**Memorandum (FINAL)**

| | | | |
|---|---|---|---|
| **Memo To:** | Joe Coffey & Harry Ermides | **Date:** | November 5, 2015 |
| **From:** | Brad Grant | **File:** | 967.002.001 |
| **Re:** | Technical Memo 2<br>Task 2: Hydraulic and Hydrologic Modeling<br>Buckingham Pond Lake Assessment | | |

## Executive Summary

Two separate evaluations were performed on the Buckingham Pond system and watershed, resulting in many findings of significance and leading to the development of a variety of holistic mitigation strategies. Each assessment required the collection and review of relevant site plans and associated data, as well as consultation with online resources and use of multiple modeling techniques. The two main evaluations included:

1. Hydrologic and Hydraulic Analysis
   a. Modeling the following: Built Conditions Model, Existing Conditions Model, 10% Volume Loss Model, 20% Volume Loss Model
   b. All included seven 24-hr storm events and 2 1-hr storm events
2. Pump Station Assessment

For all 24-hr storm events modeled in the Hydrologic and Hydraulic Analysis, the following findings were derived:

- The influent flow rate does not vary greatly between the 10-, 25-, 50-, 100-, and 500-year storms. This is due to the fact that the pipes and arches inletting into the pond from Subwatersheds 1, 3, and 4 are flowing full during the 1-year storm and, therefore, will only experience minimal change in flow-rate after those events. The pond inlet from Subwatershed 2 is the only inlet to the pond that is not full during the 1-year storm. This pipe begins flowing full during the 10-year storm, which validates the observed constant in influent flow rate beginning during the 10-year storm.
- The overflow structure, using the watershed and system data provided, will not receive stormwater from the system until the 10-year event provided the pump station is operating throughout the duration of the 1-yr and 2-yr storms. During this event, the outlet structure receives stormwater for approximately 10-12 hours, at which time the level of water in the pond is only slightly above the outlet structure. Depending on the available volume in the pond, for either the 10- or 25-year storm, the system is not adequately sized to mitigate the volume of stormwater produced over 24.


290 Elwood Davis Road · Box 3107 · Syracuse, New York 13220
Telephone: 315-457-5200 · Facsimile: 315-451-0052 · www.BartonandLoguidice.com

For all 1-hr storm events, the following findings were derived:

- Influent flow rate varies slightly more for the 1-hour storm events than for the 10- and 100-year 24-hour storm events.
- The 12" pond inlet from Subwatershed 2 is the only inlet to the pond that is not full during the 10-year 1-hr storm. It is, however, flowing full during the 100-yr 1-hr storm.
- The overflow structure, using the watershed and system data provided, will not receive stormwater from the system for either of these 1-hr events. This is consistent with rainfall data observed in the 24-hr storm events when reviewing specific 1-hr time periods during which the rainfall amounts equaled the 1-hr storm rainfall values.

The Center for Watershed Protections "Watershed Treatment Model" (WTM) was run to determine estimates of annual total suspended solids (TSS) delivered to the pond system. Findings are as follows:

- The WTM calculated that a total of 78,000 lb/yr (approximately 780 cf/yr) of sediment will be delivered to the stilling basin
- At the estimated loading rate, it will take 10 years for the first 1.5 feet of the stilling basin to be filled and 30 years for the bottom three feet of the stilling basin to be filled.
- Taking historic sediment removal projects into account, it is reasonable to assume the model provides a good approximation of sediment loading rates

For the pump station evaluation, it was assumed that the available storage in the Pond is reduced by 3.769 acre-feet because the pump is not able to remove the storage volume of water between elevations 197.1 feet (elevation of the pump suction line) and 194 feet (bottom of the pond. The modeling indicated the following findings:

- The pump station can process a maximum of 9.723 acre-feet or 3,168,000 gallons in a 24-hour time period. For basis of comparison, based on the station's capacity, the pump station can remove the volume of water received from a 1-inch rainfall in approximately 5 hours.
- The pump station can adequately handle a 1-year 24-hour storm (2.2 inches over one day), two back to back 1-year 24-hour storms (4.5 inches over two days), a 2-year 24-hour storm (2.6 inches over one day), and a 10-year 1-hour storm (1.37 inches over one hour).
- Beyond those storm events, based on the conservative modeling, the downstream outlet structure is required for use.

As a result of these analyses, several mitigation strategies were presented and include dredging, green infrastructure, buffer establishment, re-grading the pond, and others. A preliminary evaluation of these measures will be presented in the next technical memo.

