocean to Essex Dam.



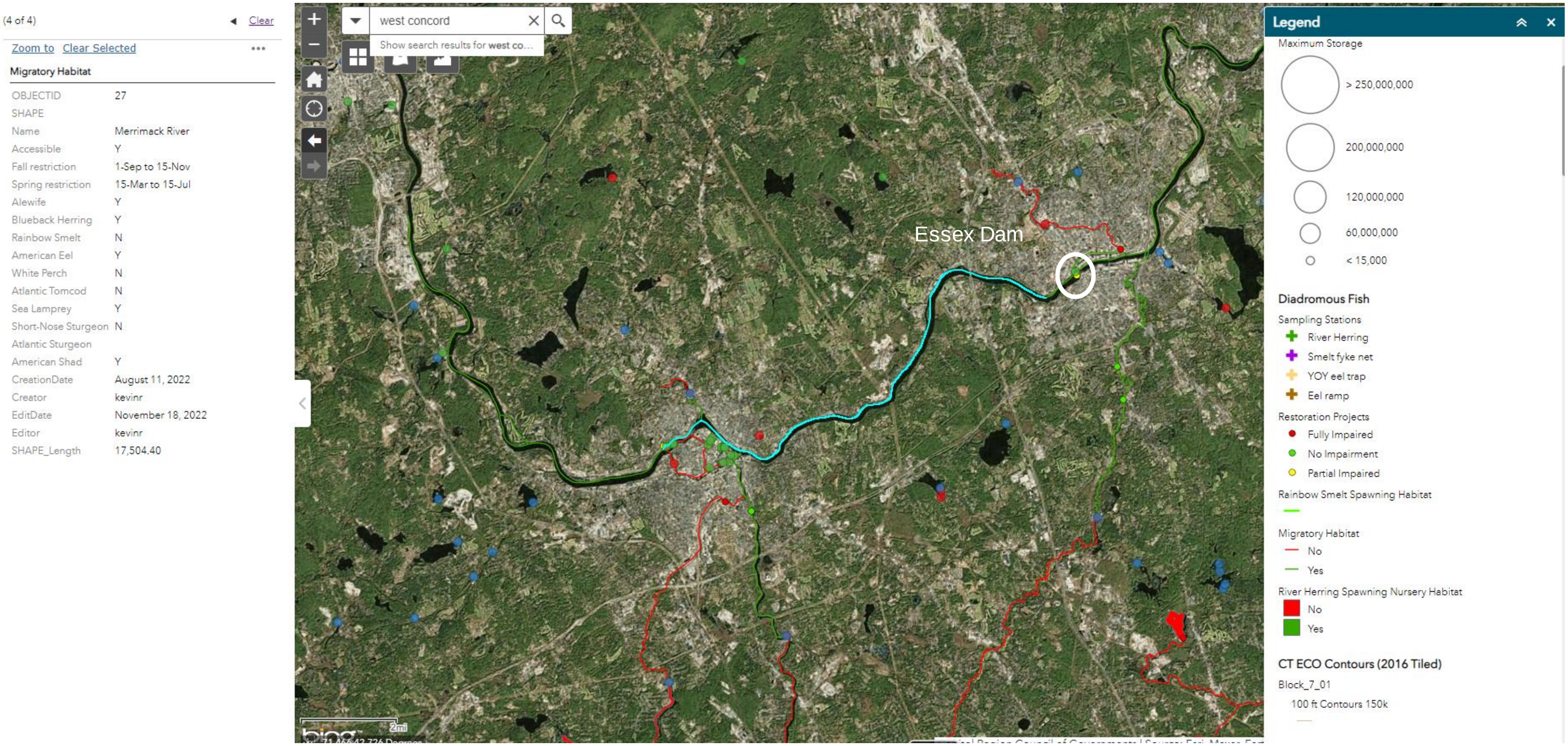
(5 of 5)

Migratory Habitat

OBJECTID	589
SHAPE	
Name	Artichoke River
Accessible	Y
Fall restriction	1-Sep to 11-Nov
Spring restriction	15-Feb to 15-July
Alewife	Y
Blueback Herring	Y
Rainbow Smelt	Y
American Eel	Y
White Perch	Y
Atlantic Tomcod	Y
Sea Lamprey	Y
Short-Nose Sturgeon	Y
Atlantic Sturgeon	Y
American Shad	Y
CreationDate	August 11, 2022
Creator	kevinr
EditDate	August 11, 2022
Editor	kevinr
SHAPE_Length	436.89

Fish… removing obstructions for migratory fish

Looking at the trip from the Atlantic to Warner's Pond… currently obstruction removal has resulted in observations of **Alewife, Blueback Herring, American Eel, Sea Lamprey and American Shad** over this stretch – which connects to the Concord River. To make this route, fish need to pass the Essex Dam.



(4 of 4) ◂ Clear

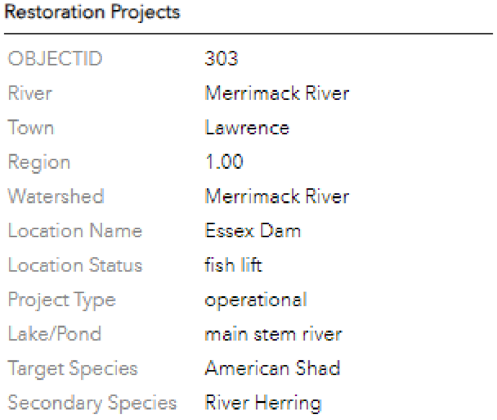
Zoom to Clear Selected •••

Migratory Habitat

OBJECTID	27
SHAPE	
Name	Merrimack River
Accessible	Y
Fall restriction	1-Sep to 15-Nov
Spring restriction	15-Mar to 15-Jul
Alewife	Y
Blueback Herring	Y
Rainbow Smelt	N
American Eel	Y
White Perch	N
Atlantic Tomcod	N
Sea Lamprey	Y
Short-Nose Sturgeon	N
Atlantic Sturgeon	
American Shad	Y
CreationDate	August 11, 2022
Creator	kevinr
EditDate	November 18, 2022
Editor	kevinr
SHAPE_Length	17,504.40

Fish… removing obstructions for migratory fish

Essex Dam, the first barrier upstream from the ocean on the Merrimack, was built in 1845 and was the largest in the world at the time. With a built-in fish ladder, it allowed fish to get by, although not in historical numbers. The lift — as in elevator — added in the 1980s improved passage at the dam, but numerous upstream dams stand between the fish and their goal. While many herring still get a boost up and over the dam, tens of thousands more now catch a ride in a truck. For the last five years, the Service and its partners — the New Hampshire Fish and Game Department and the Massachusetts Division of Marine Fisheries and Department of Fish and Game have collected herring at the Essex fishway and driven them upstream. Construction of an eel lift at the north end of the Essex Dam was approved in 2020. The purpose of the project is to improve the passage of American eel upstream of the dam. Project construction will consist of installation of a concrete pad on existing bedrock at the base of the north dam abutment; installation of a metal hopper; construction of a metal rail system attached to the side of the north abutment; and the installation of a holding tank on the top of the abutment, as well as safety fencing.



Restoration Projects

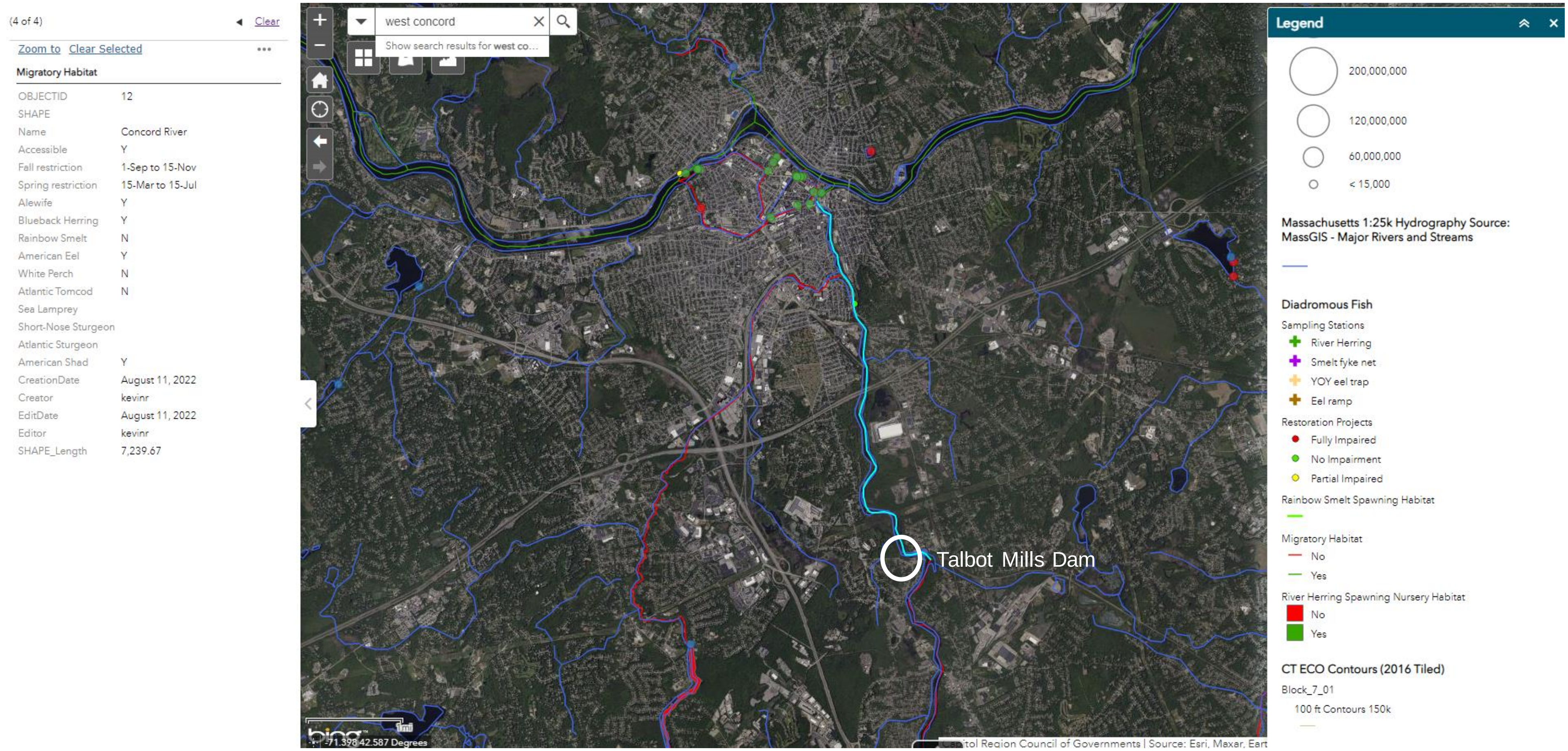
OBJECTID	303
River	Merrimack River
Town	Lawrence
Region	1.00
Watershed	Merrimack River
Location Name	Essex Dam
Location Status	fish lift
Project Type	operational
Lake/Pond	main stem river
Target Species	American Shad
Secondary Species	River Herring

The fish lift at the Essex Dam is just to the left of the former fish ladder, which appears as a concrete ramp. Bjorn Lake/NOAA Fisheries

Reaching new heights: Herring return to the Merrimack in record numbers | by Lauri Munroe-Hultman | Conserving the Nature of the Northeast | Medium

Fish… removing obstructions for migratory fish

Looking at the trip for the Atlantic to Warner’s Pond… currently obstruction removal has resulted in observations of **Alewife, Blueback Herring, American Eel and American Shad** over this stretch. This Concord River stretch goes to the Talbot Mills Dam. Removal of this dam will be the largest dam removal ever in Massachusetts, opening 135 miles and 740 acres of habitat, including 260 acres of lakes and ponds, spawning, rearing and thermal refugia habitat for native fish species.



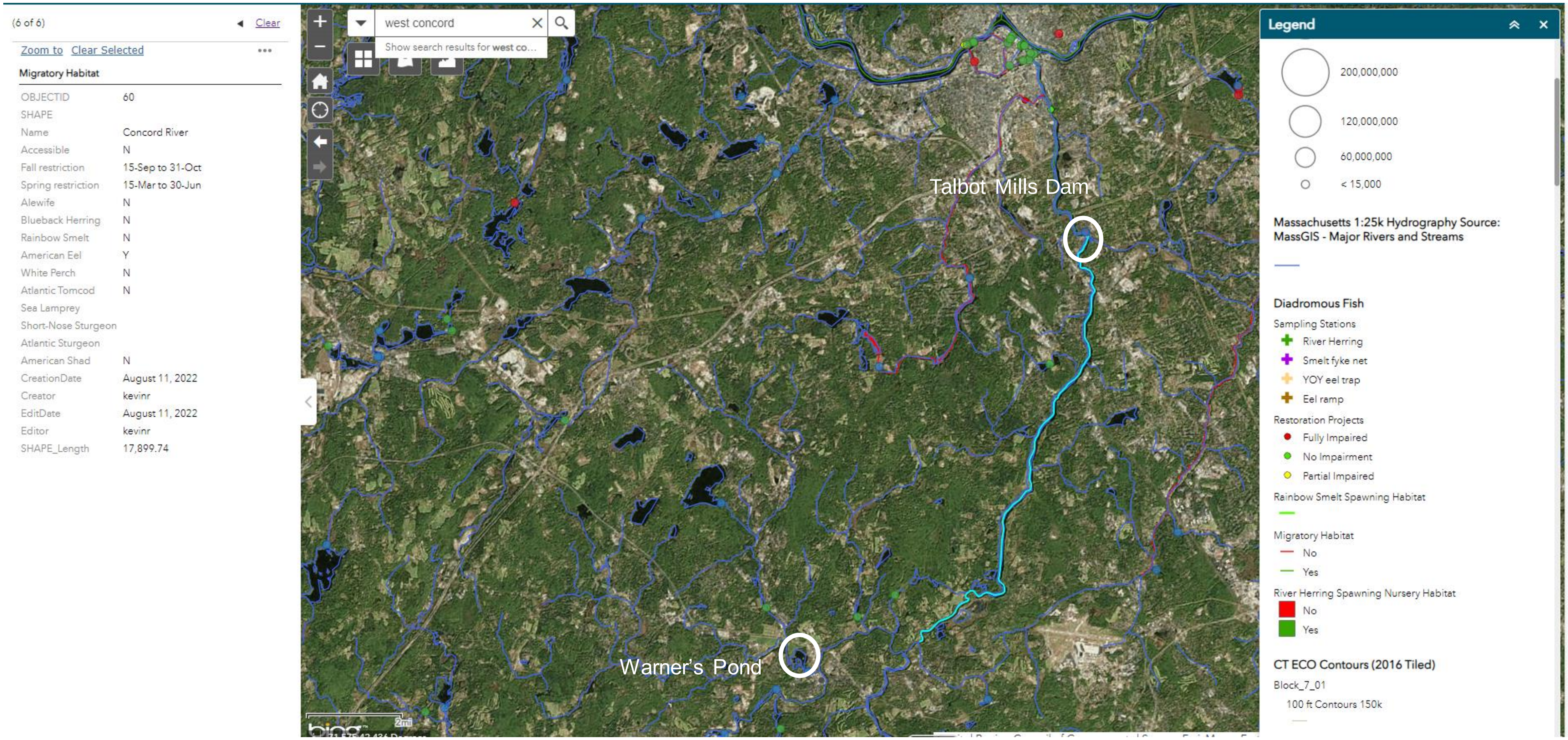
(4 of 4)

Migratory Habitat

OBJECTID	12
SHAPE	
Name	Concord River
Accessible	Y
Fall restriction	1-Sep to 15-Nov
Spring restriction	15-Mar to 15-Jul
Alewife	Y
Blueback Herring	Y
Rainbow Smelt	N
American Eel	Y
White Perch	N
Atlantic Tomcod	N
Sea Lamprey	
Short-Nose Sturgeon	
Atlantic Sturgeon	
American Shad	Y
CreationDate	August 11, 2022
Creator	kevinr
EditDate	August 11, 2022
Editor	kevinr
SHAPE_Length	7,239.67

Fish… removing obstructions for migratory fish

Looking at the trip for the Atlantic to Warner’s Pond… the last stretch to West Concord. Observed migratory fish include **American Eel** over this stretch. American Eel has been documented in Warner’s Pond.



(6 of 6)

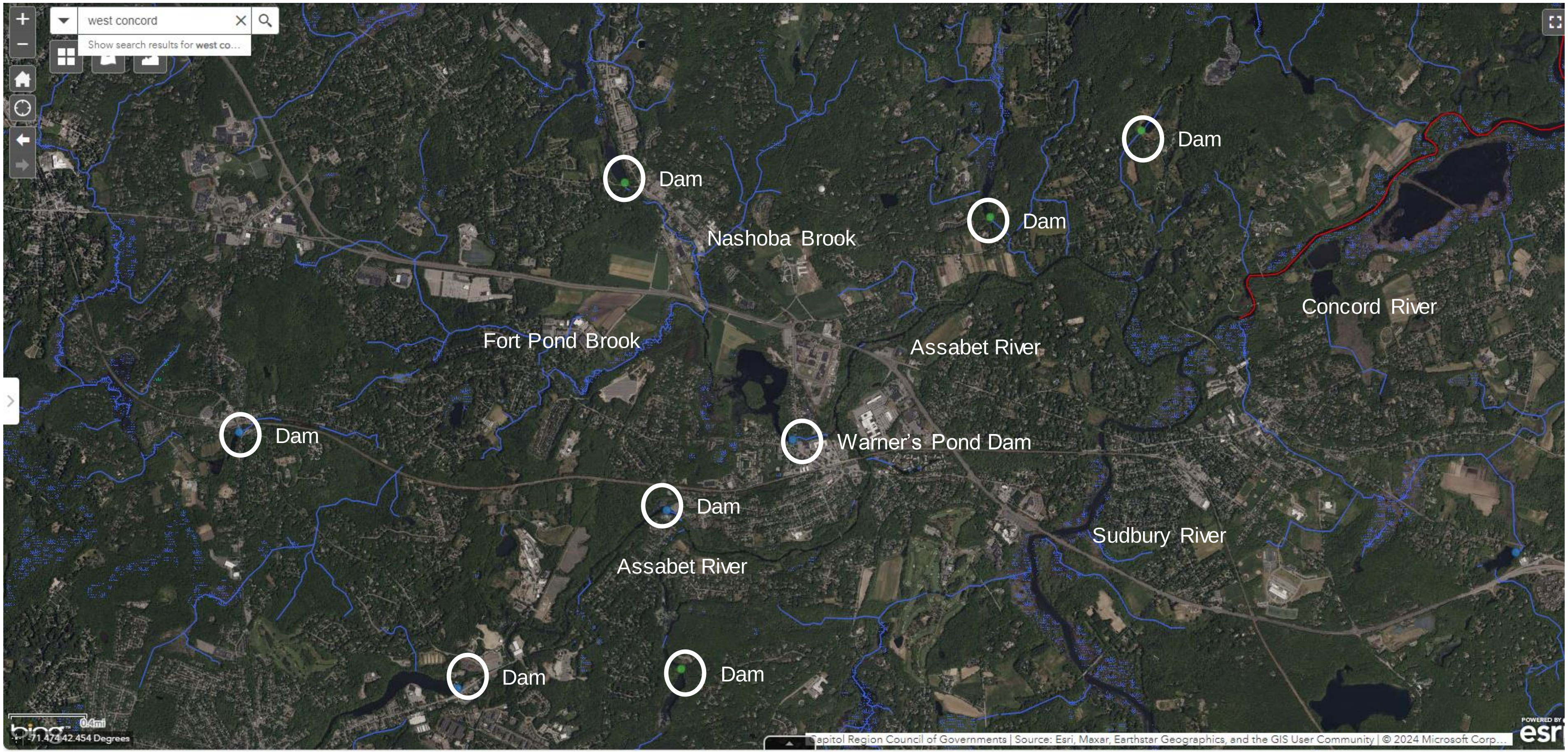
Zoom to Clear Selected

Migratory Habitat

OBJECTID	60
SHAPE	
Name	Concord River
Accessible	N
Fall restriction	15-Sep to 31-Oct
Spring restriction	15-Mar to 30-Jun
Alewife	N
Blueback Herring	N
Rainbow Smelt	N
American Eel	Y
White Perch	N
Atlantic Tomcod	N
Sea Lamprey	
Short-Nose Sturgeon	
Atlantic Sturgeon	
American Shad	N
CreationDate	August 11, 2022
Creator	kevinr
EditDate	August 11, 2022
Editor	kevinr
SHAPE_Length	17,899.74

Fish… removing obstructions for migratory fish

Looking at the trip for the Atlantic to Warner’s Pond… from West Concord onward. The Concord Rover connects to the Assabet River. At this point there are a number of downstream obstructions on the Assabet River and upstream to connected tributaries. Conceptually, to be successful migratory fish would need to swim from the Concord River to the Assabet River, from the Assabet River to Nashoba Brook, from Nashoba Brook through a new stream channel and small shallow 4.5 acre pond (dam removal) or up a fish passage into a large (+/-40-acre) pond (Warner’s Pond fish passage alternative) and then up to the Fort Pond and Nashoba Brook subwatershed upstream of Warner’s Pond – but only to the existing dams on each of these tributaries.



Fish

The target migratory fish identified by the USACE for the Concord River watershed:

“The TFC also includes as expected the following native anadromous fish species: ***American shad****,* ***alewife****, and* ***blueback herring****; and the* ***sea lamprey****. These species are expected providing that fish passage facilities are constructed and/or obstructions are removed in the Concord River watershed so that they can reach their historical spawning grounds. The US Fish and Wildlife Service (USFWS) and other stakeholders collaboratively began an active anadromous fish restoration program in the Concord River watershed in 2000 that continues to the present.”*

Microsoft Word - Cover for Report August 2010.docx (army.mil)

Fish

The target migratory fish identified by the USACE for the Concord River watershed:
Microsoft Word - Cover for Report August 2010.docx (army.mil)

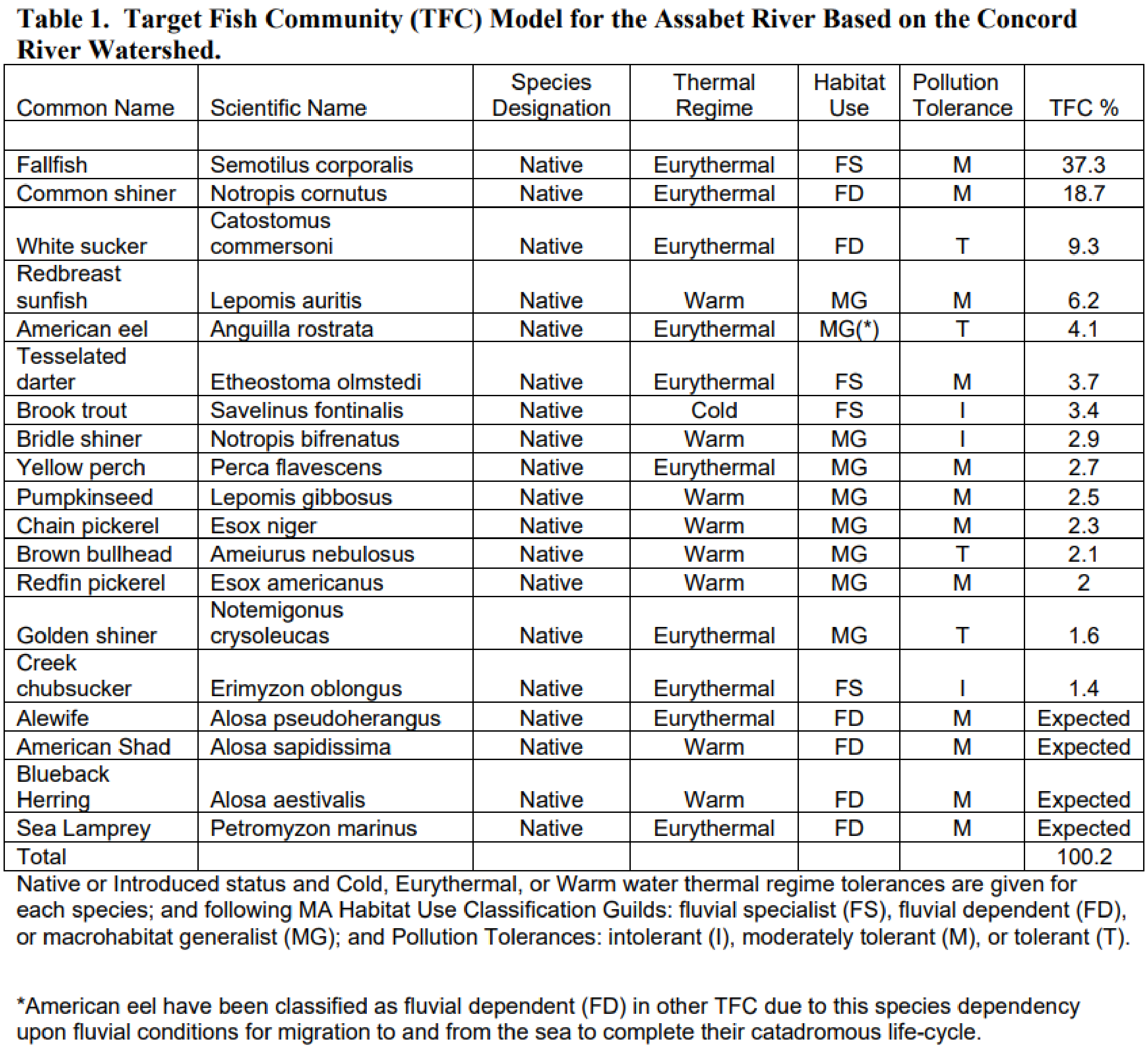


Table 1. Target Fish Community (TFC) Model for the Assabet River Based on the Concord River Watershed.

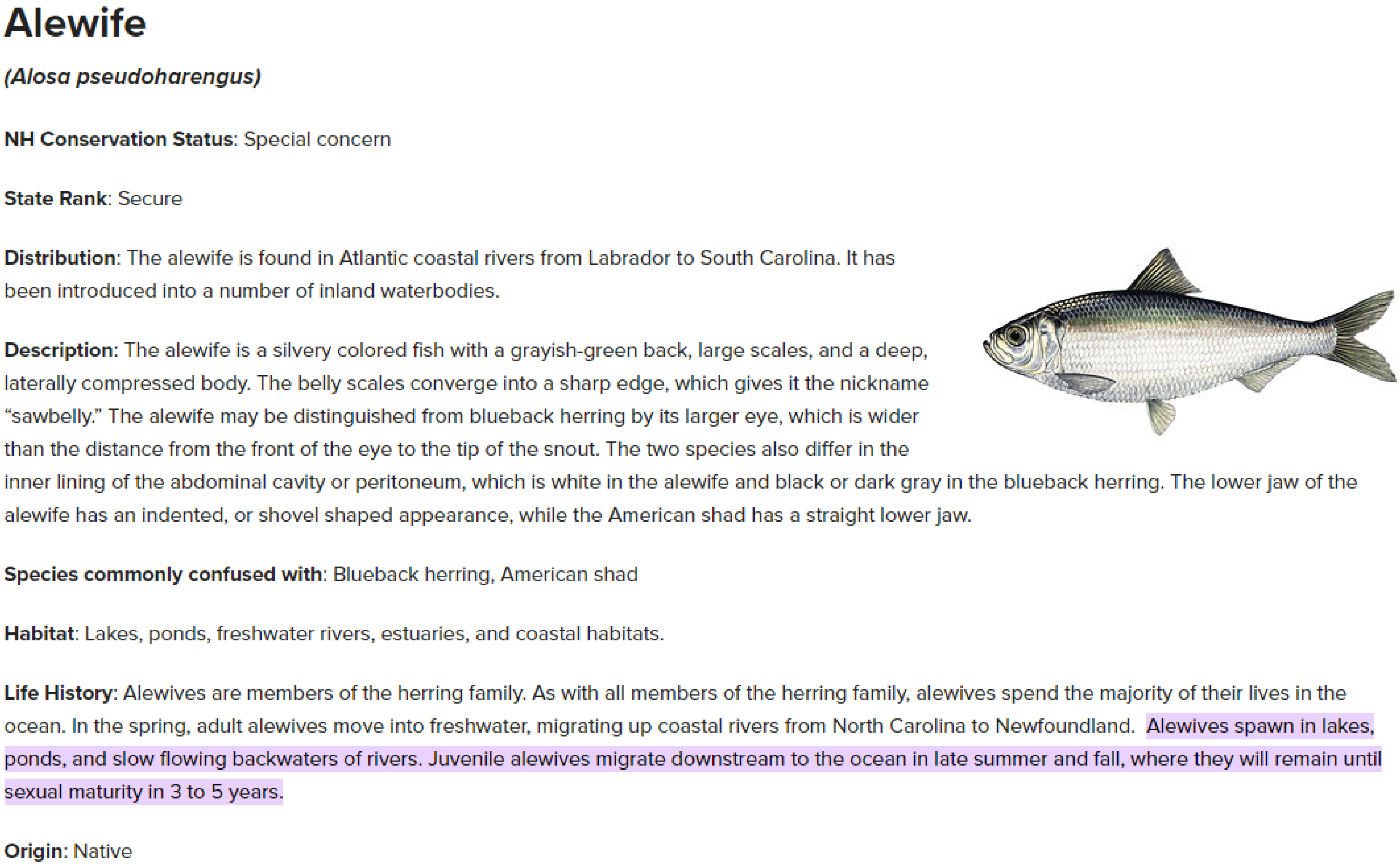
Common Name	Scientific Name	Species Designation	Thermal Regime	Habitat Use	Pollution Tolerance	TFC %
Fallfish	Semotilus corporalis	Native	Eurythermal	FS	M	37.3
Common shiner	Notropis cornutus	Native	Eurythermal	FD	M	18.7
White sucker	Catostomus commersoni	Native	Eurythermal	FD	T	9.3
Redbreast sunfish	Lepomis auritis	Native	Warm	MG	M	6.2
American eel	Anguilla rostrata	Native	Eurythermal	MG(*)	T	4.1
Tesselated darter	Etheostoma olmstedi	Native	Eurythermal	FS	M	3.7
Brook trout	Savelinus fontinalis	Native	Cold	FS	I	3.4
Bridle shiner	Notropis bifrenatus	Native	Warm	MG	I	2.9
Yellow perch	Perca flavescens	Native	Eurythermal	MG	M	2.7
Pumpkinseed	Lepomis gibbosus	Native	Warm	MG	M	2.5
Chain pickerel	Esox niger	Native	Warm	MG	M	2.3
Brown bullhead	Ameiurus nebulosus	Native	Warm	MG	T	2.1
Redfin pickerel	Esox americanus	Native	Warm	MG	M	2
Golden shiner	Notemigonus crysoleucas	Native	Eurythermal	MG	T	1.6
Creek chubsucker	Erimyzon oblongus	Native	Eurythermal	FS	I	1.4
Alewife	Alosa pseudoherangus	Native	Eurythermal	FD	M	Expected
American Shad	Alosa sapidissima	Native	Warm	FD	M	Expected
Blueback Herring	Alosa aestivalis	Native	Warm	FD	M	Expected
Sea Lamprey	Petromyzon marinus	Native	Eurythermal	FD	M	Expected
Total						100.2

Native or Introduced status and Cold, Eurythermal, or Warm water thermal regime tolerances are given for each species; and following MA Habitat Use Classification Guilds: fluvial specialist (FS), fluvial dependent (FD), or macrohabitat generalist (MG); and Pollution Tolerances: intolerant (I), moderately tolerant (M), or tolerant (T).

*American eel have been classified as fluvial dependent (FD) in other TFC due to this species dependency upon fluvial conditions for migration to and from the sea to complete their catadromous life-cycle.

Fish… desired migratory fish and spawning habitat

Note that Alewife has been documented in the Concord River up to the Talbots Mill Dam.



