FEASIBILITY STUDY—NHDES DAM #071.03

Oyster River Dam at Mill Pond

Durham, New Hampshire

PREPARED FOR

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Executive Summary

ES-1 Background

The Oyster River Dam, also known as the Mill Pond Dam, is located on the Oyster River as it flows through the Town of Durham prior to its discharge into the Great Bay. Constructed in 1913, the dam is a concrete Ambursen-style dam consisting of a spillway, a set of gated outlets at the right abutment, and a fish ladder at the left abutment. It is approximately 140 feet long, with a maximum structural height of approximately 13 feet. Due to its age, engineering significance, and association with local history, the dam is listed on the NH Register of Historic Places.

The NHDES Dam Bureau has identified several safety deficiencies associated with the current dam, including concerns with its overall structural integrity and stability. The dam does not meet current NHDES dam safety standards which require such "low-hazard" dams to pass a 50-year storm event with at least one foot of freeboard between the water surface and the top of the dam abutments. The Town was notified of these problems in multiple Letters of Deficiency (LOD), most recently in February 2018.

The dam forms the 9.5-acre "Mill Pond," a surface water feature historically used for numerous recreational activities such as fishing, boating, and birdwatching. Over the years, water quality in the pond has declined and portions of the pond have filled with sediment, converting much of the former open water area to emergent wetland habitat.

To address these concerns, this feasibility study considered various alternatives including dam removal as well as various permanent modifications to the dam.

ES-2 Alternatives Considered

The project team developed a set of five preliminary alternatives to address the known structural deficiencies of the Oyster River Dam. The review considered the 2018 NHDES LOD, but also incorporated new data and modeling generated during this feasibility study. Based on an initial analysis that considered cost, constructability, and compliance with regulatory requirements, two alternatives were determined to have merit and were therefore advanced for detailed study.

Descriptions of Alternatives

- **Alternative 3 – Dam Stabilization:** This alternative would fill the interior spillway cells with reinforced concrete to create a mass concrete section. The concrete would be reinforced, and the dam would be anchored to the underlying bedrock. Additionally, repairs would be performed to address scour of the existing right training wall and undermining of the fish ladder downstream of the spillway.

  This alternative would retain the dam in essentially its current configuration, and therefore maintain the impoundment, with no measurable changes in water depths or surface area.

However, this alternative would not comply with NHDES Dam Safety regulations, and would there require the NHDES Dam Bureau to approve a waiver to regulate the dam as a "non-menace structure." Initial analysis and coordination with NHDES found that approval of such a waiver request would be contingent on the abutting property owner recognizing that dam failure would have a detrimental impact on its property and accepting the consequences associated with such an occurrence. NHDES would require that any such agreement would run with the land such that future property owners would also be bound.

Dam Stabilization would retain Mill Pond, but would not directly address the decreased depth and poor water quality in the pond. To do this, the project team developed a conceptual plan to remove approximately 11,000 cubic yards of sediment from the pond, which would convert approximately 2.4 acres of wetland to deepwater habitat. Because the Oyster River will continue to transport and deposit sediments, this pond restoration dredge would be an ongoing maintenance task that would need to be repeated in the future as the dredged areas are re-filled with new sediment. Based on a review of sequential historical aerial imagery, field observations, and professional experience in similar settings throughout the region, the dredge areas would likely refill over a period of 5-20 years.

Additionally, it is critical to note that coordination with NHDES and the US Army Corps of Engineers, both of whom would need to approve the dredge, indicates that obtaining a permit for a freshwater dredge of this size would be extremely difficult and perhaps impossible.

- **Alternative 5 – Dam Removal:** This alternative would consist of a four-part plan that includes the removal of the existing dam structure, abutment preservation, channel shaping, and upstream channel restoration. The main dam spillway and the adjacent fish ladder would be entirely removed, but the left and right abutments would be left in place to help stabilize the riverbank and mitigate historic impacts. The channel would be reshaped to have a roughly 42-foot bankfull width, incorporating a 12-foot wide low-flow channel, to provide fish passage under low flow conditions. The active restoration of the Oyster River channel upstream of the dam removal site is also recommended. This would involve channel shaping approximately 600 feet upstream of the location of the dam to stabilize the channel and remove approximately 3,000 cubic yards of sediment deposited in the center of the Mill Pond impoundment. This would minimize potential sediment impacts downstream, as well as improve the stability and ecological integrity of the upstream area following dam removal.