## Memo

This memo serves as the deliverable for Task 2: Hydraulic and Hydrologic Modeling for the Buckingham Pond Conservancy pond evaluation project. Included in this task were two separate evaluations performed by various members of the project team. This included evaluating the system's built condition and assumed current condition, and analyzing the pump station. The Project Team for Task 2 remained consistent with the project proposal, and consisted of the following:

- Hydrologic and Hydraulic Analysis: Nadine Medina, P.E., CPESC, LEED AP (Project Engineer) and Brad Grant, Senior Project Manager.
- Pump Station Assessment: Amanda Johansen, I.E. (Engineer II) and Jason Ballard, P.E., LEED AP (Managing Engineer)

The format of this memo includes three general headings: 1) Introduction and Methodology; 2) Observations and Findings; 3) Conclusions; and 4) Next Steps. Each section includes information from each of the assessments.

## 1.0 Introduction and Methodology

Two assessments were performed under Task 2: Hydraulic and Hydrologic Modeling and Pump Station Modeling. Each assessment required the collection and review of relevant site plans and associated data. Data reviewed as part of this effort included:

- Stilling Basin Sediment Depths dated November 6, 2013, collected by BPC Volunteers Felton McLaughlin, John Caplis, and Harry Ermides.
- "Buckingham Pond Pollution Source and Restoration Assessment: A Student Internship Project for the Buckingham Pond Conservancy," prepared by Ms. Sarah Schaefer and Dr. Katherine Meierdiercks, dated December 2010.
- USDA National Resource Conservation Service (NRCS) Web Soil Survey (To review soil types and characteristics.)
- Google Earth (To review watershed elevations as well as verify completeness of mapped catch basins.)

- U.S. Geological Survey Stream Stats (To review topographic-based watershed of pond and obtain general watershed characteristics.)
- "Sewer Separation Project" record drawings dated December 6, 1993, prepared by Hershberg and Hershberg (to review the contributing watershed boundaries as well as pipe lengths, diameters, and slopes and inlets into the stilling basin)
- Submittal Data for the Davis Ave Pump Station pumps dated March 26, 1992
- Topographic/Hydrographic Survey of Buckingham Lake dated April 14, 1999, prepared by C.T. Male Associates, P.C.

### *1.1 Hydrologic and Hydraulic Analysis*

The purpose of this assessment was to review the impact the contributing watershed has on the stilling basin, pond, and pump station system during various prescriptive rainfall events. To complete the analysis, the entire contributing watershed and system features were inputted into HydroCAD Version 10.00. This software is widely used in the industry for modeling stormwater runoff and providing snapshots of flow rates and volumes, as well as the effects of storms of various intensities on watersheds, ponds, pipes, and other inputted features. The general steps involved in creating the model included:

- Reviewing the contributing watershed as it pertains to each of the four identified stilling basin inlets, and dividing the watershed into four contributing sub-watersheds accordingly. (Attachment 1)
- Gathering cover types for each sub-watershed, including buildings, roads, vegetated area, etc, and calculating the acreage of each.
- Determining time of concentration flow paths for each sub-watershed. This is the path stormwater takes to get from the furthest hydrologic point within the sub-watershed to the point of entry into the stilling basin.
- Reviewing record drawings of the stormwater system within the watershed and determining the length, diameter, material, and slope for each run of stormwater pipe between all catch basins in the system.
- Obtaining the latest 24-hr rainfall data on the Cornell University Extreme Precipitation interactive web tool (http://precip.eas.cornell.edu/). This is the current industry standard for collecting rainfall data in our region. Rainfall amounts were collected for the 1-, 2-, 10-, 25-, 50-, 100-, and 500-year, 24-hour storm events. In addition to the 24-hour storm events, the 10-year 1 hour and 100-year 1 hour events were analyzed, with rainfall data obtained from the same source (Attachment 2)
- Obtaining data pertaining to soil characteristics within the watershed. (Attachment 3)

- Reviewing the pump submittals for the flow and head associated with the pumps. (Attachment 4)
- Reviewing site survey drawings for the stilling basin and pond to determine designed storage volumes for varying elevations, as well as to review the design-depth of each. It should be noted that portions of the survey had to be interpolated, as not all elevations were illustrated in their entirety. (Attachment 5)
- Obtaining and reviewing sediment depth measurements; interpolating current pond bottom based on findings for Existing Conditions analysis. (Attachment 6)
- Entering all of these findings into HydroCAD Version 10.00.
- For the current conditions model, a sensitivity analysis was performed in addition to inputting existing sediment depths. This process included reducing the available storage of the pond by 10% and 20% of the existing storage to compare hypothetical scenarios. All existing conditions models assumed the effective bottom of the pond at elevation 197 as noted on the earlier referenced topographic survey, as this is the invert elevation of the cross culvert between the sediment basin and pond as well as the invert of the pump suction line.

### *1.2 Pump Station Assessment*

B&L was tasked to perform an evaluation of the existing Buckingham Pond Pump Station to determine the operating capacity of the pump station and the station's ability to handle storm events of varying intensities. B&L developed an existing system curve based on contract drawings, and compared the system curve to the pump curves for the existing pumps. The HydroCAD model output was compared to the derived pump station capacity to develop operating recommendations.