Alewife

(Alosa pseudoharengus)

NH Conservation Status: Special concern

State Rank: Secure

Distribution: The alewife is found in Atlantic coastal rivers from Labrador to South Carolina. It has been introduced into a number of inland waterbodies.

Description: The alewife is a silvery colored fish with a grayish-green back, large scales, and a deep, laterally compressed body. The belly scales converge into a sharp edge, which gives it the nickname "sawbelly." The alewife may be distinguished from blueback herring by its larger eye, which is wider than the distance from the front of the eye to the tip of the snout. The two species also differ in the inner lining of the abdominal cavity or peritoneum, which is white in the alewife and black or dark gray in the blueback herring. The lower jaw of the alewife has an indented, or shovel shaped appearance, while the American shad has a straight lower jaw.

Species commonly confused with: Blueback herring, American shad

Habitat: Lakes, ponds, freshwater rivers, estuaries, and coastal habitats.

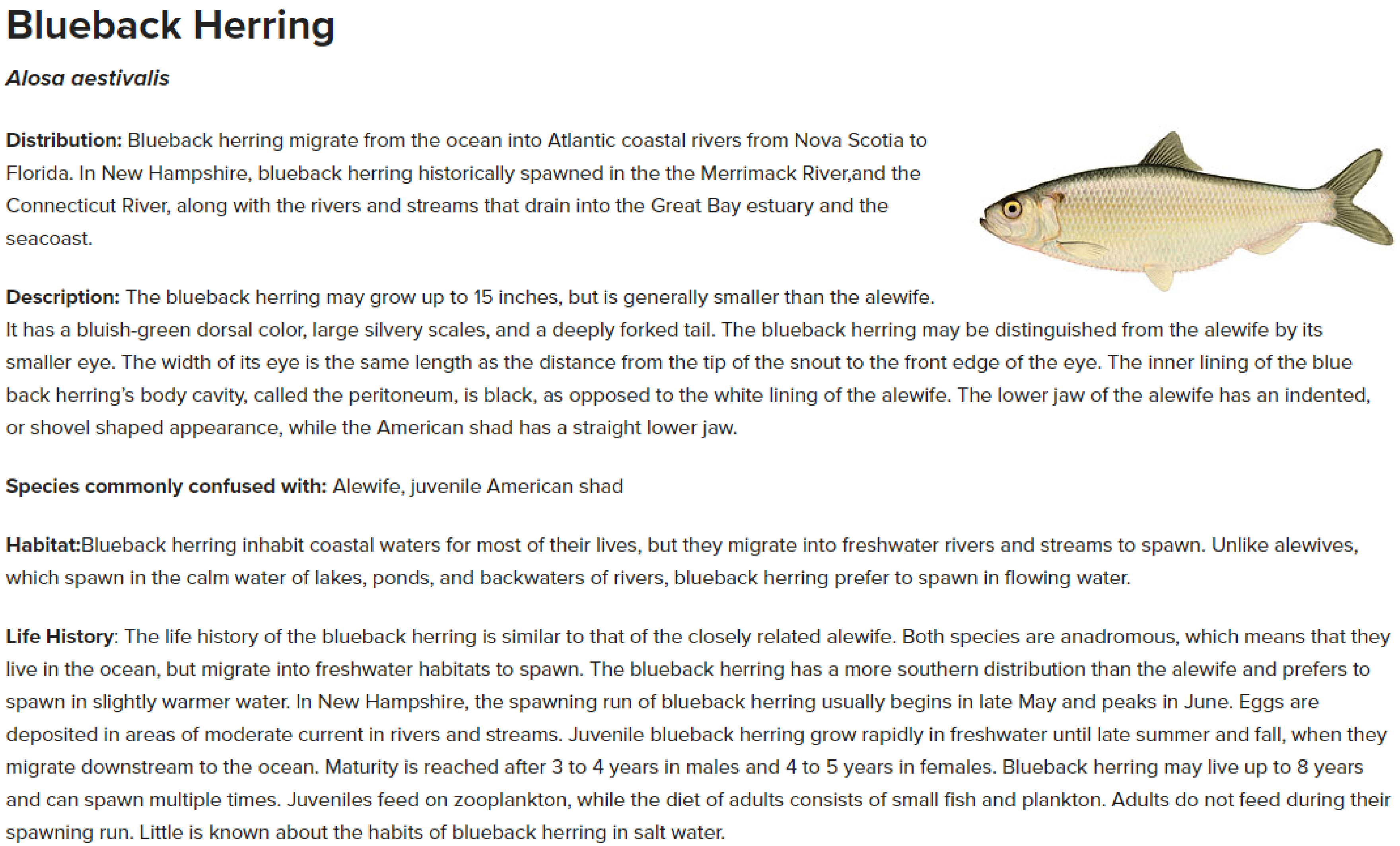
Life History: Alewives are members of the herring family. As with all members of the herring family, alewives spend the majority of their lives in the ocean. In the spring, adult alewives move into freshwater, migrating up coastal rivers from North Carolina to Newfoundland. Alewives spawn in lakes, ponds, and slow flowing backwaters of rivers. Juvenile alewives migrate downstream to the ocean in late summer and fall, where they will remain until sexual maturity in 3 to 5 years.

Origin: Native

Fish Species of NH | State of New Hampshire Fish and Game

Fish… desired migratory fish and spawning habitat

Note that Blueback Herring has been documented in the Concord River up to the Talbots Mill Dam.



Blueback Herring

Alosa aestivalis

Distribution: Blueback herring migrate from the ocean into Atlantic coastal rivers from Nova Scotia to Florida. In New Hampshire, blueback herring historically spawned in the the Merrimack River,and the Connecticut River, along with the rivers and streams that drain into the Great Bay estuary and the seacoast.

Description: The blueback herring may grow up to 15 inches, but is generally smaller than the alewife. It has a bluish-green dorsal color, large silvery scales, and a deeply forked tail. The blueback herring may be distinguished from the alewife by its smaller eye. The width of its eye is the same length as the distance from the tip of the snout to the front edge of the eye. The inner lining of the blue back herring's body cavity, called the peritoneum, is black, as opposed to the white lining of the alewife. The lower jaw of the alewife has an indented, or shovel shaped appearance, while the American shad has a straight lower jaw.

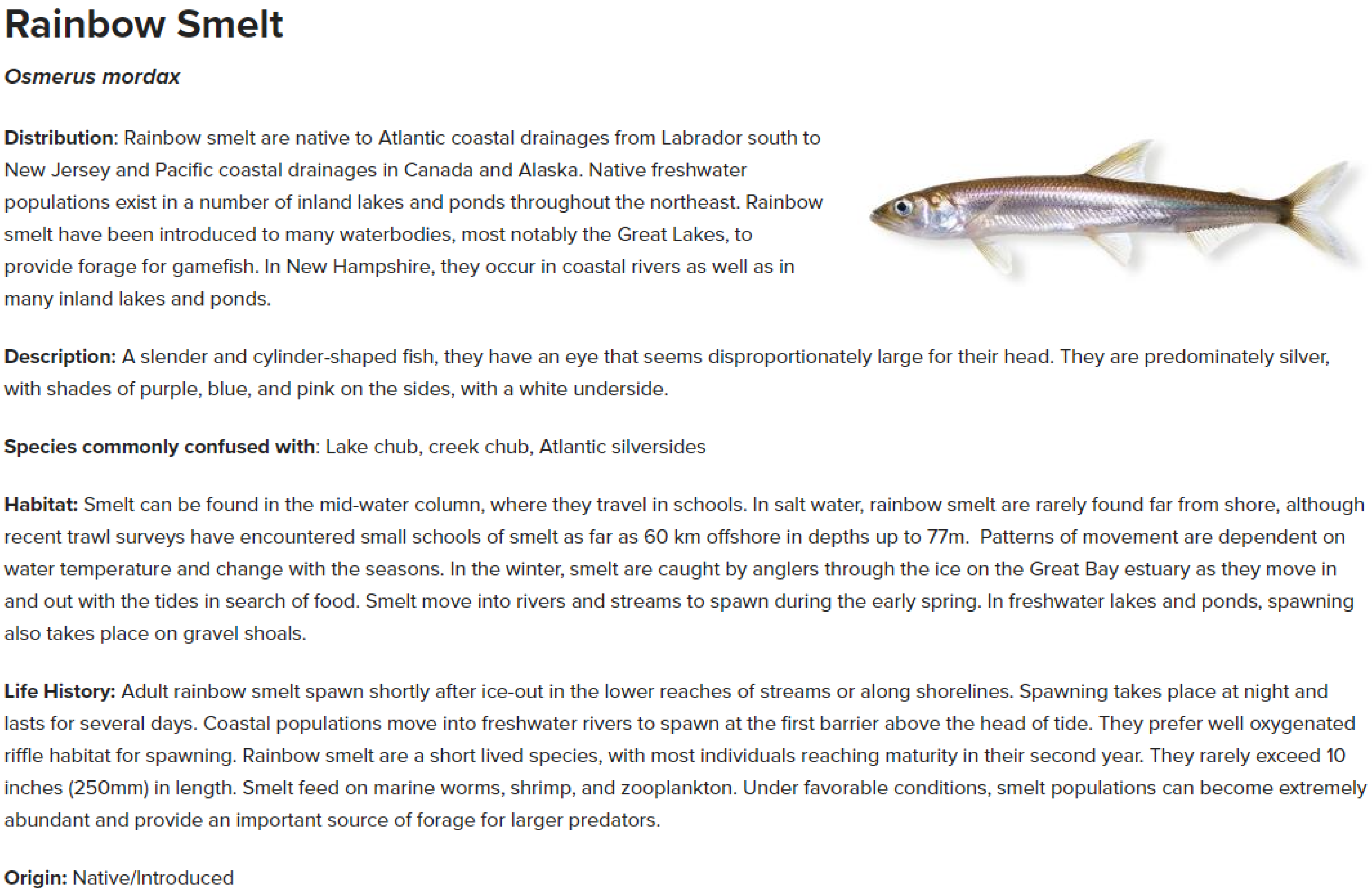
Species commonly confused with: Alewife, juvenile American shad

Habitat: Blueback herring inhabit coastal waters for most of their lives, but they migrate into freshwater rivers and streams to spawn. Unlike alewives, which spawn in the calm water of lakes, ponds, and backwaters of rivers, blueback herring prefer to spawn in flowing water.

Life History: The life history of the blueback herring is similar to that of the closely related alewife. Both species are anadromous, which means that they live in the ocean, but migrate into freshwater habitats to spawn. The blueback herring has a more southern distribution than the alewife and prefers to spawn in slightly warmer water. In New Hampshire, the spawning run of blueback herring usually begins in late May and peaks in June. Eggs are deposited in areas of moderate current in rivers and streams. Juvenile blueback herring grow rapidly in freshwater until late summer and fall, when they migrate downstream to the ocean. Maturity is reached after 3 to 4 years in males and 4 to 5 years in females. Blueback herring may live up to 8 years and can spawn multiple times. Juveniles feed on zooplankton, while the diet of adults consists of small fish and plankton. Adults do not feed during their spawning run. Little is known about the habits of blueback herring in salt water.

Fish… desired migratory fish and spawning habitat

Note that Rainbow Smelt is a Coldwater Fish, not likely suited for the warm water in Concord.



Rainbow Smelt

Osmerus mordax

Distribution: Rainbow smelt are native to Atlantic coastal drainages from Labrador south to New Jersey and Pacific coastal drainages in Canada and Alaska. Native freshwater populations exist in a number of inland lakes and ponds throughout the northeast. Rainbow smelt have been introduced to many waterbodies, most notably the Great Lakes, to provide forage for gamefish. In New Hampshire, they occur in coastal rivers as well as in many inland lakes and ponds.

Description: A slender and cylinder-shaped fish, they have an eye that seems disproportionately large for their head. They are predominately silver, with shades of purple, blue, and pink on the sides, with a white underside.

Species commonly confused with: Lake chub, creek chub, Atlantic silversides

Habitat: Smelt can be found in the mid-water column, where they travel in schools. In salt water, rainbow smelt are rarely found far from shore, although recent trawl surveys have encountered small schools of smelt as far as 60 km offshore in depths up to 77m. Patterns of movement are dependent on water temperature and change with the seasons. In the winter, smelt are caught by anglers through the ice on the Great Bay estuary as they move in and out with the tides in search of food. Smelt move into rivers and streams to spawn during the early spring. In freshwater lakes and ponds, spawning also takes place on gravel shoals.

Life History: Adult rainbow smelt spawn shortly after ice-out in the lower reaches of streams or along shorelines. Spawning takes place at night and lasts for several days. Coastal populations move into freshwater rivers to spawn at the first barrier above the head of tide. They prefer well oxygenated riffle habitat for spawning. Rainbow smelt are a short lived species, with most individuals reaching maturity in their second year. They rarely exceed 10 inches (250mm) in length. Smelt feed on marine worms, shrimp, and zooplankton. Under favorable conditions, smelt populations can become extremely abundant and provide an important source of forage for larger predators.

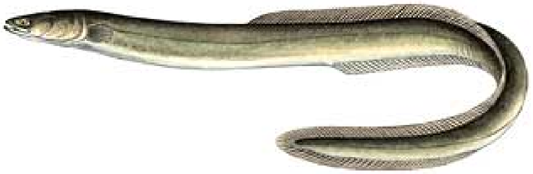
Origin: Native/Introduced

Fish… desired migratory fish and spawning habitat

Note: American Eel has been documented in Warner's Pond

American Eel

Anguilla rostrata



Distribution: The American eel ranges from Greenland and Labrador south to northern South America and west to the Mississippi Valley. Eels will ascend any accessible coastal river and were once found throughout New Hampshire. Their current distribution is limited by dams.

Description: A long, slender, snake-like fish with thick, slimy skin, a small mouth, and tiny scales. The dorsal, caudal, and anal fins are fused into one continuous fin that runs the length of the eel's body and wraps around the tail. Juvenile eels may be distinguished from lampreys by the presence of pelvic fins and a true jaw. American eels are usually dark brown to olive green on the back and grayish white below.

Species commonly confused with: Sea lamprey, American brook lamprey

Habitat: American eels may be found in almost any freshwater habitat that can be accessed from the ocean, although they reach their largest sizes and abundance in lakes, ponds, and larger rivers.

Life History: The American eel is the only catadromous species in New Hampshire waters. Adult eels migrate from freshwater rivers throughout the Atlantic coast to their spawning grounds in the Sargasso Sea. American eel larvae drift on ocean currents back to the coast line, where they migrate up rivers as juvenile eels, known as elvers. Juvenile eels have the ability to ascend obstacles that block other fish species. They can work their way through cracks in dams and climb vertical surfaces with only a trickle of water. However, dams and other barriers have greatly reduced the distribution of eels, which were once present in nearly all freshwater habitats that could be reached from the ocean. Eels may remain in freshwater for over 20 years before migrating back to the ocean. As adult eels prepare for their journey to the Sargasso Sea, their bodies undergo a transformation into what is known as the silver eel phase. Migration usually begins during the first significant rains of midsummer and continues into late fall. Silver eels do not eat as their bodies prepare for the transition into salt water. Female eels tend to migrate greater distances than males, which usually remain in estuarine habitat until sexual maturation. Hydropower turbines are a major cause of mortality as adult eels migrate downstream.

Origin: Native

Fish… desired migratory fish and spawning habitat

Note that White Perch can have a life cycle in freshwater and has been documented in Warner's Pond.

White Perch

Morone americana

Distribution: The white perch occurs in Atlantic slope drainages from the St.Lawrence River to South Carolina. Primarily a species of brackish water in nearshore habitats, the white perch has been introduced into a number of inland water bodies. White perch are relatively common in many lakes and ponds throughout New Hampshire.

Description: The white perch is related to the striped bass and the two species have similar fin structure, although the white perch is less streamlined and lacks the prominent lateral stripes of the striped bass. The white perch is silvery in color, with large scales, a dark lateral line, and two large spiny dorsal fins.

Species commonly confused with: Rock bass

Habitat: White perch are native to estuarine and coastal waters. They are often found over mud flats in tidal rivers. They have been introduced into a number of lakes and ponds, where they may be found in abundance at a variety of water depths.

Life History: White perch spawn in fresh or brackish water in tidal rivers. In lakes and ponds, white perch spawn in shallow water along the shoreline or in in the larger tributaries of the water body. Spawning usually takes place over a two week period in May or June, when water temperatures reach about 60°F (15°C). Spawning fish congregate in large groups, releasing eggs and sperm over a variety of substrates. White perch are a prolific species and may become extremely abundant in larger water bodies. A female may release between 20,000 and 300,000 eggs in the spring spawning season.

White perch usually live between 5 and 7 years. Fish eggs make up a large proportion of their diet when available, but they also feed on zooplankton, small minnows, and fish larvae. Feeding takes place in shallow water at night followed by a retreat to deeper water during the day. White perch are tolerant of a variety of habitat conditions, but they tend to thrive in water bodies that reach temperatures over 75°F (24°C).

Origin: Native/Introduced

Fish… desired migratory fish and spawning habitat

Note that Sea Lamprey has not been documented on the Merrimack or Concord Rivers west of the Essex Dam

Sea Lamprey

Petromyzon marinus

Distribution: The sea lamprey inhabits Atlantic coastal rivers throughout eastern North America and western Europe, as far south as the western Mediterranean Sea and the gulf coast of Florida. In New Hampshire, sea lamprey migrate into the Connecticut River, Merrimack River, and coastal rivers up to the first impassable barriers.

Description: An eel like fish with a disk-shaped mouth filled with concentric rings of teeth. Sea lamprey may be separated from brook lamprey by their teeth, which, in the brook lamprey, are small and arranged in clusters rather than rings. Adults reach a length of up to three feet and take on a mottled yellow and dark brown coloration during spawning. Larvae do not have teeth or fully developed eyes, but they have the same seven circular gill openings as the adults. The larvae, called ammocoetes, of sea lamprey and American brook lamprey may be distinguished by an unpigmented spot behind the nostril, which is twice the size of the nostril in the brook lamprey and smaller than the nostril in the sea lamprey. Lampreys that have recently reached maturity look like miniature 6- to 8-inch versions of the spawning adults except for their color, which is silvery gray.

Species commonly confused with: American brook lamprey, American eel

Habitat: The habitat preferences of sea lampreys in the ocean are not well understood. In fresh water, sea lampreys use river reaches with gravel substrate for spawning. Spawning habitat is similar to that used by salmon, occurring at the upstream end of riffles and the tail end of pools. Ammocoetes require fine silt and sand that is loose enough to burrow into, yet protected from washing away in higher flows. These areas often occur in the inside of river bends, along stream banks, and behind structures such as boulders or fallen trees.

Life History: Sea lampreys spend their adult lives in the ocean as parasites on fish, which they latch onto with their disk-shaped mouths. After feeding on the blood of multiple fish hosts, sea lampreys leave the ocean and migrate into coastal rivers, where they swim upstream in search of spawning areas. Sea lampreys build nests, or redds, in gravel substrate by rearranging rocks with their mouths. Spawning takes place over a shallow depression in the gravel, where the female will lay an average of 172,000 eggs. After hatching, larvae drift downstream to areas of fine silt and sand, which they burrow into. Known as ammocoetes, larval sea lampreys live as filter feeders in the sediment for up to five years. During their transformation into the adult phase, ammocoetes develop teeth, eyes, and change to a silvery gray color. These newly transformed sea lampreys make their way downstream to the ocean in search of a fish host. Migrating sea lampreys are able detect pheromones from ammocoetes, which they use to navigate to their spawning grounds.

Origin: Native

Fish… desired migratory fish and spawning habitat

Note that Shortnose sturgeon is a rare and endangered species and has not been documented on the Merrimack or Concord Rivers west of the Essex Dam

Shortnose Sturgeon

Acipenser brevirostrum

Distribution: Shortnose sturgeon are found in large coastal rivers and estuaries from New Brunswick south to Florida. Early records suggest that sturgeon were once able to move as far upstream on the Merrimack River as Amoskeag Falls. They were also once thought to be common in the Piscataqua River.

Description: Shortnose sturgeon have a prehistoric appearance, with a long pointy snout and 5 rows of hooked plates, called scutes, along its body instead of scales. They are a heavy bodied fish with an overall shape that resembles a shark in appearance. The large dorsal fin is positioned on the rear third of the body, just above the anal fin. The upper lobe of the caudal fin extends past the lower lobe. Shortnose sturgeon reach a length of about 4 feet, which is much smaller its relative, the Atlantic sturgeon, which can reach a length of 14 feet.

Species commonly confused with: Atlantic sturgeon

Habitat: Shortnose sturgeons occupy freshwater rivers, estuaries, and nearshore coastal habitat. They prefer to spawn in areas of a river with moderate flow and gravel or cobble substrate. Foraging areas are river sections that contain abundant benthic invertebrates, usually over sand or mud.

Life History: Adults return to specific spawning reaches in their natal rivers. They are a slow growing species, with age at maturity increasing as one moves north. In the St. John River, males may begin spawning within 1 to 2 years after reaching maturity (at 10 to 12 years), but females may not begin spawning until 5 years after reaching maturity (at 12 to 18 years). The average life span is about 30 years, but ages as high as 67 years have been documented.

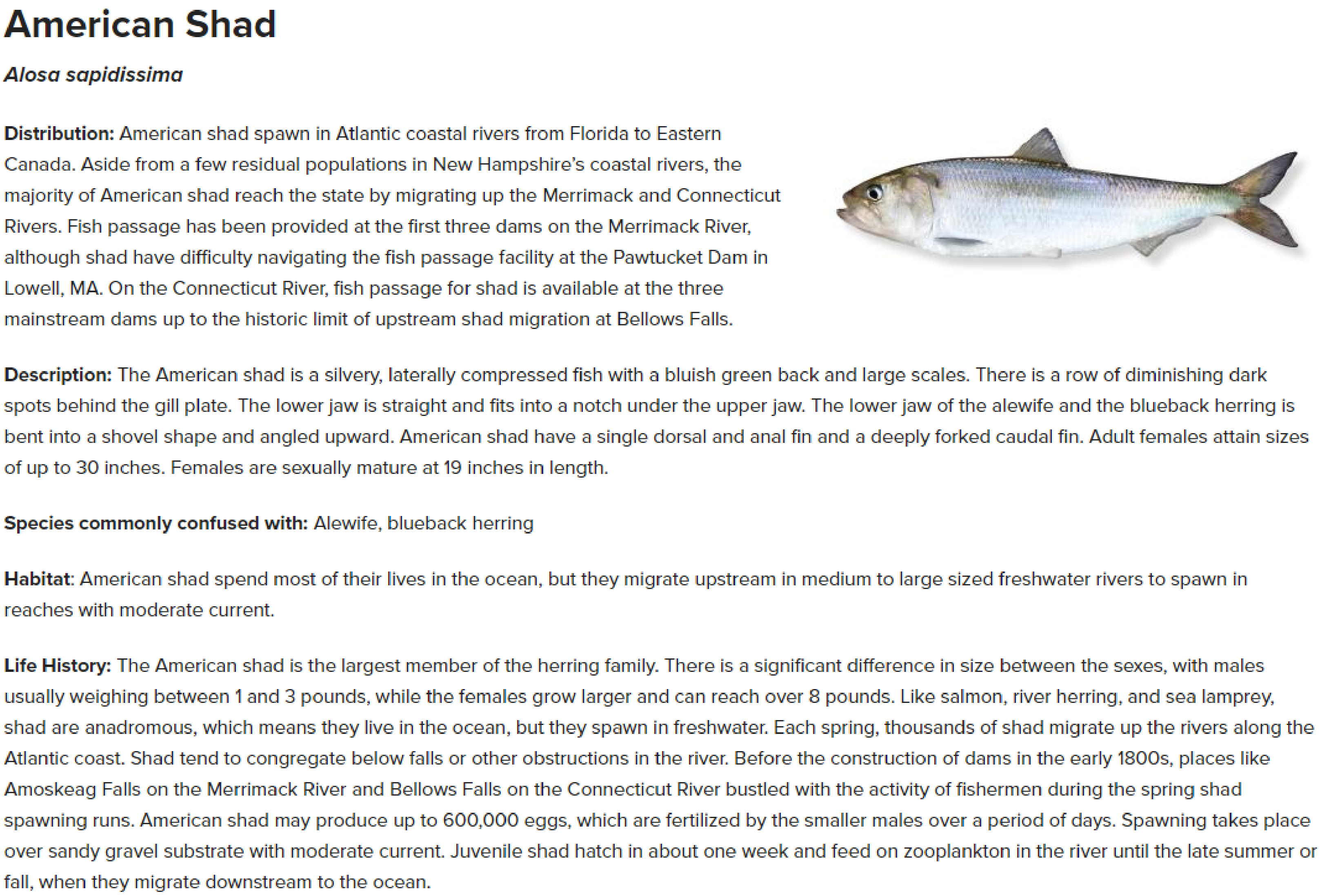
Spawning substrates consist of boulder, cobble, and gravel with water depths of 10 m or less. Water temperatures during spawning range from 9.0 to 18.0°C. Spawning runs were observed during late April in the Merrimack River, Massachusetts. Adults forage on sandy and muddy substrates often near the upper reaches of tidal influence. They use fleshy barbels on their pointed snouts to detect benthic invertebrates with their sucker-like mouths, which they use to vacuum up their prey. Shortnose sturgeon remain in preferred river reaches for overwintering. In northern populations they do not feed during the winter months.

Recent tagging studies using acoustic telemetry have revealed that some shortnose sturgeon are more migratory than previously believed. Individuals tagged in the Kennebec and Penobscot Rivers have been found to move between the two river systems. Shortnose sturgeon tagged in the Merrimack River have been detected in the Kennebec River. Multiple tagged individuals have been detected by acoustic telemetry receivers deployed forunrelated projects in the Piscataqua River and Great Bay. It is possible that shortnose sturgeon routinely move between multiple foraging areas among the rivers and estuaries that flow into the Gulf of Maine.

Origin: Native

Fish… desired migratory fish and spawning habitat

Note that American Shad has been documented in the Concord River up to the Talbots Mill Dam.



American Shad

Alosa sapidissima

Distribution: American shad spawn in Atlantic coastal rivers from Florida to Eastern Canada. Aside from a few residual populations in New Hampshire's coastal rivers, the majority of American shad reach the state by migrating up the Merrimack and Connecticut Rivers. Fish passage has been provided at the first three dams on the Merrimack River, although shad have difficulty navigating the fish passage facility at the Pawtucket Dam in Lowell, MA. On the Connecticut River, fish passage for shad is available at the three mainstream dams up to the historic limit of upstream shad migration at Bellows Falls.

Description: The American shad is a silvery, laterally compressed fish with a bluish green back and large scales. There is a row of diminishing dark spots behind the gill plate. The lower jaw is straight and fits into a notch under the upper jaw. The lower jaw of the alewife and the blueback herring is bent into a shovel shape and angled upward. American shad have a single dorsal and anal fin and a deeply forked caudal fin. Adult females attain sizes of up to 30 inches. Females are sexually mature at 19 inches in length.

Species commonly confused with: Alewife, blueback herring

Habitat: American shad spend most of their lives in the ocean, but they migrate upstream in medium to large sized freshwater rivers to spawn in reaches with moderate current.

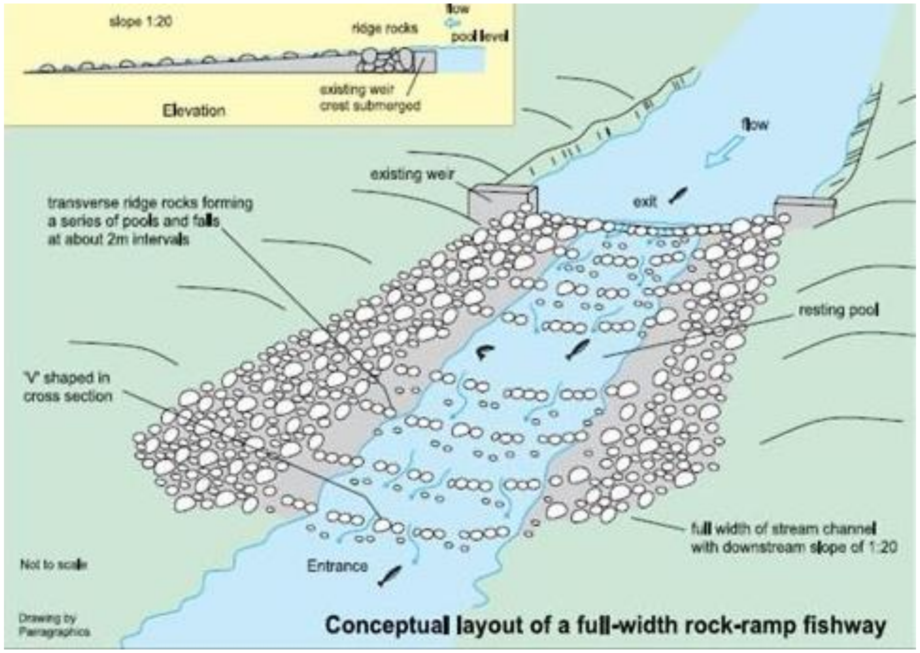
Life History: The American shad is the largest member of the herring family. There is a significant difference in size between the sexes, with males usually weighing between 1 and 3 pounds, while the females grow larger and can reach over 8 pounds. Like salmon, river herring, and sea lamprey, shad are anadromous, which means they live in the ocean, but they spawn in freshwater. Each spring, thousands of shad migrate up the rivers along the Atlantic coast. Shad tend to congregate below falls or other obstructions in the river. Before the construction of dams in the early 1800s, places like Amoskeag Falls on the Merrimack River and Bellows Falls on the Connecticut River bustled with the activity of fishermen during the spring shad spawning runs. American shad may produce up to 600,000 eggs, which are fertilized by the smaller males over a period of days. Spawning takes place over sandy gravel substrate with moderate current. Juvenile shad hatch in about one week and feed on zooplankton in the river until the late summer or fall, when they migrate downstream to the ocean.

Alternative: Construction of a naturalized fish passageway on the Auxiliary Spillway

Fish Passageway

A fish ladder was considered during the 2007-2008 dam reconstruction design. However, due to other area fish obstructions it was decided not to pursue a fish passageway at that time. It was noted by the Engineer at that time that the auxiliary spillway could be retrofitted to include a fish passageway into the pond. The low elevation and flat grade of the auxiliary spillway, along with the existing rock and rip-rap channel, indicates that an alternative (and low cost) approach to conventional fish ladders may be possible. Specifically, a naturalized channel as shown below mimics natural river channels by providing a gradually sloping, open channel with a coarse streambed consisting of gravel and boulders to mimic a series of riffles and pools. This would simply be an enhancement of the existing spillway and provides a “hybrid” approach alternative to dam removal.

Naturalized fish passageway:

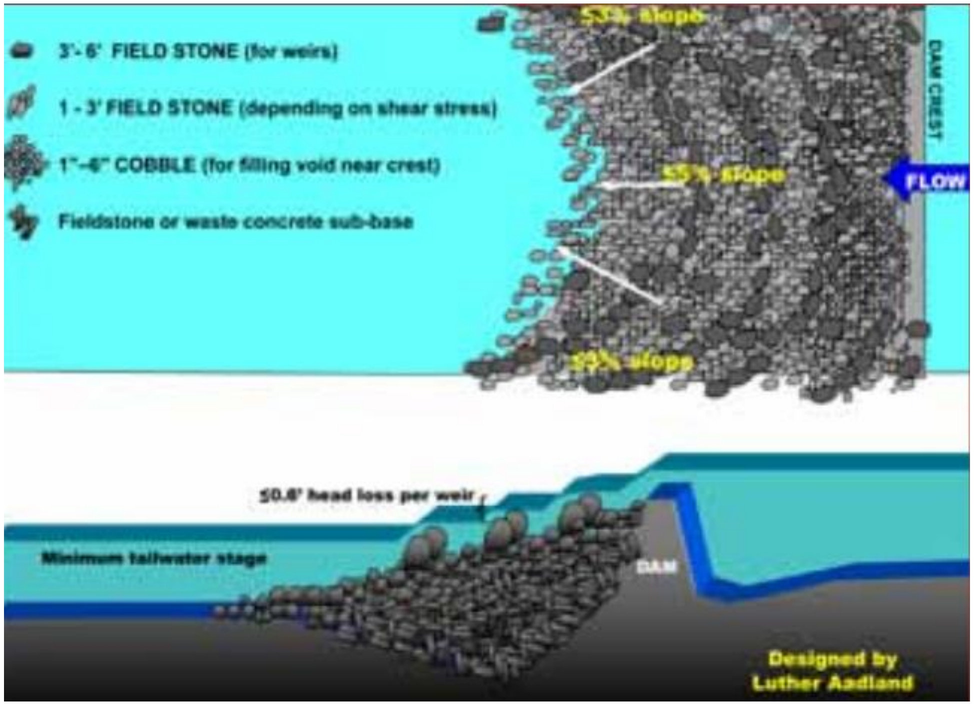


Naturalized Fish Passageway

The proposed fish pass is effectively a “Rock Ramp” alternative per USFWS.

