JOHNS POND DAM (FERC P-2801)

HYDRAULIC AND HYDROLOGIC (H&H) ANALYSES
MASHPEE, MA 02649

JULY 3, 2019

Owner/Applicant:

MASHPEE CONSERVATION COMMISSION
Mashpee Town Offices
16 Great Neck Road
Mashpee, MA 02649

BSC Job Number: 5-0261.00

Prepared by:

BSC GROUP

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Executive Summary

This report is prepared to address the Hydraulic and Hydrologic conditions of the dam (fish ladder) at Johns Pond. The following is a summary outline of the findings listed herein.

- Using Lidar topographic mapping the limits of the watershed to Johns Pond was defined to be 1,083 acres (1.7 square miles). This consists of 336 acres of surface water and 747 acres of surrounding land.

- Using USGS groundwater contours, the limits of the groundwater (subsurface) watershed that flows to Johns Pond was determined to be 4,000 acres (6.25 square miles). This includes sub subsurface flow that enters and exits Ashumet Pond. (Ashumet Pond has no exit stream. I.E. all flows from the pond are by evapotranspiration or subsurface flow).

- Johns Pond normally stands between elevation 36± (the elevation where the sand at the shore line would prevent flow from leaving the pond) and 38± with stop logs in the weirs.

- The top surface of the concrete fish ladder structure stands at elevation 40.0.

- The ground surface on either side of the fish ladder currently stands at approximately elevation 40.

- If the 100-year rainfall event occurred with the stop logs in winter position (and the pond at elevation 38.0), the 100-year flood level is calculated at elevation 39.1. This would not overtop the earth on either side of the outlet structure but is less than the desired 1 foot of freeboard.

- In approximately 2001 the fish ladder was reconstructed to its current configuration. Based on record plans, the ladder may have moved about 20 feet towards the pond to its current location (see Appendix D for record plans).

- The fish ladder within the structure is steep and narrow resulting in high velocity flows for the last distance of the fish migration. Depending on the water level of Johns Pond, the fish must climb vertically 4.5-6 feet to enter the pond. An option is described herein to modify the fish ladder to reduce its effective steepness and accompanying velocity.

- The fish ladder is operated by removing and adding stop logs as the water levels in the pond rise and fall with the season.

- In the event of a pending storm, it is possible to remove all stop logs and lower the pond at a rate of approximately 8 inches per day.

- As part of this assessment, back to back storms were evaluated to estimate the flood levels of the pond. This was completed with subsurface Curve Numbers of 30 and 48. In

this case, the larger curve number predicted higher flood levels and was used in the findings of this report. These two storms consisted of 5 inches of rain (10 inches total) separated by 24 hours. The flood levels are calculated at elevation 39.64 (subsurface CN 30) and 39.98 (subsurface CN 48). Although this results in reduced freeboard, the model does not predict overtopping of the dam.

- It is noted that the hydrologic models do not rely on the removal of any stop logs during the storm. The removal of stop logs prior to or during a storm has the ability to drop the water level of the pond significantly. Hence, the results are considered conservative when the lake is managed according to common practice.

- A draft of this report was shared with Paul Marinelli Dam Safety Engineer at DCR's Office of Dam Safety in April 2019. He had no comments.

- Based on the assessment documented herein, the following recommendations are offered.

Based on providing 100-year flood protection with the winter operating water level of 38.0 and a top of stop logs at elevation 37.5 (the maximum operating level of the pond):

1) Provide earthen fill and stabilize the surface via loam and seed to create additional freeboard to insure adequate freeboard above the 100-year calculated peak pond elevation.

2) Place filter fabric and rip rap at the outlet end of the dam structure on the steep eroding embankments to control erosion.

3) Remove failing PVC sheet piling and replace with large (2'x2'x6') concrete block or equivalent to stabilize inlet channel banks,

4) Provide rip-rap groins and granite block "sand dam" to limit sand migration from shoreline into inlet channel.

5) Dredge inlet channel to just below the lowest weir elevation (top of concrete that weirs rest on).

6) Plant shrubbery either side of channel to provide vegetative cover for migrating fish upstream of dam.

7) Consider modification of fish ladder by construction of weir within wider side of dam structure. (This has potential to result in 60% slower velocities in the travel way used by fish resulting in reduced effort to reach the pond.)

8) Establish a regular program to observe the dam and monitor weather forecasts to modify stop logs if necessary.

Based on the plans prepared to date and the understood permits required, BSC estimates the recommended improvements to be on the order of $100,000.

SECTION 1.0

PROJECT INFORMATION

1.01 BASIS OF THE REPORT

This report is based on the following Scope of Services from BSC's agreement with Town of Mashpee dated December 3, 2018:

A. SCOPE OF SERVICES

Task 1 Data Collection

- Review current dam safety and performance standards in 302 CMR 10.00 to be used as the basis of the assessment.
- Meet once with the Client to review the approach and available information.
- Review original design plans of the outlet structure and similar information which will be provided by the Client for BSC's use.
- Visit the site to observe and document conditions.
    - Create a Lidar topographic map (with 2-foot contours) of the watershed to Johns Pond and summarize the watershed characteristics.
    - Collect US-Soil Conservation Service soil classifications and runoff characteristics for the existing watershed.
    - Complete a limited instrument survey of the outlet structure and immediate downstream channel area and take soundings for about 50 feet around the control structure and prepare a topographic/hydrographic map of the dam area using NAVD 88 datum.
    - Research available software to assess the runoff and flow to the pond.
    - Collect a soil sample upgradient of the outlet and complete a grain size analysis.

Task 2 Hydrologic and Hydraulic Analysis

- Select an appropriate computer model (HydroCAD) and run hydrologic models to calculate runoff inflow and outflow.
- Review precipitation and pond water level data provided by the Client to calibrate the model to the extent possible.

- Contact the Massachusetts Dam Safety Program or NRCS for concurrence on the proposed analysis before proceeding with Task 2.

- Using HydroCAD (or equivalent model as deemed appropriate for this watershed size) complete an analysis for multiple storms and for multiple precipitation events to calculate the runoff hydrographs into the ponds and complete a stage/storage routing analysis of the pond and outlet structures to determine spillway capacities, peak outlet flow rates, peak water levels, volume of water stored and outlet channel velocities. Analysis will be for the current conditions and for future buildout (within 50 years) conditions for various precipitation events. (Impervious surfaces of future buildout will be based on current zoning and BSC's estimate of development potential over the specified time frame.)

- Using available USGS groundwater well information and available soil data, investigate the potential impact of groundwater flow into and out of the pond and it's potential to affect the water levels of the pond. In a related factor, this will include an assessment if the NRCS Technical Note 301: Runoff-Frequency: Peaks, Volumes, Timing for Low-Relief, Sandy "Cranberry Bog" Drainage Areas is applicable to estimate the peak flows into Johns Pond.

- Based on findings of the hydrologic /hydraulic assessment above, develop alternatives for necessary improvements which would need to be made to meet current dam safety and performance standards.

- Using Stokes law/ scour velocity analysis estimate sediment transport through the principle spillway and recommend any necessary improvements required for proper operation.

- Prepare conceptual sketch designs for up to three improvement alternatives.

    - Provide an opinion of costs for same improvement alternatives.

    - Evaluate alternatives and offer a recommendation of the preferred solution.

Task 3 Report

- Prepare a summary report endorsed by a Professional Engineer registered in the Commonwealth of Massachusetts that summarizes:
    - The methods used for the analysis.
    - Supporting documentation.
    - The findings of the hydrologic / hydraulic assessment.
    - The findings of potential sediment transport assessment.
    - Improvement alternatives and opinion of costs.
    - Recommended alternative.
    - Likely permitting required.

- Submit a PFD and three hard copies of the report to the Client and meet one time to review the findings.

- Assist the Client in submitting the report to the Massachusetts Dam Safety program and / or NRCS.

1.02 PROJECT DESCRIPTION

The Town of Mashpee Conservation Commission (The Applicant) required a hydrologic and hydraulic study to assess the Johns Pond dam and spillway in Mashpee, Massachusetts, hereinafter referred to as "the Project".

The assessment of the dam and spillway will determine if any improvements are needed to meet current Massachusetts and USDA-NRCS (Natural Resource Conservation Service) dam safety and performance standards. Johns Pond is a natural kettle hole waterbody whose major outlet is controlled by cast-in-place concrete weirs reportedly constructed circa 1950 and reconstructed in 2003. It is classified as a large size, low hazard structure in accordance with current Dam Safety regulations (302 CMR 10.00).

The Project involves the review of current dam safety and performance standards in 302 CMR 10.00, review of the approach, available information, and the original design plans of the outlet structure with the Applicant, a site visit to collect a soil sample upgradient of the outlet for a grain size analysis and to observe and document conditions, creation of a Lidar topographic map of the watershed, collection of US-Soil Conservation Service soil classifications and runoff characteristics, completion of a limited instrument survey of the outlet structure and immediate downstream channel area, and preparation of a topographic/hydrographic map of the dam area using NAVD 88 datum.

The hydrologic and hydraulic analysis used HydroCAD Stormwater Modeling Software version 10.0, a computer aided design program that combines SCS runoff methodology with standard hydraulic calculations. The analysis includes back to back storms and precipitation events to calculate the runoff hydrographs into the pond. With the completion of a stage/storage routing analysis of the pond and outlet structures, spillway capacities, peak outlet flow rates, peak water levels, volume of water stored, and outlet channel velocities will be determined.

Analysis is for the current conditions and for future buildout (within 50 years) conditions for various precipitation events. Using available USGS groundwater well information and available soil data, the potential impact of groundwater flow into and out of the pond and its potential to affect the water levels of the pond.

In a related factor, this includes an assessment to determine if the NRCS Technical Note 301: Runoff-Frequency: Peaks, Volumes, Timing for Low-Relief, Sandy "Cranberry Bog" Drainage Areas is applicable to estimate the peak flows into Johns pond.

Stokes' Law/scour velocity analysis was used to estimate sediment transport through the principle spillway. Any necessary improvements required for proper operation will be recommended. The Project also includes the preparation of conceptual sketch designs for improvement alternatives along with a recommendation of the preferred solution.

EXISTING CONDITIONS

Johns Pond is located in south western Mashpee and is fed by both surface water and groundwater. The dam under assessment is located at the northern end of the Pond and drains into the Quasnet River.

The following site-specific elevations/heights and are noted:

Normal Water level elevation in the pond: 38.0 (NAVD 88)
Stream channel elevation below the dam: 33.5
Dam Height at normal water level : 4.5 feet
Ground surface elevation 1,000 feet down gradient of Dam: 32

Invert of outlet weirs (concrete invert) in dam: 34.5
Normal Stop log winter elevation: 37.5
Stop log highest operational level: 38.2
Top of concrete at dam 40.0

Surface Area of Pond: 336 Acres
100-year flood water level: 39.1 (calculated below)
Water Volume impounded at normal winter water level : 1,485 acre-feet
Dam Height at 100-year flood water level : 5.5 feet
Water impounded at 100-year flood water level : 1,815 acre- feet

Surface watershed to pond : 1,083 acres (1.7 square miles)
Subsurface watershed to pond: 4,000 acres (6.25 square miles)

Fish ladder weir width: 24 inches
Outlet weir width: 3-foot 4-inches

Emergency Overflow structure: None. (Concrete dam would be over topped and serve as emergency overflow)

Normal outflow from weirs with 6 inches of head: 15 cfs. (60+/- % is through the larger weir and 40+/-% through the fish ladder) At this rate, pond drawn down is calculated at 8.5 inches per day.

Max Flow for weirs with all stop logs removed (and water level at 100-year elevation): 125 cfs. (60+/- % is through the larger weir and 40+/-% through the fish ladder) (At this rate, pond drawn down is calculated at 8.5 inches per day.)

The surface water level is shown on the USGS map at elevation 38. This elevation was confirmed by field survey on January of 2019.

USGS Map

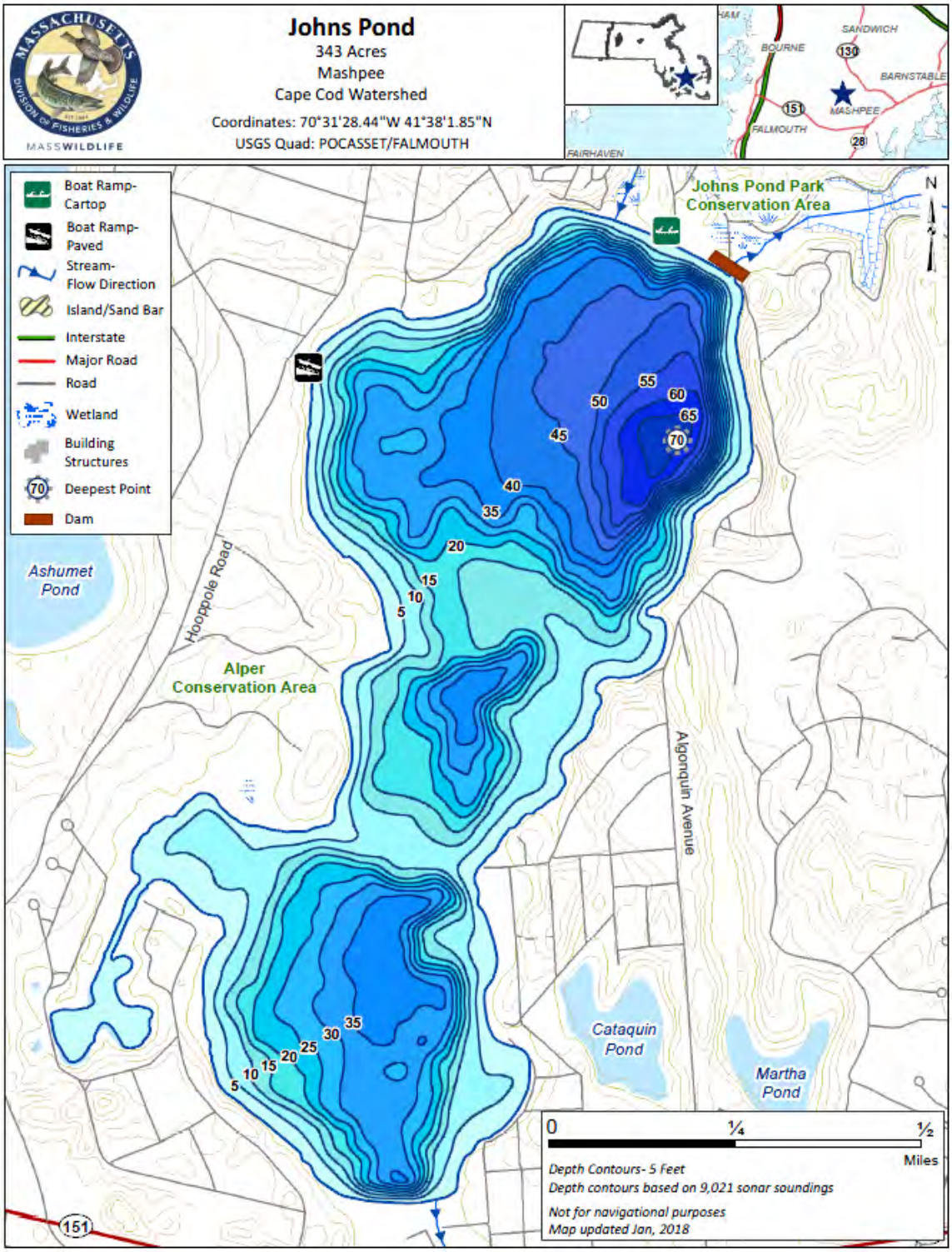
FEMA (Panel 250009) has mapped the area as being an area of Minimal Flood Hazzard

Johns Pond Dam is a groundwater intercepting kettle hole water body with an outlet at the north end known as Quashnet River.

Wells logs for wells near the dam (see Appendix A for location and Appendix F for logs) obtained from MA Military Reservation reveal sand (with some silt content in lower stratas) to depths of 134 feet at the site. This information is included as evidence of the high permeability of the local geology.

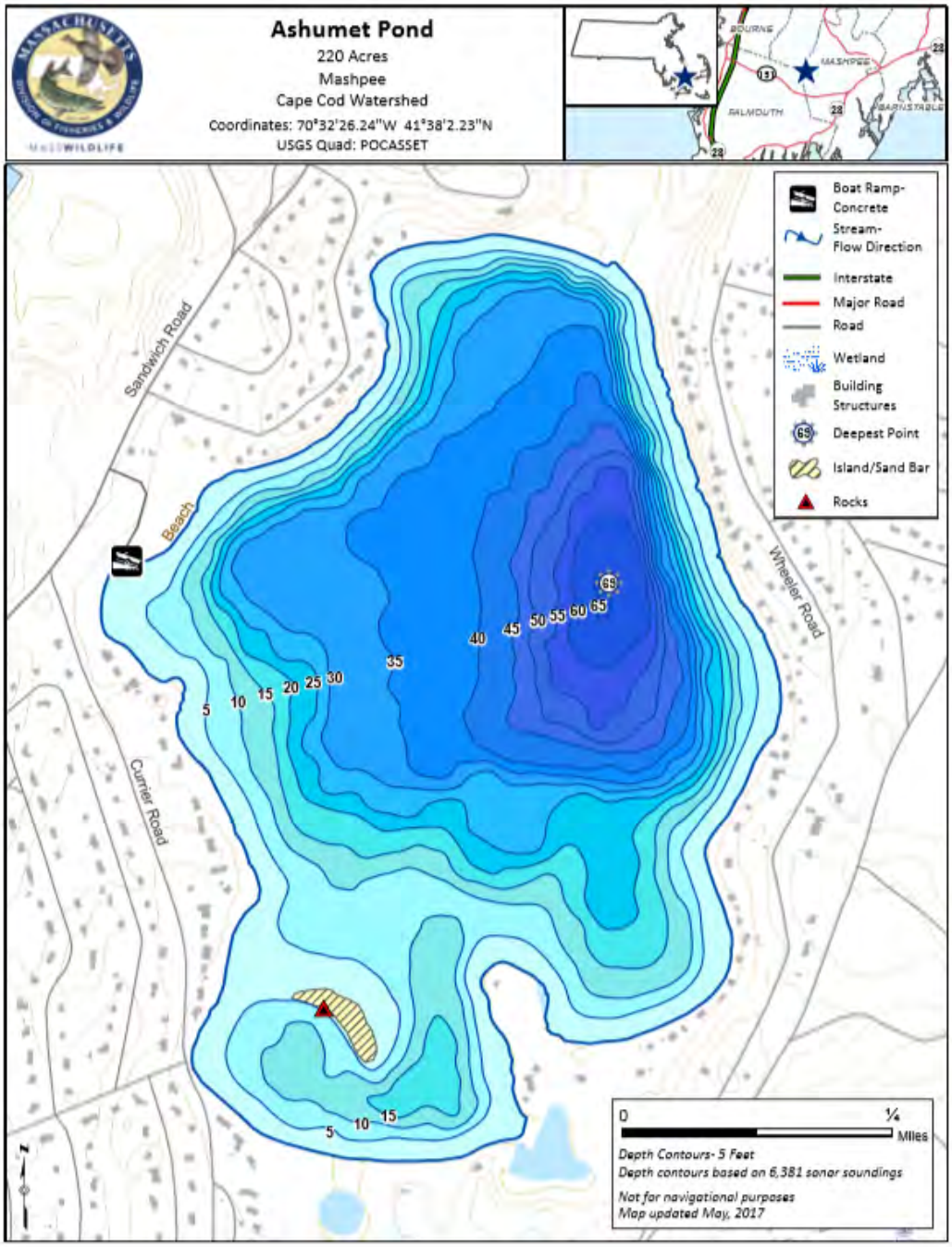
The pond a surface area of 340 acres and has a now mapped watershed of 802 acres (1.25 square miles) and a subsurface watershed of 4,000 acres (6.25 square miles).

Based on reports https://www.mass.gov/files/documents/2018/02/05/Johns_pond.pdf Johns Pond has a maximum depth of 70 feet (50 feet below sea level). A bathymetric map from that report is shown below.



Bathymetric map of Johns Pond from https://www.mass.gov/files/documents/2018/02/05/Johns_pond.pdf

Similarly , as supplemental information, Ashumet Pond , Adjacent to Johns Pond and considered in this assessment) has a similar bathometry.



Bathymetric map of Ashumet Pond from https://www.mass.gov/files/documents/2018/02/05/Johns_pond.pdf

The dam has two sharp crested weir outlets, one of which serves as a fish ladder for herring. It is classified via current Dam Safety regulations, 302 CMR 10.00 as a large size, low hazard structure. (Due to this classification, the Spillway Design Flood (SDF) for this structure is the 100-year design storm that is specified in 310 CMR 10 as 7.00 inches of rainfall in a 24-hour period.

From 302 CMR 10.00 definitions : a Dam is "Any artificial barrier, including appurtenant works, which impounds or diverts water, and which:

(a) is 25 feet or more in height from the natural bed of the stream or watercourse measured at the downstream toe of the barrier, or from the lowest elevation of the outside limit of the barrier, if it is not across a stream channel or watercourse, to the maximum water storage elevation; or" (This site does not meet this definition due to its total 100-year height being 5.5 feet).

(b) "has an impounding capacity at maximum water storage elevation of 50-acre feet or more." (This site meets this definition due to its retained volume being 1,870-acre feet.) Based on 302 CMR 10.02 this classifies the Dam as a being "large".

A Dam Breach Analysis by Weston and Sampson completed in May 2011 found the dam to be of the "low hazard" category.

A submerged 24-inch CMP outlet exists at the south end of the pond which is controlled by a valve and normally closed. For the purpose of this study, it will not be considered.

Adjacent to, but separate from Johns Pond, is Ashumet Pond which has USGS gauge # MI-JOHPD-0005 with water levels as recorded in a USGS monitoring well MA-FSW 239-0121 located only 50 feet from the shore line (thus a good reflection of the water level in the pond). Whereas this pond has no outlet or inlet, this information can be used to estimate groundwater inflow and outflow from the pond and calibrate BSC's model. It is clear from this gauge/well that the water levels of the pond have approximately a one-month lag time from major precipitation events. Furthermore, from the well data, this pond has a maximum range of about 3 feet with no physical stream outlet.

The outlet weirs are controlled by stop logs. The lower ranks of these weirs have trapped sand to a height of about 1 ½ foot above the lowest stop log. For this reason, a recommendation to provide a sand migration dam in the pond to prevent the migration of sand it the channel that feeds the weirs.

The fish ladder while reportedly deemed adequate by Fish and Wildlife, has a very steep climb and very close spacing of the ladder steps making fish migration more a challenge. Although not part of this assessment, modification of the wider overflow weir into a wider fish ladder, with alternating horizontal weirs spacing, would result in lower velocities between the fish ladder steps and hence more resting spaces for fish as they climb the ladder. It would however increase the labor effort to modify the fish ladder, as stop logs would require modification beyond that which currently occurs.

The watershed is shown below in a general sense. A more detailed plot is included in Appendix B.

Surficial Watershed Plan

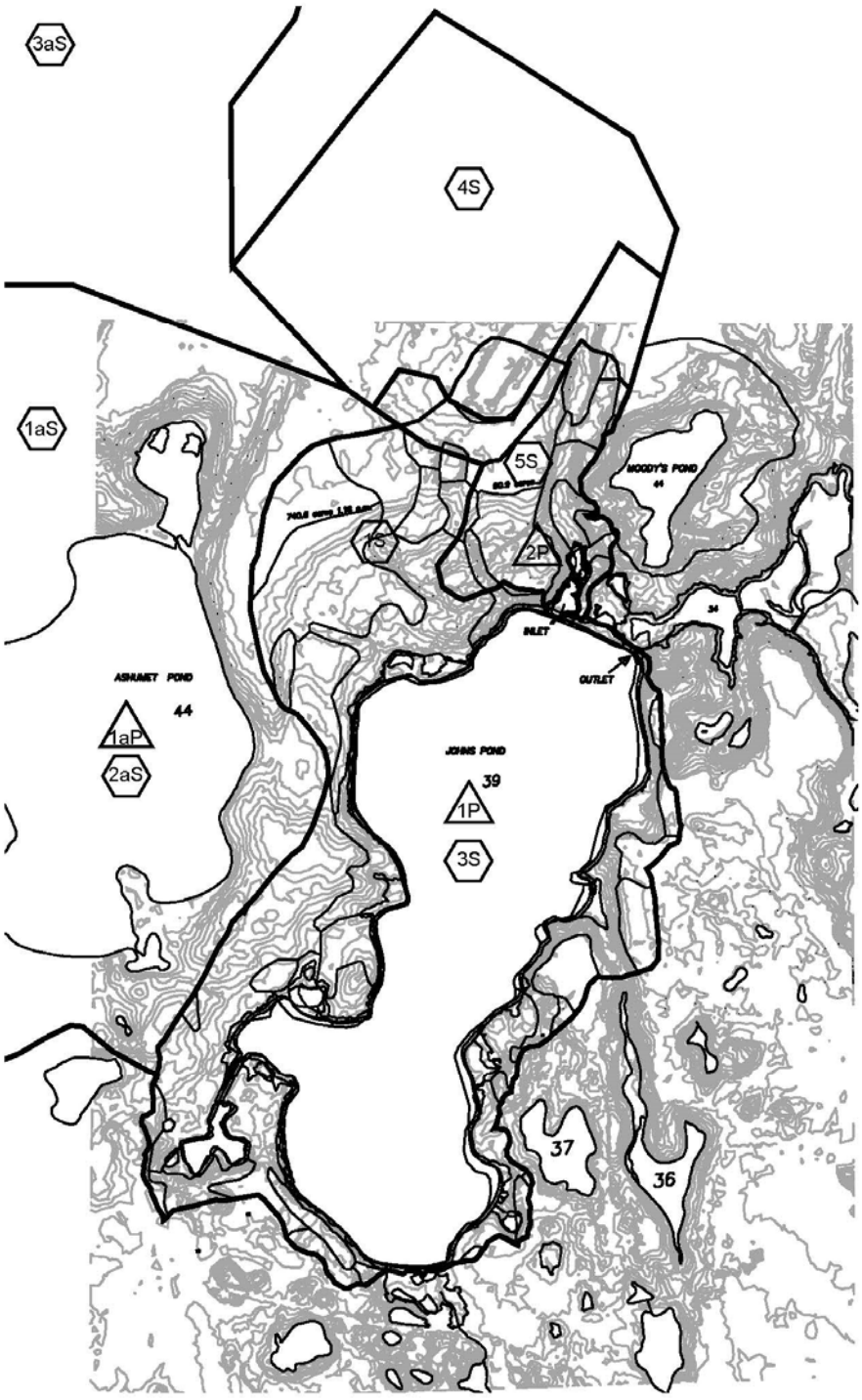


Image of Watershed map in Appendix B

- The Dam has two sharp crested weir outlets, one of which serves as a fish ladder (left in image below) for herring.

Photograph of outlet weirs (looking down stream)

- Is classified via current Dam Safety regulations, 302CMR10.00 as a large size, low hazard structure hence, the spillway design flood (SDF) for this structure is the 100-year design storm.

SECTION 2.0

DRAINAGE SUMMARY

2.01 CURRENT AND FUTURE DEVELOPMENT CONDITIONS

General

Based on the April 6, 2009 Phase I Inspection and Evaluation report completed by Churchill Engineering, Inc, Johns Pond Dam:

- Is a groundwater intercepting kettle hole water body with an outlet at the north end known as Quashnet River.
- Has a surface area of 317 to 340 acres. (verified by BSC at 336 acres by Lidar mapping.)
- Has a reported watershed of 210 square miles. (This is in error and has been confirmed by BSC to include only of surface watershed of only 1,085 acres (1.7 square miles) a subsurface watershed of 4,000 acres 6.25 square miles (See Watershed Map in Appendix C).

The watershed flowing to Johns Pond consists of 1,084± acres consisting of:

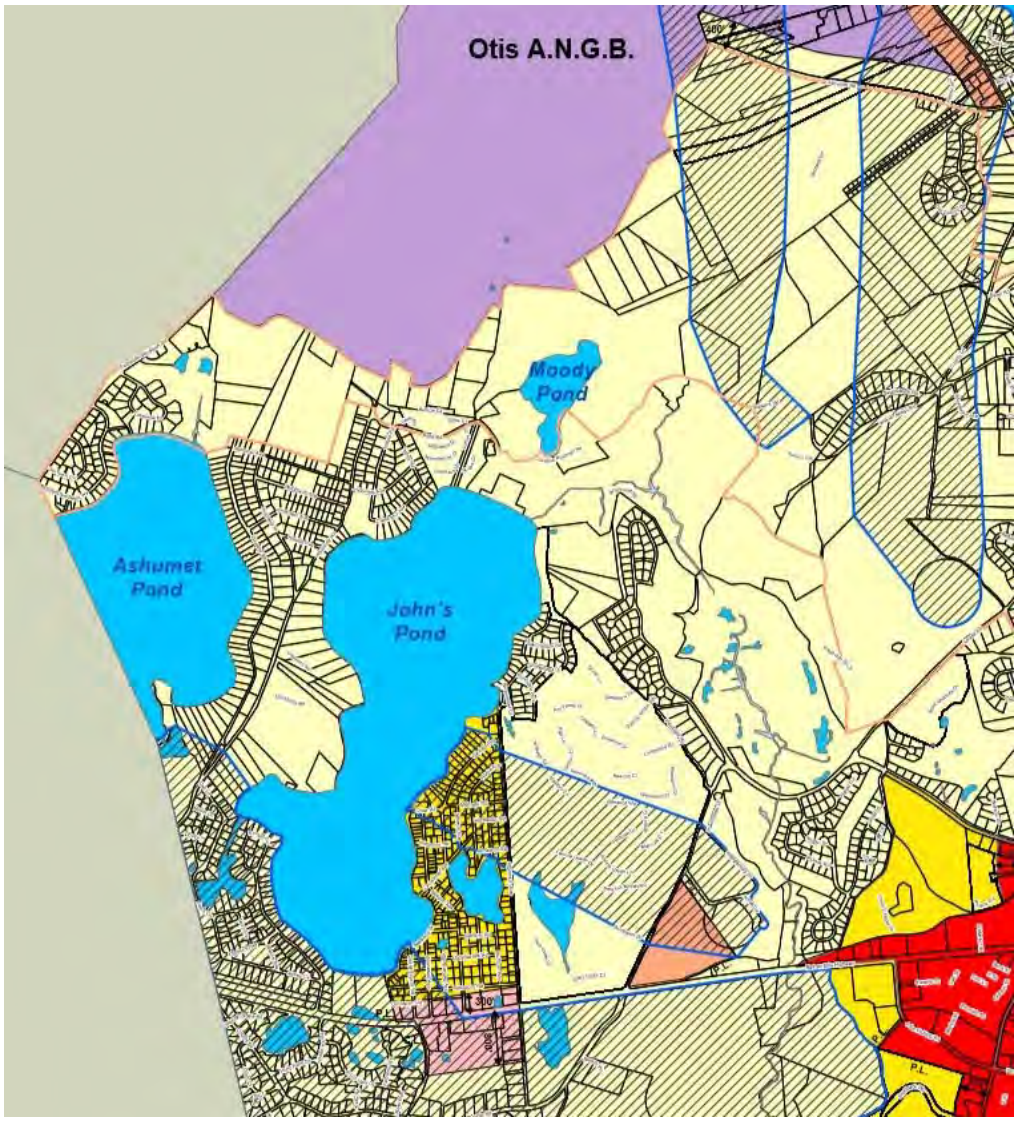
- 336 acres of water body (surface water) (31%)
- 748 acres of water shed that flows to the Pond including
- 308 acres of wooded areas with single family dwellings (29%) that is not within the heavily regulated 100-foot buffer of the pond
- 60 acres of this is within the heavily regulated 100-foot buffer to the pond bank (which is unlikely to see any significant future development) (5%)
- 110 acres of municipal land held for the purpose of open space (10%)
- 270 acres (25%) of Otis Air Base that is considered fully built.

Adjacent to, but separate from Johns Pond, is Ashumet Pond which has USGS gauge # MI-JOHPD-0005 with water levels as recorded in a USGS monitoring well MA-FSW 239-0121 located only 50 feet from the shore line (thus a good reflection of the water level in the pond). Whereas this pond has no outlet or inlet, this information can be used to estimate groundwater inflow and outflow from the pond and calibrate BSC's model. It is clear from this gauge/well that the water levels of the pond have approximately a one-month lag time from major precipitation events. Further this pond, with no outlet stream other than groundwater leakage, has a maximum ranger of about 3 feet.

As part of this assessment, back to back storms were evaluated to further estimate the flood levels of the pond. These two storms consisted of 5 inches of rain separated by 24 hours. Based on using the same watershed characteristic used previously, flood levels calculated at elevation 40.0. Although this has a reduced freeboard it does not result in overtopping of the dam.

It is noted that the hydrologic models do not rely on the removal of any stop logs during the storm. As demonstrated herein, the removal of stop logs prior to or during the storm as the ability to drop the water level of the pond significantly. Hence the results are considered conservative when the lake is managed according to common practice.

The watershed is primarily zoned Residential. See Zoning Map below:



Zoning Map- Light Yellow is R-3 and Dark Yellow is R-5

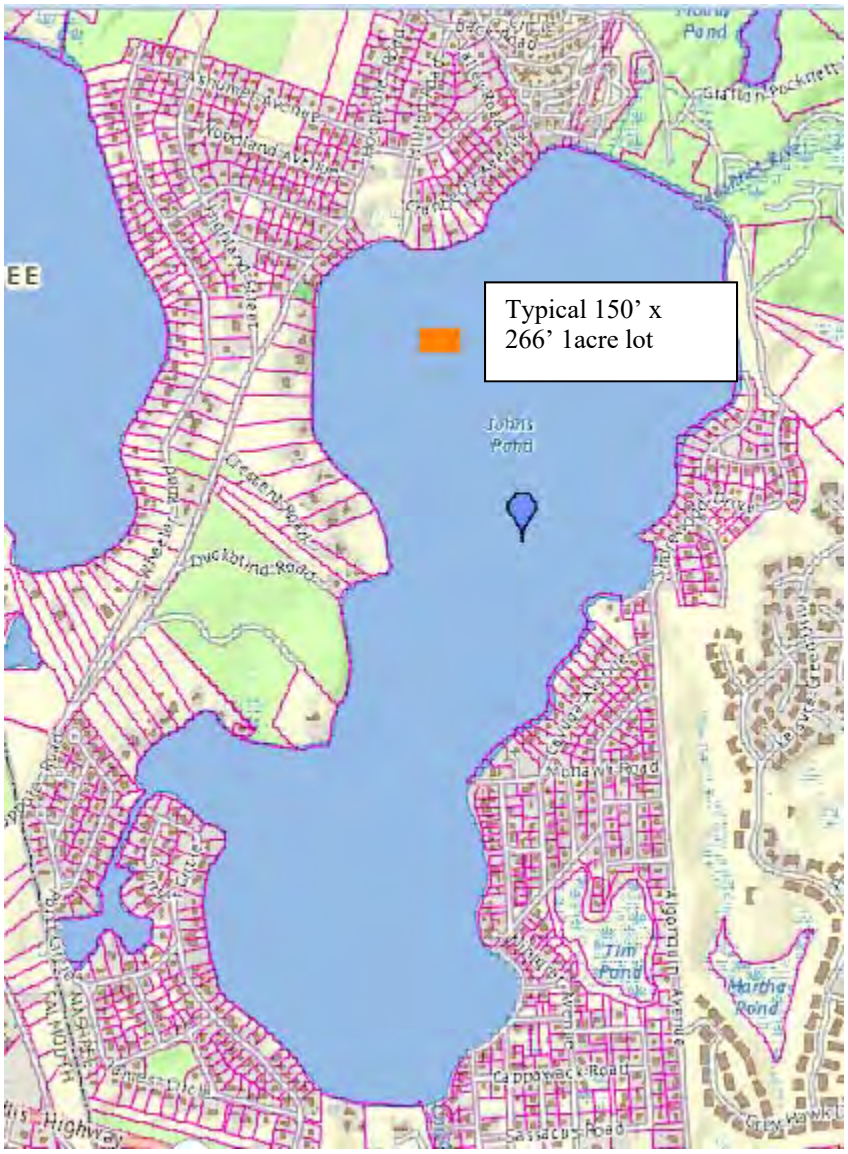
From the above map one can see the area is primarily Zone R-3 which from the table below is 1=acre residential Zone.

Town of Mashpee - Land Space Requirements Table [9,10]

			Minimum Building Setback to Lot Lines [22]			Maximum Building Height[4,17,18,21]		
Zoning District	**Minimum Lot Size[12] (square feet)**	**Minimum Lot Frontage[1,2,13] (feet)**	**Front[3,5,6,19, 20,] (feet)**	**Rear[3,5, 19,23] (feet)**	**Side[3,5,19, 23] (feet)**	**(Stories)**	**(feet)**	**Maximum of Lot Coverage[16] (percent)**
Residence Districts								
R-3	40,000	150	40	15	15	2 1/2	35	20[5]
R-5	80,000	150	40	15	15	2 1/2	35	20[5]

MASHPEE ZONING BYLAW DIMENSIONAL TABLE

Of the area not restricted as town owned land, developed military base or heavily regulated, there are many houses around the pond. Based on the map below one can see a 1-acre lot shown in the pond (for size comparison). Simple review indicated most of the lots are non-conforming and there is little area where development can occur to result in increased runoff.



MA GISmaps showing house lots

Hence, for the purpose of this assessment, the area is considered essentially built out and the potential to increase runoff over the next 50 years is very low. For this reason, the hydrologic analysis remains the same for both current and foreseeable future conditions.

- **Current Operational Plan**

The Town Herring Warden is responsible for operation of the stop logs at the site.

Water flows from the pond via two weirs, one being the fish ladder and one being the wider spillway. Each outlet has wooden stop logs that can be raised and lowered by adding or removing boards that are set in the slots of the concrete structure.

Stop logs are 2'x6' planks (planed to 1.5 " x 5.5" (or 0.125' x 0.46')).

Peak Flow Discharge Rates

2'x6' Planks	Concrete invert fish ladder	Concrete Invert Outlet Weir	Fish Ladder Overflow Elevation	Target Pond Water Level (Plank + 5")	Overflow Weir Elevation	Depth Over Outlet Weir Feet	Typical for Season
No Planks	34.56	34.51	34.56	34.98	34.51	0.47	dry summer
One Plank	34.56	34.51	35.02	35.44	34.97	0.47	dry summer
Two Planks	34.56	34.51	35.48	35.89	35.43	0.47	summer
Three Planks	34.56	34.51	35.94	36.35	35.89	0.47	late spring -summer
Four Planks	34.56	34.51	36.39	36.81	36.34	0.47	spring
Five Planks	34.56	34.51	36.85	37.27	36.80	0.47	spring
Six Planks	34.56	34.51	37.31	37.73	37.26	0.47	fall/ winter **(presumed initial conditions for analysis)**
Seven Planks	34.56	34.51	37.77	38.19	37.72	0.47	fall/ winter
Eight Planks	34.56	34.51	38.23	38.64	38.18	0.47	fall/ winter
Nine Planks	34.56	34.51	38.69	39.10	38.64	0.47	not used
Ten Planks	34.56	34.51	39.14	39.56	39.09	0.47	not used
top of structure			40.00				

Early Spring

Stop logs on both outlets are typically adjusted in the early spring for the annual herring runs. In late March/early April, the boards on the fish ladder are adjusted to ensure a minimum of 5" of water going over the top board. As such, if the pond level is high, additional boards will be inserted to the slots to maintaining the depth of water going over the weir.

Scout herring (individual fish) are typically observed coming up the rivers in late February into March with the full run starting in mid to late April. Once the full run begins, flow going over the larger spillway is restricted more (forcing more flow though the fish ladder). This condition is maintained until mid-late June when the herring emigration into the pond is winding down.

Depending on precipitation amounts, adjustments to the boards are made to ensure proper flow (i.e. 5" of water over the weir boards) for herring ascension up the fish ladder until mid-late June.

Summer

The larger spillway is often closed off all summer off by placing stop logs above the pond water level. This condition is maintained until late fall (around late November). Keeping the main spillway closed during this time to prevent herring from going down into the spillway and getting trapped in the control structure.

Keeping the main spillway closed allows the pond levels to be maintained as high as possible over the summer and fall when evapotranspiration acts to lower the pond the most. The fish ladder is maintained with flow because the herring reproduce as soon as they arrive, juvenile herring and fry begin to exit the pond, along with the adults, throughout the summer and fall via the fish ladder.

From July to October, when the fish are no longer migrating, the flow over the weir to the fish ladder is reduced to a minimum of 3 inches. This helps to "bank" pond water for recreational usage on the pond during the dry summer season.

Should the pond water level fall below the concrete invert level of the control structure (elevation 34.5) no flow leaves the pond.

Fall and Winter

In the winter months from November to February, the boards are adjusted as necessary to maintain an adequate water level and to address concerns of flooding in the event of excessive rain/snow, etc.

There is a staff gauge that was recently installed on the upstream channel of the fish ladder; however, we have no benchmark for a manageable water level at this time. This will need to be established.

2.02 DESCRIPTION OF METHODOLOGY

The following section describes the hydrologic methodology used in this assessment and the information it is based on.

Given the relatively small watershed and based on the above information, in order to calculate the 100-year hydrograph and route it the flow through the pond, BSC:

1) Used the TR-55 version of the HydroCAD program determine maximum pond levels using SCS soil hydrologic groups for surface runoff,

2) Included a sub-catchment with modified curve numbers to estimate recharge (not runoff) in order to estimate groundwater inflow and outflow as calibrated by the Ashsumet Pond data noted above,

3) Used the sharp crested weir calculations to calculate outflow from the two weirs and 100-year flood level of the pond.

The outlets from Johns Pond include three outlets:

1) An 18-inch Corrugated metal pipe that is controlled by a valve and is only opened to allow flow to the cranberry bog. For the purpose of this study, this outlet will be ignored.

2) The fish ladder. This is a 24-inch wide weir control by removable batter boards. At pond full conditions the ladder rises 5 feet from the stream to the pond surface.

3) The outlet weir. This is a 3'-4" inch wide weir control by removable batter boards (stop logs)

2.03 Assessment if the NRCS Technical Note 301: Runoff-Frequency: Peaks, Volumes, Timing for Low-Relief, Sandy "Cranberry Bog"

Technical Note 301 Runoff Frequency: Peak Volumes, Timing For Low Relief, Sandy Cranberry Bog Drainage Areas Of Southeastern Massachusetts And Rhode Island is based on an area of southeastern Massachusetts for the purpose of estimating stormwater runoff. It is based on seven projects ranging in area from 9.59 mi.^{2} to 84 mi.^{2} and all involve river flow.

The project at hand is limited to 1.7 square miles and has no river flow, thus does not seem of the relevant drainage area size to fit this methodology.

The limitations section of the method report that the method is used only for watershed from 9 to 84 square miles and the it was not intended for use in Barnstable County (the location of the site). It further qualifies that the 50 to 100- year storms were least represented in the method.

As a comparison, using the 1,085 acres (1.7 square mile) watershed calculated using the surficial topography as generated from Lidar data, figure 17 of NRCS TN 301 would report, the peak flow at 36 cfs/sm x 1.7 sm = 61 cfs per inch of runoff. Thus, the peak 100-year flow is predicted at 61 x 5.26 (from figure 3 for 100-year storm) = 320 cfs inflow using figure 17 of the NRCS TN 301.

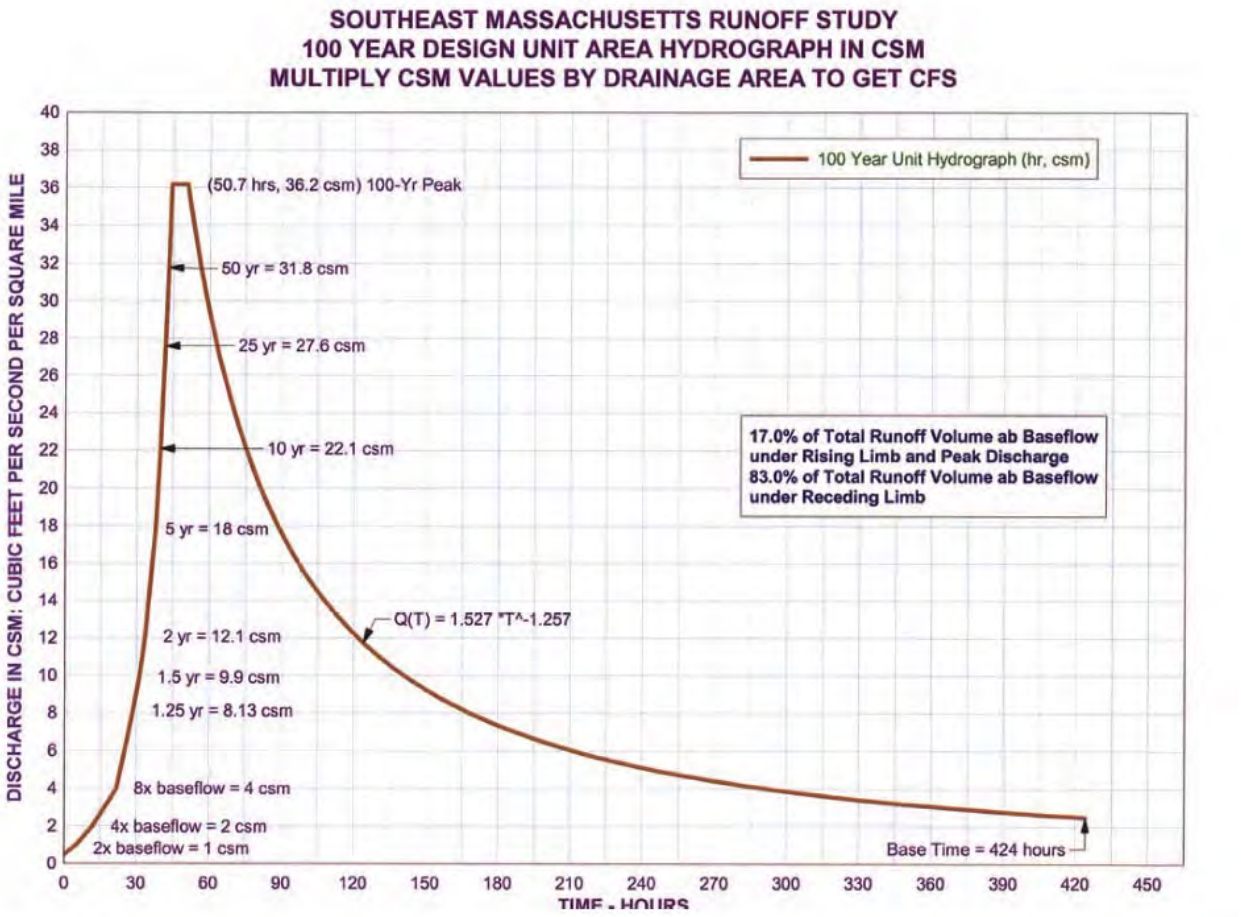


Figure 17 from Technical Note 301 Runoff Frequency: Peak Volumes, Timing for Low Relief, Sandy Cranberry Bog Drainage Areas Of Southeastern Massachusetts And Rhode Island

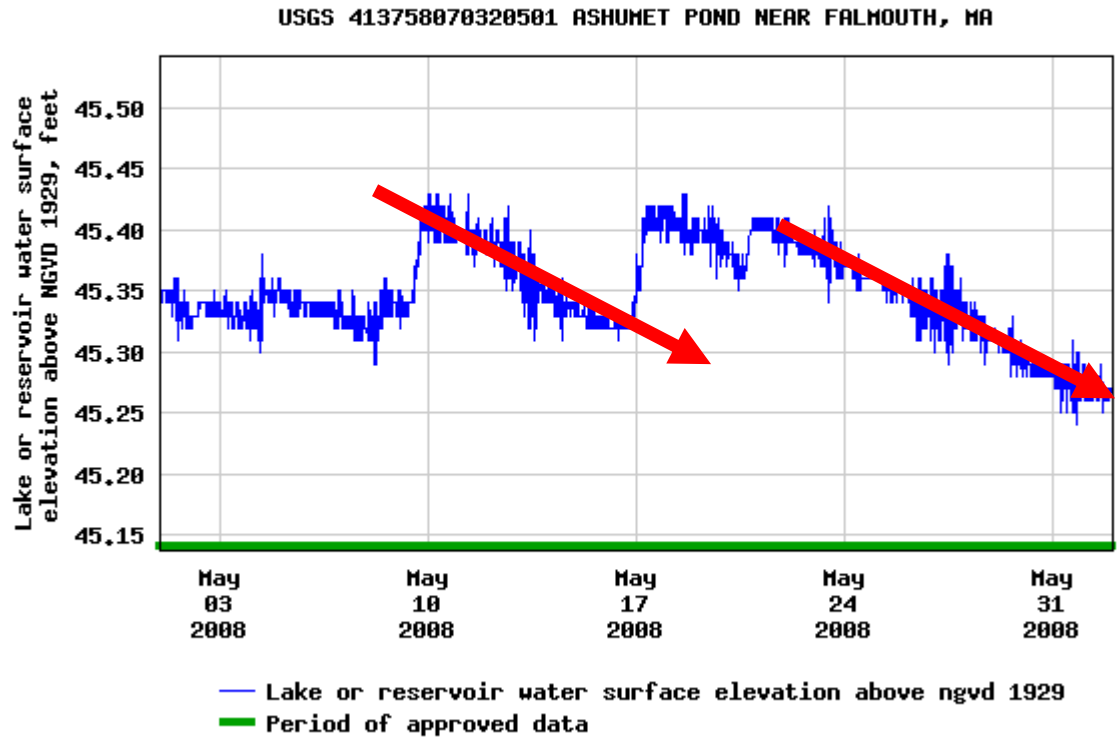
Based on the above unit hydrograph and the area under the curve and drainage area, this method predicts a runoff volume of 1,087 acre-feet. This is a depth of 1.46 feet of runoff – more than double the rain fall confirming the inaccuracy of this method. For this reason, the method has not been unitized.

