UCONN
UNIVERSITY OF CONNECTICUT

Mirror Lake Improvements

Feasibility Study

University of Connecticut
Storrs, Connecticut
Project #300174

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BVH integrated services

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1 EXECUTIVE SUMMARY

1.1 Introduction

Mirror Lake is a historic landscape, which was incorporated, in the original 1910 plan for the University. The lake has been integral to UConn's image providing an iconic foreground to campus buildings along Storrs Road while also attracting students to its shores for almost a century. The lake also provides an important role in stormwater management. Over the years, the Mirror Lake sub-watershed (within the Roberts Brook watershed) has experienced many changes that have altered the water quality, water quantity and condition of the lake. This study will address the issues with the current condition of the lake, dam, spillway and stormwater management as well as offer recommendations for landscape improvements.

1.2 Project Background

Various studies have identified issues with Mirror Lake including excessive plant growth, spillway damage, and lack of stormwater management capacity. Excessive sediment deposits from stormwater runoff have been a major contributor and cause of many of the aquatic health issues with the lake. Some of these items have been addressed temporarily; however, the University desires a more permanent, maintainable solution to the problems that persist with the lake.

1.3 Project Goals

In general, the goal of this study is to provide potential solutions to the issues noted above, as well as provide suggestions for aesthetic enhancements to the lake and area surrounding the lake. Estimated cost to implement the solutions and improvements and schedule to complete the work are also included.

1.4 Project Scope

This study analyzes potential solutions, and provides recommendations on the following items:

- Landscape improvements and enhancements including access to the lake, geese control and lake health
- Stormwater management improvements and spillway modifications, which will bring the capacity of the lake up to the current state standards and requirements and provide additional capacity for future development
- Measures to enhance the quality of stormwater runoff discharging to the lake
- Dam safety improvements including spillway design and stability analysis
- Dredging review including methods and logistics
- Aquatic life management review
- Cost Estimate
- Schedule/Permitting

1.5 Landscape

The planned infrastructure improvements to the lake have allowed the University to reassess its role in the overall fabric of the campus landscape and to amplify its purpose and function as it relates to student life. The feasibility study plan achieves these goals primarily in three ways: enhancement of the water's edge, implementation of planted forebays, and the introduction of site-specific amenities.

Water's Edge

In its current state, the water's edge has very little variation and almost the entirety of the lake can be seen from any vantage point. The new design introduces as much variation of the lake edge as possible. This variation is amplified by providing shoreline and littoral zone plantings in curvilinear beds that provide interest and lead the eye around the lake. Additionally, these plantings function as a filter for runoff into the lake keeping the water clean and suspended sediment low.

Planted Forebays

The forebays primarily function as a filter for the stormwater sediment prior to the water entering the lake. The Mirror Lake forebays are also planned to be an impactful visual improvement that reinforces the natural aesthetic. The forebays will be planted with a variety of plants and be graded in such a way that they will transform as they fill with stormwater runoff. As the water gets deeper the visible plantings shift and change. In the main forebay there are planned structure outfalls which allow the water to be viewed as it spills into the lake.

Site Amenities

While the physical components above will do much to make the lake more attractive, specific amenities are planned to further that goal. The existing condition provides limited access to the water's edge. The new design changes that by providing a promenade that forms one end of the lake. This in turn leads to an overlook and shelter that extends over the water. The existing island is turned into a destination by providing a bridge that allows visitors access, which did not exist before. Lastly, a new spillway is designed that flows into an improved stream bed and woodland garden.

Refer to Appendix A for a plan, illustrative views and sections.

1.6 Stormwater

General

Mirror Lake not only serves an aesthetic function, but is also a stormwater management facility. The lake receives stormwater discharges from seven inlets, which convey runoff from the UConn campus, E.O. Smith School, Route 195, and residential neighborhoods. The berm or dam on the north side of the lake allows stormwater to be detained and discharged in a controlled manner from the dam spillway.

Development throughout the years, both on campus and off campus has resulted in an increase in the volume of stormwater draining to the lake. The increased volume in turn causes an increase in flow out of the lake and higher water surface elevations in the lake during storm events.