In contrast to the dam removal proposal which would provide channelized fish access to a small (+/- 4 acre) pond with a low water level, this approach provides channelized fish passage with a complex flow regime and fish access to a large (54 acre), deeper pond.

Naturalized fish passageway examples:



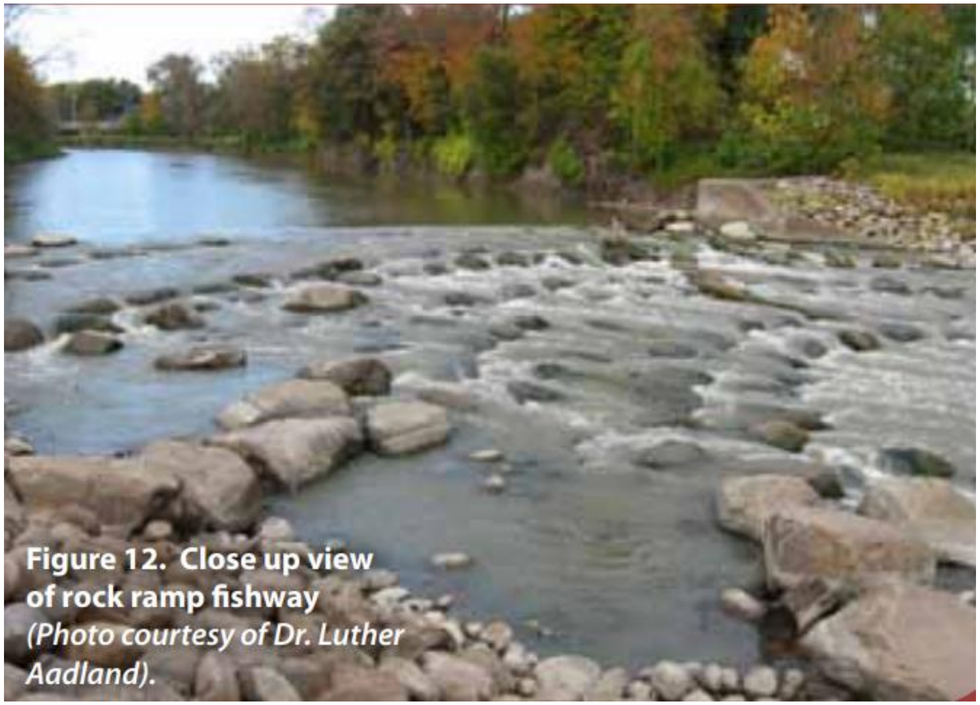


Figure 12. Close up view of rock ramp fishway *(Photo courtesy of Dr. Luther Aadland).*

[Nature-like Fishways | Salmonid Restoration Federation (calsalmon.org)]

[Reconnecting Rivers: Natural Channel Design in Dam Removals and Fish Passage | Minnesota DNR (state.mn.us)]

Naturalized Fish Passageway

The low spillway height (about 2 feet) along with the constructed "riffle" type discharge channel and Stilling Pool would appear to make the Auxiliary Spillway a good candidate for this type of "hybrid" approach. The water level downstream of the auxiliary spillway is currently observed slightly higher than the main spillway – also beneficial to this approach. E.g., During the 2023 Phase I Dam Inspection, pond water elevations were observed to be at 119.3 feet NAVD88 (0.5 foot above Normal Pool), 115.1 feet NAVD88 downstream of main spillway, and 116.5 feet NAVD88 downstream of the auxiliary spillway.

Naturalized fish passageway examples:

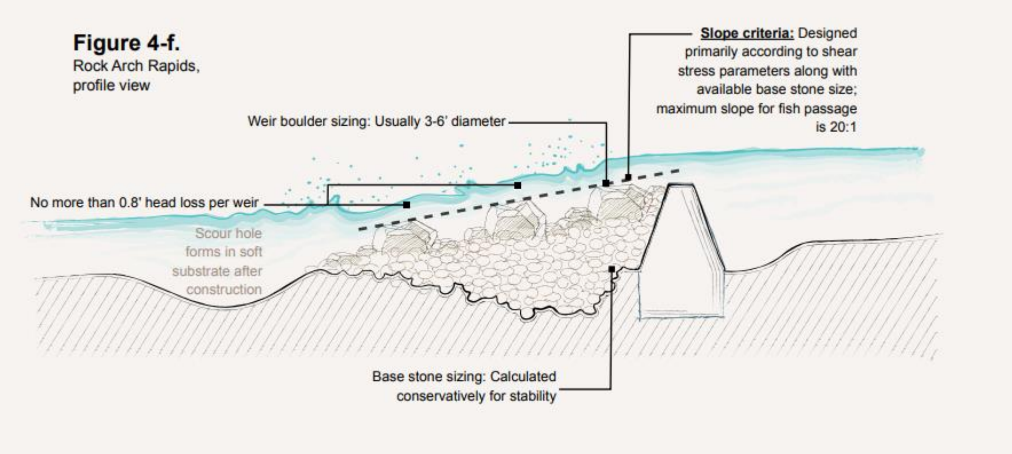


Figure 4-f.
Rock Arch Rapids,
profile view

Slope criteria: Designed primarily according to shear stress parameters along with available base stone size; maximum slope for fish passage is 20:1

Weir boulder sizing: Usually 3-6' diameter

No more than 0.8' head loss per weir

Scour hole forms in soft substrate after construction

Base stone sizing: Calculated conservatively for stability

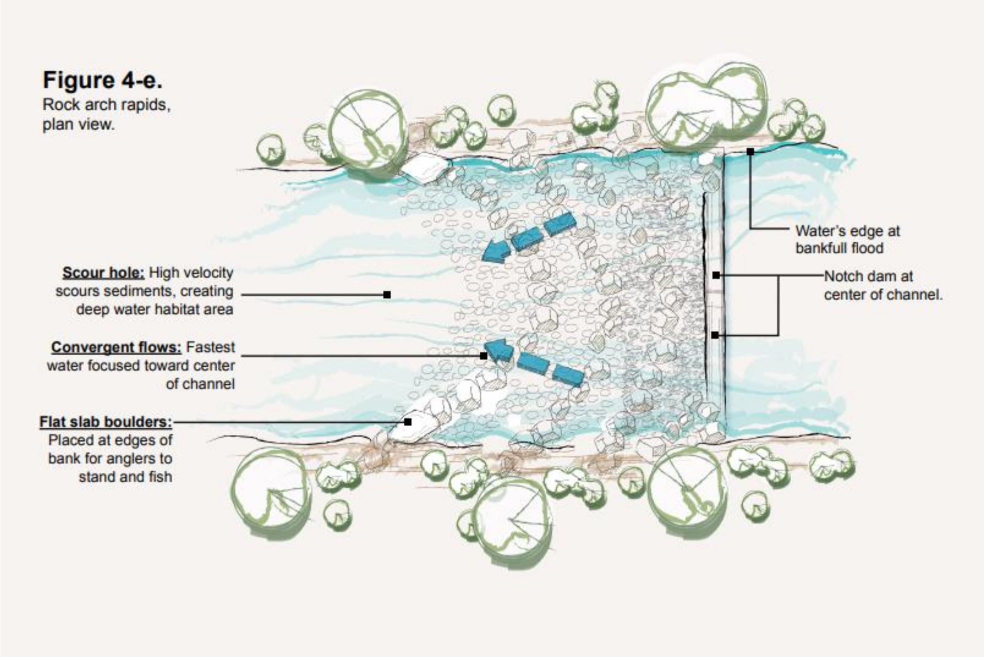


Figure 4-e.
Rock arch rapids,
plan view.

Scour hole: High velocity scours sediments, creating deep water habitat area

Convergent flows: Fastest water focused toward center of channel

Flat slab boulders: Placed at edges of bank for anglers to stand and fish

Water's edge at bankfull flood

Notch dam at center of channel.

[dam_chap4.pdf (iowadnr.gov)](dam_chap4.pdf)

Naturalized Fish Passageway

Can a naturalized fish pass work for the specific fish of interest? This would require detailed evaluation and deign. However, there are significant resources, including the USGS, USFWS and the Massachusetts Division of Marine Fisheries, in Massachusetts to assist with confirming feasibility and design. The National Fish Passage Program provides financial and technical assistance for projects that improve the ability of fish or other aquatic species to migrate by reconnecting habitat that has been fragmented by a barrier such as a dam or culvert. U.S. Fish and Wildlife Service biologists and engineers are available to provide assistance in the planning, design, implementation, and monitoring of select fish passage projects.

The five species that most often require passage and management considerations in Massachusetts rivers are **river herring (alewife and blueback herring), American shad, American eel and rainbow smelt**. Note that rainbow smelt is not likely a candidate in the wqters in West Concord.

Questions: Streamflow in Nashoba Brook downstream of the dam is modified and limited. Does it meet the optimized passage thresholds? Will the new stream channel, should the dam be removed, meet the optimized passage thresholds?

Example of specialized design considerations (see next slide for general design considerations):

American Shad:
(Note: Low percentage of American Shad pass the Essex Dam on the Merrimack).

- generally only pass obstructions by swimming. Likely achievable with naturalized pass at Warner's Pond
- water velocities over distances greater than 80 to 100 feet should be less than 6 to 7 fps. Can handle burst speeds of 13 to 16 fps: Likely achievable with naturalized pass at Warner's Pond
- tend to move in the upper layer of the water column and hesitate to pass through submerged openings: surface passage must therefore be provided in the fishway. Likely achievable with naturalized pass at Warner's Pond
- appear to need a definite current to orientate. In static or very turbulent water the species become disorientated. They seem to prefer laminar, streaming flow, even if it has a significant velocity. Likely achievable with naturalized pass at Warner's Pond, with laminar flow sections
- too small a volume of water, even for a short period, may result in a high mortality rate. Need to be check. Existing stilling pool may be a benefit
- appears to be very sensitive to sudden changes in light. Likely achievable with naturalized pass at Warner's Pond

https://www.kmae-journal.org/articles/kmae/pdf/2002/04/kmae2002364s135.pdf

https://www.mass.gov/doc/fish-passage-guidelines-2020/download
https://www.fws.gov/service/fish-passage-technical-and-planning-assistance

Naturalized Fish Passageway

General Massachusetts Design Considerations:

Fishway Pool Depth. The Federal recommendation for minimum pool depth = 1 ft + 4*body depth (BD) of target species. Pool depth can be independent of river discharge. For this reason, all new fishway construction should use the Federal threshold and rely on calculations of Energy Dissipation Factor (EDF). For fishway reconstruction in small watersheds with physical limitations, a minimum pool depth of 2 ft should be evaluated. The DMF Fishway Operation and Maintenance Plan for each fishway should include direction on maintaining pool depth.

Fishway Elevation Change. Diadromous fish generally favor elevation changes at fishway weirs with low turbulence and air entrainment, and vertical transitions of < 1 ft. DMF has long used a target elevation change between fishway weirs of 6”. This can be modified based on pool length and depth.

Fishway Weir Velocity. Haro et al. (2004) recommended 1.0 m/s as the upper limit for channel restrictions. Turek et al. (2016) recommended 6 ft/s (1.8 m/s) as the maximum weir opening velocity for river herring. In practice, view 1.0 m/s as the upper end of rainbow smelt swimming ability through restricted passageways, and 2.0 m/s as a similar metric for river herring. Depending on slope and characteristics of the run leading up to the restriction, smelt and herring may be able to pass higher velocities. However, 1-2 m/s is a suitable range to consider based on species presence.

Fishway Weir Width. The Federal recommendation for Fishway Weir Width = 2 * maximum total length (TL). This won’t be practical for rivers with low discharge. Hydrologic and hydraulic analyses should be used to size weir width when available. Otherwise, DMF recommends a minimum of 6” surface notches for flow-limited watersheds and to prevent excessive drawdown of impoundments.

Fishway Weir Depth. The Federal recommendation for Fishway Weir Depth = 3* BD of largest species. This should be the optimal target; however, by necessity, DMF targets a minimum of 6” in flow-limited watersheds and to prevent excessive drawdown of impoundments. Submergence depth (difference in elevation from pool water surface to upstream weir notch) is a critical factor related to weir depth. In all cases, there should be some level of positive submergence at the weir notch and designs should not allow the lack of submergence.

https://www.kmae-journal.org/articles/kmae/pdf/2002/04/kmae2002364s135.pdf

https://www.mass.gov/doc/fish-passage-guidelines-2020/download
https://www.fws.gov/service/fish-passage-technical-and-planning-assistance

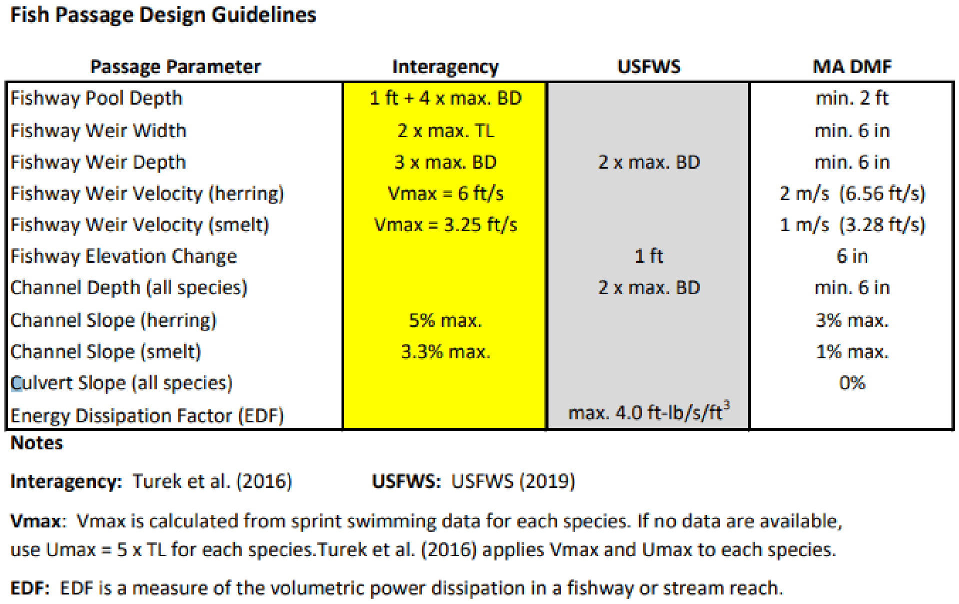
Naturalized Fish Passageway

General Massachusetts Design Considerations cont.:

Channel Depth. The Federal recommendation for channel depth = 2 x BD of target species. For river herring, this is similar to the 6” minimum channel depth long used by DMF for spring migrations.

Channel Slope. Determining channel slope for species is a highly quantified process requiring measures for channel geometry, substrate friction and species swimming performance. For nature-like fishways, Turek et al. (2016) recommended a maximum 1:20 (5%) slope for river herring and 1:30 (3.3%) for shad and smelt. In practice, DMF has found that these maximum slopes can impede passage, especially under straight “raceway” conditions. Therefore, DMF recommends a maximum 3% slope for river herring and 1% or less for smelt for channels and nature-like fishways with no weirs to grade elevation changes.

Channel/Culvert Velocity. Channel restrictions and culverts in river herring runs should be designed to not exceed 1.0 m/s (for flows > 5% exceedance).



Fish Passage Design Guidelines

Passage Parameter	Interagency	USFWS	MA DMF
Fishway Pool Depth	1 ft + 4 x max. BD		min. 2 ft
Fishway Weir Width	2 x max. TL		min. 6 in
Fishway Weir Depth	3 x max. BD	2 x max. BD	min. 6 in
Fishway Weir Velocity (herring)	Vmax = 6 ft/s		2 m/s (6.56 ft/s)
Fishway Weir Velocity (smelt)	Vmax = 3.25 ft/s		1 m/s (3.28 ft/s)
Fishway Elevation Change		1 ft	6 in
Channel Depth (all species)		2 x max. BD	min. 6 in
Channel Slope (herring)	5% max.		3% max.
Channel Slope (smelt)	3.3% max.		1% max.
Culvert Slope (all species)			0%
Energy Dissipation Factor (EDF)		max. 4.0 ft-lb/s/ft^3	

Notes

Interagency: Turek et al. (2016) **USFWS:** USFWS (2019)

Vmax: Vmax is calculated from sprint swimming data for each species. If no data are available, use Umax = 5 x TL for each species.Turek et al. (2016) applies Vmax and Umax to each species.

EDF: EDF is a measure of the volumetric power dissipation in a fishway or stream reach.

https://www.mass.gov/doc/fish-passage-guidelines-2020/download

Spawning Habitat for Desired Migratory Fish

Aquatic connectivity refers to physically linked pathways through which energy, matter, and organisms move from one place to another through water. It includes longitudinal connectivity upstream and downstream, vertical movement within a water column, as well as lateral connectivity of the main waterbody to riparian and floodplain habitat, all of which play a vital role in a functioning aquatic ecosystem. At Warner's Pond, connectivity can likely be provided via: 1) a fish pass; and/or 2) dam breaching or removal. Of the diadromous species being considered in either case, the objective benefit is to provide a quality spawning habitat. American Ell and White Perch appear to already be documented in Warner's Pond and tributaries. So…the additional fish under consideration include: **alewife, blueback herring and american shad.**

Question:

1. Which is a better spawning environment: 1) 40+ acre, variable depth pond within an 86-acre wetland system and sections of narrow shallow stream channel; or 2) a 4,700-foot long, narrow and shallow stream channel in an area of uncertain wetland viability and a very shallow, warm 4.5-acre pond?

2. Based on spawning and life cycle conditions, it seems like it makes sense to promote access to the Concord and Assabet Rivers for these fish, but is Alewife the only candidate to benefit from a fish pass or dam removal at Warner's Pond? If so, will they benefit from a much larger pond than a channel and small pond?

Spawning Habitat:

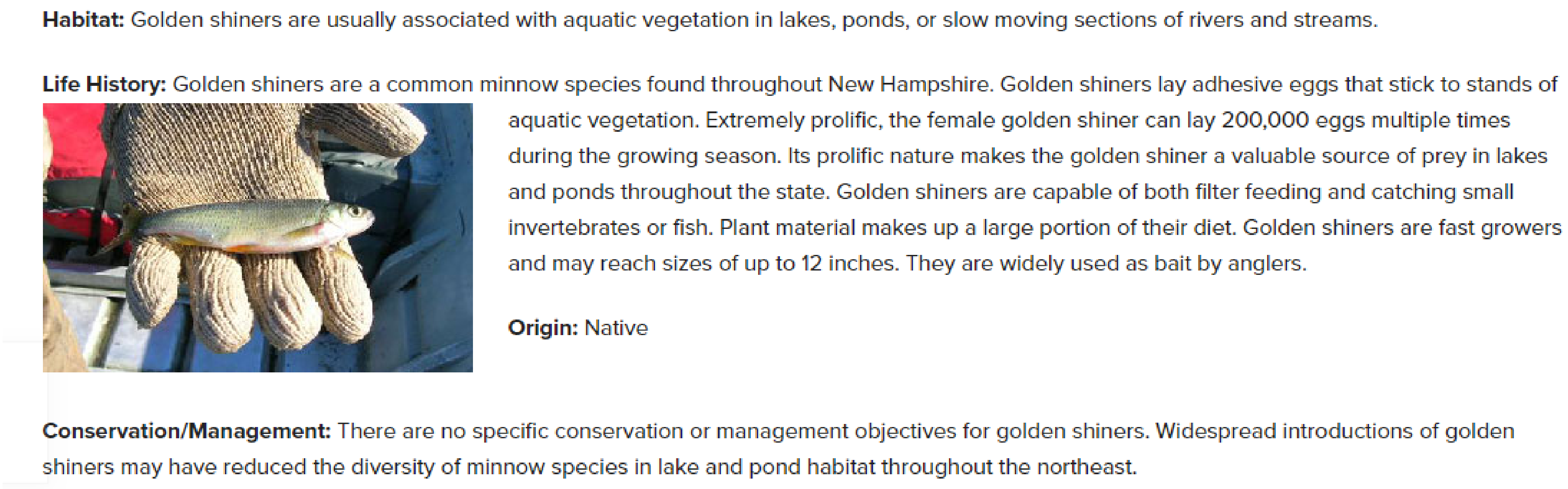
> **Alewife:** Habitat includes ponds, freshwater river, estuaries and coastal habitats. Spawn in lakes, ponds and slow flowing backwaters of rivers. Juveniles migrate downstream to the ocean in late Summer and Fall. Essex Dam?
>
> **Blueback Herring:** Most of life is spent in coastal waters, but they migrate into freshwater rivers and streams to spawn. Spawn in flowing water. Grow in freshwater until late Summer and Fall when they migrate downstream to the ocean Essex Dam?
>
> **American Shad**: Most of life is spent in ocean waters, but they migrate into medium to large sized freshwater river to spawn in reaches with moderate current (e.g., Assabet River but not joining tributaries like Nashoba Brook.) Spawning takes place over sandy gravel substrate?

Spawning Habitat for Fish Currently in Warner’s Pond and tributaries

Questions: Would the existing fish benefit from dam removal, in consideration that their current pond habitat and possibly wetland would be lost? Would the existing fish benefit from a fish pass?

Spawning Habitat:

Example Golden Shiner:



Habitat: Golden shiners are usually associated with aquatic vegetation in lakes, ponds, or slow moving sections of rivers and streams.

Life History: Golden shiners are a common minnow species found throughout New Hampshire. Golden shiners lay adhesive eggs that stick to stands of aquatic vegetation. Extremely prolific, the female golden shiner can lay 200,000 eggs multiple times during the growing season. Its prolific nature makes the golden shiner a valuable source of prey in lakes and ponds throughout the state. Golden shiners are capable of both filter feeding and catching small invertebrates or fish. Plant material makes up a large portion of their diet. Golden shiners are fast growers and may reach sizes of up to 12 inches. They are widely used as bait by anglers.

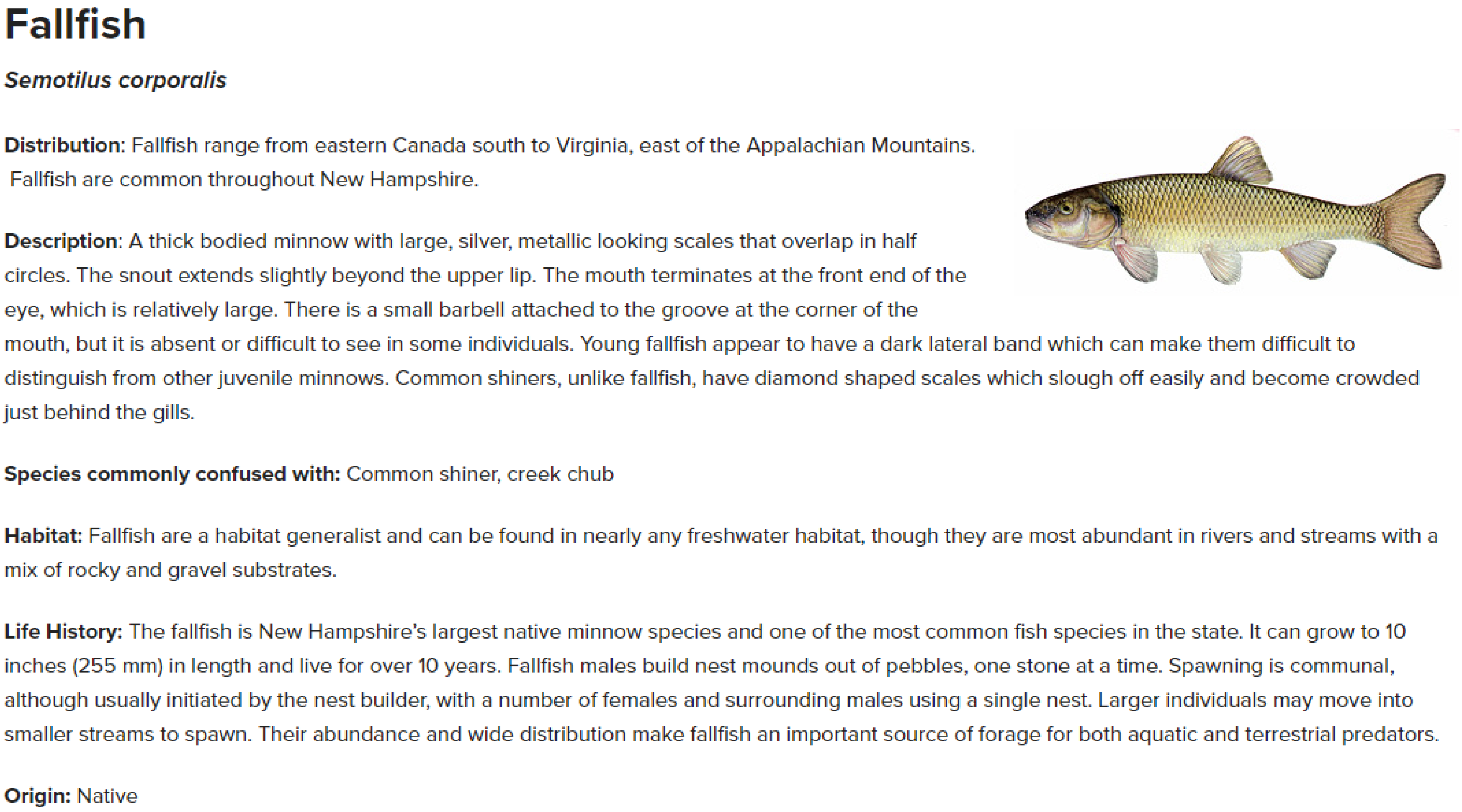
Origin: Native

Conservation/Management: There are no specific conservation or management objectives for golden shiners. Widespread introductions of golden shiners may have reduced the diversity of minnow species in lake and pond habitat throughout the northeast.

Spawning Habitat for Fish Currently in Warner's Pond and tributaries

Questions: Would the existing fish benefit from dam removal, in consideration that their current pond habitat and possible wetland would be lost? Would the existing fish benefit from a fish pass?

Spawning Habitat:



Fallfish

Semotilus corporalis

Distribution: Fallfish range from eastern Canada south to Virginia, east of the Appalachian Mountains. Fallfish are common throughout New Hampshire.

Description: A thick bodied minnow with large, silver, metallic looking scales that overlap in half circles. The snout extends slightly beyond the upper lip. The mouth terminates at the front end of the eye, which is relatively large. There is a small barbell attached to the groove at the corner of the mouth, but it is absent or difficult to see in some individuals. Young fallfish appear to have a dark lateral band which can make them difficult to distinguish from other juvenile minnows. Common shiners, unlike fallfish, have diamond shaped scales which slough off easily and become crowded just behind the gills.

Species commonly confused with: Common shiner, creek chub

Habitat: Fallfish are a habitat generalist and can be found in nearly any freshwater habitat, though they are most abundant in rivers and streams with a mix of rocky and gravel substrates.

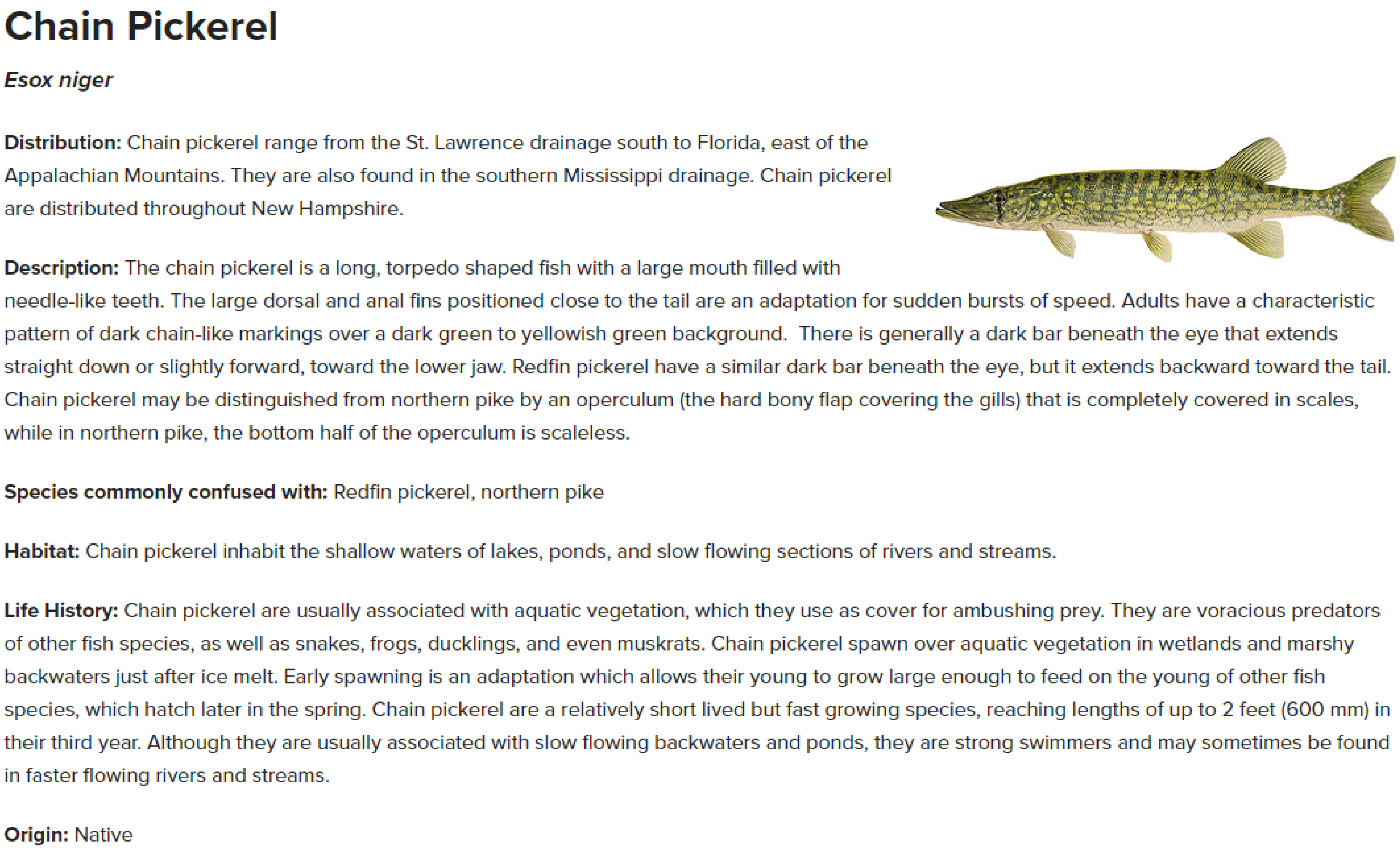
Life History: The fallfish is New Hampshire's largest native minnow species and one of the most common fish species in the state. It can grow to 10 inches (255 mm) in length and live for over 10 years. Fallfish males build nest mounds out of pebbles, one stone at a time. Spawning is communal, although usually initiated by the nest builder, with a number of females and surrounding males using a single nest. Larger individuals may move into smaller streams to spawn. Their abundance and wide distribution make fallfish an important source of forage for both aquatic and terrestrial predators.