## 2.0 Observations and Findings

### *2.1 Hydrologic and Hydraulic Analysis*

Because the pump suction line and invert of the nearly flat culvert (stabilization pipe) between the stilling basin and pond is at elevation 197 (obtained from "Topographic/Hydrographic Survey Buckingham Lake, prepared by C.T. Male Associates, P.C., dated April 14, 1999), it is assumed that standing water below elevation 197 is unable to be pumped out of the basin. Because of this condition, while the stilling basin bottom is at 193 and the pond bottom is at 194, the storage up to elevation 197 is assumed to be occupied by stormwater and sediment from previous events. For this reason, the stilling basin and pond were modeled as one pond to have the ability to apply the effect of the pump station on the entire system. All HydroCAD modeling and outputs are included as Attachment 7.

The analysis was performed for the following storm events of interest, which will be referenced throughout the remainder of this memo:

| Storm Event (24-hr) | Rainfall (in) |
|---|---|
| 1-yr | 2.22 |
| 2-yr | 2.61 |
| 10-yr | 3.78 |
| 25-yr | 4.67 |
| 50-yr | 5.48 |
| 100-yr | 6.44 |
| 500-yr | 9.39 |

| Storm Event (1-hr) | Rainfall (in) |
|---|---|
| 10-yr | 1.37 |
| 100-yr | 2.39 |

### *2.1.1 Built Conditions Analysis*

The built conditions analysis consisted of analyzing the watershed using the data provided in the record drawings and survey. The following flow rates and volumes were observed in the stilling basin and pond for the storms of interest:

| | Storm Event (24-hr) | Influent Flow Rate (cfs) | Discharge to Overflow Structure (cfs) | Discharge to Pump (cfs) | TOTAL DISCHARGE (cfs) | Influent Volume (ac-ft) | Discharge to Overflow Structure (ac-ft) | Discharge to Pump (ac-ft) | TOTAL DISCHARGE (ac-ft) | Notes |
|---|---|---|---|---|---|---|---|---|---|---|
| Built Condition (bottom el at 197 w/100% storage) | 1-year | 63.08 | 0 | 4.9 | **4.9** | 14.93 | 0 | 4.6 | **4.60** | Modeled as one pond with bottom elevation at 197 to match pump suction line and invert of culvert connecting pond and basin. |
| | 2-year | 64.90 | 0 | | **4.9** | 20.59 | 0 | 4.63 | **4.63** | |
| | 10-year | 72.67 | 52.1 | | **26.28** | 39.07 | 6.46 | 4.80 | **11.26** | |
| | 25-year | 72.78 | 36.21 | | **41.10** | 53.28 | 18.27 | 4.94 | **23.21** | |
| | 50-year | 72.28 | 44.18 | | **49.09** | 59.84 | 23.26 | 5.10 | **28.36** | |
| | 100-year | 72.28 | 55.24 | | **60.14** | 65.10 | 28.13 | 5.34 | **34.08** | |
| | 500-year | 72.28 | 57.17 | | **62.07** | 80.66 | 41.12 | 6.06 | **42.18** | |

The revised HydroCAD model and these results indicate that the overflow structure, using the watershed and system data provided, will not receive stormwater from the system until the 10-year event provided the pump station is operating throughout the duration of the storm. During this event, the outlet structure receives stormwater for approximately 10 hours during the 24-hr storm, at which time the level of water in the pond is only slightly above the outlet structure. This condition is similar for the 25-year storm. It also illustrates that, beginning with the 10-year storm, the system is generally sized to reduce the volume and rate of stormwater conveyed to the overflow over 24 hours within the selected time span for modeling. These reductions in volume and rate increase if the storm event is significant and predictable enough to begin pumping to Krum Kill watershed a day or two before the storm event arrives.

| | Storm Event (1-hr) | Influent Flow Rate (cfs) | Discharge to Overflow Structure (cfs) | Discharge to Pump (cfs) | TOTAL DISCHARGE (cfs) | Influent Volume (ac-ft) | Discharge to Overflow Structure (ac-ft) | Discharge to Pump (ac-ft) | TOTAL DISCHARGE (ac-ft) | Notes |
|---|---|---|---|---|---|---|---|---|---|---|
| **Built Condition (bottom el at 197 w/100% storage)** | 10-year | 61.89 | 0 | 4.9 | **4.9** | 4.88 | 0 | 4.40 | **4.40** | Modeled as one pond with bottom elevation at 197 to match pump suction line and invert of culvert connecting pond and basin. |
| | 100-year | 68.88 | 0 | | **4.9** | 17.53 | 0 | 17.05 | **17.05** | |