Cost Considerations

The initial investment required for each alternative would total an estimated $4,063,000 for Alternative 3 – Dam Stabilization compared to only $1,314,000 for Alternative 5 – Dam Removal (**Table ES-1**). These totals include construction work related to the dam itself, as well as the pond restoration dredge (Dam Stabilization) and active channel restoration (Dam Removal).

Table ES-1. Preliminary Cost Estimates, by Alternative

	Alt 3: Stabilization	Alt 5: Removal
Construction Components	**$485,000**	**$295,000**
General Construction Items	$77,000	$98,000
Spillway Stabilization	$327,000	N/A
Repair Scour and Undermining	$3,000	N/A
Gated Outlet Structure	$78,000	N/A
Spillway replacement	N/A	N/A
Raise Left abutment	N/A	N/A
Construct Auxiliary spillway	N/A	N/A
Construct Dike	N/A	N/A
Demolition of Dam	N/A	$197,000
Environmental Components	**$3,150,000**	**$711,000**
Pond Restoration Dredge (Option 1)	$3,150,000	N/A
Active Channel Restoration (Option 2)	N/A	$711,000
General Items	**$428,000**	**$308,000**
Bonds & Contingency	$128,000	$78,000
Engineering, Design, & Permitting	$180,000	$150,000
Construction Phase Services	$120,000	$80,000
Total Construction Phase Cost	**$4,063,000**[1]	**$1,314,000**[2]

Notes:
1 Including the cost of pond restoration
2 Including active channel restoration

In addition to the initial capital cost, the study estimated a 30-year life cycle cost, which accounts for operation and maintenance as well replacement costs. (**Table ES-2**) The total life cycle cost for Alternative 3 – Dam Stabilization would be $5,114,414 compared to $1,333,600 for Alternative 5 – Dam Removal.

Table ES-2. Life Cycle Cost Analysis (30 Year Analysis)

	Alt 3: Stabilization with Pond Dredge	Alt 5: Removal & Channel Restoration
Initial Capital Investment		
Discount Factor	1	1
Initial Capital Cost	$4,063,000	$1,314,000
Capital Replacement Cost		
Assumed Design Life (yrs)	50	N/A
Assumed CIP Cost Percentage	60%	0%
Discount Factor	0.412	0.412
Operations & Maintenance		
O&M Costs	$2,400	$1,000
Discount Factor	19.6	19.6
Total Present Cost	**$5,114,414**	**$1,333,600**

While cost estimates based on conceptual engineering are considered a reliable way of assessing the relative economic impact of each option, the actual cost can be expected to change as additional engineering is completed on the selected alternative or as the cost of energy or other factors change in the future.

ES-3 Impacts and Benefits

Flooding, Hydraulics, and Sediment Transport

There would be no change in river depths, widths or velocities downstream of the dam under any alternative.

The Oyster River Dam is a “run of the river” dam. The existing dam allows all the natural river flow to pass over the dam in a relatively consistent and steady flow; it does not significantly divert, store, or release water. Therefore, the water levels and velocities downstream of the dam would remain unchanged, except in the immediate vicinity of the dam. Tidal forces within the downstream portion of the Oyster River exert a much greater influence than the dam. This would remain unchanged under either the Dam Stabilization or Dam Removal alternative.

Dam Removal would substantially reduce the upstream depth and width of the Oyster River and Hamel Brook.

Dam removal would lower the hydraulic control of the river by approximately 9.6 feet. During typical conditions (median annual flow), the upstream surface water would decrease from about 19.7 acres to about 5.4 acres. The volume of water in the river volume would decrease from 77 ac-ft to 10 ac-ft. Dam removal would reduce the impoundment’s surface average depth from about 3.3 feet to about 1.4 feet.

This effect would be significant at the dam (and particularly pronounced at Mill Pond), but would decrease upstream until the changes diminish to zero at the upper limit of the impoundment. Additionally, the change would be less pronounced under high flow conditions. If the dam were removed, the following changes are predicted to occur:

› **Mill Pond:** Under median flow conditions, Mill Pond would be eliminated. The average water depth in the river at Mill Pond would decrease from 2.2 to 0.5 feet, and the top width is expected to shrink from 514 to 32 feet. The predicted change will decrease as river flow increases and other factors, like the NH 108 bridge and natural channel and floodplain restrictions exert relatively more control. Dam removal would also allow the tide to influence the river in the area that is now Mill Pond, so tidal effects would raise and lower water levels in this reach throughout the day.