The Connecticut Department of Energy and Environmental Protection (DEEP) and the University have agreed to maintain or reduce flows from the lake to pre-1993 levels, which represents a time-period prior to much of the recent development on campus. The lake also does not have the required one foot of freeboard (distance between the top of dam and water surface elevation) during certain storm events to comply with state stormwater regulations. BVH studied what modifications could be made to the lake and dam In order to accomplish both the freeboard and flow criteria. The proposed lake modifications were originally published in draft form with the Mirror Lake Improvements Hydrology/Hydraulic Study dated 8/25/20 and have been revisited with this study.

Freeboard

In order to achieve one foot of freeboard for the 100-year storm without drastically altering the size of the lake BVH is proposing to lower the normal water surface elevation from 585' +/- to 583.50'. GZA has recommended the dam be designed for a 500 year storm event. In order to accomplish this, and maintain dam stability the berm will need to be raised approximately 2' to an elevation of 590'. Refer to Section 1.7 and Appendix C of this report for additional information on the analysis and alterations to the berm.

Lowering the normal water surface elevation is accomplished by lowering the spillway. Lowering the water surface elevation will also require that the lake bottom is deepened to provide optimal water depth for lake health. Lake health and dredging is elaborated on in the following sections within this report.

Discharge Rate

The spillway must also be modified to control and reduce the flows out of the lake. A two stage spillway was studied with a smaller 8' wide weir at the 583.50' elevation and increasing to a 16' wide weir at elevation 587'. Refer to Appendix C for additional detail on the spillway. The volume of the lake also needed to be increased to detain additional stormwater. This was accomplished through reshaping and regrading the lake, so more water can be stored. Drawings in Appendix A illustrate this reshaping. The modifications noted above allowed the spillway to discharge flows at a rate below 1993 levels.

The May 2015 UConn Campus Masterplan includes multiple developments occurring in the Mirror Lake watershed between present day and 2025. The masterplan forecasts a decrease in impervious coverage within the watershed of approximately 0.50 acres. Most of this decrease is due to the elimination of the south campus parking lot and addition of the South Campus Woodland Corridor. However, if the woodland corridor is not constructed and additional development occurs in the watershed, there will be an increase in impervious area. The modifications to Mirror Lake outlined in this study account for the addition of 3 acres of impervious area within the Mirror Lake watershed while still maintaining the discharge rate and freeboard requirements noted above. The majority of the assumed impervious area increase is attributed to the construction of the Honors Residence Hall.

Stormwater Quality

As stated above, there are seven inlets, which discharge into Mirror Lake. Much of the stormwater runoff is generated from impervious surfaces such as roads and parking lots. This has resulted in excessive sediment and other pollutants associated with vehicles to accumulate in the lake. The

University has installed hydrodynamic separators at each inlet point, which provide a benefit for sediments and oils, but are not able to reduce some of the nutrients that enter the lake via stormwater runoff. BVH recommends that sediment forebays be installed at each discharge point in order to capture any sediment that may not have been collected by the separators and to treat some of the nutrients and other pollutants that the separators cannot. Refer to additional information included in Appendices D and E for sediment sampling results.

Discharge points can be combined or relocated in order to minimize the number of forebays. This study proposes to reroute (4) of the discharge points to allow for a total of (3) forebays. The forebays should be constructed to allow for maximum travel time through the forebay and be relatively easy to maintain. Refer to Appendix A for forebay locations and Appendix B for storm piping relocations.

On the south side of the lake there is a 42" storm pipe which transitions to (2) 24" pipes prior to discharging to the lake. BVH recommends installing a hydrodynamic separator on each 24" pipe rather than the single separator, which is currently accepting all the flow from the 42" pipe. Reducing the flows to the separators will allow for additional sediment removal and reduce required maintenance. Refer to Appendix B for the storm drainage revisions plan.