As illustrated by the modeling, the influent flow rate varies slightly more and the volume of runoff is less for the 1-hour storm events than for the 10- and 100-year 24-hour storm events. The 12” pond inlet from Sub-watershed 2 is the only inlet to the pond that is not flowing full during the 10-year 1-hr storm. It is, however, flowing full during the 100-yr 1-hr storm. The HydroCAD model and these results indicate that the overflow structure, using the watershed and system data provided, will not receive stormwater from the system for either of these events. This is consistent with rainfall data observed in the 24-hr storm events when reviewing specific 1-hr time periods during which the rainfall amounts equaled the 1-hr storm rainfall values. However, the 1-hr storm event assumes the ground has a low antecedent moisture conditions since, during the 24-hr storm events, these equivalent 1-hr rainfall amounts occur after 11-12 hours rainfall (i.e. the ground has become wet/soaked and infiltration/temporary watershed storage is less likely than it is for the 1-hr storm event).

### *2.1.2 Sensitivity Analysis*

In the absence of data pertaining to current conditions, an iterative type of analysis was performed for the pond system that included observing conditions if an additional 10% and 20%, of the pond volume was unavailable due to sediment accumulation. This loss of volume is in addition to the volume lost below the pump suction line and culvert invert. The results of this sensitivity analysis are below:

| | Storm Event (24-hr) | Influent Flow Rate (cfs) | Discharge to Overflow Structure (cfs) | Discharge to Pump (cfs) | TOTAL DISCHARGE (cfs) | Influent Volume (ac-ft) | Discharge to Overflow Structure (ac-ft) | Discharge to Pump (ac-ft) | TOTAL DISCHARGE (ac-ft) | Notes |
|---|---|---|---|---|---|---|---|---|---|---|
| 10% Volume Loss | 1-year | 63.08 | 0 | | **4.9** | 14.93 | 0 | 4.72 | **4.72** | |
| | 2-year | 64.90 | 0 | | **4.9** | 20.59 | 0 | 4.76 | **4.76** | |
| | 10-year | 72.67 | 28.24 | | **33.85** | 39.07 | 8.98 | 4.91 | **13.88** | |
| | 25-year | 72.28 | 36.38 | 4.9 | **41.29** | 53.28 | 20.78 | 5.10 | **25.88** | Modeled as one pond with bottom elevation at 197 and available storage reduced by 10% of the built condition storage. |
| | 50-year | 72.28 | 48.60 | | **53.50** | 59.84 | 25.70 | 5.33 | **31.03** | |
| | 100-year | 72.28 | 55.84 | | **60.74** | 65.70 | 31.14 | 5.61 | **36.75** | |
| | 500-year | 72.28 | 57.24 | | **62.14** | 80.66 | 43.47 | 6.38 | **49.85** | |
| 20% Volume Loss | 1-year | 63.08 | 0 | | **4.9** | 14.93 | 0 | 4.82 | **4.82** | |
| | 2-year | 64.90 | 0 | | **4.9** | 20.54 | 0 | 4.86 | **4.86** | |
| | 10-year | 72.67 | 11.36 | | **36.90** | 39.07 | 11.35 | 5.10 | **16.46** | |
| | 25-year | 72.28 | 36.92 | 4.9 | **41.82** | 53.28 | 23.07 | 5.41 | **28.48** | Modeled as one pond with bottom elevation at 197 and available storage reduced by 20% of the built condition storage. |
| | 50-year | 72.28 | 51.33 | | **56.23** | 59.84 | 27.92 | 5.71 | **33.63** | |
| | 100-year | 72.28 | 56.23 | | **61.13** | 65.70 | 33.34 | 6.02 | **39.36** | |
| | 500-year | 72.28 | 57.35 | | **62.25** | 80.66 | 45.65 | 6.81 | **52.46** | |

*10% Volume Loss:*

The model indicates that the overflow structure, using the watershed and system data provided, will not receive stormwater from the system for the 1-yr and 2-yr events. During the 10-yr event, the outlet structure receives stormwater for approximately 10 hours during the 24-hr storm, at which time the level of water in the pond is effectively above the outlet structure. This condition is similar for the 25-year storm. It also illustrates that, for storm events of equal to and of greater magnitude than the 10-year storm, the system is not adequately sized to mitigate the volume of stormwater produced within the time span modeled (72 hours).

*20% Volume Loss:*

The model indicates that the overflow structure, using the watershed and system data provided, will not receive stormwater from the system until the 10-year event. During this event, the outlet structure receives stormwater for approximately 12 hours during the 24-hr storm, at which time the level of water in the pond is effectively above the outlet structure. This condition is similar for the 25-year storm, with the pond level being above the outlet structure for a longer duration. It also illustrates that, beginning with the 10-year storm, the system is generally sized to reduce the volume and rate of stormwater conveyed to the overflow over 24 hours within the selected time span for modeling.