2.04 Hydrologic Calculations

Pond Floor Leakage (groundwater outflow)Estimate:

Based on well levels at the adjacent Ashumet Pond and presuming a linear relationship to leakage per square foot of pond area:

Lake or reservoir water surface elevation above NGVD 1929, feet
Most recent instantaneous value: 46.45 03-11-2019 16:15 EDT



Create presentation-quality / stand-alone graph. Subscribe to WaterAlert

USGS water level graph showing drop in pond at 3/16 " / day

As an estimate of the leakage from Ashumet Pond, the water level in Ashumet Pond from May 24-May 31 2008 (after the very wet prior season, dropped 0.1 ft (from 45.38 to 45.28) in seven days. Or about 3/16 inch per day. (This slope is observed several times regularly in the pond.) Over the 210-acre surface area of the pond this represents: 0.01 inch/hour and is used in the Hydrocad model to predict leakage from Johns Pond.

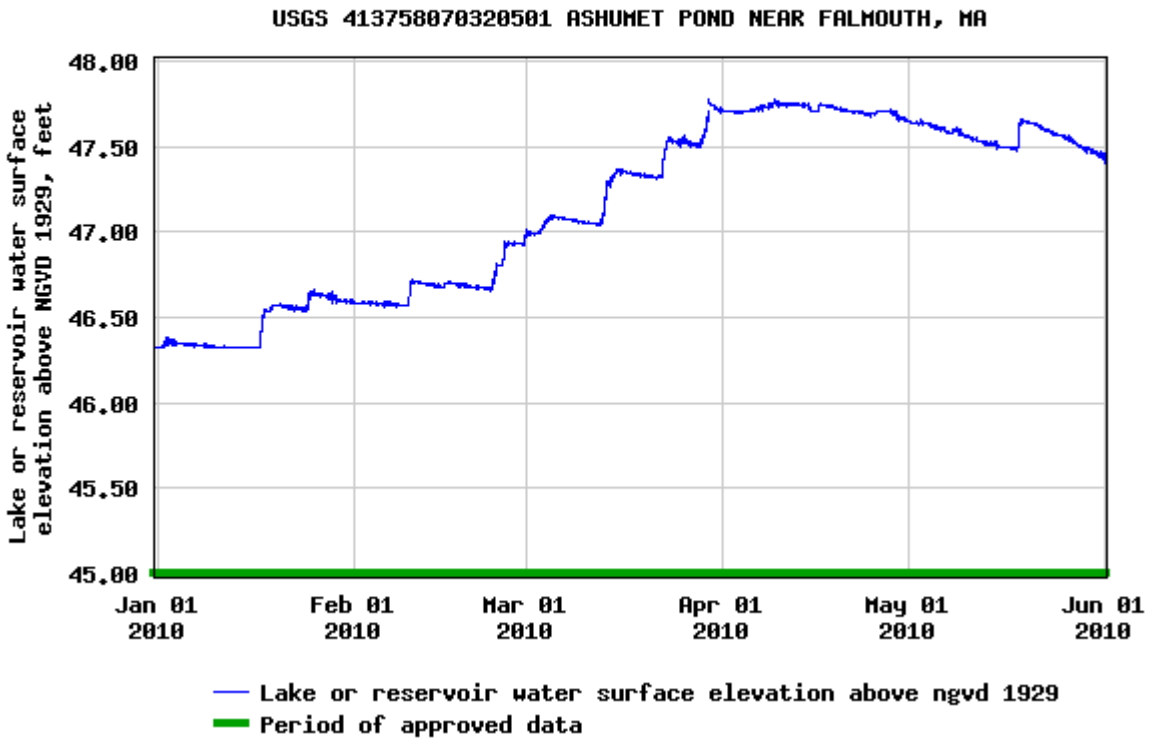
As an estimate of subsurface flow to Johns Ponds the storms of March 2010 were used to estimate the impact of runoff and subsurface flow to the Pond. See USGS 413758070320501 ASHUMET POND

NEAR FALMOUTH, MA
https://waterdata.usgs.gov/ma/nwis/uv?site_no=413758070320501

	2010	2010	2010
	February	March	April
Pond Water level	46.8	47.8	48.4
Rise from Prior month	0.05	1	0.6
Precipitation (inches)	4.29	7.78	1.55

The chart below graphs the water level of Ashumet Pond during the period of very heavy precipitation in 2010. During the March -April time frame it shows a 1 ½ foot water level rise.

Lake or reservoir water surface elevation above NGVD 1929, feet
Most recent instantaneous value: 46.45 03-21-2019 13:15 EDT



In an effort to characterize the subsurface flow a subsurface Curve number resulted in a 1.5-foot rise in the pond and for the purpose of this study the subsurface curve number of 30 is used for Johns Pond.

Outlet Flow From Johns Pond Weirs:

The Table below summarizes flows from the two sharp crested weirs up to elevation 40. At elevation 39 the flow out the two weirs is about 15 cfs. Based on reported levels in the adjacent Ashumet Pond the leakage from the pond is also tabulated below.

Elevation (feet)	Discharge (cfs)	Discarded (cfs)	Primary (cfs)
37.56	0.00	0.00	0.00
37.76	0.00	0.00	0.00
37.96	0.00	0.00	0.00
38.16	3.36	3.36	0.00
38.36	4.54	3.42	1.12
38.56	7.17	3.47	3.70
38.76	10.60	3.52	7.08
38.96	14.62	3.57	11.05
39.16	19.12	3.63	15.49
39.36	24.01	3.68	20.33
39.56	29.22	3.73	25.48
39.76	34.69	3.79	30.91
39.96	40.40	3.84	36.56

15 cfs at 100-year elevation

During the 100-year storm with the stop logs at the high level (elevation 38.16) Q_{out} = 15 cfs (including leakage thought the pond bottom).

This means the water level drop per day = 15*3,600*24= 1,296,000 c.f / 15,246,000 =0.085 ft/day (one inch per day).

Maximum Draw Down

If the stop logs were all to be removed, I.E. opened down to elevation 34.5 (top of concrete) and the pond was at or near elevation 39, (ie a head of 4.5 feet) the flow out of the pond through the weirs and pond floor leakage would be approximately 125 c.f.s. By the same calculation the water level drop per day = 125 *3,600*24= 10,800,000 c.f ./ 15,246,000 =0.7 ft/day (8.5 inches per day) . Based on this limited analysis, it can be seen that the dam could be operated to readily lower the pond levels with only a few days' notice.

Subsurface Flow

The subsurface flow calculations were completed in two alternatives

First is considered a conservative estimate of subsurface flow to the pond.

Knowing the data from Ashumet Pond indicates that it takes about 1 month to peak after significant rainfall and due to limitations in the HydroCAD model the time of concentration is limited to 7 days and thus results in a higher peak subsurface flow than would be expected if a longer Tc could be used. Thus, the addition is conservative in predicating peak inflow. Further the subsurface curve number is derived below.

Based on:

1) The area of surface runoff has a curve number 52-58 with 2+/- inches of runoff, and,
2) The annual recharge 40% annual recharge at 3 inches

3) Leaving evapotranspiration at 3 inches

The curve number for the subsurface flow is targeted at 1.5 inches of runoff. This is based on the given that the known time frame for peak runoff to occur at the pond from subsurface flow is measured in multiple weeks (and not one week as limited by HydroCAD). As such, most of flow in the hydrograph has not passed by the time the surface peak flows are long past and this target is considered appropriate. Thus, BSC has used a CN for subsurface that shows 50% of the above runoff depth as subsurface flow. This occurs at CN =48.

Second, less conservative using the Subsurface Curve Number of 30 noted above from Ashumet Pond, the Model was run and revealed a 100-year flood elevation of Johns Pond to be the same as when the subsurface curve number of 48 was used, As such, it is clear that the subsurface flow has little impact to the flood levels of the pond.

Stormwater Runoff

Watershed modeling was performed using HydroCAD Stormwater Modeling Software version 10.0, a computer aided design program that combines SCS runoff methodology with standard hydraulic calculations. One model of the site's hydrology was developed to represent both existing and future development conditions.(see discussion above).

The Watershed Map in Appendix C shows the limits of the watersheds and the location of the points of analysis summarized on the tables below.

2.05 Hydrologic Curve Numbers

Hydrologic curve numbers were calculated based on Soil class use and areas to allow a weighted curve number to be calculated. See Appendix C for SCS soil report used as the basis of the Hydrologic Soil Group. The spread sheet for this calculation summaries curve numbers from 52-58 and is as follows:

Subcatchment 5S

Number	HSG	Area (SF)	Description	Curve Number	CNxArea	Weighted CN
1	A	34653	Woods - Fair	36	1247508	
2	B	30598	Woods - Fair	60	1835880	
3	A	251209	Woods - Fair	36	9043524	
4	A	242220	Sand/Gravel Pits	81	19619820	
5	A	10581	Sand/Gravel Pits	81	857061	
6	B	491683	Woods - Fair	60	29500980	
7	A	401963	Woods - Fair	36	14470668	
8	A	52989	Trailer Parks - 1/8 acre lots	77	4080153	
9	A	720068	Trailer Parks - 1/8 acre lots	77	55445236	
10	A	201335	Woods - Fair	36	7248060	
11	A	84751	Woods - Fair	36	3051036	
12	B/D	193835	Abandoned Cranberry Bog	79	15312965	
13	A	90281	Woods - Fair	36	3250116	
14	A	99410	Houses - 1/2 acre lots	54	5368140	
15	A	185130	Houses - 1/2 acre lots	54	9997020	
TOTAL		3090706			180328167	58.34
		70.95285				

Johns Pond - 3S

Number	HSG	Area (SF)	Description	Curve Number	CNxArea	Weighted CN
		14355225	Water surface	98	1406812050	
Lake	-	298562	Water surface	98	29259076	
		11578	Water surface	98	1134644	
Total		14665365			1437205770	98
		336.6705				

Subcatchment 1S	HSG	Area (SF)	Description	Curve Number	CNxArea	Weighted CN
16	-	607335	Airport	88	53445480	
17	B	740373	Woods - Fair	60	44422380	
18	B	105103	Sand/Gravel Pits	88	9249064	
19	A	621099	Woods - Fair	36	22359564	
20	A	250420	Houses - 1/2 acre lots	54	13522680	
21	A	138658	Woods - Fair	36	4991688	
22	B	781250	Woods - Fair	60	46875000	
23	B	1612694	Woods - Fair and 1/2acre lots	65	104825110	
24	A	1469845	Houses - 1/2 acre lots	54	79371630	
25	A	151440	Houses - 1/2 acre lots	54	8177760	
26	A	3953020	Woods - Fair and 1/2acre lots	45	177885900	
27	A	204080	Beach and 1 acre lots	43	8775440	
28	A	23003	Trailer Parks - 1/8 acre lots	77	1771231	
29	A	190827	Houses - 1/2 acre lots	54	10304658	
30	B/D	12920	Beach	80	1033600	
31	A	80174	Beach	39	3126786	
32	A/D	13597	Beach	80	1087760	
33	A	1395919	Woods - Fair and 1/2 acre lots	45	62816355	
34	B	51514	Woods - Fair	60	3090840	
35	A	107449	Houses - 1/2 acre lots	54	5802246	
36	B	204101	Houses - 1/2 acre lots	70	14287070	
37	A	101621	Beach	39	3963219	
38	A	331773	Houses - 1/2 acre lots	54	17915742	
39	A	340025	Houses - 1/2 acre lots	54	18361350	
40	B	48061	Houses - 1/2 acre lots	70	3364270	
41	A	350328	Houses - 1/2 acre lots	54	18917712	
42	A	192031	Houses - 1/2 acre lots	54	10369674	
43	A	43078	Houses - 1/2 acre lots	54	2326212	
44	A	649746	Houses - 1/2 acre lots	54	35086284	

45	A	10213	Houses - 1/2 acre lots	54	551502	
46	A	93150	Houses - 1/2 acre lots	54	5030100	
47	A	20728	Houses - 1/2 acre lots	54	1119312	
48	A	884	Houses - 1/2 acre lots	54	47736	
49	A	40055	Houses - 1/2 acre lots	54	2162970	
50	A	163356	Houses - 1/2 acre lots	54	8821224	
51	A	186699	Houses - 1/4 acre lots	61	11388639	
52	A	301860	Houses - 1/2 acre lots	54	16300440	
53	B	88580	Woods - Fair	60	5314800	
54	A	43286	Houses - 1/2 acre lots	54	2337444	
55	A	208141	Woods - Fair	36	7493076	
56	A/D	91204	Woods - Fair	79	7205116	
57	B/D	67144	Woods - Fair	79	5304376	
58	A	264846	Woods - Fair	36	9534456	
59	A	371711	Woods - Fair	36	13381596	
60	A	567096	Houses - 2 acre lots	46	26086416	
61	A	1809	Woods - Fair	36	65124	
62	A	2372	Woods - Fair	36	85392	
63	A	350	Houses - 1/2 acre lots	54	18900	
64	B	61761	Woods/Grass	65	4014465	
TOTAL		17356729			913789789	52.6
		398.4557				

Peak In-Flow & Discharge Rates

Johns Pond Dam

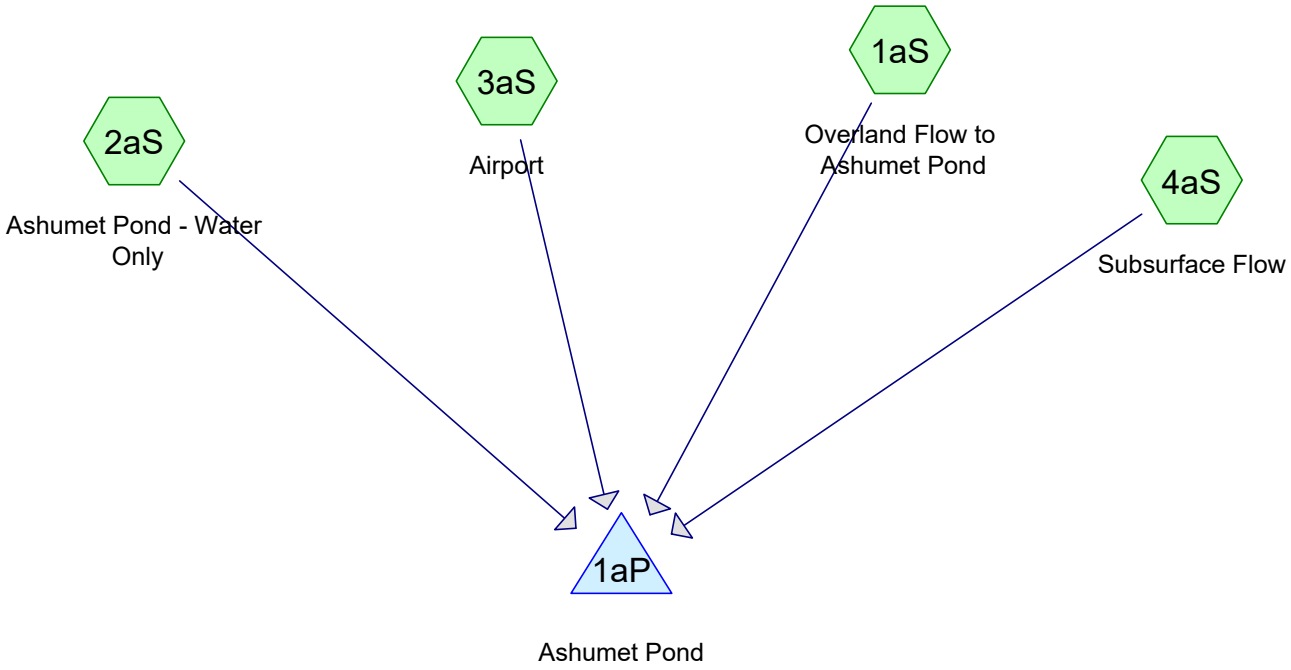
Storm Event	Peak Inflow Rate (cfs)	Peak Discharge Rate (cfs) through weirs and pond floor leakage	Starting Pond Water Level	Pond Water Level
10-year	753	27.8	37.7	38.7
50-year	980	35.1	37.7	39.0
100-year	1,110	39.8	37.7	39.1

2.06 Hydrologic Calculations (HydroCAD™ Printouts)

The following pages are the printouts of the various Hydrologic runs. Including:

- Ashumet Pond Assessment
- Johns Pond Assessment with CN subsurface = 30 (100-year flood elevation =39.1)
- Johns Pond Assessment with CN subsurface = 48 (100-year flood elevation =39.1)
- Johns Pond with Back to Back 5-inch Storms

Ashumet Pond Assessment



Subcat Reach Pond Link

Routing Diagram for hydrologoc analysis acuhsett pond
Prepared by {enter your company name here}, Printed 3/21/2019

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
1,900.000	30	(4aS)
488.240	39	>75% Grass cover, Good, HSG A (3aS)
86.160	98	Paved parking, HSG A (3aS)
526.600	53	See Spreadsheet (1aS)
210.000	98	Water Surface, 0% imp, HSG A (2aS)
3,211.000	**41**	**TOTAL AREA**

Soil Listing (all nodes)

Area (acres)	Soil Group	Subcatchment Numbers
784.400	HSG A	2aS, 3aS
0.000	HSG B	
0.000	HSG C	
0.000	HSG D	
2,426.600	Other	1aS, 4aS
3,211.000		**TOTAL AREA**

Ground Covers (all nodes)

HSG-A (acres)	HSG-B (acres)	HSG-C (acres)	HSG-D (acres)	Other (acres)	Total (acres)	Ground Cover	Subcatchment Numbers
0.000	0.000	0.000	0.000	1,900.000	1,900.000		4aS
488.240	0.000	0.000	0.000	0.000	488.240	>75% Grass cover, Good	3aS
86.160	0.000	0.000	0.000	0.000	86.160	Paved parking	3aS
0.000	0.000	0.000	0.000	526.600	526.600	See Spreadsheet	1aS
210.000	0.000	0.000	0.000	0.000	210.000	Water Surface, 0% imp	2aS
784.400	**0.000**	**0.000**	**0.000**	**2,426.600**	**3,211.000**	**TOTAL AREA**	

Time span=1.00-999.00 hrs, dt=0.05 hrs, 19961 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1aS: Overland Flow to Runoff Area=526.600 ac 0.00% Impervious Runoff Depth=2.57"
Flow Length=4,678' Tc=488.1 min CN=53 Runoff=131.48 cfs 112.710 af

Subcatchment 2aS: Ashumet Pond - Runoff Area=210.000 ac 0.00% Impervious Runoff Depth>7.75"
Tc=0.0 min CN=98 Runoff=2,695.03 cfs 135.684 af

Subcatchment 3aS: Airport Runoff Area=574.400 ac 15.00% Impervious Runoff Depth=2.04"
Flow Length=10,401' Tc=1,419.8 min CN=48 Runoff=50.10 cfs 97.728 af

Subcatchment 4aS: Subsurface Flow Runoff Area=1,900.000 ac 0.00% Impervious Runoff Depth=0.42"
Tc=9,999.0 min CN=30 Runoff=5.35 cfs 65.972 af

Pond 1aP: Ashumet Pond Peak Elev=45.50' Storage=356.583 af Inflow=2,695.02 cfs 412.093 af
Outflow=2.43 cfs 198.404 af

Total Runoff Area = 3,211.000 ac Runoff Volume = 412.093 af Average Runoff Depth = 1.54"
97.32% Pervious = 3,124.840 ac 2.68% Impervious = 86.160 ac

Summary for Subcatchment 1aS: Overland Flow to Ashumet Pond

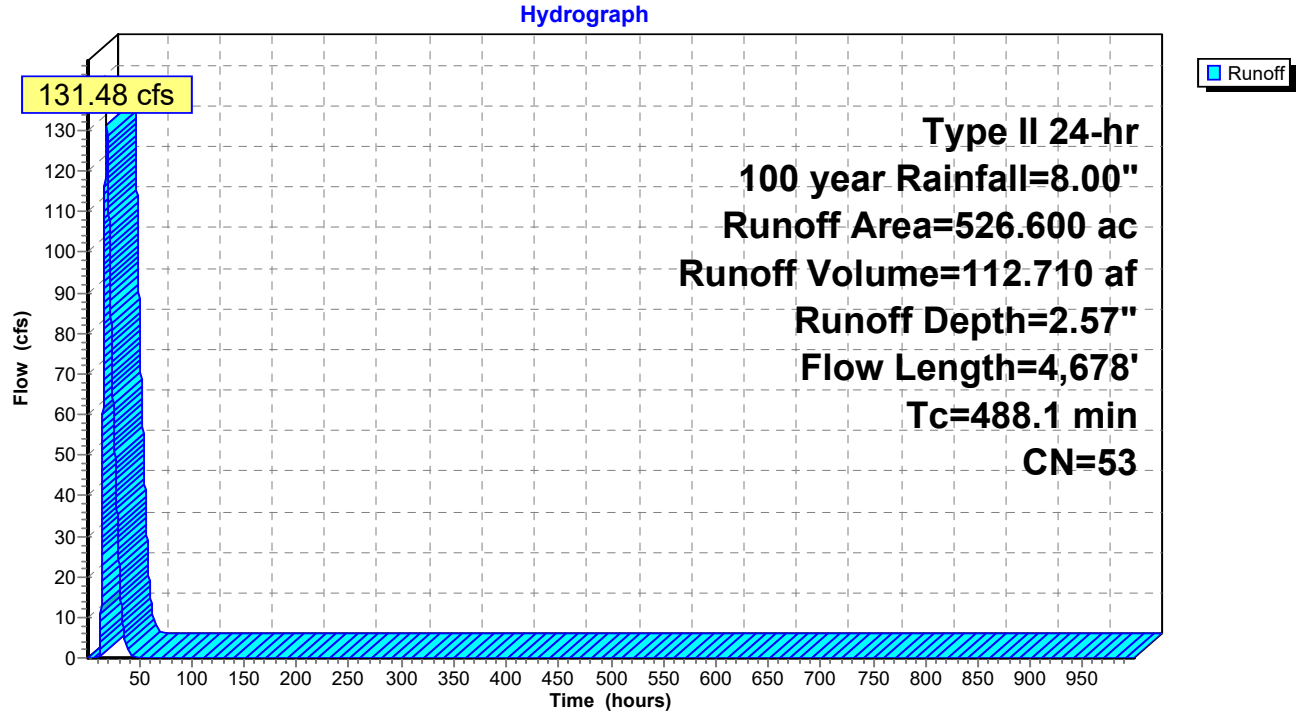
Runoff = 131.48 cfs @ 18.95 hrs, Volume= 112.710 af, Depth= 2.57"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-999.00 hrs, dt= 0.05 hrs
Type II 24-hr 100 year Rainfall=8.00"

	Area (ac)	CN	Description
*	526.600	53	See Spreadsheet
	526.600		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
36.0	50	0.0075	0.02		**Sheet Flow,** Woods: Dense underbrush n= 0.800 P2= 2.50"
3.8	100	0.0075	0.43		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
448.3	4,528	0.0141	0.17	3.37	**Channel Flow,** Area= 20.0 sf Perim= 30.0' r= 0.67' n= 0.800 Sheet flow: Woods+dense brush
488.1	4,678	Total			

Subcatchment 1aS: Overland Flow to Ashumet Pond



Summary for Subcatchment 2aS: Ashumet Pond - Water Only

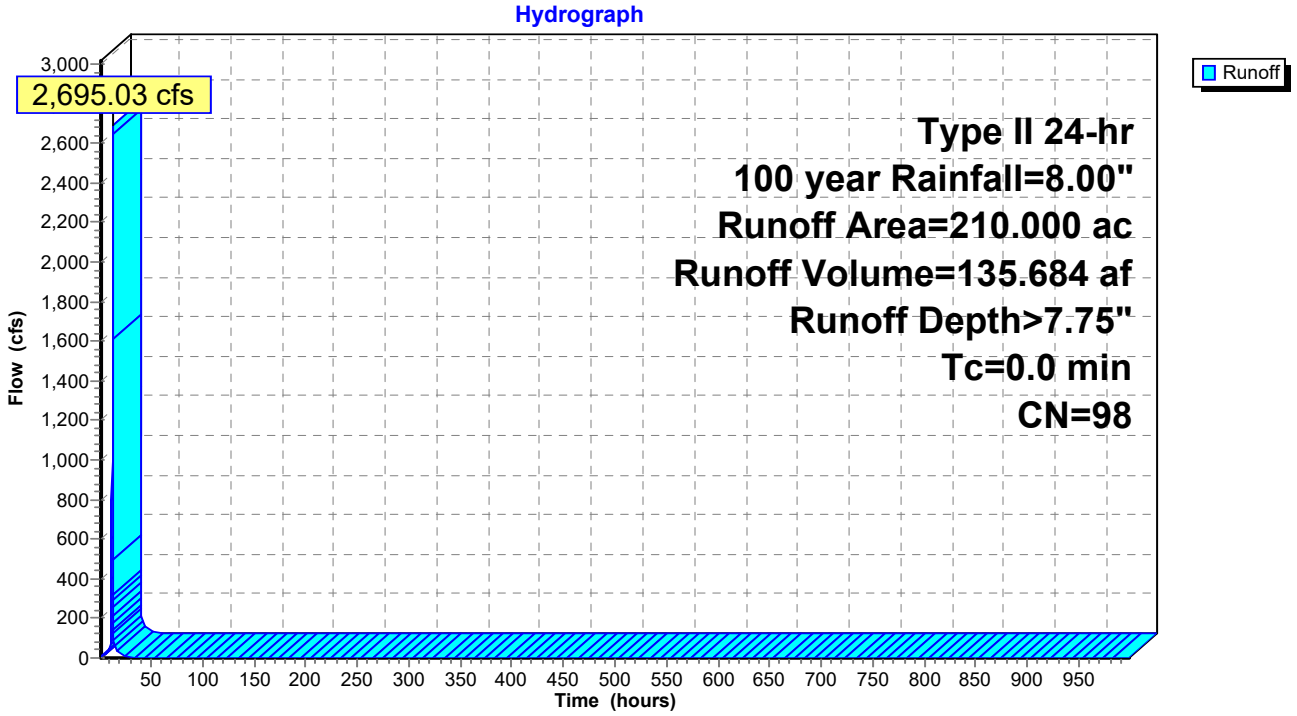
Runoff = 2,695.03 cfs @ 11.89 hrs, Volume= 135.684 af, Depth> 7.75"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-999.00 hrs, dt= 0.05 hrs
Type II 24-hr 100 year Rainfall=8.00"

Area (ac)	CN	Description
210.000	98	Water Surface, 0% imp, HSG A
210.000		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.0					**Direct Entry, 260**

Subcatchment 2aS: Ashumet Pond - Water Only



Summary for Subcatchment 3aS: Airport

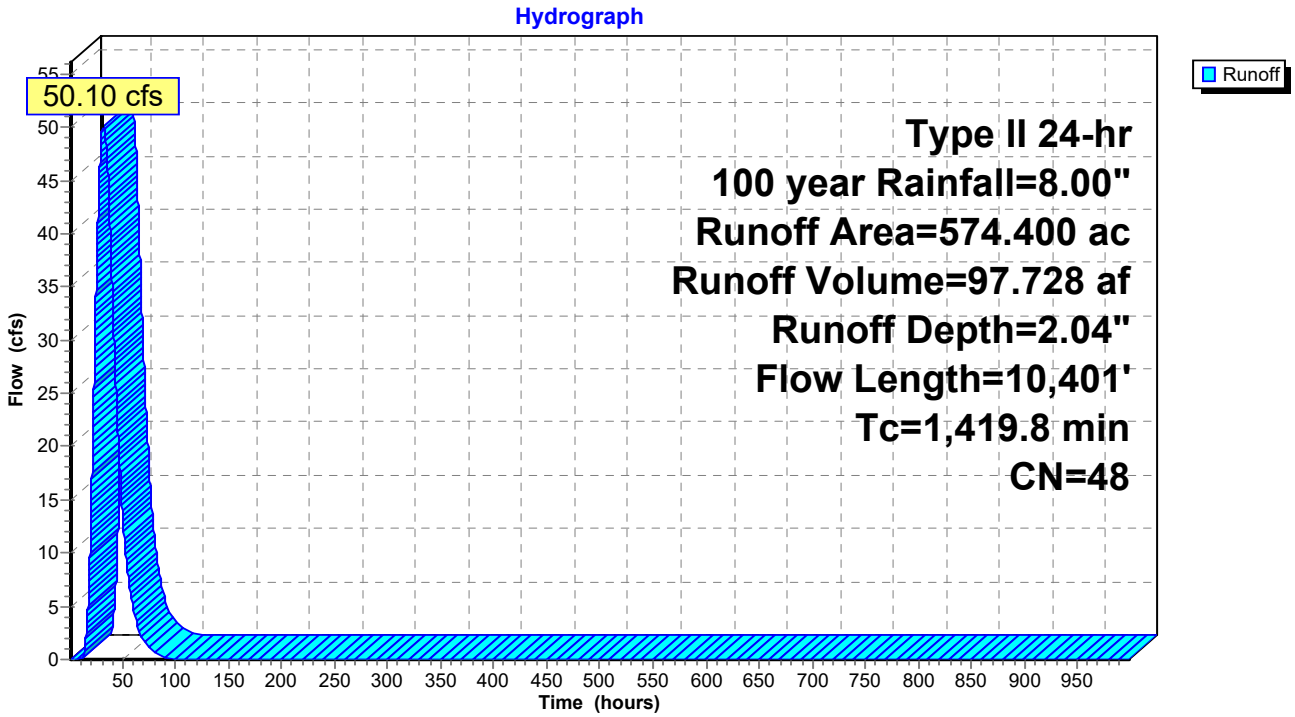
Runoff = 50.10 cfs @ 31.56 hrs, Volume= 97.728 af, Depth= 2.04"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-999.00 hrs, dt= 0.05 hrs
Type II 24-hr 100 year Rainfall=8.00"

Area (ac)	CN	Description
86.160	98	Paved parking, HSG A
488.240	39	>75% Grass cover, Good, HSG A
574.400	48	Weighted Average
488.240		85.00% Pervious Area
86.160		15.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
49.4	50	0.0034	0.02		**Sheet Flow,** Woods: Dense underbrush n= 0.800 P2= 2.50"
5.7	100	0.0034	0.29		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
1,364.7	10,251	0.0078	0.13	2.50	**Channel Flow,** Area= 20.0 sf Perim= 30.0' r= 0.67' n= 0.800 Sheet flow: Woods+dense brush
1,419.8	10,401	Total			

Subcatchment 3aS: Airport



Summary for Subcatchment 4aS: Subsurface Flow

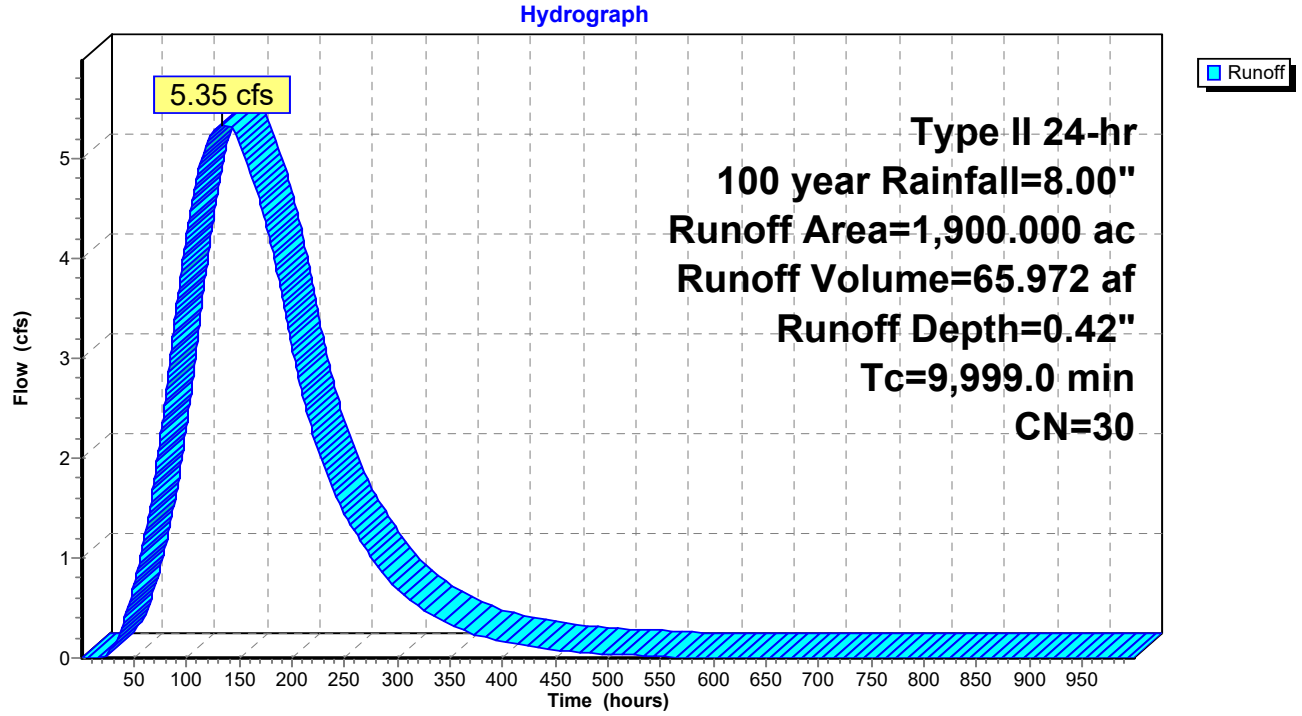
Runoff = 5.35 cfs @ 133.35 hrs, Volume= 65.972 af, Depth= 0.42"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-999.00 hrs, dt= 0.05 hrs
Type II 24-hr 100 year Rainfall=8.00"

	Area (ac)	CN	Description
*	1,900.000	30	
	1,900.000		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9,999.0					**Direct Entry,**

Subcatchment 4aS: Subsurface Flow



Summary for Pond 1aP: Ashumet Pond

Inflow Area = 3,211.000 ac, 2.68% Impervious, Inflow Depth > 1.54" for 100 year event
Inflow = 2,695.02 cfs @ 11.89 hrs, Volume= 412.093 af
Outflow = 2.43 cfs @ 215.42 hrs, Volume= 198.404 af, Atten= 100%, Lag= 12,212.3 min
Discarded = 2.43 cfs @ 215.42 hrs, Volume= 198.404 af

Routing by Stor-Ind method, Time Span= 1.00-999.00 hrs, dt= 0.05 hrs
Peak Elev= 45.50' @ 215.42 hrs Surf.Area= 240.569 ac Storage= 356.583 af

Plug-Flow detention time= 29,259.8 min calculated for 198.382 af (48% of inflow)
Center-of-Mass det. time= 27,379.2 min (30,099.9 - 2,720.7)

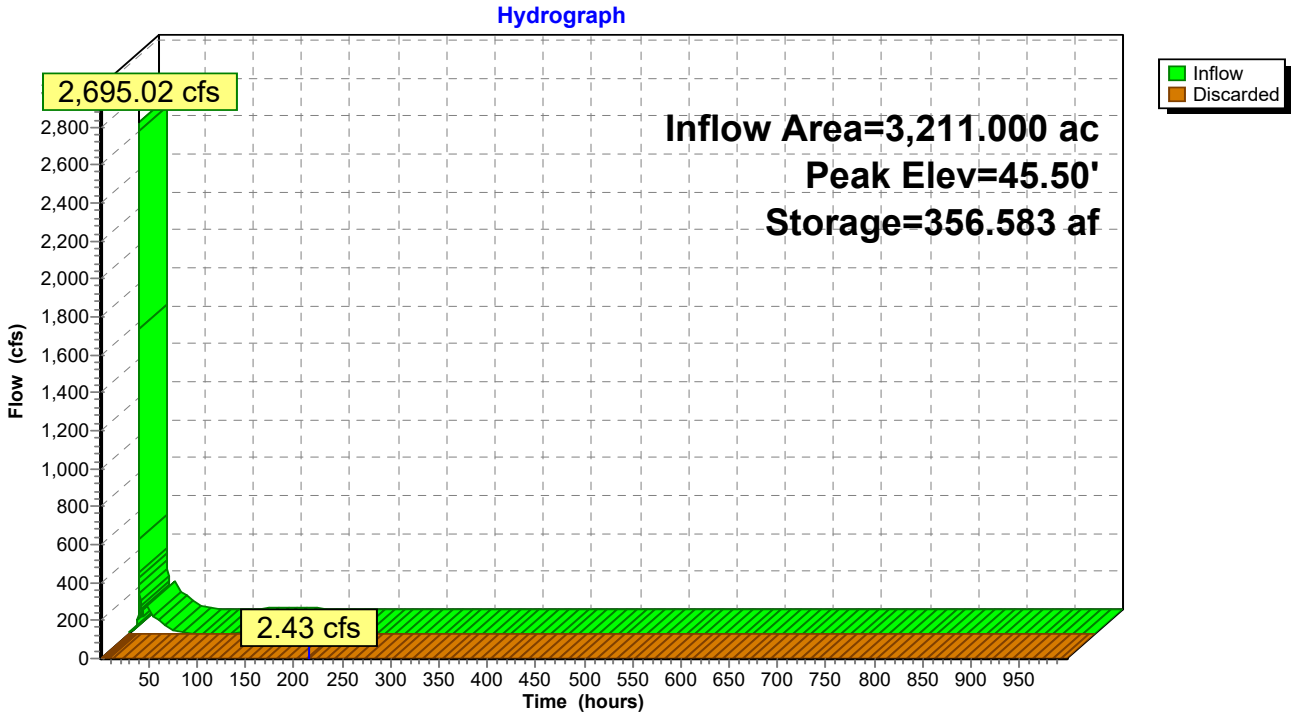
Volume	Invert	Avail.Storage	Storage Description
#1	44.00'	1,474.837 af	**Custom Stage Data (Conic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)	Wet.Area (acres)
44.00	235.000	0.000	0.000	235.000
48.00	250.000	969.845	969.845	250.037
50.00	255.000	504.992	1,474.837	255.066

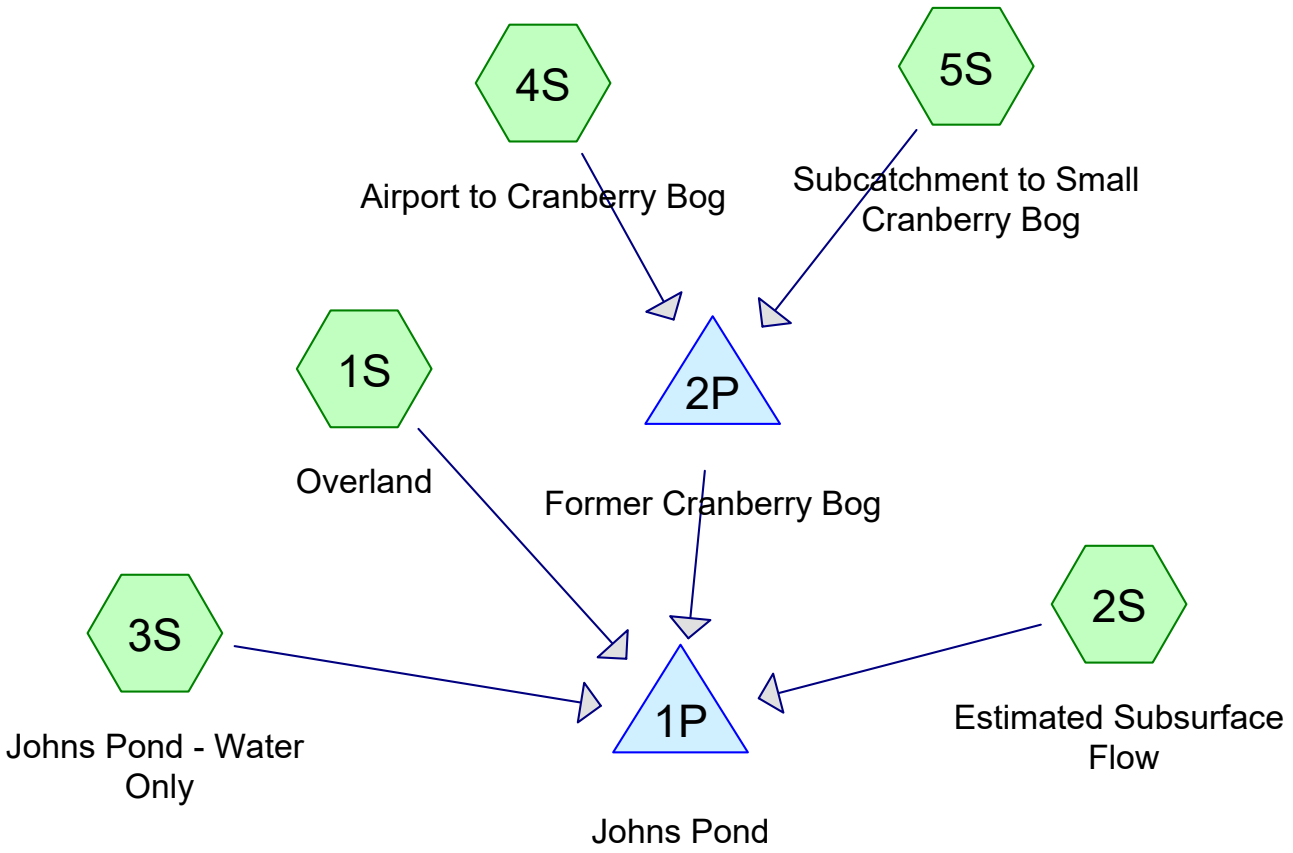
Device	Routing	Invert	Outlet Devices
#1	Discarded	44.00'	**0.010 in/hr Exfiltration 1/4/day 210 acres=104fs over Wetted area**

Discarded OutFlow Max=2.43 cfs @ 215.42 hrs HW=45.50' (Free Discharge)
↑—**1=Exfiltration 1/4/day 210 acres=104fs** (Exfiltration Controls 2.43 cfs)

Pond 1aP: Ashumet Pond



Johns Pond Assessment with CN subsurface = 30 (100-year flood elevation =39.1)



Subcat Reach Pond Link

Routing Diagram for johns pond 1-22-19
Prepared by {enter your company name here}, Printed 3/21/2019

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
4,000.000	30	(2S)
228.600	39	>75% Grass cover, Good, HSG A (4S)
40.300	98	Paved parking, HSG A (4S)
368.300	53	See Spreadsheet (1S)
109.800	58	See Spreadsheet (5S)
336.670	98	Water Surface, 0% imp, HSG A (3S)
5,083.670	**38**	**TOTAL AREA**

Soil Listing (all nodes)

Area (acres)	Soil Group	Subcatchment Numbers
605.570	HSG A	3S, 4S
0.000	HSG B	
0.000	HSG C	
0.000	HSG D	
4,478.100	Other	1S, 2S, 5S
5,083.670		**TOTAL AREA**

Ground Covers (all nodes)

HSG-A (acres)	HSG-B (acres)	HSG-C (acres)	HSG-D (acres)	Other (acres)	Total (acres)	Ground Cover	Subcatchment Numbers
0.000	0.000	0.000	0.000	4,000.000	4,000.000		2S
228.600	0.000	0.000	0.000	0.000	228.600	>75% Grass cover, Good	4S
40.300	0.000	0.000	0.000	0.000	40.300	Paved parking	4S
0.000	0.000	0.000	0.000	478.100	478.100	See Spreadsheet	1S, 5S
336.670	0.000	0.000	0.000	0.000	336.670	Water Surface, 0% imp	3S
605.570	**0.000**	**0.000**	**0.000**	**4,478.100**	**5,083.670**	**TOTAL AREA**	

Time span=5.00-400.00 hrs, dt=0.05 hrs, 7901 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: Overland Runoff Area=368.300 ac 0.00% Impervious Runoff Depth=1.94"
Flow Length=2,760' Tc=211.3 min CN=53 Runoff=130.27 cfs 59.482 af

Subcatchment 2S: Estimated Runoff Area=4,000.000 ac 0.00% Impervious Runoff Depth>0.21"
Tc=9,999.0 min CN=30 Runoff=5.72 cfs 69.806 af

Subcatchment 3S: Johns Pond - Water Runoff Area=336.670 ac 0.00% Impervious Runoff Depth>6.58"
Tc=60.0 min CN=98 Runoff=1,100.19 cfs 184.635 af

Subcatchment 4S: Airport to Cranberry Runoff Area=268.900 ac 14.99% Impervious Runoff Depth=1.49"
Flow Length=5,988' Tc=641.3 min CN=48 Runoff=31.19 cfs 33.414 af

Subcatchment 5S: Subcatchment to Small Runoff Area=109.800 ac 0.00% Impervious Runoff Depth=2.41"
Flow Length=2,615' Tc=246.1 min CN=58 Runoff=44.12 cfs 22.045 af

Pond 1P: Johns Pond Peak Elev=39.12' Storage=308.157 af Inflow=1,109.41 cfs 369.381 af
Discarded=2.68 cfs 52.637 af Primary=37.14 cfs 392.676 af Outflow=39.82 cfs 445.314 af

Pond 2P: Former Cranberry Bog Peak Elev=40.65' Storage=4.201 af Inflow=49.82 cfs 55.458 af
Outflow=45.69 cfs 55.458 af

Total Runoff Area = 5,083.670 ac Runoff Volume = 369.381 af Average Runoff Depth = 0.87"
99.21% Pervious = 5,043.370 ac 0.79% Impervious = 40.300 ac

