APPENDIX E

CHANNEL DESIGN ANALYSIS REPORT

BY ANCHOR QEA

REPORT

NINEMILE CREEK REACH CD
FINAL CHANNEL DESIGN ANALYSIS REPORT

Prepared for

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June 2012

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LIST OF ACRONYMS AND ABBREVIATIONS

Anchor QEA, LLC	Anchor QEA
cfs	cubic feet per second
EPA	United States Environmental Protection Agency
FS	Feasibility Study
HEC-RAS	Hydraulic Engineering Center – River Analysis System
HSI	Habitat Suitability Index
LWD	large woody debris
NAVD88	North American Vertical Datum of 1988
NYSDEC	New York State Department of Environmental Conservation
OU	Operable Unit
ROD	Record of Decision
SFS	Supplemental Feasibility Study
SUNY-ESF	State University of New York – Environmental Science and Forestry
USACE	United States Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service

1 INTRODUCTION

Channel design and habitat restoration are important components of the remedy for Ninemile Creek, a major tributary to Onondaga Lake. This report provides analyses completed to support the development of the final (100%) design for the restoration of the channel, wetlands, and floodplain for Reach CD. Results of certain hydrologic analyses are also provided for Reaches AB and BC to demonstrate overall function of the channel as a whole, in particular for the channel erosion protection and habitat material types and thickness, and bridge clearances. Figure 1 illustrates the general extent of the channel design and habitat restoration, as well as the subdivision of the channel into Reaches AB, BC, and CD.

The purpose of these analyses was to evaluate hydrologic and hydraulic functions of channel design elements, including channel planform, channel bed elevation, channel slope, bank slope, bed and bank stability, water surface elevation, and channel substrate requirements. Although this report focuses on Reach CD, the channel planform and profile for all three reaches used to evaluate channel function are consistent with the requirements specified in the Records of Decisions (RODs) for the Ninemile Creek site. The channel and floodplain design for Reach CD provides the following ecological and community benefits:

- Increased sinuosity and length of Ninemile Creek
- Improved channel substrate (i.e., bed material) for fish and macroinvertebrates
- Channel stability that protects surrounding infrastructure while providing ecological function
- Increased connectivity between Ninemile Creek and the floodplain
- Sufficient water depths during periods of low flow for fish and canoe passage (minimum depth greater than 6 inches)
- Increased buffer between Ninemile Creek and Wastebeds 9 and 10
- Habitat features such as pools, riffles, microtopography, and native vegetation

The channel design and floodplain restoration for Reaches AB and BC will be described in a separate report addendum. Modeling results for bridge clearances and water depths in those reaches will be revised based on the final channel design if needed.

1.1 Background

The Geddes Brook/Ninemile Creek Feasibility Study (FS) Report (Parsons 2005) presented a variety of alternatives for remediating the channel and floodplains of Geddes Brook and Ninemile Creek. Since submittal of the FS, the site was organized into two operable units (OUs). OU-1 includes Geddes Brook and the two most upstream reaches of Ninemile Creek where remediation will occur (Reaches CD and BC). OU-2 includes the most downstream reach of Ninemile Creek, Reach AB (see Figure 1 for Reach extents). After the FS was submitted, several site investigations and assessments were performed that formed the basis for Supplemental Feasibility Studies (SFSs) prepared for OU-1 (Parsons 2008) and OU-2 (Parsons 2009a). Those documents identified opportunities for integrating remediation with habitat restoration, and made specific recommendations for channel and other habitat enhancements and improvements, including channel realignment.

The RODs prepared by New York State Department of Environmental Conservation (NYSDEC) and United States Environmental Protection Agency (EPA) for OU-1 (NYSDEC and EPA 2009a) and OU-2 (NYSDEC and EPA 2009b) describe the selected alternatives for remediating these areas. Figures from those decision documents, provided in Attachment A, illustrate that the selected alternatives include relocating Reach CD of Ninemile Creek to facilitate remediation and habitat restoration. Bathymetric modifications within the Reach CD channel will result in sediment removal and placement of clean substrate in Reach CD. Soil/sediment removal and placement of clean material will occur along the channel banks and in portions of the Ninemile Creek Reach CD floodplain. Following placement of clean material, these areas will be planted and seeded with a variety of native wetland and riparian species to restore the site and increase plant species diversity over existing conditions.

Thew Associates (2009) performed a detailed site topographic and bathymetric survey and that survey information was used to update the site hydraulic model for all three reaches. Using the survey and updated model as a basis, a preliminary channel design was developed in December 2009 (Anchor QEA, LLC [Anchor QEA] 2009). Subsequently, the intermediate channel design (Parsons 2010) advanced that design using the results of the pre-design investigation data (Parsons 2010). This report presents the final channel design and habitat restoration for Ninemile Creek Reach CD channel and floodplain. Where appropriate,

results of the modeling are provided for Reaches AB and BC to demonstrate channel function. An operations, maintenance, and monitoring program to evaluate and maintain (as needed) specific elements of the channel and habitat restoration is provided as Appendix H.