› **Middle Impoundment, Above Mill Pond:** The river’s average depth is expected to decrease from 4.7 to 1.4 feet, while the maximum depth would decrease from 7.1 feet to 2.1 feet. Its width will decrease accordingly, from 91 to 41 feet. The significant reduction in both height and width indicates a decrease in cross-sectional flow area, and, therefore, an increase in average velocity, from 0.1 to 0.6 fps. Again, the proportional change from existing conditions is expected to decrease as river flows increase. The removal of the dam will certainly change the hydraulics of the Oyster River in this area, but the scale of the changes in the Middle Impoundment are not as significant as they are predicted to be in Mill Pond, in large part because Middle Impoundment retains a more "riverine" and less "ponded" form in its present state.

- **Oyster River Mainstem:** Above its confluence with Hamel Brook, the Oyster River Mainstem reach would be relatively less affected than downstream areas, especially during higher flows. Under a median annual flow condition, the river's average depth is expected to decrease from 1.4 to 0.3 feet and its velocity is expected to increase accordingly, from 0.5 to 2.9 fps, similar to upstream reaches. However, during flow conditions expected during the 2-year storm event, dam removal would reduce the river's average depth from 2.7 to 2.0 feet and its width from 45 to 41.6 feet.
- **Hamel Brook:** Under median annual flow conditions, the top width of the impounded portion of Hamel Brook would decrease substantially - from about 135 feet to 18 feet as a result of the dam removal. The average depth would decrease from 3.4 feet to less than 1 foot. The significant reduction in flow area and the elimination of the backwater effect from Oyster River Dam would increase typical velocities to about 0.7 fps. As flow events become larger, the significance of dam removal on the brook's hydraulic character is reduced. The impacts of dam removal are mixed under 2-year flood conditions, with the average depth decreasing from 4.5 to 1.9 feet, but the top width only decreasing from 143 feet to 112 feet and the average velocity still only 0.2 fps, indicative of a largely backwatered reach.

Removal will restore tidal flow upstream of the dam.

If the dam were removed, tidal flows would return to the reach of the Oyster River upstream of the dam location. The upstream limits of tidal flows would depend on tide conditions as well as the adjustment of the river bed following dam removal as sediment transport is restored. Several feet of soft sediment have accumulated over the decades against the upstream side of the dam. If the dam were removed, that sediment would eventually be mobilized downstream by the free-flowing river, or by active channel restoration. As the river reformed its channel at a lower elevation, with that sediment displaced, the influence of tidal waters at high tide could extend further upstream, as much as 2,250 feet upstream of the dam's current location, extending into the middle impoundment reach near the confluence of the Oyster River and Hamel Brook. This would restore tidal habitats that were impacted by the original construction of the dam, as discussed further below. Based on predicted sea level rise, the head of tide could migrate even further upstream, potentially influencing the Hamel Brook reach over a period of decades as sea levels rise in response to climate change.

Removal of the dam will restore sediment transport to pre-dam conditions, mobilizing some accumulated sediment downstream.

In total, dam removal is expected to increase the sediment load to the tidal reach downstream of NH 108. Sediment transport model simulations suggest that sediment may be deposited in a relatively short reach, roughly located between the Three Chimneys Inn and Durham Landing. If deposited uniformly across the river in this area, the deposition of sediment from upstream could reach a depth of between 0.5 and 1.5 feet after 50 years.

However, tidal action will likely disseminate the sediment over a wider range, reducing the depth of deposition.

The potential effect of downstream sediment transport can be minimized by active channel restoration.

Under the Dam Removal Alternative, the active restoration of the Oyster River channel upstream of the dam removal site is recommended. This would involve channel shaping approximately 600 feet upstream of the location of the dam to stabilize the channel and remove approximately 3,000 cubic yards of sediment deposited in the center of the Mill Pond impoundment. Sediment transport modeling indicates that this sediment deposit is expected to become mobilized and re-deposited in the tidally-influenced reach downstream of the former dam location if it is left in place. An active channel restoration would minimize the potential for adverse downstream impacts, and improve the stability and ecological integrity of the upstream area following dam removal.