Summary for Subcatchment 1S: Overland

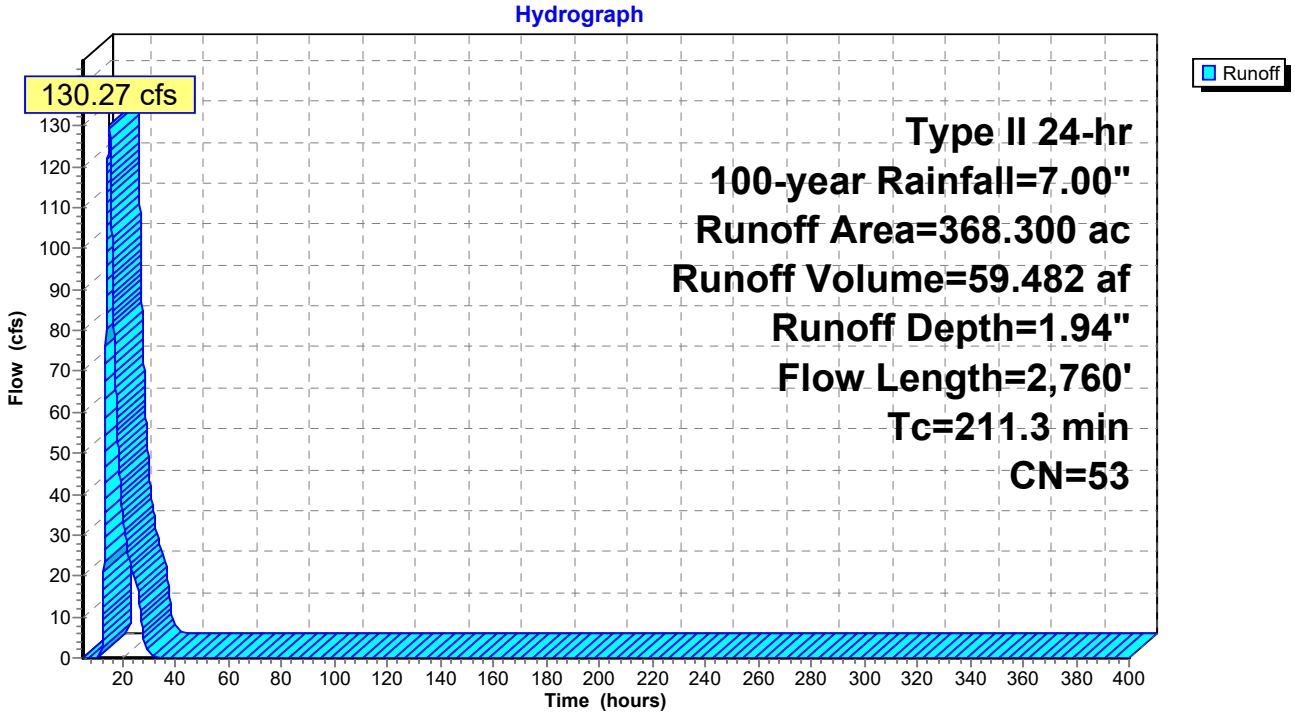
Runoff = 130.27 cfs @ 14.81 hrs, Volume= 59.482 af, Depth= 1.94"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-400.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-year Rainfall=7.00"

	Area (ac)	CN	Description
*	368.300	53	See Spreadsheet
	368.300		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
30.8	50	0.0100	0.03		**Sheet Flow,** Woods: Dense underbrush n= 0.800 P2= 2.70"
3.3	100	0.0100	0.50		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
177.2	2,610	0.0300	0.25	4.91	**Channel Flow,** Area= 20.0 sf Perim= 30.0' r= 0.67' n= 0.800 Sheet flow: Woods+dense brush
211.3	2,760	Total			

Subcatchment 1S: Overland



Summary for Subcatchment 2S: Estimated Subsurface Flow

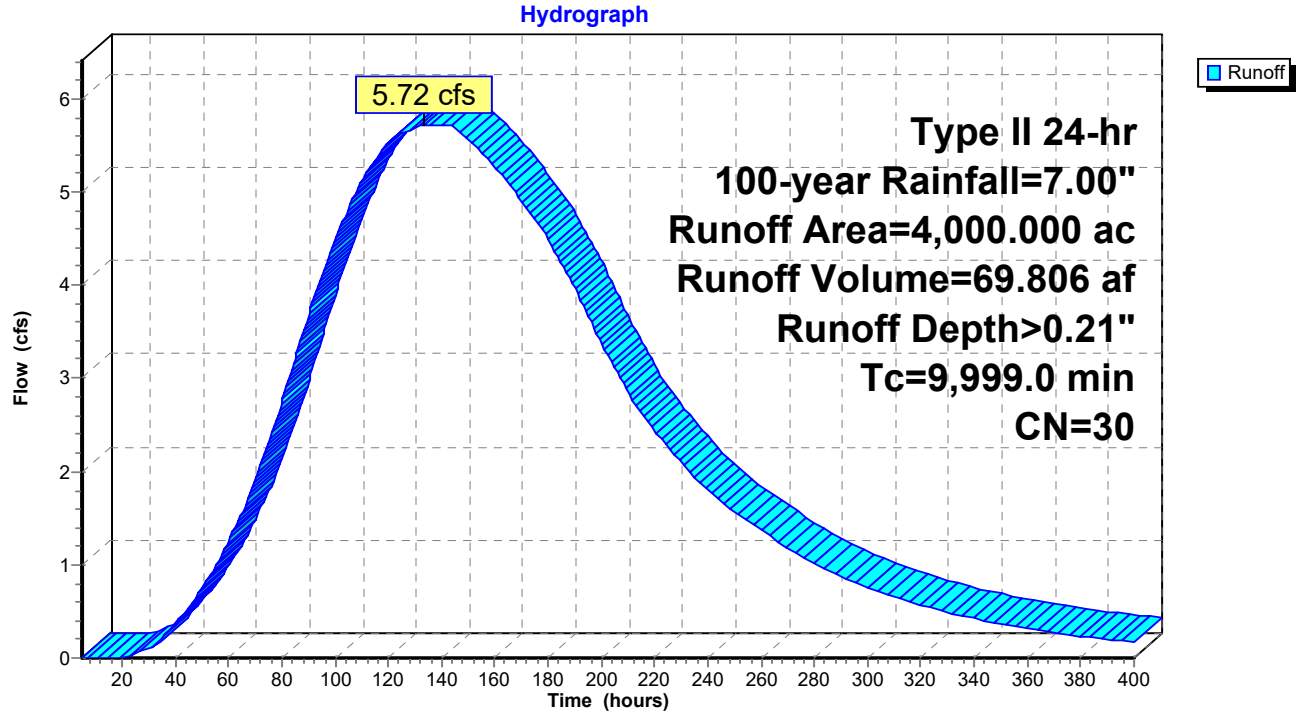
Runoff = 5.72 cfs @ 133.36 hrs, Volume= 69.806 af, Depth> 0.21"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-400.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-year Rainfall=7.00"

	Area (ac)	CN	Description
*	4,000.000	30	
	4,000.000		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9,999.0					**Direct Entry,**

Subcatchment 2S: Estimated Subsurface Flow



Summary for Subcatchment 3S: Johns Pond - Water Only

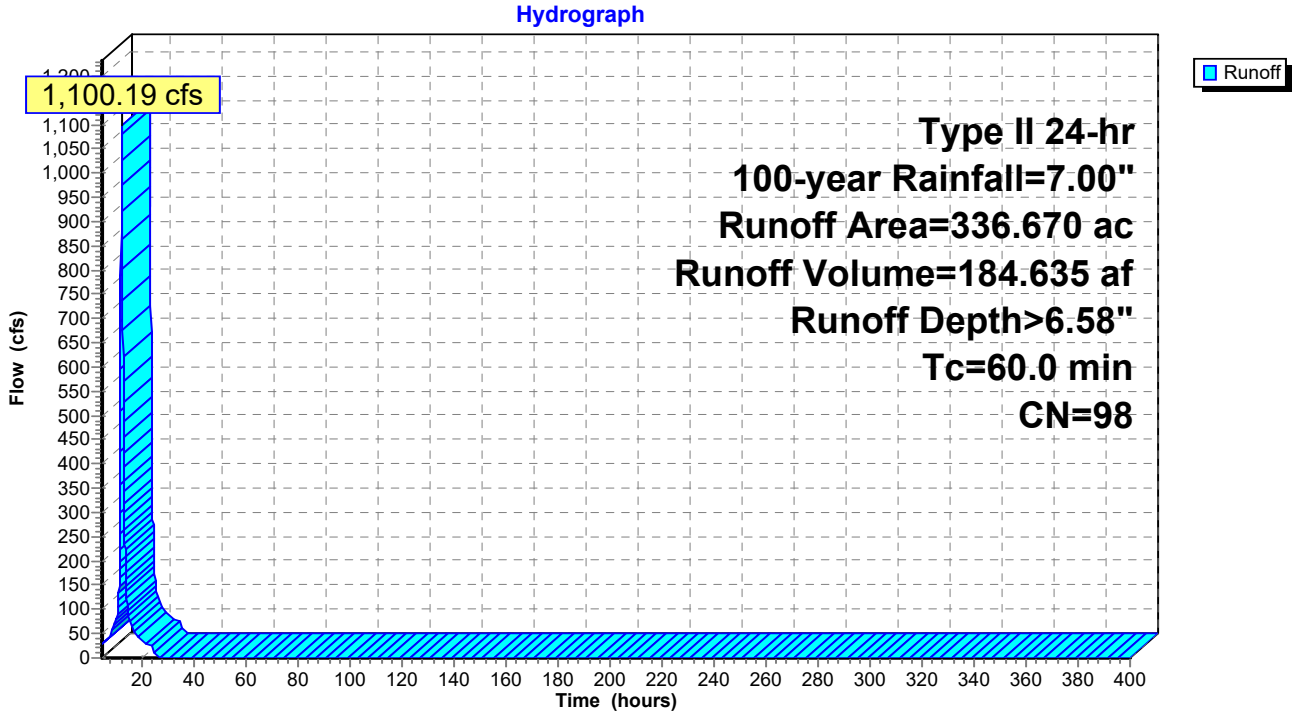
Runoff = 1,100.19 cfs @ 12.59 hrs, Volume= 184.635 af, Depth> 6.58"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-400.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-year Rainfall=7.00"

Area (ac)	CN	Description
336.670	98	Water Surface, 0% imp, HSG A
336.670		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
60.0					**Direct Entry, 60**

Subcatchment 3S: Johns Pond - Water Only



Summary for Subcatchment 4S: Airport to Cranberry Bog

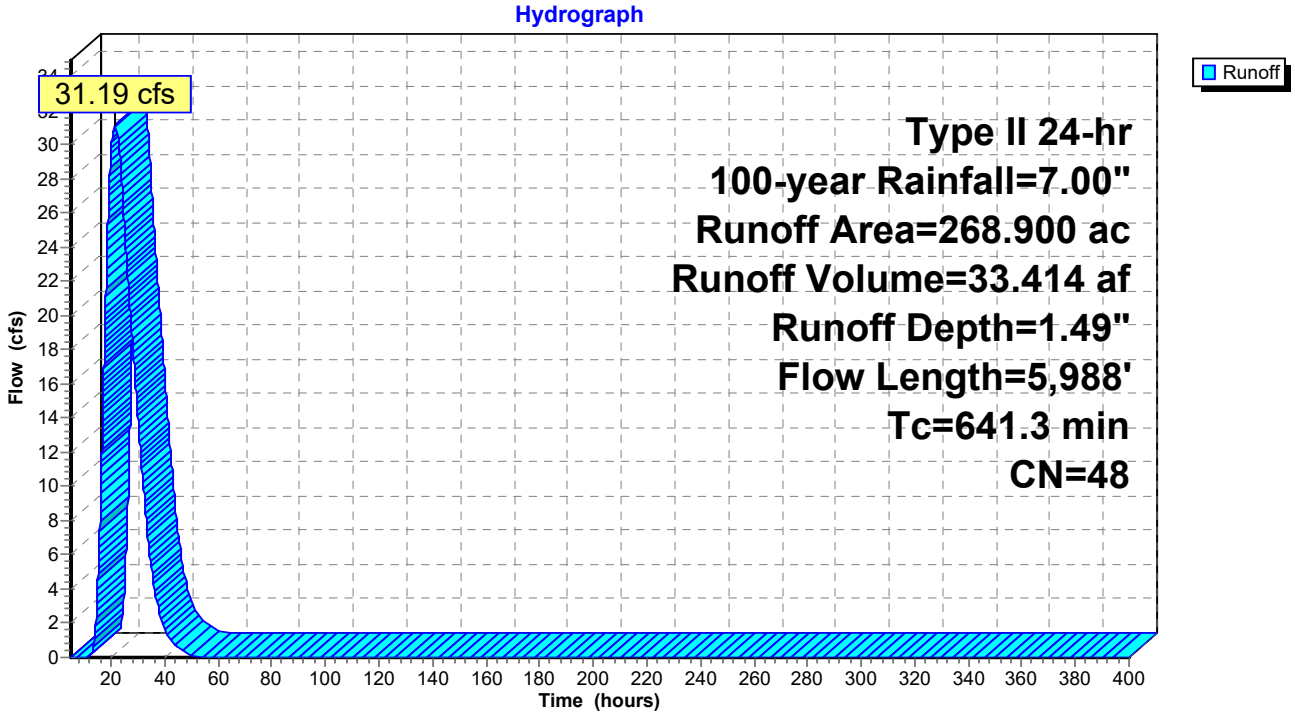
Runoff = 31.19 cfs @ 21.40 hrs, Volume= 33.414 af, Depth= 1.49"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-400.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-year Rainfall=7.00"

Area (ac)	CN	Description
40.300	98	Paved parking, HSG A
228.600	39	>75% Grass cover, Good, HSG A
268.900	48	Weighted Average
228.600		85.01% Pervious Area
40.300		14.99% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
20.4	50	0.0280	0.04		**Sheet Flow,** Woods: Dense underbrush n= 0.800 P2= 2.70"
2.0	100	0.0280	0.84		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
618.9	5,838	0.0123	0.16	3.14	**Channel Flow,** Area= 20.0 sf Perim= 30.0' r= 0.67' n= 0.800 Sheet flow: Woods+dense brush
641.3	5,988	Total			

Subcatchment 4S: Airport to Cranberry Bog



Summary for Subcatchment 5S: Subcatchment to Small Cranberry Bog

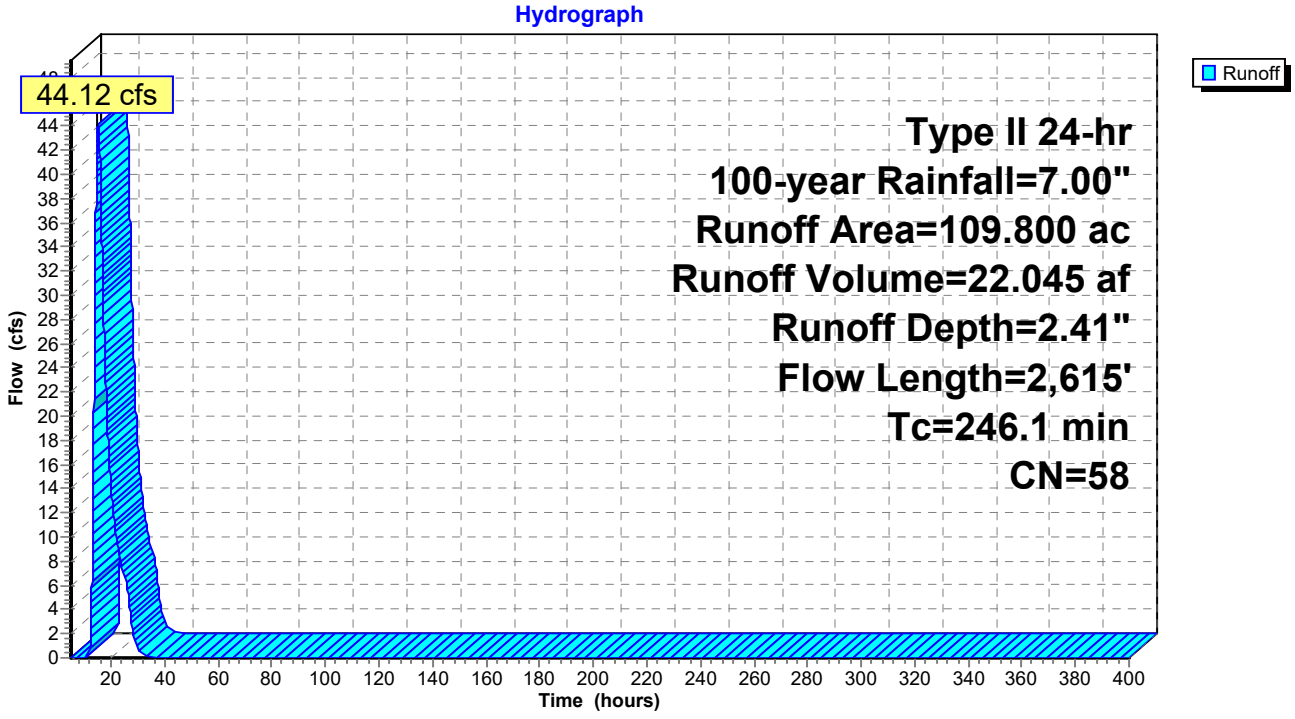
Runoff = 44.12 cfs @ 15.05 hrs, Volume= 22.045 af, Depth= 2.41"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-400.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-year Rainfall=7.00"

	Area (ac)	CN	Description
*	109.800	58	See Spreadsheet
	109.800		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
15.6	50	0.0550	0.05		**Sheet Flow,** Woods: Dense underbrush n= 0.800 P2= 2.70"
1.4	100	0.0550	1.17		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
229.1	2,465	0.0160	0.18	3.59	**Channel Flow,** Area= 20.0 sf Perim= 30.0' r= 0.67' n= 0.800 Sheet flow: Woods+dense brush
246.1	2,615	Total			

Subcatchment 5S: Subcatchment to Small Cranberry Bog



Summary for Pond 1P: Johns Pond

Inflow Area = 5,083.670 ac, 0.79% Impervious, Inflow Depth > 0.87" for 100-year event
Inflow = 1,109.41 cfs @ 12.60 hrs, Volume= 369.381 af
Outflow = 39.82 cfs @ 26.69 hrs, Volume= 445.314 af, Atten= 96%, Lag= 845.6 min
Discarded = 2.68 cfs @ 26.69 hrs, Volume= 52.637 af
Primary = 37.14 cfs @ 26.69 hrs, Volume= 392.676 af

Routing by Stor-Ind method, Time Span= 5.00-400.00 hrs, dt= 0.05 hrs
Starting Elev= 38.20' Surf.Area= 252.600 ac Storage= 75.899 af
Peak Elev= 39.12' @ 26.69 hrs Surf.Area= 252.600 ac Storage= 308.157 af (232.257 af above start)

Plug-Flow detention time= 4,920.4 min calculated for 369.309 af (100% of inflow)
Center-of-Mass det. time= 3,850.9 min (6,498.7 - 2,647.8)

Volume	Invert	Avail.Storage	Storage Description
#1	37.56'	1,151.961 af	**Custom Stage Data (Conic)** Listed below (Recalc)

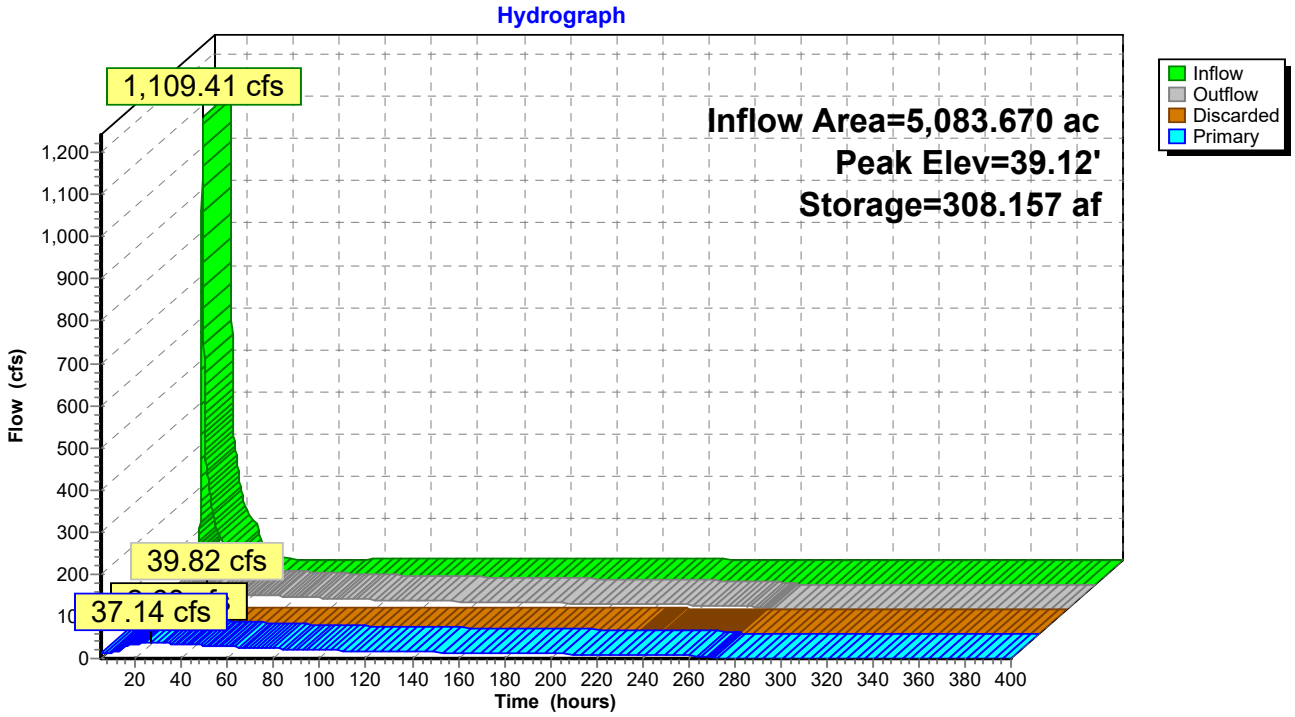
Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)	Wet.Area (acres)
37.56	0.010	0.000	0.000	0.010
37.70	0.011	0.001	0.001	0.011
38.00	252.400	25.408	25.409	252.400
38.10	252.400	25.240	50.649	252.427
38.20	252.600	25.250	75.899	252.629
40.00	252.600	454.680	530.579	253.115
42.00	372.660	621.382	1,151.961	373.176

Device	Routing	Invert	Outlet Devices
#1	Primary	37.31'	**2.0' long x 5.00' rise Sharp-Crested Rectangular Weir west - Fish Ladder** 2 End Contraction(s) 5.4' Crest Height
#2	Primary	37.35'	**3.3' long x 5.00' rise Sharp-Crested Rectangular Weir east - Bypass** 2 End Contraction(s) 5.5' Crest Height
#3	Primary	40.00'	**28.0' long (Profile 1) Broad-Crested Rectangular Weir** Head (feet) 0.49 0.98 1.48 Coef. (English) 2.92 3.37 3.59
#4	Discarded	37.56'	**0.010 in/hr Exfiltration over Wetted area** Conductivity to Groundwater Elevation = 15.00'

Discarded OutFlow Max=2.68 cfs @ 26.69 hrs HW=39.12' (Free Discharge)
└**4=Exfiltration** (Controls 2.68 cfs)

Primary OutFlow Max=37.14 cfs @ 26.69 hrs HW=39.12' (Free Discharge)
├**1=Sharp-Crested Rectangular Weir west - Fish Ladder** (Weir Controls 13.57 cfs @ 4.58 fps)
├**2=Sharp-Crested Rectangular Weir east - Bypass** (Weir Controls 23.57 cfs @ 4.52 fps)
└**3=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Pond 1P: Johns Pond



Summary for Pond 2P: Former Cranberry Bog

Inflow Area = 378.700 ac, 10.64% Impervious, Inflow Depth = 1.76" for 100-year event
Inflow = 49.82 cfs @ 15.59 hrs, Volume= 55.458 af
Outflow = 45.69 cfs @ 16.68 hrs, Volume= 55.458 af, Atten= 8%, Lag= 65.6 min
Primary = 45.69 cfs @ 16.68 hrs, Volume= 55.458 af

Routing by Stor-Ind method, Time Span= 5.00-400.00 hrs, dt= 0.05 hrs
Peak Elev= 40.65' @ 16.68 hrs Surf.Area= 2.954 ac Storage= 4.201 af

Plug-Flow detention time= 78.6 min calculated for 55.451 af (100% of inflow)
Center-of-Mass det. time= 78.7 min (1,396.4 - 1,317.7)

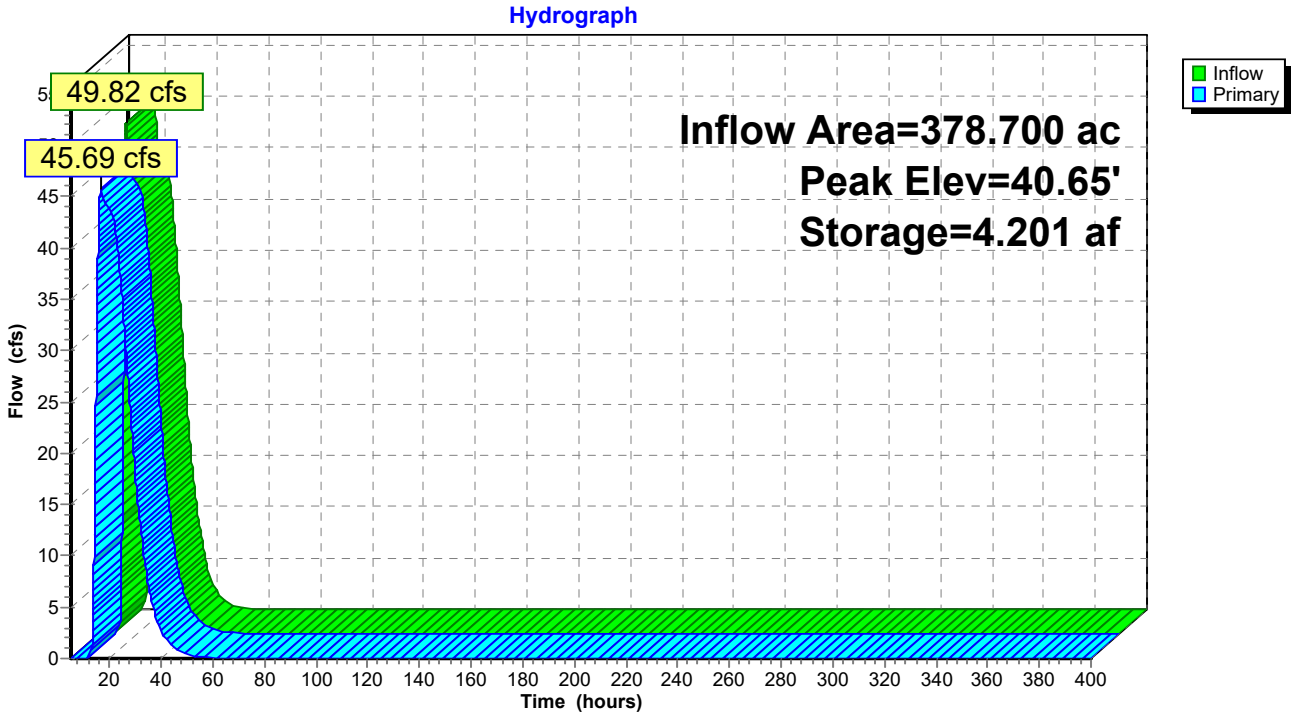
Volume	Invert	Avail.Storage	Storage Description
#1	39.00'	19.585 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
39.00	1.890	0.000	0.000
40.00	2.780	2.335	2.335
45.00	4.120	17.250	19.585

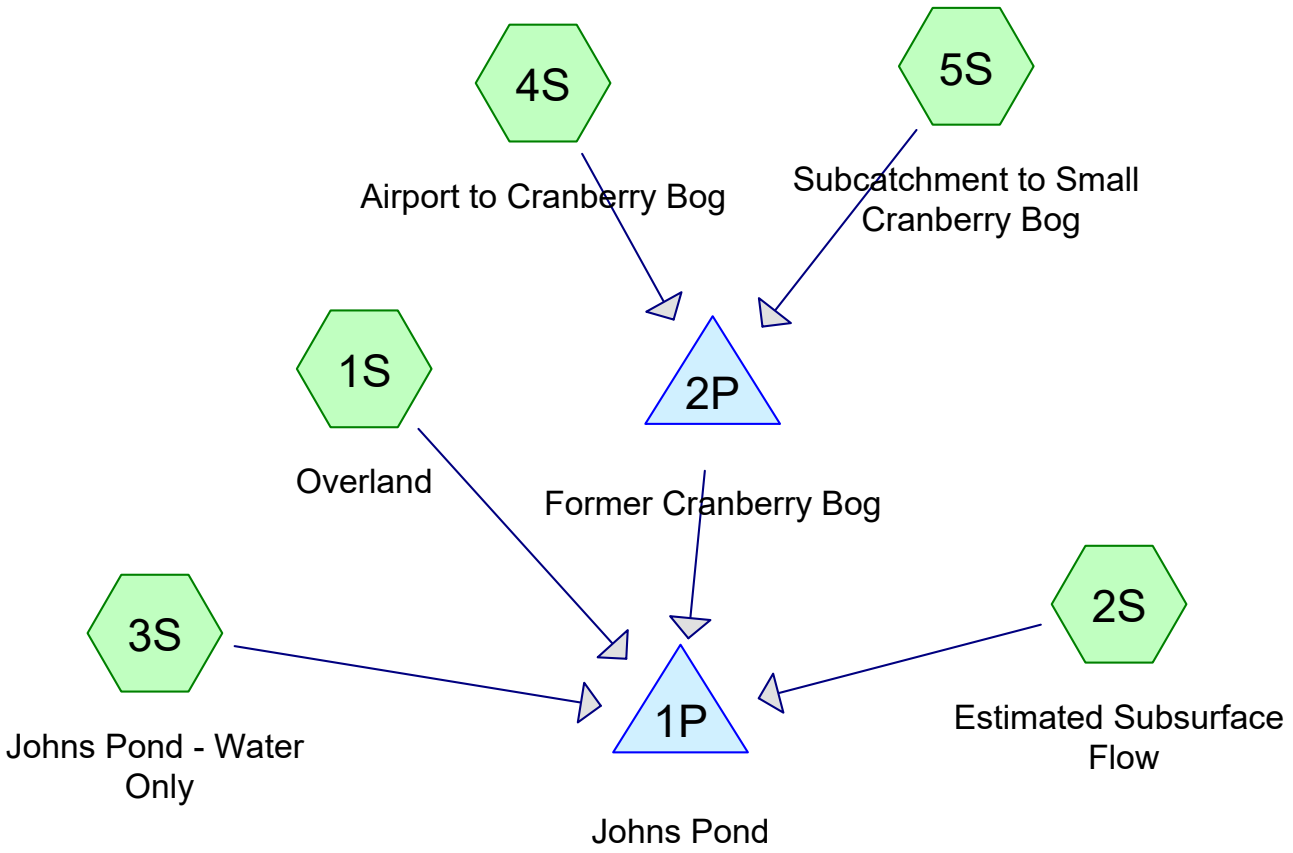
Device	Routing	Invert	Outlet Devices
#1	Primary	39.00'	**6.0' long Broad-Crested Rectangular Weir** Head (feet) 0.49 0.98 1.48 Coef. (English) 2.92 3.37 3.59

Primary OutFlow Max=45.68 cfs @ 16.68 hrs HW=40.65' (Free Discharge)
↑**1=Broad-Crested Rectangular Weir** (Weir Controls 45.68 cfs @ 4.61 fps)

Pond 2P: Former Cranberry Bog



Johns Pond Assessment with CN subsurface = 48 (100-year flood elevation =39.1)



Subcat Reach Pond Link

Routing Diagram for johns pond 1-22-19
Prepared by {enter your company name here}, Printed 3/21/2019

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
4,000.000	48	(2S)
228.600	39	>75% Grass cover, Good, HSG A (4S)
40.300	98	Paved parking, HSG A (4S)
368.300	53	See Spreadsheet (1S)
109.800	58	See Spreadsheet (5S)
336.670	98	Water Surface, 0% imp, HSG A (3S)
5,083.670	**52**	**TOTAL AREA**

Soil Listing (all nodes)

Area (acres)	Soil Group	Subcatchment Numbers
605.570	HSG A	3S, 4S
0.000	HSG B	
0.000	HSG C	
0.000	HSG D	
4,478.100	Other	1S, 2S, 5S
5,083.670		**TOTAL AREA**

Ground Covers (all nodes)

HSG-A (acres)	HSG-B (acres)	HSG-C (acres)	HSG-D (acres)	Other (acres)	Total (acres)	Ground Cover	Subcatchment Numbers
0.000	0.000	0.000	0.000	4,000.000	4,000.000		2S
228.600	0.000	0.000	0.000	0.000	228.600	>75% Grass cover, Good	4S
40.300	0.000	0.000	0.000	0.000	40.300	Paved parking	4S
0.000	0.000	0.000	0.000	478.100	478.100	See Spreadsheet	1S, 5S
336.670	0.000	0.000	0.000	0.000	336.670	Water Surface, 0% imp	3S
605.570	**0.000**	**0.000**	**0.000**	**4,478.100**	**5,083.670**	**TOTAL AREA**	

Time span=5.00-400.00 hrs, dt=0.05 hrs, 7901 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: Overland Runoff Area=368.300 ac 0.00% Impervious Runoff Depth=1.94"
Flow Length=2,760' Tc=211.3 min CN=53 Runoff=130.27 cfs 59.482 af

Subcatchment 2S: Estimated Runoff Area=4,000.000 ac 0.00% Impervious Runoff Depth>1.47"
Tc=9,999.0 min CN=48 Runoff=40.41 cfs 490.875 af

Subcatchment 3S: Johns Pond - Water Runoff Area=336.670 ac 0.00% Impervious Runoff Depth>6.58"
Tc=60.0 min CN=98 Runoff=1,100.19 cfs 184.635 af

Subcatchment 4S: Airport to Cranberry Runoff Area=268.900 ac 14.99% Impervious Runoff Depth=1.49"
Flow Length=5,988' Tc=641.3 min CN=48 Runoff=31.19 cfs 33.414 af

Subcatchment 5S: Subcatchment to Small Runoff Area=109.800 ac 0.00% Impervious Runoff Depth=2.41"
Flow Length=2,615' Tc=246.1 min CN=58 Runoff=44.12 cfs 22.045 af

Pond 1P: Johns Pond Peak Elev=39.12' Storage=308.231 af Inflow=1,109.41 cfs 790.449 af
Discarded=2.68 cfs 85.488 af Primary=37.15 cfs 762.519 af Outflow=39.83 cfs 848.007 af

Pond 2P: Former Cranberry Bog Peak Elev=40.65' Storage=4.201 af Inflow=49.82 cfs 55.458 af
Outflow=45.69 cfs 55.458 af

Total Runoff Area = 5,083.670 ac Runoff Volume = 790.449 af Average Runoff Depth = 1.87"
99.21% Pervious = 5,043.370 ac 0.79% Impervious = 40.300 ac

Summary for Subcatchment 1S: Overland

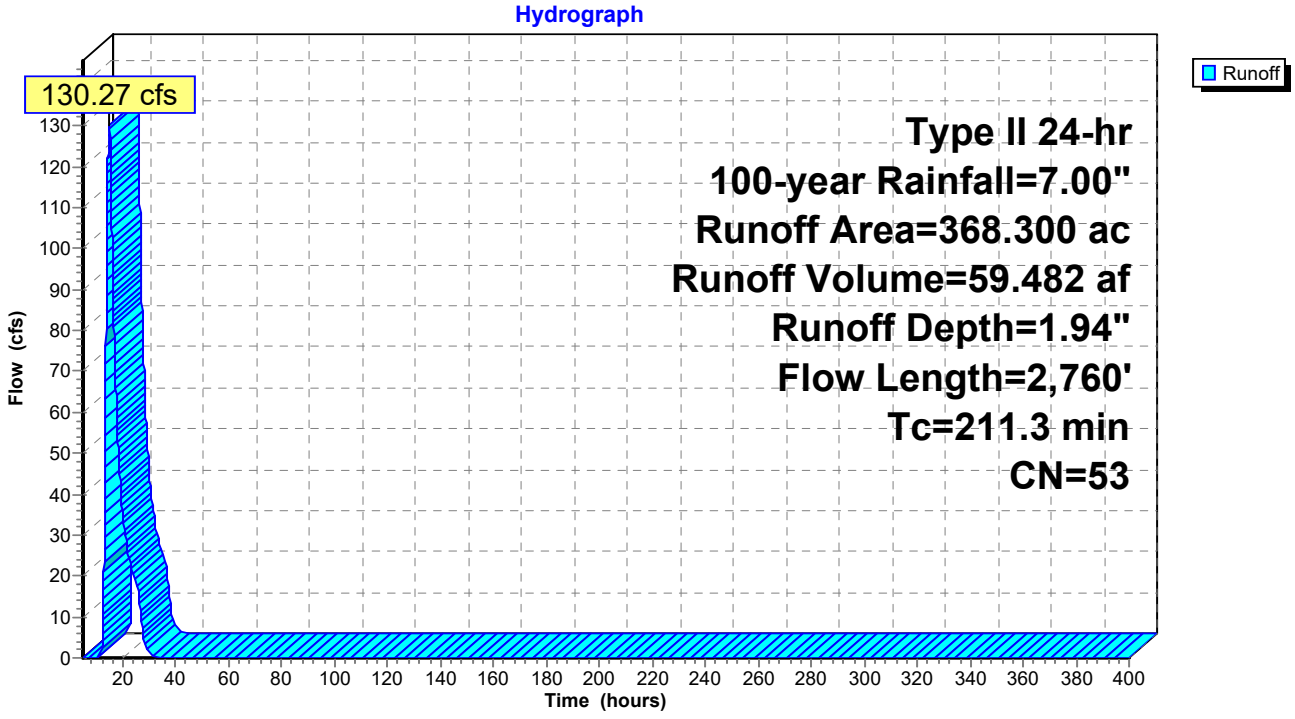
Runoff = 130.27 cfs @ 14.81 hrs, Volume= 59.482 af, Depth= 1.94"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-400.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-year Rainfall=7.00"

	Area (ac)	CN	Description
*	368.300	53	See Spreadsheet
	368.300		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
30.8	50	0.0100	0.03		**Sheet Flow,** Woods: Dense underbrush n= 0.800 P2= 2.70"
3.3	100	0.0100	0.50		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
177.2	2,610	0.0300	0.25	4.91	**Channel Flow,** Area= 20.0 sf Perim= 30.0' r= 0.67' n= 0.800 Sheet flow: Woods+dense brush
211.3	2,760	Total			

Subcatchment 1S: Overland



Summary for Subcatchment 2S: Estimated Subsurface Flow

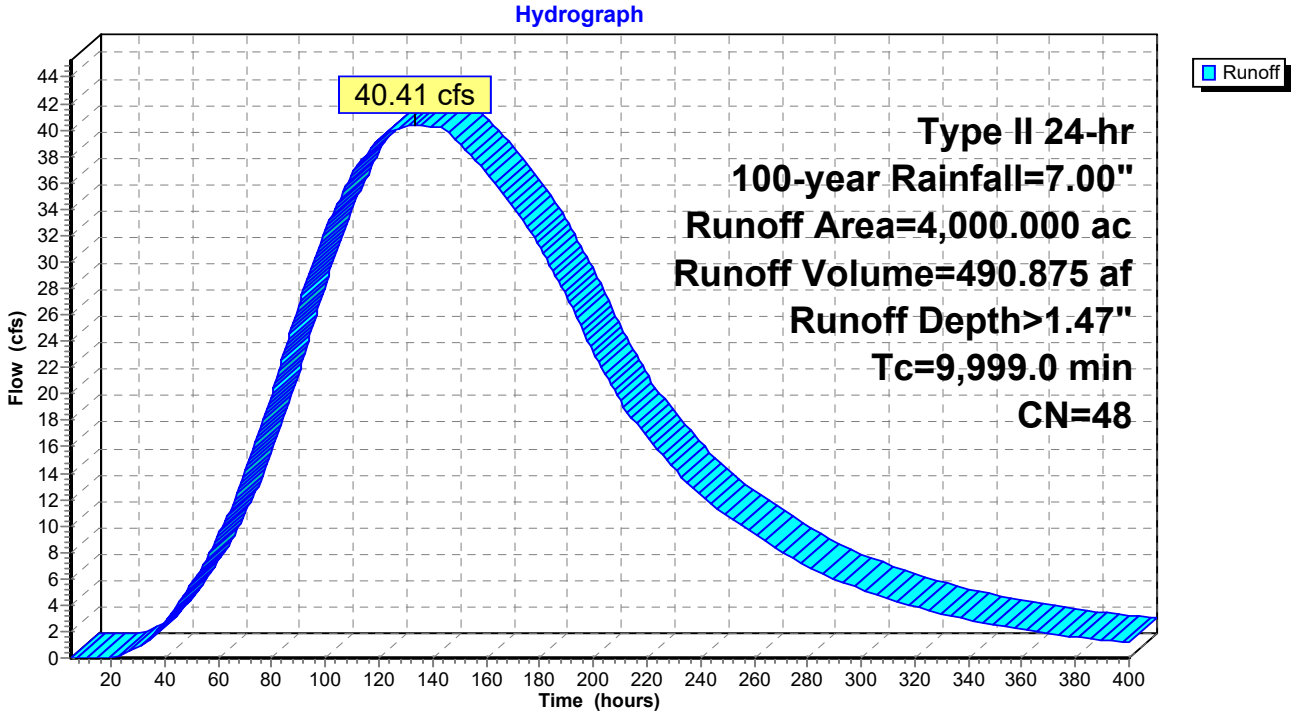
Runoff = 40.41 cfs @ 133.34 hrs, Volume= 490.875 af, Depth> 1.47"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-400.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-year Rainfall=7.00"

	Area (ac)	CN	Description
*	4,000.000	48	
	4,000.000		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9,999.0					**Direct Entry,**

Subcatchment 2S: Estimated Subsurface Flow



Summary for Subcatchment 3S: Johns Pond - Water Only

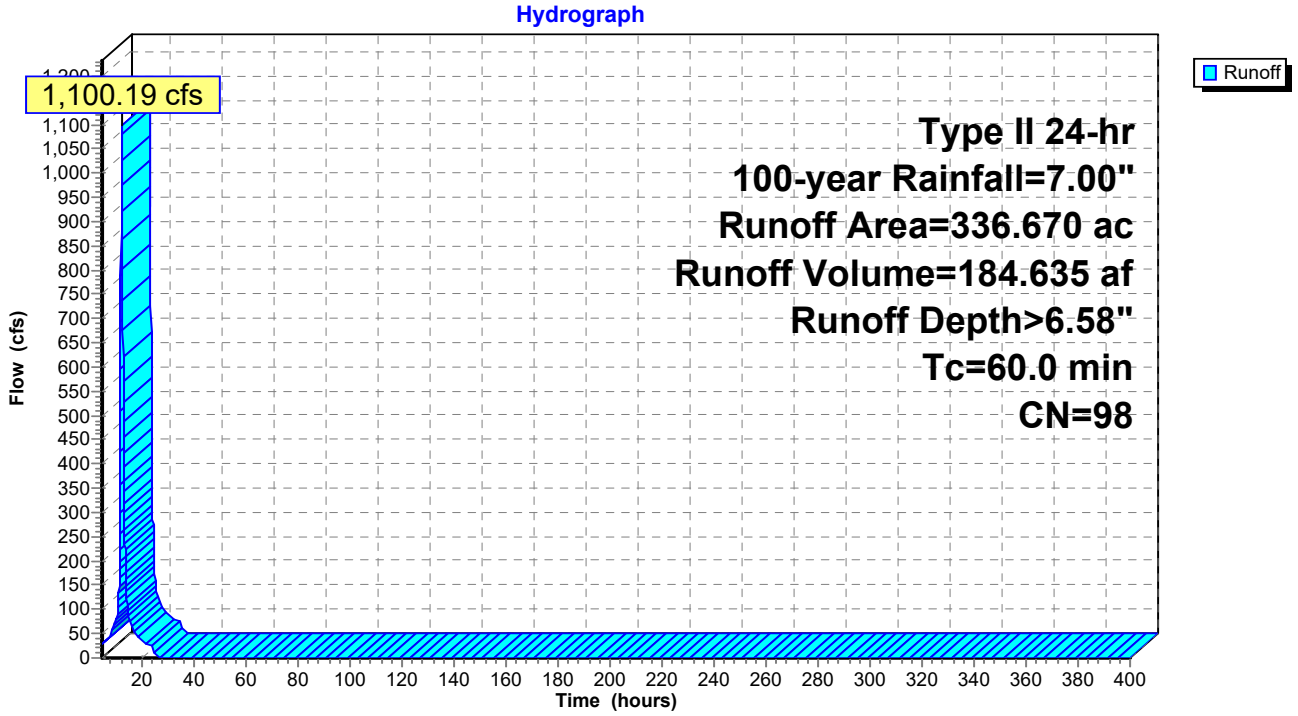
Runoff = 1,100.19 cfs @ 12.59 hrs, Volume= 184.635 af, Depth> 6.58"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-400.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-year Rainfall=7.00"

Area (ac)	CN	Description
336.670	98	Water Surface, 0% imp, HSG A
336.670		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
60.0					**Direct Entry, 60**

Subcatchment 3S: Johns Pond - Water Only



Summary for Subcatchment 4S: Airport to Cranberry Bog

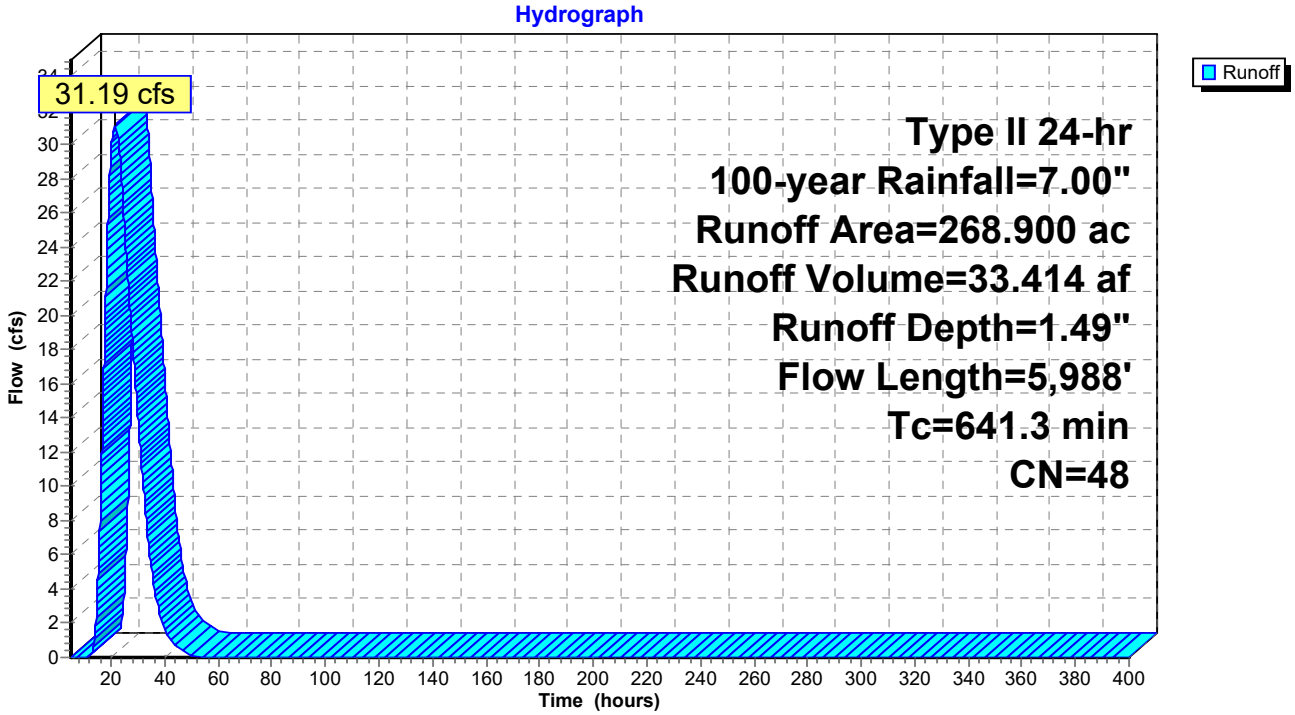
Runoff = 31.19 cfs @ 21.40 hrs, Volume= 33.414 af, Depth= 1.49"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-400.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-year Rainfall=7.00"