1.2 Methodology

The channel design, based on the channel layouts described in the RODs for OU-1 and OU-2 (NYSDEC and EPA 2009a, 2009b; Attachment A of this report), was prepared using AutoCAD Civil 3D. The Hydraulic Engineering Center – River Analysis System (HEC-RAS) geometry extension for AutoCAD Civil 3D was used to incorporate the surface into the HEC-RAS hydraulic modeling software (United States Army Corps of Engineers [USACE] 2008). HEC-RAS is a mathematical representation of a three-dimensional hydraulic system that predicts cross-sectional average conditions for a proposed channel at user-defined transects. Although HEC-RAS is a one-dimensional model (i.e., there is no direct simulation of the hydraulic effects of cross section shape changes, bends, and other two- and three-dimensional aspects of flow in a channel), it incorporates three-dimensional bathymetric/topographic data and other information for calculating water profiles and current velocities. The model assumes steady-state, gradually varied, open-channel flow, and predicts cross-sectional average current velocity and water surface elevation at each transect for the proposed channel. The boundary conditions for Onondaga Lake and Ninemile Creek (e.g., lake surface elevation, stream flows) and the HEC-RAS model are discussed in Attachments B and C, respectively. The HEC-RAS model developed for Geddes Brook and Ninemile Creek was fully described in the Geddes Brook/Ninemile Creek HEC-RAS Model Report (Anchor QEA 2009)[1] and an updated version, which includes additional field data, is provided in Attachment C. HEC-RAS model results for the final design conditions are summarized in this report and described in more detail in Attachment C (hydraulic results) and Attachment D (stable sediment size evaluation and grain size distribution design).

[1] Additional assumptions, model capabilities, and the theoretical basis for the HEC-RAS model are discussed in the reference manual (United States Army Corps of Engineers [USACE] 2008).

2 NINEMILE CREEK CHANNEL DESIGN

2.1 Channel Planform

The channel planform for all three reaches of Ninemile Creek is shown on Figure 1. The stationing used for design and modeling analyses is shown on Figure 2. More detailed planview drawings of the final channel design for Reach CD are provided on Figures 3 and 4[2]. The channel planform is consistent with the conceptual approaches illustrated on the figures from the NYSDEC/EPA decision documents in Attachment A. Habitat enhancements such as pools, hydraulic refuge features, a low-flow channel, and bank features are incorporated into the design for Reach CD, as summarized in Table 1 and described below.

2.1.1 Reach CD (Station 52+50 to 75+00)

The channel planform for Reach CD is based on the original alignment proposed in the ROD for OU-1 (as shown in Attachment A) and refined during the design process using geomorphic principles and pre-design bathymetry and topography data (Thew Associates 2009) to better coordinate with site features and enhance overall stability. Specific features of the channel design include the following:

- Relocation of the channel through Reach CD toward the large island, opposite the existing wastebeds
- Conversion of the channel from a split-channel system to a single-thread, meandering channel (Figures 3 and 4)
- Providing adequate sinuosity for stability and a buffer between the right top-of-bank and the State Fair landfill
  - The sinuosity ratio of the channel is approximately 1.12, which falls within the computed stable range calculated in Attachment D of the SFS for OU-1 (Parsons 2008), and closely resembles the natural channel planform observed upstream.

[2] The profile view for this full channel alignment is provided on Figure 5. Representative channel cross sections showing existing and proposed bathymetry for Reach CD are provided in the Design Drawings in Appendix C of the main report.

  - The target width of this buffer was assumed to be approximately 25 feet, although the width was narrowed in some locations in confined sections of the floodplain.

- Backfilling the former channel to floodplain/wetland grade for planting and seeding with native species
- Blending the proposed grade smoothly into the existing grade above the confluence with Geddes Brook to reduce the possibility of hydraulic jumps and excess erosion or deposition at the transition between the existing and modified channels; the new alignment of Geddes Brook will position the confluence with Ninemile Creek just upstream of the current location

The slope of the Reach CD finished channel bottom is approximately 0.16%. This slope is very similar to the existing average bottom slope for the reach. The channel will have a bottom width of approximately 50 feet. Downstream of Geddes Brook, accommodating the realigned channel will require a cut through the floodplain. The depth of cut along the alignment varies from approximately 1 foot to approximately 8 feet (see Appendix C). The channel bottom through Reach CD will include a thalweg with a typical depth of 2 feet and a typical width of 16 feet. The thalweg will be blended back into the existing channel bed upstream of the confluence with Geddes Brook.

Pools will be created along the outer meanders of the realigned channel to provide habitat and hydraulic refuge for fish (Figures 3 and 4). Live cribs with rootwads and/or light stone filling with joint plantings and rootwads will be placed at these locations to stabilize the banks, provide forcing features to maintain the pools and provide hydraulic refuge as further discussed in Section 2.3. Riverine fringing wetlands will be created along the banks of Reach CD, with larger connected emergent and forested wetlands in the floodplains (Figures 3 and 4 and Section 3).

2.1.2 Hydraulic Model Geometry

The geometries for each reach were created within the AutoCAD Civil 3D surface for the site and incorporated into the HEC-RAS model (Attachment C) to represent the post-remediation bathymetry. The model was used to evaluate both existing and design conditions for water surface elevation during high-flow conditions to evaluate bridge

clearance and water depths during low-flow conditions to evaluate fish passage. It was also used to determine current velocities and bed shear stresses for stability requirements under various flow conditions. More information on these analyses is provided in Attachments C and D.

As discussed at a meeting between Honeywell and NYSDEC on August 12, 2010, the definition of low-flow conditions is the 90% exceedance probability discharge in July (46 cubic feet per second [cfs]; Attachment B). As discussed at that meeting, the minimum required low-flow depth for canoe access and fish passage is 6 inches.

2.2 Habitat and Erosion Protection Layer

The channel bed material will serve two different functions: 1) habitat for aquatic organisms; and 2) stability to resist erosion where required. The types of bed material suitable for aquatic organisms were identified through review of relevant literature and guidance documents and from work on Onondaga Lake as discussed below. The types of material that would be needed to provide required stability were evaluated using multiple particle stability calculation methods (Attachment D).

2.2.1 Channel Substrate Composition and Thickness

The channel substrates were selected based on an evaluation of substrate use by fish and benthic macroinvertebrates and stability under various current velocities and bed shear stresses predicted by the hydraulic model. Habitat suitability index (HSI) models developed by the U.S. Fish and Wildlife Service (USFWS) were used to evaluate the type and size of sediment used by several fish species during various life stages (Stuber et al. 1982; Edwards et al. 1983; Krieger et al. 1983; Trial et al. 1983; McMahon et al. 1984; and Raleigh et al. 1986). The range of sediment sizes suitable for fish likely to be present in Ninemile Creek was summarized from the HSI models and is shown in Table 2.