Origin: Native

Spawning Habitat for Fish Currently in Warner's Pond and tributaries

Questions: Would the existing fish benefit from dam removal, in consideration that their current pond habitat and possibly wetland would be lost? Would the existing fish benefit from a fish pass?.

Spawning Habitat:



Chain Pickerel

Esox niger

Distribution: Chain pickerel range from the St. Lawrence drainage south to Florida, east of the Appalachian Mountains. They are also found in the southern Mississippi drainage. Chain pickerel are distributed throughout New Hampshire.

Description: The chain pickerel is a long, torpedo shaped fish with a large mouth filled with needle-like teeth. The large dorsal and anal fins positioned close to the tail are an adaptation for sudden bursts of speed. Adults have a characteristic pattern of dark chain-like markings over a dark green to yellowish green background. There is generally a dark bar beneath the eye that extends straight down or slightly forward, toward the lower jaw. Redfin pickerel have a similar dark bar beneath the eye, but it extends backward toward the tail. Chain pickerel may be distinguished from northern pike by an operculum (the hard bony flap covering the gills) that is completely covered in scales, while in northern pike, the bottom half of the operculum is scaleless.

Species commonly confused with: Redfin pickerel, northern pike

Habitat: Chain pickerel inhabit the shallow waters of lakes, ponds, and slow flowing sections of rivers and streams.

Life History: Chain pickerel are usually associated with aquatic vegetation, which they use as cover for ambushing prey. They are voracious predators of other fish species, as well as snakes, frogs, ducklings, and even muskrats. Chain pickerel spawn over aquatic vegetation in wetlands and marshy backwaters just after ice melt. Early spawning is an adaptation which allows their young to grow large enough to feed on the young of other fish species, which hatch later in the spring. Chain pickerel are a relatively short lived but fast growing species, reaching lengths of up to 2 feet (600 mm) in their third year. Although they are usually associated with slow flowing backwaters and ponds, they are strong swimmers and may sometimes be found in faster flowing rivers and streams.

Origin: Native

Attachment 6
Warner's Pond Recreational and Community Benefits

Introduction

The future of Warner's Pond is being considered by the Town government and citizens. Although the Town's policy relative to Warner's Pond has consistently, over the last 40 years, been to invest in the improvement, restoration and recreational enhancement of the Pond. Very recently, the Town of Concord Natural Resources Commission has pursued removal of the dam and pond.

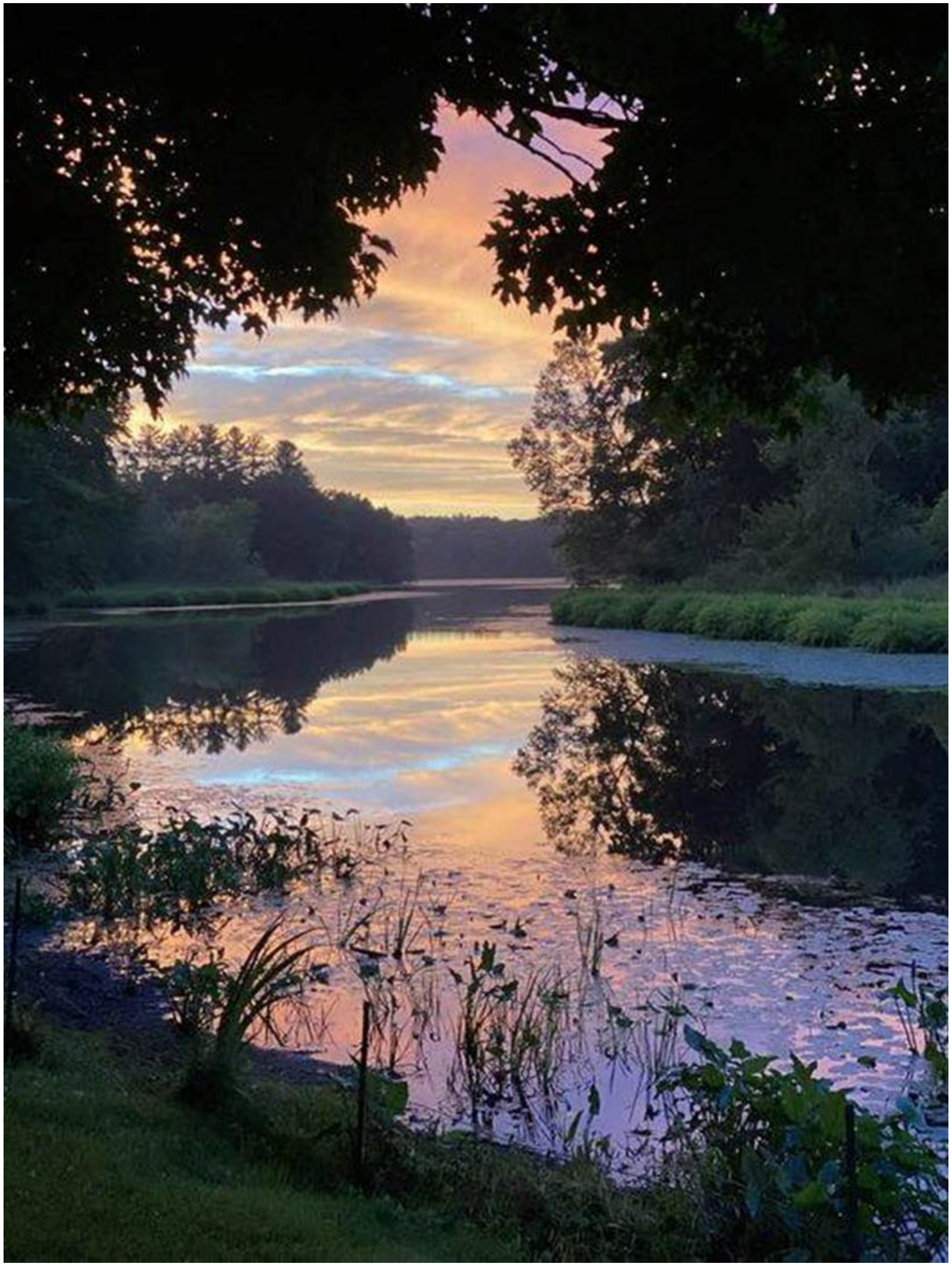
Alternatives ranging from dam removal to pond restoration, enhancement and management are presented, discussed and compared.

Warner's Pond is a 54-acre jewel located as a welcoming entrance to West Concord Village, a vibrant neighborhood and cultural district in Concord, MA and home to many locally-owned businesses, artists and restaurants.

The Pond is a key component of West Concord's community, culture and history, and provides unique walkable access from the Village to water, trails, waterfront and views of scenic landscape, with adjacent parks and public water access - all located along the Commonwealth Avenue entrance to West Concord Village and the West Concord Cultural District.

Although the impoundment that creates the Pond originated as part of the Industrial Revolution and founding of West Concord during the early 1800s, the Pond has provided over 165 years of recreational, aesthetic, natural and ecological benefits to the citizens of Concord and visitors. Its current, renewed importance to West Concord residents and visitors, in coincidence with on-going redevelopment and revitalization of West Concord Village, is only beginning come into focus.

This attachment looks at the recreational and community benefits of Warner's Pond.



Community, Culture and History

Warner’s Pond came into being starting with a small dam in the late 1600s. The current configuration of the Pond was created in the 1850s after Ralph Warner elevated the pond dam for powering the factory equipment for the Warner Pail and Tub Factory, located at the fork of Laws Brook Road and Commonwealth Avenue. Concord Junction, one of three early West Concord villages, grew up around the factory. In 2007/2008 the dam was completely rehabilitated by the Town.

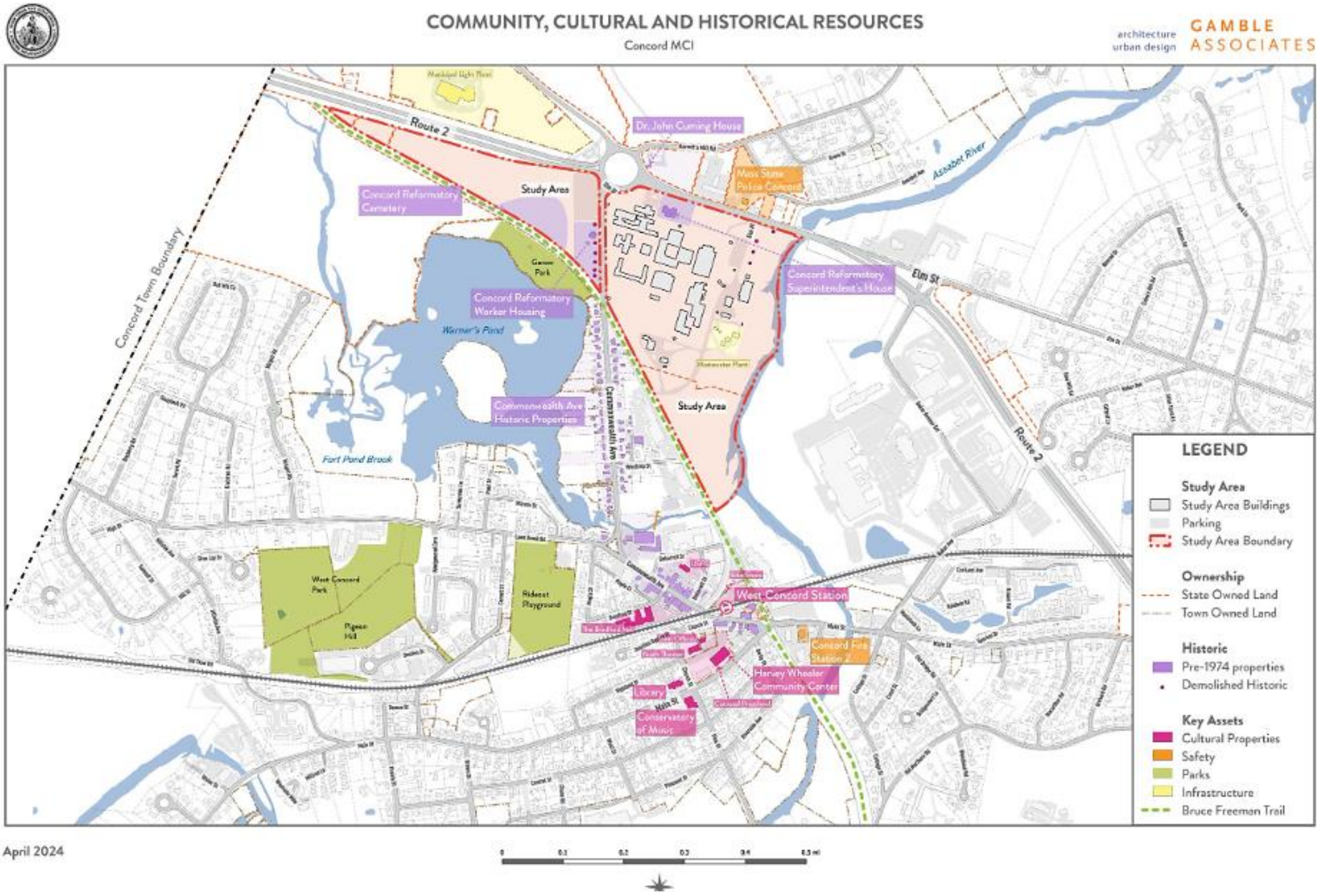
As shown on the map (next slide) of West Concord Community, Cultural and Historical Resources, Warner’s Pond continues to be a key historic, cultural aesthetic community resource in West Concord.

The decision to close the MCI Prison has opened up potential opportunities for further recreational and community benefits (e.g., a Pond circumference trail).

Warner’s Pond current, renewed importance to West Concord residents and visitors, in coincidence with on-going redevelopment and revitalization of West Concord Village, is only beginning come into focus.

https://www.mass.gov/files/documents/2016/08/vo/concord-with-map.pdf

Community, Culture and History



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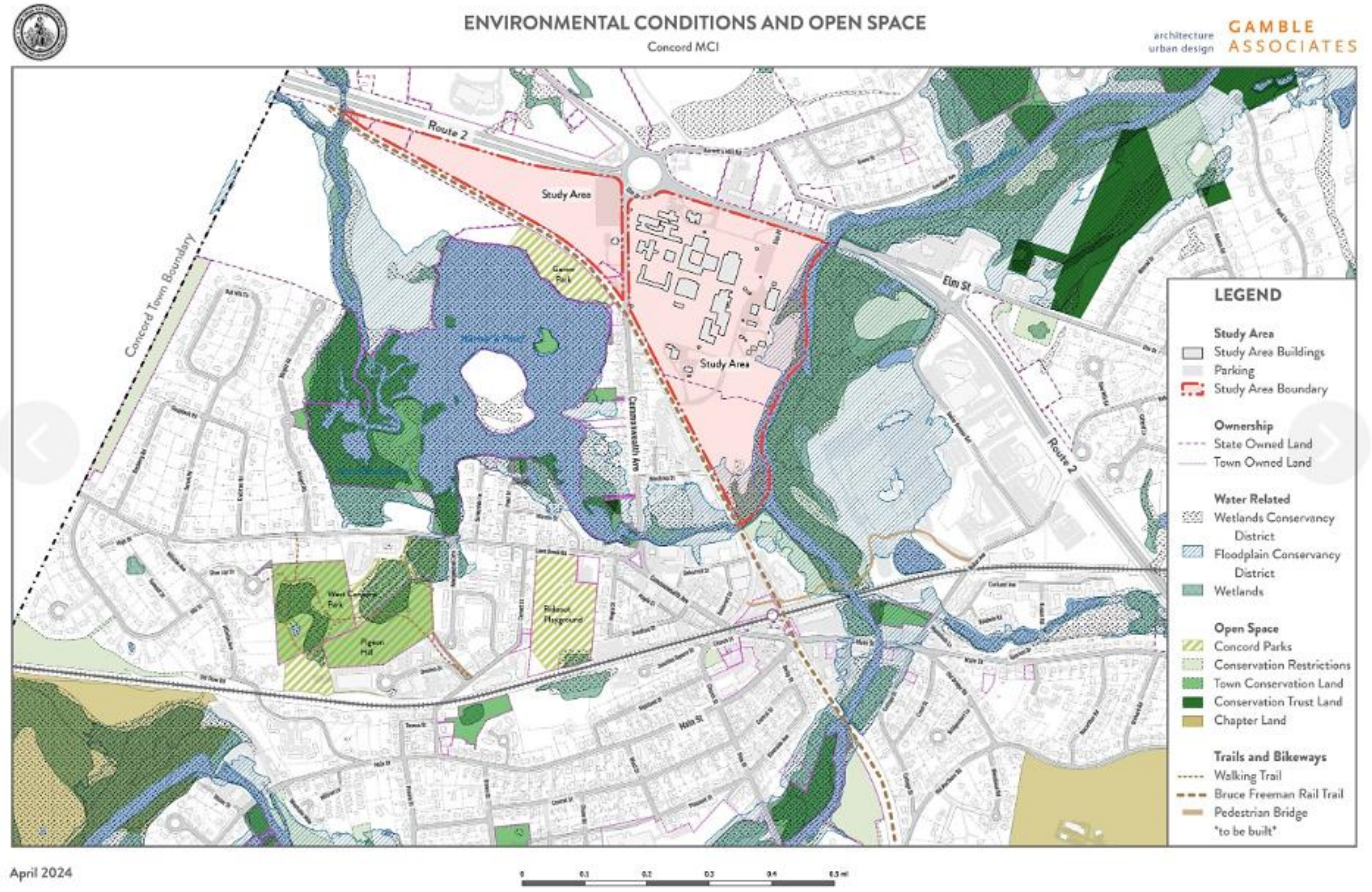
Open Space and The Environment

Warner's Pond is also a key component of West Concord's Open Space and Environmental setting, providing walkable and handicap-accessible "in town" access to vistas and extensive wildlife – unique by its central and accessible location within West Concord Village.

Although created by an artificial impoundment, Warner's Pond is an integral part of the area ecology, wetlands and river system. Without Warner's Pond. Much of the area wetlands may depend upon the impounded water level created by the dam.



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Open Space and The Environment

This slide and the following slide show a "to-scale" comparison of Warner's Pond water surface area to other significant Concord ponds showing comparable open space.

Warner's Pond:
Area: about 54 acres (with islands; 48 acres water; about 84 acres with adjacent wetlands)
Average Depth: about 4 feet
Deepest Depth: about 12 feet
Stream Fed
Impoundment

Walden Pond:
Area: about 62 acres
Average Depth: 40 feet
Deepest Depth: about 97 feet
Spring Fed
Natural Kettle Pond

Note: red line indicates 500 feet and is provided for scale

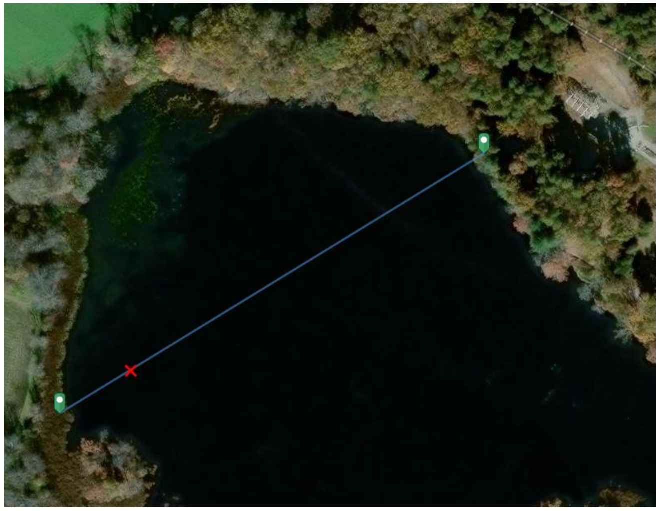
Open Space and The Environment

Warner's Pond:
Area: about 54 acres (with islands; 48 acres water; about 84 acres with adjacent wetlands)
Average Depth: about 4 feet
Deepest Depth: about 12 feet
Stream Fed
Impoundment

White Pond:
Area: about 40 acres
Average Depth: 27 feet
Deepest Depth: about 63 feet
Spring Fed
Natural Kettle Pond

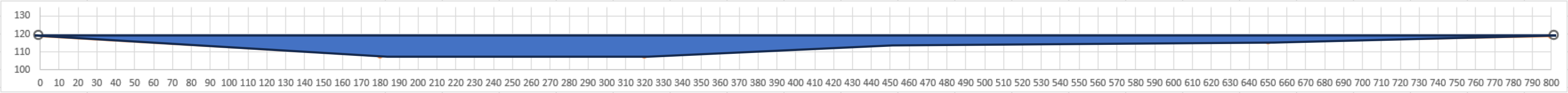
Note: red line indicates 500 feet and is provided for scale

Open Space and The Environment

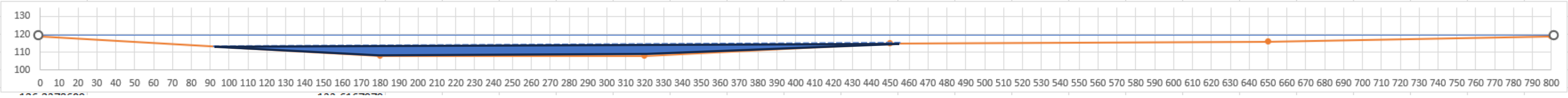


The profile below shows the extent of water that is currently visible at Gerow Recreation Area and would be visible under the Dam Removal Alternative, standing at the bank. See profile line (right). Profile 1:1 scale.

Existing:

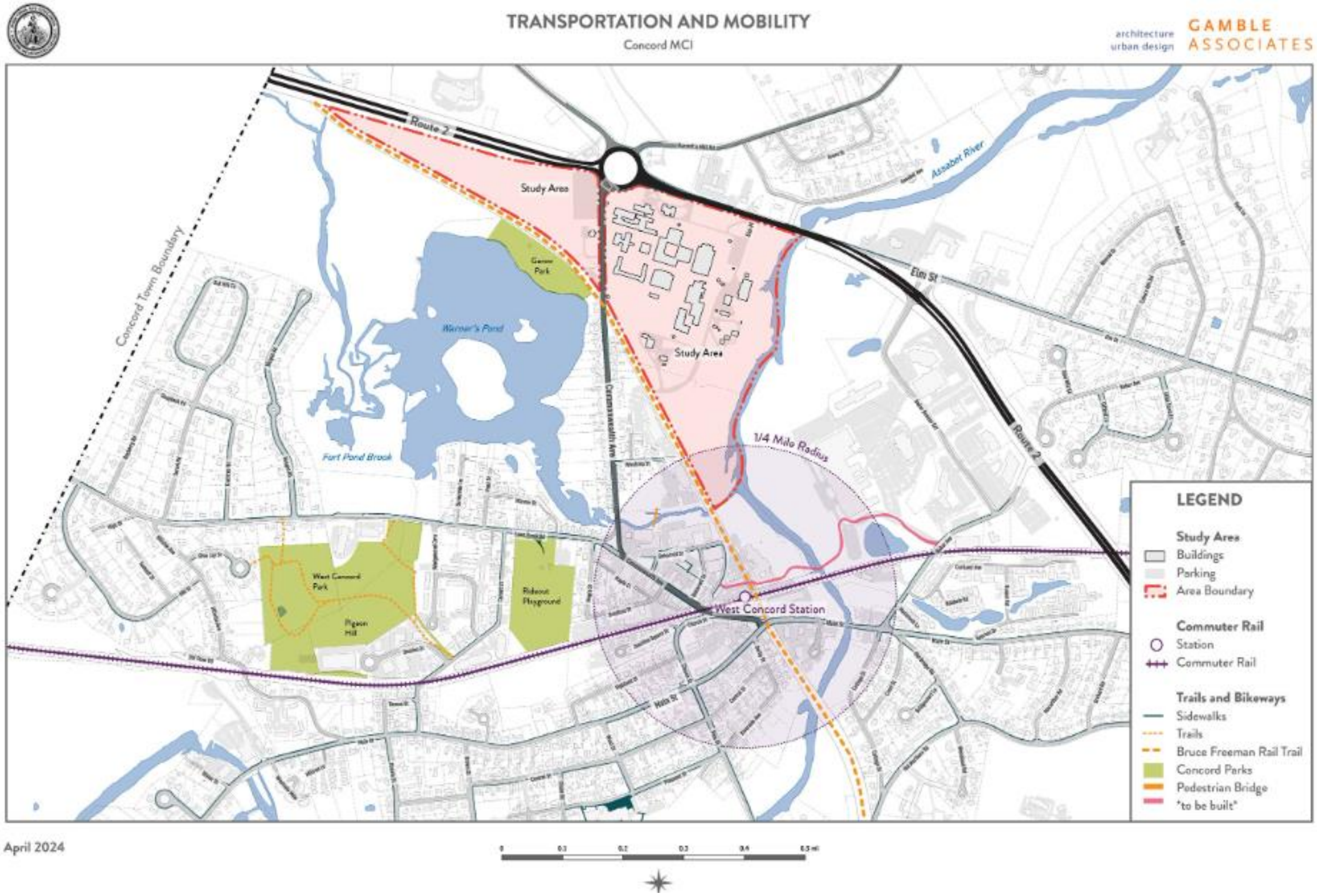


Dam Removal:



Transportation and Mobility

Warner's Pond is strategically located as a key stop along West Concord's multi-modal transportation system and is accessible via the Bruce Freeman Rail Trail which provides walkable, bikeable and handicap accessibility between the Village Center and the Pond/Gerow Recreation Area. It is also accessible via Town-owned public access locations along Laws Brook Road and Commonwealth Avenue.



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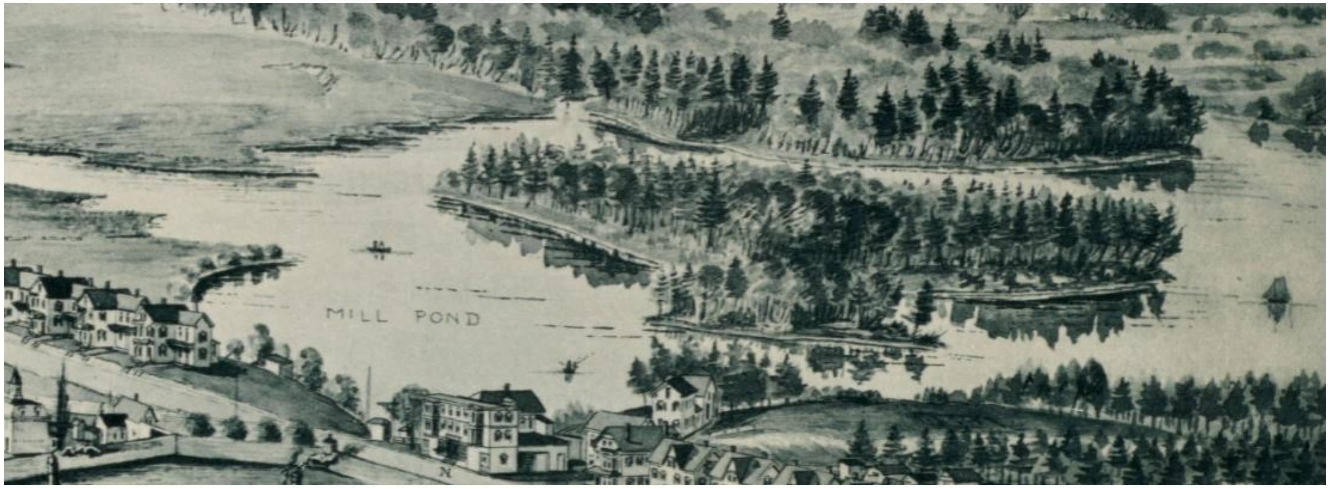
Recreation

By 1880, Warner's Pond was a popular site for recreation including ice skating, fishing, sledding, and boating. The "Maude Blake" steam launch steamed around the Pond. Summer camps operated on the island.

Warner's Pond has provided recreational opportunities to West Concord residents and visitors for over 160 years and continues to do so, including:

- Fishing
- Ice Skating
- Pond Hockey
- Boating
- Paddling
- Viewing
- Birding
- Swimming (potentially)
- Boy Scouts/Girl Scouts

Since the 1990s, the Town has consistently maintained goals to improve the recreational uses of Warner's Pond to the benefit of Town residents.



Recreating on Warner's Pond 1893 (above) to now

"Warner's Pond is the best place for Birding in Concord"... Active Birder

Gerow Recreation Area

The Town has long been committed to maintaining Warner‘s Pond as a community resource.

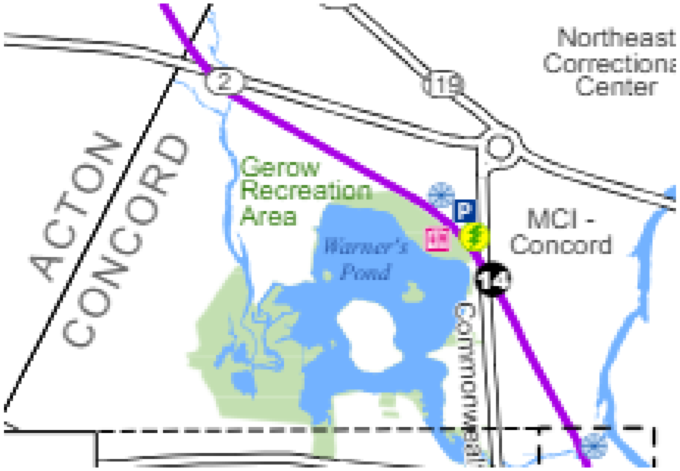
Gerow Recreation Area, a major newly-constructed Town recreational facility, is comprised of 7.03 acres of cleared and wooded land abutting Warner’s Pond in West Concord. Gerow Recreation Area provides walkable and handicap-accessible trails and landscaped areas providing Town residents from the young to old with access to the shoreline and dramatic views of the Pond, along with parking, a pavilion and restrooms.

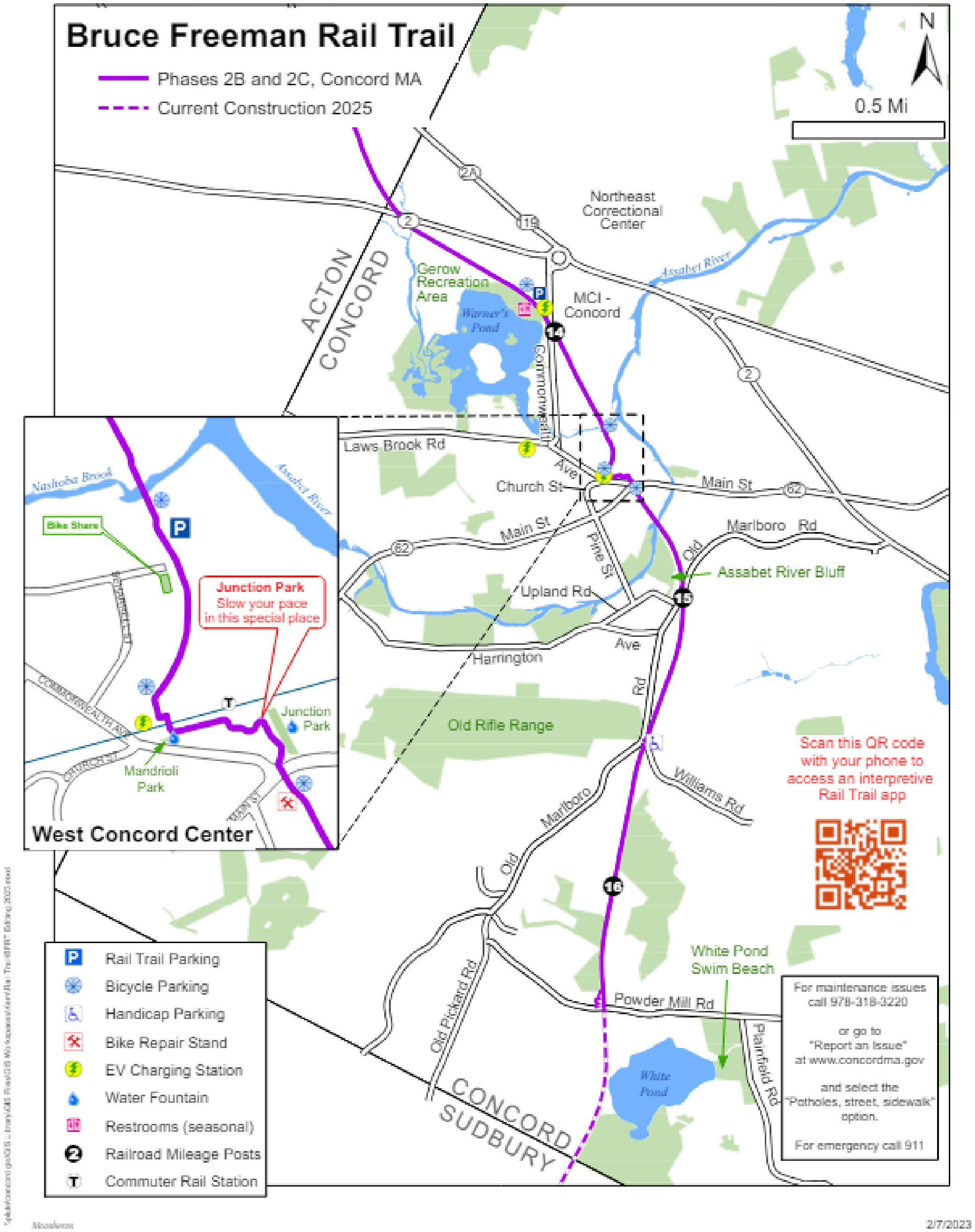
The property was purchased in July of 2018 with the goal of establishing a Town recreational facility that utilized Warner’s Pond. As shown in the image upper right, recreational components included fishing, shoreline walk, a kayak/boat launch, swimming and wading area and beach. The rendering lower right represents the final constructed park.