Area (ac)	CN	Description
40.300	98	Paved parking, HSG A
228.600	39	>75% Grass cover, Good, HSG A
268.900	48	Weighted Average
228.600		85.01% Pervious Area
40.300		14.99% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
20.4	50	0.0280	0.04		**Sheet Flow,** Woods: Dense underbrush n= 0.800 P2= 2.70"
2.0	100	0.0280	0.84		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
618.9	5,838	0.0123	0.16	3.14	**Channel Flow,** Area= 20.0 sf Perim= 30.0' r= 0.67' n= 0.800 Sheet flow: Woods+dense brush
641.3	5,988	Total			

Subcatchment 4S: Airport to Cranberry Bog



Summary for Subcatchment 5S: Subcatchment to Small Cranberry Bog

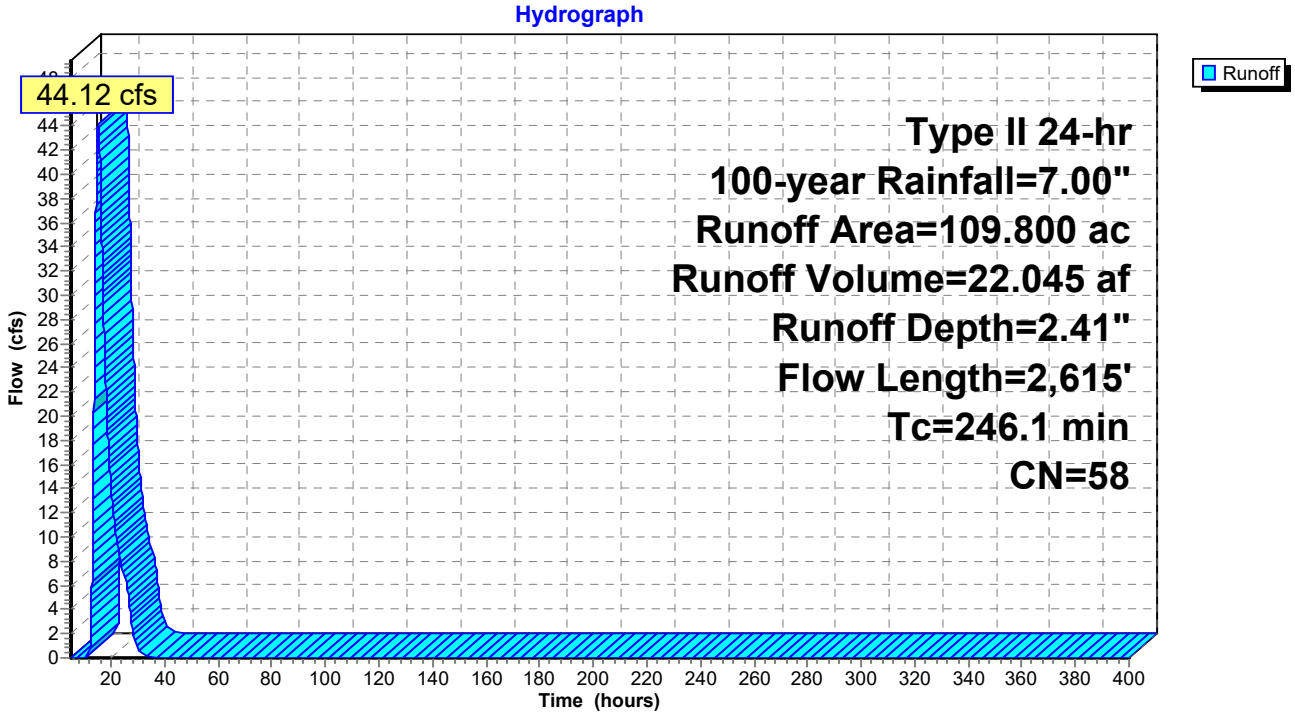
Runoff = 44.12 cfs @ 15.05 hrs, Volume= 22.045 af, Depth= 2.41"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-400.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-year Rainfall=7.00"

	Area (ac)	CN	Description
*	109.800	58	See Spreadsheet
	109.800		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
15.6	50	0.0550	0.05		**Sheet Flow,** Woods: Dense underbrush n= 0.800 P2= 2.70"
1.4	100	0.0550	1.17		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
229.1	2,465	0.0160	0.18	3.59	**Channel Flow,** Area= 20.0 sf Perim= 30.0' r= 0.67' n= 0.800 Sheet flow: Woods+dense brush
246.1	2,615	Total			

Subcatchment 5S: Subcatchment to Small Cranberry Bog



Summary for Pond 1P: Johns Pond

Inflow Area = 5,083.670 ac, 0.79% Impervious, Inflow Depth > 1.87" for 100-year event
Inflow = 1,109.41 cfs @ 12.60 hrs, Volume= 790.449 af
Outflow = 39.83 cfs @ 26.73 hrs, Volume= 848.007 af, Atten= 96%, Lag= 848.0 min
Discarded = 2.68 cfs @ 26.73 hrs, Volume= 85.488 af
Primary = 37.15 cfs @ 26.73 hrs, Volume= 762.519 af

Routing by Stor-Ind method, Time Span= 5.00-400.00 hrs, dt= 0.05 hrs
Starting Elev= 38.20' Surf.Area= 252.600 ac Storage= 75.899 af
Peak Elev= 39.12' @ 26.73 hrs Surf.Area= 252.600 ac Storage= 308.231 af (232.332 af above start)

Plug-Flow detention time= 5,278.0 min calculated for 772.049 af (98% of inflow)
Center-of-Mass det. time= 4,035.0 min (10,480.4 - 6,445.4)

Volume	Invert	Avail.Storage	Storage Description
#1	37.56'	1,151.961 af	**Custom Stage Data (Conic)** Listed below (Recalc)

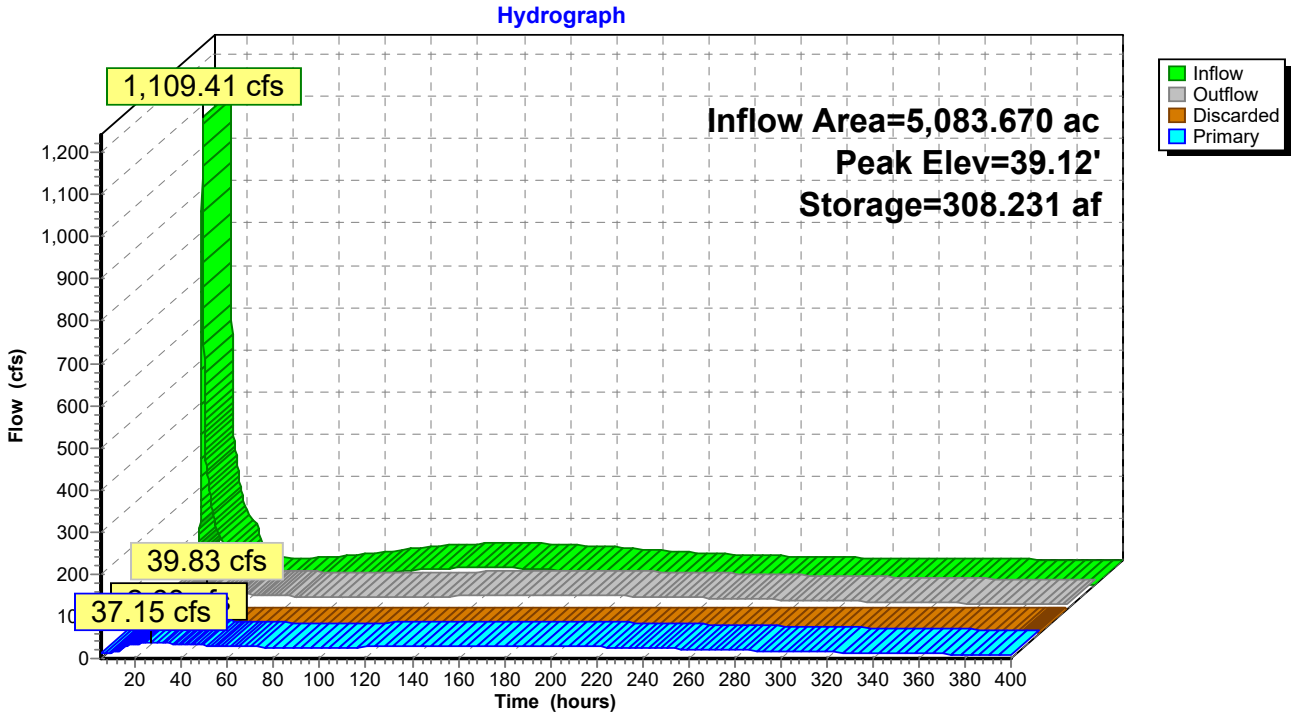
Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)	Wet.Area (acres)
37.56	0.010	0.000	0.000	0.010
37.70	0.011	0.001	0.001	0.011
38.00	252.400	25.408	25.409	252.400
38.10	252.400	25.240	50.649	252.427
38.20	252.600	25.250	75.899	252.629
40.00	252.600	454.680	530.579	253.115
42.00	372.660	621.382	1,151.961	373.176

Device	Routing	Invert	Outlet Devices
#1	Primary	37.31'	**2.0' long x 5.00' rise Sharp-Crested Rectangular Weir west - Fish Ladder** 2 End Contraction(s) 5.4' Crest Height
#2	Primary	37.35'	**3.3' long x 5.00' rise Sharp-Crested Rectangular Weir east - Bypass** 2 End Contraction(s) 5.5' Crest Height
#3	Primary	40.00'	**28.0' long (Profile 1) Broad-Crested Rectangular Weir** Head (feet) 0.49 0.98 1.48 Coef. (English) 2.92 3.37 3.59
#4	Discarded	37.56'	**0.010 in/hr Exfiltration over Wetted area** Conductivity to Groundwater Elevation = 15.00'

Discarded OutFlow Max=2.68 cfs @ 26.73 hrs HW=39.12' (Free Discharge)
└**4=Exfiltration** (Controls 2.68 cfs)

Primary OutFlow Max=37.15 cfs @ 26.73 hrs HW=39.12' (Free Discharge)
├**1=Sharp-Crested Rectangular Weir west - Fish Ladder** (Weir Controls 13.58 cfs @ 4.58 fps)
├**2=Sharp-Crested Rectangular Weir east - Bypass** (Weir Controls 23.57 cfs @ 4.52 fps)
└**3=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Pond 1P: Johns Pond



Summary for Pond 2P: Former Cranberry Bog

Inflow Area = 378.700 ac, 10.64% Impervious, Inflow Depth = 1.76" for 100-year event
Inflow = 49.82 cfs @ 15.59 hrs, Volume= 55.458 af
Outflow = 45.69 cfs @ 16.68 hrs, Volume= 55.458 af, Atten= 8%, Lag= 65.6 min
Primary = 45.69 cfs @ 16.68 hrs, Volume= 55.458 af

Routing by Stor-Ind method, Time Span= 5.00-400.00 hrs, dt= 0.05 hrs
Peak Elev= 40.65' @ 16.68 hrs Surf.Area= 2.954 ac Storage= 4.201 af

Plug-Flow detention time= 78.6 min calculated for 55.451 af (100% of inflow)
Center-of-Mass det. time= 78.7 min (1,396.4 - 1,317.7)

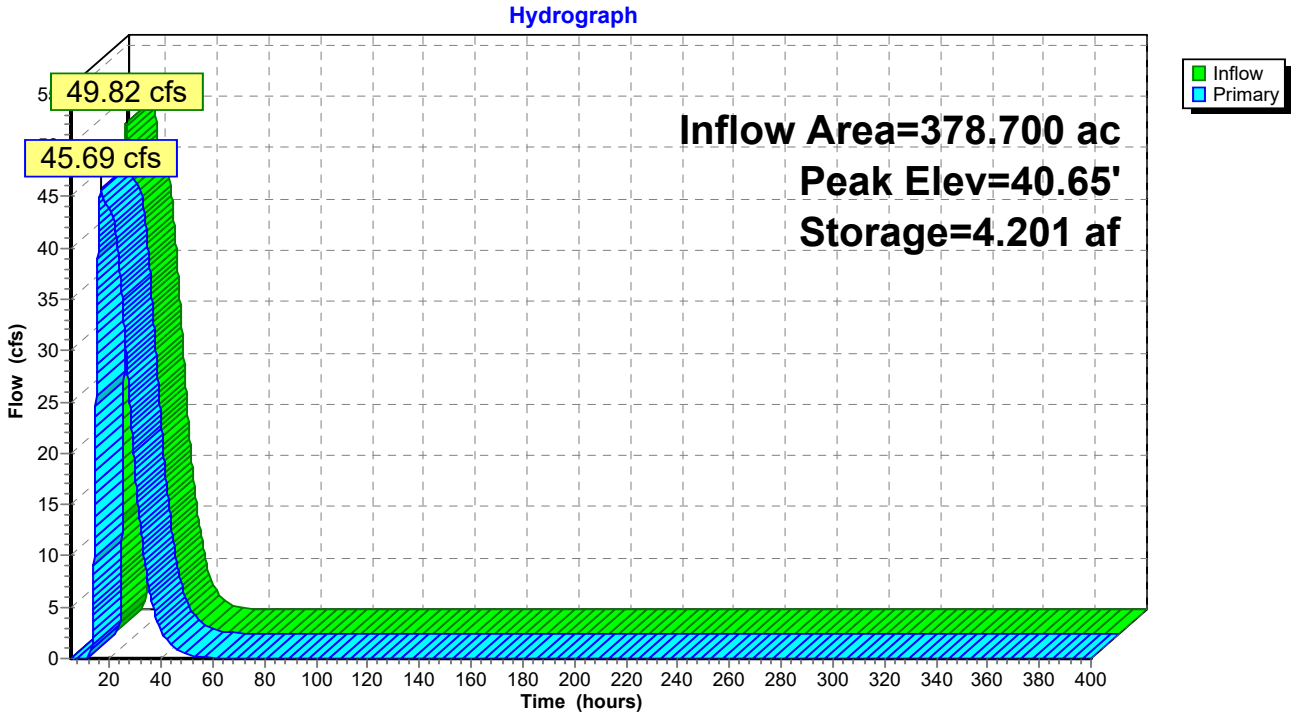
Volume	Invert	Avail.Storage	Storage Description
#1	39.00'	19.585 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
39.00	1.890	0.000	0.000
40.00	2.780	2.335	2.335
45.00	4.120	17.250	19.585

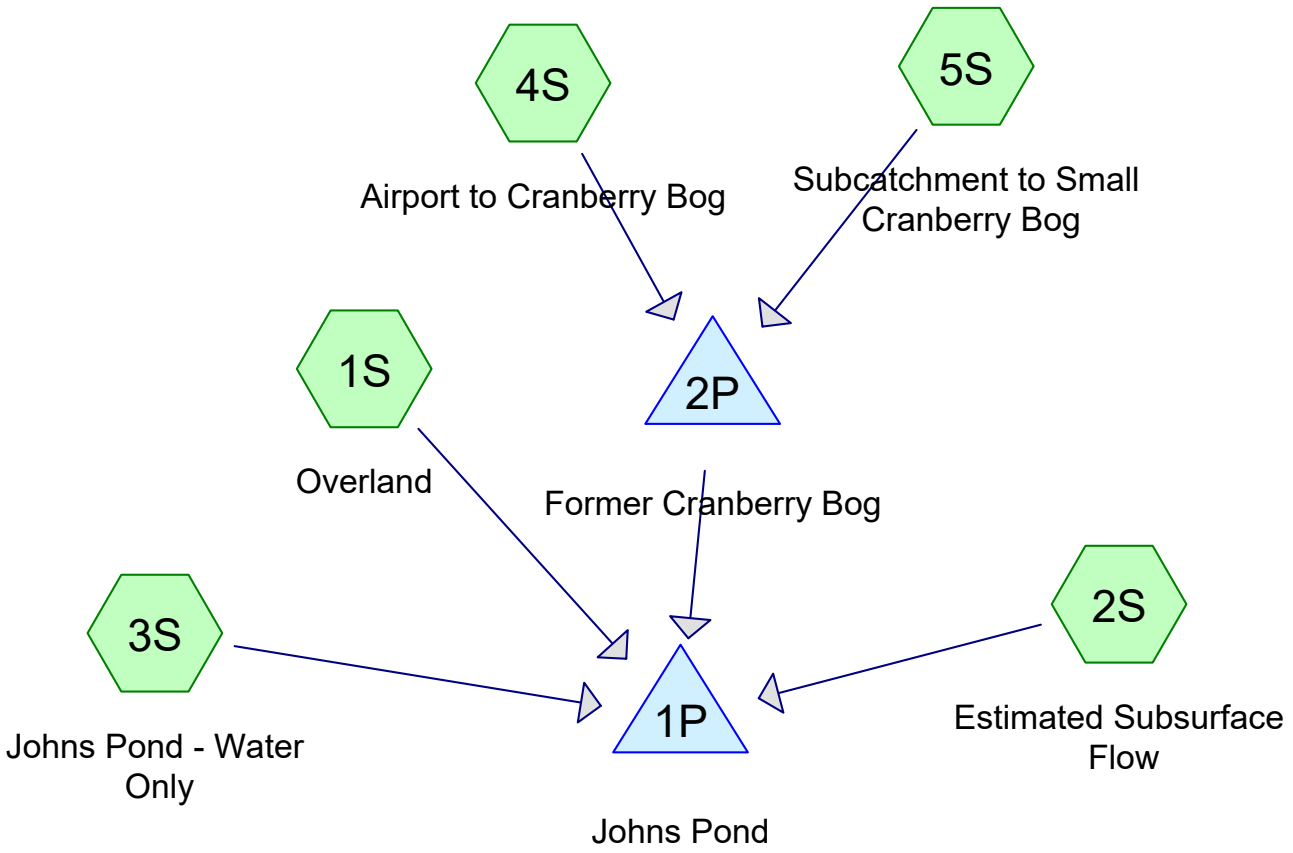
Device	Routing	Invert	Outlet Devices
#1	Primary	39.00'	**6.0' long Broad-Crested Rectangular Weir** Head (feet) 0.49 0.98 1.48 Coef. (English) 2.92 3.37 3.59

Primary OutFlow Max=45.68 cfs @ 16.68 hrs HW=40.65' (Free Discharge)
↑**1=Broad-Crested Rectangular Weir** (Weir Controls 45.68 cfs @ 4.61 fps)

Pond 2P: Former Cranberry Bog



Johns Pond with Back to Back 5-inch Storms



Subcat Reach Pond Link

Routing Diagram for johns pond 1-22-19
Prepared by {enter your company name here}, Printed 3/21/2019

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
4,000.000	48	(2S)
228.600	39	>75% Grass cover, Good, HSG A (4S)
40.300	98	Paved parking, HSG A (4S)
368.300	53	See Spreadsheet (1S)
109.800	58	See Spreadsheet (5S)
336.670	98	Water Surface, 0% imp, HSG A (3S)
5,083.670	**52**	**TOTAL AREA**

Soil Listing (all nodes)

Area (acres)	Soil Group	Subcatchment Numbers
605.570	HSG A	3S, 4S
0.000	HSG B	
0.000	HSG C	
0.000	HSG D	
4,478.100	Other	1S, 2S, 5S
5,083.670		**TOTAL AREA**

Ground Covers (all nodes)

HSG-A (acres)	HSG-B (acres)	HSG-C (acres)	HSG-D (acres)	Other (acres)	Total (acres)	Ground Cover	Subcatchment Numbers
0.000	0.000	0.000	0.000	4,000.000	4,000.000		2S
228.600	0.000	0.000	0.000	0.000	228.600	>75% Grass cover, Good	4S
40.300	0.000	0.000	0.000	0.000	40.300	Paved parking	4S
0.000	0.000	0.000	0.000	478.100	478.100	See Spreadsheet	1S, 5S
336.670	0.000	0.000	0.000	0.000	336.670	Water Surface, 0% imp	3S
605.570	**0.000**	**0.000**	**0.000**	**4,478.100**	**5,083.670**	**TOTAL AREA**	

Time span=5.00-400.00 hrs, dt=0.05 hrs, 7901 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: Overland Runoff Area=368.300 ac 0.00% Impervious Runoff Depth=3.96"
Flow Length=2,760' Tc=211.3 min CN=53 Runoff=211.85 cfs 121.504 af

Subcatchment 2S: Estimated Runoff Area=4,000.000 ac 0.00% Impervious Runoff Depth>3.23"
Tc=9,999.0 min CN=48 Runoff=88.08 cfs 1,077.403 af

Subcatchment 3S: Johns Pond - Water Runoff Area=336.670 ac 0.00% Impervious Runoff Depth>9.66"
Tc=60.0 min CN=98 Runoff=788.52 cfs 270.939 af

Subcatchment 4S: Airport to Cranberry Runoff Area=268.900 ac 14.99% Impervious Runoff Depth=3.29"
Flow Length=5,988' Tc=641.3 min CN=48 Runoff=58.66 cfs 73.661 af

Subcatchment 5S: Subcatchment to Small Runoff Area=109.800 ac 0.00% Impervious Runoff Depth=4.63"
Flow Length=2,615' Tc=246.1 min CN=58 Runoff=63.13 cfs 42.370 af

Pond 1P: Johns Pond Peak Elev=39.98' Storage=524.312 af Inflow=864.26 cfs 1,585.877 af
Discarded=2.78 cfs 88.393 af Primary=62.98 cfs 1,429.770 af Outflow=65.76 cfs 1,518.163 af

Pond 2P: Former Cranberry Bog Peak Elev=41.38' Storage=6.421 af Inflow=83.51 cfs 116.031 af
Outflow=79.01 cfs 116.031 af

Total Runoff Area = 5,083.670 ac Runoff Volume = 1,585.877 af Average Runoff Depth = 3.74"
99.21% Pervious = 5,043.370 ac 0.79% Impervious = 40.300 ac

Summary for Subcatchment 1S: Overland

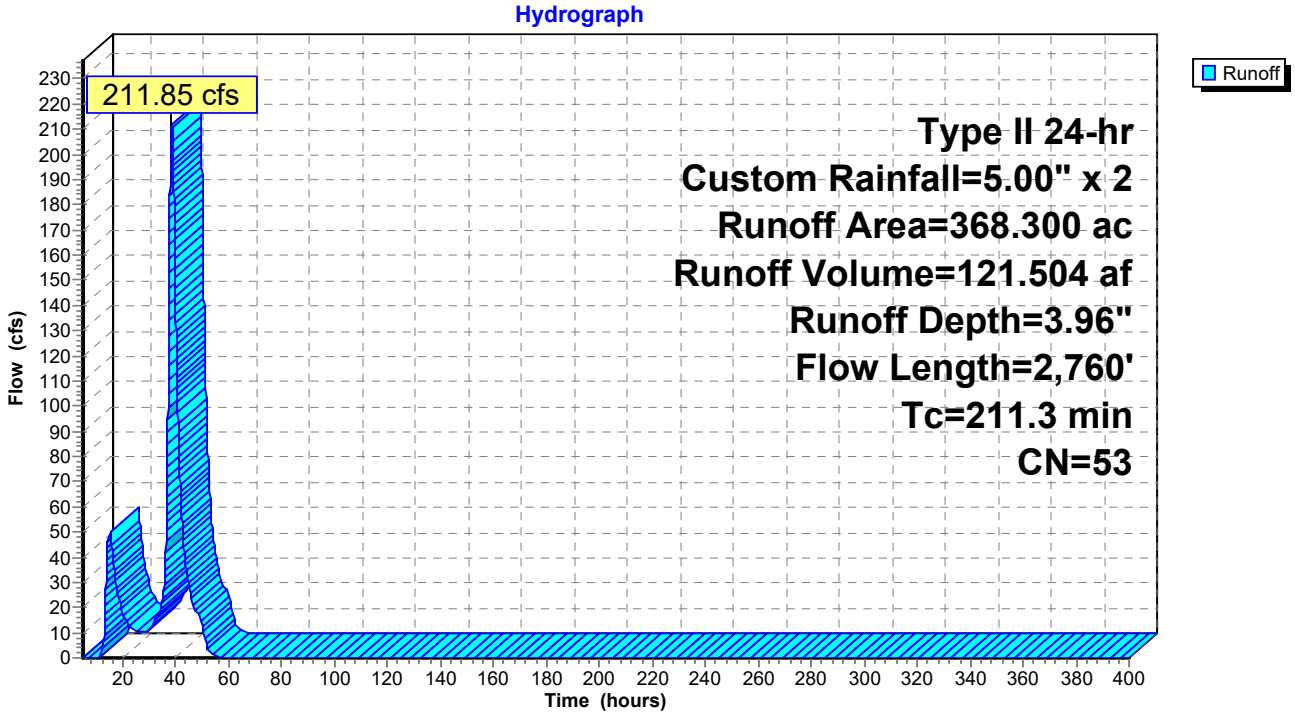
Runoff = 211.85 cfs @ 38.53 hrs, Volume= 121.504 af, Depth= 3.96"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-400.00 hrs, dt= 0.05 hrs
Type II 24-hr Custom Rainfall=5.00" x 2

	Area (ac)	CN	Description
*	368.300	53	See Spreadsheet
	368.300		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
30.8	50	0.0100	0.03		**Sheet Flow,** Woods: Dense underbrush n= 0.800 P2= 2.70"
3.3	100	0.0100	0.50		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
177.2	2,610	0.0300	0.25	4.91	**Channel Flow,** Area= 20.0 sf Perim= 30.0' r= 0.67' n= 0.800 Sheet flow: Woods+dense brush
211.3	2,760	Total			

Subcatchment 1S: Overland



Summary for Subcatchment 2S: Estimated Subsurface Flow

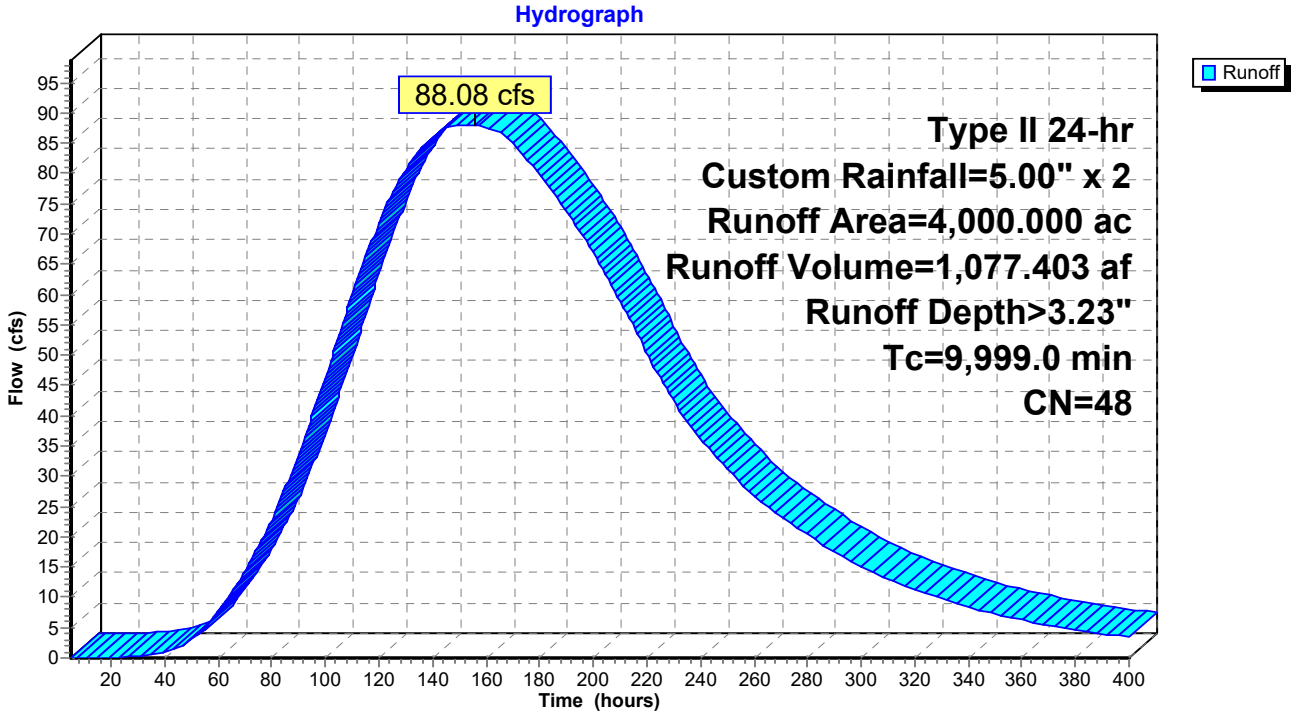
Runoff = 88.08 cfs @ 155.50 hrs, Volume= 1,077.403 af, Depth> 3.23"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-400.00 hrs, dt= 0.05 hrs
Type II 24-hr Custom Rainfall=5.00" x 2

	Area (ac)	CN	Description
*	4,000.000	48	
	4,000.000		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9,999.0					**Direct Entry,**

Subcatchment 2S: Estimated Subsurface Flow



Summary for Subcatchment 3S: Johns Pond - Water Only

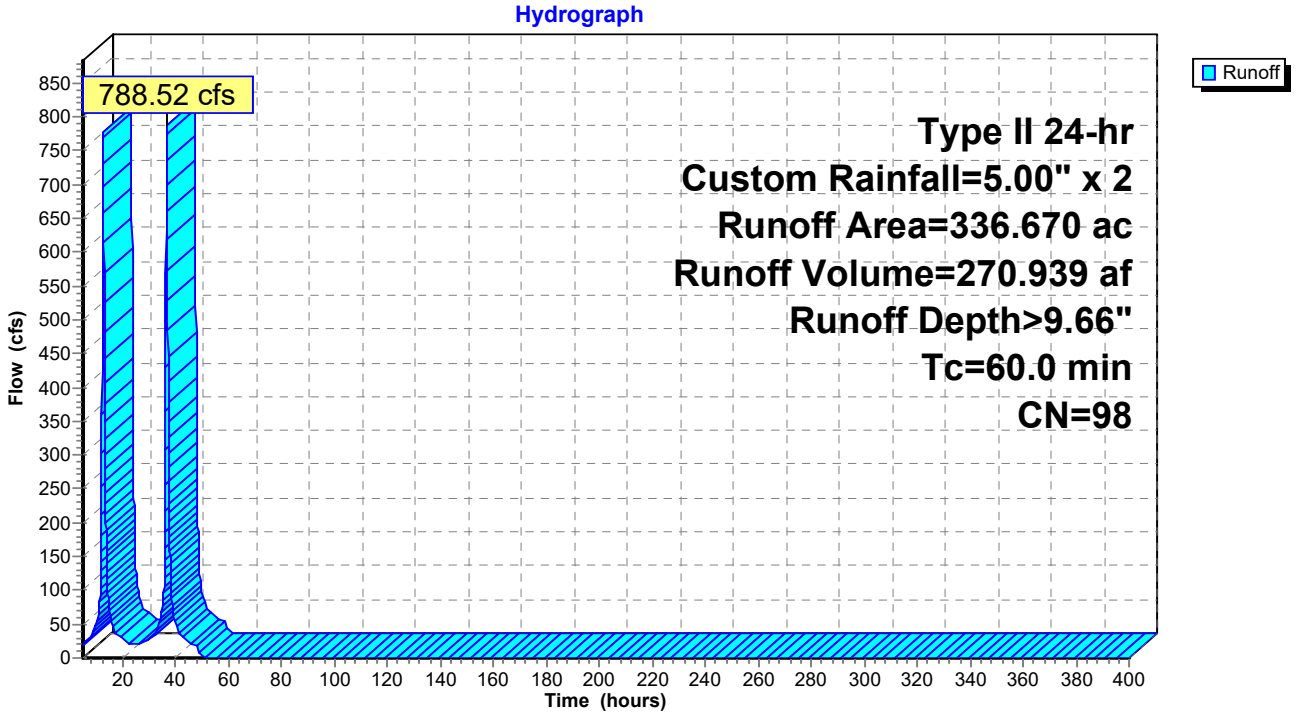
Runoff = 788.52 cfs @ 36.59 hrs, Volume= 270.939 af, Depth> 9.66"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-400.00 hrs, dt= 0.05 hrs
Type II 24-hr Custom Rainfall=5.00" x 2

Area (ac)	CN	Description
336.670	98	Water Surface, 0% imp, HSG A
336.670		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
60.0					**Direct Entry, 60**

Subcatchment 3S: Johns Pond - Water Only



Summary for Subcatchment 4S: Airport to Cranberry Bog

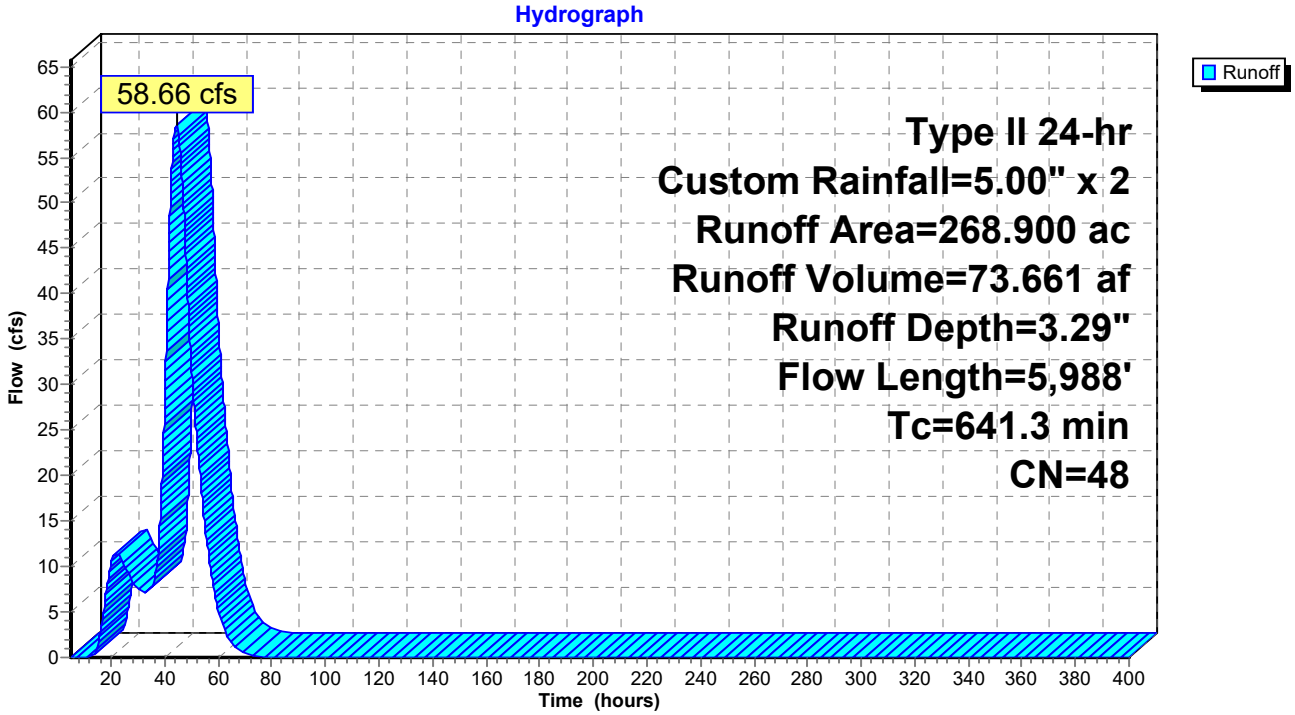
Runoff = 58.66 cfs @ 44.21 hrs, Volume= 73.661 af, Depth= 3.29"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-400.00 hrs, dt= 0.05 hrs
Type II 24-hr Custom Rainfall=5.00" x 2

Area (ac)	CN	Description
40.300	98	Paved parking, HSG A
228.600	39	>75% Grass cover, Good, HSG A
268.900	48	Weighted Average
228.600		85.01% Pervious Area
40.300		14.99% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
20.4	50	0.0280	0.04		**Sheet Flow,** Woods: Dense underbrush n= 0.800 P2= 2.70"
2.0	100	0.0280	0.84		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
618.9	5,838	0.0123	0.16	3.14	**Channel Flow,** Area= 20.0 sf Perim= 30.0' r= 0.67' n= 0.800 Sheet flow: Woods+dense brush
641.3	5,988	Total			

Subcatchment 4S: Airport to Cranberry Bog



Summary for Subcatchment 5S: Subcatchment to Small Cranberry Bog

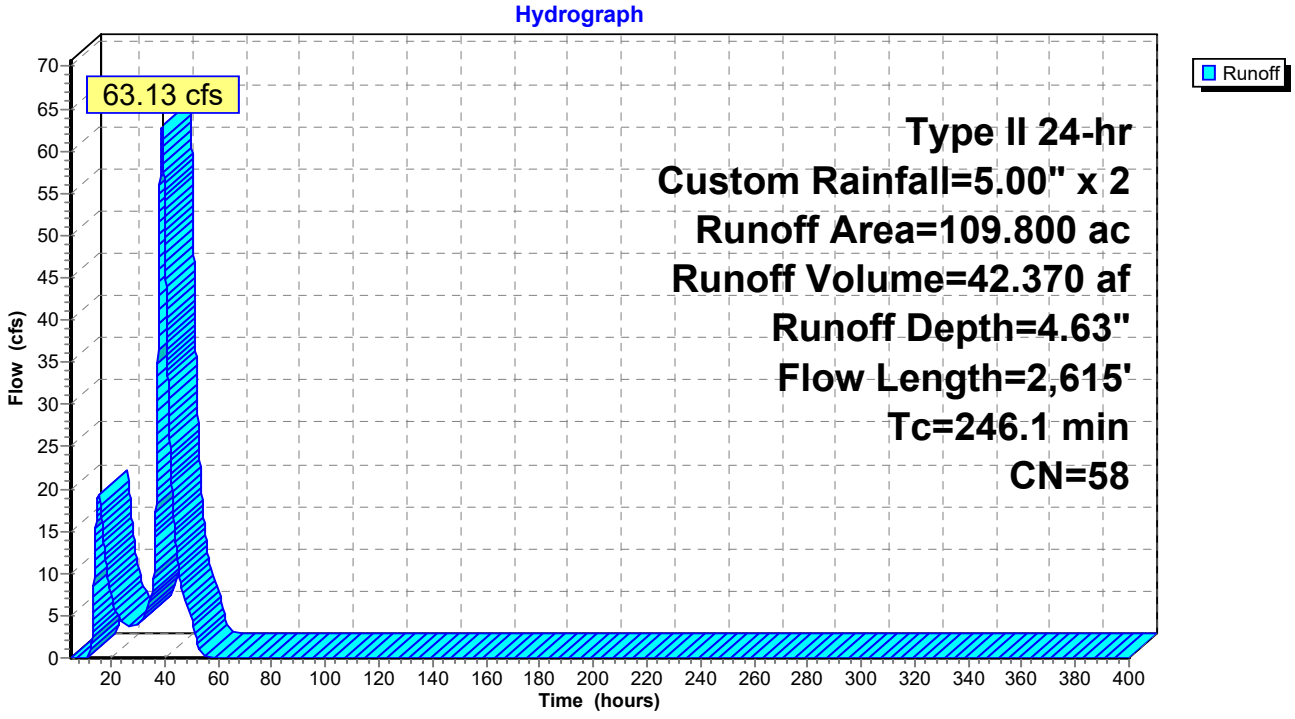
Runoff = 63.13 cfs @ 39.08 hrs, Volume= 42.370 af, Depth= 4.63"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-400.00 hrs, dt= 0.05 hrs
Type II 24-hr Custom Rainfall=5.00" x 2

	Area (ac)	CN	Description
*	109.800	58	See Spreadsheet
	109.800		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
15.6	50	0.0550	0.05		**Sheet Flow,** Woods: Dense underbrush n= 0.800 P2= 2.70"
1.4	100	0.0550	1.17		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
229.1	2,465	0.0160	0.18	3.59	**Channel Flow,** Area= 20.0 sf Perim= 30.0' r= 0.67' n= 0.800 Sheet flow: Woods+dense brush
246.1	2,615	Total			

Subcatchment 5S: Subcatchment to Small Cranberry Bog



Summary for Pond 1P: Johns Pond

Inflow Area = 5,083.670 ac, 0.79% Impervious, Inflow Depth > 3.74" for Custom event
Inflow = 864.26 cfs @ 36.60 hrs, Volume= 1,585.877 af
Outflow = 65.76 cfs @ 201.55 hrs, Volume= 1,518.163 af, Atten= 92%, Lag= 9,896.7 min
Discarded = 2.78 cfs @ 201.55 hrs, Volume= 88.393 af
Primary = 62.98 cfs @ 201.55 hrs, Volume= 1,429.770 af

Routing by Stor-Ind method, Time Span= 5.00-400.00 hrs, dt= 0.05 hrs
Starting Elev= 38.20' Surf.Area= 252.600 ac Storage= 75.899 af
Peak Elev= 39.98' @ 201.55 hrs Surf.Area= 252.600 ac Storage= 524.312 af (448.413 af above start)

Plug-Flow detention time= 5,313.9 min calculated for 1,442.226 af (91% of inflow)
Center-of-Mass det. time= 3,750.6 min (11,711.2 - 7,960.7)

Volume	Invert	Avail.Storage	Storage Description
#1	37.56'	1,151.961 af	**Custom Stage Data (Conic)** Listed below (Recalc)

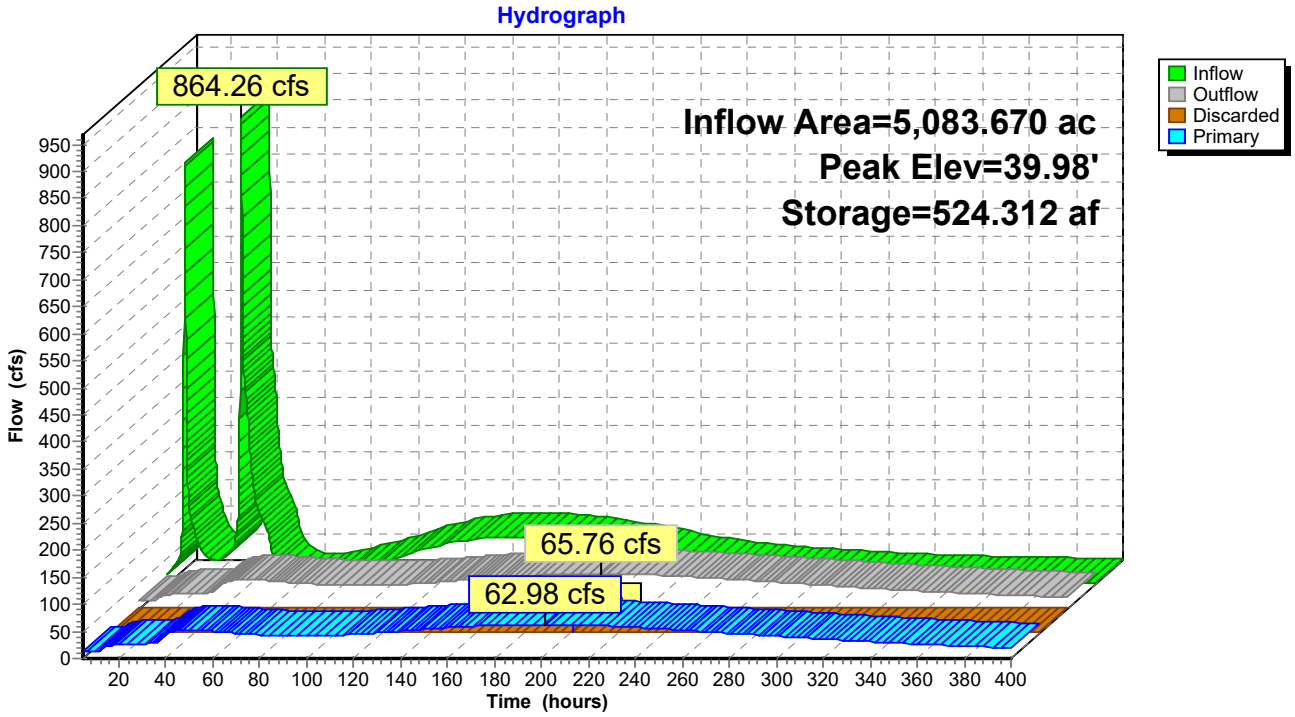
Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)	Wet.Area (acres)
37.56	0.010	0.000	0.000	0.010
37.70	0.011	0.001	0.001	0.011
38.00	252.400	25.408	25.409	252.400
38.10	252.400	25.240	50.649	252.427
38.20	252.600	25.250	75.899	252.629
40.00	252.600	454.680	530.579	253.115
42.00	372.660	621.382	1,151.961	373.176

Device	Routing	Invert	Outlet Devices
#1	Primary	37.31'	**2.0' long x 5.00' rise Sharp-Crested Rectangular Weir west - Fish Ladder** 2 End Contraction(s) 5.4' Crest Height
#2	Primary	37.35'	**3.3' long x 5.00' rise Sharp-Crested Rectangular Weir east - Bypass** 2 End Contraction(s) 5.5' Crest Height
#3	Primary	40.00'	**28.0' long (Profile 1) Broad-Crested Rectangular Weir** Head (feet) 0.49 0.98 1.48 Coef. (English) 2.92 3.37 3.59
#4	Discarded	37.56'	**0.010 in/hr Exfiltration over Wetted area** Conductivity to Groundwater Elevation = 15.00'

Discarded OutFlow Max=2.78 cfs @ 201.55 hrs HW=39.98' (Free Discharge)
└**4=Exfiltration** (Controls 2.78 cfs)

Primary OutFlow Max=62.98 cfs @ 201.55 hrs HW=39.98' (Free Discharge)
├**1=Sharp-Crested Rectangular Weir west - Fish Ladder** (Weir Controls 22.13 cfs @ 5.66 fps)
├**2=Sharp-Crested Rectangular Weir east - Bypass** (Weir Controls 40.85 cfs @ 5.61 fps)
└**3=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Pond 1P: Johns Pond



Summary for Pond 2P: Former Cranberry Bog

Inflow Area = 378.700 ac, 10.64% Impervious, Inflow Depth = 3.68" for Custom event
Inflow = 83.51 cfs @ 39.36 hrs, Volume= 116.031 af
Outflow = 79.01 cfs @ 40.31 hrs, Volume= 116.031 af, Atten= 5%, Lag= 57.0 min
Primary = 79.01 cfs @ 40.31 hrs, Volume= 116.031 af

Routing by Stor-Ind method, Time Span= 5.00-400.00 hrs, dt= 0.05 hrs
Peak Elev= 41.38' @ 40.31 hrs Surf.Area= 3.149 ac Storage= 6.421 af

Plug-Flow detention time= 75.1 min calculated for 116.031 af (100% of inflow)
Center-of-Mass det. time= 74.6 min (2,459.4 - 2,384.8)

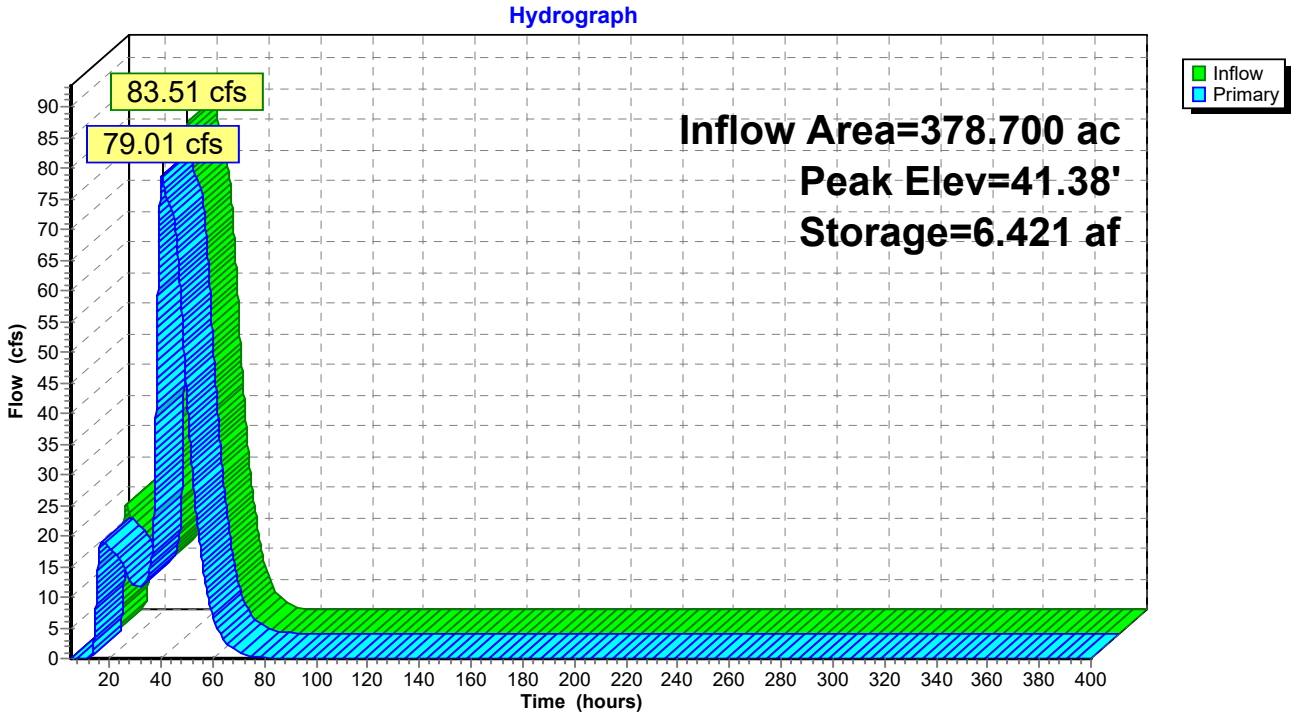
Volume	Invert	Avail.Storage	Storage Description
#1	39.00'	19.585 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