Benthic macroinvertebrates colonize a wide range of substrate sizes. Several species, including mayflies, caddisflies, dragonflies, and crayfish are commonly found in gravel and cobble substrates (Voshell 2002). Many invertebrate taxa prefer coarse sediments (cobble, pebble, gravel; 1 to 256 mm [0.04 to 10 inches]) typical of stream riffles including species of

mayflies, caddisflies, stoneflies, dipterans, and coleoptera (Merritt and Cummins 1984). Williams and Mundie (1978) found that medium-sized gravel (mean particle size 24.2 mm [0.95 inches]) supported the greatest number and biomass of benthic invertebrates in a stream channel. They found that mayfly and blackfly preferred medium and large gravel, with small and medium gravel preferred by stoneflies and chironomids (Williams and Mundie 1978).

The cross-sectional averaged current velocity and bed shear stress predicted by the proposed conditions model were used to develop estimates of the size of bed material that will remain stable in all three reaches. The highest current velocities and bed shear stresses are associated with the 100-year flow event (3,400 cfs) and a low water surface elevation in Onondaga Lake of 367 feet (North American Vertical Datum of 1988 [NAVD88]). This condition is conservative (rare) in that the lake level is typically higher during storm events. The hydraulic model results for this flow condition are provided in Attachment C.

The erosion protection function of the material needed to protect infrastructure and the chemical isolation layer (where present) was evaluated using industry-standard methods published by the USACE (1994) and the EPA (2005) for constructing and maintaining channels. The results of the analyses are applicable to erosion protection of a chemical isolation layer, scour protection of infrastructure and utilities, and general channel stability.

An EPA guidance document (Palermo et al. 1998) recommends that the thickness of the erosion protection layer be twice the median particle diameter (2 D_{50}) or 1.5 times the maximum particle size (1.5 D_{100}) when sediment will be exposed to turbulent flow. Based on the specified grain size distribution given in Table 1 of Attachment D (D_{50} = 1.2 inches, D_{100} = 12 inches) the required minimum thickness of channel substrate in Ninemile Creek ranges from 2.4 to 18 inches.

The ROD OU-1 indicates that the habitat layer will be a minimum of 24 inches thick. The 24 inches (placed minimum thickness) of suitable habitat/erosion protection layer as described above will be appropriate to support organisms using the creek and function as an erosion protection layer. This thickness is consistent with the habitat layer thicknesses being

used for shallow water depths and moderate to high energy zones in the Onondaga Lake habitat designs (Parsons 2009b).

USACE (1994) indicates that a layer thickness greater than 15 inches does not require higher factors of safety to accommodate impacts from light to medium debris, trees, and ice. Therefore, areas where the habitat/erosion protection layer will be placed as a single 24-inch-thick layer of the same material are not expected to require additional consideration of impact forces.

2.2.2 Material Sourcing

A material sourcing evaluation has been ongoing as part of the design work for Ninemile Creek and Onondaga Lake, to identify potential sources of backfill and substrate material. Based on the habitat and stability requirements for the material to be used in Ninemile Creek described above, a bank-run material has been identified as part of the sourcing evaluation that meets both requirements. The bank-run material is a glacio-fluvial deposit consisting of rounded and sub-angular material with a wide range of grain sizes. The grain size envelope of the material is provided on Figure 4 of Attachment D. Glacio-fluvial material was moved by glaciers and subsequently sorted and deposited by streams flowing from the melting ice and, as such, provides a suitable stream substrate. This material has the benefit of being local and would require minimal pre-processing before being used at the site, factors that support EPA Region 2's Clean and Green policy.

2.2.3 Sediment Transport

An evaluation using the grain size distribution of the bank-run material was conducted using a fractional sediment transport analysis. The analytical method and a detailed presentation of the results are provided in Attachment D. The results of that evaluation indicate that the system will be capable of selectively transporting finer grain sizes to create surface sediment grain size distribution diversity without compromising the overall integrity of the habitat/erosion protection layer.

Sediment transport capacity for the 1-year recurrence interval discharge (750 cfs) was evaluated for anticipated sediment load grain sizes. This evaluation provided an indication of

how sediment from upstream may be transported into, deposited, and transported out of the channel during more typical flood events. The evaluation method and results are provided in Attachment D. The evaluation shows that the proposed channel configuration will transport sand and fine gravel at the 1-year recurrence interval discharge. The system's ability to transport sand and fine gravel at the 1-year return period flow will help maintain water depths and prevent excessive silting in of the channel over time.

2.3 Channel and Bank Features

Pools and hydraulic refuge features (i.e., live cribs with rootwads and soil wraps, light stone filling and plantings and rootwads, and large woody debris [LWD]) have been incorporated into the channel and banks of Ninemile Creek Reach CD (Figures 3 and 4). Table 1 provides a summary of channel and bank restoration features by location in Reach CD, where pools or hydraulic refuge features are located every 300 feet on average.

The habitat and erosion protection material described above (i.e., bank-run material) will be sufficient to maintain stability through a majority of Ninemile Creek. As discussed at the January 12, 2012 meeting with NYSDEC, the sizing of the channel habitat/erosion protection material described in Section 2.2.1 is sufficient to withstand velocities and scour associated with the 100-year flow event. The velocities are less than 5.0 feet per second, which do not necessitate the need for any additional grade control beyond the stability provided by the channel habitat/erosion protection material. However, additional stabilization will be required along the channel banks in select locations based on their relative location within the channel planform (i.e., outside of a bend), predicted current velocities, bank slope, and habitat considerations. Stabilization treatments for these areas will be required to maintain bank stability and prevent significant bank erosion or channel migration to protect adjacent infrastructure and help maintain the overall channel planform.