Bruce Freeman Rail Trail

The Bruce Freeman Rail Trail, a developing rail trail that winds for nearly 16 miles through Chelmsford, Westford, Carlisle, Acton, and Concord provides users with beautiful vistas and connectivity to Warner's Pond.

Crossing MA-2 via a pedestrian bridge, the Bruce Freeman Rail Trail generally follows the Nashoba River through the town of Action before winding south into Concord. **Passing Warners Pond and crossing the Assabet River, the route continues south providing "pond to pond" passage between Warner's and Whites Ponds.**





P	Rail Trail Parking
✱	Bicycle Parking
♿	Handicap Parking
✖	Bike Repair Stand
●	EV Charging Station
💧	Water Fountain
🚻	Restrooms (seasonal)
❷	Railroad Mileage Posts
Ⓣ	Commuter Rail Station

For maintenance issues call 978-318-3220

or go to "Report an Issue" at www.concordma.gov

and select the "Potholes, street, sidewalk" option.

For emergency call 911

The Dam

The Warner's Pond Dam, is a visually stunning, approximately 320-foot-long earthen dam. The Town invested in a significant reconstruction of the Dam during 2007/2008. The Dam has been inspected every 5 years since then and continues to be in "Satisfactory" condition.

The Dam has two spillways (a Main Spillway and an Auxiliary Spillway) as well as a "stilling pond". The spillways are constructed with natural rock and stone rip rap to create "riffle style" flowing water. The combined spillways and stilling pond provide a complex, diverse ecological habitat of flowing and still water with abutting vegetated banks.

With a Normal Pool Elevation of 118.8 feet NAVD88, under normal pond water levels, the vertical spillway weirs are low in height (a few feet) and aesthetically scaled for the surroundings. The spillway walls are constructed with rock masonry veneer for aesthetic reasons. The Dam is accessible and viewable via two Town-owned, publicly-accessible areas along Commonwealth Avenue.

The spillways, stilling pond and vegetated banks create complexity of habitat, with pools, flowing water and shade and as well as surface turbulence and eddies, providing hiding and cover for fish and other aquatic organisms. However, the spillways also become barriers to fish passage. The Auxiliary Spillway, along with the existing rock and rip-rap channel, is conducive to construction of a "naturalized" non-structural fish passage in the future.

Town Policy and Warner's Pond

The combination of nutrients within the watershed and sedimentation have resulted in on-going excessive native and invasive vegetation and eutrophication. The Town's policy relative to Warner's Pond has consistently been to invest in improvement, restoration and recreational enhancement of the Pond:

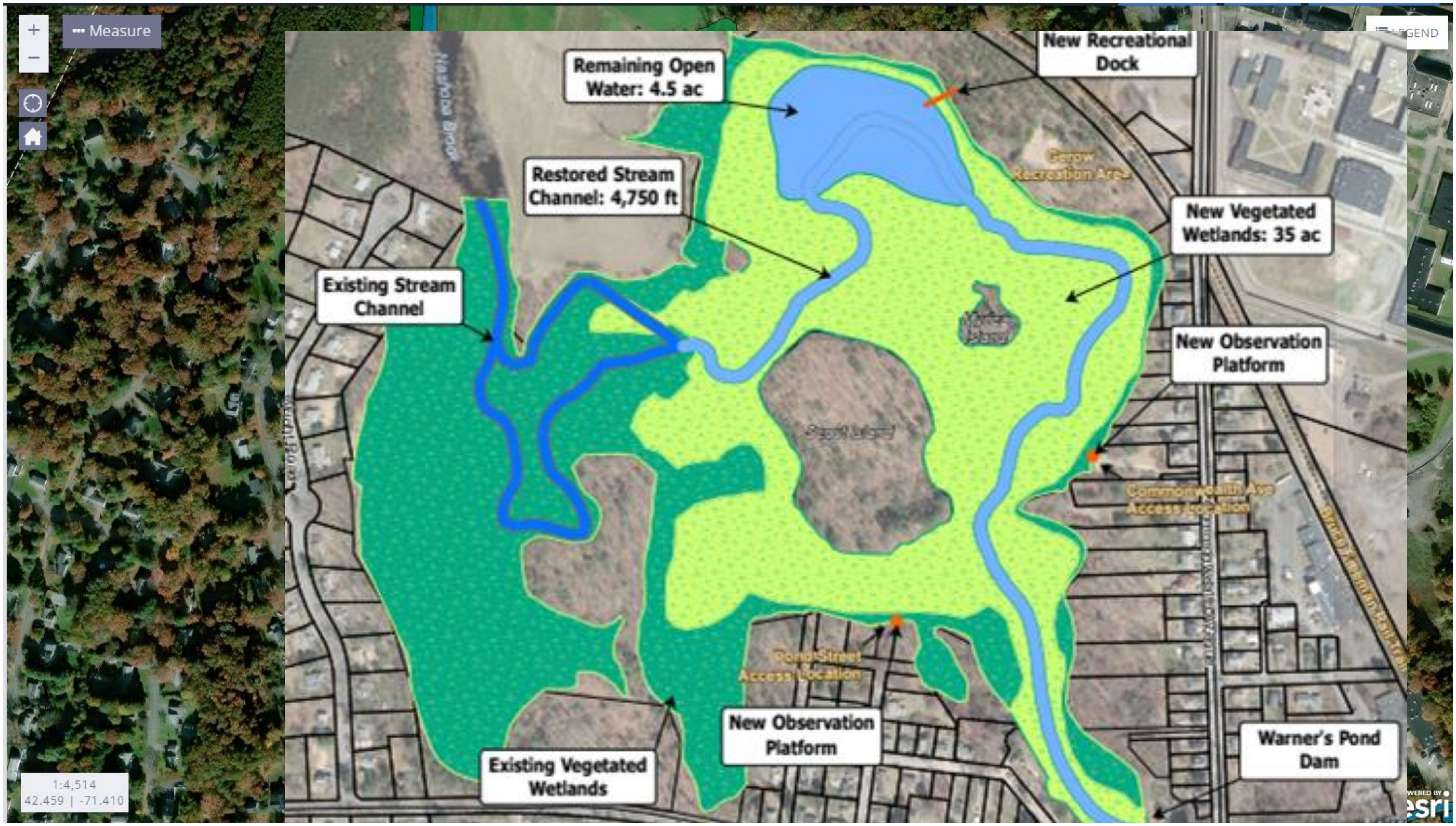
- Town Studies:
  - 1983 Warner's Pond Fisheries Report
  - 1999 Warner's Pond Management Plan
  - 1999 Wildlife and Habitat Assessment
  - 2003 Updated Aquatic Vegetation Survey and Management Recommendations
  - 2005 Project Completion Report for Nuisance Aquatic Plant Management Program
  - 2007 Water Quality Sampling
  - 2011 Warner's Pond Field Guide
  - 2012 Watershed Management Study (ESS)
  - 2018 Dredging Feasibility Study (ESS)
  - 2018 Town Plans for Swimming Beach at Warner's Pond (North Beach concepts plans)
  - 2023 Alternative Analysis Report (EA)

Town Capital Investment:

  - 2007/2008 Significant Town investment to restore and reconstruct the Dam
  - Current: Gerow Recreational Area (Gerow Park)
  - Funds allocation for dredging of Warner's Pond (Town vote)
  - 2022 Warner's Pond Restoration Contract Bid

Recreational uses if the dam is removed

The image blow shows the proposed new stream channel and pond, a dock and two observation platforms. Nor other amenities were included in the Alternatives Analysis. Although details are not available at this time, it is predicted that the new stream channel will be shallow (a few feet deep), with water depths ranging from about 0.5 to 1 foot. The new 4.5-acre pond will also be very shallow. The current pond bottom elevations within the new pond limits range from 113 to 107 feet NAVD88. Assuming a new water level of around 115 feet NAVD88 and no additional dredging, the typical pond depths will be about 2 to 8 feet. However, stream discharge is expected to reduce to about 11 cfs in August which may further reduce the pond water levels.



Attachment 7

Overview of Warner's Pond Alternatives

Introduction

The primary issue with Warner’s Pond is high aquatic vegetation productivity, which is adversely affecting the Pond’s recreational values and possibly leading to a condition of advanced eutrophication in the future. Over the last 40 years the Town’s policy relative to Warner’s Pond has consistently been to invest in the improvement, restoration and recreational enhancement of the Pond. Very recently, however, the Town of Concord Natural Resources Commission has proposed removal of the dam and Pond and creation of a new river channel and small (+/- 4.5 acre), shallow pond with a water level about 4 feet lower than current.

This attachment presents a summary of the mitigation alternatives being considered, which include: 1) Do Nothing; 2) Pond Restoration and Management; and 3) Dam Removal. Several sub-alternatives are part of Pond Restoration and Management, in particular dredging.

The limitations, benefits and negatives of each of the alternatives are also presented. The factors in consideration of these alternatives and their benefits and limitation are wide-ranging and include:

- Expected costs of each of the alternatives
- Funding availability
- Regulatory Feasibility
- Technical Effectiveness
- Ecological effects, benefits and limitations, including fisheries, wildlife and wetlands
- Flood control and FEMA flood hazard characterization (Flood Insurance Study and Flood Insurance Rate Map)
- Climate resilience
- Aesthetic value
- Community and cultural value in particular in light of recent Town developments and improvements (e.g., Gerow Recreational Facility)
- Historical value
- Recreational benefits
- Town Liability

The benefits and limitations of each alternative should be considered in terms of both the present and future (at least the next 50 to 100 years). In particular, a dam removal alternative is permanent - once gone, the Pond will not be a future community resource.

In addition to the alternative currently considered, an alternative of limited dredging, pond management, improved amenities and construction of a naturalized (rack ramp) fish pass appear to be viable and cost effective and keeps the 86-acre Warner’s Pond and Wetland System as a valuable community resource for the future.

Alternative One: Do Nothing

“Do Nothing” alternatives include both short-term and long-term approaches. For both of these approaches, it is assumed that the Town will continue to maintain the dam to Massachusetts and federal standards and perform Phase I Inspections.

“Do Nothing” Short-term Approach: postpones decisions and mitigation actions, including dredging and/or dam removal, for a few years (assume 1 to 5) while more information becomes available including the future of the abutting MCI property and the next generation of West Concord long range planning.

“Do Nothing” Long-term Approach: allows the future eutrophication of the Pond since neither pond management nor dam removal would be performed.

Alternative Two: Pond Restoration and Management

The Town has had a Watershed Management Plan, which includes recommendations for pond management, for a number of years; however, the Town has only implemented minimal mitigation action.

A Pond Restoration and Management alternative includes both short-term and long-term approaches and actions:

- Short-term actions include herbicides and biological controls as well mechanical vegetation removal.
- Long-term actions principally include in-pond dredging.
- Long term measures can also include working with the surrounding communities, in particular Acton (Nashoba Brook up to Ice House Pond), to implement storm water regulations, streambank management and low impact development to reduce sediment and nutrient load to the streams, rivers and the Pond.

Each of these approaches has been studied extensively in the past. One limited herbicide program was implemented.

Dredging, as a long-term management approach was recommended by past Town consultants (ESS, 2012) as the primary focus for Pond management because it addresses multiple in-pond problems and lasts for decades. Since 2012, several different dredging schemes have been developed and are presented here. A dredging plan was advanced though design, plans and specifications, permitting and construction bid.

Alternative Two: Pond Restoration and Management

Review of possible pond management goals and objectives:

Goals:

- Preserve open water habitat (also for recreational purposes)
- Control non-native vegetation
- Preserve diverse habitat types
- Overall, about 40% to 60% plant cover (by biomass)

Objectives:

- Leave western portion of the pond (water depths less than 3 feet) “as is”.
- Reduce plant density to improve open water habitat within the: 1) eastern (15 to 20 acres), deeper water areas (>4 feet); and 2) western channel of the main island - see open water management area on next slide
- Maintain open water continuity with deeper areas to the north and channel at the outlet

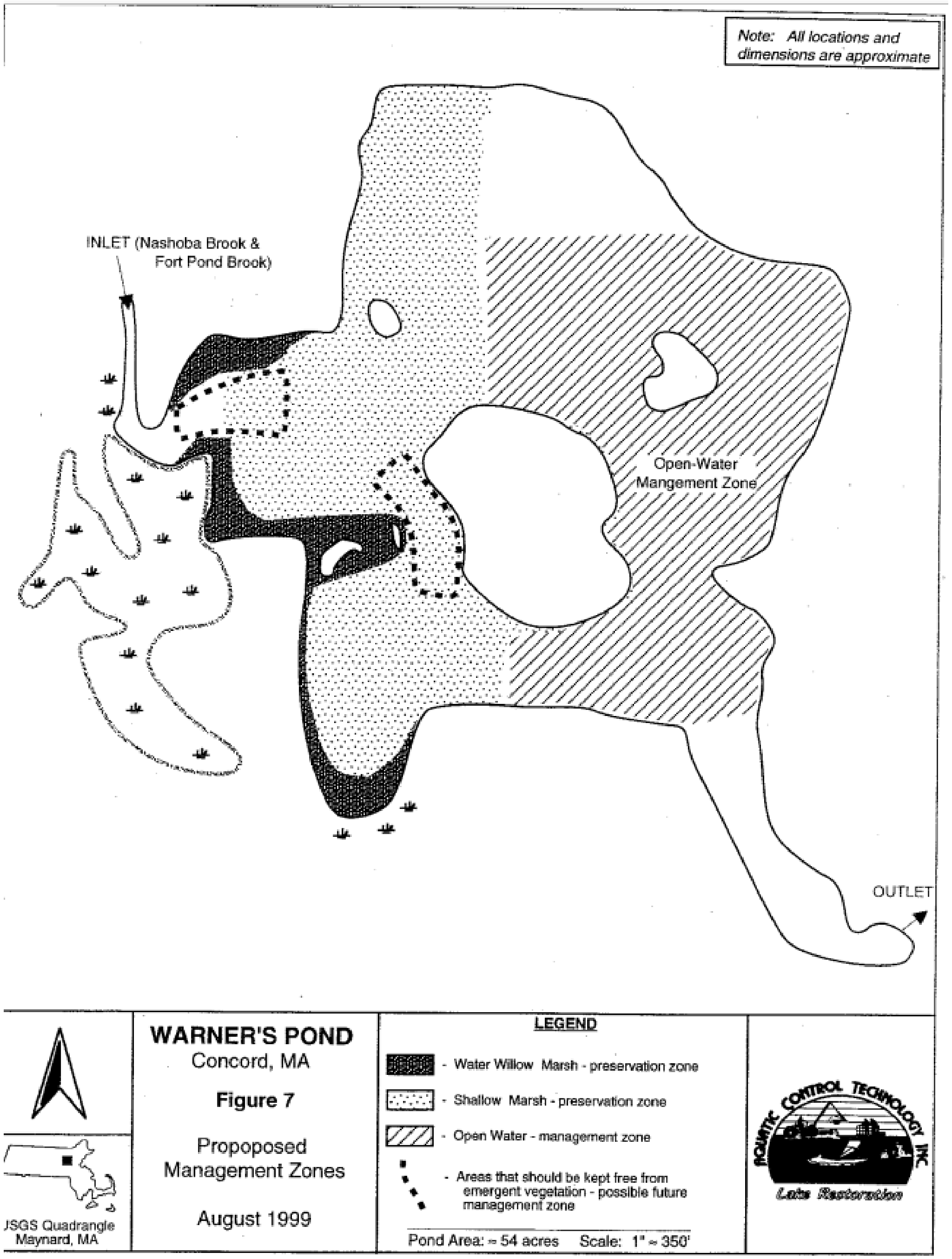
Methods:

- Long-term management vis a one-time partial dredging within the open water management area to create enough area with pond bottom elevations greater than the euphotic zone.
- Periodic hand and/or mechanical vegetation harvesting (localized)
- Periodic herbicide treatment
- Periodic pond drawdown (should be evaluated)
- Select biological treatment (should be evaluated)

Note: Possible additional, specific pond management objectives goals based on observed conditions (preliminary): Improvement to achieve better to optimum littoral zone plant coverage: 1) reduce littoral zone to pond margins, and about 30% of pond area; 2) within this littoral zone maintain 65% to 100% plant coverage; 3) less than 15% to no invasive species; 4) maintain 5 or more native species; 5) no single native species constitutes more than 30% of plant coverage; and 6) all aquatic plant coverage (submerged, emerged and floating) is greater than 30% and less than 85% of pond area. It appears that this could likely be achieved by dredging to about Elevation 111 feet NAVD88 (or lower) over 15% to 30% of the Pond area. Reference Littoral Zone Scorecard Littoral Zone Scorecard (ufl.edu)

Note: Results of past herbicide treatment: Post treatment survey indicated that:) plant cover was also very high to the north and northeast of Scout Island where swift-moving water through the pond was likely to have limited herbicide contact time and thus appeared to be less effective in these areas; and 2) the Sonar treatment was highly effective in the northern and eastern portions of the pond where fanwort, variable watermilfoil and coontail showed signs of chlorosis and had dropped out of the water column due to decay.

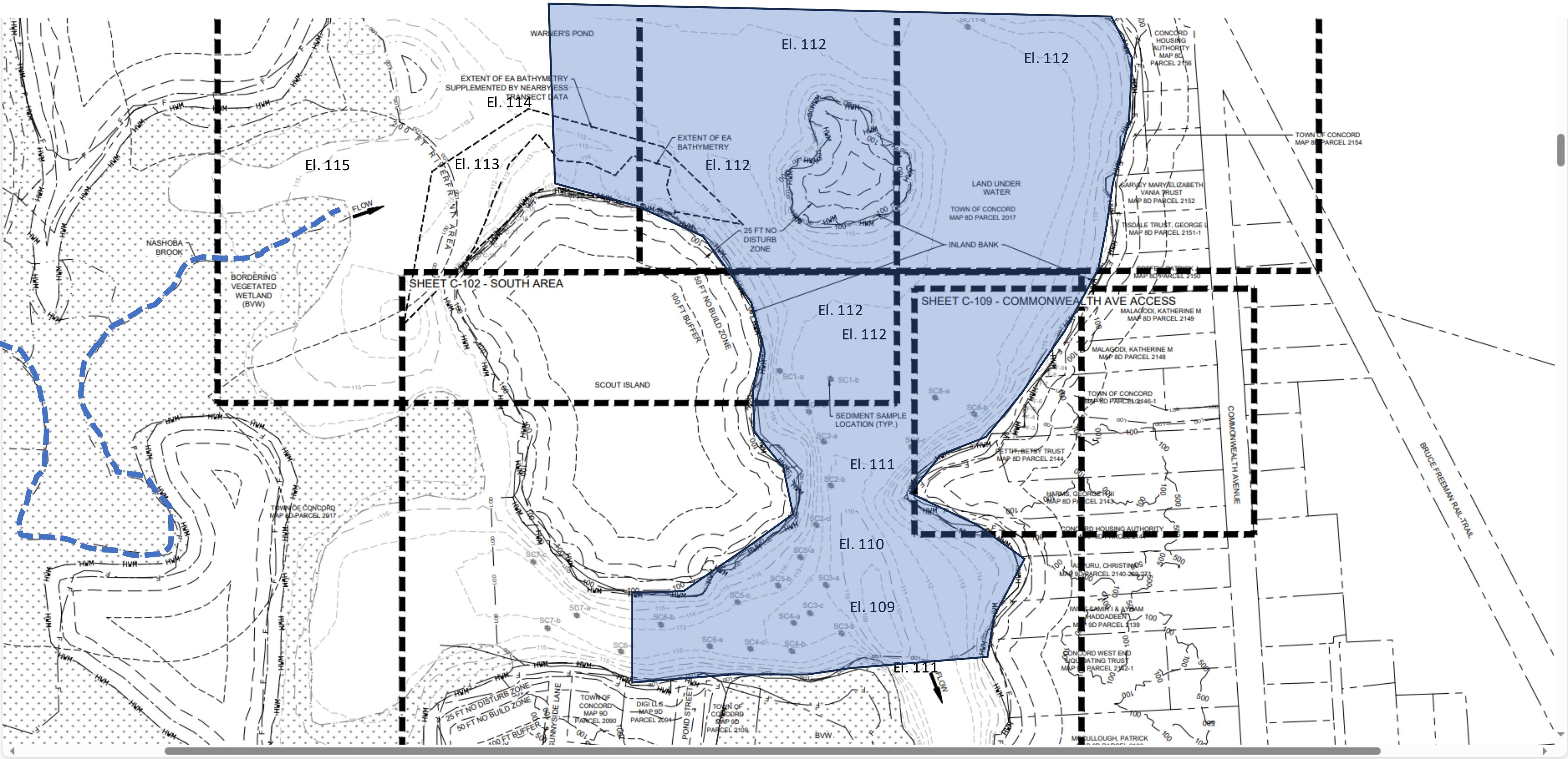
Alternative Two: Pond Restoration and Management



Open Water Management Area (1999 ACT Report)

Alternative Two: Pond Restoration and Management

Open water management area shown relative to the existing pond bottom elevation. The bottom elevations within the surface water area was developed based on bathymetric surveys (note that detailed bathymetric data is presented on the dredge bid construction plans.)



Alternative Two: Pond Restoration and Management Short Term Approach

Pond Restoration and Management: Short-Term Approaches

There are a number of short-term pond management techniques that are potentially viable for Warner's Pond. The 2012 ESS report presents a detailed discussion of each and summarizes the pros and cons in the table shown here and on the following slide. The potential methods include: 1) herbicides; 2) hand harvesting; 3) biological controls; 4) pond bottom sealing; 5) pond drawdown; and 6) hydroraking. As shown on the table, there are significant limitations and cons to each of these methods. Therefore, these short-term approaches will likely only be beneficial as a limited supplement to a long-term pond management approach – specifically, dredging.

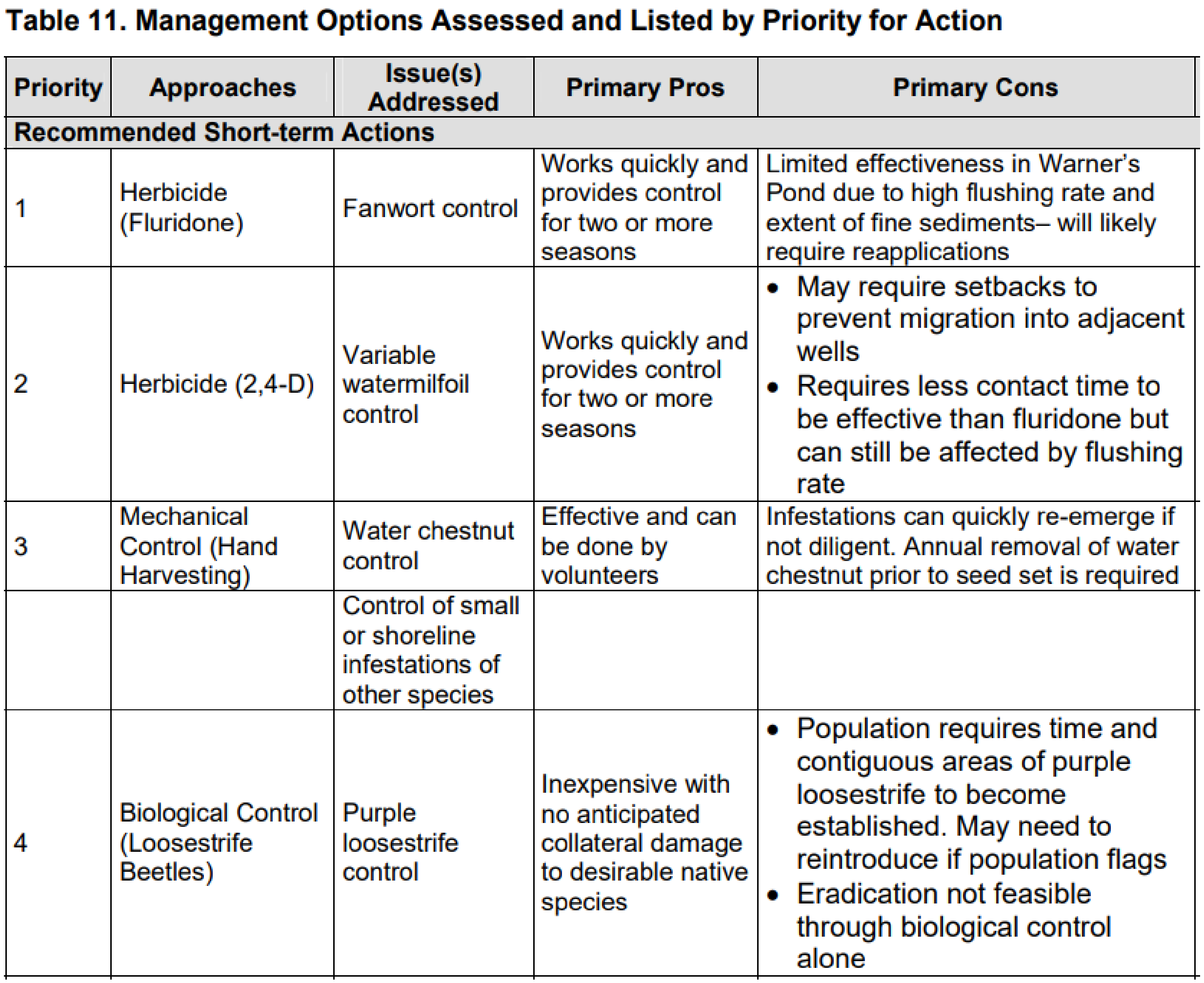


Table 11. Management Options Assessed and Listed by Priority for Action

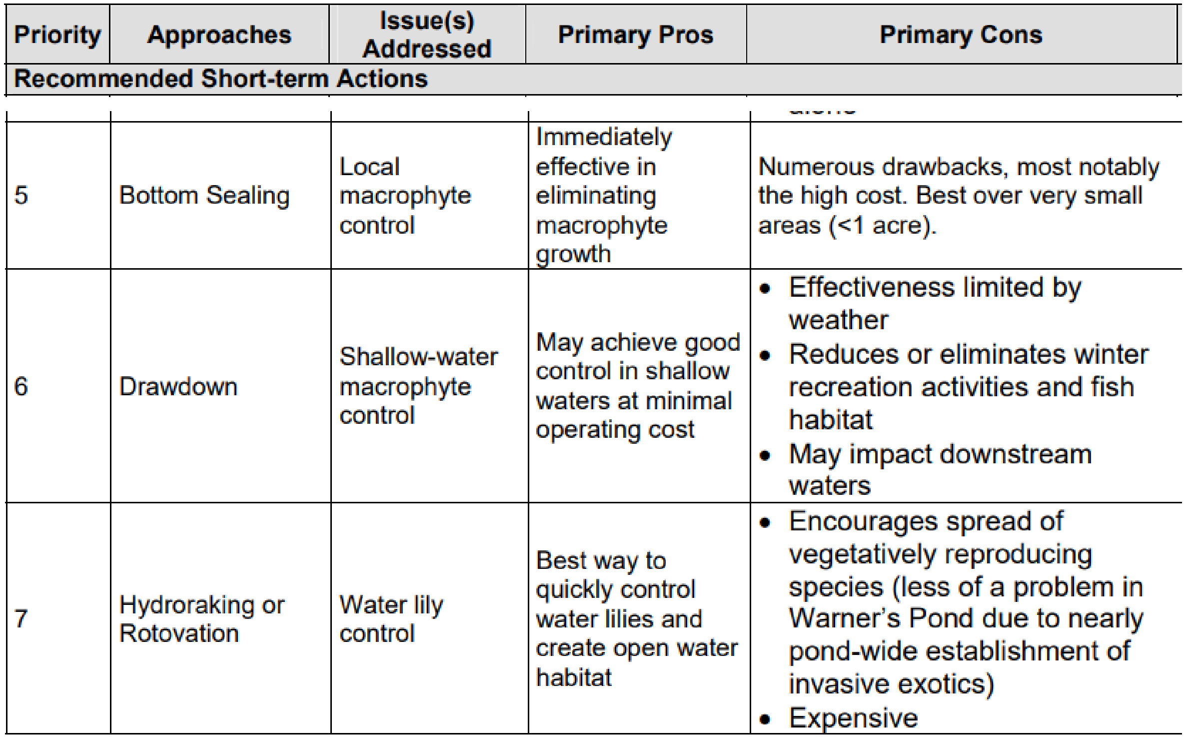
Priority	Approaches	Issue(s) Addressed	Primary Pros	Primary Cons
Recommended Short-term Actions				
1	Herbicide (Fluridone)	Fanwort control	Works quickly and provides control for two or more seasons	Limited effectiveness in Warner's Pond due to high flushing rate and extent of fine sediments– will likely require reapplications
2	Herbicide (2,4-D)	Variable watermilfoil control	Works quickly and provides control for two or more seasons	• May require setbacks to prevent migration into adjacent wells • Requires less contact time to be effective than fluridone but can still be affected by flushing rate
3	Mechanical Control (Hand Harvesting)	Water chestnut control	Effective and can be done by volunteers	Infestations can quickly re-emerge if not diligent. Annual removal of water chestnut prior to seed set is required
		Control of small or shoreline infestations of other species		
4	Biological Control (Loosestrife Beetles)	Purple loosestrife control	Inexpensive with no anticipated collateral damage to desirable native species	• Population requires time and contiguous areas of purple loosestrife to become established. May need to reintroduce if population flags • Eradication not feasible through biological control alone

Alternative Two: Pond Restoration and Management Short Term Approach

In addition to the short-term pond management techniques shown in Table 11, there are a number of other options that were considered but determined to not be viable or appropriate for Warner's Pond. These include:

- Aeration and destratification
- Plant competition
- Dilution and/or flushing (not that the Pond already has an exceptionally high flushing rate)
- Chemical sediment treatment
- Shading dye
- Other herbicide treatments
- Biological treatments (other than loosestrife beetles)
- Nutrient inactivation

Table 11. Management Options Assessed and Listed by Priority for Action



Priority	Approaches	Issue(s) Addressed	Primary Pros	Primary Cons
Recommended Short-term Actions				
5	Bottom Sealing	Local macrophyte control	Immediately effective in eliminating macrophyte growth	Numerous drawbacks, most notably the high cost. Best over very small areas (<1 acre).
6	Drawdown	Shallow-water macrophyte control	May achieve good control in shallow waters at minimal operating cost	• Effectiveness limited by weather • Reduces or eliminates winter recreation activities and fish habitat • May impact downstream waters
7	Hydroraking or Rotovation	Water lily control	Best way to quickly control water lilies and create open water habitat	• Encourages spread of vegetatively reproducing species (less of a problem in Warner's Pond due to nearly pond-wide establishment of invasive exotics) • Expensive

Note: The dam has two features that support pond drawdown: sluicegate and 24-inch ductile iron pipe with gate box. Drawdown would require evaluation and documentation of potential adverse effects and regulatory review.

Alternative Two: Pond Restoration and Management Short Term Approach

Past Mitigation Activities at Warner's Pond

Aquatic Weed Harvesting and Hydro-raking:

In 1999, a major restoration effort was suggested by NEE to restore Warner's Pond water quality. Two approaches (**aquatic weed harvesting and hydro-raking**) to manage water chestnut and fanwort were implemented in 2004 by the Town at NEE's recommendation.