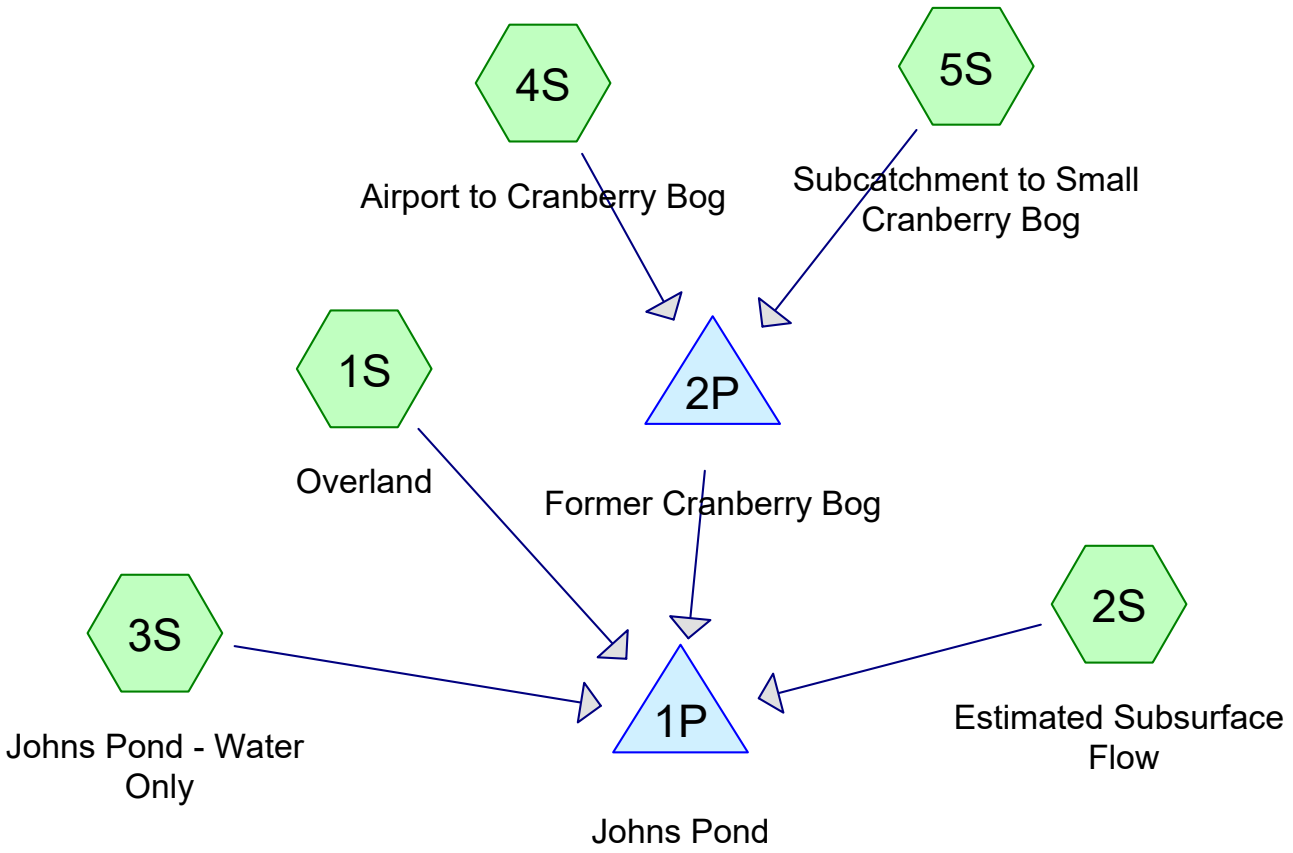
Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
39.00	1.890	0.000	0.000
40.00	2.780	2.335	2.335
45.00	4.120	17.250	19.585

Device	Routing	Invert	Outlet Devices
#1	Primary	39.00'	**6.0' long Broad-Crested Rectangular Weir** Head (feet) 0.49 0.98 1.48 Coef. (English) 2.92 3.37 3.59

Primary OutFlow Max=79.00 cfs @ 40.31 hrs HW=41.38' (Free Discharge)
↑—**1=Broad-Crested Rectangular Weir** (Weir Controls 79.00 cfs @ 5.54 fps)

Pond 2P: Former Cranberry Bog





Subcat Reach Pond Link

Routing Diagram for johns pond 1-22-19
Prepared by {enter your company name here}, Printed 3/21/2019

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
4,000.000	30	(2S)
228.600	39	>75% Grass cover, Good, HSG A (4S)
40.300	98	Paved parking, HSG A (4S)
368.300	53	See Spreadsheet (1S)
109.800	58	See Spreadsheet (5S)
336.670	98	Water Surface, 0% imp, HSG A (3S)
5,083.670	**38**	**TOTAL AREA**

Soil Listing (all nodes)

Area (acres)	Soil Group	Subcatchment Numbers
605.570	HSG A	3S, 4S
0.000	HSG B	
0.000	HSG C	
0.000	HSG D	
4,478.100	Other	1S, 2S, 5S
5,083.670		**TOTAL AREA**

Ground Covers (all nodes)

HSG-A (acres)	HSG-B (acres)	HSG-C (acres)	HSG-D (acres)	Other (acres)	Total (acres)	Ground Cover	Subcatchment Numbers
0.000	0.000	0.000	0.000	4,000.000	4,000.000		2S
228.600	0.000	0.000	0.000	0.000	228.600	>75% Grass cover, Good	4S
40.300	0.000	0.000	0.000	0.000	40.300	Paved parking	4S
0.000	0.000	0.000	0.000	478.100	478.100	See Spreadsheet	1S, 5S
336.670	0.000	0.000	0.000	0.000	336.670	Water Surface, 0% imp	3S
605.570	**0.000**	**0.000**	**0.000**	**4,478.100**	**5,083.670**	**TOTAL AREA**	

Time span=5.00-400.00 hrs, dt=0.05 hrs, 7901 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: Overland Runoff Area=368.300 ac 0.00% Impervious Runoff Depth=3.96"
Flow Length=2,760' Tc=211.3 min CN=53 Runoff=211.85 cfs 121.504 af

Subcatchment 2S: Estimated Runoff Area=4,000.000 ac 0.00% Impervious Runoff Depth>0.97"
Tc=9,999.0 min CN=30 Runoff=26.85 cfs 324.870 af

Subcatchment 3S: Johns Pond - Water Runoff Area=336.670 ac 0.00% Impervious Runoff Depth>9.66"
Tc=60.0 min CN=98 Runoff=788.52 cfs 270.939 af

Subcatchment 4S: Airport to Cranberry Runoff Area=268.900 ac 14.99% Impervious Runoff Depth=3.29"
Flow Length=5,988' Tc=641.3 min CN=48 Runoff=58.66 cfs 73.661 af

Subcatchment 5S: Subcatchment to Small Runoff Area=109.800 ac 0.00% Impervious Runoff Depth=4.63"
Flow Length=2,615' Tc=246.1 min CN=58 Runoff=63.13 cfs 42.370 af

Pond 1P: Johns Pond Peak Elev=39.64' Storage=440.712 af Inflow=863.51 cfs 833.343 af
Discarded=2.74 cfs 85.008 af Primary=52.76 cfs 813.069 af Outflow=55.50 cfs 898.077 af

Pond 2P: Former Cranberry Bog Peak Elev=41.38' Storage=6.421 af Inflow=83.51 cfs 116.031 af
Outflow=79.01 cfs 116.031 af

Total Runoff Area = 5,083.670 ac Runoff Volume = 833.343 af Average Runoff Depth = 1.97"
99.21% Pervious = 5,043.370 ac 0.79% Impervious = 40.300 ac

Summary for Subcatchment 1S: Overland

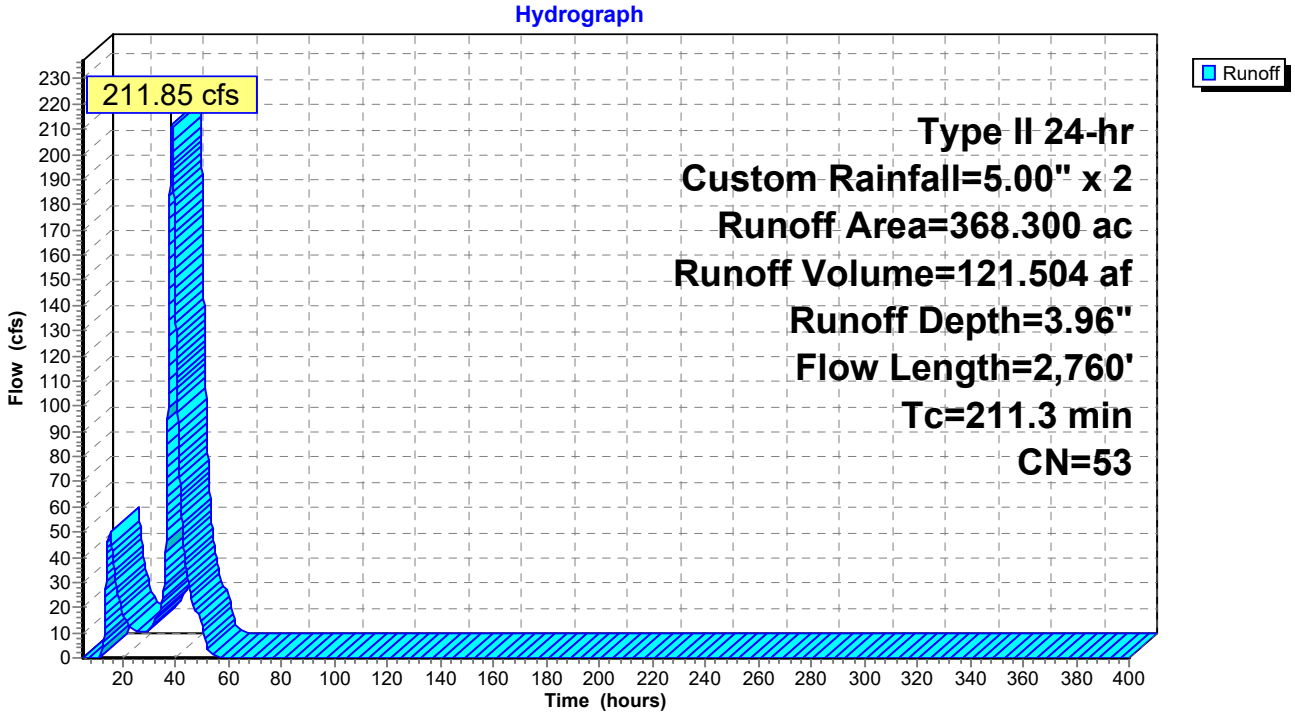
Runoff = 211.85 cfs @ 38.53 hrs, Volume= 121.504 af, Depth= 3.96"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-400.00 hrs, dt= 0.05 hrs
Type II 24-hr Custom Rainfall=5.00" x 2

	Area (ac)	CN	Description
*	368.300	53	See Spreadsheet
	368.300		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
30.8	50	0.0100	0.03		**Sheet Flow,** Woods: Dense underbrush n= 0.800 P2= 2.70"
3.3	100	0.0100	0.50		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
177.2	2,610	0.0300	0.25	4.91	**Channel Flow,** Area= 20.0 sf Perim= 30.0' r= 0.67' n= 0.800 Sheet flow: Woods+dense brush
211.3	2,760	Total			

Subcatchment 1S: Overland



Summary for Subcatchment 2S: Estimated Subsurface Flow

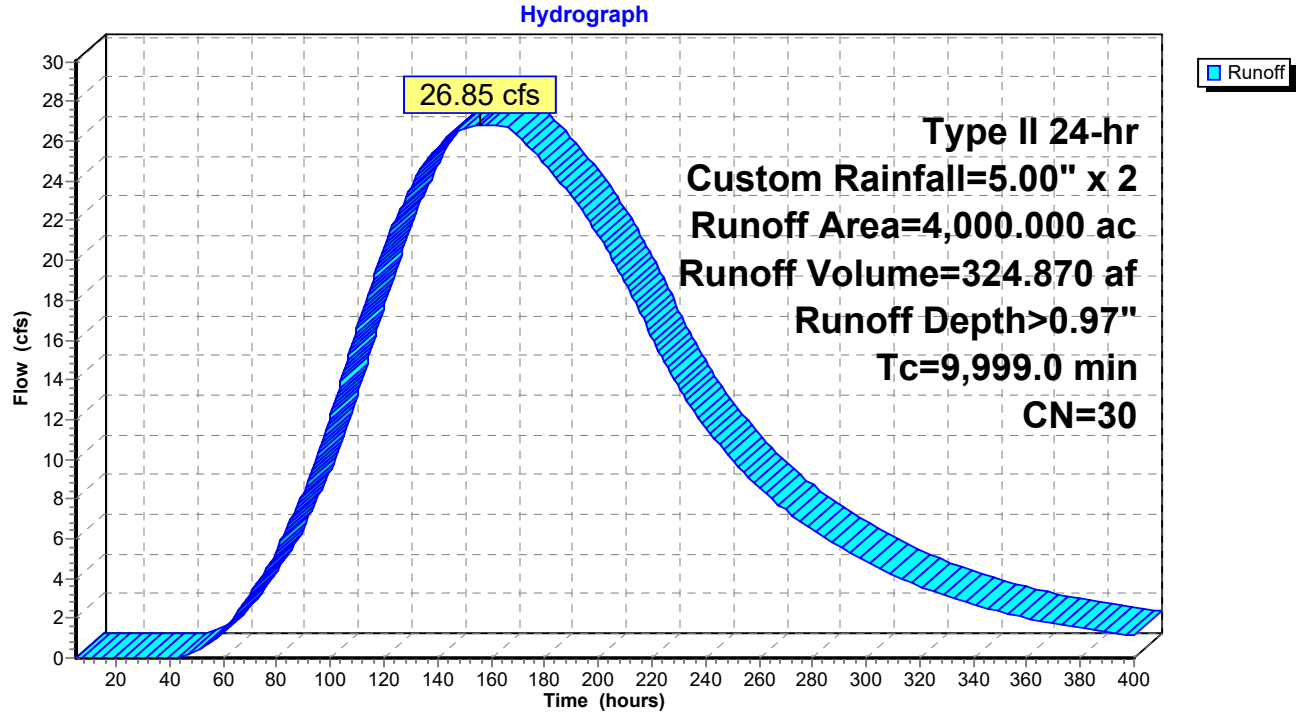
Runoff = 26.85 cfs @ 155.56 hrs, Volume= 324.870 af, Depth> 0.97"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-400.00 hrs, dt= 0.05 hrs
Type II 24-hr Custom Rainfall=5.00" x 2

	Area (ac)	CN	Description
*	4,000.000	30	
	4,000.000		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9,999.0					**Direct Entry,**

Subcatchment 2S: Estimated Subsurface Flow



Summary for Subcatchment 3S: Johns Pond - Water Only

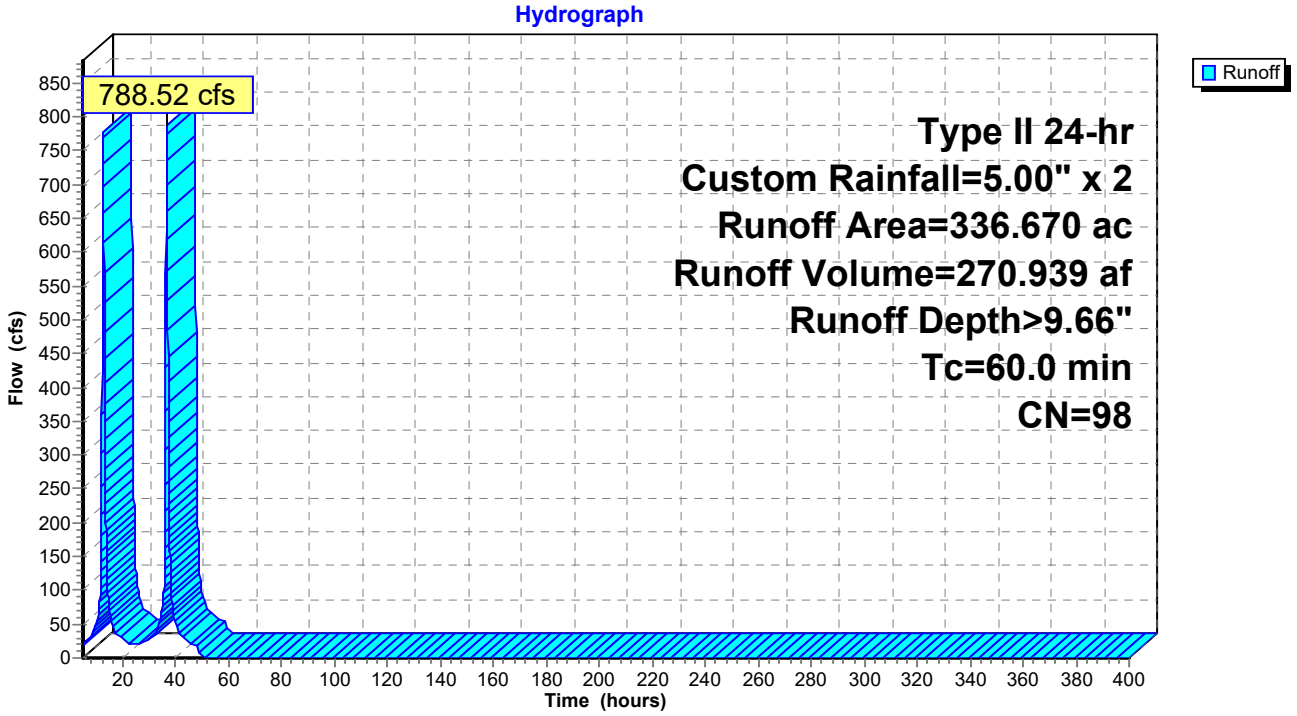
Runoff = 788.52 cfs @ 36.59 hrs, Volume= 270.939 af, Depth> 9.66"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-400.00 hrs, dt= 0.05 hrs
Type II 24-hr Custom Rainfall=5.00" x 2

Area (ac)	CN	Description
336.670	98	Water Surface, 0% imp, HSG A
336.670		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
60.0					**Direct Entry, 60**

Subcatchment 3S: Johns Pond - Water Only



Summary for Subcatchment 4S: Airport to Cranberry Bog

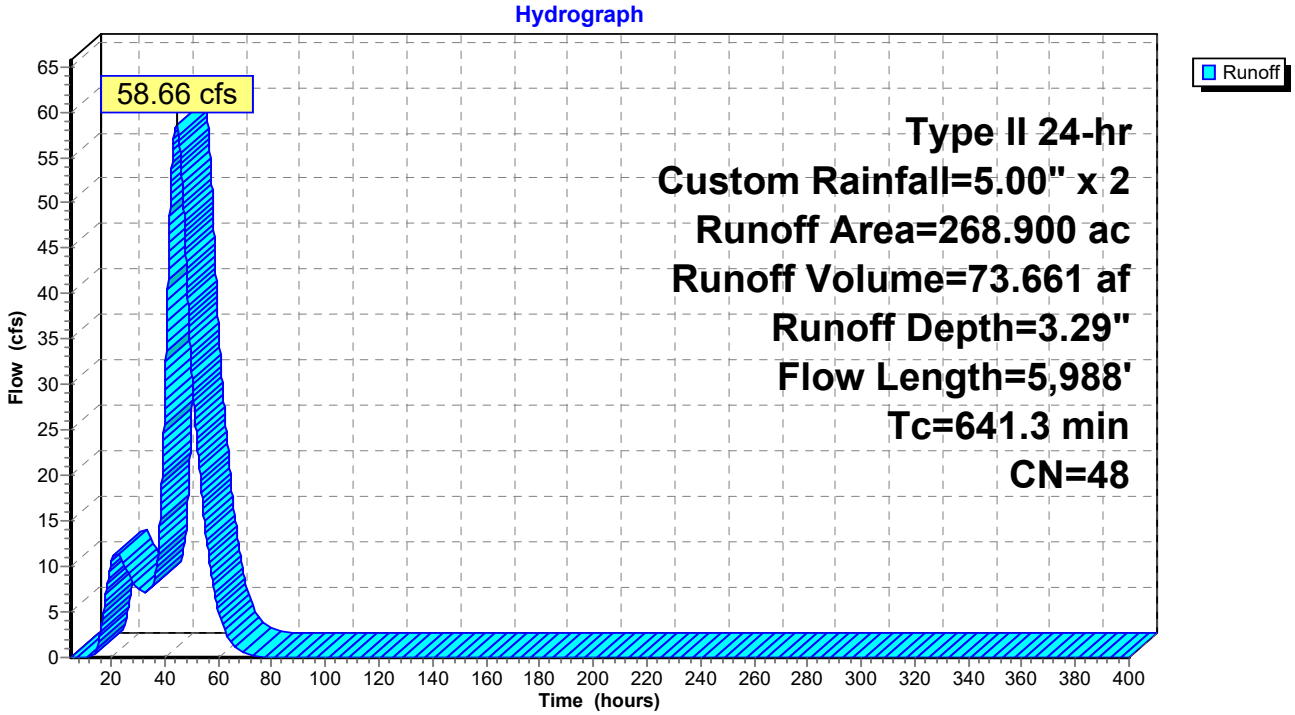
Runoff = 58.66 cfs @ 44.21 hrs, Volume= 73.661 af, Depth= 3.29"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-400.00 hrs, dt= 0.05 hrs
Type II 24-hr Custom Rainfall=5.00" x 2

Area (ac)	CN	Description
40.300	98	Paved parking, HSG A
228.600	39	>75% Grass cover, Good, HSG A
268.900	48	Weighted Average
228.600		85.01% Pervious Area
40.300		14.99% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
20.4	50	0.0280	0.04		**Sheet Flow,** Woods: Dense underbrush n= 0.800 P2= 2.70"
2.0	100	0.0280	0.84		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
618.9	5,838	0.0123	0.16	3.14	**Channel Flow,** Area= 20.0 sf Perim= 30.0' r= 0.67' n= 0.800 Sheet flow: Woods+dense brush
641.3	5,988	Total			

Subcatchment 4S: Airport to Cranberry Bog



Summary for Subcatchment 5S: Subcatchment to Small Cranberry Bog

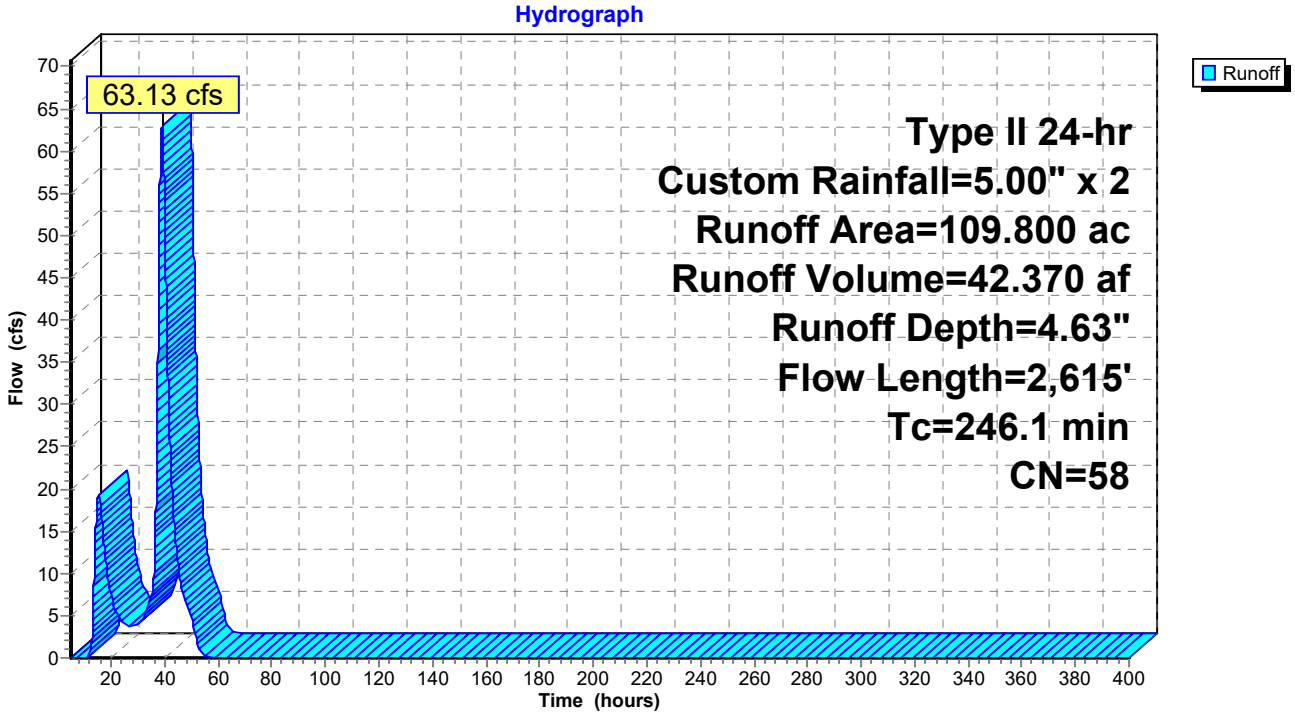
Runoff = 63.13 cfs @ 39.08 hrs, Volume= 42.370 af, Depth= 4.63"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-400.00 hrs, dt= 0.05 hrs
Type II 24-hr Custom Rainfall=5.00" x 2

	Area (ac)	CN	Description
*	109.800	58	See Spreadsheet
	109.800		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
15.6	50	0.0550	0.05		**Sheet Flow,** Woods: Dense underbrush n= 0.800 P2= 2.70"
1.4	100	0.0550	1.17		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
229.1	2,465	0.0160	0.18	3.59	**Channel Flow,** Area= 20.0 sf Perim= 30.0' r= 0.67' n= 0.800 Sheet flow: Woods+dense brush
246.1	2,615	Total			

Subcatchment 5S: Subcatchment to Small Cranberry Bog



Summary for Pond 1P: Johns Pond

Inflow Area = 5,083.670 ac, 0.79% Impervious, Inflow Depth > 1.97" for Custom event
Inflow = 863.51 cfs @ 36.60 hrs, Volume= 833.343 af
Outflow = 55.50 cfs @ 50.06 hrs, Volume= 898.077 af, Atten= 94%, Lag= 807.3 min
Discarded = 2.74 cfs @ 50.06 hrs, Volume= 85.008 af
Primary = 52.76 cfs @ 50.06 hrs, Volume= 813.069 af

Routing by Stor-Ind method, Time Span= 5.00-400.00 hrs, dt= 0.05 hrs
Starting Elev= 38.20' Surf.Area= 252.600 ac Storage= 75.899 af
Peak Elev= 39.64' @ 50.06 hrs Surf.Area= 252.600 ac Storage= 440.712 af (364.813 af above start)

Plug-Flow detention time= 5,339.4 min calculated for 822.141 af (99% of inflow)
Center-of-Mass det. time= 4,349.5 min (9,813.8 - 5,464.3)

Volume	Invert	Avail.Storage	Storage Description
#1	37.56'	1,151.961 af	**Custom Stage Data (Conic)** Listed below (Recalc)

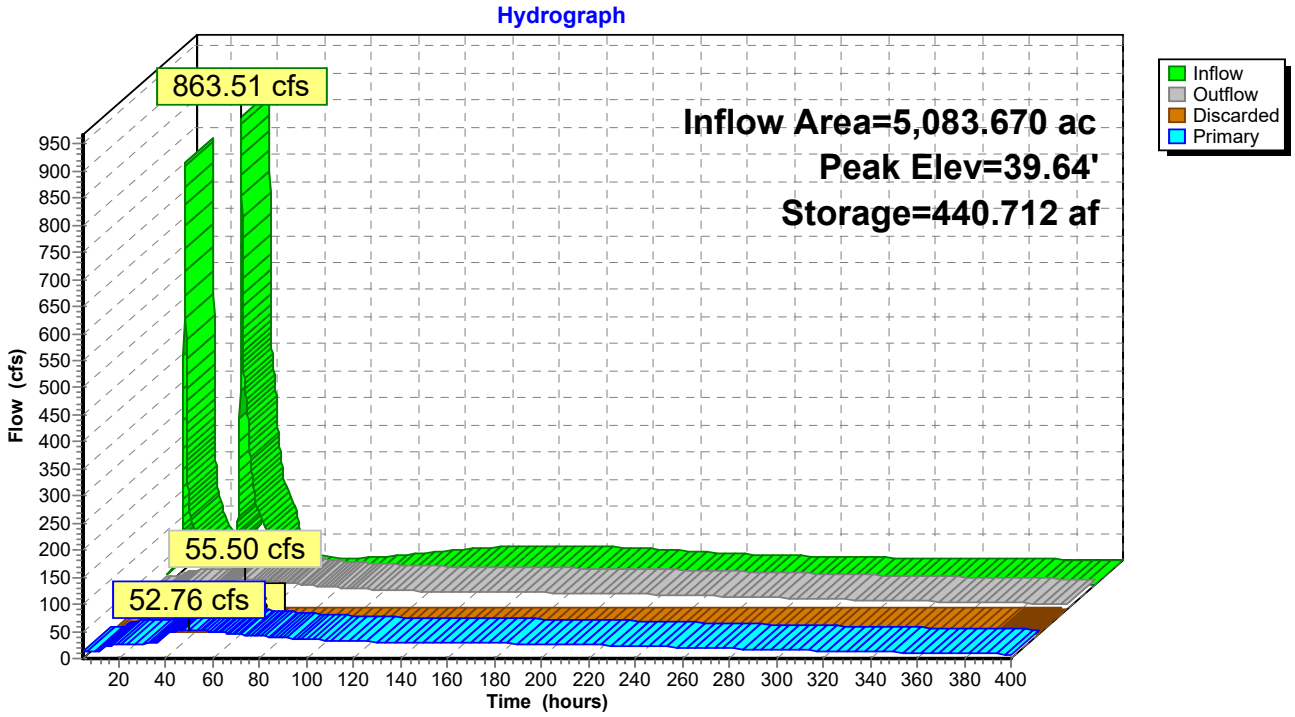
Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)	Wet.Area (acres)
37.56	0.010	0.000	0.000	0.010
37.70	0.011	0.001	0.001	0.011
38.00	252.400	25.408	25.409	252.400
38.10	252.400	25.240	50.649	252.427
38.20	252.600	25.250	75.899	252.629
40.00	252.600	454.680	530.579	253.115
42.00	372.660	621.382	1,151.961	373.176

Device	Routing	Invert	Outlet Devices
#1	Primary	37.31'	**2.0' long x 5.00' rise Sharp-Crested Rectangular Weir west - Fish Ladder** 2 End Contraction(s) 5.4' Crest Height
#2	Primary	37.35'	**3.3' long x 5.00' rise Sharp-Crested Rectangular Weir east - Bypass** 2 End Contraction(s) 5.5' Crest Height
#3	Primary	40.00'	**28.0' long (Profile 1) Broad-Crested Rectangular Weir** Head (feet) 0.49 0.98 1.48 Coef. (English) 2.92 3.37 3.59
#4	Discarded	37.56'	**0.010 in/hr Exfiltration over Wetted area** Conductivity to Groundwater Elevation = 15.00'

Discarded OutFlow Max=2.74 cfs @ 50.06 hrs HW=39.64' (Free Discharge)
└**4=Exfiltration** (Controls 2.74 cfs)

Primary OutFlow Max=52.76 cfs @ 50.06 hrs HW=39.64' (Free Discharge)
├**1=Sharp-Crested Rectangular Weir west - Fish Ladder** (Weir Controls 18.82 cfs @ 5.26 fps)
├**2=Sharp-Crested Rectangular Weir east - Bypass** (Weir Controls 33.93 cfs @ 5.21 fps)
└**3=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Pond 1P: Johns Pond



Summary for Pond 2P: Former Cranberry Bog

Inflow Area = 378.700 ac, 10.64% Impervious, Inflow Depth = 3.68" for Custom event
Inflow = 83.51 cfs @ 39.36 hrs, Volume= 116.031 af
Outflow = 79.01 cfs @ 40.31 hrs, Volume= 116.031 af, Atten= 5%, Lag= 57.0 min
Primary = 79.01 cfs @ 40.31 hrs, Volume= 116.031 af

Routing by Stor-Ind method, Time Span= 5.00-400.00 hrs, dt= 0.05 hrs
Peak Elev= 41.38' @ 40.31 hrs Surf.Area= 3.149 ac Storage= 6.421 af

Plug-Flow detention time= 75.1 min calculated for 116.031 af (100% of inflow)
Center-of-Mass det. time= 74.6 min (2,459.4 - 2,384.8)

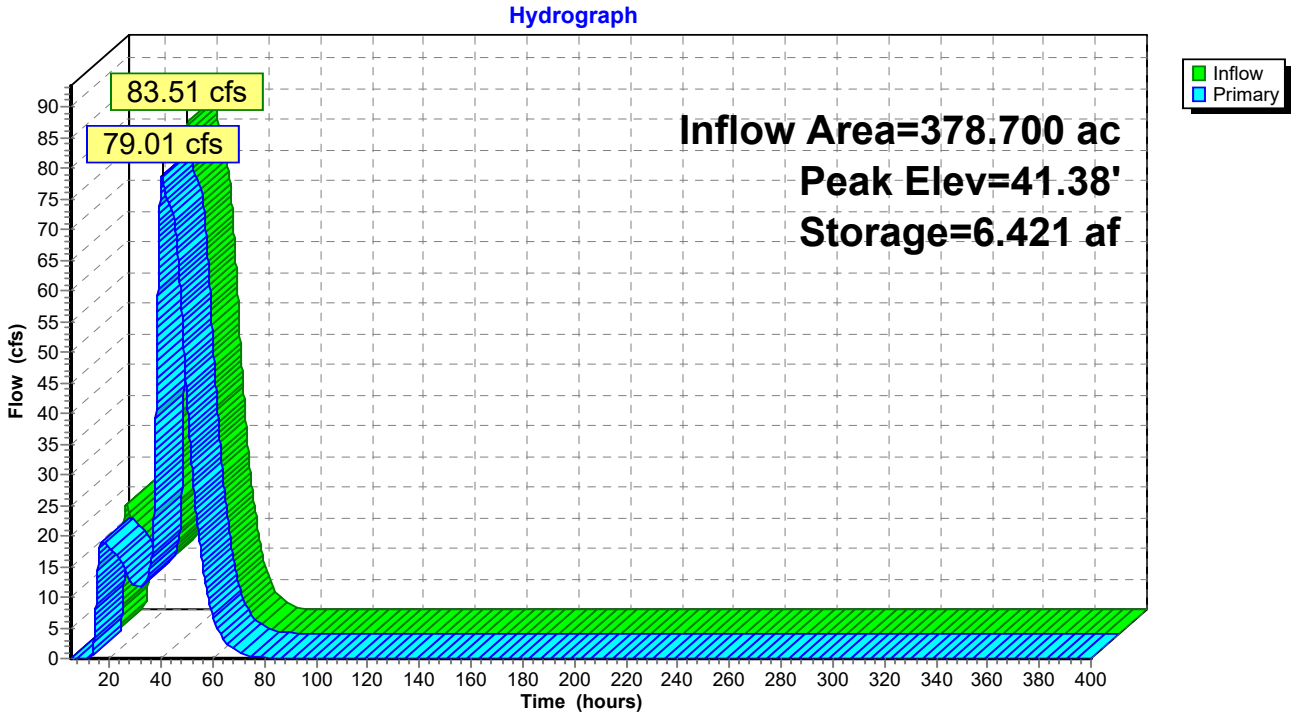
Volume	Invert	Avail.Storage	Storage Description
#1	39.00'	19.585 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
39.00	1.890	0.000	0.000
40.00	2.780	2.335	2.335
45.00	4.120	17.250	19.585

Device	Routing	Invert	Outlet Devices
#1	Primary	39.00'	**6.0' long Broad-Crested Rectangular Weir** Head (feet) 0.49 0.98 1.48 Coef. (English) 2.92 3.37 3.59

Primary OutFlow Max=79.00 cfs @ 40.31 hrs HW=41.38' (Free Discharge)
↑—**1=Broad-Crested Rectangular Weir** (Weir Controls 79.00 cfs @ 5.54 fps)

Pond 2P: Former Cranberry Bog



2.07 Fish Ladder

As a coincidental issue related to but not required in this study, the fish ladder is seen to be a narrow (only 2 feet wide) step with a step every foot resulting in confined rest areas for fish between steps that have high velocities up to (13 feet / sec in the lower reach of the ladder). Velocities (far right column) in the spaces between each step are tabulated below :

Elev	depth over	water	Depth ft	**Existing Fish Ladder**				
Weir Inv	weir	level		channel	Q	channel	area	vel
				height	cfs	width	s.f	ft/sec
32.70	0.50	33.20						sideways
33.26	0.50	33.76	0.56	1.06		1	1.06	13.3
33.81	0.50	34.31	1.11	1.61		1.00	1.61	8.7
34.37	0.50	34.87	1.67	2.17		1.00	2.17	6.5
34.92	0.50	35.42	2.22	2.72		1.00	2.72	5.1
35.48	0.50	35.98	2.78	3.28		1.00	3.28	4.3
36.03	0.50	36.53	3.33	3.83		1.00	3.83	3.7
36.59	0.50	37.09	3.89	4.39		1.00	4.39	3.2
37.14	0.50	37.64	4.44	4.94		1.00	4.94	2.8
37.70	0.50	38.20	5.00	5.50		1.00	5.50	2.5
38.26	0.50	38.76	5.56	6.06		1.00	6.06	2.3

This ladder rises 5 feet over a horizonatal length of about 15 feet (3:1 average slope)

View of existing turbulent - high velocity - fish ladder

If the ladder is reconfigured to be serpentine and steps 2 feet apart, the velocities in the resting pools will fall to 1/3 of those currently existing. This option would result in about nine 6"-7" steps rising the same 5 feet as exists over a running line of 35 feet or a slope of 7:1 which is less than ½ as steep as the existing option. This does not affect the capacity of the weir to pass flood level because critical flow will occur at the most upstream weir and the flow is to steep to result in back water conditions.

Conceptual serpentine fish ladder configuration within existing structure

	depth over	water	d	**Existing Fish Ladder**				
weir	weir	level		channel	Q	channel	area	vel
				height	cfs	width	s.f	ft/sec
32.70	0.50	33.20						sideways
33.26	0.50	33.76	0.56	1.06		1	1.06	13.3
33.81	0.50	34.31	1.11	1.61		1.00	1.61	8.7
34.37	0.50	34.87	1.67	2.17		1.00	2.17	6.5
34.92	0.50	35.42	2.22	2.72		1.00	2.72	5.1
35.48	0.50	35.98	2.78	3.28		1.00	3.28	4.3
36.03	0.50	36.53	3.33	3.83		1.00	3.83	3.7
36.59	0.50	37.09	3.89	4.39		1.00	4.39	3.2
37.14	0.50	37.64	4.44	4.94		1.00	4.94	2.8
37.70	0.50	38.20	5.00	5.50		1.00	5.50	2.5
38.26	0.50	38.76	5.56	6.06		1.00	6.06	2.3

elev	depth over	water	Depth ft	channel	Q	channel	area	vel
weir	weir	level		height	cfs	width	s.f	ft/sec
				Alternate Fish Ladder				sideways
32.70	0.50	33.20			14	3.33		
33.26	0.50	33.76	0.56	1.06		3.33	3.52	4.0
33.81	0.50	34.31	1.11	1.61		3.33	5.37	2.6
34.37	0.50	34.87	1.67	2.17		3.33	7.22	1.9
34.92	0.50	35.42	2.22	2.72		3.33	9.07	1.5
35.48	0.50	35.98	2.78	3.28		3.33	10.92	1.3
36.03	0.50	36.53	3.33	3.83		3.33	12.77	1.1
36.59	0.50	37.09	3.89	4.39		3.33	14.62	1.0
37.14	0.50	37.64	4.44	4.94		3.33	16.47	0.9
37.70	0.50	38.20	5.00	5.50		3.33	18.32	0.8
38.26	0.50	38.76	5.56	6.06		3.33	20.17	0.7

3.0 Entrance Channel and Erosion

The weir entrance channel consists of an 8-foot wide, 35-foot long, gently sloping sandy channel bed. The current sand level at the edge of the control structure is elevation 36. The concrete base on the control structure is at elevation 34.5 meaning that the bed of the discharge channel is 1.5 feet above the concrete. The sand stream bed at the edge of the pond is elevation 36.3 as there is no sand above elevation 36.3 as the pond bottom then slopes back downward to deeper water.

Based on a grain size analysis of the sediment in the channel (see Appendix G) , 95% of the sediment is coarser that 0.5 mm. Based on the width of the channel and calculated depth of flow during the 100-year storm event, the flow depth will be about 2.5 feet deep (surface elevation 38.5 and channel floor of elevation 36.0 (i.e. 2.5 feet deep)) with a flow rate of 45 CFS rendering an average 100-year velocity of 2.25 ft/sec.

The sediment is a fairly uniform medium sand. Based on 95% of the particles being larger than 500 microns (0.5 mm), the Stokes' Law settling velocity of 500-micron particles is such that 95 % of the particles will settle out before they pass 40% of the channel length (i.e. they will drop the depth of the channel at the 100-year outflow velocity. This indicates a very small sediment transport potential.

The issue seems to be that even with little sand migration, which would occur most when the fish ladder is operated at the lowest stop log (hence the stop logs would not act to retain sand), there is a need to prevent sand from entering the channel through a sand migration barrier across the end of the channel.

The channel downstream of the structure has steep sandy banks that exhibit ongoing erosion. This is best controlled by placement of rip rap.

4.0 Recommended Improvements

Based on providing 100-year flood protection with the winter operating water level of 38.0 and a top of stop logs at elevation 37.5 (the maximum operating level of the pond):

1) Provide earthen fill and stabilize the surface via loam and seed to create additional freeboard to insure adequate freeboard above the 100-year calculated peak pond elevation.

2) Place filter fabric and rip rap at the outlet end of the dam structure on the steep eroding embankments to control erosion.

3) Remove failing PVC sheet piling and replace with large (2'x2'x6') concrete block or equivalent to stabilize inlet channel banks,

4) Provide rip-rap groins and granite block "sand dam" to limit sand migration from shoreline into inlet channel.

5) Dredge inlet channel to just below the lowest weir elevation (top of concrete that weirs rest on).

6) Plant shrubbery either side of channel to provide vegetative cover for migrating fish upstream of dam.

7) Consider modification of fish ladder by construction of weir within wider side of dam structure. (This has potential to result in 60% slower velocities in the travel way used by fish resulting in reduced effort to reach the pond.)

8) Establish a regular program to observe the dam and monitor weather forecasts to modify stop logs if necessary.

5.0 Opinion of Costs for Construction

Based on the plans prepared to date and the understood permits required, BSC estimates the recommended improvements to be on the order of $100,000.

Johns Pond Dam				
Mashpee, MA				
Hydrologic/Hydraulic Assessment				
Opinion of Cost				
Item	**Units**	**Quantity**	**Unit Cost**	**Cost**
2'x2'x4' Concrete Bin Block	EA	26	$250.00	$6,500.00
Shrubs	EA	11	$150.00	$1,650.00
Dredging	CY	31	$16.22	$502.82
Riprap and rock lining	CY	25	$66.32	$1,658.00
fill (regrade)	cy	150	$20.00	$3,000.00
screen, place, spread 6" loam and seed	SY	185	$11.00	$2,035.00
Sand Migration Dam and groin	LS	1	$10,000.00	$10,000.00
fish ladder improvements	LS	1	$15,000.00	$15,000.00
Cleanup	LS	1	$5,000.00	$5,000.00
Engineering and permitting	Allowance	1	$30,000.00	$30,000.00
Subtotal				$75,345.82
General Conditions 12 %				$9,041.50
Sub total				$84,387.32
Contingency (10%)				$8,438.73
Net				**$92,826.05**

6.0 Expected Permits

The permits required to implement are expected to include :

1) Order of Conditions from the Conservation Commission under the wetland Protection Act and Mashpee Wetland Bylaw.

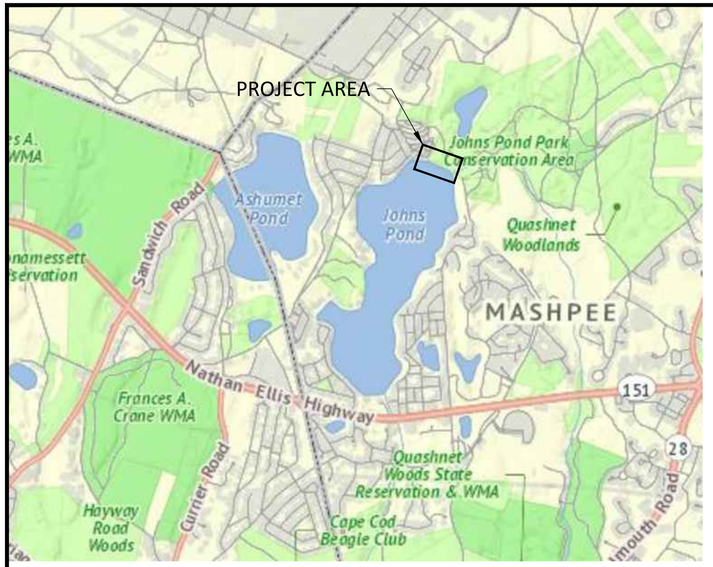
2) Chapter 91 Waterways permit for work within a Great Pond.

3) USACOE permit for a structure in a navigable waterway.

4) Office of Dam Safety Permit: Any person(s), who proposes to construct, repair, materially alter, breach or remove a dam, pursuant to M.G.L. Chapter 253, as amended by Chapter 330 of the Acts of 2002, must file with the Commissioner a notice for jurisdictional determination and/or file for a permit (if applicable). Further, any maintenance work or water level change(s) that affect safety conditions must file for a determination. No work is to commence before a determination is made by the Commissioner. If a permit is deemed necessary, then one must be obtained.

