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TECHNICAL MEMORANDUM

TO: Delia Kaye, Natural Resources Director

FROM: Amy Hunt, PE, Senior Engineer
Erika Towne, PE, Project Engineer

SUBJECT: Warner's Pond Dam Removal Preliminary Design
Fish Passage Conceptual Feasibility Assessment
EA Project No. 64040-01-00-LS

EA Engineering, Science, and Technology, Inc., PBC (EA) was contracted by the Town of Concord (the Town) in September 2023 to prepare preliminary engineering designs for the removal of the Warner's Pond dam (see Figure 1 for the site location). EA's scope of services under this contract also includes a general evaluation of up to five alternative/supplemental projects related to the management and/or restoration of Warner's Pond. Based on our discussions with the Town, one such project is the installation of a fishway at the Warner's Pond dam. This technical memorandum provides a discussion of key concepts related to the feasibility of this conceptual project.

Additional discussion related to considerations for installation of a fish passageway at the Warner's Pond dam is provided in Section 4.4.4 of the Warner's Pond Alternatives Analysis Report (EA 2023).

Background

According to the U.S. Fish and Wildlife Service (USFWS), "a fishway is the combination of elements… necessary to ensure the safe, timely, and effective movement of fish past a barrier" (USFWS 2019). These barriers include culverts, dams, levees, increased sediment in waterways, abnormal increases or decreases in water temperature, water diversions, high velocities or lack of water flow, and poor water quality (USFWS Service 2025c). Diadromous fish, which are fish that migrate between the ocean and freshwater habitats, are the type of fish that use these fishways (Division of Marine Fisheries [DMF] 2025b. Diadromous fish are an integral part of the ecological community as they are forage for other fish and wildlife and carry nutrients between marine to freshwater environments (Gomez and Sillivan 2016). Some species of diadromous fish are also valued for sport fishing (DMF 2025b) and provide a cultural benefit to populations that associate abundant diadromous fish runs with a healthy river (Gomez and Sullivan 2016). Without fishways, in-stream barriers prevent diadromous fish from completing their full life-cycle, which decreases the abundance of the species. Comparison of historical records to current fish populations show that diadromous fish populations are significantly smaller in present day than in pre-colonial times. Fishways allow diadromous fish to move past in-stream barriers and complete their full life-cycle, thereby increasing their population and supporting the ecological, recreational, and cultural roles diadromous fish provide.

In Massachusetts, the Division of Marine Fisheries (DMF) "works to identify and restore areas critical to diadromous spawning". DMF supports restoration of deteriorating fishways and the construction of new fishways (DMF 2025c). DMF biologists also conduct research and monitoring of diadromous fisheries to inform stock assessments and create fisheries policies (DMF 2025d). DMF released a Diadromous Fisheries Updates on 29 June 2023 that reported increased counts for river herring (a species of diadromous fish) across coastal Massachusetts compared with the previous three years after multiple fishway improvements (DMF 2023). Another DMF fisheries update released on 24 January 2025 reported that the Mystic River has the highest count of river herring among count stations in Massachusetts during three of the last eight years following fishway installations (DMF 2025a.)

DMF also produces and maintains Geographic Information System (GIS) data layers, available on the MassGIS website, that contain information about diadromous fish passageways, impediments, habitat, species presence, and sampling stations in coastal Massachusetts. One of the GIS data layers has information on 492 restoration projects, including whether fish passage is fully impaired (fish passage not possible), partially impaired (fish passage possible with partial impairment), or not impaired (suitable for fish passage). Table 1 below shows the distribution:

Table 1. Massachusetts Fish Passage Status

Fish Passage Status	Number of Locations
Fully Impaired	142
Partial Impaired	103
No Impairment	247

Of DMF's 492 restoration projects, 147 have an existing fishway and 135 have no present passage. The projects consist of passage improvement for 133 locations, fishway maintenance for 91 locations, dam removal at 47 locations, and adding a fish ladder at 43 locations (MassGIS 2023).

In addition to DMF, the Division of Fisheries and Wildlife (MassWildlife) also manages "freshwater fisheries in lakes, ponds, streams, and rivers across the state". MassWildlife supervises fishways located at dams on the Connecticut, Merrimack, and Westfield Rivers, performs fish counts, and collects data on fish health (Division of Fisheries and Wildlife 2025).

Types of Fishways

Most fishways fall into one of two categories: technical fishways and nature-like fishways. Technical fishways are structures typically made of "concrete, aluminum, polymer, and wood, with standardized dimensions" and built "using common construction techniques". Some technical fishways are designed for upstream fish passage, while others are designed for downstream fish passage. Downstream fish passage is typically only applicable at hydropower facilities or high head dams, so these types of fishways will not be discussed in this memo. Nature-like fishways are "constructed of boulders, cobbles, and other natural materials to create diverse physical structures" and provide upstream and downstream fish passage (USFWS 2019). The following sections provide a short description of different types of fishways that fall within these two categories.

Technical Fishway Types

Pool-and-Weir Fishways

Pool-and-weir fishways consist of a series of pools separated by overflow weirs that begin at the channel bed downstream of the dam and end past the top of the dam. Each pool-weir pair increases in elevation from the adjacent downstream pool-weir so that the fish can traverse past the dam by jumping from one pool up to the next through the weirs. The pools provide an area for the fish to recover their energy before ascending to the next pool. This fishway requires enough space to account for certain design criteria, such as maximum slope, pool geometry, weir geometry, and maximum hydraulic drop (USFWS 2019).