1.7 Dam Improvements

Current DEEP dam safety regulations do not provide specific flood magnitudes to use for the dam's Spillway Design Flood (SDF). In the absence of DEEP regulatory criteria, GZA used a risk-based approach called an Incremental Damage Assessment (IDA) to identify an appropriate SDF. The IDA process was developed by federal agencies including the Federal Emergency Management Agency and the Federal Energy Regulatory Commission to support the selection of appropriate SDFs.

The appropriate SDF is defined as the flood where dam failure would not create a significant increase in the hazard to life and/or property above the natural base flood. The IDA process, therefore, acknowledges that natural floods (e.g., the Probable Maximum Flood (PMF)) can be so large that failure of a dam during such a large flood is not noticeable for areas downstream of the dam. The IDA process iteratively evaluates floods, generally from the PMF as an upper bound to the 100-year flood as a lower bound, to identify the threshold flood where the consequences of dam failure are significant.

At Mirror Lake Dam, our IDA analysis indicated that the 500-year flood represented this threshold. Floods larger than the 500-year flood would overwhelm the downstream area through natural flooding such that dam failure during the flood would not create significant additional consequences. Correspondingly, dam failure during floods lower than the 500-year flood, such as during the 100-year flood, would create additional, significant consequences. Therefore, it is recommended that rehabilitation and dam improvement measures be implemented to mitigate potential dam failure for floods up to and including the 500-year flood.

As stated under the Stormwater section of this report, the design team is proposing replacement of the existing spillway with a stepped structure and raising the dam/berm approximately 2 feet to better control stormwater and allow for a 500 year SDF.

The proposed dam improvements also consist of adding upstream erosion protection, and re-grading the upstream and downstream slopes of the dam

A conventional toe drain with a perforated PVC pipe surrounded by free draining soils will be constructed at the downstream embankment toe. The toe drain will help lower the shallow groundwater at the toe of the dam, lower the groundwater table through the dam, and improve stability.

The downstream channel will consist of a concrete apron that transitions to Roberts Brook. The Roberts Brook side channels will be lined with riprap for erosion/scour protection.

Refer to Appendix C for *Mirror Lake Dam Improvements – Conceptual Design Report*.

1.8 Aquatic Health

In order to provide recommendations for improving the aquatic health of Mirror Lake, a bathymetric survey was performed, as well as analyzing sediment samples taken from the lake. Previous aquatic health studies were reviewed to develop a sense of how the lake has been impacted by various activities and developments over the years.

The results of the study and field investigations lead to a recommendation of removing the accumulated sediments within the lake, and the option to deepen the lake to a maximum depth of 12', as well as providing shoreline plantings and planting within littoral shelf of the lake.

Further recommendations are to provide sediment forebays with soil amendments that are high in phosphorus attenuation and ongoing monitoring and measurement of various properties of the lake water.

Refer to Appendix D *Historical Data Review and Findings Technical Memorandum* for detailed findings and recommendations to improve the water quality, plant and animal life within Mirror Lake.

1.9 Lake Dredging

Accumulated sediment from stormwater runoff is a large contributor to the poor health of the lake. Removing or dredging the existing sediment and preventing or slowing the buildup of future sediment is a key factor in improving the lake. Establishing an optimal lake depth is also important to the health of the lake. A feasibility study level plan was developed for dredging of the lake to determine methods that could be implemented, quantity of material to be removed and associated permitting time line and fees.

Hydraulic dredging is recommended to remove the soft sediments that have accumulated in the lake from stormwater runoff. This is achieved without having to drain the lake. The sediments would then be stored in large geotextile dewatering tubes and allowed to dry before being transported to a disposal facility. The effluent from the sediment dewatering would most likely need to be treated prior to pumping back into the lake, however, additional testing of the water will need to be conducted to verify this assumption.

To achieve the lake depth proposed in the *Historical Data Review and Findings Technical Memorandum* and according to sections provided by Towers Golde, the native till soils will need to be excavated up to

6’ in some locations. The hydraulic dredging process does not work well with dense till type soils. Given the volume of material proposed to be removed, draining of the lake and conventional excavation is being proposed for the till soils.