Sediments in the impoundment contain concentrations of PAHs and metals considered to have moderate to high potential for adverse effects to ecological receptors.

Sediment sampling results indicate that sediments throughout the study area are impacted by certain contaminants in concentrations that create concerns for aquatic organisms. PAHs and metals are commonly found in urban environments, and may be the result of anthropogenic or naturally occurring sources. Average PAH concentrations are slightly greater within and downgradient of Mill Pond, as compared to the upstream samples. There also appears to be more variability in the spatial trends for target metals, with greater concentrations of mercury and chromium observed within Mill Pond and/or downstream of the dam, compared to those further upstream. These results reinforce the benefits of an active channel restoration.

Contaminants in impounded sediments are unlikely to represent an additional or unacceptable risk to human health, but additional screening is warranted if these sediments are dredged.

Two PAH constituents were detected slightly above applicable NH Department of Environmental Services "S-1 standards" in samples located in the northeastern portion of Mill Pond and arsenic concentrations in many samples were slightly above the applicable S-1 standard. The relatively narrow range of arsenic concentrations and their consistent spatial distribution (exceedances of the S-1 standard in both upstream and downstream locations) suggest that these results are indicative of a naturally occurring background condition. Nevertheless, for the purposes of this screening level assessment, sediment analytical data exceeding the S-1 standards generally suggest additional assessment or risk mitigation may be warranted for sediments removed from Mill Pond through the Pond Restoration Dredge or Active Channel Restoration project components.

Infrastructure

Dam Removal would not adversely affect the downstream NH 108 Bridge or pedestrian bridge.

NHDOT Bridge No. 114/111 which carries NH 108/Newmarket Road over the Oyster River and the Town of Durham footbridge are scour-stable under existing conditions. Based on the hydraulic model results, neither of these two structures are likely to be adversely affected by implementation of any of the alternatives evaluated in this study.

Dam Removal would mitigate flooding of adjacent properties.

Dam Removal would drop the 50-year flood below the basement floor at 20 Newmarket Road and therefore reduce the risk of the building flooding. The 100-year flood elevation similarly drops, but due to tailwater from the NH 108 bridge remains above the basement flood elevation. However, it is lower than existing condition and therefore would reduce the magnitude of flooding for this event. Flood velocities near the building for all alternatives are less than 2 feet/second, which indicates low scour potential.

Water Quality

Dam Removal would substantially improve dissolved oxygen levels in the Oyster River.

This improvement of dissolved oxygen levels would possibly eliminate the existing dissolved oxygen impairment. The reduced surface water size, increased travel time and reduced solar thermal inputs will help to lower water temperatures, which would also improve dissolved oxygen conditions. The improved dissolved oxygen levels and lower water temperatures will positively affect habitat conditions for diadromous fish.

Dam Removal would reduce the amount of algae and aquatic plant biomass generated on an annual basis compared to the existing impoundment.

Algal and plant biomass growth can affect the nutrient dynamics and although the impoundment may temporarily retain nitrogen during the summer months, a potentially greater release of dissolved organic nitrogen could occur following plant die-off and the decomposition process. The decomposition of organic material also exerts a dissolved oxygen demand. Eliminating or reducing this biomass production would diminish the dissolved oxygen and nitrogen fluctuations produced under existing conditions.

Dam Removal would affect salinity levels in the current impoundment.

Increased salinity would result from the upstream migration of high tide levels after removing the dam, which will affect the distribution of vegetation species and aquatic organisms that prefer brackish conditions in tidally influenced areas.

Dam Stabilization would not improve water quality, except for temporary, minor benefits associated with the Pond Restoration Dredge option.

The pond restoration dredge associated with Dam Stabilization could improve water quality by lowering the potential dissolved oxygen demand and potential nutrient inputs from the nutrient-enriched bottom sediment and organic material that is removed. The magnitude of the overall improvement is difficult to predict but since the bottom sediments represent only one of many factors that exert a demand on lower dissolved oxygen levels. It seems unlikely that the current dissolved oxygen impairment could be eliminated, and any benefits would last only until new sediments are eventually deposited in the dredge areas.