Ice Harbor Fishways

An Ice Harbor fishway is a modified pool-and-weir fishway. Like the pool-and-weir fishway, the Ice Harbor fishway also consists of a series of pools separated by overflow weirs; however, the overflow weir consists of two weir crests with a non-overflow section in between. Additionally, there is a submerged orifice centered beneath each weir crest. The "orifices provide an alternate route for upstream movement through the structure" (USFWS 2019). There are variants of the Ice Harbor fishway called the Alternative Ice Harbor fishway and the Half Ice Harbor fishway, which are intended for low flow conditions. The Ice Harbor fishway requires enough space to account for certain design criteria, such as maximum slope, pool geometry, and weir geometry (USFWS 2019).

Vertical Slot Fishways

Vertical slot fishways consist of a rectangular channel with regularly spaced walls that contain vertical slots, or spaces, for fish to pass through. The fishway begins at the channel bed downstream of the dam and ends past the top of the dam. The vertical slot fishways can "accommodate large fluctuations in headwater and tailwater levels" and are applicable to medium head dams. Additionally, the vertical slot allows a wide variety of species to pass through since the slot spans the full depth of the wall. There is a risk of debris accumulation at the vertical slots, which could block fish passage. This fishway requires enough space to account for certain design criteria, such as a maximum slope and spacing between walls (USFWS 2019).

Standard Denil Fishways

A Standard Denil fishway consists of a two to four feet wide prismatic channel that contains small structures (baffles) which slow the velocity of water, allowing fish to swim up the channel. The baffles also increase the turbulence of the water in the channel, which can reduce passage efficiency. However, Standard Denil fishways have been used successfully for certain species and can be installed at relatively steep slopes. Also, these fishways "can operate over a moderate range of impoundment water level fluctuation". Standard Denil fishways can become clogged with debris and require cleaning and inspection on a regular basis. This fishway requires enough space to account for certain design criteria, such as a maximum slope and channel width (USFWS 2019).

Steeppass Fishways

A Steeppass fishway is a variant of the Standard Denil fishway. The Steeppass fishway has a lower flow capacity than the Standard Denil fishway and is design to be portable. Due to its

limited flow capacity, Steeppass fishways are only applicable to small, coastal watersheds and low head dams. Different models of the Steeppass (Model A, Model A40) have associated allowable fluctuations in headwater level and maximum drainage areas. This fishway requires enough space to account for certain design criteria, such as a maximum slope (USFWS 2019).

Fish Lift

Fish lifts (or elevators) are structures that direct fish to a large bucket at the bottom of the dam, lift the bucket containing the fish to the top of the dam, and then release the fish. Fish lifts "are comprised of numerous mechanical, hydraulic, and electrical components." Fish lifts typically have a smaller footprint when compared to other fishway types (USFWS 2019).

Fish Locks

A fish lock consists of a columnar structure with a fluctuating water level; fish enter the structure at the bottom of the dam when the water is low, then are carried to the top of the dam by filling the structure with water. Fish locks "are characterized by the particularly long cycle times required to evacuate fish from the lock". This type of fishway is not typically found on the East Coast (USFWS 2019).

Nature-Like Fishways

Roughened Channel

Roughened channels use natural materials, such as boulders or bedrock outcroppings, to slow water velocities, allowing fish to travel up the channel and past the dam. Generally, the slopes of roughened channels are mild and require a large footprint. Types of roughened channels include rock ramps and arch rapids. A rock ramp spans the entire width of a channel and connects the downstream channel bed to the upstream impoundment. The downstream side of the dam is filled with material to create a continuous, sloped channel. Since the rock ramp spans the entire width of the channel, there are no competing flows or concerns related to attraction of fish to the fishway. A variant of the rock ramp is a partial rock ramp, which also connects the downstream channel bed to the upstream impoundment but only spans a portion of the channel width. Since the partial rock ramp does not span the entire channel width, the fish are "subject to false attraction from gates, spill, and other adjacent watercourses" (USFWS 2019).

Step-Pool

Step-pools are constructed and operate in a similar way as a pool-and-weir fishway, but use natural materials such as rocks and stones. A series of pools, each pool higher than the adjacent downstream pool, connects the downstream channel bed to the top of the dam. Fish travel up the step pools by leaping between the pools and using the pools as a resting area. The maximum slope for step-pools is lower than the maximum slope for a pool-and-weir fishway, thereby requiring a larger footprint (USFWS 2019).

Hybrid

This type of fishway can "function as a roughened channel or step-pool depending on depth, approach velocity and flow conditions (e.g. pool and riffle structure)". Hybrid nature-like fishways require detailed evaluation to develop a site-specific design (USFWS 2019).

Fish Passageway Conceptual Feasibility for Warner's Pond

Assumptions

The following is a list of assumptions for the conceptual feasibility assessment of fish passage at Warner's Pond:

- Significant excavation or grading of the slopes adjacent to the auxiliary spillway channel and the main spillway is not feasible due to the proximity of existing infrastructure and private properties.
- Lowering water levels within the upstream impoundment is not feasible (i.e. by lowering the elevation of the main or auxiliary spillway).

Habitat Feasibility

In the 57.5 river miles between Warner's Pond and the Gulf of Maine, there are currently four dams present (see Figure 2). Three of these dams have had fish passage reestablished. The Talbot Mills dam in Billerica, which is presently an obstacle to fish passage, is currently slated for removal. Following removal of the Talbot Mills dam, there will be no remaining obstacles to diadromous fish migration between the Gulf of Maine and Warner's Pond dam (EA 2024a).