2.3.1 Local Bank Stabilization

Based on HEC-RAS modeling results for design conditions, the areas with the largest hydraulic forces in Reach CD correspond to bends that are near Stations 66+50, 63+50, and 60+50. Figures 3 and 4 depict the locations where local bank stabilization measures will be applied.

Bank stabilization measures along the outside of bends will consist of live cribs with rootwads and soil wraps at three locations. Alongside portions of the live cribs, light stone with joint plantings and rootwads will be used due to the steep slopes and/or to facilitate construction. These measures are also intended to provide forcing features to help maintain the pools that will be created at these locations (i.e., outside meanders), hydraulic refuge, cover habitat, and stream shading.

2.3.1.1 Live Cribs with Rootwads and Soil Wraps

Live cribs with rootwads and soil wraps are biotechnical measures for erosion and sedimentation control (Rosgen, undated). In Reach CD, a hybrid technique was developed in consultation with NYSDEC and USFWS, that combines the box-like structure of a live crib and rootwads on the lower portion of the bank with soil wraps (constructed with rolled erosion control products) and plantings at elevations above the elevation associated with the long term median flow (180 cfs). The rootwad logs are placed perpendicular to the bank to protrude into the flow to help maintain the pool and create hydraulic refuge and provide cover habitat for fish. The live stakes and cuttings take root in the structure and grow outward providing stream shading. This technique is generally appropriate for locations where current velocities are less than 6 feet per second. Vegetation growth enhances the long-term habitat benefits and stability of the bank.

2.3.1.2 Light Stone with Joint Plantings

Light stone with joint plantings is a NYSDEC-recommended biotechnical measure (technique) for erosion and sedimentation control (NYSDEC 2005). The purpose of this technique is to create a living root mat, integrated with the stone filling, which stabilizes the bank by reinforcing and binding the bank material together. This measure provides both short-term stability (light stone filling) and sustainable long-term bank stability (vegetation growth). Vegetation growth enhances the long-term habitat benefits and stability of the bank. Rootwads will be incorporated into the light stone and extend perpendicular into the channel to help maintain pools (excavated during construction) and provide hydraulic refuge and cover during periods of higher and lower flows, respectively.

2.3.1.3 Other Measures

Rolled Erosion Control Product

In Reach CD, biodegradable rolled erosion control product will be used along the new and disturbed banks. Areas will be seeded prior to placing the fabric and live stakes will be installed through the fabric. This measure is adopted from the NYSDEC *Standards and Specification for Erosion and Sediment Control* (2005) and is appropriate for providing immediate bank stability while fostering vegetation growth to provide enhanced habitat and sustainable long-term bank stability. Rolled erosion control product is also used to construct the soil wraps described in Section 2.3.1.1.

2.3.2 Large Woody Debris

LWD in streams provides complexity that creates hydraulic refuge and cover habitat and is a recommended high-value habitat feature (Fischenich and Morrow 1999). For this project, LWD placements consist of multiple logs with rootwads that will be installed in the channel banks perpendicular to flow (see Appendix C of the main report for design drawings). The rootwad ends will act as hard points that will maintain a small localized pool (excavated during construction). During high-flow conditions, the low-velocity area in the lee of the rootwad and within the root mass creates hydraulic refuge. During low-flow conditions, the rootwad provides cover and diversity within the channel.

2.4 Water Surface Elevation and Depth

The channel and floodplain topography in the existing conditions HEC-RAS model (Attachment C) were modified within AutoCAD Civil 3D to incorporate the channel realignment and re-grading of Ninemile Creek discussed in the previous sections. The model of proposed conditions was compared to the model of existing conditions for all reaches to evaluate changes in water surface elevations/water depths and clearance during high-flow events at the bridge crossings with the lowest deck elevations within Reach BC (Attachment C). As shown in Table 3, the predicted water surface elevations at bridge locations for the design alignment are at or below the existing water surface elevations for the 50-year and 100-year events, indicating that the proposed design will not increase water surface elevations at these locations. The proposed conditions model, in addition to not

showing an increase in the water surface elevation at the bridges, satisfies the NYSDEC requirements for no-rise at all modeled cross-sections (Attachment C).

It should be noted that the HEC-RAS model results of the existing conditions at the bridges show that the predicted water surface elevation does not clear the lowest point of the State Fair Boulevard and CSX railroad bridges during a 100-year flood event. However, the results presented in Table 3 were predicted with a high lake level, which produces a high estimate of water surface elevations due to backwater from Onondaga Lake. As described above, the predicted water surface elevations of the proposed condition is equal to or less than the predicted water surface elevations of the existing condition.

In addition to high-flow conditions, low and median flow conditions were simulated for the existing and proposed channel geometry in Reach CD (Table 4). Those results show that the low water depths for the proposed condition closely resemble those for the existing condition. The water depths presented in Table 4 show the average, minimum, and maximum water depths for each reach based on the 90% exceedance probability and long-term median summer low-flow conditions. These depths satisfy the design goal of maintaining approximately 6 inches of water for canoe and fish passage.

3 NINEMILE CREEK HABITAT RESTORATION

The habitat restoration design for the Ninemile Creek Reach CD channel and adjacent floodplain is based on post-remediation conditions. Historical and existing conditions, including the presence of infrastructure and wetlands, were taken into consideration in the design. Existing conditions and other background information on Ninemile Creek and the surrounding area are provided in the Draft Onondaga Lake Habitat Plan (Parsons 2009b) and the SFSs for OU-1 (Parsons 2008).