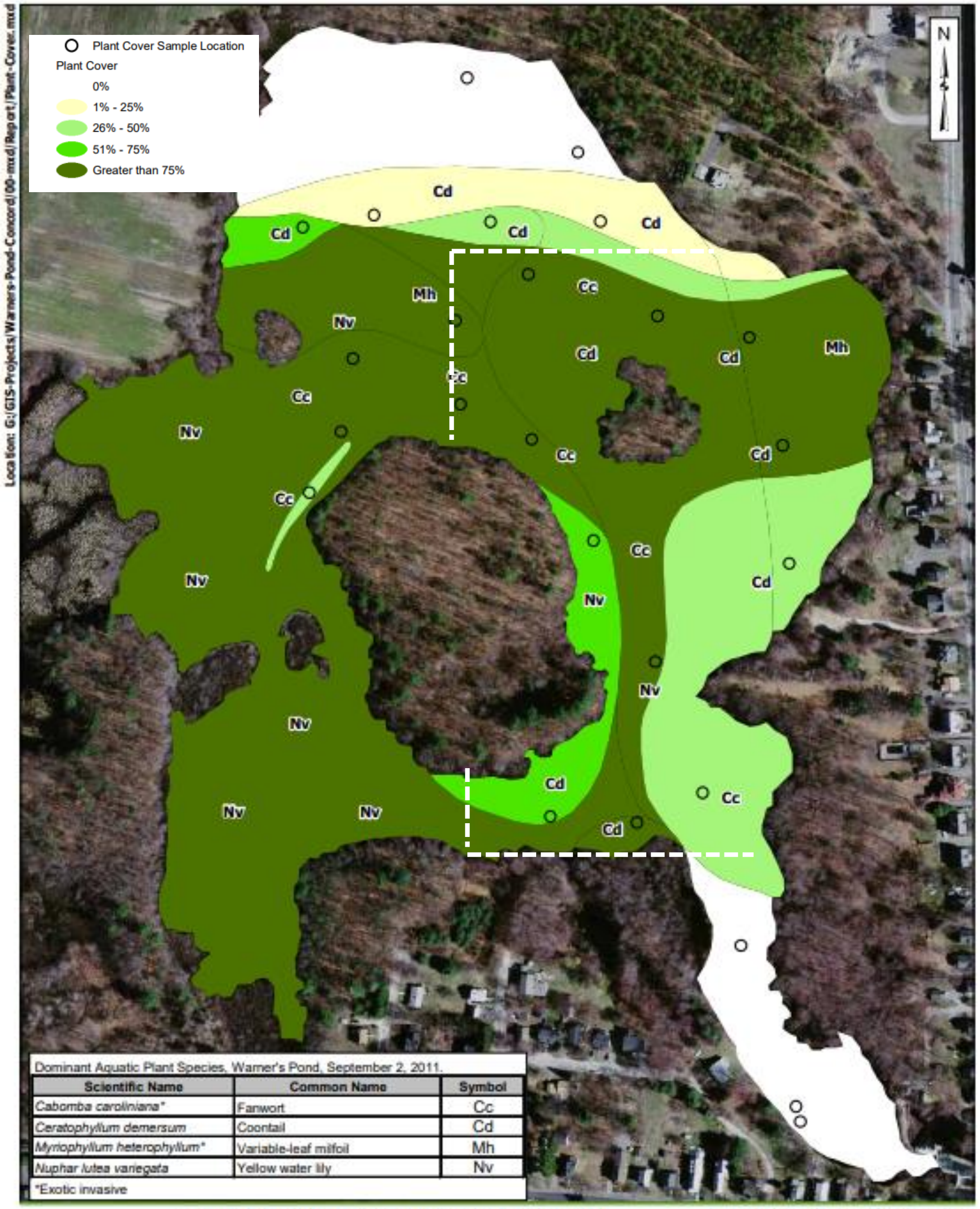
It was later determined that the aquatic weed harvester should not be used where invasive variable watermilfoil was also present, due to its ability to fracture and re-root from cuttings, which is also probably true for fanwort growth as this plant also is known to spread through vegetative fragmentation.

Hand Harvesting:

Grassroots efforts began in 2004 to hand harvest water chestnut in areas where variable watermilfoil also occurred.

Herbicides:

The most recent invasive macrophyte treatment program was conducted using the Sonar and Sonar One herbicide formulations during the 2011 growing season. ACT applied these formulations three times in 2011 to control the growth of non-native invasive fanwort and variable watermilfoil. A pre-treatment survey was conducted by ACT on May 20, 2011, which included both plant cover and biovolume mapping from pre-determined sampling locations. ACT documented numerous macrophyte species in the pond, as well as filamentous green algae and the macroalgal species stonewort (Nitella sp.). See following slides.



Dominant Aquatic Plant Species, Warner's Pond, September 2, 2011.

Scientific Name	Common Name	Symbol
*Cabomba caroliniana**	Fanwort	Cc
Ceratophyllum demersum	Coontail	Cd
*Myriophyllum heterophyllum**	Variable-leaf milfoil	Mh
Nuphar lutea variegata	Yellow water lily	Nv

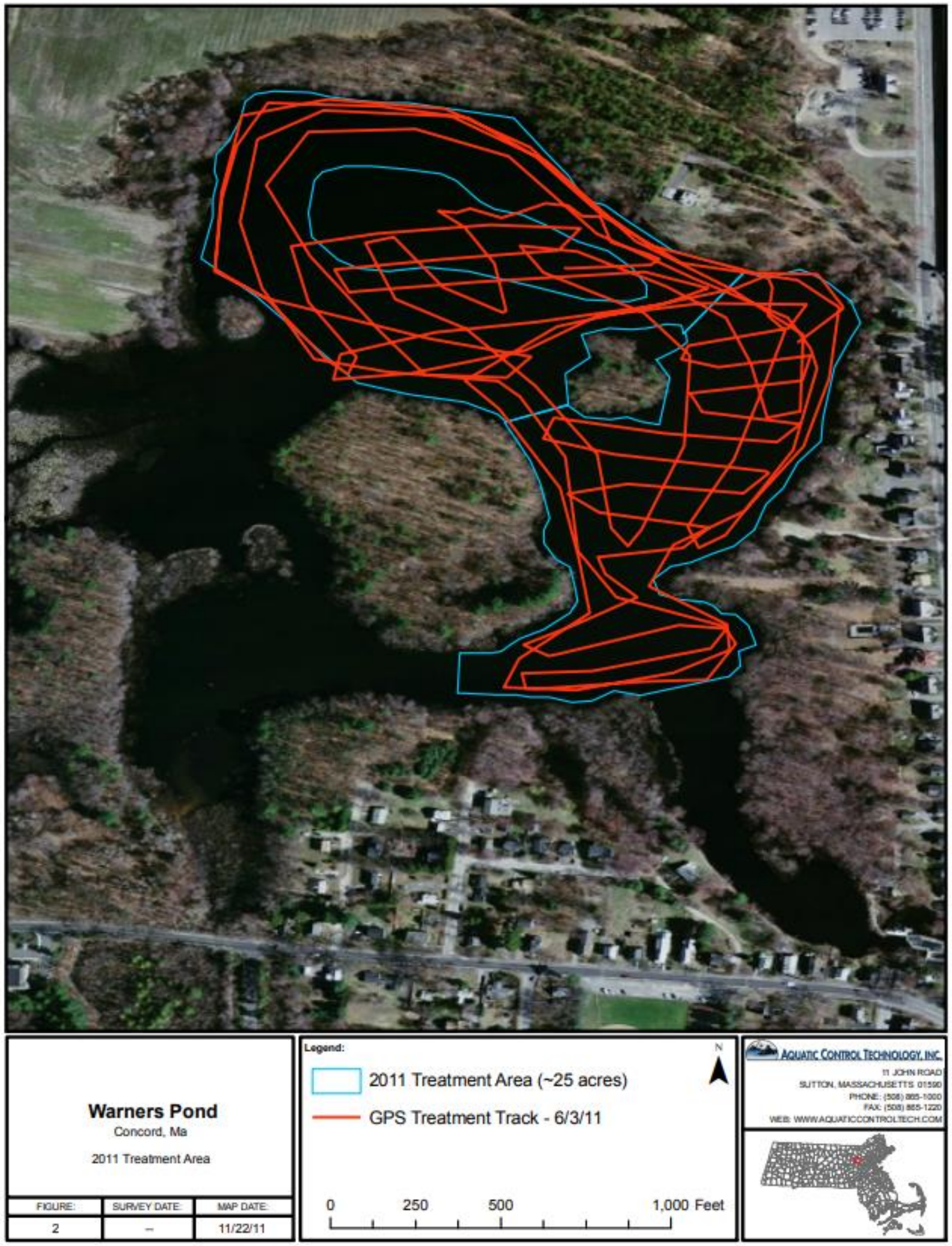
*Exotic invasive

WARNER'S POND WATERSHED MANAGEMENT PLAN

Warner's Pond Plant Cover

Alternative Two: Pond Restoration and Management Short Term Approach

Treatment Summary: Consistent with the proposed treatment scope provided to the Town on March 4, 2011 the 25 acre "open water" area of Warner's Pond was treated with Sonar (active ingredient fluridone) herbicide for control of fanwort (Cabomba caroliniana) and variable watermilfoil (Myriophyllum heterophyllum). Sonar AS (liquid) – EPA Reg. No. 67690-4] were applied on three separate occasions. Herbicide applications were conducted by Aquatic Control using an airboat.



Alternative Two: Pond Restoration and Management Short Term Approach

Warner's Pond 2011 Sonar Herbicide Treatment Program

Pre-treatment: Waterlily cover near Boy Scout Island

Pre-treatment: Submersed weed growth

During treatment: boat ramp looking north

During treatment: chlorosis evident on fanwort

Post-treatment: boat ramp looking north

Post-treatment: decomposing coontail growth

Alternative Two: Pond Restoration and Management Short Term Approach

Herbicide Results/Discussion:

Fanwort and Milfoil (Cc and Mh):

- Fanwort and milfoil plants in the treatment area showed signs of fluridone exposure soon after the initial treatment and clorosis or bleaching was evident at the time of the first FasTEST sample collection on 6/22/11.
- While fanwort and variable watermilfoil were visible and even abundant outside the treatment area, especially west of Boy Scout Island, little to no growth was found within treated areas.
- While both fanwort and variable watermilfoil plants in the treatment area remained in the water column well into early August, chlorosis persisted and progressed throughout the summer. By the time of the final application fanwort in the pond was bleached white in the upper 6-10 inches of the plant and variable watermilfoil had collapsed out of the water column.

Coontail (Cd):

- Coontail was slow to develop signs of fluridone exposure but was exhibiting some slight chlorosis at the time of the second FasTEST sample collection on 7/26/11. This slow progression is typical with coontail and has been observed at many other waterbodies treated with fluridone.
- By the time of the post-treatment survey conducted on 9/2/11, fanwort, variable watermilfoil and coontail were all heavily impacted in the treatment area and only low-density, severely damaged coontail existed within the designated 25-acre treatment area.

Water Lilly (Nv):

- Some thinning of waterlilies (Nymphaea & Nuphar) was evident in the treated portion of the pond and what remained floating showed signs of chlorosis (yellowing around their edges). Estimated 50% of the waterlilies remained. Waterlily coverage outside of the treatment areas appeared untouched by treatment save for some slight discoloration in some of the waterlily pads towards the edge of the treated area.

Overall:

The treatment performed in 2011 appears to have provided excellent control of both fanwort and variable watermilfoil in the designated treatment area, while also providing suppression and thinning of the native coontail and waterlily growth. Expected to see nuisance-level fanwort control throughout the 2012 and possibly the 2013 seasons within the treated areas.

Variable milfoil often recovers more rapidly following treatment with Sonar herbicide, but control through the 2012 season is anticipated. The native waterlily and coontail growth usually recovers more rapidly than the invasive fanwort and milfoil but thinned-out populations of these plants should persist throughout the 2012 season.

Warner's Pond will continue to suffer from problematic aquatic weed growth. The presence of fanwort in the western (inflow) portion of the pond, high water flows, and mucky bottom sediments will limit the duration of control that can be achieved using Sonar (fluridone) herbicide. Herbicides with a faster mode of action may be more appropriate for partial pond treatments in the future.

Alternative Two: Pond Restoration and Management Short Term Approach - Drawdown

Warner's Pond Dam has drawdown capabilities:

- The Pond Normal Pool Elevation 118.8 feet NAVD88
- sluicegate with an invert of Elevation 115 feet NAVD88
- The 24-inch ID DI Pipe has an outlet invert at Elevation 113 feet NAVD88
- Hydraulic calculations are required to evaluate drawdown capacity; however, these structures likely have the capacity to significantly draw down the pond level, in particular during periods of low flow.
- Potentially, pond drawdown can reduce water levels to about Elevation 113 feet to 114 feet NAVD88
- This corresponds to drawdown of about 5 to 6 feet.

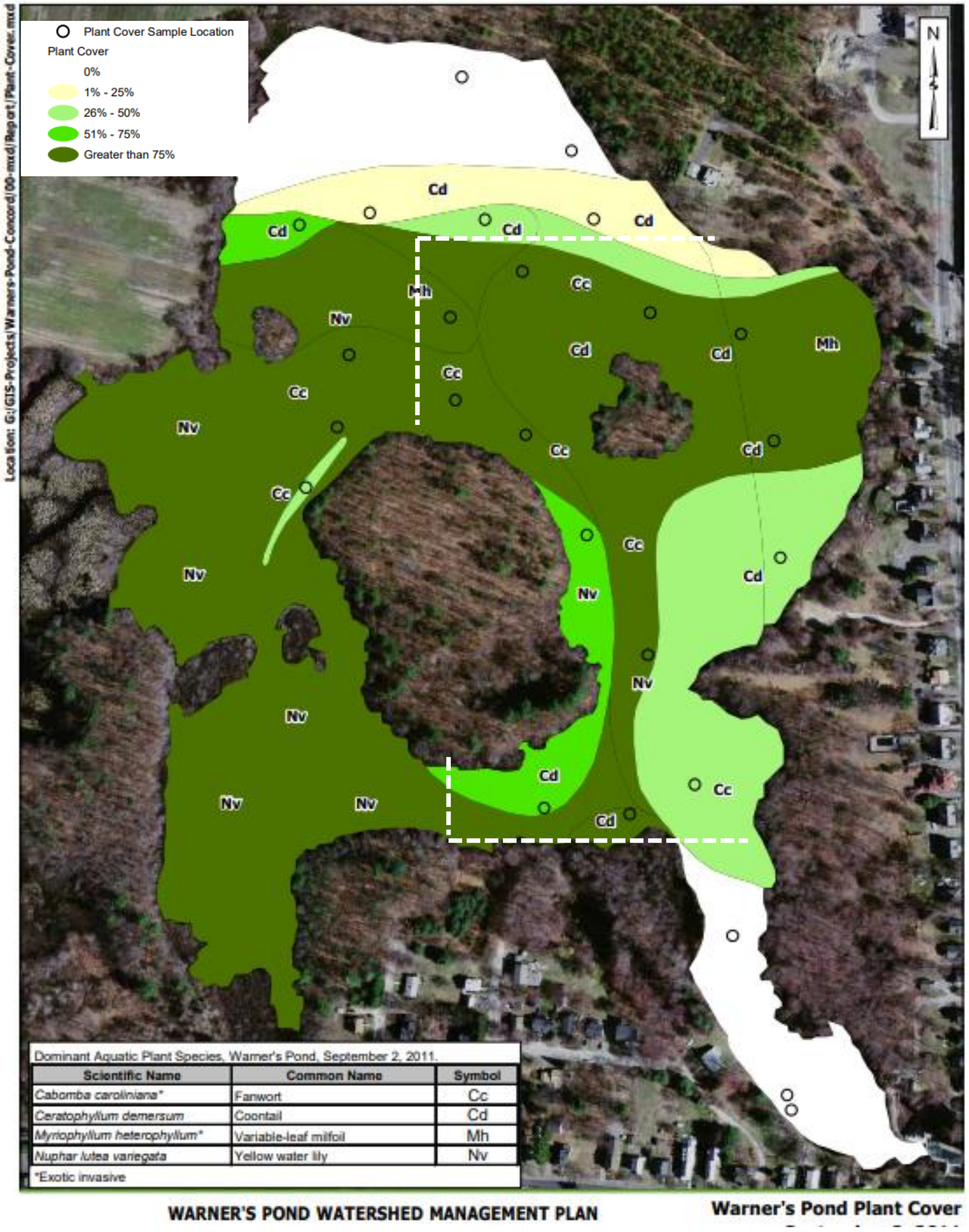
Drawdown is an alternative for shallow vegetation management. It is also a techniques used for mechanical dredging.

Drawdown involves lowering the water level of a pond to expose shallow bottom sediments and associated plants (both native and non-native) to drying and/or freezing. It is most effective against species that reproduce mainly by vegetative means, including fanwort and variable watermilfoil. Drawdown is less effective on species that reproduce primarily by seed (such as the invasive exotic species water chestnut and curly-leaf pondweed) and may expand beds of these species. Under some circumstances, drawdown may also encourage the spread of purple loosestrife in hydrologically connected wetlands.In Warner's Pond, this would primarily be a concern in the water willow dominated wetlands on the western margin of the pond, where purple loosestrife is already present.

Due to the shallow bathymetry of much of Warner's Pond, drawdown is only likely to provide limited control of aquatic invasive plant growth. Although drawdown can be conducted at any time, the interaction of drying and freezing that occurs with winter drawdown is usually most effective. Environmental restrictions and recreational uses also limit the appropriate window for drawdown to the winter period.

If drawdown is pursued as a management strategy, **a drawdown feasibility study** would first need to be developed that would identify potentially sensitive habitats or biota that may be present within the pond, its downstream waters, or within hydrologically connected wetlands.A **Drawdown Operations Plan** would need to be developed, inclusive of all hydrologic calculations, to guide dam operators on methods for managing the drawdown timing, the release rate, and the magnitude of drawdown. it will then be necessary to file a **Notice of Intent** application with the NRC. Assuming that a Drawdown Operations Plan is developed, filing a permit to conduct a drawdown at Warner's Pond is likely to cost between $3,000 and $4,000 to prepare and file based upon the nature of the impacts and the supporting studies.

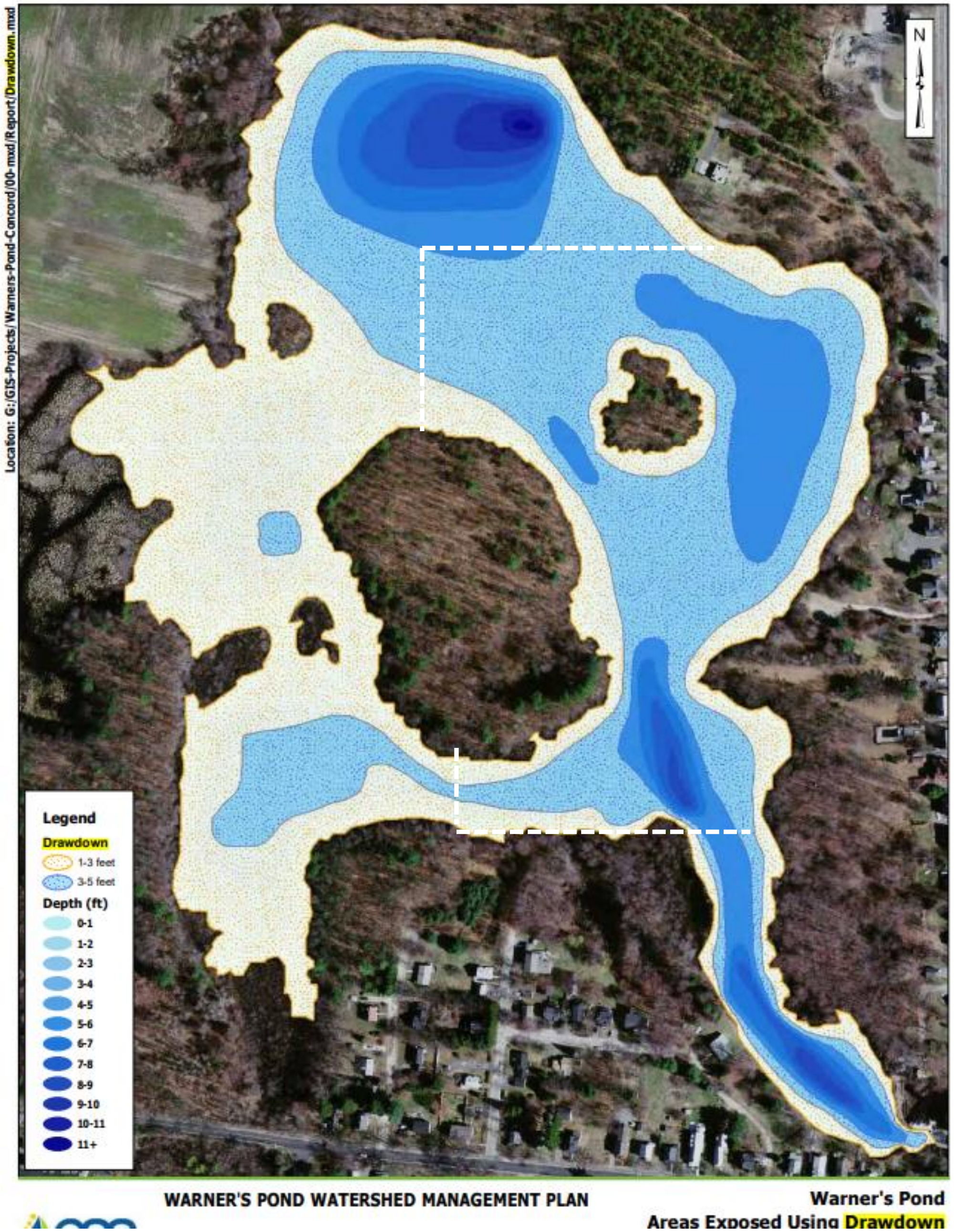
Alternative Two: Pond Restoration and Management Short Term Approach - Drawdown



Dominant Aquatic Plant Species, Warner's Pond, September 2, 2011.

Scientific Name	Common Name	Symbol
*Cabomba caroliniana**	Fanwort	Cc
Ceratophyllum demersum	Coontail	Cd
*Myriophyllum heterophyllum**	Variable-leaf milfoil	Mh
Nuphar lutea variegata	Yellow water lily	Nv

*Exotic invasive



Alternative Two: Pond Restoration and Management Long-Term Approach

There appears to be, effectively, only one viable long-term pond management approach - dredging. Based on sediment deposition estimates, this approach is estimated to be a long-term solution ranging from 50 to 100 years. The 2012 ESS report presents a detailed discussion of dredging. A dredging feasibility study was performed in 2018 by ESS. Construction drawings for the ESS dredge plan were prepared and permitting completed between 2018 and 2022. Town funds were allocated (by Town Meeting vote) for dredging. In 2022, a construction bid was prepared and issued, with only one bid response (Charter Construction). Additional dredging concepts are under consideration including in the 2023 EA Alternatives Report.

As presented in the ESS Watershed Management Study…"Since Warner's Pond is an impounded pond, the dredging program should be designed to not only remove the accumulated sediment, but also to deepen the pond to a depth that will preclude the growth of rooted plants from the areas of the pond that are envisioned to remain weed free. Ultimately, the goal of the restoration is to retain the pond's historic character as an open water amenity within the Town while also maintaining the site's value as an ecological resource. Therefore, in addition to developing a design and cost estimate for a dredging project to improve the deep-water habitat, areas in which the restoration could be configured to also improve the shallower wetland and wildlife habitat around the pond's perimeter have also been identified."

There are several viable dredging methods, including:

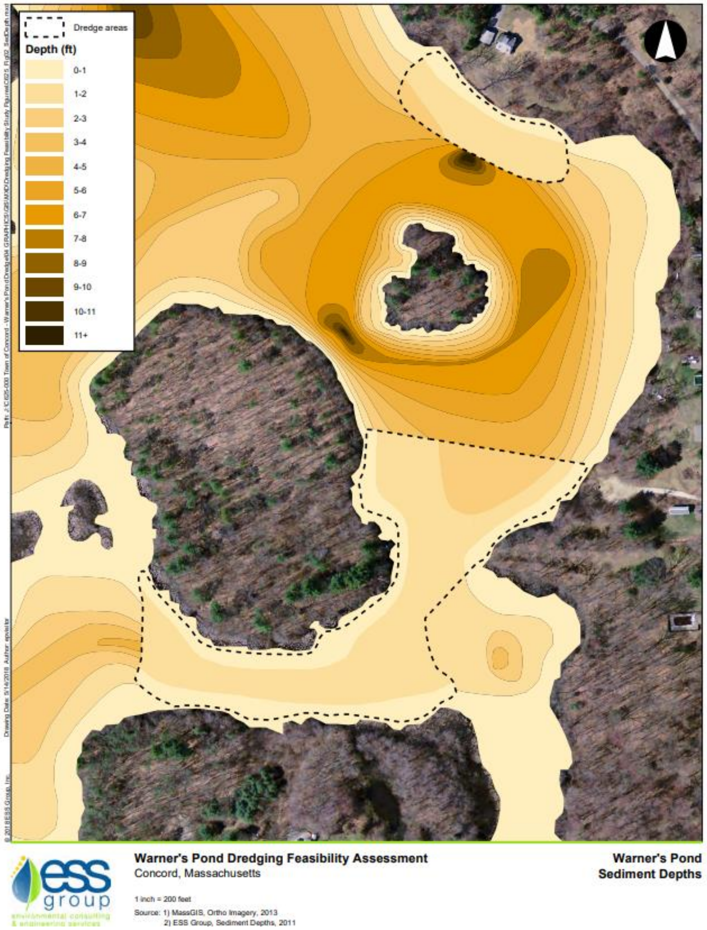
- Mechanical dredging
- Mechanical dredging with pond drawdown
- Hydraulic dredging

The following slides present the different dredge options.

Alternative Two: Pond Restoration and Management Long-Term Approach

ESS dredge plan:

The Plan recommended dredging of a portion of the pond, specifically the area between Scout Island, Pond Street, and the Commonwealth Avenue public access points, as the more realistic alternative to dredging the entire pond. The Town decided to pursue further study of limited dredging in this location as well as a small section in the northeastern corner of the pond adjacent to the recently-constructed Gerow parcel where a swimming beach was under consideration. These areas are illustrated here. This dredge alternatives was bid in 2022.



Alternative Two: Pond Restoration and Management Long-Term Approach

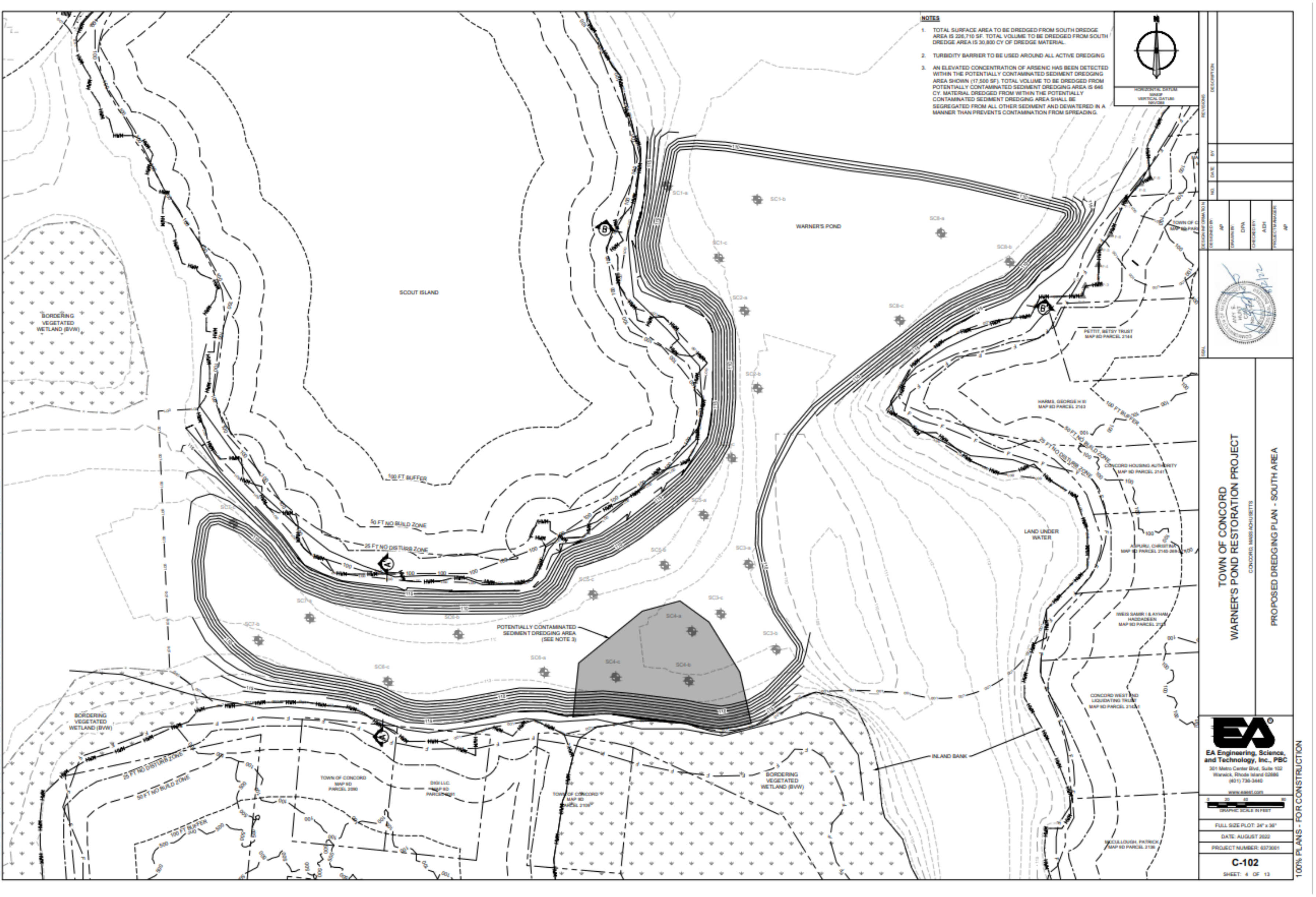
ESS (EA) 2022 Dredge Plan and Construction Bid Scope of Work:

The plan and bid specified: 1) limited dredging of two areas (North and South) using hydraulic dredging methods; 2) placement of dredge spoil within the pond to create additional emergent wetlands; 3) dewatering the remaining dredge spoil and transport for off-site disposal; 4) improvements to the parking area and access road including resurfacing a parking lot; 5) improvements to the stormwater management system; and 6) reconstructing a boat ramp.