APPENDIX A

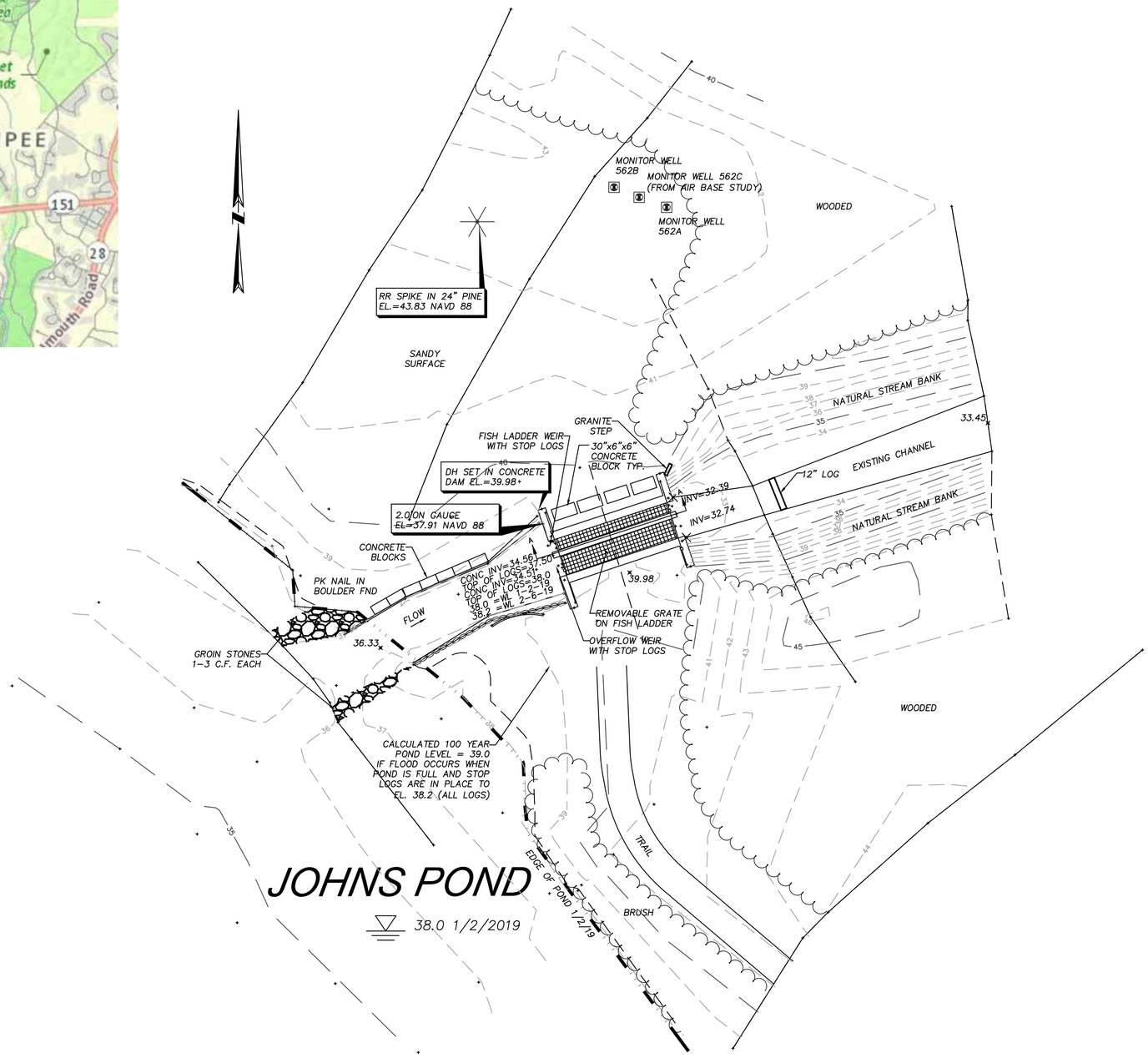
SURVEY OF EXISTING OUTLET STRUCTURE



LOCUS

SCALE: 1" = 2,000'

0 500 1,000 2,000 FEET



DATE OF SURVEY: 1-2-2019

NOTE: WETLANDS WERE NOT DELINEATED AS PART OF THIS SURVEY

DATE

PROFESSIONAL ENGINEER

HYDROLOGIC/ HYDRAULIC ASSESSMENT

JOHNS POND

IN

MASHPEE
MASSACHUSETTS
(BARNSTABLE COUNTY)

EXISTING CONDITIONS PLAN

FEBRUARY 22, 2019

REVISIONS:

NO.	DATE	DESC.

PREPARED FOR:
TOWN OF MASHPEE
CONSERVATION COMMISSION
16 GREAT NECK ROAD
MASHPEE, MA 02649

BSC GROUP
803 Summer Street
Boston, Massachusetts
02127
617 896 4300

SCALE: 1" = 10'

0 10 20 40 FEET

FILE: P\YAR\5026100\S\D

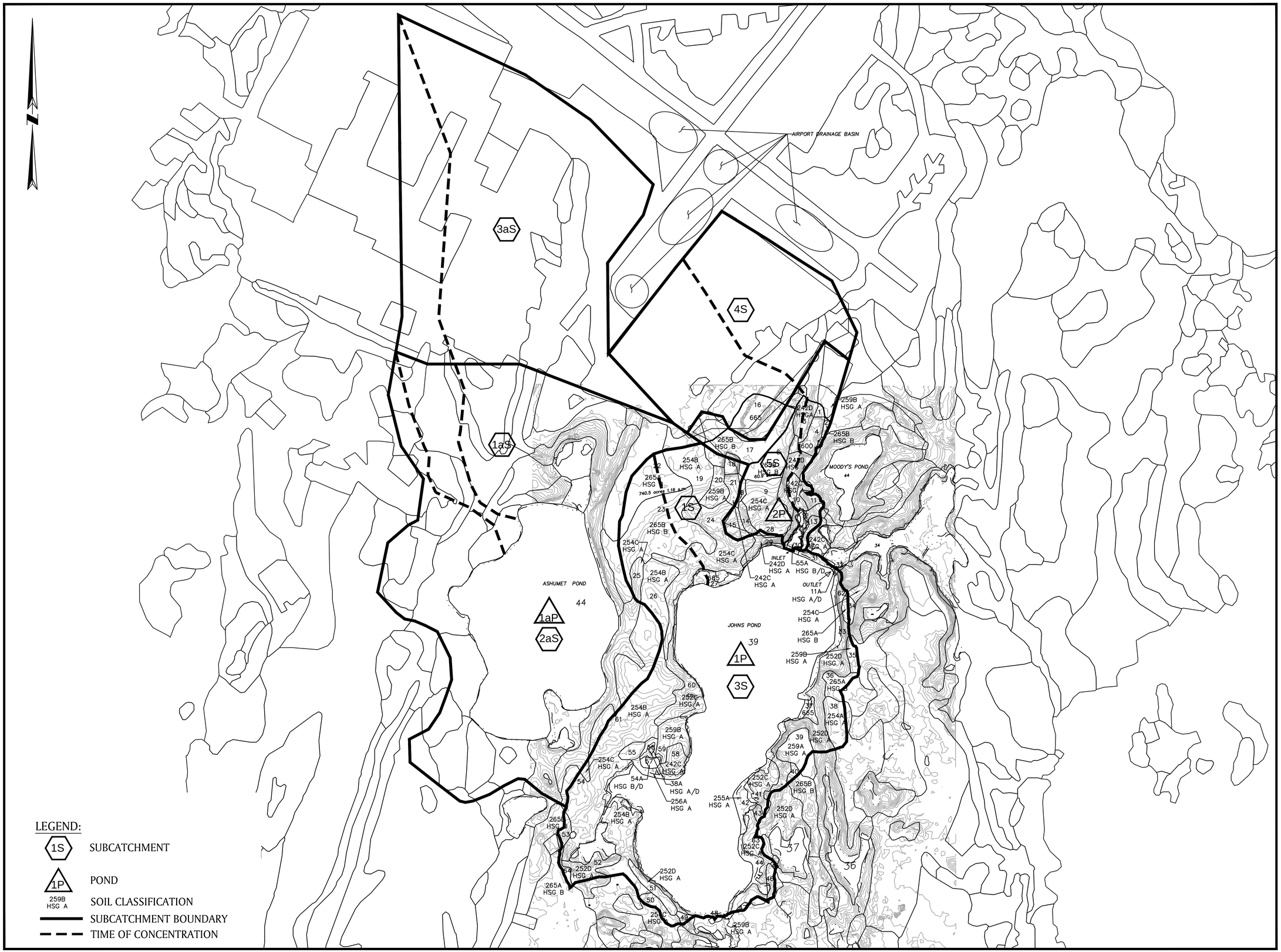
DWG.: DWG

JOB. NO: 5-0261.00

SHEET 1 OF 1

APPENDIX B

WATERSHED MAP



LEGEND:

- 1S — SUBCATCHMENT
- 1P — POND
- 259B HSG A — SOIL CLASSIFICATION
- SUBCATCHMENT BOUNDARY
- TIME OF CONCENTRATION

DATE

PROFESSIONAL ENGINEER

HYDROLOGIC/ HYDRAULIC ASSESSMENT

JOHNS POND

IN

MASHPEE
MASSACHUSETTS
(BARNSTABLE COUNTY)

WATERSHED MAP

MARCH 20, 2019

REVISIONS:

NO.	DATE	DESC.

PREPARED FOR:
TOWN OF MASHPEE
CONSERVATION COMMISSION
16 GREAT NECK ROAD
MASHPEE, MA 02649

BSC GROUP
803 Summer Street
Boston, Massachusetts
02127
617 896 4300

SCALE: 1" = 800'
0 400 800 1600 FEET

FILE: P\YAR\506100\DD\WATERSHED
DWG.: DWG
JOB. NO: 5-0261.00
SHEET 1 OF 1

APPENDIX C

NRCS SOIL SURVEY

United States Department of Agriculture

NRCS

Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for Barnstable County, Massachusetts

December 10, 2018

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (https://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

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Contents

How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil

scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

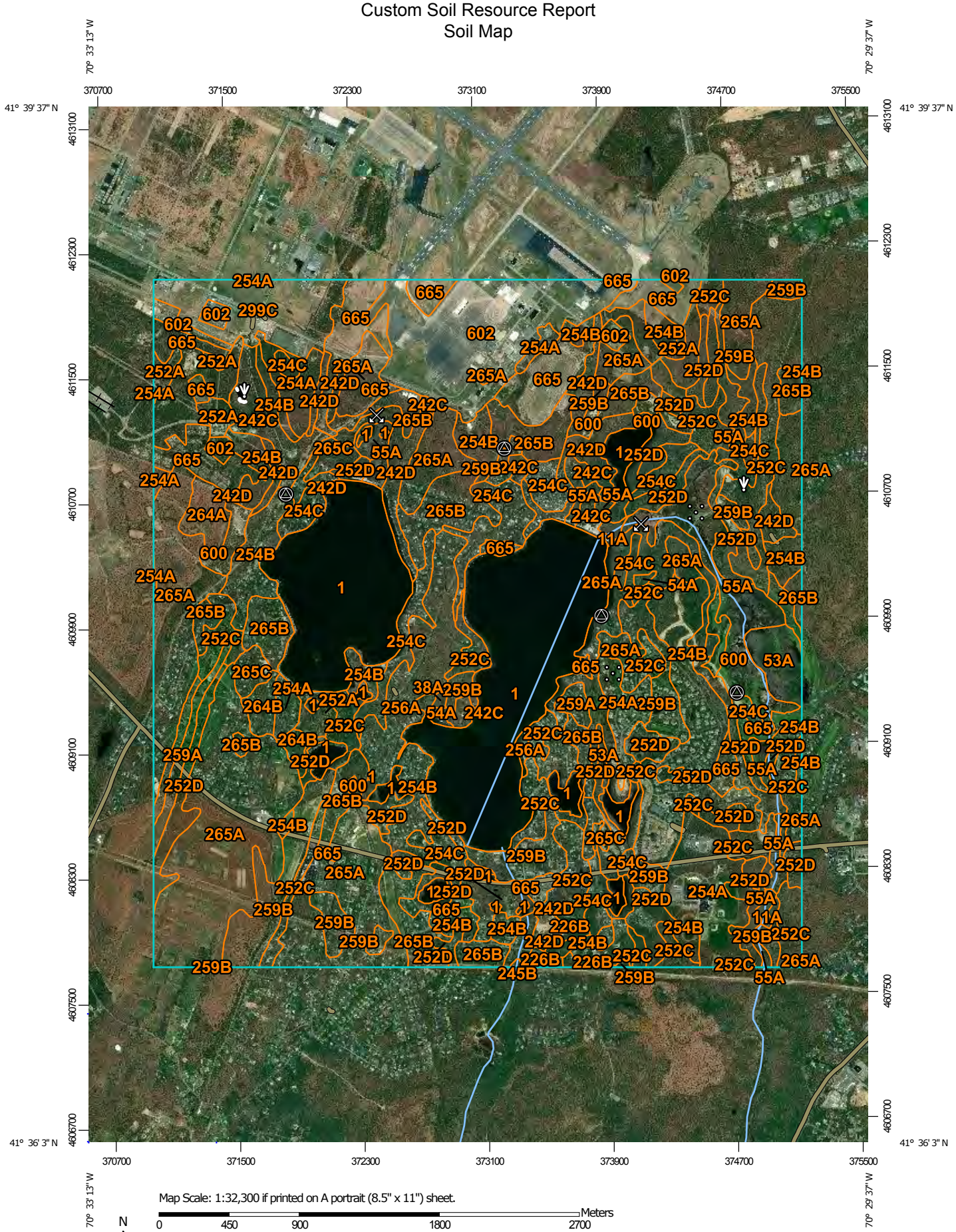
After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and

identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Custom Soil Resource Report
Soil Map



MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:25,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Barnstable County, Massachusetts
Survey Area Data: Version 15, Sep 5, 2018

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Dec 31, 2009—Jul 3, 2017

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
1	Water	613.2	13.5%
11A	Berryland mucky loamy coarse sand, 0 to 2 percent slopes	8.1	0.2%
38A	Pipestone loamy coarse sand, 0 to 3 percent slopes	2.1	0.0%
53A	Freetown muck, ponded, coastal lowland, 0 to 1 percent slopes	37.3	0.8%
54A	Freetown and Swansea mucks, coastal lowland, 0 to 1 percent slopes	9.2	0.2%
55A	Freetown coarse sand, 0 to 3 percent slopes, sanded surface	139.0	3.1%
226B	Hinesburg sandy loam, 3 to 8 percent slopes	9.2	0.2%
242C	Hinckley loamy sand, 8 to 15 percent slopes	71.2	1.6%
242D	Hinckley loamy sand, 15 to 35 percent slopes	141.1	3.1%
245B	Hinckley loamy sand, 3 to 8 percent slopes	0.6	0.0%
252A	Carver coarse sand, 0 to 3 percent slopes	37.5	0.8%
252C	Carver coarse sand, 8 to 15 percent slopes	340.4	7.5%
252D	Carver coarse sand, 15 to 35 percent slopes	419.8	9.2%
254A	Merrimac fine sandy loam, 0 to 3 percent slopes	229.7	5.1%
254B	Merrimac fine sandy loam, 3 to 8 percent slopes	482.2	10.6%
254C	Merrimac fine sandy loam, 8 to 15 percent slopes	165.9	3.7%
256A	Deerfield loamy fine sand, 0 to 3 percent slopes	9.1	0.2%
259A	Carver loamy coarse sand, 0 to 3 percent slopes	29.3	0.6%
259B	Carver loamy coarse sand, 3 to 8 percent slopes	208.3	4.6%
264A	Eastchop loamy fine sand, 0 to 3 percent slopes	24.1	0.5%
264B	Eastchop loamy fine sand, 3 to 8 percent slopes	23.0	0.5%

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
265A	Enfield silt loam, 0 to 3 percent slopes	658.3	14.5%
265B	Enfield silt loam, 3 to 8 percent slopes	241.3	5.3%
265C	Enfield silt loam, 8 to 15 percent slopes	34.7	0.8%
299C	Merrimac-Udipsamments-Urban land complex	99.9	2.2%
600	Pits, sand and gravel	56.1	1.2%
602	Urban land	227.3	5.0%
665	Udipsamments, smoothed	225.2	5.0%
Totals for Area of Interest		**4,543.1**	**100.0%**

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate

pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Barnstable County, Massachusetts

1—Water

Map Unit Setting

National map unit symbol: 98s8
Frost-free period: 120 to 220 days
Farmland classification: Not prime farmland

Map Unit Composition

Water: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

11A—Berryland mucky loamy coarse sand, 0 to 2 percent slopes

Map Unit Setting

National map unit symbol: 98q5
Elevation: 600 to 1,000 feet
Mean annual precipitation: 28 to 48 inches
Mean annual air temperature: 46 to 54 degrees F
Frost-free period: 120 to 240 days
Farmland classification: Not prime farmland

Map Unit Composition

Berryland and similar soils: 70 percent
Minor components: 30 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Berryland

Setting

Landform: Terraces
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Tread
Down-slope shape: Concave
Across-slope shape: Concave
Parent material: Loose sandy glaciofluvial deposits

Typical profile

H1 - 0 to 12 inches: loamy coarse sand
H2 - 12 to 23 inches: gravelly loamy coarse sand
H3 - 23 to 64 inches: stratified gravelly coarse sand to loamy coarse sand

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Very poorly drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): High to very high (2.00 to 20.00 in/hr)
Depth to water table: About 0 to 6 inches
Frequency of flooding: Occasional

Frequency of ponding: Frequent
Available water storage in profile: Low (about 5.1 inches)

Interpretive groups
Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 5w
Hydrologic Soil Group: A/D
Hydric soil rating: Yes

Minor Components

Freetown
Percent of map unit: 10 percent
Landform: Bogs
Hydric soil rating: Yes

Swansea
Percent of map unit: 5 percent
Landform: Bogs
Hydric soil rating: Yes

Maybid
Percent of map unit: 5 percent
Landform: Depressions
Hydric soil rating: Yes

Walpole variant, loamy substratum
Percent of map unit: 5 percent
Landform: Terraces
Hydric soil rating: Yes

Pipestone
Percent of map unit: 5 percent
Landform: Terraces
Hydric soil rating: Yes

38A—Pipestone loamy coarse sand, 0 to 3 percent slopes

Map Unit Setting
National map unit symbol: 98rp
Elevation: 0 to 1,000 feet
Mean annual precipitation: 28 to 55 inches
Mean annual air temperature: 45 to 54 degrees F
Frost-free period: 120 to 240 days
Farmland classification: Not prime farmland

Map Unit Composition
Pipestone and similar soils: 70 percent
Minor components: 30 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Pipestone

Setting

Landform: Terraces
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Tread
Down-slope shape: Concave
Across-slope shape: Concave
Parent material: Loose sandy glaciofluvial deposits

Typical profile

H1 - 0 to 18 inches: loamy coarse sand
H2 - 18 to 37 inches: loamy coarse sand
H3 - 37 to 64 inches: coarse sand

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Poorly drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): High to very high (6.00 to 20.00 in/hr)
Depth to water table: About 6 to 18 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 4.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4w
Hydrologic Soil Group: A/D
Hydric soil rating: Yes

Minor Components

Walpole variant, loamy substratum

Percent of map unit: 10 percent
Landform: Terraces
Hydric soil rating: Yes

Deerfield

Percent of map unit: 10 percent
Hydric soil rating: No

Berryland

Percent of map unit: 10 percent
Landform: Terraces
Hydric soil rating: Yes

53A—Freetown muck, ponded, coastal lowland, 0 to 1 percent slopes

Map Unit Setting

National map unit symbol: 2t2qg
Elevation: 0 to 210 feet
Mean annual precipitation: 40 to 52 inches
Mean annual air temperature: 48 to 55 degrees F
Frost-free period: 190 to 250 days
Farmland classification: Farmland of unique importance

Map Unit Composition

Freetown, ponded, and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Freetown, Ponded

Setting

Landform: Bogs, marshes, kettles, depressions, swamps
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Tread, dip
Down-slope shape: Concave
Across-slope shape: Concave
Parent material: Highly decomposed organic material

Typical profile

Oe - 0 to 2 inches: mucky peat
Oa - 2 to 79 inches: muck

Properties and qualities

Slope: 0 to 1 percent
Percent of area covered with surface fragments: 0.0 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Very poorly drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to high (0.14 to 14.17 in/hr)
Depth to water table: About 0 to 6 inches
Frequency of flooding: Rare
Frequency of ponding: Frequent
Available water storage in profile: Very high (about 19.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 5w
Hydrologic Soil Group: B/D
Hydric soil rating: Yes

Minor Components

Swansea, ponded

Percent of map unit: 5 percent
Landform: Bogs, marshes, kettles, depressions, swamps
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Tread, dip
Down-slope shape: Concave
Across-slope shape: Concave
Hydric soil rating: Yes

Whitman, ponded

Percent of map unit: 5 percent
Landform: Depressions on ground moraines
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave
Across-slope shape: Concave
Hydric soil rating: Yes

Scarboro

Percent of map unit: 5 percent
Landform: Depressions, drainageways
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Base slope, tread, dip
Down-slope shape: Concave
Across-slope shape: Concave
Hydric soil rating: Yes

54A—Freetown and Swansea mucks, coastal lowland, 0 to 1 percent slopes

Map Unit Setting

National map unit symbol: 2tyqd
Elevation: 0 to 250 feet
Mean annual precipitation: 40 to 52 inches
Mean annual air temperature: 48 to 55 degrees F
Frost-free period: 190 to 250 days
Farmland classification: Farmland of unique importance

Map Unit Composition

Swansea, coastal lowland, and similar soils: 45 percent
Freetown, coastal lowland, and similar soils: 45 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Swansea, Coastal Lowland

Setting

Landform: Swamps, marshes, bogs

Landform position (three-dimensional): Dip
Down-slope shape: Concave
Across-slope shape: Concave
Parent material: Highly decomposed organic material over loose sandy and gravelly glaciofluvial deposits

Typical profile

Oa - 0 to 36 inches: muck
Cg - 36 to 79 inches: coarse sand

Properties and qualities

Slope: 0 to 1 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Very poorly drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to high (0.14 to 14.17 in/hr)
Depth to water table: About 0 to 6 inches
Frequency of flooding: Rare
Frequency of ponding: Frequent
Available water storage in profile: Very high (about 17.3 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 5w
Hydrologic Soil Group: B/D
Hydric soil rating: Yes

Description of Freetown, Coastal Lowland

Setting

Landform: Marshes, bogs, swamps
Landform position (three-dimensional): Dip
Down-slope shape: Concave
Across-slope shape: Concave
Parent material: Highly decomposed organic material

Typical profile

Oe - 0 to 2 inches: mucky peat
Oa - 2 to 79 inches: muck

Properties and qualities

Slope: 0 to 1 percent
Percent of area covered with surface fragments: 0.0 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Very poorly drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to high (0.14 to 14.17 in/hr)
Depth to water table: About 0 to 6 inches
Frequency of flooding: Rare
Frequency of ponding: Frequent
Available water storage in profile: Very high (about 19.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 5w
Hydrologic Soil Group: B/D

Hydric soil rating: Yes

Minor Components

Rainberry, coastal lowland

Percent of map unit: 10 percent
Landform: Kettles, depressions
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Tread
Down-slope shape: Concave
Across-slope shape: Linear
Hydric soil rating: Yes

55A—Freetown coarse sand, 0 to 3 percent slopes, sanded surface

Map Unit Setting

National map unit symbol: 2t2qj
Elevation: 0 to 180 feet
Mean annual precipitation: 40 to 52 inches
Mean annual air temperature: 48 to 55 degrees F
Frost-free period: 190 to 250 days
Farmland classification: Farmland of unique importance

Map Unit Composition

Freetown, sanded surface, and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Freetown, Sanded Surface

Setting

Landform: Bogs, kettles, depressions
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Talf
Down-slope shape: Concave
Across-slope shape: Concave
Parent material: Sandy human-transported material over highly decomposed organic material

Typical profile

^Ap - 0 to 15 inches: coarse sand
2Oa - 15 to 79 inches: muck

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Very poorly drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to high (0.14 to 14.17 in/hr)

Depth to water table: About 0 to 6 inches
Frequency of flooding: Frequent
Frequency of ponding: None
Available water storage in profile: Very high (about 20.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 5w
Hydrologic Soil Group: B/D
Hydric soil rating: Yes

Minor Components

Swansea, sanded surface, inactive

Percent of map unit: 5 percent
Landform: Depressions, bogs, kettles
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Talf
Down-slope shape: Concave
Across-slope shape: Concave
Hydric soil rating: Yes

Rainberry, sanded surface

Percent of map unit: 4 percent
Landform: Depressions, kettles
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Tread
Down-slope shape: Concave
Across-slope shape: Linear
Hydric soil rating: Yes

Tihonet

Percent of map unit: 3 percent
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: Yes

Udipsamments, wet substratum

Percent of map unit: 3 percent
Landform: Dikes on bogs
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Tread
Down-slope shape: Convex, concave
Across-slope shape: Linear, concave
Hydric soil rating: No

226B—Hinesburg sandy loam, 3 to 8 percent slopes

Map Unit Setting

National map unit symbol: 98r4
Elevation: 90 to 1,000 feet
Mean annual precipitation: 41 to 48 inches
Mean annual air temperature: 50 to 54 degrees F
Frost-free period: 160 to 240 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Hinesburg and similar soils: 70 percent
Minor components: 30 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Hinesburg

Setting

Landform: Glacial lakes (relict)
Landform position (two-dimensional): Shoulder
Landform position (three-dimensional): Riser
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Loose sandy glaciofluvial deposits over hard loamy glaciolacustrine deposits; loose sandy glaciofluvial deposits over hard loamy glaciolacustrine deposits; loose sandy glaciofluvial deposits over hard loamy glaciolacustrine deposits

Typical profile

H1 - 0 to 10 inches: sandy loam
H2 - 10 to 32 inches: loamy sand
H3 - 32 to 64 inches: sandy clay loam

Properties and qualities

Slope: 3 to 8 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: About 18 to 30 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Moderate (about 8.4 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2s
Hydrologic Soil Group: C/D
Hydric soil rating: No

Minor Components

Amostown
Percent of map unit: 10 percent
Hydric soil rating: No

Carver
Percent of map unit: 10 percent
Hydric soil rating: No

Plymouth
Percent of map unit: 10 percent
Hydric soil rating: No

242C—Hinckley loamy sand, 8 to 15 percent slopes

Map Unit Setting
National map unit symbol: 2svm9
Elevation: 0 to 1,480 feet
Mean annual precipitation: 36 to 71 inches
Mean annual air temperature: 39 to 55 degrees F
Frost-free period: 140 to 240 days
Farmland classification: Not prime farmland

Map Unit Composition
Hinckley and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Hinckley

Setting
Landform: Moraines, outwash terraces, outwash deltas, kame terraces, outwash plains, kames, eskers
Landform position (two-dimensional): Shoulder, toeslope, footslope, backslope
Landform position (three-dimensional): Nose slope, side slope, crest, head slope, riser
Down-slope shape: Convex, linear, concave
Across-slope shape: Linear, convex, concave
Parent material: Sandy and gravelly glaciofluvial deposits derived from gneiss and/or granite and/or schist

Typical profile
Oe - 0 to 1 inches: moderately decomposed plant material
A - 1 to 8 inches: loamy sand
Bw1 - 8 to 11 inches: gravelly loamy sand
Bw2 - 11 to 16 inches: gravelly loamy sand
BC - 16 to 19 inches: very gravelly loamy sand
C - 19 to 65 inches: very gravelly sand

Properties and qualities

Slope: 8 to 15 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Excessively drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to very high (1.42 to 99.90 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Salinity, maximum in profile: Nonsaline (0.0 to 1.9 mmhos/cm)
Available water storage in profile: Low (about 3.1 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: A
Hydric soil rating: No

Minor Components

Windsor

Percent of map unit: 5 percent
Landform: Kame terraces, moraines, outwash plains, outwash terraces, outwash deltas, kames, eskers
Landform position (two-dimensional): Shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Nose slope, side slope, crest, head slope, riser
Down-slope shape: Linear, convex, concave
Across-slope shape: Convex, linear, concave
Hydric soil rating: No

Sudbury

Percent of map unit: 5 percent
Landform: Outwash plains, moraines, outwash deltas, outwash terraces, kame terraces
Landform position (two-dimensional): Backslope, footslope
Landform position (three-dimensional): Base slope, tread
Down-slope shape: Concave, linear
Across-slope shape: Linear, concave
Hydric soil rating: No

Merrimac

Percent of map unit: 5 percent
Landform: Outwash plains, kames, eskers, moraines, outwash terraces
Landform position (two-dimensional): Shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Side slope, crest, head slope, nose slope, riser
Down-slope shape: Convex
Across-slope shape: Convex
Hydric soil rating: No

242D—Hinckley loamy sand, 15 to 35 percent slopes

Map Unit Setting

National map unit symbol: 2svmd
Elevation: 0 to 860 feet
Mean annual precipitation: 36 to 71 inches
Mean annual air temperature: 39 to 55 degrees F
Frost-free period: 140 to 240 days
Farmland classification: Not prime farmland

Map Unit Composition

Hinckley and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Hinckley

Setting

Landform: Kame terraces, outwash deltas, outwash plains, kames, eskers, moraines, outwash terraces
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Crest, nose slope, side slope, head slope, riser
Down-slope shape: Linear, convex, concave
Across-slope shape: Convex, linear, concave
Parent material: Sandy and gravelly glaciofluvial deposits derived from gneiss and/or granite and/or schist

Typical profile

Oe - 0 to 1 inches: moderately decomposed plant material
A - 1 to 8 inches: loamy sand
Bw1 - 8 to 11 inches: gravelly loamy sand
Bw2 - 11 to 16 inches: gravelly loamy sand
BC - 16 to 19 inches: very gravelly loamy sand
C - 19 to 65 inches: very gravelly sand

Properties and qualities

Slope: 15 to 35 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Excessively drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to very high (1.42 to 99.90 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Salinity, maximum in profile: Nonsaline (0.0 to 1.9 mmhos/cm)
Available water storage in profile: Low (about 3.1 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: A
Hydric soil rating: No

Minor Components

Windsor

Percent of map unit: 10 percent
Landform: Outwash plains, outwash terraces, outwash deltas, kames, eskers, moraines, kame terraces
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Nose slope, crest, side slope, head slope, riser
Down-slope shape: Convex, linear, concave
Across-slope shape: Linear, convex, concave
Hydric soil rating: No

Merrimac

Percent of map unit: 3 percent
Landform: Kames, eskers, moraines, outwash terraces, outwash plains, kame terraces
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope, crest, head slope, nose slope, riser
Down-slope shape: Convex, concave, linear
Across-slope shape: Concave, convex, linear
Hydric soil rating: No

Sudbury

Percent of map unit: 2 percent
Landform: Moraines, outwash terraces, kame terraces, outwash plains, outwash deltas
Landform position (two-dimensional): Backslope, footslope, toeslope
Landform position (three-dimensional): Base slope, tread
Down-slope shape: Linear, concave
Across-slope shape: Concave, linear
Hydric soil rating: No

245B—Hinckley loamy sand, 3 to 8 percent slopes

Map Unit Setting

National map unit symbol: 2svm8
Elevation: 0 to 1,430 feet
Mean annual precipitation: 36 to 53 inches
Mean annual air temperature: 39 to 55 degrees F
Frost-free period: 140 to 250 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Hinckley and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Hinckley

Setting

Landform: Kame terraces, kames, outwash terraces, outwash plains, outwash deltas, eskers, moraines
Landform position (two-dimensional): Summit, backslope, footslope, shoulder
Landform position (three-dimensional): Nose slope, side slope, base slope, crest, tread, riser
Down-slope shape: Linear, convex, concave
Across-slope shape: Convex, linear, concave
Parent material: Sandy and gravelly glaciofluvial deposits derived from gneiss and/or granite and/or schist

Typical profile

Oe - 0 to 1 inches: moderately decomposed plant material
A - 1 to 8 inches: loamy sand
Bw1 - 8 to 11 inches: gravelly loamy sand
Bw2 - 11 to 16 inches: gravelly loamy sand
BC - 16 to 19 inches: very gravelly loamy sand
C - 19 to 65 inches: very gravelly sand

Properties and qualities

Slope: 3 to 8 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Excessively drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to very high (1.42 to 99.90 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Salinity, maximum in profile: Nonsaline (0.0 to 1.9 mmhos/cm)
Available water storage in profile: Very low (about 3.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3s
Hydrologic Soil Group: A
Hydric soil rating: No

Minor Components

Windsor

Percent of map unit: 8 percent
Landform: Outwash deltas, kame terraces, outwash plains, kames, eskers, moraines, outwash terraces
Landform position (two-dimensional): Summit, shoulder, backslope, footslope
Landform position (three-dimensional): Nose slope, side slope, base slope, crest, riser, tread
Down-slope shape: Linear, convex, concave
Across-slope shape: Convex, linear, concave

Hydric soil rating: No

Sudbury

Percent of map unit: 5 percent
Landform: Moraines, outwash terraces, outwash deltas, kame terraces, outwash plains
Landform position (two-dimensional): Backslope, footslope
Landform position (three-dimensional): Side slope, base slope, head slope, tread
Down-slope shape: Concave, linear
Across-slope shape: Linear, concave
Hydric soil rating: No

Agawam

Percent of map unit: 2 percent
Landform: Kame terraces, outwash plains, kames, eskers, moraines, outwash terraces, outwash deltas
Landform position (two-dimensional): Summit, shoulder, backslope, footslope
Landform position (three-dimensional): Nose slope, side slope, base slope, crest, tread, riser
Down-slope shape: Linear, convex, concave
Across-slope shape: Convex, linear, concave
Hydric soil rating: No

252A—Carver coarse sand, 0 to 3 percent slopes

Map Unit Setting

National map unit symbol: 98qc
Elevation: 0 to 1,000 feet
Mean annual precipitation: 37 to 50 inches
Mean annual air temperature: 45 to 55 degrees F
Frost-free period: 120 to 240 days
Farmland classification: Not prime farmland

Map Unit Composition

Carver and similar soils: 80 percent
Minor components: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Carver

Setting

Landform: Outwash plains
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Tread
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Loose sandy glaciofluvial deposits

Typical profile

H1 - 0 to 7 inches: coarse sand
H2 - 7 to 17 inches: coarse sand

H3 - 17 to 64 inches: coarse sand

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Excessively drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): Very high (20.00 to 99.90 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 3.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: A
Hydric soil rating: No

Minor Components

Merrimac

Percent of map unit: 6 percent
Hydric soil rating: No

Hinckley

Percent of map unit: 6 percent
Hydric soil rating: No

Eastchop

Percent of map unit: 4 percent
Hydric soil rating: No

Enfield

Percent of map unit: 4 percent
Hydric soil rating: No

252C—Carver coarse sand, 8 to 15 percent slopes

Map Unit Setting

National map unit symbol: 98qf
Elevation: 0 to 1,000 feet
Mean annual precipitation: 37 to 50 inches
Mean annual air temperature: 45 to 55 degrees F
Frost-free period: 120 to 240 days
Farmland classification: Not prime farmland

Map Unit Composition

Carver and similar soils: 75 percent
Minor components: 25 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Carver

Setting

Landform: Ice-contact slopes
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Riser
Down-slope shape: Linear
Across-slope shape: Convex
Parent material: Sandy glaciofluvial deposits; loose sandy glaciofluvial deposits

Typical profile

H1 - 0 to 7 inches: coarse sand
H2 - 7 to 17 inches: coarse sand
H3 - 17 to 64 inches: coarse sand

Properties and qualities

Slope: 8 to 15 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Excessively drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): Very high (20.00 to 99.90 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 3.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: A
Hydric soil rating: No

Minor Components

Merrimac

Percent of map unit: 9 percent
Hydric soil rating: No

Hinckley

Percent of map unit: 8 percent
Hydric soil rating: No

Eastchop

Percent of map unit: 4 percent
Hydric soil rating: No

Plymouth

Percent of map unit: 4 percent
Hydric soil rating: No

252D—Carver coarse sand, 15 to 35 percent slopes

Map Unit Setting

National map unit symbol: 98qg
Elevation: 0 to 1,000 feet
Mean annual precipitation: 37 to 50 inches
Mean annual air temperature: 45 to 55 degrees F
Frost-free period: 120 to 240 days
Farmland classification: Not prime farmland

Map Unit Composition

Carver and similar soils: 65 percent
Minor components: 35 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Carver

Setting

Landform: Ice-contact slopes
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Riser
Down-slope shape: Linear
Across-slope shape: Convex
Parent material: Sandy glaciofluvial deposits; loose sandy glaciofluvial deposits

Typical profile

H1 - 0 to 7 inches: coarse sand
H2 - 7 to 17 inches: coarse sand
H3 - 17 to 64 inches: coarse sand

Properties and qualities

Slope: 15 to 35 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Excessively drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): Very high (20.00 to 99.90 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 3.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: A
Hydric soil rating: No

Minor Components

Plymouth
Percent of map unit: 10 percent
Hydric soil rating: No

Hinckley
Percent of map unit: 10 percent
Hydric soil rating: No

Eastchop
Percent of map unit: 10 percent
Hydric soil rating: No

Freetown
Percent of map unit: 3 percent
Landform: Bogs
Hydric soil rating: Yes

Swansea
Percent of map unit: 2 percent
Landform: Bogs
Hydric soil rating: Yes

254A—Merrimac fine sandy loam, 0 to 3 percent slopes

Map Unit Setting
National map unit symbol: 2tyqr
Elevation: 0 to 1,100 feet
Mean annual precipitation: 36 to 71 inches
Mean annual air temperature: 39 to 55 degrees F
Frost-free period: 140 to 240 days
Farmland classification: All areas are prime farmland

Map Unit Composition
Merrimac and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Merrimac

Setting
Landform: Eskers, moraines, outwash terraces, outwash plains, kames
Landform position (two-dimensional): Backslope, footslope, summit, shoulder
Landform position (three-dimensional): Side slope, crest, riser, tread
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Loamy glaciofluvial deposits derived from granite, schist, and gneiss over sandy and gravelly glaciofluvial deposits derived from granite, schist, and gneiss

Typical profile

Ap - 0 to 10 inches: fine sandy loam
Bw1 - 10 to 22 inches: fine sandy loam
Bw2 - 22 to 26 inches: stratified gravel to gravelly loamy sand
2C - 26 to 65 inches: stratified gravel to very gravelly sand

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Somewhat excessively drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to very high (1.42 to 99.90 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 2 percent
Salinity, maximum in profile: Nonsaline (0.0 to 1.4 mmhos/cm)
Sodium adsorption ratio, maximum in profile: 1.0
Available water storage in profile: Low (about 4.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2s
Hydrologic Soil Group: A
Hydric soil rating: No

Minor Components

Sudbury

Percent of map unit: 5 percent
Landform: Terraces, deltas, outwash plains
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Tread, dip
Down-slope shape: Concave
Across-slope shape: Linear
Hydric soil rating: No

Hinckley

Percent of map unit: 5 percent
Landform: Deltas, outwash plains, eskers, kames
Landform position (two-dimensional): Summit, shoulder, backslope
Landform position (three-dimensional): Nose slope, side slope, crest, head slope, rise
Down-slope shape: Convex
Across-slope shape: Convex, linear
Hydric soil rating: No

Agawam

Percent of map unit: 3 percent
Landform: Stream terraces, kames, eskers, moraines, outwash plains, outwash terraces
Landform position (three-dimensional): Rise
Down-slope shape: Convex
Across-slope shape: Convex
Hydric soil rating: No

Windsor

Percent of map unit: 2 percent
Landform: Dunes, outwash plains, outwash terraces, deltas
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Tread, riser
Down-slope shape: Convex, linear
Across-slope shape: Convex, linear
Hydric soil rating: No

254B—Merrimac fine sandy loam, 3 to 8 percent slopes

Map Unit Setting

National map unit symbol: 2tyqs
Elevation: 0 to 1,290 feet
Mean annual precipitation: 36 to 71 inches
Mean annual air temperature: 39 to 55 degrees F
Frost-free period: 140 to 240 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Merrimac and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Merrimac

Setting

Landform: Eskers, moraines, outwash terraces, outwash plains, kames
Landform position (two-dimensional): Backslope, footslope, summit, shoulder
Landform position (three-dimensional): Side slope, crest, riser, tread
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Loamy glaciofluvial deposits derived from granite, schist, and gneiss over sandy and gravelly glaciofluvial deposits derived from granite, schist, and gneiss

Typical profile

Ap - 0 to 10 inches: fine sandy loam
Bw1 - 10 to 22 inches: fine sandy loam
Bw2 - 22 to 26 inches: stratified gravel to gravelly loamy sand
2C - 26 to 65 inches: stratified gravel to very gravelly sand

Properties and qualities

Slope: 3 to 8 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Somewhat excessively drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to very high (1.42 to 99.90 in/hr)
Depth to water table: More than 80 inches

Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 2 percent
Salinity, maximum in profile: Nonsaline (0.0 to 1.4 mmhos/cm)
Sodium adsorption ratio, maximum in profile: 1.0
Available water storage in profile: Low (about 4.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2s
Hydrologic Soil Group: A
Hydric soil rating: No

Minor Components

Hinckley

Percent of map unit: 5 percent
Landform: Kames, deltas, outwash plains, eskers
Landform position (two-dimensional): Summit, shoulder, backslope
Landform position (three-dimensional): Nose slope, side slope, crest, head slope, rise
Down-slope shape: Convex
Across-slope shape: Convex, linear
Hydric soil rating: No

Sudbury

Percent of map unit: 5 percent
Landform: Terraces, deltas, outwash plains
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Tread, dip
Down-slope shape: Concave
Across-slope shape: Linear
Hydric soil rating: No

Windsor

Percent of map unit: 3 percent
Landform: Deltas, dunes, outwash terraces, outwash plains
Landform position (two-dimensional): Shoulder
Landform position (three-dimensional): Riser, tread
Down-slope shape: Linear, convex
Across-slope shape: Linear, convex
Hydric soil rating: No

Agawam

Percent of map unit: 2 percent
Landform: Stream terraces, moraines, outwash terraces, outwash plains, kames, eskers
Landform position (three-dimensional): Rise
Down-slope shape: Convex
Across-slope shape: Convex
Hydric soil rating: No

254C—Merrimac fine sandy loam, 8 to 15 percent slopes

Map Unit Setting

National map unit symbol: 2tyqt
Elevation: 0 to 1,030 feet
Mean annual precipitation: 36 to 71 inches
Mean annual air temperature: 39 to 55 degrees F
Frost-free period: 140 to 240 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Merrimac and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Merrimac

Setting

Landform: Outwash plains, eskers, outwash terraces, kames, moraines
Landform position (two-dimensional): Backslope, footslope, shoulder, summit
Landform position (three-dimensional): Side slope, crest, riser, tread
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Loamy glaciofluvial deposits derived from granite, schist, and gneiss over sandy and gravelly glaciofluvial deposits derived from granite, schist, and gneiss

Typical profile

Ap - 0 to 10 inches: fine sandy loam
Bw1 - 10 to 22 inches: fine sandy loam
Bw2 - 22 to 26 inches: stratified gravel to gravelly loamy sand
2C - 26 to 65 inches: stratified gravel to very gravelly sand

Properties and qualities

Slope: 8 to 15 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Somewhat excessively drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to very high (1.42 to 99.90 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 2 percent
Salinity, maximum in profile: Nonsaline (0.0 to 1.4 mmhos/cm)
Sodium adsorption ratio, maximum in profile: 1.0
Available water storage in profile: Low (about 4.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified

Land capability classification (nonirrigated): 2s
Hydrologic Soil Group: A
Hydric soil rating: No

Minor Components

Sudbury
Percent of map unit: 5 percent
Landform: Deltas, outwash plains, terraces
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Tread, dip
Down-slope shape: Concave
Across-slope shape: Linear
Hydric soil rating: No

Hinckley
Percent of map unit: 5 percent
Landform: Kames, deltas, outwash plains, eskers
Landform position (two-dimensional): Summit, shoulder, backslope
Landform position (three-dimensional): Nose slope, side slope, crest, head slope, rise
Down-slope shape: Convex
Across-slope shape: Convex, linear
Hydric soil rating: No

Windsor
Percent of map unit: 5 percent
Landform: Dunes, outwash plains, outwash terraces, deltas
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Tread, riser
Down-slope shape: Convex, linear
Across-slope shape: Convex, linear
Hydric soil rating: No

256A—Deerfield loamy fine sand, 0 to 3 percent slopes

Map Unit Setting
National map unit symbol: 2xfg8
Elevation: 0 to 1,100 feet
Mean annual precipitation: 36 to 71 inches
Mean annual air temperature: 39 to 55 degrees F
Frost-free period: 145 to 240 days
Farmland classification: Farmland of statewide importance

Map Unit Composition
Deerfield and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Deerfield

Setting

Landform: Outwash deltas, outwash terraces, kame terraces, outwash plains
Landform position (three-dimensional): Tread
Down-slope shape: Concave, convex, linear
Across-slope shape: Linear, convex, concave
Parent material: Sandy outwash derived from granite, gneiss, and/or quartzite

Typical profile

Ap - 0 to 9 inches: loamy fine sand
Bw - 9 to 25 inches: loamy fine sand
BC - 25 to 33 inches: fine sand
Cg - 33 to 60 inches: sand

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Moderately well drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to very high (1.42 to 99.90 in/hr)
Depth to water table: About 15 to 37 inches
Frequency of flooding: None
Frequency of ponding: None
Salinity, maximum in profile: Nonsaline (0.0 to 1.9 mmhos/cm)
Sodium adsorption ratio, maximum in profile: 11.0
Available water storage in profile: Moderate (about 6.5 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2w
Hydrologic Soil Group: A
Hydric soil rating: No

Minor Components

Windsor

Percent of map unit: 7 percent
Landform: Outwash terraces, outwash plains, outwash deltas, kame terraces
Landform position (three-dimensional): Tread
Down-slope shape: Linear, convex, concave
Across-slope shape: Concave, linear, convex
Hydric soil rating: No

Wareham

Percent of map unit: 5 percent
Landform: Depressions, drainageways
Down-slope shape: Concave
Across-slope shape: Concave
Hydric soil rating: Yes

Sudbury

Percent of map unit: 2 percent
Landform: Outwash plains, outwash terraces, outwash deltas, kame terraces
Landform position (three-dimensional): Tread
Down-slope shape: Linear, convex, concave

Across-slope shape: Concave, linear, convex
Hydric soil rating: No

Ninigret

Percent of map unit: 1 percent
Landform: Outwash plains, kame terraces, outwash terraces
Landform position (three-dimensional): Tread
Down-slope shape: Convex, linear
Across-slope shape: Convex, concave
Hydric soil rating: No

259A—Carver loamy coarse sand, 0 to 3 percent slopes

Map Unit Setting

National map unit symbol: 98q9
Elevation: 0 to 1,000 feet
Mean annual precipitation: 37 to 50 inches
Mean annual air temperature: 45 to 55 degrees F
Frost-free period: 120 to 240 days
Farmland classification: Not prime farmland

Map Unit Composition

Carver and similar soils: 80 percent
Minor components: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Carver

Setting

Landform: Outwash plains
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Tread
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Loose sandy glaciofluvial deposits

Typical profile

H1 - 0 to 7 inches: loamy coarse sand
H2 - 7 to 17 inches: coarse sand
H3 - 17 to 64 inches: coarse sand

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Excessively drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): Very high (20.00 to 99.90 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None

Available water storage in profile: Low (about 3.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4s
Hydrologic Soil Group: A
Hydric soil rating: No

Minor Components

Merrimac

Percent of map unit: 6 percent
Hydric soil rating: No

Hinckley

Percent of map unit: 6 percent
Hydric soil rating: No

Eastchop

Percent of map unit: 4 percent
Hydric soil rating: No

Enfield

Percent of map unit: 4 percent
Hydric soil rating: No

259B—Carver loamy coarse sand, 3 to 8 percent slopes

Map Unit Setting

National map unit symbol: 98qb
Elevation: 0 to 1,000 feet
Mean annual precipitation: 37 to 50 inches
Mean annual air temperature: 45 to 55 degrees F
Frost-free period: 120 to 240 days
Farmland classification: Not prime farmland

Map Unit Composition

Carver and similar soils: 80 percent
Minor components: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Carver

Setting

Landform: Outwash plains
Landform position (two-dimensional): Shoulder
Landform position (three-dimensional): Riser
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Loose sandy glaciofluvial deposits

Typical profile

H1 - 0 to 7 inches: loamy coarse sand
H2 - 7 to 17 inches: coarse sand
H3 - 17 to 64 inches: coarse sand

Properties and qualities

Slope: 3 to 8 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Excessively drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): Very high (20.00 to 99.90 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 3.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4s
Hydrologic Soil Group: A
Hydric soil rating: No