3.1 Channel Bed

A 2-foot-thick habitat/erosion protection layer will be installed following sediment removal in Ninemile Creek, as described in Section 2.2. The sediment that will be used for the habitat and erosion layer will have a wide range of particle sizes suitable for several fish likely to be present in Ninemile Creek (Table 2; Figure 6) as well as benthic macroinvertebrates, including mayflies, caddisflies, dragonflies, and crayfish (Voshell 2002). As shown on Figures 3 and 4, pools have been created throughout Reach CD to provide additional instream habitat. Wood features and bank treatments have been included to provide hydraulic refuge (Sections 2.3 and 2.3.1).

3.2 Channel Banks

Channel banks provide the transition zone between the aquatic and terrestrial environments (Figures 3 and 4). Remediated areas will be covered with a 2-foot-thick habitat layer, which will be seeded and planted. The species being planted in Reach CD are based on the *100% Design Report for the Geddes Brook Interim Remedial Measure* (Parsons 2011) and NYSDEC-approved species lists, which included similarriparian and wetland conditions. The list of species and planting designs incorporate feedback from NYSDEC, State University of New York – Environmental Science and Forestry (SUNY-ESF), and other community groups. A diverse mix of native species will be used for restoration. The specific areas that will be restored along the channel banks include the following:

- On the lower portions of the banks, from the median water surface elevation (based on a flow rate of 180 cfs) to 2.5 feet above that elevation, there is sufficient interaction with the surface water to create wetland conditions (i.e., riverine fringing

wetlands; see Figures 3 and 4 and the Drawings in Appendix C of the main report). Specifically, in these transition areas, wetland vegetation will be seeded and planted with species as described in Section 02910 of the specifications in the Ninemile Creek Reach CD Draft Final Design Report.

- At higher elevations along the creek banks (i.e., greater than 2.5 feet above the median flow water surface elevation), terrestrial species will be seeded and planted with shrubs and trees. These understory and overstory species will provide shading of the creek to reduce water temperature and reduce the potential for Phragmites colonization, and will provide leaf litter input to support benthic macroinvertebrates.
- The channel banks will need stabilization in high-velocity areas. In specific locations (e.g., along outer meanders), live cribs with rootwads and soil wraps and light stone with joint plantings and rootwads will be used to stabilize the banks. Over time, the vegetation associated with these features should provide stream shading and leaf litter input to support benthic organisms; the rootwads will provide cover habitat and hydraulic refuge for fish species.

3.3 Ninemile Creek Floodplains

As discussed in the ROD for OU-1, a habitat layer will be used in the Ninemile Creek Reach CD floodplain areas to provide substrate necessary for the restoration of a diversity of habitats through the stream corridor. The habitat layer will be constructed with three different types of earthen materials of varying thickness depending on location. These materials are described below.

- Habitat subgrade material will be a generally granular material containing a low to medium organic content (0.5% to 6%, augmented if necessary to achieve the specified range) that will serve as a suitable rooting material for plants. It is intended for this material to contain predominantly sand and gravel sized particles with occasional cobbles so that it will have a reasonable resistance to erosion and will provide good anchoring for plant roots so that they can better resist scour, erosion, and wind throw. The generally granular nature of the materials should allow for full-depth penetration by roots and reduce perched water buildup that could destabilize the slope surface during spring thaw and wet weather.

- Fine-grained material, as described in Specification 02200, will be placed in several locations underlying topsoil to assist in retaining water. The fine-grained material should result in a relatively low permeability layer to help maintain moisture in the overlying topsoil, which could support the development of hydric conditions. This material is available from local borrow pits within several miles of the site, as well as from on-site soils that may be available for re-use (subject to testing as described in Specification 02200).
- Topsoil will be a loam material with a medium to high organic content (minimum 3% for non-wetland areas and minimum 5% for wetland areas) to provide a growing medium that will allow vegetation to be established. It is anticipated that plant roots will quickly stabilize the topsoil against surficial erosion and that many of the plants will establish deeper roots into the habitat subgrade fill on the bank slopes to further stabilize the habitat layer.

3.3.1 Wetland Areas

Interaction with surface water from the creek and the depth of the overlying surface water are the primary factors that determine whether an area will support wetland vegetation or have more terrestrial (or upland) characteristics. Under the existing condition, wetland areas occur in the floodplains and in long narrow bands along the creek. The elevations of the existing wetland areas were used in combination with the predicated water surface elevations from the HEC-RAS model (Attachment C) for the proposed condition to delineate areas that will support wetland and upland habitats. Specifically, the long-term median flow, 180 cfs (with a corresponding elevation of 362.5 feet), was used as the basis for defining wetland areas. Areas with an elevation up to 365 feet, or 2.5 feet above the median water surface elevation, are expected to have sufficient hydrology to develop into wetlands (the existing wetlands in Ninemile Creek occur up to an elevation of 365.5 feet).

Three wetland types are proposed in Reach CD: riverine fringing wetlands, emergent wetlands, and forested wetlands. Narrow linear wetlands are proposed along the creek banks (i.e., riverine fringing wetlands). The composition of the habitat layer in the riverine fringing wetlands varies depending on location and will consist of 12 inches of topsoil over 12 inches of fine-grained material, or 6 inches of topsoil over 18 inches of habitat subgrade

material. In addition, larger discrete areas have been designed as emergent wetlands. These areas will be subject to more prolonged inundation compared to the riverine fringing wetlands along Ninemile Creek. The emergent wetlands in Reach CD are located outside of the main channel; in these locations, the habitat layer will consist of 12 inches of topsoil over 12 inches of habitat subgrade material at the base and 12 inches of topsoil over 12 inches of fine-grained material on the banks. In the forested wetland in Reach CD, the habitat layer will consist of 12 inches of topsoil over 12 inches of habitat subgrade material.

Plan views of these areas are provided on Figures 3 and 4. Existing and planned wetland acreage for Reach CD is provided in Table 5.