The target species identified for restoration in the Concord River Diadromous Fish Restoration Feasibility Study include diadromous species such as river herring (blueback herring [*Alosa aestivalis]* and alewife [*Alosa pseudoharengus]*), American shad (*Alosa sapidissima)*, American eel (*Anguilla rostrata)*, and sea lamprey (*Petromyzon marinus)* (Gomez and Sullivan 2016). The blueback herring, alewife, American shad, and sea lamprey are anadromous species, meaning they spawn in freshwater, migrate to marine water where they spend a portion of their life, and then return to freshwater habitats to spawn. The American eel is a catadromous species, meaning that it spends most of its life in freshwater habitats and migrates to marine water to spawn (Gomez and Sullivan 2016).

Alewives prefer ponds and lakes for their spawning areas, and begin to spawn when water temperatures reach about 51 degrees Fahrenheit (usually in late March to mid-May, or earlier following mild winters). Alewife have been known to spawn in habitats with submerged aquatic vegetation and organic detritus. Optimal substrate material for Alewife spawning, egg, and larval habitat contains "75% silt or other soft material containing detritus and vegetation", although they can spawn in areas with sand, gravel, or coarse substrate (Atlantic States Marine Fisheries Commission 2025). Blueback herring prefer riverine environments, and begin to spawn when water temperatures reach about 57 degrees Fahrenheit (usually late April through June). The American shad spawns in rivers and begin their journey to freshwater habitats when water temperatures reach 62 degrees (usually in May) (Gomez and Sullivan 2016). American eels live in riverine environments, hiding in vegetation along the shoreline (USFWS 2025a). Sea lamprey travel to freshwater habitats in the spring (Gomez and Sullivan 2016) to create pit and mound rock nests in rivers and streams for their larva, primarily consisting of silt and very fine to medium sands (USFWS 2025b).

Installation of a fishway at Warner's Pond would reconnect a total of 17.31 river miles of aquatic habitat upstream of the dam (Division of Ecological Restoration 2025). The aquatic habitat that

would become available for diadromous fish upstream of the Warner's Pond dam consists of Warner's Pond, Nashoba Brook, an unnamed tributary to Nashoba Brook, Fort Pond Brook, and Coles Brook. Barring any unknown barriers such as perched culverts, the next upstream barriers to fish passage are Allen Dam (MA00127) on Nashoba Brook approximately 1.3 miles upstream of Warner's Pond Dam and Erikson Dam (MA00195) on Fort Pond Brook approximately 4.1 miles upstream of Warner's Pond Dam. Neither of these dams have fish passage facilities according to the National Inventory of Dams (U.S. Army Corps of Engineers [USACE 2020]). Warner's Pond, Nashoba Brook, the unnamed tributary to Nashoba Brook, Fort Pond Brook, and Coles Brook are all classified as Class B waterbodies, which are waters "designated as habitat for fish, other aquatic life, and wildlife, including for their reproduction, migration, growth and other critical functions" (MassDEP 2023). According to the Massachusetts Integrated List of Waters for the Clean Water Act 2022 Reporting cycle, Warner's Pond is impaired for water chestnut and mercury in fish tissue, Nashoba Brook is impaired for dewatering and benthic macroinvertebrates, Coles Brook is impaired for chloride and *Escherichia Coli*, and Fort Pond Brook and the unnamed tributary have met their designated use as a habitat for fish, other aquatic life and wildlife. Fort Pond Brook and the unnamed tributary provide approximately 5.5 miles of suitable habitat for those species that prefer riverine environments (blueback herring, American shad, American eel, and sea lamprey). Although Warner's Pond is impaired, it does provide a habitat with submerged aquatic vegetation (EA 2023) and fine silt and clay (EA 2024b), indicating that it could be a suitable habitat for alewife. Figure 3 displays the upstream waterbodies that would be made accessible via installation of a fish passageway at Warner's Pond.

Design Feasibility

Fishways can be installed at the dam itself in the existing river channel or in a bypass channel that conveys fish around the dam (USFWS 2019). Warner's Pond dam consists of a main spillway, abutted on the northwestern side by an earthen dam and on the southeastern side by a small island, and an auxiliary spillway located on a bypass channel that connects back into the main channel approximately 170 feet downstream of the main spillway. Implementation of a fishway at Warner's Pond was considered at both the main spillway and at the auxiliary spillway; a fishway installed at the auxiliary spillway would be considered a bypass channel fishway. Bypass channels are prone to attraction problems since the bypass channel will have competing flow attraction coming from the main spillway (USFWS 2019).

Based on the site characteristics and design criteria for the fishways described above, two types of fishways were considered; a nature-like step-pool fishway and a Standard Denil fishway. The following sections describe the conceptual analysis of implementing each type of fishway at Warner's Pond.

Step-Pool

The main design criteria for a step-pool fishway are provided in the USFWS Fish Passage Engineering Design Criteria guidance document and include the maximum slope, pool geometry, and weir geometry, which are dependent upon the target species (USFWS 2019). The table below presents the key design criteria for the target species.