Minor Components

Hinckley

Percent of map unit: 6 percent
Hydric soil rating: No

Merrimac

Percent of map unit: 6 percent
Hydric soil rating: No

Enfield

Percent of map unit: 4 percent
Hydric soil rating: No

Eastchop

Percent of map unit: 4 percent
Hydric soil rating: No

264A—Eastchop loamy fine sand, 0 to 3 percent slopes

Map Unit Setting

National map unit symbol: 98qp
Elevation: 0 to 1,000 feet
Mean annual precipitation: 40 to 50 inches
Mean annual air temperature: 45 to 55 degrees F
Frost-free period: 140 to 240 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Eastchop and similar soils: 75 percent
Minor components: 25 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Eastchop

Setting

Landform: Outwash plains
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Tread
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Sandy glaciofluvial deposits; loose sandy glaciofluvial deposits

Typical profile

H1 - 0 to 6 inches: loamy fine sand
H2 - 6 to 10 inches: loamy fine sand
H3 - 10 to 25 inches: very fine sand
H4 - 25 to 64 inches: very fine sand

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Excessively drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): High to very high (6.00 to 20.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 4.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3s
Hydrologic Soil Group: A
Hydric soil rating: No

Minor Components

Hinckley

Percent of map unit: 8 percent
Hydric soil rating: No

Merrimac

Percent of map unit: 7 percent
Hydric soil rating: No

Carver

Percent of map unit: 5 percent
Hydric soil rating: No

Enfield

Percent of map unit: 5 percent
Hydric soil rating: No

264B—Eastchop loamy fine sand, 3 to 8 percent slopes

Map Unit Setting

National map unit symbol: 98qq
Elevation: 0 to 1,000 feet
Mean annual precipitation: 40 to 50 inches
Mean annual air temperature: 45 to 55 degrees F
Frost-free period: 140 to 240 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Eastchop and similar soils: 75 percent
Minor components: 25 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Eastchop

Setting

Landform: Outwash plains
Landform position (two-dimensional): Shoulder
Landform position (three-dimensional): Riser
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Sandy glaciofluvial deposits; loose sandy glaciofluvial deposits

Typical profile

H1 - 0 to 6 inches: loamy fine sand
H2 - 6 to 10 inches: loamy fine sand
H3 - 10 to 25 inches: very fine sand
H4 - 25 to 64 inches: very fine sand

Properties and qualities

Slope: 3 to 8 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Excessively drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): High to very high (6.00 to 20.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 4.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3s
Hydrologic Soil Group: A
Hydric soil rating: No

Minor Components

Hinckley
Percent of map unit: 8 percent
Hydric soil rating: No

Merrimac
Percent of map unit: 7 percent
Hydric soil rating: No

Enfield
Percent of map unit: 5 percent
Hydric soil rating: No

Carver
Percent of map unit: 5 percent
Hydric soil rating: No

265A—Enfield silt loam, 0 to 3 percent slopes

Map Unit Setting
National map unit symbol: 98qs
Elevation: 0 to 1,000 feet
Mean annual precipitation: 40 to 50 inches
Mean annual air temperature: 45 to 55 degrees F
Frost-free period: 140 to 240 days
Farmland classification: All areas are prime farmland

Map Unit Composition
Enfield and similar soils: 80 percent
Minor components: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Enfield

Setting
Landform: Outwash plains
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Tread
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Silty, friable loamy eolian deposits over loose sandy glaciofluvial deposits

Typical profile
H1 - 0 to 12 inches: silt loam
H2 - 12 to 31 inches: silt loam
H3 - 31 to 64 inches: gravelly coarse sand

Properties and qualities
Slope: 0 to 3 percent

Depth to restrictive feature: 16 to 40 inches to strongly contrasting textural stratification
Natural drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Moderate (about 7.4 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 1
Hydrologic Soil Group: B
Hydric soil rating: No

Minor Components

Merrimac

Percent of map unit: 10 percent
Hydric soil rating: No

Hinckley

Percent of map unit: 5 percent
Hydric soil rating: No

Carver

Percent of map unit: 5 percent
Hydric soil rating: No

265B—Enfield silt loam, 3 to 8 percent slopes

Map Unit Setting

National map unit symbol: 98qt
Elevation: 0 to 1,000 feet
Mean annual precipitation: 40 to 50 inches
Mean annual air temperature: 45 to 55 degrees F
Frost-free period: 140 to 240 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Enfield and similar soils: 80 percent
Minor components: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Enfield

Setting

Landform: Outwash plains
Landform position (two-dimensional): Shoulder

Landform position (three-dimensional): Riser
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Silty, friable loamy eolian deposits over loose sandy glaciofluvial deposits; silty, friable loamy eolian deposits over loose sandy glaciofluvial deposits

Typical profile

H1 - 0 to 12 inches: silt loam
H2 - 12 to 31 inches: silt loam
H3 - 31 to 60 inches: gravelly coarse sand

Properties and qualities

Slope: 3 to 8 percent
Depth to restrictive feature: 16 to 40 inches to strongly contrasting textural stratification
Natural drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Moderate (about 7.4 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: B
Hydric soil rating: No

Minor Components

Merrimac

Percent of map unit: 10 percent
Hydric soil rating: No

Carver

Percent of map unit: 5 percent
Hydric soil rating: No

Hinckley

Percent of map unit: 5 percent
Hydric soil rating: No

265C—Enfield silt loam, 8 to 15 percent slopes

Map Unit Setting

National map unit symbol: 98qv
Elevation: 0 to 1,000 feet
Mean annual precipitation: 40 to 50 inches
Mean annual air temperature: 45 to 55 degrees F

Frost-free period: 140 to 240 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Enfield and similar soils: 70 percent
Minor components: 30 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Enfield

Setting

Landform: Outwash plains
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Riser
Down-slope shape: Linear
Across-slope shape: Convex
Parent material: Silty, friable loamy eolian deposits over loose sandy glaciofluvial deposits; silty, friable loamy eolian deposits over loose sandy glaciofluvial deposits

Typical profile

H1 - 0 to 12 inches: silt loam
H2 - 12 to 31 inches: silt loam
H3 - 31 to 64 inches: gravelly coarse sand

Properties and qualities

Slope: 8 to 15 percent
Depth to restrictive feature: 16 to 40 inches to strongly contrasting textural stratification
Natural drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Moderate (about 7.4 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3e
Hydrologic Soil Group: B
Hydric soil rating: No

Minor Components

Plymouth

Percent of map unit: 10 percent
Hydric soil rating: No

Merrimac

Percent of map unit: 10 percent
Hydric soil rating: No

Hinckley

Percent of map unit: 5 percent
Hydric soil rating: No

Carver

Percent of map unit: 5 percent
Hydric soil rating: No

299C—Merrimac-Udipsamments-Urban land complex

Map Unit Setting

National map unit symbol: 2tx0h
Elevation: 20 to 210 feet
Mean annual precipitation: 40 to 52 inches
Mean annual air temperature: 48 to 55 degrees F
Frost-free period: 190 to 250 days
Farmland classification: Not prime farmland

Map Unit Composition

Udipsamments and similar soils: 30 percent
Merrimac and similar soils: 30 percent
Urban land: 20 percent
Minor components: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Udipsamments

Setting

Landform: Dunes
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Sandy marine deposits and/or eolian sands

Typical profile

A - 0 to 6 inches: sand
C1 - 6 to 36 inches: sand
C2 - 36 to 90 inches: sand

Properties and qualities

Slope: 0 to 8 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Excessively drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): Very high (14.17 to 99.90 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: Very rare
Frequency of ponding: None
Calcium carbonate, maximum in profile: 2 percent
Salinity, maximum in profile: Nonsaline to strongly saline (0.0 to 111.6 mmhos/cm)
Sodium adsorption ratio, maximum in profile: 15.0
Available water storage in profile: Low (about 3.3 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 8c
Hydrologic Soil Group: A
Hydric soil rating: No

Description of Merrimac

Setting

Landform: Outwash plains, kames, eskers, moraines, outwash terraces
Landform position (two-dimensional): Backslope, footslope, shoulder, summit
Landform position (three-dimensional): Side slope, crest, riser, tread
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Loamy glaciofluvial deposits derived from granite, schist, and gneiss over sandy and gravelly glaciofluvial deposits derived from granite, schist, and gneiss

Typical profile

Ap - 0 to 10 inches: fine sandy loam
Bw1 - 10 to 22 inches: fine sandy loam
Bw2 - 22 to 26 inches: stratified gravel to gravelly loamy sand
2C - 26 to 65 inches: stratified gravel to very gravelly sand

Properties and qualities

Slope: 0 to 8 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Somewhat excessively drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to very high (1.42 to 99.90 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 2 percent
Salinity, maximum in profile: Nonsaline (0.0 to 1.4 mmhos/cm)
Sodium adsorption ratio, maximum in profile: 1.0
Available water storage in profile: Low (about 4.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: A
Hydric soil rating: No

Description of Urban Land

Typical profile

M - 0 to 10 inches: cemented material

Properties and qualities

Slope: 0 to 8 percent
Depth to restrictive feature: 0 inches to manufactured layer
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Very low (0.00 to 0.00 in/hr)
Available water storage in profile: Very low (about 0.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 8
Hydrologic Soil Group: D
Hydric soil rating: Unranked

Minor Components

Enfield

Percent of map unit: 10 percent
Landform: Kame terraces, moraines, outwash terraces, kames, outwash plains
Landform position (two-dimensional): Shoulder, footslope, backslope, summit
Landform position (three-dimensional): Crest, side slope, riser, tread, rise
Down-slope shape: Convex
Across-slope shape: Convex
Hydric soil rating: No

Carver

Percent of map unit: 10 percent
Landform: Kames, eskers, moraines, outwash terraces, outwash plains, deltas
Landform position (two-dimensional): Backslope, footslope, shoulder, summit
Landform position (three-dimensional): Side slope, crest, riser, tread
Down-slope shape: Convex
Across-slope shape: Convex
Hydric soil rating: No

600—Pits, sand and gravel

Map Unit Setting

National map unit symbol: 98rq
Frost-free period: 120 to 220 days
Farmland classification: Not prime farmland

Map Unit Composition

Pits: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Pits

Setting

Parent material: Loose sandy and gravelly glaciofluvial deposits

602—Urban land

Map Unit Setting

National map unit symbol: 98s7
Frost-free period: 120 to 220 days
Farmland classification: Not prime farmland

Map Unit Composition

Urban land: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Urban Land

Setting

Parent material: Excavated and filled land

Minor Components

Udipsamments

Percent of map unit: 15 percent
Hydric soil rating: Unranked

665—Udipsamments, smoothed

Map Unit Setting

National map unit symbol: 98s6
Mean annual precipitation: 41 to 48 inches
Mean annual air temperature: 50 to 54 degrees F
Frost-free period: 160 to 240 days
Farmland classification: Not prime farmland

Map Unit Composition

Udipsamments and similar soils: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Udipsamments

Setting

Landform position (two-dimensional): Summit
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Sandy excavated or filled land

Properties and qualities

Depth to restrictive feature: More than 80 inches
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None

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APPENDIX D

ORIGINAL FISH WEIR DESIGN PLAN

2983ws1

WORKSHEET PLOT ONLY, NOT TO BE USED FOR CONSTRUCTION
SFC Engineering Partnership, Inc.
25 SUNDIAL AVENUE, SUITE 205W
MANCHESTER, NH 03103-7230
TEL. (603) 647-8700
FAX. (603) 647-8711

PROJECT NAME: MASHPEE FISH LADDER RE-BUILD
PROJECT NUMBER: 298301
SCALE: 1 In.=10 ft.
DATE: 10/31/00
BENCHMARK JOB No: K:\2983\SDATA\2983J1
DRAWING FILE: K:\2983\DWG\2983WS1
FIELD BOOK REF: Bk 166 Pg 67 (D.L. Bk R11 Pg 90-104)
CREATED BY: RBH

NOTES
1) THIS PLAN DOES NOT REPRESENT A BOUNDARY SURVEY BY S.F.C. ENGINEERING PARTNERSHIP, INC.
2) THIS PLAN REPRESENTS FIELD CONDITIONS AS LAST OBSERVED ON 10-30-00
3) SURVEYED BY: RBH & BRH
4) BENCHMARK: MON. WELL RISER ELEVATIONS PROVIDED BY TOWN OF MASHPEE (NGVD 29)

RECEIVED
NOV 27 2000
MASSACHUSETTS DEPARTMENT OF ENVIRONMENTAL PROTECTION

PROGRESS PRINT

POINT INDEX
1-2 TRAVERSE
100-286 TOPOGRAPHY

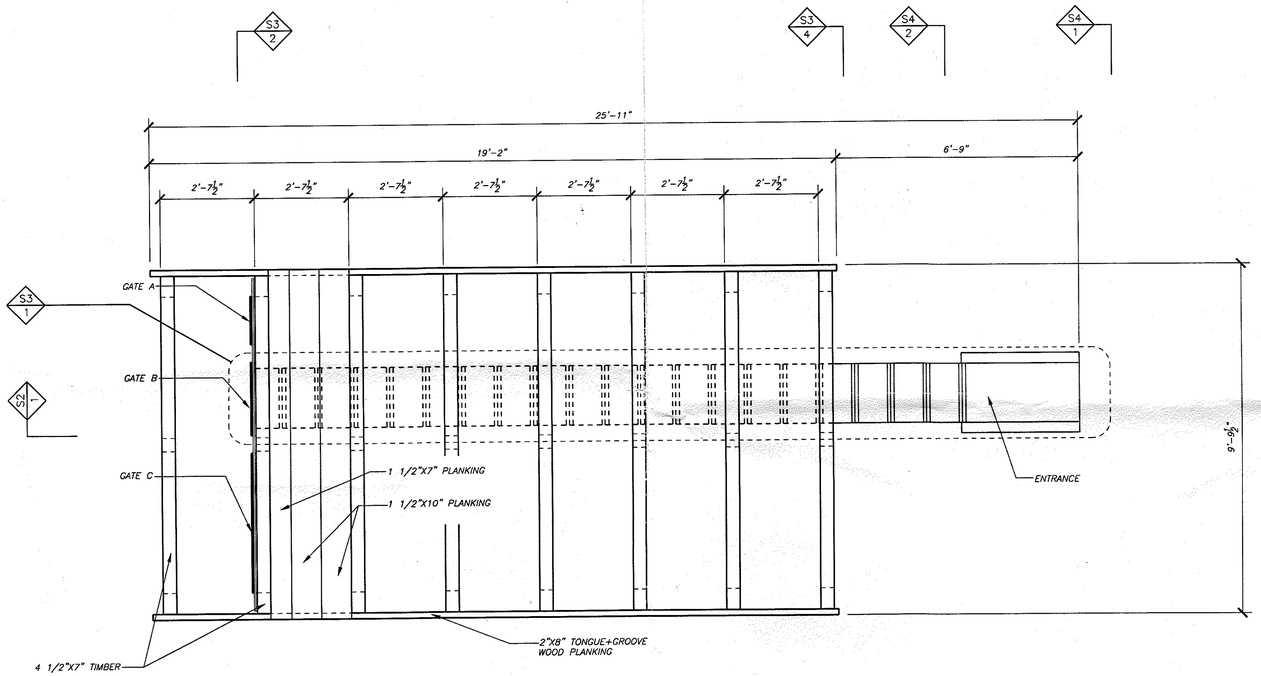
TOWN BEACH
ACCESS ROAD
JOHN'S POND
Sand
GRASSED AREA
Cove Block Ret. Wall
Grass Ret. Wall
Grass Ret Wall Rough Shape
TRAIL
FISHWAY (INN)
JACOBS ENGINEERING MON. WELL # 562 B
JACOBS ENGINEERING MON. WELL # 562 C
JACOBS ENGINEERING MON. WELL # 562 A
Elev. @ Top Cap (all wells)
TBM C RRSPK SET IN 24" PINE UP 0.5' ELEV.= 44.69'
TBM B DUPLEX NAIL IN 10" OAK UP 0.5' ELEV.= 42.38'
Some information Shut OFF for Clarity (℄ of Main Beams & Fishway) (Layer ND-CL)

BASED ON PLAN OF REFERENCE
Map. 10-30-00

GRAPHIC SCALE
10 0 5 10 20 40
(IN FEET)
1 inch = 10 ft.

2' Contour Interval

2983ws1



EXISTING FISHWAY PLAN

S1 / 1

1/2" = 1'-0"

DRAFT
AS-BUILT

GRAPHIC SCALE

0 1'-0" 2'-0" 4'-0" 8'-0"

SCALE: 1/2"=1'-0"

PREPARED FOR:
MASHPEE CONSERVATION COMMISSION
16 GREAT NECK RD NORTH, BOX208
MASHPEE, MA 02649
(508)539-1400 EXT 538
TAX MAP: XXX LOT NO. XX-XX

NO.	DATE	REVISION	BY
1	XX/XX/XX	XXX	XXX

SFC ENGINEERING PARTNERSHIP Inc.
25 SUNDIAL AVENUE, SUITE 205W
MANCHESTER, NH 03103-7220
PH. 603-647-8700
FAX 603-647-8711

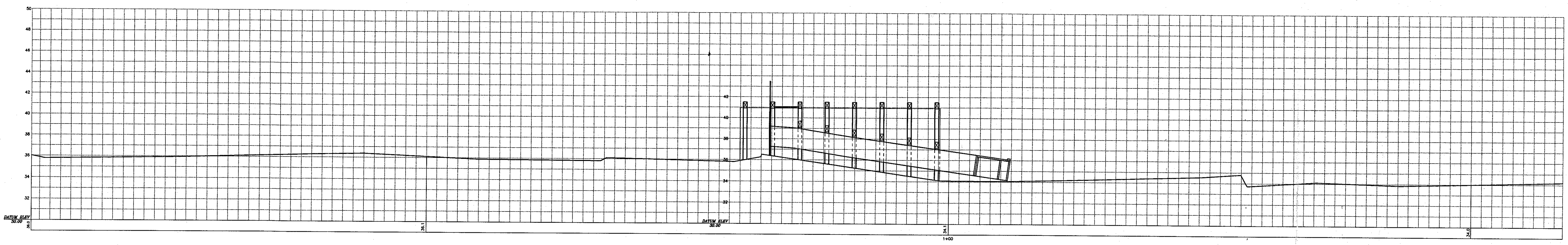
MASHPEE FISH BYPASS REHABILITATION
MASHPEE, MA
JOHN'S POND

EXISTING PLAN

SCALE: 1/2"=1'-0"
APPROVED BY:
CHECKED BY:
DRAWN BY: XXX
DESIGNED BY:
SHEET: XX OF XX
DATE: XX/XX/XX

DWG NO.
S1

2983-S1



FISH BYPASS CHANNEL
PROFILE
C2 / 1
1" = 5'

DRAFT
AS-BUILT

GRAPHIC SCALE
0 2'-6" 5'-0" 10'-0" 20'-0"
SCALE: 1"=5'-0"

PREPARED FOR:
MASHPEE CONSERVATION COMMISSION
16 GREAT NECK RD NORTH, BOX208
MASHPEE, MA 02649
(508)539-1400 EXT 538
TAX MAP: XXX LOT NO. XX-XX

NO.	DATE	REVISION	BY
△	XX/XX/XX 2/8/01	XXX	XXX

SFC ENGINEERING PARTNERSHIP Inc.
25 SUNDIAL AVENUE, SUITE 205W
MANCHESTER, NH 03103-7230
TEL 603-647-8700
FAX 603-647-8711

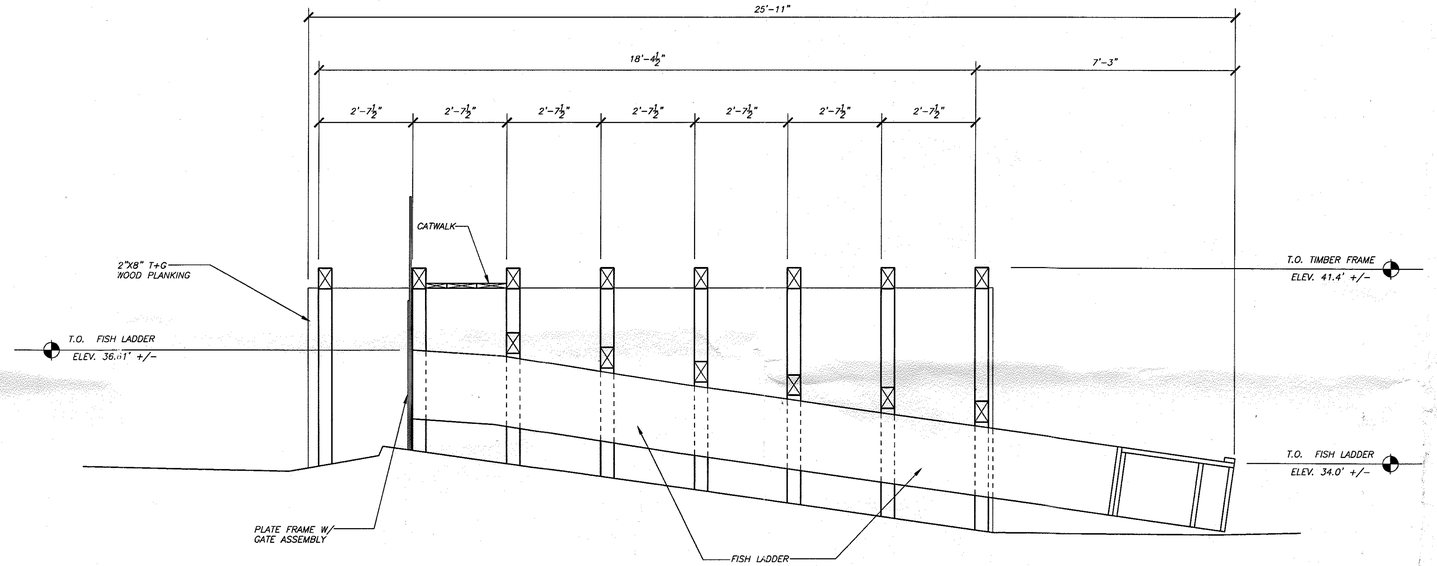
MASHPEE FISH BYPASS REHABILITATION
JOHN'S POND MASHPEE MA

FISHWAY PROFILE & SITE DETAILS

SCALE: AS NOTED
SHEET: C2
DATE: XX/XX/XX
DESIGNED BY:
DRAWN BY: XXX
CHECKED BY:
APPROVED BY:

DWG NO.
C2

2983-C2



S2/1 EXISTING FISHWAY SECTION

1/2" = 1'-0"

DRAFT
AS-BUILT

GRAPHIC SCALE

0 1'-0" 2'-0" 4'-0" 8'-0"

SCALE: 1/2"=1'-0"

PREPARED FOR:

MASHPEE CONSERVATION COMMISSION
16 GREAT NECK RD NORTH, BOX208
MASHPEE, MA 02649
(508)539-1400 EXT 538

TAX MAP: XXX LOT NO. XX-XX

NO.	DATE	REVISION	BY
1	XX/XX/XX	XXX	XXX

2/8/01

SFC ENGINEERING PARTNERSHIP Inc.
25 SUNDIAL AVENUE, SUITE 205W
MANCHESTER, NH 03103-7230
(603) 647-8700
FAX 603-647-8711

MASHPEE FISH BYPASS REHABILITATION
JOHN'S POND MASHPEE, MA

PROFILE SECTION

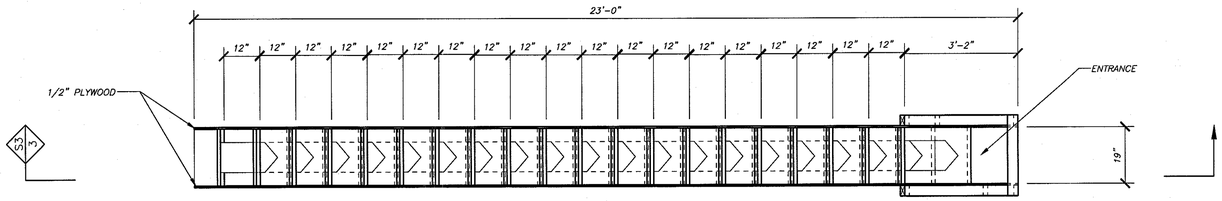
SCALE: 1/2"=1'-0"

SHEET: XX OF XX | DESIGNED BY: | DRAWN BY: XXX | CHECKED BY: | APPROVED BY:

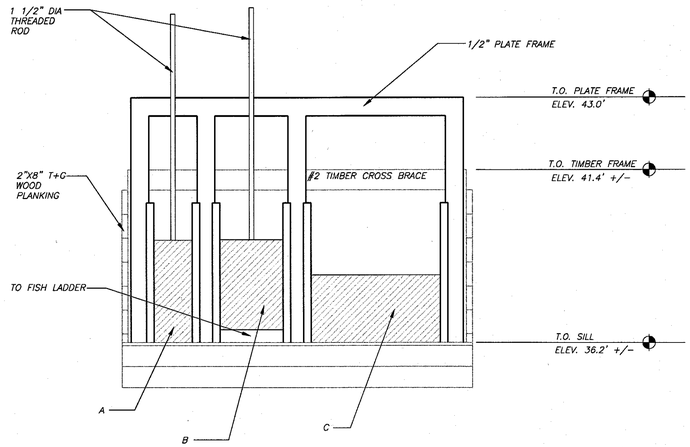
DATE: XX/XX/XX

DWG NO.
S2

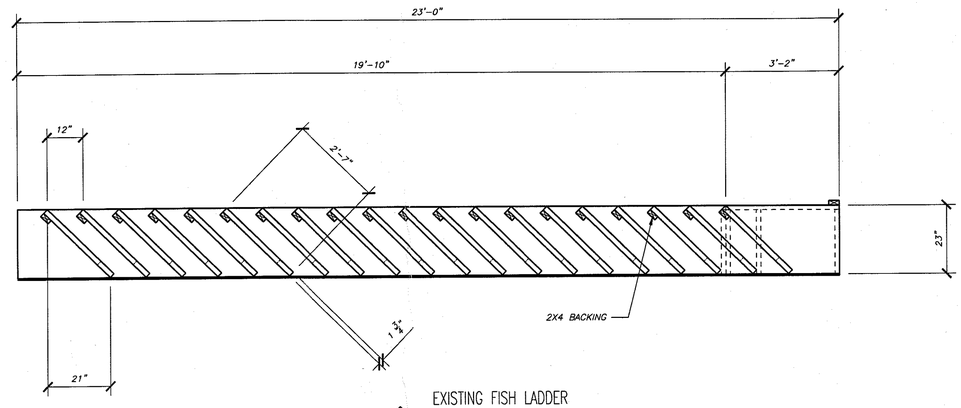
2983-S2



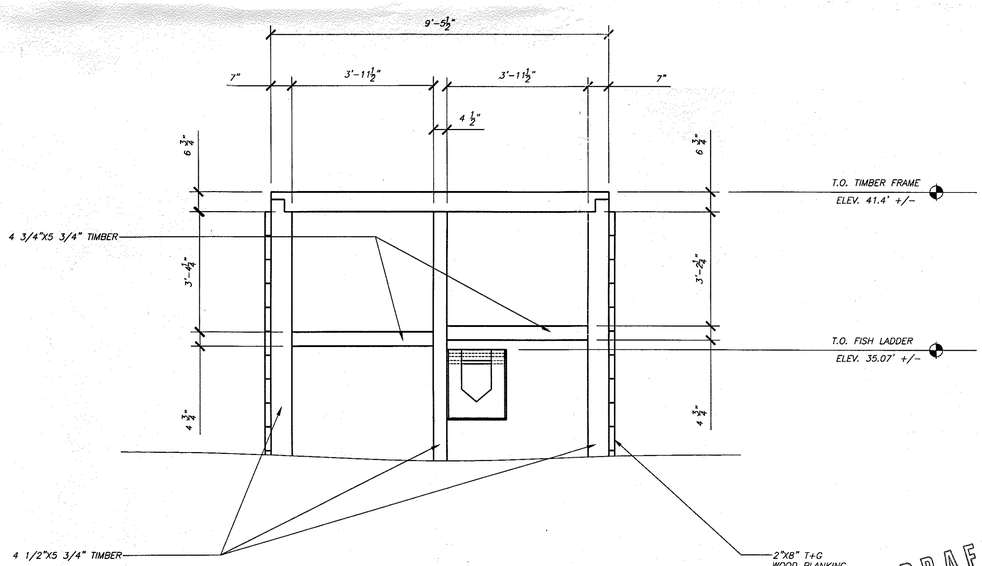
EXISTING FISH LADDER
PLAN
S3 1
1/2" = 1'-0"



EXISTING FISHWAY
ELEVATION
S3 2
1/2"= 1'-0"



EXISTING FISH LADDER
SECTION
S3 3
1/2" = 1'-0"



DRAFT
AS-BUILT

EXISTING FISHWAY
ELEVATION
S3 4
1/2" = 1'-0"

GRAPHIC SCALE
0 1'-0" 2'-0" 4'-0" 8'-0"
SCALE: 1/2"=1'-0"

PREPARED FOR:
MASHPEE CONSERVATION COMMISSION
16 GREAT NECK RD NORTH, BOX208
MASHPEE, MA 02649
(508)539-1400 EXT 538
TAX MAP: XXX LOT NO. XX-XX

NO.	DATE	REVISION	BY
1	2/8/01	XXX	XXX
2	XX/XX/XX	XXX	XXX

SFC ENGINEERING PARTNERSHIP Inc.
25 SUNDIAL AVENUE, SUITE 205W
MANCHESTER, NH 03103-7230
TEL 603-647-8700
FAX 603-647-0711

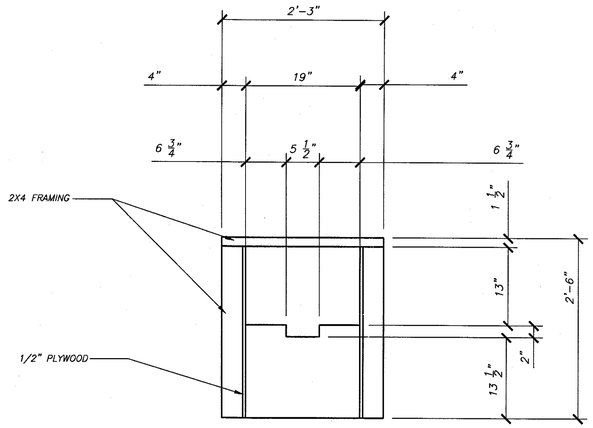
MASHPEE FISH BYPASS REHABILITATION
MASHPEE, MA
JOHN'S POND

EXISTING PLANS, ELEVATIONS, SECTIONS

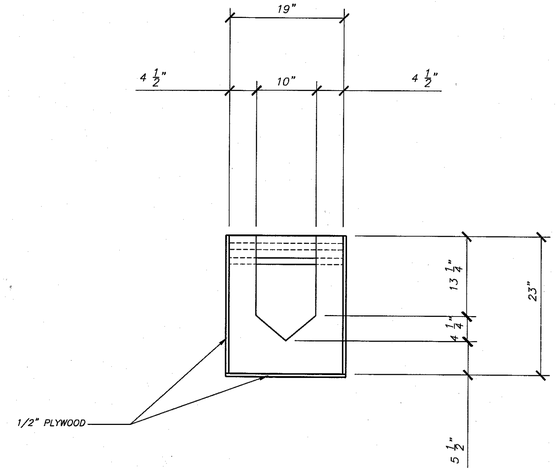
SCALE: 1/2"=1'-0"
APPROVED BY:
CHECKED BY:
DRAWN BY: XXX
DESIGNED BY:
SHEET: XX OF XX
DATE: XX/XX/XX

DWG NO.
S3

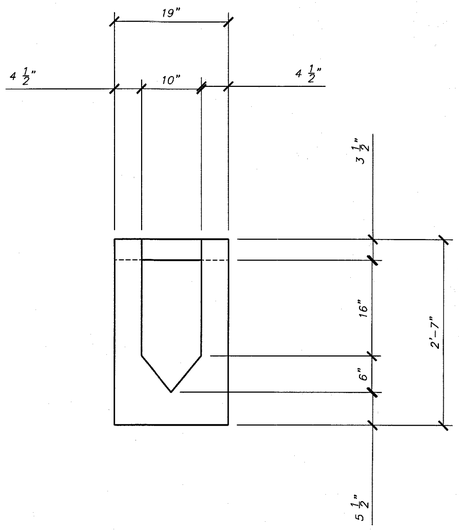
2983-S3



FISH LADDER BOX ENTRANCE
ELEVATION
S4 / 1
1" = 1'-0"



FISH LADDER
SECTION
S4 / 2
1" = 1'-0"



DENIL SLOT
ELEVATION
S4 / 3
1" = 1'-0"

DRAFT
AS-BUILT

GRAPHIC SCALE
0 6" 1'-0" 2'-0" 4'-0"
SCALE: 1"=1'-0"

PREPARED FOR:
MASHPEE CONSERVATION COMMISSION
16 GREAT NECK RD NORTH, BOX 208
MASHPEE, MA 02649
(508)539-1400 EXT 538
TAX MAP: XXX LOT NO. XX-XX

NO.	DATE	REVISION	BY
1	2/8/01	XXX	XXX
2	XX/XX/XX	XXX	

SFC ENGINEERING PARTNERSHIP INC.
25 SUNDIAL AVENUE, SUITE 205W
MANCHESTER, NH 03103-7280
TEL 603-641-6570
FAX 603-641-8771

MASHPEE FISH BYPASS REHABILITATION
MASHPEE MA
JOHN'S POND

SECTIONS & ELEVATIONS

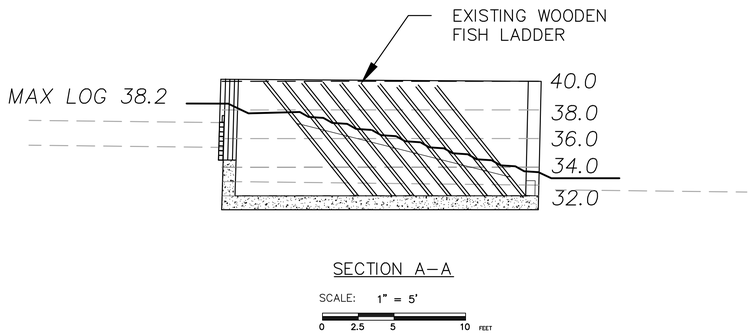
SCALE: 1"=1'-0"
APPROVED BY:
CHECKED BY:
DRAWN BY: XXX
DESIGNED BY:
SHEET: XX OF XX
DATE: XX/XX/XX

DWG NO.
S4

2983-S4

APPENDIX E

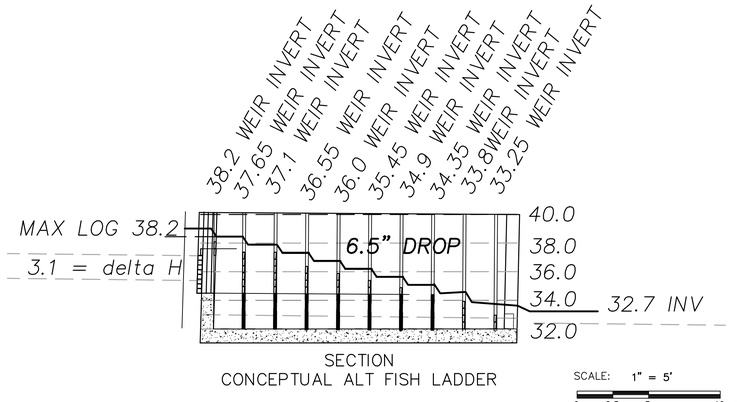
PLAN OF RECOMMENDED IMPROVEMENTS



SECTION A–A

SCALE: 1" = 5'

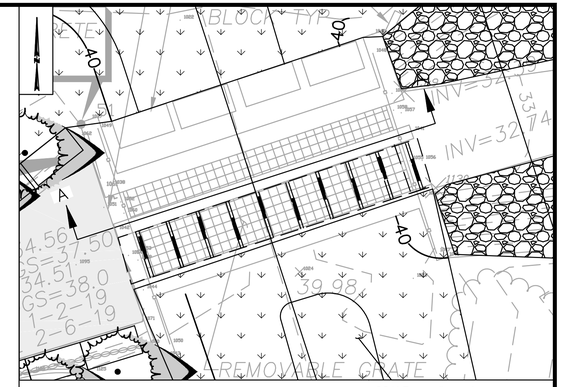
0 2.5 5 10 FEET



SECTION
CONCEPTUAL ALT FISH LADDER

SCALE: 1" = 5'

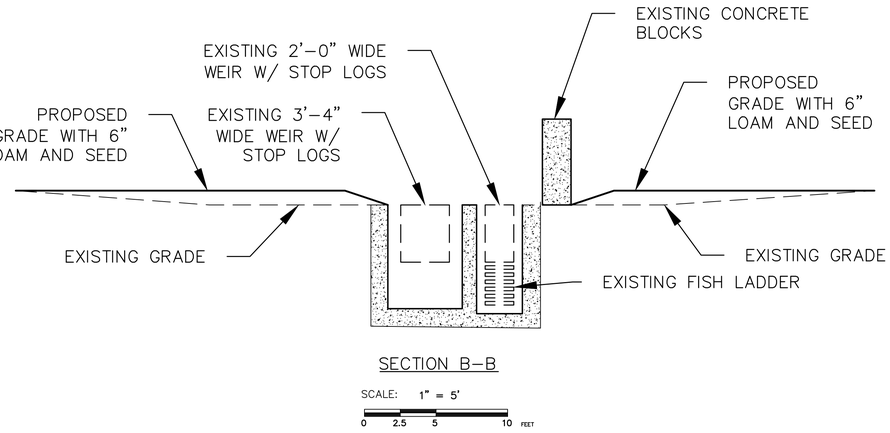
0 2.5 5 10 FEET



PLAN VIEW
CONCEPTUAL ALT FISH LADDER

SCALE: 1" = 5'

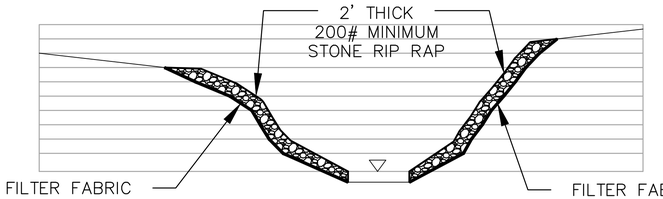
0 2.5 5 10 FEET



SECTION B–B

SCALE: 1" = 5'

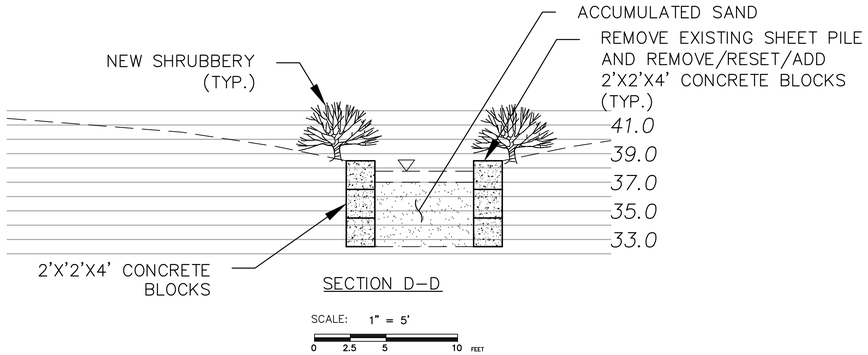
0 2.5 5 10 FEET



SECTION C–C

SCALE: 1" = 5'

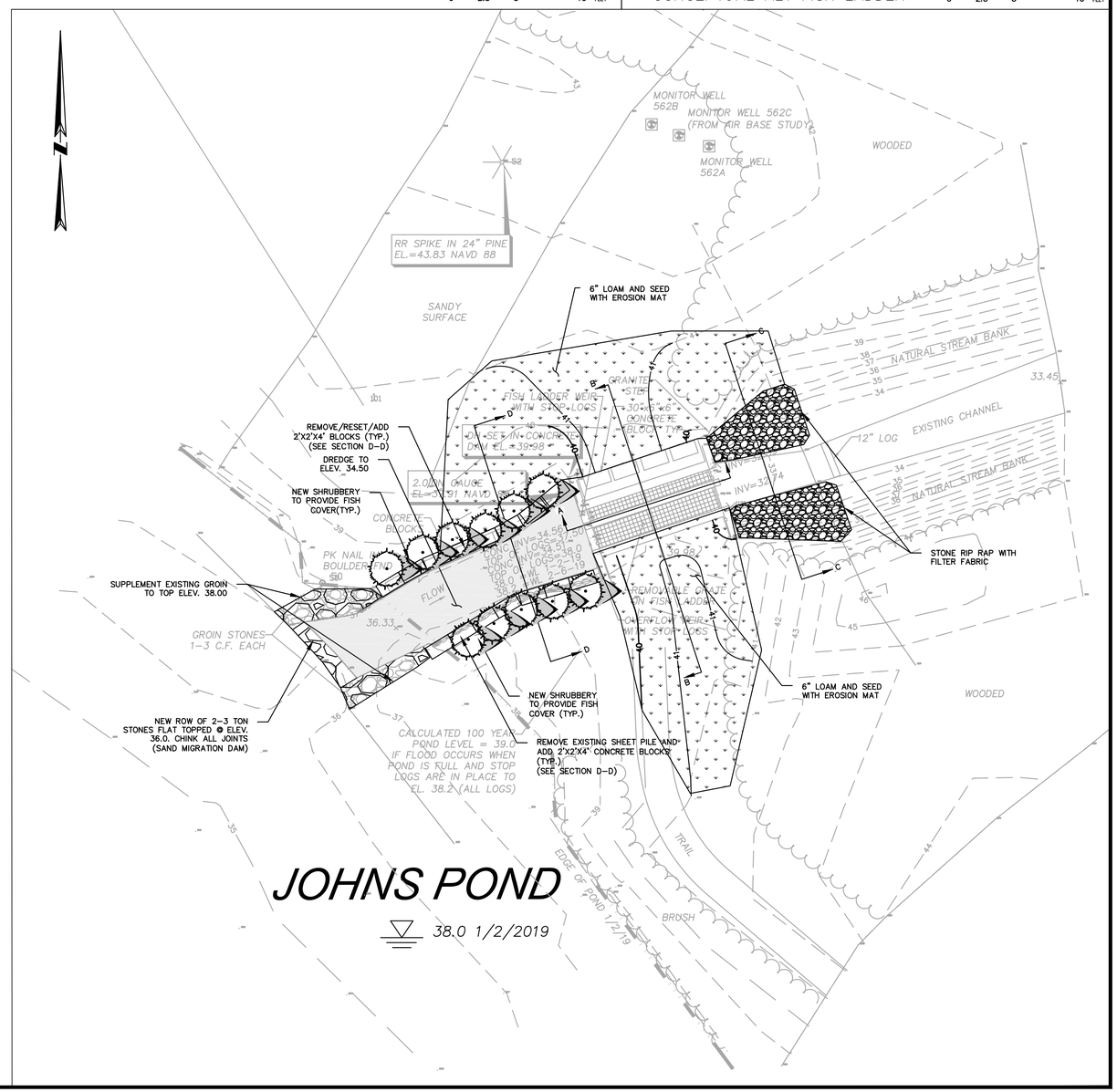
0 2.5 5 10 FEET



SECTION D–D

SCALE: 1" = 5'

0 2.5 5 10 FEET



DATE

PROFESSIONAL ENGINEER

HYDROLOGIC/ HYDRAULIC ASSESSMENT

JOHNS POND

IN

MASHPEE
MASSACHUSETTS
(BARNSTABLE COUNTY)

RECOMMENDED SITE IMPROVEMENTS PLAN

MARCH 20, 2019

REVISIONS:

NO.	DATE	DESC.