3.3.2 Upland Mix Riparian Areas and Red Maple Swamp or Woods

In one portion of the floodplain where the final elevation will be lower than the surrounding area (see Figure 4 and Drawing C-037 in Appendix D), 12 inches of topsoil will be placed over 12 inches of fine-grained material (see Specification 02200). This material is expected to increase water retention to facilitate the establishment of hydric conditions and the area will be planted and seeded with species associated with a red maple/hardwood swamp or woods (see Specification 02910). Stormwater runoff from Wastebeds 9 to 11 and the access road will be directed to this area. In addition, Ninemile Creek flows associated with the 2-year return events will inundate the area. As such, rain events or high creek flows will temporarily inundate the area with up to 1 foot of water (the design height of the spillway for the weir). This may provide sufficient water for hydric soils to develop without prolonged periods that could affect the development of the trees and shrubs planned for this area. Any wetlands that ultimately become established in this area would provide a net increase to wetland acreage in Reach CD. The acreage for this area is not included in Table 5. Similarly, the two upland areas (peninsulas) located between Ninemile Creek and the emergent wetlands will be restored with 12 inches of topsoil over 12 inches of the fine-grained material. Routine inundation from Ninemile Creek may provide sufficient water for hydric soils to develop. Any wetlands that become established in these areas would provide a net increase to wetland acreage in Reach CD. The acreage for these areas is not included in Table 5.

3.3.3 Non-wetland Areas

The habitat layer will be 2 feet thick and consist of either 12 inches of topsoil over 12 inches of habitat subgrade material or 6 inches of topsoil over 18 inches of habitat subgrade material, depending on location. An additional small area adjacent to the red maple swamp or wood consists of 12 inches of topsoil over 12 inches of fine-grained material consistent with the adjacent areas. The 2-foot-thick habitat layer will be sufficient to support the trees, shrubs, and herbaceous species that will be planted within the floodplain.

The ROD includes a number of habitat enhancements for Reach CD, including deepening, widening, and relocating the channel, and the establishment of buffer zones between the new channel and the wastebeds. In the contiguous flatter areas shown on Drawings C-029A and C-030A, to enhance these buffer zones, 12 inches of topsoil will be placed over 12 inches of habitat subgrade material. On the steeper slopes and where otherwise indicated on the drawings, 6 inches of topsoil will be placed over 18 inches of habitat subgrade material.

3.4 Plantings

Once the channel, floodplains, wetlands and riparian areas have been constructed (Figures 3 and 4), they will be planted and seeded with a diversity of species based on final elevations and the anticipated frequency and duration of wetting. This latter information was used to identify the following specific restoration zones for use on the drawings:

- Zone A1a is upland riparian area that will be seeded with the conservation seed mix (uplands and side slopes) and planted with upland native species. This zone is generally consistent with Onondaga Lake habitat modules 8a and 8b.
- Zone A1b is upland riparian area that may be inundated enough to support both wetland and upland species. This area will be seeded with conservation and wetland seed mixes and planted with native upland and wetland species. This zone is generally consistent with Onondaga Lake habitat modules 8a, 8b, 9a, and 9b. A portion of this zone will be planted and seeded with species to support development of a red maple/hardwood swamp or woods.
- Zone A2 is riverine fringing wetland area and will be seeded and planted with species that can grow in both wet and dry conditions. This zone is generally consistent with Onondaga Lake habitat modules 9a and 9b, and the upper range of module 6a.

- Zone B1e is shallow water wetland area that will be seeded and planted with emergent wetland plants. This zone is generally consistent with Onondaga Lake habitat module 5a.
- Zone B1f is a forested wetland area with slightly higher ground surface elevation that will support woody species (trees and shrubs). This zone is generally consistent with Onondaga Lake habitat module 9b. This area will be planted and seeded with species to support development of a red maple/hardwood swamp.
- Zone C provides open water areas.

4 SUMMARY

Both the modeling analysis and channel design analysis for Ninemile Creek described in this report were completed to evaluate the modifications to the channel bed and banks, including channel realignment, to meet the objectives presented in the ROD for Reach CD of Ninemile Creek. The results of the analyses indicate the following:

- A 2-foot-thick habitat/erosion protection layer comprised with a wide range of sediment sizes will provide suitable habitat for fish and benthic macroinvertebrate species and erosion protection.
- The predicted water surface elevations for the channel design are at or below the existing water surface elevations for the 100-year event at all modeled cross-sections, indicating that the proposed condition will satisfy the NYSDEC no-rise criteria for work in a floodplain.
- The predicated minimum water depths under low-flow conditions are the same or greater than the existing minimum water depths, and adequate for fish and canoe passage (minimum depth greater than 6 inches).

The channel design analysis for Reach CD of Ninemile Creek includes the following ecological and community benefits:

- Increased sinuosity and length in Ninemile Creek Reach CD
- Improved channel substrate (i.e., bed material) for fish and macroinvertebrates
- Channel stability that protects surrounding infrastructure while providing ecological function
- Increased connectivity between Ninemile Creek and the floodplain for moderate flood events
- Sufficient water depths during low-flow conditions for fish and canoe passage (minimum depth greater than 6 inches)
- Increased buffer between Ninemile Creek and Wastebeds 9 and 10
- Habitat enhancements such as pools, hydraulic refuge locations, cover habitat, and stream shading vegetation
- Increased native plant species and habitat diversity