These reductions in volume and rate increase if the storm event is significant and predictable enough to begin pumping to Krum Kill watershed a day or two before the storm event arrives

| | Storm Event (1-hr) | Influent Flow Rate (cfs) | Discharge to Overflow Structure (cfs) | Discharge to Pump (cfs) | TOTAL DISCHARGE (cfs) | Influent Volume (ac-ft) | Discharge to Overflow Structure (ac-ft) | Discharge to Pump (ac-ft) | TOTAL DISCHARGE (ac-ft) | Notes |
|---|---|---|---|---|---|---|---|---|---|---|
| **10% Volume Loss** | 10-year | 61.89 | 0 | 4.9 | **4.9** | 4.88 | 0 | 4.57 | **4.47** | Modeled as one pond with bottom elevation at 197 and available storage reduced by 10% of the built condition storage. |
| | 100-year | 68.88 | 0 | | **4.9** | 17.53 | 0 | 9.32 | **9.32** | |
| **20% Volume Loss** | 10-year | 61.89 | 0 | 4.9 | **4.9** | 4.88 | 0 | 4.88 | **4.88** | Modeled as one pond with bottom elevation at 197 and available storage reduced by 20% of the built condition storage. |
| | 100-year | 68.88 | 0 | | **4.9** | 17.53 | 0 | 9.40 | **9.40** | |

This Sensitivity analysis for the 1-hr storm events mimics the results identified in the Built Condition Model.

### *2.1.3 Existing Conditions Analysis*

The existing conditions analysis consisted of analyzing the watershed using the data provided in the record drawings and survey, and reducing the available storage in the stilling basin and pond at various elevations based on field measurements. On February 4, 2015, City Personnel measured sediment depths within the pond. Seventeen holes were hand-augured through the accumulated ice and a graduated pole was pushed through the hole until reaching resistance (presumably top of sediment) and a measurement was taken. It was then pushed further down to refusal, which was presumably the compacted clay liner, and another measurement was taken. The difference between the two measurements indicted the approximate sediment depth at that location. This process closely followed the methodology of measuring sediment depths within the stilling basin, which was completed by Buckingham Pond Conservancy volunteers on November 6, 2013. Two differences were 1) the pond was not frozen over at the time of stilling basin measurements, and 2) the stilling basin bottom is comprised of stone. Once the Existing Conditions model was revised for the observed conditions, the volume loss due to sedimentation could be determined. Based on the field measurements and modeling, the following were observed:

- The interpolated volume loss due to sedimentation is approximately 4.019 acre-feet
- This loss represents approximately 15% loss in overall available storage above elevation 197 (elevation of the inverts and pond suction line).

Therefore, it can be assumed that the pond is operating between the two conditions presented in the sensitivity analysis section. The following flow rates and volumes were observed in the stilling basin and pond for the storms of interest:

| | Storm Event (24-hr) | Influent Flow Rate (cfs) | Discharge to Overflow Structure (cfs) | Discharge to Pump (cfs) | TOTAL DISCHARGE (cfs) | Influent Volume (ac-ft) | Discharge to Overflow Structure (ac-ft) | Discharge to Pump (ac-ft) | TOTAL DISCHARGE (ac-ft) | Notes |
|---|---|---|---|---|---|---|---|---|---|---|
| **15% Volume Loss (Current Conditions)** | 1-year | 62.67 | 0 | 4.9 | **4.9** | ‘4.90 | 0 | 4.72 | **4.72** | Modeled as one pond with bottom elevation at 197 and available storage reduced based on field measurements taken on 2/4/015. |
| | 2-year | 64.33 | 0 | | **4.9** | 20.55 | 0 | 4.76 | **4.76** | |
| | 10-year | 71.35 | 30.45 | | **51.77** | 38.98 | 10.22 | 4.9 | **15.12** | |
| | 25-year | 73.14 | 36.52 | | **41.43** | 53.15 | 22.00 | 5.10 | **27.10** | |
| | 50-year | 73.20 | 50.18 | | **55.08** | 59.69 | 26.90 | 5.33 | **32.23** | |
| | 100-year | 72.93 | 56.02 | | **60.92** | 65.50 | 32.29 | 5.61 | **37.90** | |
| | 500-year | 72.28 | 57.20 | | **62.10** | 80.34 | 44.50 | 6.38 | **50.88** | |

The model indicates that the overflow structure, using the watershed and system data provided, will not receive stormwater from the system for the 1-yr and 2-yr events. During the 10-yr event, the outlet structure receives stormwater for approximately 12 hours during the 24-hr storm, at which time the level of water in the pond is effectively above the outlet structure. This condition is similar for the 25-year storm. It also illustrates that, for storm events of equal to and of greater magnitude than the 10-year storm, the system is not adequately sized to mitigate the volume of stormwater produced within the time span modeled (72 hours).