PREPARED FOR:
TOWN OF MASHPEE
CONSERVATION COMMISSION
16 GREAT NECK ROAD
MASHPEE, MA 02649

BSC GROUP
803 Summer Street
Boston, Massachusetts
02127
617 896 4300

SCALE: 1" = 10'

0 10 20 40 FEET

FILE: P\YAR\5026100\C\D\–SP

DWG.: DWG

JOB. NO: 5–2061.00

SHEET 1 OF 1

APPENDIX F

AVAILABLE WELL LOGS (FROM OTIS AIRBASE STUDIES)

~~NAVAL ASSESSMENT AND CONTROL OF~~
~~SERGEANT MAJOR BOMINGDOG~~

Client: HAZWRAP/IRP	Project No.	Study Area: SERGOU	
Contractor: ABB/MAHER	Date Started: 10-25-93	Boring No.: MW-562A	
Method: HSA	Casing Size: 4.25" (ID)	Protection: D	
Ground Elev.:	Soil Drilled: 134'	Completed: 10-27-93	
Logged by: HCT	Checked by:	PI Meter: TE-3	
Screen: (ft.)	Riser: (ft.)	Diam: 2" (ID)	Material: PVC
		Total Depth: 134'	
		▽ Below Ground: 71	
		Page 3 of: 3'	

DEPTH (FT)	SAMPLE NUMBER	SAMPLE DEPTH	~~RECOVERY~~ GPM	PID (ppm)	PURGE VOL. (gallons)	COMMENTS/DESCRIPTION		WELL DATA	ELEVATION (FT)
109									
114'	S-20	114		0	50+	00BW562114 93XF - 1671	silty, yellow color		
119'	S-21	119		0	45+	00BW562119 93XF - 1672 00BW562119 93DF - 1684 00BW562119 93XX - 1683	cloudy		
124'	S-22	124			45+	00BW562124 93XF - 1673	cloudy w/ silt + fine sand		
129'	S-23	129		0	45+	00BW562129 93XF - 1674	cloudy, slightly silty		
134'	S-24	134		0	40+	00BW562134 93XF - 1675	cloudy, slightly silty		
						BOB @ 134' bgs			
						HCT			

MMR TASK 2 FC PRIORITY 1 AOC
SCREENED AUGER BORING LOG

Client: HAZWRAP/IRP	Project No.	Study Area: SERGOU
		Boring No.: MW-562A
		Protection: D
Contractor: ABB / DL Maher	Date Started: 10-25-93	Completed: 10-27-93
Method: HSA	Casing Size: 4.25" (ID)	PI Meter: TE-3
Ground Elev.:	Soil Drilled: 124'	Total Depth: 124'
Logged by: HCT	Checked by:	▽ Below Ground: 7'
Screen: (ft.) Riser: (ft.)	Diam: 2" (ID) Material: PVC	Page 2 of: 3

DEPTH (FT)	SAMPLE NUMBER	SAMPLE DEPTH	~~RECOVERY~~ GPM	PID (ppm)	PURGE VOL. (gallons)	COMMENTS/DESCRIPTION	WELL DATA	ELEVATION (FT.)
59'	S-10	59		0	40+	00BW562X5993XF - 1611 clear		
64'	S-11	64		0	45+	00BW562X6493XF - 1612 clear 00BW562X6493DF - 1617 00BW562X6493XX - 1619		
69'	S-12	69		0	45+	00BW562X6993XF - 1615 clear		
79'	S-13	79		0	45+	00BW562X7993XF - 1613 clear		
84'	S-14	84		0	45+	00BW562X8493XF - 1614 clear		
89'	S-15	89		0	50+	00BW562X8993XF - 1666 clear		
94'	S-16	94		0	45+	00BW562X9493XF - 1667 clear		
99'	S-17	99		0	45+	00BW562X9993XF - 1668 slightly silty bony, gravelly.		
104'	S-18	104		0	45+	00BW56210493XF - 1669 slightly silty gravelly		
109'	S-19	109		0	45+	00BW56210993XF - 1670 Slightly silty		

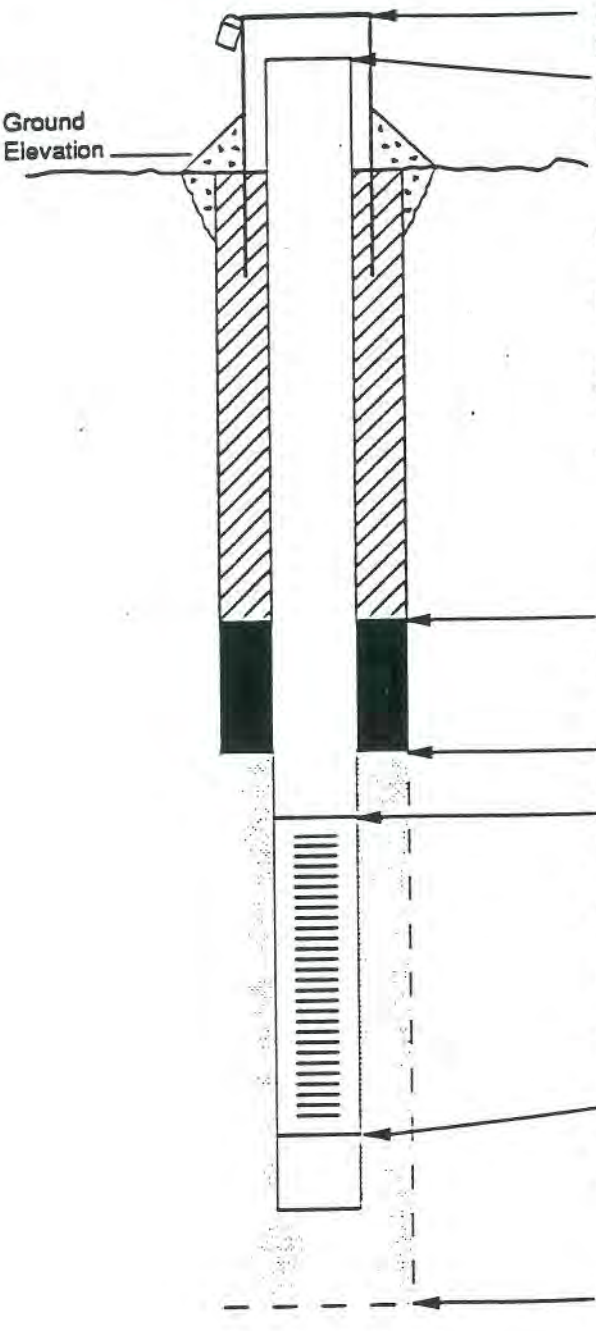
MMR TASK 2-5C PRIORITY 1 AOC
SCREENED-AUGER BORING LOG

Client: HAZWRAP/IRP		Project No.	Study Area: SERGOU
Contractor: ABB/DLMake	Date Started: 10-25-93		Boring No.: MW562A
Method: HSA	Casing Size: 4.25" (ID)		Protection: D
Ground Elev.:	Soil Drilled: 134'		Completed: 10-27-93
Logged by: HCT	Checked by:		PI Meter: TE-3
Screen: (ft.)	Riser: (ft.)	Diam: 2" (ID)	Material: PVC
			Total Depth: 134'
			▽ Below Ground: 71
			Page 1 of: 3

DEPTH (FT)	SAMPLE NUMBER	SAMPLE DEPTH	RECOVERY GPM	PID (ppm)	PURGE VOL. (gallons)	COMMENTS/DESCRIPTION	WELL DATA	ELEVATION (FT.)
						0-14' drilled, WL = 7' bgs.		
14'	S-1	14		0	85+	00BW562X1493XF - 1618 00BW562X1493DF - 1616 00BW562X1493XX - 1602 clear		
19'	S-2	19		0	45+	00BW562X1993XF - 1603 clear		
24'	S-3	24		0	45+	00BW562X2493XF - 1604 cloudy		
29'	S-4	29		0	45+	00BW562X2993XF -1605 fairly clear		
34'	S-5	34		0	40+	00BW562X3493XF - 1606 orange-yellow-color		
39'	S-6	39		0	45+	00BW562X3993XF - 1607 clear		
44'	S-7	44		0	45+	00BW562X4493XF - 1608 clear		
49'	S-8	49		0	40+	00BW562X4993XF - 1609 Fairly silty		
54'	S-9	54		0	50+	00BW562X5493XF - 1610 clear		

MONITORING WELL CONSTRUCTION DIAGRAM

Project MMR Task 2.5C Location MMR Driller DLMaher (Graglia/Jensen)
Project No. 7637-32 Boring No. MW-562A Drilling Method HSA Screened-auger
Date Installed 10-27-93 Development Method
Field Geologist Trish



Elevation of Top of Surface Casing:
Stick-up of Casing Above Ground Surface: 2 1/2'
Elevation of Top of Riser Pipe:
Type of Surface Seal: Cement
Type of Surface Casing: steel protective casing

ID of Surface Casing:

Diameter of Borehole: 6"

Riser Pipe ID: 2" PVC
Type of Riser Pipe: Sch 80

Type of Backfill: Natural Sand
cave in

Elevation of Top of Seal:
Depth of Top of Seal: 116'
Type of Seal: Super Gelex

Elevation of Top of Sand: —
Depth of Top of Sand: 122'
Elevation of Top of Screen: —
Depth of Top of Screen: 128'

Type of Screen: Sch 80 PVC
Slot Size x Length: 0.01" x 5'
ID of Screen: 2" PVC

Type of Sandpack: Natural cave-in

Elevation of Bottom of Screen: —
Depth of Bottom of Screen: 133'
Depth of Sediment Sump with Plug: 133.1'

Elevation of Bottom of Borehole: —
Depth of Bottom of Borehole: 134'

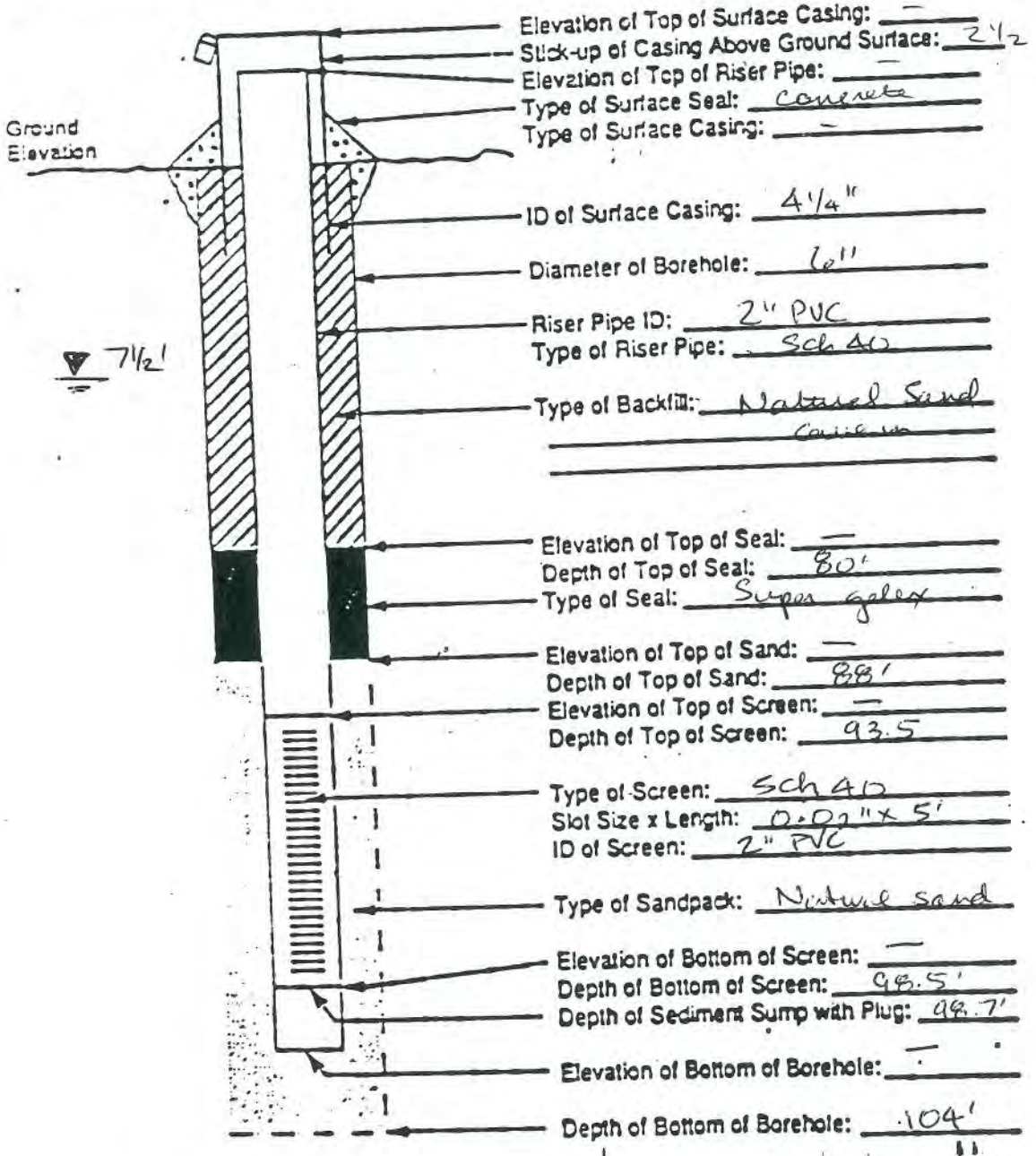
ABB Environmental Services, Inc.

9105091D

MONITORING WELL CONSTRUCTION DIAGRAM

Project MMR
Project No. 7637-32
Location Task 2 SC
Boring No. MW562B
Date Installed 11-4-93
Driller DL Maher
Drilling Method HSA
Development Method —

Field Geologist: Trish



Elevation of Top of Surface Casing: —
Stick-up of Casing Above Ground Surface: 2 1/2
Elevation of Top of Riser Pipe: —
Type of Surface Seal: Concrete
Type of Surface Casing: —

ID of Surface Casing: 4 1/4"

Diameter of Borehole: 6"

Riser Pipe ID: 2" PVC
Type of Riser Pipe: Sch 40

Type of Backfill: Natural Sand
Cuttings

Elevation of Top of Seal: —
Depth of Top of Seal: 80'
Type of Seal: Super gelex

Elevation of Top of Sand: —
Depth of Top of Sand: 88'

Elevation of Top of Screen: —
Depth of Top of Screen: 93.5

Type of Screen: Sch 40
Slot Size x Length: 0.02" x 5'
ID of Screen: 2" PVC

Type of Sandpack: Natural sand

Elevation of Bottom of Screen: —
Depth of Bottom of Screen: 98.5'
Depth of Sediment Sump with Plug: 99.7'

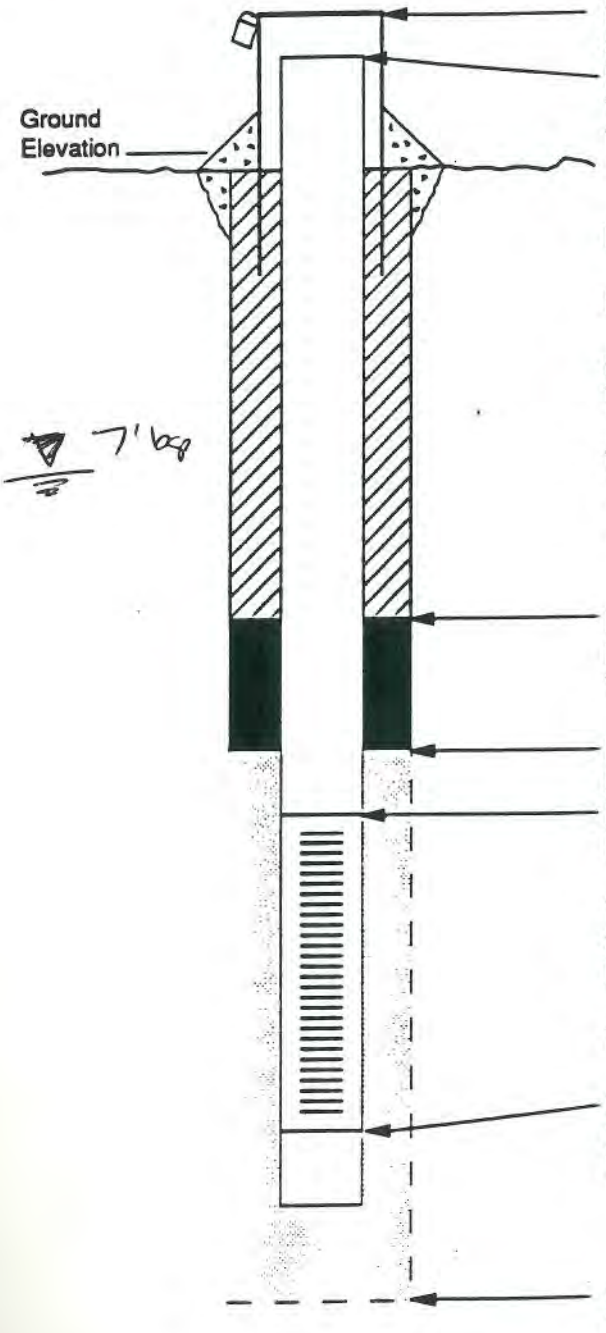
Elevation of Bottom of Borehole: —

Depth of Bottom of Borehole: 104'

ABB Environmental Services, Inc.

MONITORING WELL CONSTRUCTION DIAGRAM

Project MMR Location Task 2.5C Driller DL Mackie
Project No. 7637-32 Boring No. ~~MW~~-562C Drilling Method HSA
Date Installed 11-3-93 Development Method —
Field Geologist Trinh



Elevation of Top of Surface Casing: —
Stick-up of Casing Above Ground Surface: 2 1/2'
Elevation of Top of Riser Pipe: —
Type of Surface Seal: concrete
Type of Surface Casing: —

ID of Surface Casing: 4 1/4"

Diameter of Borehole: 6"

Riser Pipe ID: 2" PVC
Type of Riser Pipe: Sch 40

Type of Backfill: Concrete mix

Elevation of Top of Seal: —
Depth of Top of Seal: 3.5'
Type of Seal: Bentonite / Dry concrete

Elevation of Top of Sand: —
Depth of Top of Sand: 4.0'
Elevation of Top of Screen: —
Depth of Top of Screen: 4.5'

Type of Screen: Sch 40
Slot Size x Length: 0.01" x 10'
ID of Screen: 2" PVC

Type of Sandpack: Natural Sand

Elevation of Bottom of Screen: —
Depth of Bottom of Screen: 14.5
Depth of Sediment Sump with Plug: 14.7

Elevation of Bottom of Borehole: —
Depth of Bottom of Borehole: 15.0

APPENDIX G

GRAIN SIZE ANALYSIS OF POND BOTTOM AT CHANNEL ENTRANCE

ANALYTICAL REPORT

Lab Number:	L1852543
Client:	The BSC Group, Inc. 803 Summer Street Boston, MA 02127
ATTN:	David Crispin
Phone:	(617) 896-4451
Project Name:	JOHNS POND
Project Number:	5-0261.00
Report Date:	01/04/19

Certifications & Approvals: MA (M-MA086), NH NELAP (2064), CT (PH-0574), IL (200077), ME (MA00086), MD (348), NJ (MA935), NY (11148), NC (25700/666), PA (68-03671), RI (LAO00065), TX (T104704476), VT (VT-0935), VA (460195), USDA (Permit #P330-17-00196).

320 Forbes Boulevard, Mansfield, MA 02048-1806
508-822-9300 (Fax) 508-822-3288 800-624-9220 - www.alphalab.com

Project Name: JOHNS POND
Project Number: 5-0261.00

Lab Number: L1852543
Report Date: 01/04/19

Alpha Sample ID	Client ID	Matrix	Sample Location	Collection Date/Time	Receive Date
L1852543-01	JOHNS POND 1	SOIL	MASHPEE	12/19/18 11:00	12/20/18

Project Name: JOHNS POND
Project Number: 5-0261.00

Lab Number: L1852543
Report Date: 01/04/19

Case Narrative

The samples were received in accordance with the Chain of Custody and no significant deviations were encountered during the preparation or analysis unless otherwise noted. Sample Receipt, Container Information, and the Chain of Custody are located at the back of the report.

Results contained within this report relate only to the samples submitted under this Alpha Lab Number and meet NELAP requirements for all NELAP accredited parameters unless otherwise noted in the following narrative. The data presented in this report is organized by parameter (i.e. VOC, SVOC, etc.). Sample specific Quality Control data (i.e. Surrogate Spike Recovery) is reported at the end of the target analyte list for each individual sample, followed by the Laboratory Batch Quality Control at the end of each parameter. Tentatively Identified Compounds (TICs), if requested, are reported for compounds identified to be present and are not part of the method/program Target Compound List, even if only a subset of the TCL are being reported. If a sample was re-analyzed or re-extracted due to a required quality control corrective action and if both sets of data are reported, the Laboratory ID of the re-analysis or re-extraction is designated with an "R" or "RE", respectively. When multiple Batch Quality Control elements are reported (e.g. more than one LCS), the associated samples for each element are noted in the grey shaded header line of each data table. Any Laboratory Batch, Sample Specific % recovery or RPD value that is outside the listed Acceptance Criteria is bolded in the report. All specific QC information is also incorporated in the Data Usability format of our Data Merger tool where it can be reviewed along with any associated usability implications. Soil/sediments, solids and tissues are reported on a dry weight basis unless otherwise noted. Definitions of all data qualifiers and acronyms used in this report are provided in the Glossary located at the back of the report.

In reference to questions H (CAM) or 4 (RCP) when "NO" is checked, the performance criteria for CAM and RCP methods allow for some quality control failures to occur and still be within method compliance. In these instances the specific failure is not narrated but noted in the associated QC table. The information is also incorporated in the Data Usability format of our Data Merger tool where it can be reviewed along with any associated usability implications.

Please see the associated ADEx data file for a comparison of laboratory reporting limits that were achieved with the regulatory Numerical Standards requested on the Chain of Custody.

HOLD POLICY
For samples submitted on hold, Alpha's policy is to hold samples (with the exception of Air canisters) free of charge for 21 calendar days from the date the project is completed. After 21 calendar days, we will dispose of all samples submitted including those put on hold unless you have contacted your Client Service Representative and made arrangements for Alpha to continue to hold the samples. Air canisters will be disposed after 3 business days from the date the project is completed.

Please contact Client Services at 800-624-9220 with any questions.

Project Name: JOHNS POND **Lab Number:** L1852543
Project Number: 5-0261.00 **Report Date:** 01/04/19

Case Narrative (continued)

Grain Size Analysis

The WG1193062-1 Laboratory Duplicate RPD for % total fines (57%), performed on L1852543-01, is outside the acceptance criteria. The elevated RPD has been attributed to the non-homogeneous nature of the native sample.

I, the undersigned, attest under the pains and penalties of perjury that, to the best of my knowledge and belief and based upon my personal inquiry of those responsible for providing the information contained in this analytical report, such information is accurate and complete. This certificate of analysis is not complete unless this page accompanies any and all pages of this report.

Authorized Signature: Susan E O'Neil Susan O' Neil

Title: Technical Director/Representative Date: 01/04/19

INORGANICS
&
MISCELLANEOUS

Project Name: JOHNS POND
Project Number: 5-0261.00

Lab Number: L1852543
Report Date: 01/04/19

SAMPLE RESULTS

Lab ID: L1852543-01
Client ID: JOHNS POND 1
Sample Location: MASHPEE

Date Collected: 12/19/18 11:00
Date Received: 12/20/18
Field Prep: Not Specified

Sample Depth:
Matrix: Soil

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor	Date Prepared	Date Analyzed	Analytical Method	Analyst
Grain Size Analysis - Mansfield Lab										
Cobbles	ND		%	0.100	NA	1	-	12/27/18 09:57	12,D6913/D7928	GD
% Coarse Gravel	ND		%	0.100	NA	1	-	12/27/18 09:57	12,D6913/D7928	GD
% Fine Gravel	0.600		%	0.100	NA	1	-	12/27/18 09:57	12,D6913/D7928	GD
% Total Gravel	0.600		%	0.100	NA	1	-	12/27/18 09:57	12,D6913/D7928	GD
% Coarse Sand	3.70		%	0.100	NA	1	-	12/27/18 09:57	12,D6913/D7928	GD
% Medium Sand	92.1		%	0.100	NA	1	-	12/27/18 09:57	12,D6913/D7928	GD
% Fine Sand	3.10		%	0.100	NA	1	-	12/27/18 09:57	12,D6913/D7928	GD
% Total Sand	98.9		%	0.100	NA	1	-	12/27/18 09:57	12,D6913/D7928	GD
% Total Fines	0.500		%	0.100	NA	1	-	12/27/18 09:57	12,D6913/D7928	GD

Lab Duplicate Analysis
Batch Quality Control

Project Name: JOHNS POND
Project Number: 5-0261.00

Lab Number: L1852543
Report Date: 01/04/19

Parameter	Native Sample	Duplicate Sample	Units	RPD	Qual	RPD Limits
Grain Size Analysis - Mansfield Lab Associated sample(s): 01 QC Batch ID: WG1193062-1 QC Sample: L1852543-01 Client ID: JOHNS POND 1						
Cobbles	ND	ND	%	NC		20
% Coarse Gravel	ND	ND	%	NC		20
% Fine Gravel	0.600	0.700	%	15		20
% Total Gravel	0.600	0.700	%	15		20
% Coarse Sand	3.70	4.40	%	17		20
% Medium Sand	92.1	90.8	%	1		20
% Fine Sand	3.10	3.20	%	3		20
% Total Sand	98.9	98.4	%	1		20
% Total Fines	0.500	0.900	%	**57**	Q	20

Project Name: JOHNS POND
Project Number: 5-0261.00

Lab Number: L1852543
Report Date: 01/04/19

Sample Receipt and Container Information

Were project specific reporting limits specified? YES

Cooler Information

Cooler	Custody Seal
A	Absent

Container Information

Container ID	Container Type	Cooler	Initial pH	Final pH	Temp deg C	Pres	Seal	Frozen Date/Time	Analysis(*)
L1852543-01A	Plastic 8oz unpreserved for Grain Size	A	NA		18.5	Y	Absent		A2-HYDRO-TFINE(),A2-HYDRO-CGRAVEL(),A2-HYDRO-FSAND(),A2-HYDRO-MSAND(),A2-HYDRO-TGRAVEL(),A2-HYDRO-CSAND(),A2-HYDRO-TSAND(),A2-HYDRO-COBBLES(),A2-HYDRO-FGRAVEL()

*Values in parentheses indicate holding time in days

Project Name:	JOHNS POND	**Lab Number:**	L1852543
Project Number:	5-0261.00	**Report Date:**	01/04/19

GLOSSARY

Acronyms

EDL	- Estimated Detection Limit: This value represents the level to which target analyte concentrations are reported as estimated values, when those target analyte concentrations are quantified below the reporting limit (RL). The EDL includes any adjustments from dilutions, concentrations or moisture content, where applicable. The use of EDLs is specific to the analysis of PAHs using Solid-Phase Microextraction (SPME).
EMPC	- Estimated Maximum Possible Concentration: The concentration that results from the signal present at the retention time of an analyte when the ions meet all of the identification criteria except the ion abundance ratio criteria. An EMPC is a worst-case estimate of the concentration.
EPA	- Environmental Protection Agency.
LCS	- Laboratory Control Sample: A sample matrix, free from the analytes of interest, spiked with verified known amounts of analytes or a material containing known and verified amounts of analytes.
LCSD	- Laboratory Control Sample Duplicate: Refer to LCS.
LFB	- Laboratory Fortified Blank: A sample matrix, free from the analytes of interest, spiked with verified known amounts of analytes or a material containing known and verified amounts of analytes.
MDL	- Method Detection Limit: This value represents the level to which target analyte concentrations are reported as estimated values, when those target analyte concentrations are quantified below the reporting limit (RL). The MDL includes any adjustments from dilutions, concentrations or moisture content, where applicable.
MS	- Matrix Spike Sample: A sample prepared by adding a known mass of target analyte to a specified amount of matrix sample for which an independent estimate of target analyte concentration is available.
MSD	- Matrix Spike Sample Duplicate: Refer to MS.
NA	- Not Applicable.
NC	- Not Calculated: Term is utilized when one or more of the results utilized in the calculation are non-detect at the parameter's reporting unit.
NDPA/DPA	- N-Nitrosodiphenylamine/Diphenylamine.
NI	- Not Ignitable.
NP	- Non-Plastic: Term is utilized for the analysis of Atterberg Limits in soil.
RL	- Reporting Limit: The value at which an instrument can accurately measure an analyte at a specific concentration. The RL includes any adjustments from dilutions, concentrations or moisture content, where applicable.
RPD	- Relative Percent Difference: The results from matrix and/or matrix spike duplicates are primarily designed to assess the precision of analytical results in a given matrix and are expressed as relative percent difference (RPD). Values which are less than five times the reporting limit for any individual parameter are evaluated by utilizing the absolute difference between the values; although the RPD value will be provided in the report.
SRM	- Standard Reference Material: A reference sample of a known or certified value that is of the same or similar matrix as the associated field samples.
STLP	- Semi-dynamic Tank Leaching Procedure per EPA Method 1315.
TEF	- Toxic Equivalency Factors: The values assigned to each dioxin and furan to evaluate their toxicity relative to 2,3,7,8-TCDD.
TEQ	- Toxic Equivalent: The measure of a sample¿s toxicity derived by multiplying each dioxin and furan by its corresponding TEF and then summing the resulting values.
TIC	- Tentatively Identified Compound: A compound that has been identified to be present and is not part of the target compound list (TCL) for the method and/or program. All TICs are qualitatively identified and reported as estimated concentrations.

Footnotes

1	- The reference for this analyte should be considered modified since this analyte is absent from the target analyte list of the original method.

Terms

Analytical Method: Both the document from which the method originates and the analytical reference method. (Example: EPA 8260B is shown as 1,8260B.) The codes for the reference method documents are provided in the References section of the Addendum.

Final pH: As it pertains to Sample Receipt & Container Information section of the report, Final pH reflects pH of container determined after adjustment at the laboratory, if applicable. If no adjustment required, value reflects Initial pH.

Frozen Date/Time: With respect to Volatile Organics in soil, Frozen Date/Time reflects the date/time at which associated Reagent Water-preserved vials were initially frozen. Note: If frozen date/time is beyond 48 hours from sample collection, value will be reflected in 'bold'.

Initial pH: As it pertains to Sample Receipt & Container Information section of the report, Initial pH reflects pH of container determined upon receipt, if applicable.

Total: With respect to Organic analyses, a 'Total' result is defined as the summation of results for individual isomers or Aroclors. If a 'Total' result is requested, the results of its individual components will also be reported. This is applicable to 'Total' results for methods 8260, 8081 and 8082.

Report Format: Data Usability Report

Project Name:	JOHNS POND	**Lab Number:**	L1852543
Project Number:	5-0261.00	**Report Date:**	01/04/19

Data Qualifiers

A - Spectra identified as "Aldol Condensation Product".

B - The analyte was detected above the reporting limit in the associated method blank. Flag only applies to associated field samples that have detectable concentrations of the analyte at less than ten times (10x) the concentration found in the blank. For MCP-related projects, flag only applies to associated field samples that have detectable concentrations of the analyte at less than ten times (10x) the concentration found in the blank. For DOD-related projects, flag only applies to associated field samples that have detectable concentrations of the analyte at less than ten times (10x) the concentration found in the blank AND the analyte was detected above one-half the reporting limit (or above the reporting limit for common lab contaminants) in the associated method blank. For NJ-Air-related projects, flag only applies to associated field samples that have detectable concentrations of the analyte above the reporting limit. For NJ-related projects (excluding Air), flag only applies to associated field samples that have detectable concentrations of the analyte, which was detected above the reporting limit in the associated method blank or above five times the reporting limit for common lab contaminants (Phthalates, Acetone, Methylene Chloride, 2-Butanone).

C - Co-elution: The target analyte co-elutes with a known lab standard (i.e. surrogate, internal standards, etc.) for co-extracted analyses.

D - Concentration of analyte was quantified from diluted analysis. Flag only applies to field samples that have detectable concentrations of the analyte.

E - Concentration of analyte exceeds the range of the calibration curve and/or linear range of the instrument.

G - The concentration may be biased high due to matrix interferences (i.e, co-elution) with non-target compound(s). The result should be considered estimated.

H - The analysis of pH was performed beyond the regulatory-required holding time of 15 minutes from the time of sample collection.

I - The lower value for the two columns has been reported due to obvious interference.

M - Reporting Limit (RL) exceeds the MCP CAM Reporting Limit for this analyte.

NJ - Presumptive evidence of compound. This represents an estimated concentration for Tentatively Identified Compounds (TICs), where the identification is based on a mass spectral library search.

P - The RPD between the results for the two columns exceeds the method-specified criteria.

Q - The quality control sample exceeds the associated acceptance criteria. For DOD-related projects, LCS and/or Continuing Calibration Standard exceedences are also qualified on all associated sample results. Note: This flag is not applicable for matrix spike recoveries when the sample concentration is greater than 4x the spike added or for batch duplicate RPD when the sample concentrations are less than 5x the RL. (Metals only.)

R - Analytical results are from sample re-analysis.

RE - Analytical results are from sample re-extraction.

S - Analytical results are from modified screening analysis.

J - Estimated value. This represents an estimated concentration for Tentatively Identified Compounds (TICs).

ND - Not detected at the reporting limit (RL) for the sample.

Report Format: Data Usability Report

REFERENCES

12 Annual Book of ASTM Standards. (American Society for Testing and Materials) ASTM International.

LIMITATION OF LIABILITIES

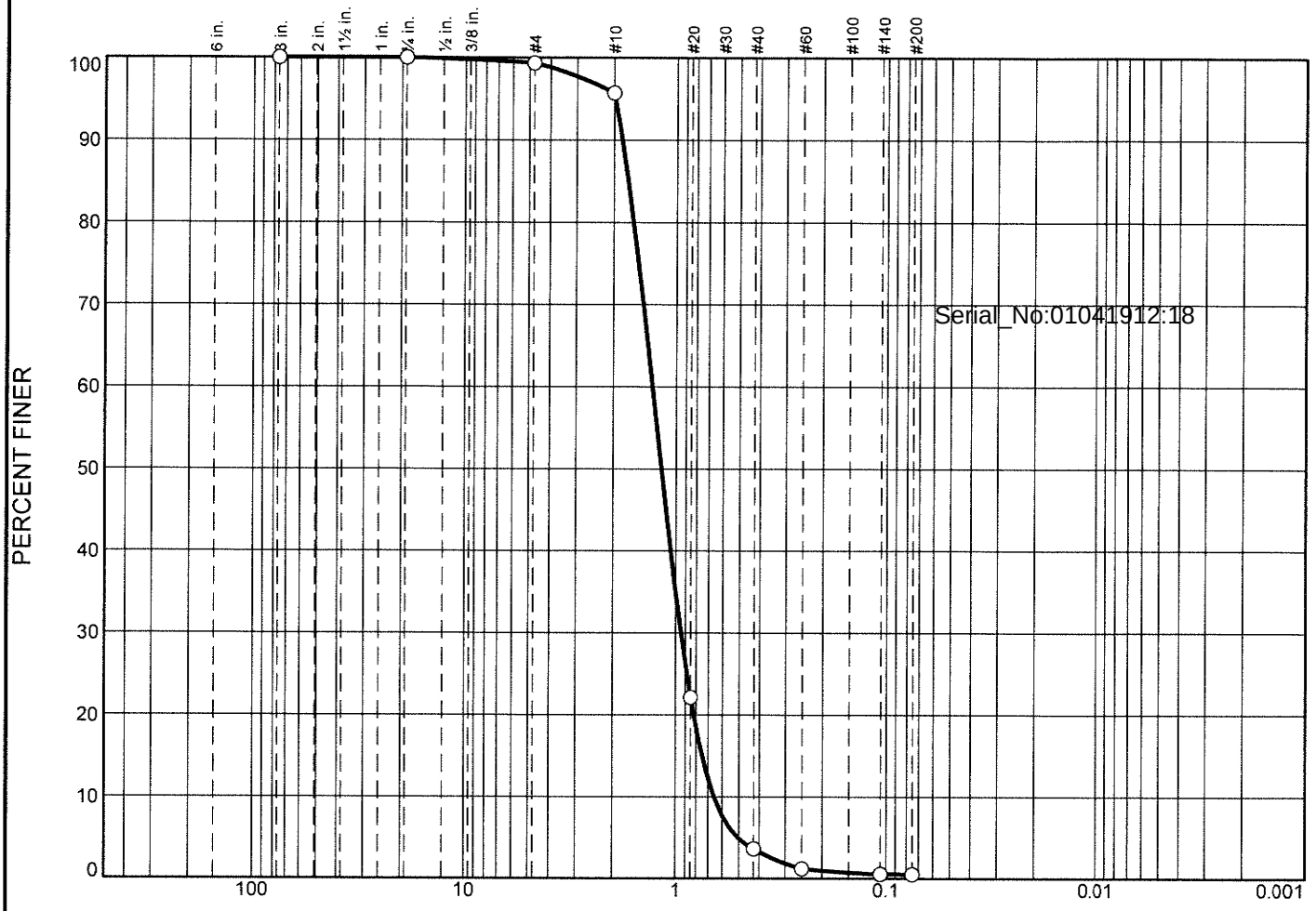
Alpha Analytical performs services with reasonable care and diligence normal to the analytical testing laboratory industry. In the event of an error, the sole and exclusive responsibility of Alpha Analytical shall be to re-perform the work at it's own expense. In no event shall Alpha Analytical be held liable for any incidental, consequential or special damages, including but not limited to, damages in any way connected with the use of, interpretation of, information or analysis provided by Alpha Analytical.

We strongly urge our clients to comply with EPA protocol regarding sample volume, preservation, cooling, containers, sampling procedures, holding time and splitting of samples in the field.

ASTM D6913/D7928

GRAIN SIZE ANALYSIS

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	0.0	0.6	3.7	92.1	3.1	0.5	

	Colloids	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○				1.7090	1.3022	1.1768	0.9452	0.7479	0.6559	1.05	1.99

	Material Description	USCS	AASHTO
○		SP	

Project No. **Client:**

Project:

○ **Source of Sample:** JOHNS POND I **Sample Number:** L1852543-01

Date: ○

Alpha Analytical

Mansfield, MA

Remarks:

Figure

GRAIN SIZE DISTRIBUTION TEST DATA

1/4/2019

Location: JOHNS POND 1

Sample Number: L1852543-01

USCS Classification: SP

Sieve Test Data

Post #200 Wash Test Weights (grams): **Dry Sample and Tare =** 80.23
Tare Wt. = 0.00
Minus #200 from wash = 0.0%

Dry Sample and Tare (grams)	Tare (grams)	Sieve Opening Size	Weight Retained (grams)	Sieve Weight (grams)	Percent Finer
80.23	0.00	3	0.00	0.00	100.0
		0.75	0.00	0.00	100.0
		#4	0.51	0.00	99.4
		#10	2.92	0.00	95.7
		#20	59.03	0.00	22.1
		#40	14.85	0.00	3.6
		#60	1.94	0.00	1.2
		#140	0.53	0.00	0.6
		#200	0.04	0.00	0.5

Serial_No:01041912:18

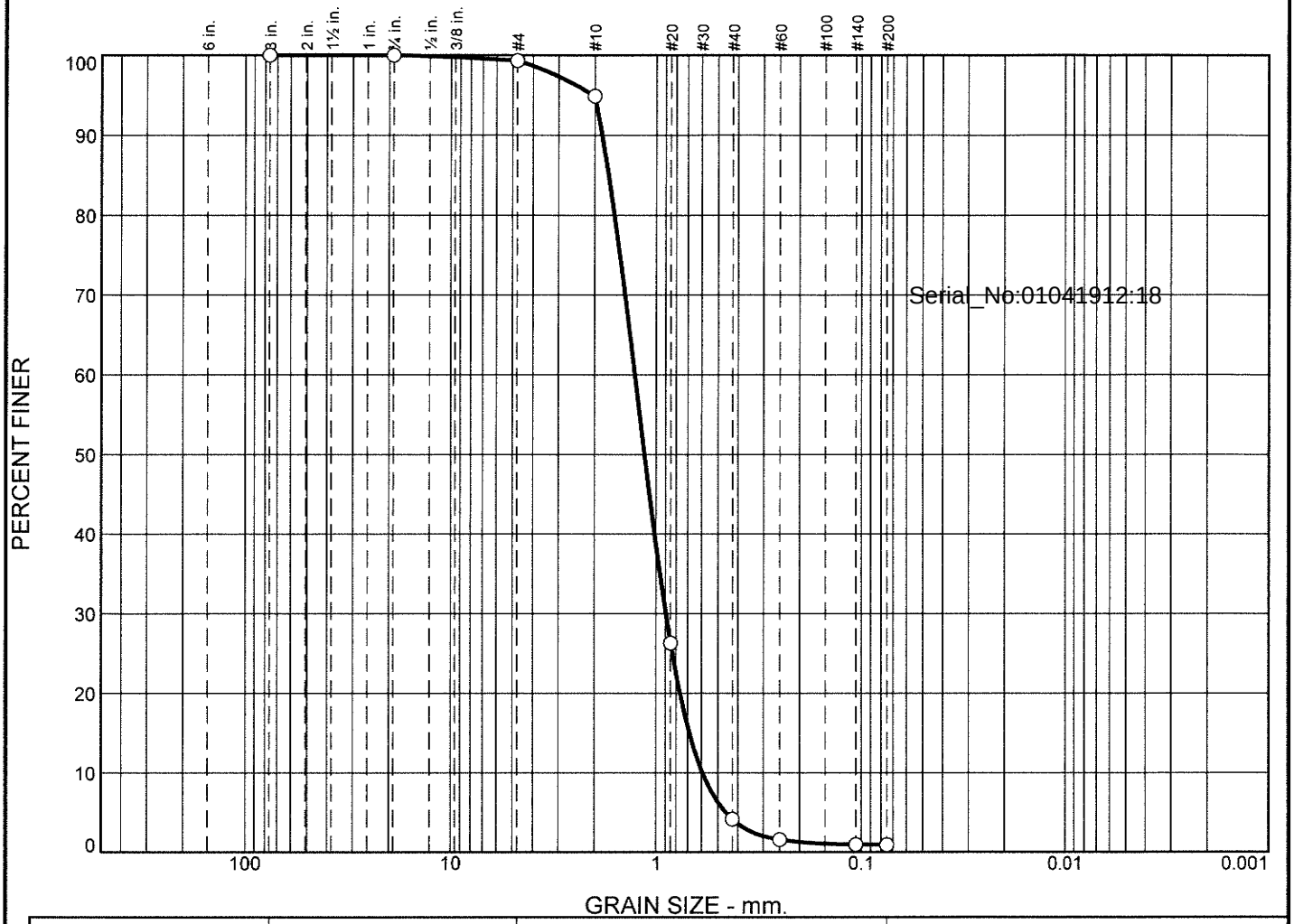
Fractional Components

Cobbles	Gravel			Sand				Fines		
	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total
0.0	0.0	0.6	0.6	3.7	92.1	3.1	98.9			0.5

D_5	D_{10}	D_{15}	D_{20}	D_{30}	D_{40}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
0.5058	0.6559	0.7479	0.8215	0.9452	1.0599	1.1768	1.3022	1.6096	1.7090	1.8262	1.9743

Fineness Modulus	C_u	C_c
3.44	1.99	1.05

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	0.0	0.7	4.4	90.8	3.2	0.9	

	Colloids	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○				1.7071	1.2715	1.1395	0.8964	0.6871	0.5937	1.06	2.14

	Material Description	USCS	AASHTO
○		SP	

Project No. **Client:**

Project:

○ **Source of Sample:** JOHNS POND 1 **Sample Number:** WG1193062-1

Date: ○

Alpha Analytical

Mansfield, MA

Remarks:

Figure

GRAIN SIZE DISTRIBUTION TEST DATA

1/4/2019

Location: JOHNS POND 1
Sample Number: WG1193062-1
USCS Classification: SP

Sieve Test Data

Post #200 Wash Test Weights (grams): **Dry Sample and Tare =** 80.88
Tare Wt. = 0.00
Minus #200 from wash = 0.0%

Dry Sample and Tare (grams)	Tare (grams)	Sieve Opening Size	Weight Retained (grams)	Sieve Weight (grams)	Percent Finer
80.88	0.00	3	0.00	0.00	100.0
		0.75	0.00	0.00	100.0
		#4	0.56	0.00	99.3
		#10	3.57	0.00	94.9
		#20	55.48	0.00	26.3
		#40	17.92	0.00	4.1
		#60	2.07	0.00	1.6
		#140	0.50	0.00	1.0
		#200	0.03	0.00	0.9

Serial_No:01041912:18

Fractional Components

Cobbles	Gravel			Sand				Fines		
	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total
0.0	0.0	0.7	0.7	4.4	90.8	3.2	98.4			0.9

D_5	D_{10}	D_{15}	D_{20}	D_{30}	D_{40}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
0.4587	0.5937	0.6871	0.7645	0.8964	1.0169	1.1395	1.2715	1.5992	1.7071	1.8363	2.0313

Fineness Modulus	C_u	C_c
3.38	2.14	1.06

Certification Information

The following analytes are not included in our Primary NELAP Scope of Accreditation:

Westborough Facility
EPA 624/624.1: m/p-xylene, o-xylene
EPA 8260C: NPW: 1,2,4,5-Tetramethylbenzene; 4-Ethyltoluene, Azobenzene; SCM: Iodomethane (methyl iodide), Methyl methacrylate, 1,2,4,5-Tetramethylbenzene; 4-Ethyltoluene.
EPA 8270D: NPW: Dimethylnaphthalene,1,4-Diphenylhydrazine; SCM: Dimethylnaphthalene,1,4-Diphenylhydrazine.

EPA 6860: SCM: Perchlorate

SM4500: NPW: Amenable Cyanide; SCM: Total Phosphorus, TKN, NO2, NO3.

Mansfield Facility
SM 2540D: TSS
EPA 8082A: NPW: PCB: 1, 5, 31, 87,101, 110, 141, 151, 153, 180, 183, 187.
EPA TO-15: Halothane, 2,4,4-Trimethyl-2-pentene, 2,4,4-Trimethyl-1-pentene, Thiophene, 2-Methylthiophene, 3-Methylthiophene, 2-Ethylthiophene, 1,2,3-Trimethylbenzene, Indan, Indene, 1,2,4,5-Tetramethylbenzene, Benzothiophene, 1-Methylnaphthalene.
Biological Tissue Matrix: EPA 3050B

The following analytes are included in our Massachusetts DEP Scope of Accreditation

Westborough Facility:

Drinking Water
EPA 300.0: Chloride, Nitrate-N, Fluoride, Sulfate; **EPA 353.2**: Nitrate-N, Nitrite-N; **SM4500NO3-F**: Nitrate-N, Nitrite-N; **SM4500F-C, SM4500CN-CE, EPA 180.1, SM2130B, SM4500Cl-D, SM2320B, SM2540C, SM4500H-B**
EPA 332: Perchlorate; **EPA 524.2:** THMs and VOCs; **EPA 504.1:** EDB, DBCP.
Microbiology: **SM9215B; SM9223-P/A, SM9223B-Colilert-QT,SM9222D**.

Non-Potable Water
SM4500H,B, EPA 120.1, SM2510B, SM2540C, SM2320B, SM4500CL-E, SM4500F-BC, SM4500NH3-BH: Ammonia-N and Kjeldahl-N, **EPA 350.1**: Ammonia-N, **LACHAT 10-107-06-1-B**: Ammonia-N, **EPA 351.1, SM4500NO3-F, EPA 353.2**: Nitrate-N**, SM4500P-E, SM4500P-B, E, SM4500SO4-E, SM5220D, EPA 410.4, SM5210B, SM5310C, SM4500CL-D, EPA 1664, EPA 420.1, SM4500-CN-CE, SM2540D, EPA 300: Chloride, Sulfate, Nitrate.**
EPA 624.1: Volatile Halocarbons & Aromatics,
EPA 608.3: Chlordane, Toxaphene, Aldrin, alpha-BHC, beta-BHC, gamma-BHC, delta-BHC, Dieldrin, DDD, DDE, DDT, Endosulfan I, Endosulfan II, Endosulfan sulfate, Endrin, Endrin Aldehyde, Heptachlor, Heptachlor Epoxide, PCBs
EPA 625.1: SVOC (Acid/Base/Neutral Extractables), **EPA 600/4-81-045**: PCB-Oil.
Microbiology: **SM9223B-Colilert-QT; Enterolert-QT, SM9221E, EPA 1600, EPA 1603.**

Mansfield Facility:

Drinking Water
EPA 200.7: Al, Ba, Cd, Cr, Cu, Fe, Mn, Ni, Na, Ag, Ca, Zn. **EPA 200.8:** Al, Sb, As, Ba, Be, Cd, Cr, Cu, Pb, Mn, Ni, Se, Ag, TL, Zn. **EPA 245.1** Hg.
EPA 522.

Non-Potable Water
EPA 200.7: Al, Sb, As, Be, Cd, Ca, Cr, Co, Cu, Fe, Pb, Mg, Mn, Mo, Ni, K, Se, Ag, Na, Sr, TL, Ti, V, Zn.
EPA 200.8: Al, Sb, As, Be, Cd, Cr, Cu, Fe, Pb, Mn, Ni, K, Se, Ag, Na, TL, Zn.
EPA 245.1 Hg.
SM2340B

For a complete listing of analytes and methods, please contact your Alpha Project Manager.

CHAIN OF CUSTODY

PAGE ____ OF ____

Date Rec'd in Lab: 12/20/18

ALPHA Job #: L1852543

ALPHA ANALYTICAL
8 Walkup Drive, Westboro, MA 01581, Tel: 508-898-9220
320 Forbes Blvd, Mansfield, MA 02048, Tel: 508-822-9300

Client Information

Client: BSC

Address: 803 Summer ST
Boston MA

Phone: 617 896 4451

Email: DCRISAFI@BSCGROUP.COM

Additional Project Information:

Project Information

Project Name: Johns Pond

Project Location: Mashpee

Project #: 5-0261.00

Project Manager: CRISAFI

ALPHA Quote #:

Turn-Around Time

☒ Standard ☐ RUSH (only confirmed if pre-approved)

Date Due:

Report Information - Data Deliverables

☐ ADEx ☐ EMAIL

Billing Information

☐ Same as Client info PO #:

Regulatory Requirements & Project Information Requirements

☐ Yes ☐ No MA MCP Analytical Methods ☐ Yes ☐ No CT RCP Analytical Methods
☐ Yes ☐ No Matrix Spike Required on this SDG? (Required for MCP Inorganics)
☐ Yes ☐ No GW1 Standards (Info Required for Metals & EPH with Targets)
☐ Yes ☐ No NPDES RGP
☐ Other State /Fed Program _____ Criteria _____

ANALYSIS

VOC: ☐ 8260 ☐ 624 ☐ 524.2
SVOC: ☐ ABN ☐ PAH
METALS: ☐ MCP 13 ☐ MCP 14 ☐ RCP 15
METALS: ☐ RCRA5 ☐ RCRA8 ☐ PP13
EPH: ☐ Ranges & Targets ☐ Ranges Only
VPH: ☐ Ranges & Targets ☐ Ranges Only
☐ PCB ☐ PEST
TPH: ☐ Quant Only ☐ Fingerprint
GRAIN SIZE

SAMPLE INFO

Filtration
☐ Field
☐ Lab to do

Preservation
☐ Lab to do

ALPHA Lab ID (Lab Use Only)	Sample ID	Collection Date	Collection Time	Sample Matrix	Sampler Initials	Sample Comments	TOTAL # BOTTLES
52543-01	Johns Pond 1	12/19	11-	S	AJC		X

Container Type
P= Plastic
A= Amber glass
V= Vial
G= Glass
B= Bacteria cup
C= Cube
O= Other
E= Encore
D= BOD Bottle

Preservative
A= None
B= HCl
C= HNO_3
D= H_2SO_4
E= NaOH
F= MeOH
G= $NaHSO_4$
H = $Na_2S_2O_3$
I= Ascorbic Acid
J = NH_4Cl
K= Zn Acetate
O= Other

	Container Type											
	Preservative											

Relinquished By:	Date/Time	Received By:	Date/Time
	12/19 1235	AAL	12/20/18 1235
	12/20/18 1350		12/20/18 1350
DLZHCK OG20			12/21/18 0620

All samples submitted are subject to Alpha's Terms and Conditions. See reverse side.

FORM NO: 01-01 (rev. 12-Mar-2012)