Table 2. Target Species Design Thresholds for Step-Pool Fishway (USFWS)

Species	Min. Pool Width (ft)	Min. Pool Length (ft)	Max. Fishway Channel Slope
Blueback Herring	5.0	10.0	1:20
Alewife	5.0	10.0	1:20
American Shad	**20.0**	**30.0**	**1:30**
American Eel ≤ 15 cm Total Length	3.0	5.0	1:20
American Eel > 15 cm Total Length	6.0	10.0	1:20
Sea Lamprey	10.0	20.0	**1:30**

Notes:
Min. = Minimum
Max. = Maximum
ft = Foot (feet)

The limiting values for each category are associated with the American shad (shown in bold). DMF has also released Massachusetts-specific design criteria for river herring and rainbow smelt passage through structural and nature-like pool and weir fishways (DMF 2020). Rainbow smelt was not identified as a target species in the Concord River Diadromous Fish Restoration Feasibility Study, so those design criteria were not considered in the assessment. The table below presents the DMF design criteria.

Table 3. River Herring Design Thresholds for Pool and Weir Fishways (DMF)

Species	Min. Pool Width (ft)	Fishway Elevation Change (ft)	Max. Fishway Channel Slope
Alewife and Blueback Herring	-	-	3% (1:33)
All Species	0.5	0.5	-

Notes:
Min. = Minimum
Max. = Maximum
ft = Foot (feet)

Both design guidelines provide additional criteria regarding weir size, pool depth, and maximum velocity values; incorporation of these other design criteria would require analysis that is outside the scope of this conceptual feasibility assessment.

One of the driving design parameters for fishways is the maximum fishway slope requirement. The slopes on either side of the main spillway are too steep for a step-pool fishway; therefore, the step-pool fishway was evaluated as a bypass channel fishway at the auxiliary spillway. The entrance (e.g., downstream) elevation of the fishway was set at 115 ft NAVD88, 0.4 feet above the water surface elevation measured by SGC in October 2023 downstream of the dam (114.6 ft NAVD88 [EA 2024a]) to create a slightly steeper slope to create an attraction flow to draw fish into the fishway. The exit (e.g., upstream) elevation of the fishway was set at 118.6 feet NAVD88, which is the elevation of the top of the auxiliary spillway, to maintain the current levels of the impoundment. A step-pool fishway approximately 110 feet long, consisting of 3

pools (each 37 feet long and 20 to 29 feet wide), 4 weirs (0.5 feet high), a slope of 1.4% between weirs, and contained within the auxiliary spillway channel with limited bank excavation was sketched out at this location. This step-pool conceptual design is assumed to accommodate all target species. A conceptual sketch of a step-pool fishway at Warner's Pond shown in Figure 4. An example photo of a step-pool fishway EA designed in Acushnet, Massachusetts is provided below in Exhibit 1.

Exhibit 1. Step-pool fishway at the former Sawmill Dam (National Oceanic and Atmospheric Administration [NOAA] 2020)

Standard Denil

The main design criteria for a Standard Denil fishway are provided in the USFWS Fish Passage Engineering Design Criteria guidance document and include the maximum slope and channel width. The maximum slope of a Standard Denil fishway designed to pass American shad is 12.5% (1:8), with a preferable maximum slope of 10% (1:10). The channel width in a Standard Denil fishway designed to pass American shad is 4 feet (USFWS 2019).

Standard Denil fishways are typically installed at the main spillway of the dam. Based on the Warner's Pond dam site characteristics, the Standard Denil fishway would likely be placed on the earthen berm on the northwestern side of the main spillway. A low level outlet pipe is also in this area; the fishway would be located further northwest on the berm so that it does not interfere with the low level outlet pipe. A section of the earthen berm would need to be excavated to meet the maximum slope and channel width requirements. More detailed analysis would be necessary to estimate the volume of excavation needed and to ensure this fishway would meet the design criteria for target species. A conceptual sketch of a Standard Denil at Warner's Pond for all target species is shown in Figure 5. An example photo of a Standard Denil fishway is provided below in Exhibit 2.

Exhibit 2. Denil Fishway (USFWS)

Design Process

The components necessary to advance design of a fishway at Warner's Pond would be a detailed topobathymetric survey of the proposed fishway location, existing hydrologic data such as low and high fish passage flows, and a wetland delineation in the vicinity of the proposed work for permitting. SGC completed a detailed topobathymetric survey of the dam and surrounding area, including the auxiliary spillway, in October 2023 for the 30% Warner's Pond Dam Removal design. Sources of hydrologic data for this area include StreamStats, USGS stream gage data, and a hydrologic model completed by Aterra as part of the 30% Warner's Pond Dam Removal design.

Once the required survey and hydrologic data was collected, a proposed conditions hydraulic model would need to be completed for the fishway and then the design would progress through various design phases; 60% design, permitting, and 100% design.

Regulatory Considerations

Installation of a fish passageway at Warner's Pond would require multiple regulatory permits and approvals from federal, state, and local agencies as summarized below.