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TABLES

Table 1

Channel Restoration Feature Benefit Summary

Reach	Approximate Station[1]	Feature	Benefits
CD	52+50 to 71+00	Bio-degradable rolled erosion control product	Vegetation growth and long term bank stability
	56+00 to 57+50	Multiple LWD placements (4)	Small pools (individual pool volume[2] 10 cu yd), hydraulic refuge, and cover habitat
	59+85 to 60+10	Stone with joint plantings and LWD (2)	Bank stability, stream shading, hydraulic refuge, and cover habitat
	59+85 to 61+90	Pool	Holding habitat, cooler temperatures, and lower velocities (volume[2] 398 cu yd)
	60+10 to 61+90	Live crib	Bank stability, stream shading, hydraulic refuge, and cover habitat
	60+10 to 61+90	Pool	Holding habitat, cooler temperatures, and lower velocities (volume[2] 635 cu yd)
	62+80 to 64+30	Live crib	Bank stability, stream shading, hydraulic refuge, and cover habitat
	66+10 to 66+50	Live crib	Large pool, bank stability, stream shading, hydraulic refuge, and cover habitat
	66+10 to 67+10	Pool	Holding habitat, cooler temperatures, and lower velocities (volume[2] 483 cu yd)
	66+50 to 67+10	Stone with joint plantings and LWD (2)	Bank stability, stream shading, hydraulic refuge, and cover habitat

Notes:

1 Location given by the approximate station extent of the feature. See Figures 3 and 4 for locations and full extents of each feature.

2 Pool volume calculated at the long term median water surface elevation (180 cubic feet per second [cfs]) under the pool extents shown in Figures 3 and 4.

LWD – large woody debris

cu yd – cubic yards

Table 2
Range of Particle Sizes (inches) Used by Representative Fish Species

Habitat Parameter	Yellow Perch[1]	Largemouth Bass[2]	Smallmouth Bass[3]	Walleye[4]	Brown Trout[5]	Common Shiner[6]
Spawning substrate	Silt and sand with vegetation[1]	Gravel: 0.02 to 2.5; nest builder	Gravel, cobble: 0.63 to 0.78 and boulder with interstitial space; nest builder	Gravel, rubble: 0.98 to 5.9; eggs broadcast	Gravel: 0.11 to 3.94	Depressions in sand or gravel: 0.20 to 2.36
Fry/juveniles substrate	Silt and sand with vegetation[1]	Primary habitat need is area with adequate cover	Gravel, broken rock, boulders with interstitial space	Primary habitat need is area with adequate cover	Cover important; rocky substrate: 3.94 to 15.76	Sand and gravel: 0.08 to 2.5
Adult substrate	Silt, sand, and gravel with vegetation[1]	Primary habitat need is area with adequate cover	Gravel, broken rock, boulders with interstitial space	Primary habitat need is area with adequate cover	Cover important, including brush cover and instream objects such as large rocks, logs, and debris piles	Gravel to rubble substrate: 0.20 to 2.36

Notes:
1 Krieger et al. 1983
2 Stuber et al. 1982
3 Edwards et al. 1983
4 McMahon et al. 1984
5 Raleigh et al. 1986
6 Trial et al. 1983

Table 3
Water Surface Elevation and Bridge Clearance at Ninemile Creek Bridges

Bridge Description	Approximate Station	Lower Chord Elevation (ft)	Existing Conditions				Proposed Conditions			
			WSEL (ft)		Clearance (ft)		WSEL (ft)		Clearance (ft)	
			50[1]	100[1]	50	100	50	100	50	100
West I-690	31+20	377	370.38	371.11	6.62	5.89	370.27	370.99	6.73	6.01
East I-690	32+20	378.1	370.45	371.18	7.65	6.92	370.32	371.05	7.78	7.05
Railroad	38+25	371.35	370.87	371.65	0.48	-0.30	370.72	371.47	0.63	-0.12
State Fair	39+64	371.3	370.97	371.82	0.33	-0.52	370.80	371.62	0.50	-0.32
Utility	41+20	372.95	371.03	371.87	1.92	1.08	370.87	371.69	2.08	1.26
Access Road	49+14	372.6	371.41	372.25	1.19	0.35	371.25	372.07	1.35	0.53

Notes:
1 50 and 100 indicate the 50-year and 100-year return events, respectively.
WSEL – Water Surface Elevation
ft – feet

Table 4
Water Depths Under Low and Median Flow Conditions

Reach	90% Exceedance, July						Long-term Median					
	Existing Depth (ft)			Proposed Depth (ft)			Existing Depth (ft)			Proposed Depth (ft)		
	Avg.	Min.	Max.	Avg.	Min.	Max.	Avg.	Min.	Max.	Avg.	Min.	Max.
CD	3.4	0.7	9.1	3.1	0.9	5.7	4.6	1.9	10.0	4.2	1.9	7.0

Notes:

1 The 90% exceedance discharge in July is 46 cubic feet per second (cfs) with a design lake level of 362.0 feet North American Vertical Datum of 1988 (NAVD88).

2 The long-term median discharge is 180 cfs with a design lake level of 362.5 feet NAVD88.

3 Exceedance probability discharges are for the period of record from 1997 to 2007.

4 The long-term median is from the full period of record (occasional measurements, water years 1959 to 1970; November 1970 to September 1973; July 1975 to 2007).