- **Dredging:** hydraulic dredging of 35,750 cy from two areas (North and South) totaling 6.3 acres. The North dredge area is 1.1 acres and was intended to create a swimming beach as part of Gerow Recreation Area. The South dredge area is 5.2 acres located east and south of Scout Island.
- **Emergent Wetland Creation:** 4,470 cy of dredge spoil to be used to construct a 1-acre emergent wetland shelf on the north shore of Scout Island. Native emergent wetland plant species to be planted within the wetland shelf (12,700 plant starts). Proposed wetland shelf meets the definition of “Ecological Restoration Project” per 310 CMR 10.04.
- **Dewatering of Dredge Spoil:** 31,280 cy to be temporarily stockpiled and dewatered (location adjacent to Warner’s Pond)
- **Disposal of Dredge Spoil:** 31,280 cy of dewatered dredge spoil to be disposed off-site (MCI property specified proposed in bid)

Alternative Two: Pond Restoration and Management Long-Term Approach

ESS Dredge Plan South Dredge Area



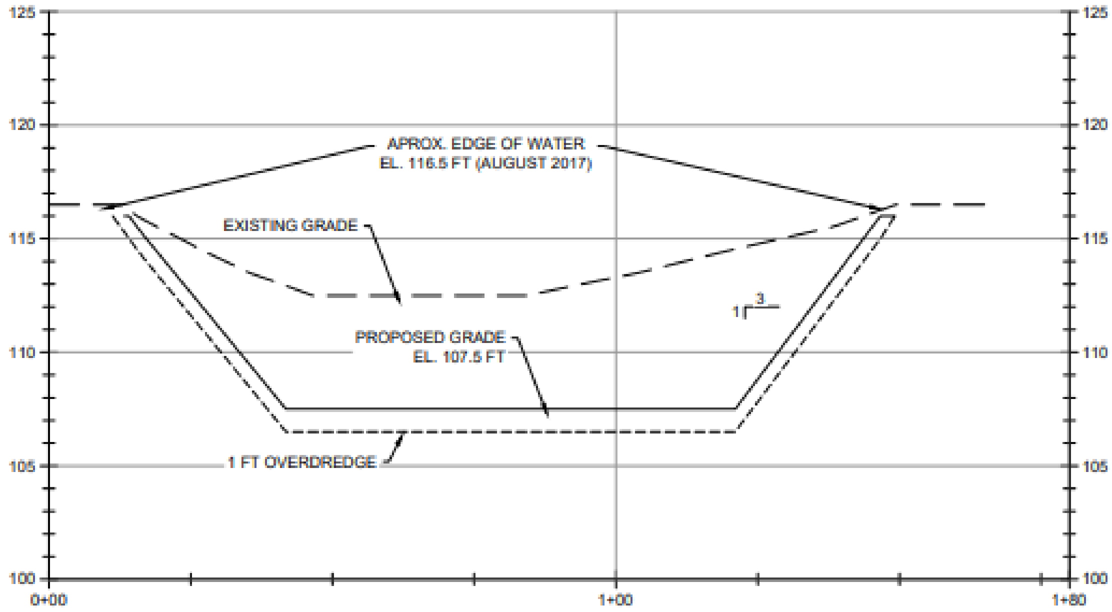
NOTES

1. TOTAL SURFACE AREA TO BE DREDGED FROM SOUTH DREDGE AREA IS 226,710 SF. TOTAL VOLUME TO BE DREDGED FROM SOUTH DREDGE AREA IS 30,800 CY OF DREDGE MATERIAL.
2. TURBIDITY BARRIER TO BE USED AROUND ALL ACTIVE DREDGING
3. AN ELEVATED CONCENTRATION OF ARSENIC HAS BEEN DETECTED WITHIN THE POTENTIALLY CONTAMINATED SEDIMENT DREDGING AREA SHOWN (17,500 SF). TOTAL VOLUME TO BE DREDGED FROM POTENTIALLY CONTAMINATED SEDIMENT DREDGING AREA IS 646 CY. MATERIAL DREDGED FROM WITHIN THE POTENTIALLY CONTAMINATED SEDIMENT DREDGING AREA SHALL BE SEGREGATED FROM ALL OTHER SEDIMENT AND DEWATERED IN A MANNER THAN PREVENTS CONTAMINATION FROM SPREADING.

Alternative Two: Pond Restoration and Management Long-Term Approach

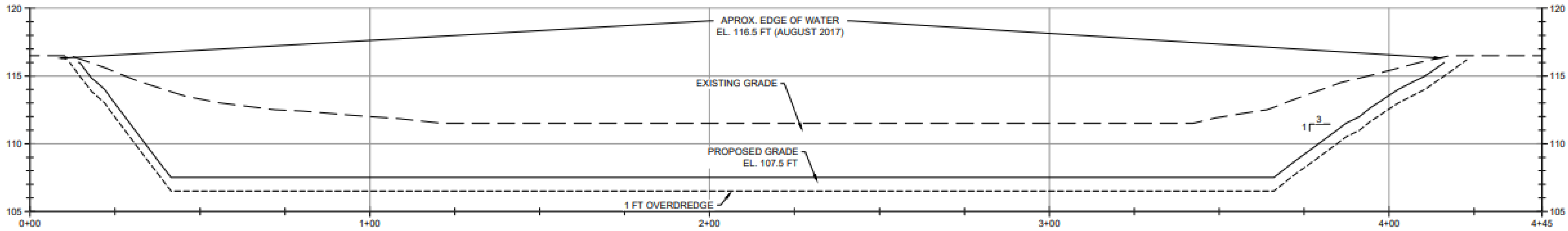
ESS Dredge Plan South Dredge Area Sections

The South dredge area will be dredged to bottom elevations of 107.5 feet NAVD88 (11.3 feet below the Normal Pool Elevation of 118.8 feet NAVD88). Dredge side slopes will be 3H:1V.



SECTION A-A'

H: 1" = 20'
V: 1" = 5'



SECTION B-B'

H: 1" = 20'
V: 1" = 5'

Alternative Two: Pond Restoration and Management Long-Term Approach

ESS Dredge Plan North Dredge Area

NOTES

1. TOTAL SURFACE AREA TO BE DREDGED FROM NORTH DREDGE AREA IS 67,800 SF. TOTAL VOLUME TO BE DREDGED FROM NORTH DREDGE AREA IS 5,000 CY OF DREDGE MATERIAL.
2. TURBIDITY BARRIER TO BE USED AROUND ALL ACTIVE DREDGING.
3. MATERIAL FROM NORTH DREDGE AREA WILL BE PRIMARILY PIPED TO WETLAND SHELF AREA. ONCE WETLAND SHELF IS COMPLETE, REMAINING DREDGE MATERIAL FROM NORTH DREDGE AREA WILL BE PIPED TO THE DEWATERING AREA TO BE DEWATERED.

REVISIONS
NO | DATE | BY | DESCRIPTION

DESIGN INFORMATION
DESIGNED BY AP
DRAWN BY EPA
CHECKED BY ADH
PROJECT MANAGER AP

SEAL

TOWN OF CONCORD
WARNER'S POND RESTORATION PROJECT
CONCORD, MASSACHUSETTS

PROPOSED DREDGING PLAN - NORTH AREA

EA Engineering, Science, and Technology, Inc., PBC
301 Metro Center Blvd, Suite 102
Warwick, Rhode Island 02886
(401) 736-3440
www.eaest.com

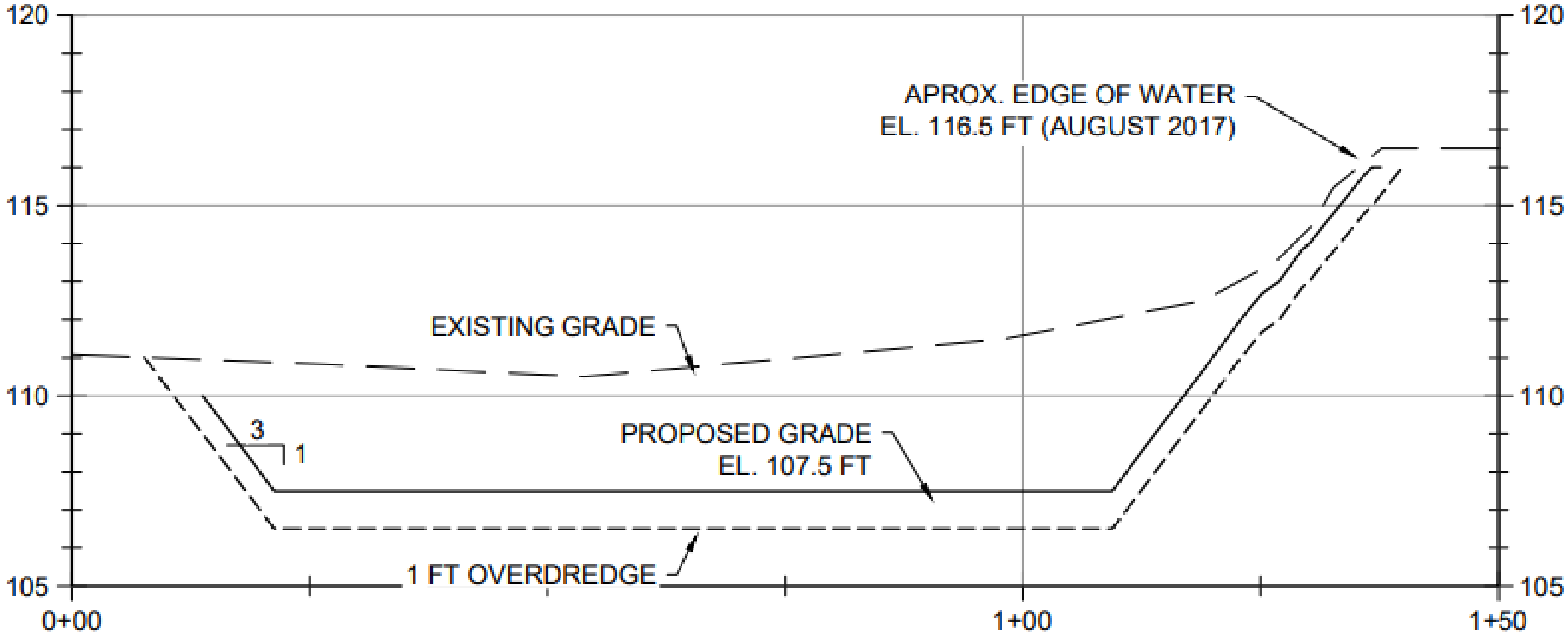
FULL SIZE PLOT: 24" x 36"
DATE: AUGUST 2022
PROJECT NUMBER: 6373001

C-103
SHEET: 5 OF 13

100% PLANS - FOR CONSTRUCTION

Alternative Two: Pond Restoration and Management Long-Term Approach

ESS Dredge Plan North Dredge Area

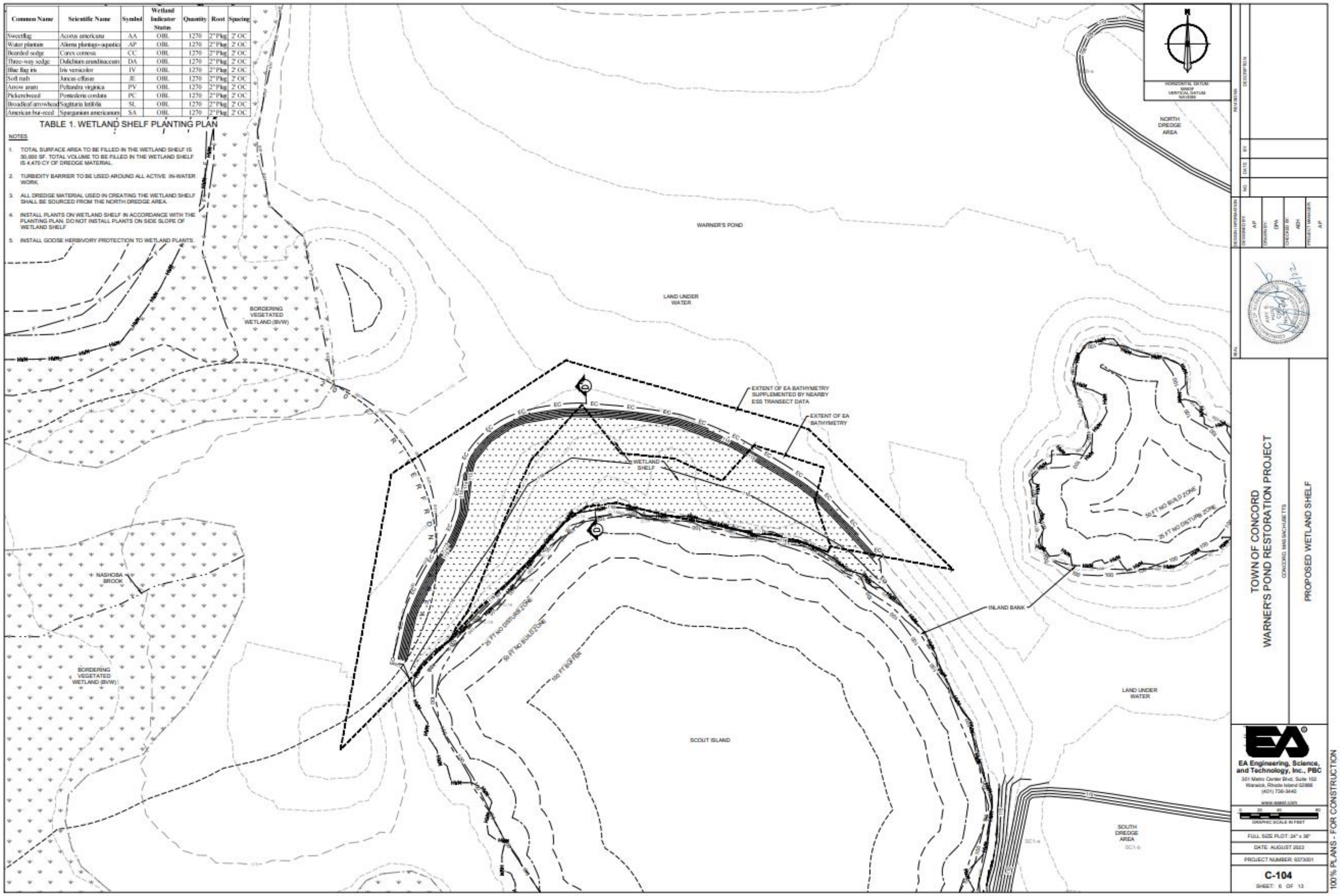


SECTION C-C'

H: 1" = 20'
V: 1" = 5'

Alternative Two: Pond Restoration and Management Long-Term Approach

ESS Dredge Plan Emergent Wetland Shelf



Common Name	Scientific Name	Symbol	Wetland Indicator Status	Quantity	Root	Spacing
Sweetflag	Acorus americanus	AA	OBL	1270	2" Plug	2' OC
Water plantain	Alisma plantago-aquatic	AP	OBL	1270	2" Plug	2' OC
Bearded sedge	Carex comosa	CC	OBL	1270	2" Plug	2' OC
Three-way sedge	Dulichium arundinaceum	DA	OBL	1270	2" Plug	2' OC
Blue flag iris	Iris versicolor	IV	OBL	1270	2" Plug	2' OC
Soft rush	Juncus effusus	JE	OBL	1270	2" Plug	2' OC
Arrow arum	Peltandra virginica	PV	OBL	1270	2" Plug	2' OC
Pickerelweed	Pontederia cordata	PC	OBL	1270	2" Plug	2' OC
Broadleaf arrowhead	Sagittaria latifolia	SL	OBL	1270	2" Plug	2' OC
American bur-reed	Sparganium americanum	SA	OBL	1270	2" Plug	2' OC

TABLE 1. WETLAND SHELF PLANTING PLAN

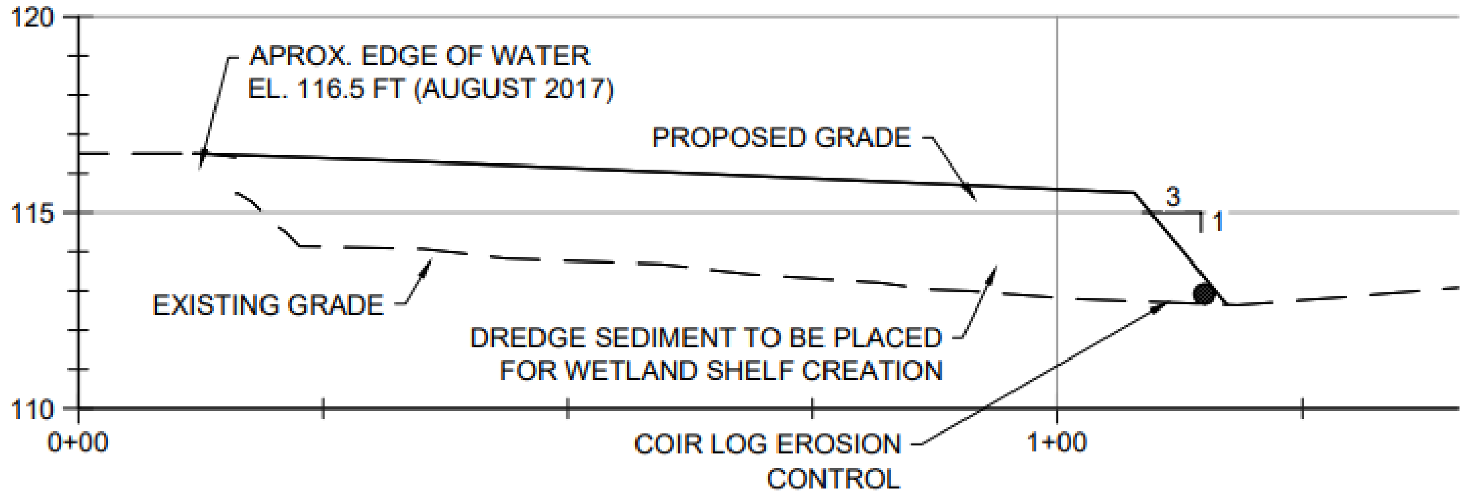
NOTES

1. TOTAL SURFACE AREA TO BE FILLED IN THE WETLAND SHELF IS 50,000 SF. TOTAL VOLUME TO BE FILLED IN THE WETLAND SHELF IS 4,470 CY OF DREDGE MATERIAL.
2. TURBIDITY BARRIER TO BE USED AROUND ALL ACTIVE IN-WATER WORK.
3. ALL DREDGE MATERIAL USED IN CREATING THE WETLAND SHELF SHALL BE SOURCED FROM THE NORTH DREDGE AREA.
4. INSTALL PLANTS ON WETLAND SHELF IN ACCORDANCE WITH THE PLANTING PLAN. DO NOT INSTALL PLANTS ON SIDE SLOPE OF WETLAND SHELF
5. INSTALL GOOSE HERBIVORY PROTECTION TO WETLAND PLANTS.

Alternative Two: Pond Restoration and Management Long-Term Approach

ESS Dredge Plan Emergent Wetland Shelf

The Emergent Wetland Shelf will include placement of 2 to 3 feet of dredge spoil to proposed grades of about 116.5 to 115 feet NAVD88 (about 2 to 4 feet below Normal Pool Elevation of 118.8 feet NAVD88).

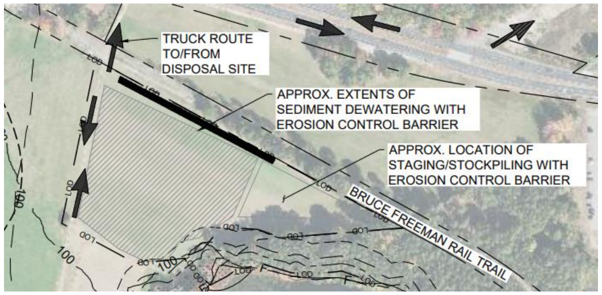


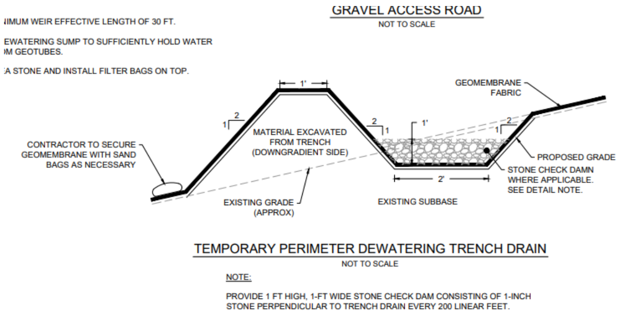
SECTION D-D'

H: 1" = 20'
V: 1" = 5'

Alternative Two: Pond Restoration and Management Long-Term Approach

ESS Dredge Plan Dewatering Area



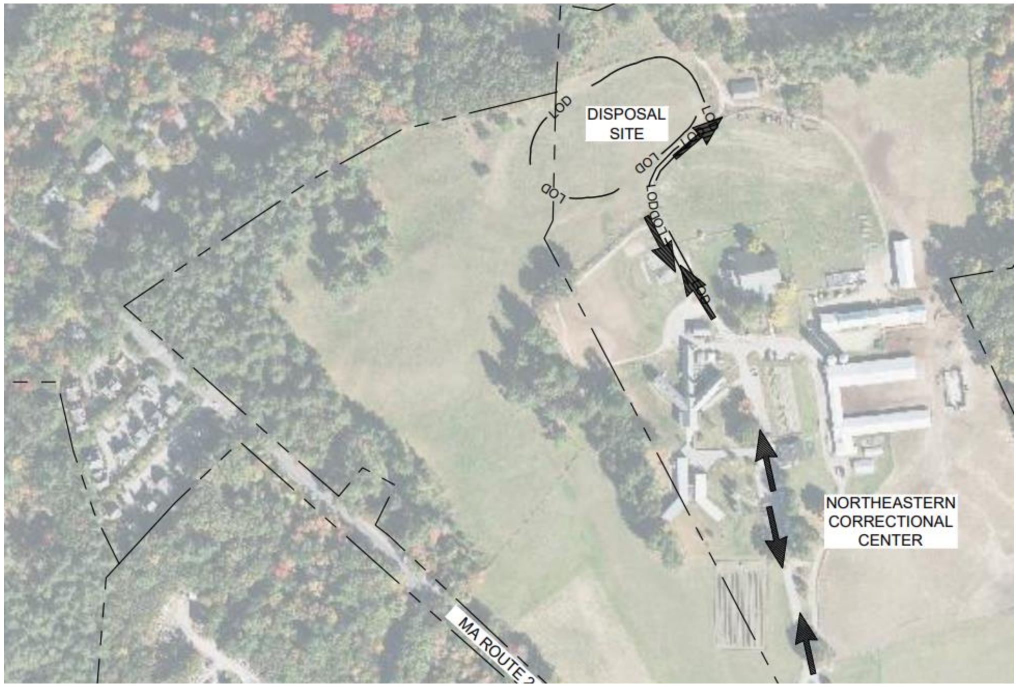


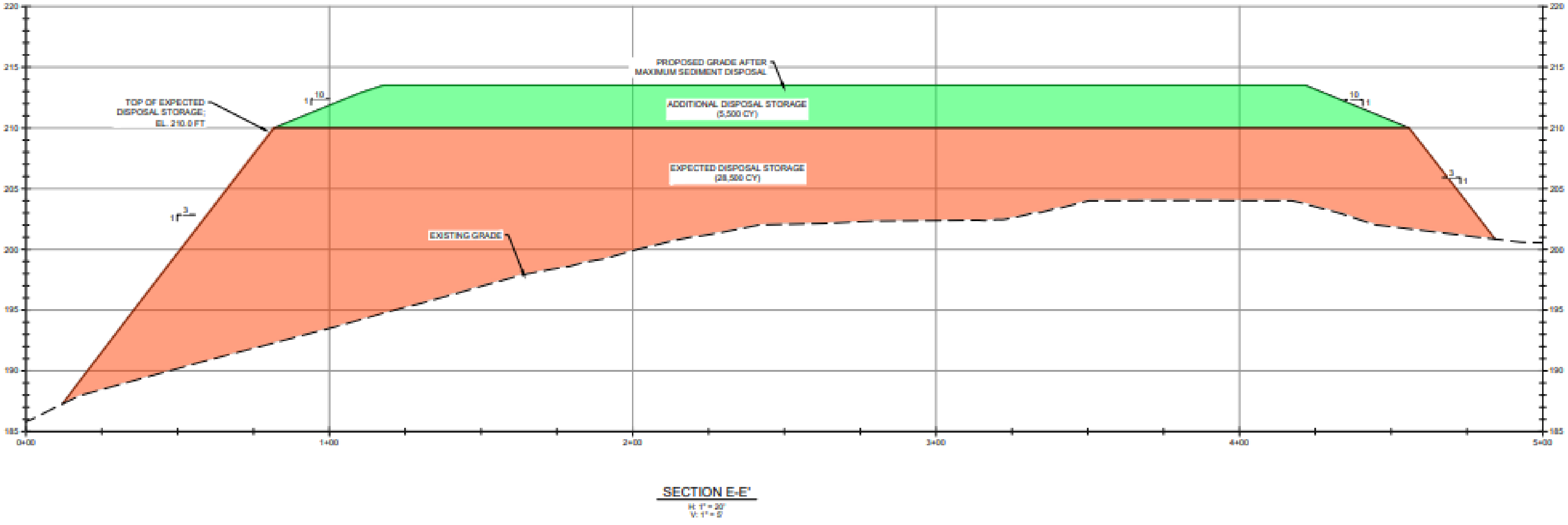
NOTES:

1. INSTALL PERIMETER DEWATERING DRAIN ALONG LOWEST GRADES IN DEWATERING AREA TO COLLECT WATER FROM DEWATERING DREDGE MATERIAL. GRADE PERIMETER DEWATERING DRAIN TO THE OUTFLOW POINT INDICATED. ENSURE SIZE OF DRAIN IS SUFFICIENT TO CONVEY WATER FROM DEWATERING DREDGE MATERIAL AND ENSURE WATER DOES NOT BACK UP AS A RESULT OF HIGH INFLOW RATES.
2. INSTALL GEOTUBES AND SUMP WITHIN DEWATERING AREA. ENSURE ALL WATER IS CAPTURED IN THE SUMP AND THAT THE SUMP IS LOCATED ON THE LOWEST POINT IN THE GRADING.
3. INSTALL GEOTUBES WITHIN DEWATERING AREA UPGRADIENT OF THE PERIMETER DEWATERING DRAIN. ENSURE ALL WATER IS CAPTURED IN THE DRAIN.
4. ANY TEMPORARY COVER USED ON SITE SHALL BE 40% ANNUAL RYEGRASS AND 60% PERENNIAL RYEGRASS APPLIED AT A RATE OF 18 LBS/ACRE.

Alternative Two: Pond Restoration and Management Long-Term Approach

ESS Dredge Plan MCI Disposal Area

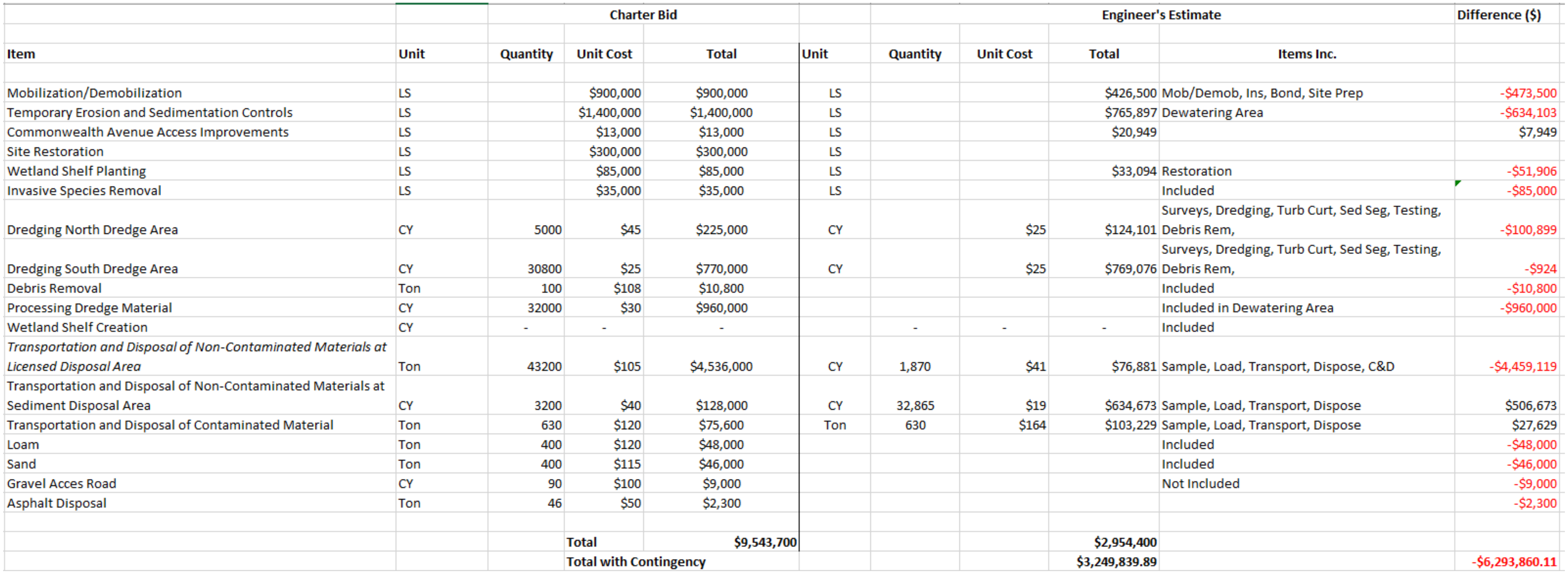




SECTION E-E'
H: 1" = 20'
V: 1" = 5'

Alternative Two: Long Term Approach Cost Comparison

There are two cost data sources for the pond dredge alternative : 1) 2022 Engineer's Estimate; and 2) Charter Construction Bid (only bidder). The following provides an approximate comparison of the two data sources. The following slide provides a summary of the cost similarities and differences.



		Charter Bid				Engineer's Estimate				Difference ($)
Item	Unit	Quantity	Unit Cost	Total	Unit	Quantity	Unit Cost	Total	Items Inc.	
Mobilization/Demobilization	LS		$900,000	$900,000	LS			$426,500	Mob/Demob, Ins, Bond, Site Prep	-$473,500
Temporary Erosion and Sedimentation Controls	LS		$1,400,000	$1,400,000	LS			$765,897	Dewatering Area	-$634,103
Commonwealth Avenue Access Improvements	LS		$13,000	$13,000	LS			$20,949		$7,949
Site Restoration	LS		$300,000	$300,000	LS					
Wetland Shelf Planting	LS		$85,000	$85,000	LS			$33,094	Restoration	-$51,906
Invasive Species Removal	LS		$35,000	$35,000	LS				Included	-$85,000
Dredging North Dredge Area	CY	5000	$45	$225,000	CY		$25	$124,101	Surveys, Dredging, Turb Curt, Sed Seg, Testing, Debris Rem,	-$100,899
Dredging South Dredge Area	CY	30800	$25	$770,000	CY		$25	$769,076	Surveys, Dredging, Turb Curt, Sed Seg, Testing, Debris Rem,	-$924
Debris Removal	Ton	100	$108	$10,800					Included	-$10,800
Processing Dredge Material	CY	32000	$30	$960,000					Included in Dewatering Area	-$960,000
Wetland Shelf Creation	CY	-	-	-		-	-	-	Included	
Transportation and Disposal of Non-Contaminated Materials at Licensed Disposal Area	Ton	43200	$105	$4,536,000	CY	1,870	$41	$76,881	Sample, Load, Transport, Dispose, C&D	-$4,459,119
Transportation and Disposal of Non-Contaminated Materials at Sediment Disposal Area	CY	3200	$40	$128,000	CY	32,865	$19	$634,673	Sample, Load, Transport, Dispose	$506,673
Transportation and Disposal of Contaminated Material	Ton	630	$120	$75,600	Ton	630	$164	$103,229	Sample, Load, Transport, Dispose	$27,629
Loam	Ton	400	$120	$48,000					Included	-$48,000
Sand	Ton	400	$115	$46,000					Included	-$46,000
Gravel Acces Road	CY	90	$100	$9,000					Not Included	-$9,000
Asphalt Disposal	Ton	46	$50	$2,300						-$2,300
			Total	**$9,543,700**				**$2,954,400**		
			Total with Contingency					**$3,249,839.89**		**-$6,293,860.11**

Alternative Two: Long Term Approach Cost Comparison

The following slide provides a summary of the cost similarities and differences. Line item cost comparisons should be considered approximate since different line items were used (i.e., bid form vs Engineer's Estimate); regardless, the key differences and similarities are apparent.

1. The unit and total costs for hydraulic dredging (about $25/cy)) are similar. The bid unit cost for the dredge with wetland shelf placement ($45/cy).
2. The unit and total costs disposal of contaminated dredge spoil disposal are similar.
3. The unit costs for disposal of non-contaminated sediment at the specified Sediment Disposal Area were different with the bid value (about $40/cy) approximately twice the Engineer's Estimate.
4. The most significant and impactful differences appear to include:
   - The costs associated with dewatering including preparation of the dewatering area and transport and placement of the sediment to be dewatered. To make a comparison, it was assumed that the bid items including Temporary Erosion and Sediment Controls and Processing Dredge Material constitute the "dewatering" costs ($2,360,000). These are compared to the Engineer's Estimate line items for: 1) Dewatering Area (all line items); and 2) Load, Transport and Place dewatered sediment ($1,400,570). This is an approximate difference of about $960,000).
   - The costs associated with disposal of non-contaminated dredge spoil at a licensed, off-site facility (bid item) ($4,536,000) versus disposal at the specified (MCI) Sediment Disposal Area ($634,673), a difference of about $3,901,327.
5. The estimated, approximate cost of project bid with all non-contaminated sediment disposed of at the specified Sediment Disposal Area and all other item costs the same is about $6,134,500 – still about $2.9M above the Engineer's Estimate.
6. In summary, the costs associated with placing dredge spoil off-site (versus in-pond placement) represents a major portion of the dredge costs (about 60%). In-pond placement of all of 31,370 cy dredge material (32,000 cy total dredge less 630 cy contaminated) would reduce the total project cost, based on the bid item costs, to about $2.6M to $3.5M.
7. Assuming 2-foot thick average sediment placement and 31,370 cy total placed, in-pond placement would require about a 10-acre placement area (assumed to add to emergent wetlands area).