Massachusetts Environmental Policy Act (MEPA)

The project would be subject to MEPA jurisdiction because it would require one or more permits from a state agency; however, based on this initial evaluation, EA believes the need for MEPA review would differ between the two conceptual-level alternatives presented herein. The step-

pool fishway option would require MEPA review because it would trigger one or more MEPA review thresholds listed in 301 CMR 11.03. Specifically, this option would likely trigger the review thresholds at 301 CMR 11.03(3)(a)(4): "structural alteration of an existing dam that causes an expansion of 20% or any decrease in impoundment capacity" and 301 CMR 11.03(3)(b)(1)(e): "new fill or structure or expansion of existing fill or structure, except a pile-supported structure, in a velocity zone or regulatory floodway." The review threshold at 301 CMR 11.03(3)(a)(4) requires submittal of an Environmental Notification Form (ENF) and mandatory Environmental Impact Report (EIR). The project is not expected to be eligible for a Restoration Order of Conditions under the Massachusetts Wetlands Protection Act because it would not "involve the restoration or repair of a fish passageway as identified by the Division of Marine Fisheries in its Marine Fisheries Technical Reports, TR 15 through 18, dated 2004" and would therefore not be eligible to take advantage of MEPA's streamlined process for ecological restoration projects. Additionally, pursuant to 301 CMR 11.06(7)(b), the recently revised MEPA regulations require the submittal of an EIR for any project requiring MEPA review located within one mile of an Environmental Justice (EJ) population. Warner's Pond is located within one mile of an EJ population (Block Group 3, Census Tract 3612). It should be noted, however, that this EJ population is associated with MCI-Concord which is now closed. Therefore, if this EJ population is removed from future iterations of the Massachusetts EJ Populations map, the project could complete MEPA review through submittal of an Expanded Environmental Notification Form (EENF) with an EIR waiver request.

The Denil fishway option would not be expected to trigger any MEPA review thresholds and therefore would not require MEPA review.

Federal Clean Water Act (CWA)

The project would entail a discharge of dredged and fill material to a jurisdictional Water of the United States and therefore will require authorization by the USACE under Section 404 of the federal Clean Water Act (CWA). The project is expected to be eligible for coverage under the Massachusetts General Permit 23: Aquatic Habitat Restoration, Enhancement, and Establishment Activities. A Pre-Construction Notification would be required to seek coverage under the General Permit.

Massachusetts Public Waterfront Act (Chapter 91)

The project would be located within a geographic area subject to jurisdiction under Chapter 91 (310 CMR 9.04(1)(e)) and would involve an activity requiring a Chapter 91 license (310 CMR 9.05(1)(a)) issued by the Massachusetts Department of Environmental Protection (MassDEP). The project may also involve an activity requiring a Chapter 91 permit (310 CMR 9.05(2)(c)) issued by MassDEP.

Massachusetts Dam Safety Statutes

The project will result in the alteration of a dam which is regulated by the Office of Dam Safety and will therefore require a permit pursuant to Chapter 253 of the Massachusetts General Laws and 302 CMR 10.00.

Massachusetts Wetlands Protection Act and Concord Wetlands Protection Bylaw

The project would alter one or more areas subject to protection under the Wetlands Protection Act (310 CMR 10.02) and the Concord Wetlands Protection Bylaw and will therefore require an Order of Conditions issued by the Concord Natural Resources Commission. The project would not be expected to be eligible for a Restoration Order of Conditions pursuant to 310 CMR 10.13 because the project would not "involve the restoration or repair of a fish passageway as identified by the Division of Marine Fisheries in its Marine Fisheries Technical Reports, TR 15 through 18, dated 2004." The project would be expected to be eligible for review as an Ecological Restoration Limited Project pursuant to 310 CMR 10.53(4)(e)(5). Resource areas expected to be affected by the project include bank, land under waterbodies and waterways, and Riverfront Area, as well as the buffer zones associated with the bank resource area established by the Massachusetts Wetlands Protection Act and the Concord Wetlands Protection Bylaw.

DMF Fishway Construction Permit

A Fishway Construction Permit issued by DMF is required for the installation of fish passageways in Massachusetts. The Fishway Construction Permit is issued by DMF after design plans have been finalized and a construction contractor has been selected. DMF will also provide input on the design plans submitted as part of the WPA permitting process described above.

Cost Considerations

The cost of implementing a fishway at Warner's Pond would involve design and permitting costs, construction costs, and maintenance costs. The design and permitting required for the step-pool fishway and the Standard Denil fishway were assumed to be approximately the same, and assumed to be similar to the design and permitting costs predicted for the Warner's Pond dam removal. Maintenance of each fishway was assumed to be $5,000 every 5 years, based on previous EA project experience with similar projects.

EA's opinion of probable construction cost for installation of a fishway at Warner's Pond dam is based on the conceptual sketches shown in Figure 4 and 5, a survey completed by SGC in October 2023, and EA project experience with similar projects in New England. Estimated quantity takeoffs for the major construction items were developed, and engineer's estimates of the probable construction costs were completed based on reference material, including RS Means Heavy Construction Cost Data, previous similar construction projects, Massachusetts Department of Transportation Weighted Bid Prices, and Rhode Island Department of Transportation Weighted Average Unit Prices. A contingency of 50% has been applied to the estimate to account for uncertainties in the conceptual stages of a project. Table 4 below shows the total anticipated costs to implement a step-pool fish way and a Standard Denil fishway at Warner's Pond.

Table 4. Cost Estimate

Project Phase	Opinion of Probable Cost
60% Design	$75,000
Permitting	$70,000
100% Design	$35,000
Total Design	**$180,000**
Construction	
Step-Pool	$215,900
Standard Denil	$1,004,500
Maintenance (every 5 years)	$5,000
Total Cost (Design, Construction, and Maintenance)	
Step-Pool	$400,900
Standard Denil	$1,189,500

Limitations of Conceptual Feasibility Analysis

This technical memorandum is a high-level overview of different fishways, their applications, and a conceptual sketch of what two possible fishway options could look like at Warner's Pond. This technical memorandum and conceptual sketches are based on limited calculations and measurements and do not constitute a fish passage design. Additionally, installing a fishway provides the opportunity for fish passage, but does not guarantee that it will be used by fish. Finally, it should be noted that installation of a fishway at Warner's Pond would not address other impairments to the pond system, including sediment accumulation in the pond and widespread growth of aquatic invasive plant species.