Refer to Appendix E *Dredging Conceptual Level Design Memorandum* for a detailed analysis of the lake dredging.

1.10 Permitting/Schedule

Permitting

Permitting was reviewed for the dam improvements, stormwater management and dredging.

It is expected that and Environmental Impact Evaluation (EIE) will be required for the Mirror Lake Improvements project under the Connecticut Environmental Policy Act (CEPA).

For the dam and berm improvements, multiple permits would be required with approval durations ranging from 1-2 months up to 5-7 months, however, some permits are contingent on the approval of others. An overall review process of 12 months should be expected, refer to table below.

Regulator	Permit ID	Estimated Approval Duration
CT DEEP Dam Safety	Individual Permit	5-7 Months
CT DEEP Water Quality	Section 401 Water Quality Certificate	5-7 Months
CT DEEP Fisheries	Determination of Need for Fishway	1-2 Months
Army Corps of Engineers	Pre-Construction Notification	5-7 Months
CT DEEP NDDB	Rare Species Review	2 Months

Stormwater management would require a masterplan Flood Management Certification for the Roberts Brook Watershed be submitted to CT DEEP as well as a revision to the campus Memorandum of Understanding with CT DEEP. Based on past experience with DEEP, the anticipated review and approval process for these items would take approximately 9-12 months.

The CT DEEP Construction Stormwater General Permit for the Discharge of Stormwater and Dewatering Wastewaters from Construction Activities would be required for the construction with an approval time of 60 days.

Baystate Environmental Consultants (now part of GZA) prepared dredging plans and permitting for Mirror Lake between 2009 and 2013. For that project the permitting process and public outreach extended approximately 2 years before a plan was approved. The approval timeline for dredging should be anticipated at 2 years or longer based on the project scope and methodologies detailed in the *Dredging Conceptual Level Design Memorandum* included in Appendix E. The permits below will be required.

Regulator	Permit ID	Estimated Approval Duration
CT DEEP	Inland Wetlands and Waterways	TBD*
CT DEEP Water Quality	Section 401 Water Quality Certificate/Diversion Permit	TBD*
Army Corps of Engineers	Section 404 Authorization	TBD*
CT DEEP	Wastewater Discharges from Manufacturing, Commercial, and Other Activities	TBD*

*Approval times are dependent on the public outreach process anticipated at 2+ years

Schedule

- Design
  - Schematic Design/Additional Field Investigation – 2 Months
  - Design Development – 3-4 Months
    - Begin Permitting Process and Public Outreach
  - Contract Documents – 4-5 Months
- Permitting/Public Outreach – 2+ years concurrent with design efforts
- Bid, Negotiation and Award – 2 Months
- Construction – 12-18 months
  - First Construction Season - Dredging, Dam, Forebays, Storm Relocation
  - Second Construction Season – Site Restoration and Landscape Improvements

1.11 Estimated Cost

The cost to perform the above improvements has been estimated based on the materials provided in this feasibility study.

The bulk of the project cost is associated with the dredging and dam repairs. The landscape costs have been separated out as a base project, with four separate alternates that could be added to the base should the University choose to pursue them. The remainder of the work involves storm drainage relocations and miscellaneous construction costs.

A summary of costs are below. Additional design and field investigation will be required to obtain a more accurate level of cost.

Summary of Cost	
Trade Cost	$11,934,915
Total Construction Cost	$17,626,659
Alternate # 1 – Shelter	$970,420*
Alternate #2 – South Promenade	$1,624,235*
Alternate #3 – Downstream Improvements	$757,476*
Alternate #4 – Bridge to Island	$1,515,433*

*Includes all mark-ups

Refer to Appendix F for a detailed breakdown of costs.

1.12 Phasing

The recommendations in this report could be constructed in phases. Below are aspects of the project that could be constructed in separate construction seasons, or as separate projects.