| | Storm Event (1-hr) | Influent Flow Rate (cfs) | Discharge to Overflow Structure (cfs) | Discharge to Pump (cfs) | TOTAL DISCHARGE (cfs) | Influent Volume (ac-ft) | Discharge to Overflow Structure (ac-ft) | Discharge to Pump (ac-ft) | TOTAL DISCHARGE (ac-ft) | Notes |
|---|---|---|---|---|---|---|---|---|---|---|
| **15% Volume Loss (Current Conditions)** | 10-year | 61.71 | 0 | 4.9 | **4.9** | 4.87 | 0 | 4.56 | **4.56** | Modeled as one pond with bottom elevation at 197 and available storage reduced based on field measurements taken on 2/4/015. |
| | 100-year | 67.74 | 0 | | **4.9** | 17.49 | 0 | 9.32 | **9.32** | |

This Sensitivity analysis for the 1-hr storm events mimics the results identified in the Built Condition Model

### *2.1.4 Sedimentation*

The Center for Watershed Protections "Watershed Treatment Model" (WTM) was run to determine estimates of annual total suspended solids (TSS), nutrients, and other metrics delivered to the pond system (Attachment 8). Because all direct inlets to the system are in the stilling basin, it is assumed that the total suspended solids likely accumulate within the stilling basin with the exception of those resulting from overland flow/extreme intensity precipitation events that deliver sediment directly to the pond via sheet flow and/or erosion.

Based on the inputs, the WTM calculated that a total of 78,000 lb/yr of sediment will be delivered to the stilling basin. Because the average weight of sand is 100 lb/cf, the annual loading is equivalent to 780 cf/yr of TSS. As such, it will take 10 years for the first 1.5 feet of the stilling basin to be filled and 30 years for the bottom three feet of the stilling basin to be filled.

The WTM outputs are applied to the condition of the stilling basin, as the stilling basin is the location of the direct outlets from the watershed. The most recent sediment removal project took place approximately 15 years ago. In 15 years, based on the WTM outputs, this should result in approximately 12,000 cf or 0.28 ac-ft of sediment build-up within the stilling basin. Based on a special HydroCAD model, which takes into account a variety of perimeters at different elevations for the stilling basin, this volume is reached between elevations 194.4 and 195.8. Interpolating the data indicates that a volume of 0.27 ac-ft occurs at approximately elevation 195, 2 feet above the bottom of the stilling basin. It is also likely that, due to high velocities experienced in the pond inlets, erosion at the outlet of these conveyances may have resulted in additional sediment deposition. With measured depths of sediment in the stilling basin between 1.5 and 4 feet depending on location, it is reasonable to assume the model provides a good approximation of sediment loading rates. See table below for stilling basin storage at various elevations.

| Elevation (feet) | Surface (acres) | Storage (acre-feet) |
|---|---|---|
| 193 | 0.06 | 0 |
| 194.4 | 0.169 | 0.165 |
| 195.8 | 0.278 | 0.467 |
| 197.2 | 0.401 | 0.942 |
| 198.6 | 0.543 | 1.607 |
| 200 | 0.65 | 2.446 |

| Elevation (feet) | Surface (acres) | Storage (acre-feet) |
|---|---|---|
| 201.4 | 0.695 | 3.395 |
| 202.8 | 0.7 | 3.813 |

Recent sediment measurements taken within the pond indicate an additional loss of volume within the system, not accounted for in the stilling basin. This additional volume loss is approximately 3.7 acre-feet. A portion of this volume loss is attributable to sediment accumulation in the channel between the stilling basin and the pond, which was likely transferred into the pond via the connecting culvert and represents additional accumulation from the contributing watershed. The balance, however, is likely not attributed to one of the four watershed outlets into the stilling basin and is more likely a result of sediment transport from overland stormwater flow during precipitation events as well as erosion along the banks of the pond. It should be noted that this extrapolated sediment loading rate was based on watershed factors at the time of modeling and that a change in impervious area, tree cover, disturbed area, or size of sub watershed areas may result in a change to the sediment loading rate.

*2.2 Pump Station Assessment*

Survey data from Contract Drawings titled “Berkshire Boulevard & Vicinity Sewer Separation Project in Albany, NY,” dated September 5, 1991 and designed by Hershberg & Hershberg Consulting Engineers was used to create a system curve. A system curve is a graphical comparison of the amount of pressure (represented in “feet of water” or “total dynamic head”) that a pump must overcome to pump water at defined flow rates to a designated location (Attachment 9). Pump curves are developed for a specific pump by the pump manufacturer, and define the flow a pump can deliver at varying pressure (total dynamic head). The system curve was compared with the pump curves for one pump in operation, as well as for two pumps in operation to identify an operating point. The operating point is the intersection of the manufacturer produced pump curve and the system curve, and is defined as the conditions (a specified flow and the pressure which the pump must overcome at that flow) under which the specific pump will operate in the specified system. Based on our analysis, the Buckingham Pond Pump Station operates at 2,100 gallons per minute (gpm) or 4.7 cubic feet per second (cfs) at 42.3 feet total dynamic head (TDH) with one pump in operation and 2,200 gpm or 4.9 cfs at 44.3 feet TDH with two pumps in operation. For purposes of the Hydraulic and Hydrologic Analysis, discussed above, it was assumed that two pumps were running for the entirety of each storm event. Contract drawings indicate this is the maximum rate at which stormwater can be pumped into the receiving line.