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Figures

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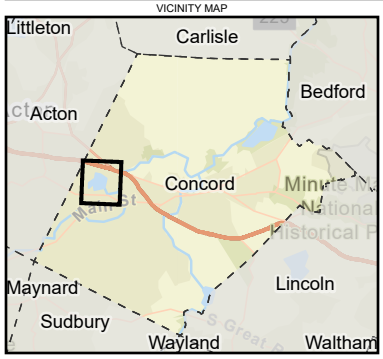
VICINITY MAP

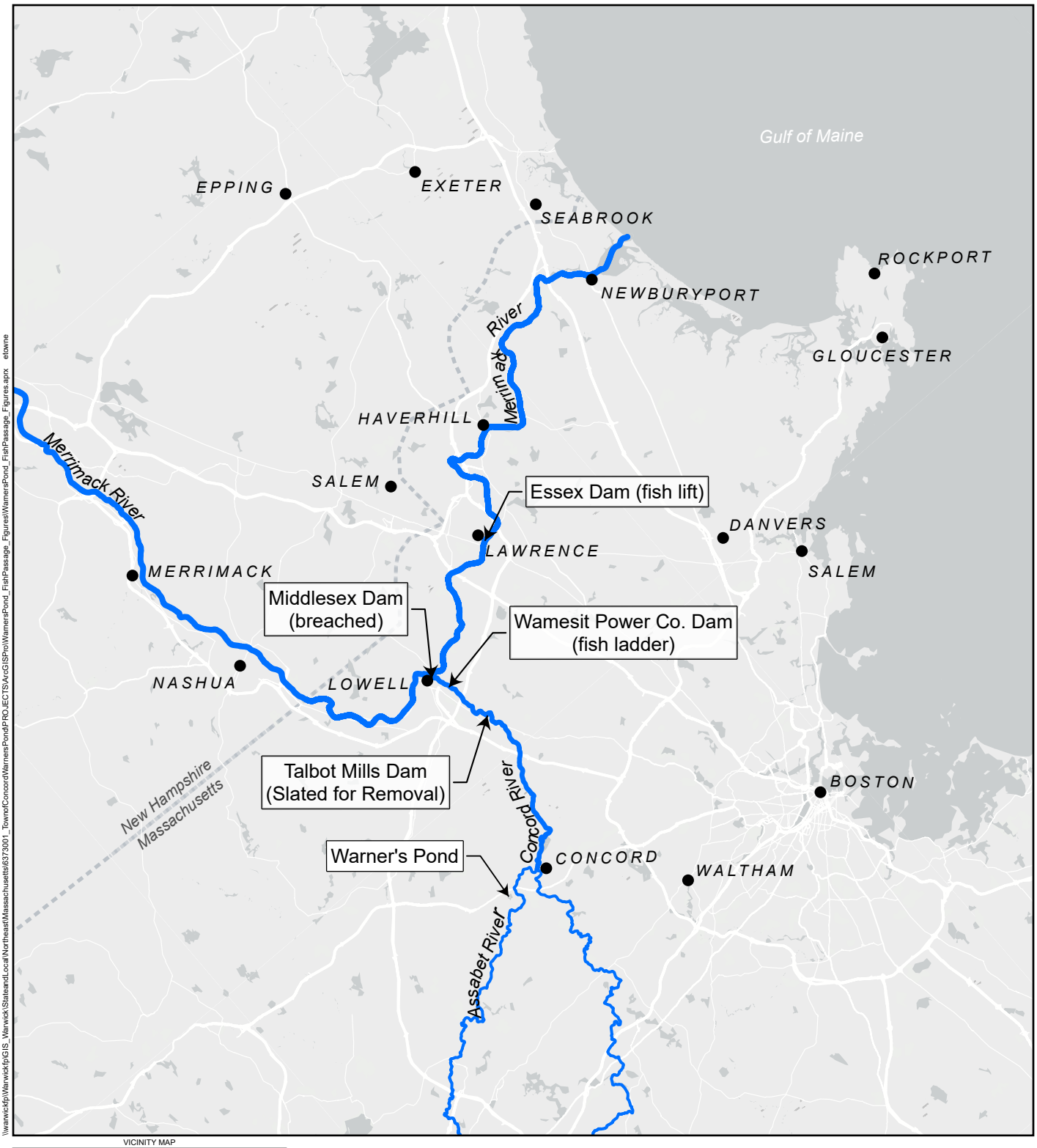


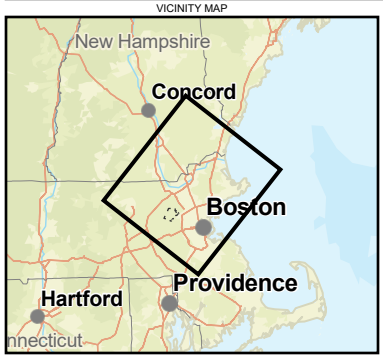
0 500 1,000
Feet

N

Figure 1
Site Locus
Warner's Pond Fish Passage
Conceptual Feasibility Assessment
Concord, MA