Cultural Resources

Modification to the dam structure under the under Alternative 3 – Dam Stabilization is expected to be deemed a Section 106 "adverse effect" to the State Register-listed resource.

The dam is significant under Criterion C for its design and construction value, as an embodiment of the distinctive characteristics of an Ambursen dam-type and concrete slab and buttress method of construction. The characteristics that make it strongly representative of this type of dam include the evenly spaced downstream buttresses with hollow cells between, and the solid sloping reinforced concrete slab on the upstream side, with curved concrete spillway crest. Alternative 3 proposes to construct a "new" spillway within the confines of the existing spillway by pumping reinforced concrete within each of the spillway cells, which would alter the original design and construction, for which the resource derives its significance under Criterion C.

Dam removal would eliminate a State Register-listed resource, which would require substantial mitigation to offset.

Not only is the dam significant for its engineering and design under Criterion C, it is also significant under Criterion A. The dam played an important role in the local history of the Town of Durham. Its construction in the early twentieth century was part of a pattern of philanthropic activities and community planning and development that helped create the University of New Hampshire Campus and Downtown Durham. In addition, removal of the dam and restoration of the river channel would create a landscape that has not existed since the seventeenth century. The elimination of the dam would be an adverse effect under Section 106 of the National Historic Preservation Act, which would trigger a substantial mitigation effort.

The area surrounding the impoundment is sensitive for archaeological resources.

Dam removal may cause potential impacts to archaeological resources due to changes in sediment transport (erosion and aggradation) near potential archaeological sites along Hamel Brook and the Oyster River. In addition, removal of the dam may expose previously submerged sites, making any potential sites below the current waterline vulnerable to degradation.

Natural Resources

Dam Removal would eliminate the barrier to upstream fish passage and address the declining water quality in Mill Pond and the upstream impoundment.

These two effects would have a significant net benefit on fishery resources. This alternative involves restoring a more natural profile of the Oyster River at and immediately above the dam. This suggests that river herring will successfully ascend the restoration reach that would be exposed following dam removal, supporting a self-sustaining river herring run.

If the Pond Restoration Dredge is implemented as part of the Dam Stabilization alternative, approximately 2.4 acres of freshwater emergent and aquatic bed wetlands would be directly impacted.

These impacted areas would be converted from wetlands to open water habitat. This impact would reduce the structural diversity of the Mill Pond system, and would decrease plant and animal diversity on a local scale. Beneficial effects on dissolved oxygen levels and water temperatures would be associated with deepening the pond. However, given concerns regarding the sustainability of the pond dredge, obtaining regulatory approvals for this component of the project would be extremely difficult to impossible.

Dam removal would restore tidal wetlands in the lower portion of the study area.

Based on the existing bathymetry data, it appears that the upstream migration of tidal inflow following a possible dam removal would be confined primarily within the main river channel given that the main river within Mill Pond is confined within a submerged channel with top of bank limits that are generally at elevations of 6 to 8 feet (NAVD88). However, tidal action on adjacent wetland areas is also possible, especially as predicted sea level rise occurs over the next century, and the wetland community would shift towards salt water tolerant species. Based on the estimated high tide elevations and salinity changes, portions of the dewatered pond that have bottom elevations of 4.4 feet or less would likely be inundated or influenced by tidal waters on a daily basis. Occasionally, the brackish waters may extend as high as 5.4 feet or more based on the highest observable tide line. In general, the new tidally-influenced area within the potentially dewatered pond is anticipated to be contained within the eastern portion of the main river channel, based on the bathymetry data.

The area subject to tidal action on a daily basis would eventually acquire some of the characteristics of the portion of the Oyster River located immediately downstream of the dam, which is classified as a subtidal estuarine system with an unconsolidated bottom (E1UBL). Within this habitat type, brackish tidal water enters from the ocean, while the river carries nutrients, organic matter, and sediments to the downstream estuaries. These inputs combine to make estuaries extremely productive habitats with a great abundance of plants and animals. Outside of the immediate river channel, existing salt tolerant species observed downstream of the dam could provide a seed source for salt tolerant vegetation to become established in the new tidal influenced zone. The existing salt tolerant vegetation species include saltmeadow cordgrass (*Spartina patens*), prairie cordgrass (*Spartina pectinata*), blackgrass (*Alopecurus myosuroides*), and saltmarsh bulrush (*Scirpus robustus*).