Storm event volumes for the 24-hour storms included in the Hydraulic and Hydrologic analysis were obtained from the HydroCAD model. The table below shows the varying storm events and the volumes of water that enter the stilling basin and Buckingham Pond from the four subcatchments identified (see attached figure):

| Storm Event | Volume of Water (acre-feet) | Volume of Water (gallons) |
|---|---|---|
| 1-inch rainfall | 1.84 | 599525 |
| 1-year 24-hour | 14.93 | 4,864;624 |
| 2-year 24-hour | 20.53 | 6,689,265 |
| 10-year 24-hour | 39.07 | 12,730,131 |
| 25-year 24-hour | 53.27 | 17,356,900 |
| 50-year 24-hour | 59.84 | 19,497,595 |
| 100-year 24-hour | 65.69 | 21,403,693 |
| 500-year 24-hour | 80.64 | 26,274,834 |
| 10-year 1-hour | 4.88 | 1,590,045 |
| 100-year 1-hour | 17.53 | 5,711,779 |

The available storage of the stilling basin and pond was determined from survey data. The suction (intake) for the pumps in the pond is at elevation 197.1 feet. The survey data notes the floor of the pond at 194 feet. For this evaluation, it was assumed that the available storage in the Pond is reduced by 3.769 acre-feet because the pump is not able to remove the storage volume of water between elevations 197.1 feet and 194 feet. Therefore, the existing total storage of the stilling basin and the pond is 19.4 acre-feet. Two one-inch rainfall events, however, would again fill the system with stormwater up to the level of the culvert invert. It will not, however, fill the system to that level with sediment so incoming TSS can still serve to displace the accumulated stormwater. However, at this time the 3.769 acre-feet loss of storage is not necessary for the system's ability to handle the 1- or 2-year storm, and does not increase storage enough to allow the system to process a 10-year storm without use of the downstream overflow.

Based on a pump station capacity of 2,200 gpm, assuming two pumps are operating, the pump station can process a maximum of 9.723 acre-feet or 3,168,000 gallons in a 24-hour time period. For basis of comparison, based on the station's capacity, the pump station can remove the volume of water received from a 1-inch rainfall in approximately 5 hours. Data indicated that the pump station could adequately handle a 1-year 24-hour storm (2.2 inches over one day), two back to back 1-year 24-hour storms (4.5 inches over two days), a 2-year 24-hour storm (2.6 inches over one day), and both a 10-year 1-hour storm and 100-year 1-hour storm(1.37 inches/2.39 inches over one hour). Beyond those storm events, based on the conservative modeling, the downstream outlet structure is required for use.

The system curve, pump station capacity calculation and the evaluation of the pump station's ability to handle storm events of varying degrees of intensity are included in Attachment 9.

## 3.0 Conclusions

Based on the 24-hour pump station capacity, and assuming that the pond is full to the invert of the downstream outlet structure (an assumption that was not made in the HydroCAD analysis) it is recommended that the level of water in the pond system be lowered prior to significant precipitation events to provide sufficient (or maximum) available storage for flow attenuation. The table below contains the specific recommendations for each storm event:

| Storm Event | Rainfall (in) | Volume to Remove Before Storm Arrives (acre-feet) | Volume to Remove Before Storm Arrives (gallons) | Time to Remove Water (hours) | When to Start Pumping |
|---|---|---|---|---|---|
| 1-year 24-hour | 2.22 | 5.479 | 1,785,250 | 13.5 | 1 day prior |
| Two Back to back 1-year 24-hour storms | 4.44 | 10.958 | 3,571,500 | 27.1 | 2 days prior |
| 2-year 24-hour | 2.61 | 11.056 | 3,602,400 | 27.3 | 2 days prior |
| 10-year 1-hour | 1.37 | 5.434 | 1,770,514 | 13.41 | 1 day prior |