Alternative Two: Long Term Approach - Additional Dredging Concept

2023 EA Alternatives Analysis Report – Another Dredging Concept

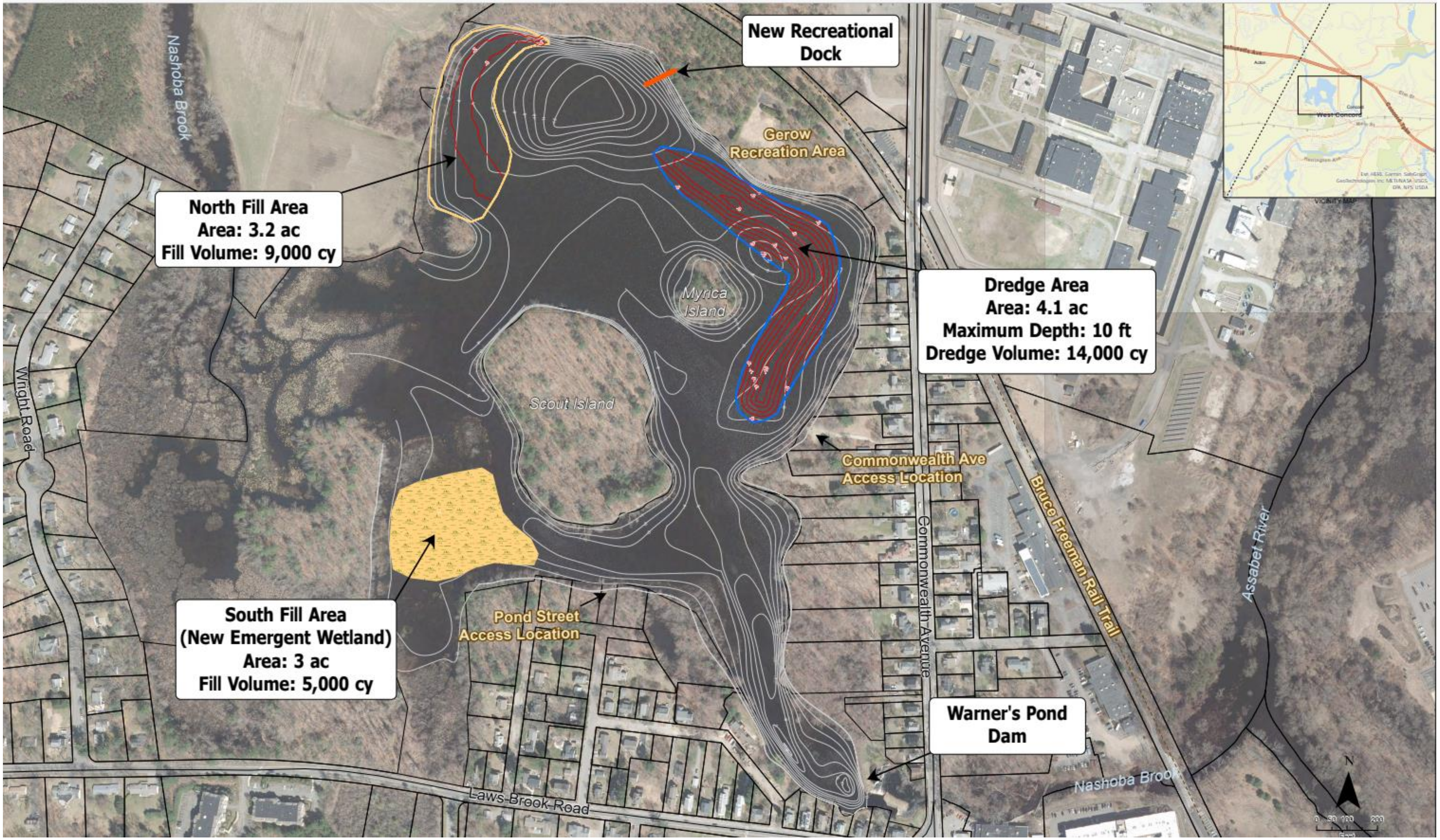
An alternative dredge concept was presented in the 2023 EA Alternatives Analysis Report:

- **Dredging:** Hydraulic dredging of approximately 14,000 cy sediment from an approximately 4.1 acres area at the eastern portion of Warner's Pond, dredged to a maximum depth of about 10 feet. Typical side slopes for coarse sandy material in still water generally range from 15-20 degrees (4H:1V to 3H:1V). Previous sediment sampling at Warner's Pond revealed that sediments in an area southeast of Scout Island exceeded state standards for arsenic concentrations. The Dredging and Filling Alternative will be designed to avoid dredging or filling in this area to avoid potential water quality, ecological and human health, and regulatory concerns.
- **Emergent Wetland Creation:**
  - Placing approximately 9,000 cy of dredge material within an approximately 3.2-acre area along the pond's northwestern shoreline, filling the area at a 60:1 slope to within 1 foot of the water surface.
  - Placing the remaining approximately 5,000 cy of dredged material within an approximately 3-acre area in the pond's southwestern cove within 1 foot of the water surface to create a shallow emergent wetland.
- **Dewatering of Dredge Spoil:** not required
- **Disposal of Dredge Spoil:** no off-site disposal required

The EA estimate (preliminary) for this additional dredging concept is $3.1M (range of $2.7M to $4.1M) with 20% contingency, including design, permitting and construction, of which about $2.9M is construction (range of ($2.5M to $3.8M). Note that, for comparison using the Charter Construction bid line item costs and 4% inflation, the construction cost estimate for the additional dredge concept would be about $1.2M to $1.6M – which is less than the EA estimate.

Alternative Two: Pond Restoration and Management cont.

2023 EA Alternatives Analysis Report – Another Dredging Concept



Alternative Two: Pond Restoration and Management cont.

2023 EA Alternatives Analysis Report – Another Dredging Concept

Note: visual rendering presented here may not accurately reflect: 1) water level of Normal Pool Elevation, which would actually be a larger area of surface water; and 2) channel flow to the east of Scout Island, which would remain.

Dredging and Filling Alternative - Aerial view of Warner’s Pond facing South

Warner’s Pond Alternatives Analysis | Concord, Massachusetts | April, 2023

PEA GROUP

Alternative Two: Pond Restoration and Management cont.

Dredging and Filling Alternative - Warner's Pond from Gerow Park facing Southwest

Warner's Pond Alternatives Analysis | Concord, Massachusetts | April, 2023

PEA GROUP

Alternative Two: Pond Restoration and Management cont.

Dredging and Filling Alternative - Warner’s Pond from Commonwealth St. facing West

Alternative Two: Pond Restoration and Management cont.

The estimated costs presented in the Alternatives Analysis Report for the additional dredging alternative are summarized below.

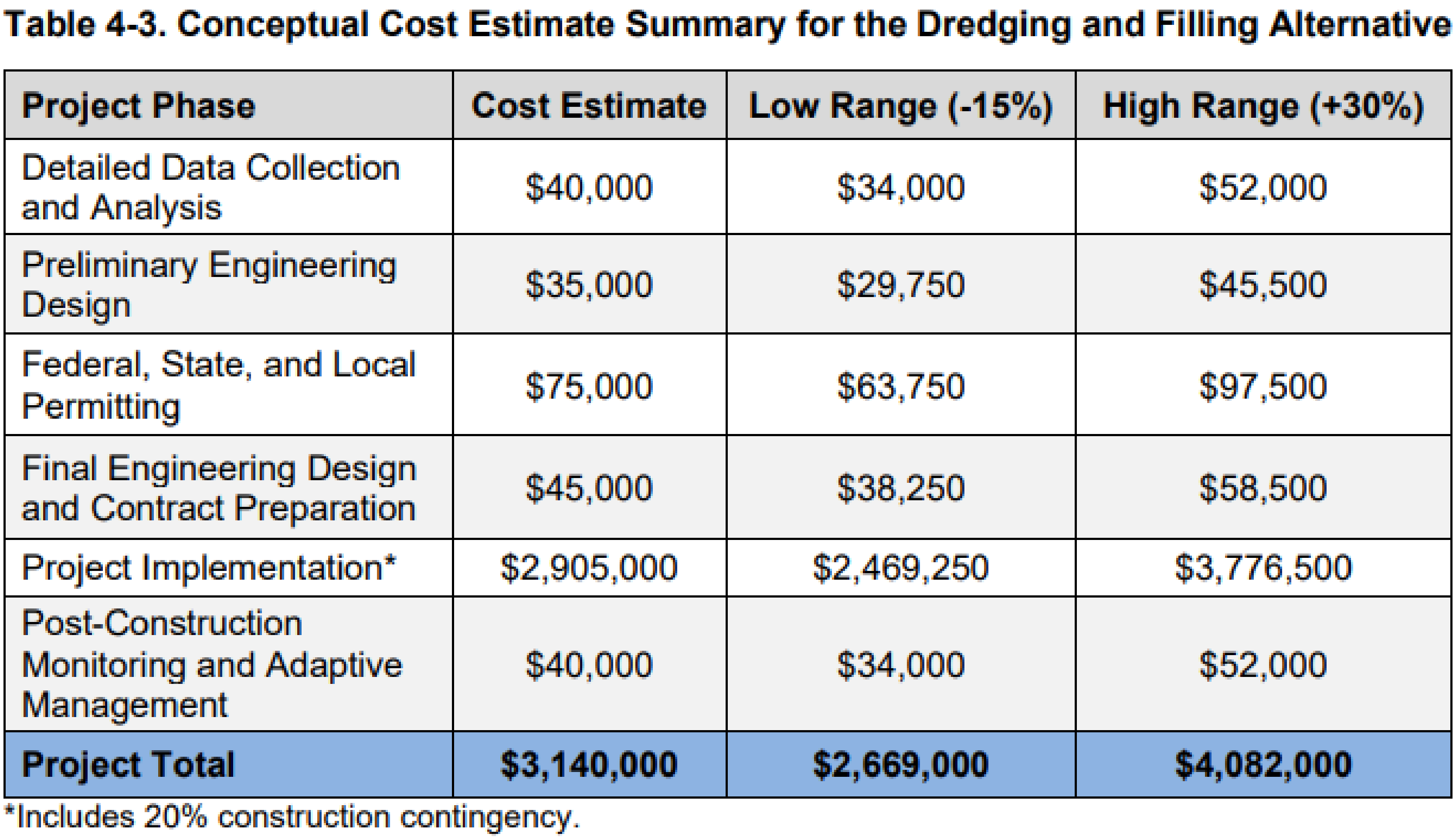


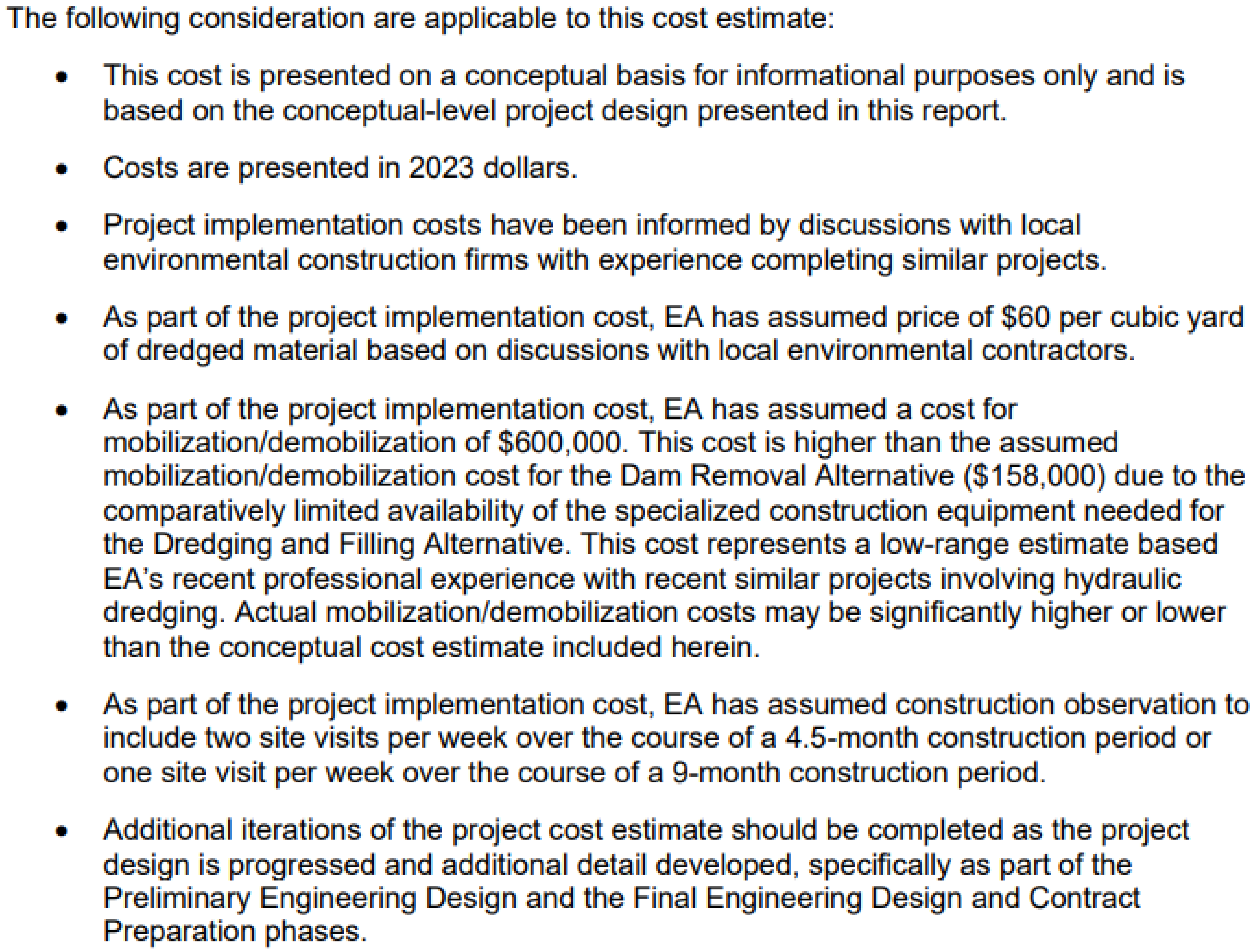
Table 4-3. Conceptual Cost Estimate Summary for the Dredging and Filling Alternative

Project Phase	Cost Estimate	Low Range (-15%)	High Range (+30%)
Detailed Data Collection and Analysis	$40,000	$34,000	$52,000
Preliminary Engineering Design	$35,000	$29,750	$45,500
Federal, State, and Local Permitting	$75,000	$63,750	$97,500
Final Engineering Design and Contract Preparation	$45,000	$38,250	$58,500
Project Implementation*	$2,905,000	$2,469,250	$3,776,500
Post-Construction Monitoring and Adaptive Management	$40,000	$34,000	$52,000
Project Total	**$3,140,000**	**$2,669,000**	**$4,082,000**

*Includes 20% construction contingency.

Alternative Two: Pond Restoration and Management cont.

The estimated cost assumptions presented in the Alternatives Analysis Report for the additional dredging alternative are summarized below.



The following consideration are applicable to this cost estimate:

- This cost is presented on a conceptual basis for informational purposes only and is based on the conceptual-level project design presented in this report.
- Costs are presented in 2023 dollars.
- Project implementation costs have been informed by discussions with local environmental construction firms with experience completing similar projects.
- As part of the project implementation cost, EA has assumed price of $60 per cubic yard of dredged material based on discussions with local environmental contractors.
- As part of the project implementation cost, EA has assumed a cost for mobilization/demobilization of $600,000. This cost is higher than the assumed mobilization/demobilization cost for the Dam Removal Alternative ($158,000) due to the comparatively limited availability of the specialized construction equipment needed for the Dredging and Filling Alternative. This cost represents a low-range estimate based EA's recent professional experience with recent similar projects involving hydraulic dredging. Actual mobilization/demobilization costs may be significantly higher or lower than the conceptual cost estimate included herein.
- As part of the project implementation cost, EA has assumed construction observation to include two site visits per week over the course of a 4.5-month construction period or one site visit per week over the course of a 9-month construction period.
- Additional iterations of the project cost estimate should be completed as the project design is progressed and additional detail developed, specifically as part of the Preliminary Engineering Design and the Final Engineering Design and Contract Preparation phases.

Alternative Three: Dam Removal

This alternative, as proposed, includes removal of the dam in its entirety, creation of a new +/- 4,700 lf stream channel and creation of a shallow, 4.5-acre pond. It is proposed to also include creation of about 35-acres of wetlands and maintain the extent of existing wetlands. However, no technical assessment has been provided to support future wetland viability under this alternative.

Alternative Three: Dam Removal

As stated in the Alternatives Analysis report…"the Dam Removal Alternative would restore the Nashoba Brook system to its pre-alteration state as a free-flowing river and bordering vegetated wetland complex by removing the impounding effects of the Warner's Pond dam." This statement is not correct since the proposed new river channel is not the pre-colonial river location. It may also not be correct since the existing wetlands, which depend upon the impounded water level, will be impacted.

Regardless, the proposed components of the alternative include:

- removal of the Warner's Pond dam
- restore approximately 4,750 linear feet (0.9 mile) of stream channel
- establishment of 35-acres of new wetlands
- An approximately 4.5-acre open water area, corresponding with the existing pond's deep hole

The Town's consultant, EA, is currently performing a preliminary dam removal design and assessment, which is not currently available. The following presents some preliminary assumptions:

- Based on estimated stream thalweg elevations upgradient and downgradient of Warner's Pond, new channel bottom elevations are expected to range from about 115 NAVD88 (north end) to 113 NAVD88 (at bridge). This will require a near flat channel gradient and may requires some dredging.
- The impounded water level affects the stream elevations upgradient of Warner's Pond so prediction of water levels within the proposed stream channel and new pond is difficult without numerical modeling. Based on stream water levels upgradient (about 120 to 121 feet NAVD88) and downgradient (about 115 feet) of Warner's Pond, typical water levels within the new stream channel and new 4.5-acre pond could be about 115 to 116 feet NAVD88 (about 3 to 4 feet below current Normal Pool Elevation).
- The new pond depth will vary from 1 to 8 feet and average about 4 feet.

Alternative Three: Dam Removal

Note: This estimate does not include any dredging costs although some dredging may be required.

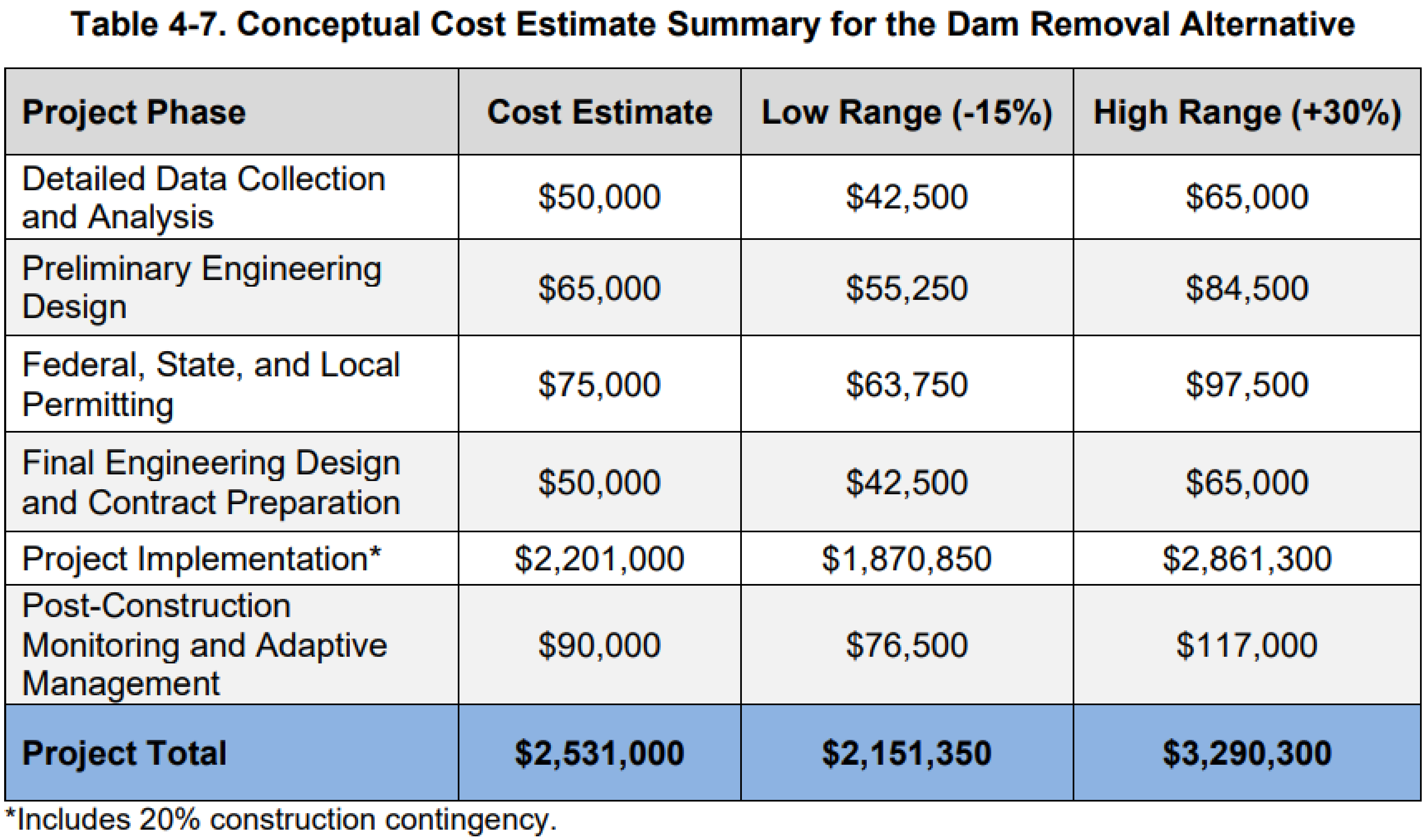


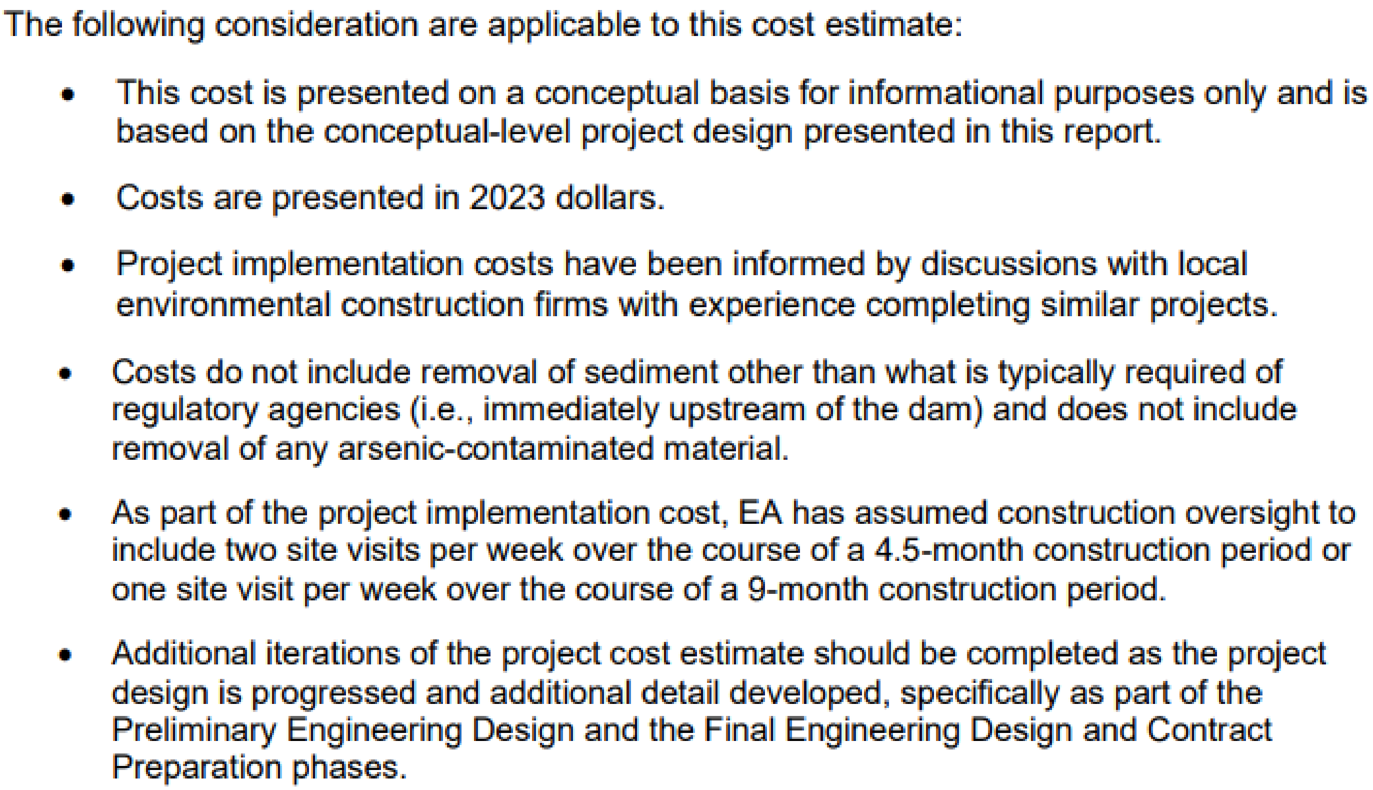
Table 4-7. Conceptual Cost Estimate Summary for the Dam Removal Alternative

Project Phase	Cost Estimate	Low Range (-15%)	High Range (+30%)
Detailed Data Collection and Analysis	$50,000	$42,500	$65,000
Preliminary Engineering Design	$65,000	$55,250	$84,500
Federal, State, and Local Permitting	$75,000	$63,750	$97,500
Final Engineering Design and Contract Preparation	$50,000	$42,500	$65,000
Project Implementation*	$2,201,000	$1,870,850	$2,861,300
Post-Construction Monitoring and Adaptive Management	$90,000	$76,500	$117,000
Project Total	**$2,531,000**	**$2,151,350**	**$3,290,300**

*Includes 20% construction contingency.

Alternative Three: Dam Removal

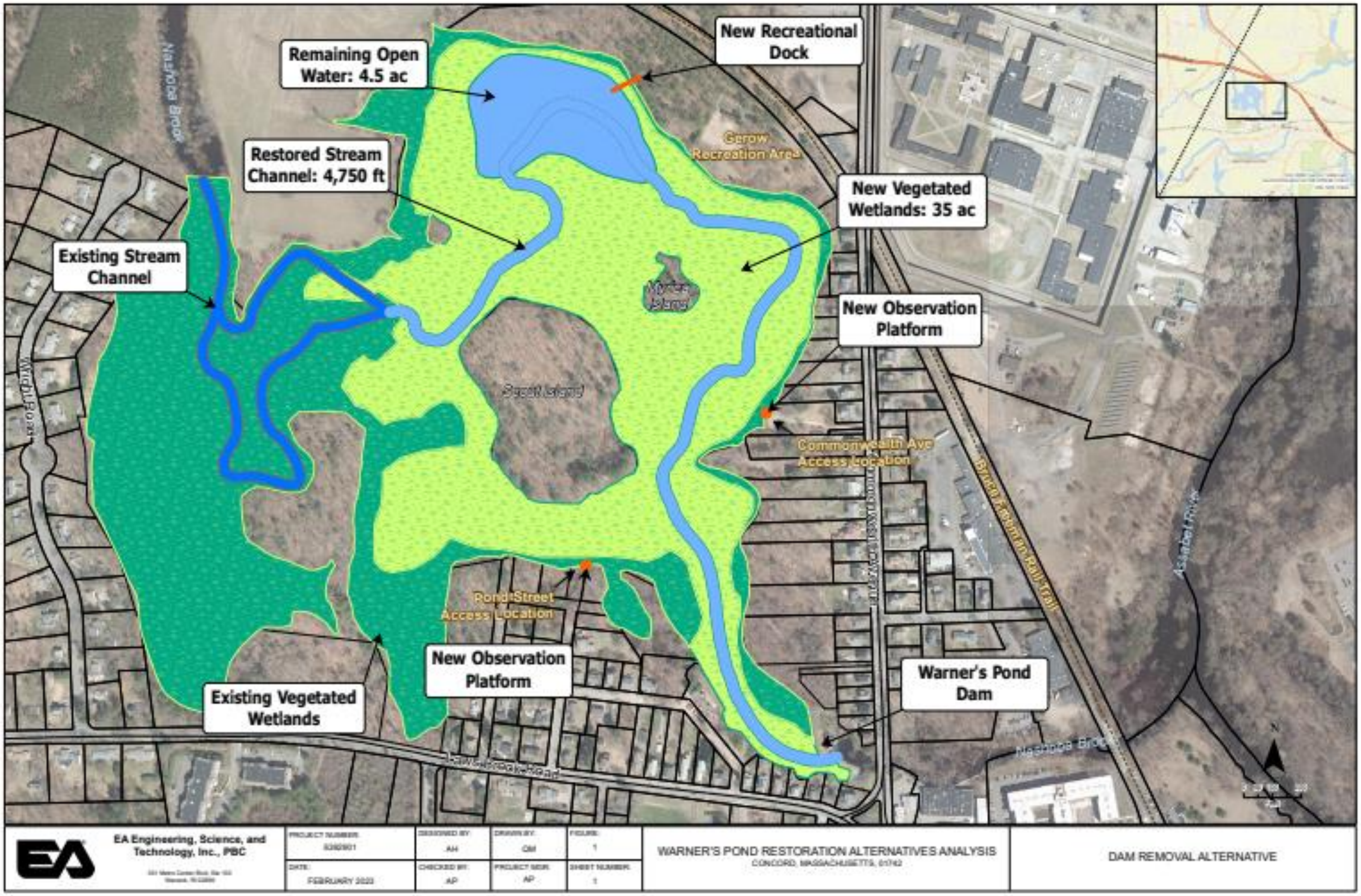
The estimated cost assumptions presented in the Alternatives Analysis Report for the additional dredging alternative are summarized below.



The following consideration are applicable to this cost estimate:

- This cost is presented on a conceptual basis for informational purposes only and is based on the conceptual-level project design presented in this report.
- Costs are presented in 2023 dollars.
- Project implementation costs have been informed by discussions with local environmental construction firms with experience completing similar projects.
- Costs do not include removal of sediment other than what is typically required of regulatory agencies (i.e., immediately upstream of the dam) and does not include removal of any arsenic-contaminated material.
- As part of the project implementation cost, EA has assumed construction oversight to include two site visits per week over the course of a 4.5-month construction period or one site visit per week over the course of a 9-month construction period.
- Additional iterations of the project cost estimate should be completed as the project design is progressed and additional detail developed, specifically as part of the Preliminary Engineering Design and the Final Engineering Design and Contract Preparation phases.

Alternative Three: Dam Removal



Alternative Three: Dam Removal

Dam Removal Alternative - Aerial view of Warner's Pond facing South

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Alternative Three: Dam Removal

Dam Removal Alternative - Warner's Pond from Gerow Park facing Southwest

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Alternative Three: Dam Removal

Dam Removal Alternative - Warner’s Pond from Commonwealth St. facing West

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