Hydraulic Dredging, Storm Drainage and Forebays:

Hydraulic dredging could be done ahead of any of the other construction, however, it would be recommended to construct some version of the sediment forebays with required pipe re-rerouting and the upgrades to the hydrodynamic separator concurrent with or within a short time period after dredging is complete. This would slow down accumulation of sediment, extending the time necessary for additional future dredging. Forebay design and location may differ from what is shown in this report if it is not performed concurrent with, or after the mechanical dredging required to lower the lake surface.

Mechanical Dredging, Spillway, Berm, and Optional Landscape Walls

The above activities should be constructed concurrently. The spillway shape and dam height presented in this report are based on the deepening and reshaping of the lake through mechanical dredging and should therefore be performed as one project. The drain down of the lake required for mechanical dredging will also make their construction less costly than using a cofferdam system. Should the optional landscape walls for the promenade and overlook be pursued, the drain down of the lake would also make their construction less costly than if a cofferdam approach were used.

Landscape Features

The base option landscape features could be broken out into a separate Phase of construction. Other options, such as the bridge and downstream landscape features could be constructed as separate projects at any date. As stated above, it would be recommended to construct the promenade and overlook during the mechanical dredging process.

1.13 Alternate Options

The alternate options outlined below have not been studied to the level of the recommended options within this report. The options provide a cost savings, but do not provide the same level of benefit as the recommended strategy for the lake.

Dredge Sediment Only

Dredging just the soft sediment would improve the health of the lake, however there would be no benefit to stormwater control. Sediment would likely build back up over time without the installation of the forebays. Stormwater strategies for future development in the watershed would need to be reviewed with DEEP if stormwater management is not resolved at Mirror Lake. The estimated trade cost for hydraulic dredging is approximately $4.2M.

Mechanically Dredge Sediment and Hard Bottom

Mechanically dredging both the sediment and hard bottom may be less costly than hydraulically dredging the soft sediment and mechanically dredging the hard bottom. It is likely the water treatment costs and geotextile filter tube costs could be eliminated. However, this approach may be harder to permit based on past experience by Baystate Environmental Company (now part of GZA) who prepared Mirror Lake dredging plans in 2009. Eliminating the costs to hydraulically dredge could result in a $2.2M trade cost savings, for a total trade cost of $9.8M.

Mechanically Dredge Less Material

The proposed depth of the pond is based on limnologist recommendations in the *Historical Data Review and Findings Technical Memorandum* included in Appendix D of this report as well as sections prepared by Towers Golde. The maximum proposed depth is approximately 12'. The limnologist recommendations do suggest that the maximum depth could be less than 12' and as low as 6'. Currently removal and disposal of the native till is estimated between $1.2M to $3.2M depending on if the soil is impacted. Reducing the depth would allow for less material to be removed from the lake and could result in a substantial savings.

Enlarge the Footprint of the Lake and Raise the Berm

In a previous study, BVH presented an option to enlarge the footprint of the lake and raise the berm without deepening the lake or altering the spillway. Forebays and removal of soft sediment were recommended with this option. These alterations served strictly to provide stormwater management and runoff quality enhancements. Minimal landscape improvements were proposed. Aquatic health and dam stability were not reviewed with this study. The enlargement of the lake was not received well from the University from an aesthetic standpoint and this option was eliminated from the previous study. However, eliminating mechanical dredging, spillway replacement and the majority of the landscape improvements could results in a trade cost savings of approximately $5M for a total trade cost of approximately $7M. Again, this option did not look at aquatic health, dam stability and aesthetic benefits.

1.14 Closing Statements

Mirror Lake is an iconic feature and gathering place on the University of Connecticut Storrs campus that also serves as a stormwater facility. Continued development on and around the campus has created a need to provide additional stormwater storage in the lake, as well as additional water quality measures to maintain the health of the lake. This study is a first step in creating a plan to address these issues, as well as provide aesthetic improvements and additional opportunities to connect with the lake. We recommend that the scope of work and strategies in this report be further developed to create a project to implement the improvements for Mirror Lake. Permitting future development within the watershed may be contingent on the agreement between UConn and DEEP to reduce flows to 1993 levels, and provide the required 1' of freeboard.