Map Date: 1/27/2025
Source: Census 2020
Projection: NAD 1983 UTM Zone 19N

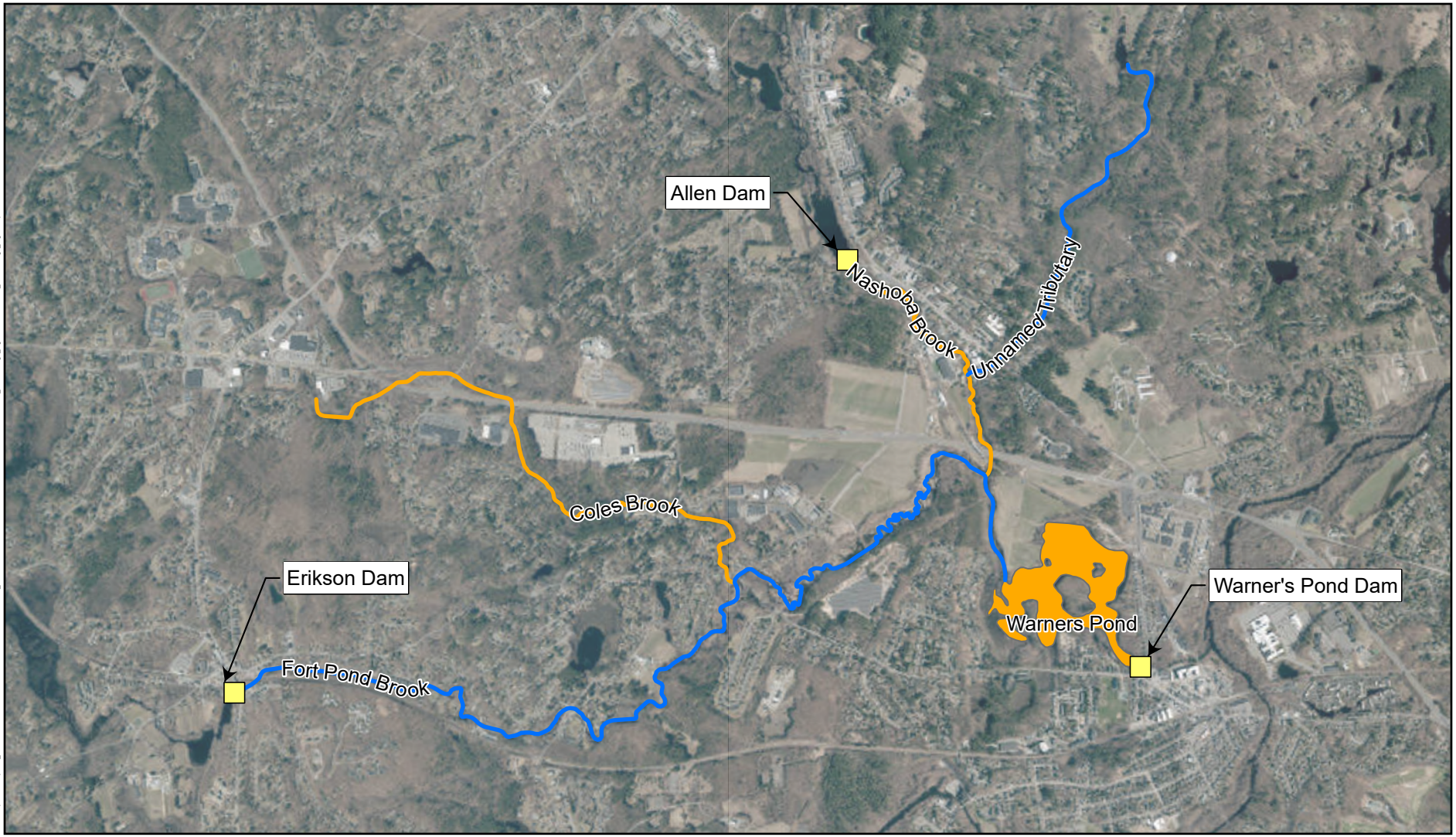




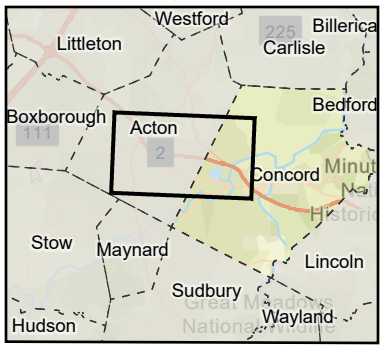
0 5 10
Miles

Figure 2
Dam and Fish Passage Locations
Warner's Pond Fish Passage
Conceptual Feasibility Assessment
Concord, MA

Map Date: 1/27/2025
Source: Census 2020, USGS 2022, ESRI 2022
Projection: NAD 1983 UTM Zone 18N



VICINITY MAP



Legend

- Dam
- Impaired Pond Habitat (MassDEP 2023)
- Impaired River Habitat (MassDEP 2023)
- Unimpaired River Habitat (MassDEP 2023)

0 2,000 4,000
Feet

N

Figure 3
Upstream Aquatic Habitat Suitability
Warner's Pond Fish Passage
Conceptual Feasibility Assessment
Concord, MA