Based on the attached calculations, the pump station alone cannot handle a 10-year 24-hour storm event (3.8 inches) or greater in a 24 hour period which will result in excess stormwater passing through the overflow structure located on the east end of Buckingham Pond. For the above referenced storm events, it is recommended that the stilling basin and Pond be drained to the elevation of the culvert invert (approximately 14.655 acre-feet or 4,775,020 gallons) via the pump station prior to the predicted arrival of the storm event. It is also recommended that both pumps remain in operation throughout the duration of the storm event. It is known, however, that downstream conditions may not permit the pumps to operate during the entirety of each storm, as this condition is dependent upon the depth of stormwater flow in the receiving pipe. Those conditions, being unknown, were not modeled. Each model assumed the pumps station would be operating throughout the duration of each event. The table below shows the calculated volume of stormwater that will likely pass through the overflow for the 10-yr storm event and higher, as well as the additional capacity the pump station would need in order to handle each storm event without use of the downstream overflow structure.

| | | | | |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

Some of this stormwater volume may be lost to exfiltration through the Pond floor or evaporation, the unknowns of which were not accounted for in the either modeling so as to ensure a conservative approach.

In summary, the pump station and available storage in the pond and stilling basin have the capacity to handle 1-year and 2-year 24-hour storm events and 10-year and 100-year1-hour storm events. Based on the modeling, the overflow in the Pond will only be utilized for storm events with rainfalls of a 10-year 24-hour storm, 100-year 1-hour storm or greater.
Because the pond appears to be functioning as intended in terms of stormwater quantity management, unless it is desired to not utilize the overflow structure, the pond is sized adequately. Within the previous 5 years, the incidents of storms exceeding the 2-yr 24-hr storm are as follows:

| 2-yr 24-hr Storm Events or Higher Since January, 2010 | | | |
|---|---|---|---|
| Year | Date(s) | Rainfall (in) | Time Span (hr) |
| 2014 | - | - | - |
| 2013 | - | - | - |
| 2012 | September 18 | 3.19 | 14 |
| | August 15 | 2.67 | 20 |
| 2011 | August 28 | 4.69 | 18 |
| 2010 | September 30 – October 1 | 4.92 | 21 |

Based on this observation, significant volumes of stormwater will not frequently pass through the pond overflow. Therefore, it may not be cost effective to consider upgrades to the pump station or the pond solely for the sake of capacity. Additionally, upgrades to the pump station would require a downstream analysis since it is known that the pumps were designed to accommodate downstream constraints at the time of construction. However, in addition to recommendations made in Technical Memo 1, it is advisable to remove the existing accumulated sediment to ensure that the stilling basin and pond have adequate storage volume available to aid in water quality treatment via removal and deposition of sediment.

Additionally, the original storage capacity of the stilling basin and pond (approximately 24.5 acre-feet, or 1 million gallons) can be near fully restored by dredging the Pond and installing a drop pipe (extension) on the pump suction line to extend it below its current elevation of 197 as well as lowering the connecting culvert to match the suction line elevation. In doing so, precautions must be taken to prevent sediment from entering the suction line. Therefore, a short baffle (or berm) is recommended around the suction line. It should be noted that this new baffle height will serve as the effective sediment depth, and that sediment removal activities should be at a frequency necessary to ensure protection of the suction line. This will, however, enable more water to be pumped from the pond system, if needed, as well as restore volume for stormwater management purposes. An analysis of various baffle heights is recommended to ensure a reasonable volume of storage is provided for sediment accumulation between storm events.

Consideration can be given to deepening the system, and further lowering the invert of the pump suction line and cross culvert between the pond and stilling basin. This will provide a greater storage capacity. Additionally, green infrastructure may be considered for implementation within the watershed as a means of slowing down or infiltrating contributing stormwater, as well as an underground detention system near the pond inlets to temporarily detain a portion of contributing stormwater flow.

In an effort to reduce the potential for erosion due to the storm events analyzed herein, outlet protection at each of the pond inlets should be enhanced if not currently present.

One other item of note is that the pump station is located near the inlets in the stilling basin. This results in untreated stormwater being pumped into the receiving system during times of pumping (presumably when stormwater is entering the pond system). This is called "short circuiting" because the stormwater does not have time to go through the system and benefit from the deposition of sediment before being released. A more ideal location for the pump station, in terms of water quality, would be further east, toward the outlet structure. This will ensure maximum settling time for stormwater entering the pond. While it will not have a noticeable impact on the water quality or overall function of Buckingham Pond, it will provide environmental benefits downstream.

## 4.0 Next Steps

This memo will help form the basis of future prioritization, selection, and design of mitigation measures. The next task within the project scope is to perform the evaluation of mitigation strategies. Results of the analysis will be presented in Technical Memo #3.

BDG/akg/ojf
Attachments

# Attachment 1

# Watershed Map

# Attachment 2

# Rainfall Values

# Attachment 3

# Web Soil Survey

# Attachment 4

# Pump Submittal

# Attachment 5

# Topographic Map

# Attachment 6

# Stilling Basin and Pond Sediment Depth Measurements

# Attachment 7

# HydroCAD Calculations

# Attachment 8

# Watershed Treatment Model

# Attachment 9

# Pump Station Assessment