Map Date: 2/4/2025
Source: Census 2020
Projection: NAD 1983 UTM Zone 19N

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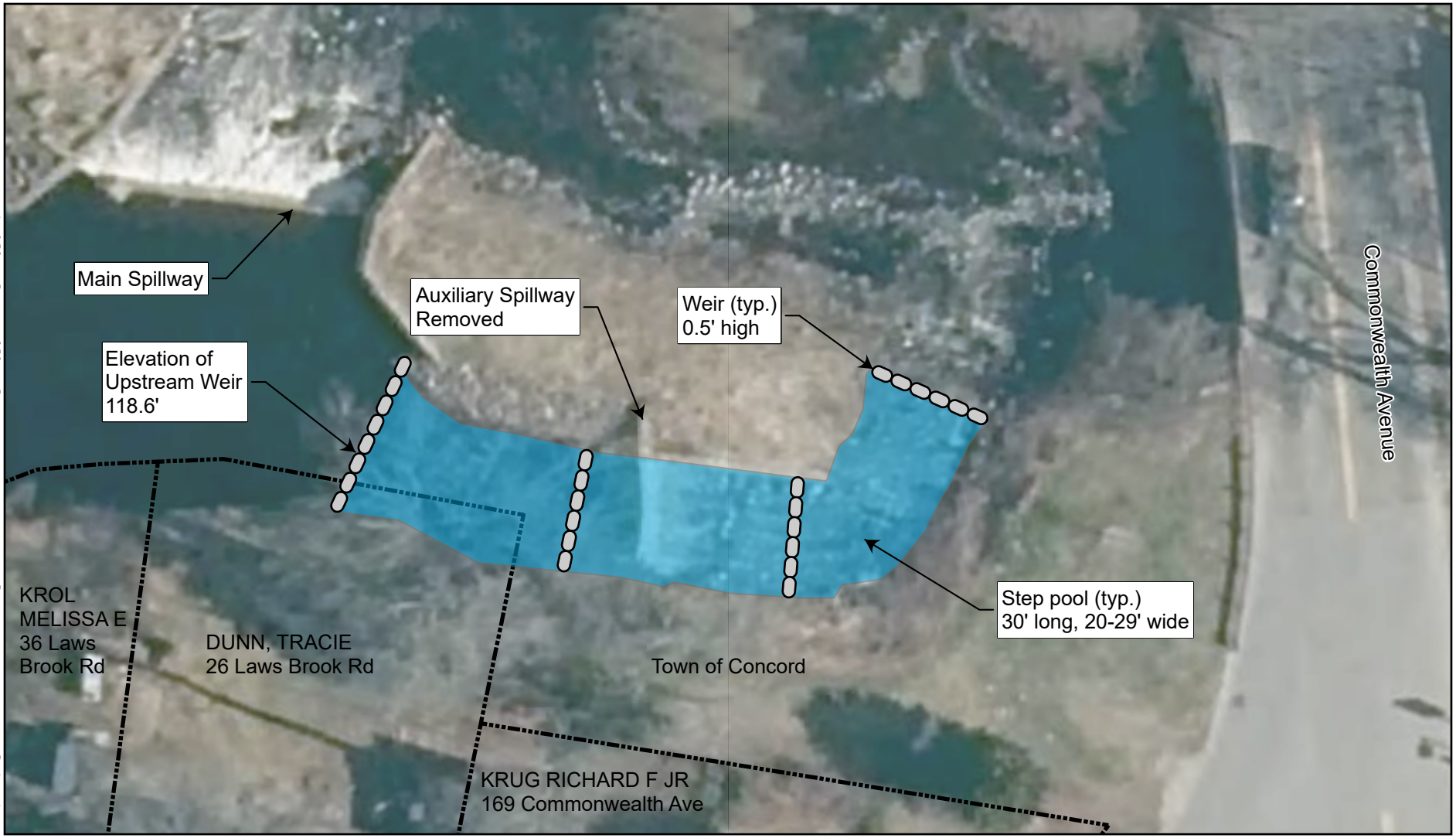

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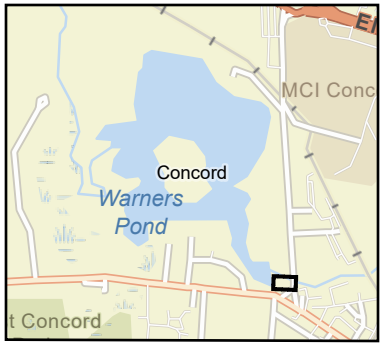

Legend

- Weir
- Pool
- Property Boundary

0 20 40
Feet

N

Figure 4
Step-Pool Fishway Conceptual Sketch
Warner's Pond Fish Passage
Conceptual Feasibility Assessment
Concord, MA

Map Date: 1/29/2025
Source: Census 2020
Projection: NAD 1983 UTM Zone 19N

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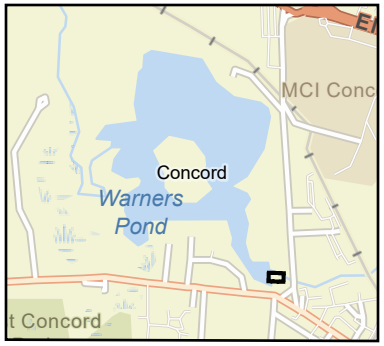
VICINITY MAP



Legend

- Concrete Wall
- Pipe

0 10 20
Feet

N

Figure 5
Standard Denil Fishway Conceptual Sketch
Warner's Pond Fish Passage
Conceptual Feasibility Assessment
Concord, MA

Map Date: 1/29/2025
Source: Census 2020
Projection: NAD 1983 UTM Zone 19N