Table 5
Existing and Proposed Wetland Acreages

Reach	Wetland Acreage		Open Water Acreage[3]	
	Existing[1]	Proposed[2]	Existing	Proposed
CD	1.55	1.55	3.08	2.59
Total[4]	1.55	1.55	3.08	2.59

Note:

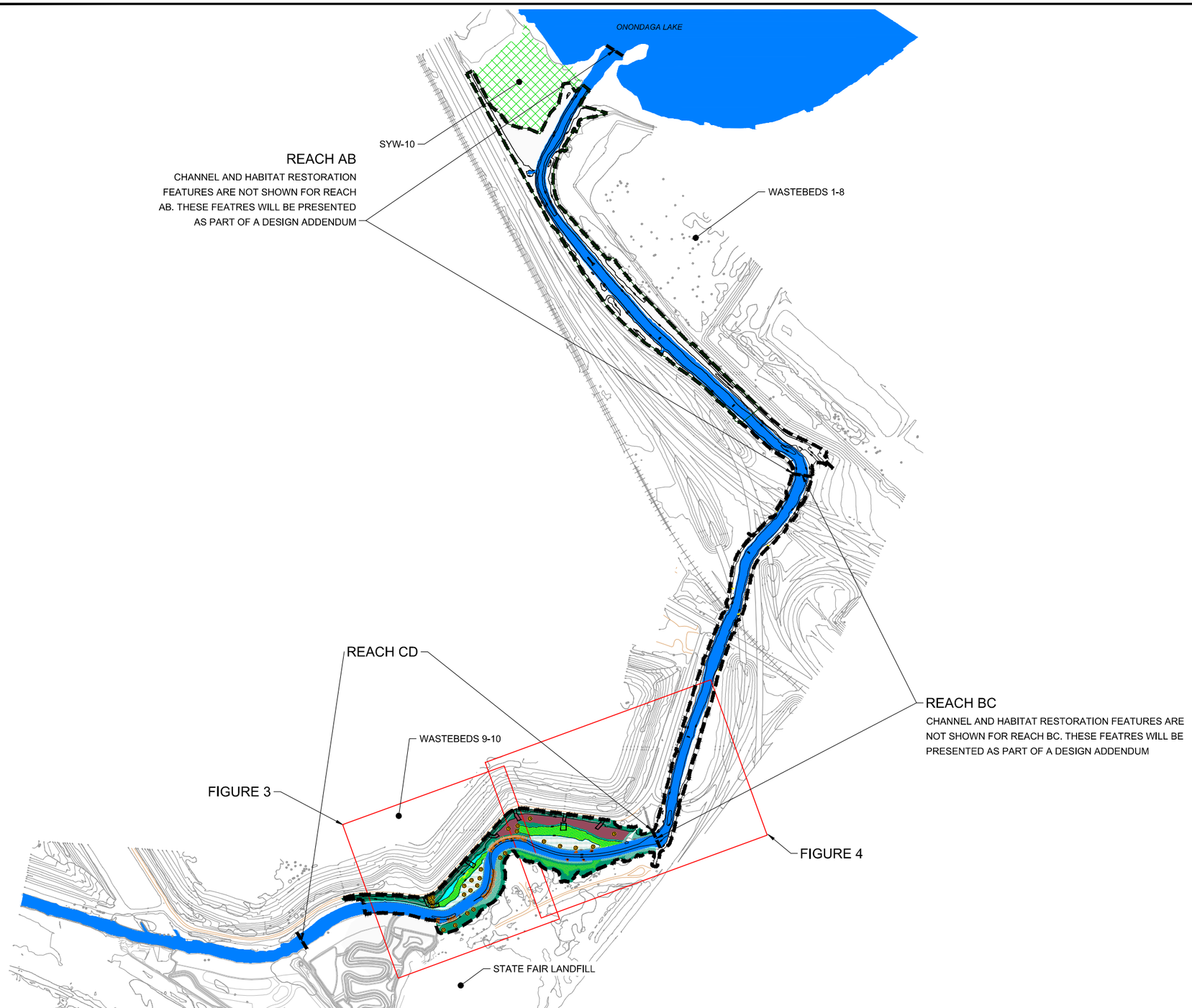
1 Existing wetland acreages are from Terrestrial Environmental Specialists (TES; 2009). Proposed wetland acreages are based on wetland areas shown in Figures 3 and 4.

2 Proposed wetland acreage is based on the design assumption that there is sufficient interaction with the surface water to create wetland conditions 2.5 feet above the long-term median water surface elevation.

3 Open water acreage is for the long-term median discharge of 180 cubic feet per second (cfs) and a lake water surface elevation of 362.5 feet (North American Vertical Datum of 1988 (NAVD88). There is less open water in the proposed condition due to the creation of a single, sinuous channel in Reach CD. The existing small channel south of the large island is dry during portions of the growing season, but is included in the calculation of existing open water.

4 The total areas provided in this table do not include SYW-10, Reach AB, and Reach BC. These areas will be provided in an addendum to the design report.

FIGURES



LEGEND:

- APPROX. LIMITS OF GRADING
- FINISHED GRADE MAJOR CONTOUR
- FINISHED GRADE MINOR CONTOUR
- EXISTING GRADE MAJOR CONTOUR
- EXISTING GRADE MINOR CONTOUR
- EXISTING TREE LINE
- EXISTING DELINEATED WETLAND BOUNDARIES
- PROPOSED POOL EXTENT
- SOIL WRAPS
- LIGHT STONE FILLING MATERIAL
- APPROX. EXTENT OF STORMWATER OUTFALL PROTECTION FEATURES
- BIO-DEGRADABLE RECP
- EMERGENT WETLAND (ZONE B1e)
- FORESTED WETLAND (ZONE B1f)
- FORESTED UPLAND (ZONE A1a)
- FORESTED UPLAND MIX (ZONE A1b)
- RED MAPLE/HARDWOOD SWAMP OR WOODS
- RIVERINE FRINGING WETLAND (ZONE A2)
- OPEN WATER
- SYW-10
- PROPOSED LARGE TREE

0 300 600
SCALE IN FEET

NOTES:

1. FIGURES ARE FOR REPRESENTATION ONLY. NOT FOR CONSTRUCTION.
2. HORIZONTAL DATUM: NY STATE PLANE CENTRAL ZONE (FT).
3. VERTICAL DATUM: NAVD 88 (FT).
4. CONTOURS ARE 5' INTERVAL.

ONE INCH
AT FULL SIZE, IF NOT ONE INCH SCALE ACCORDINGLY

ANCHOR QEA

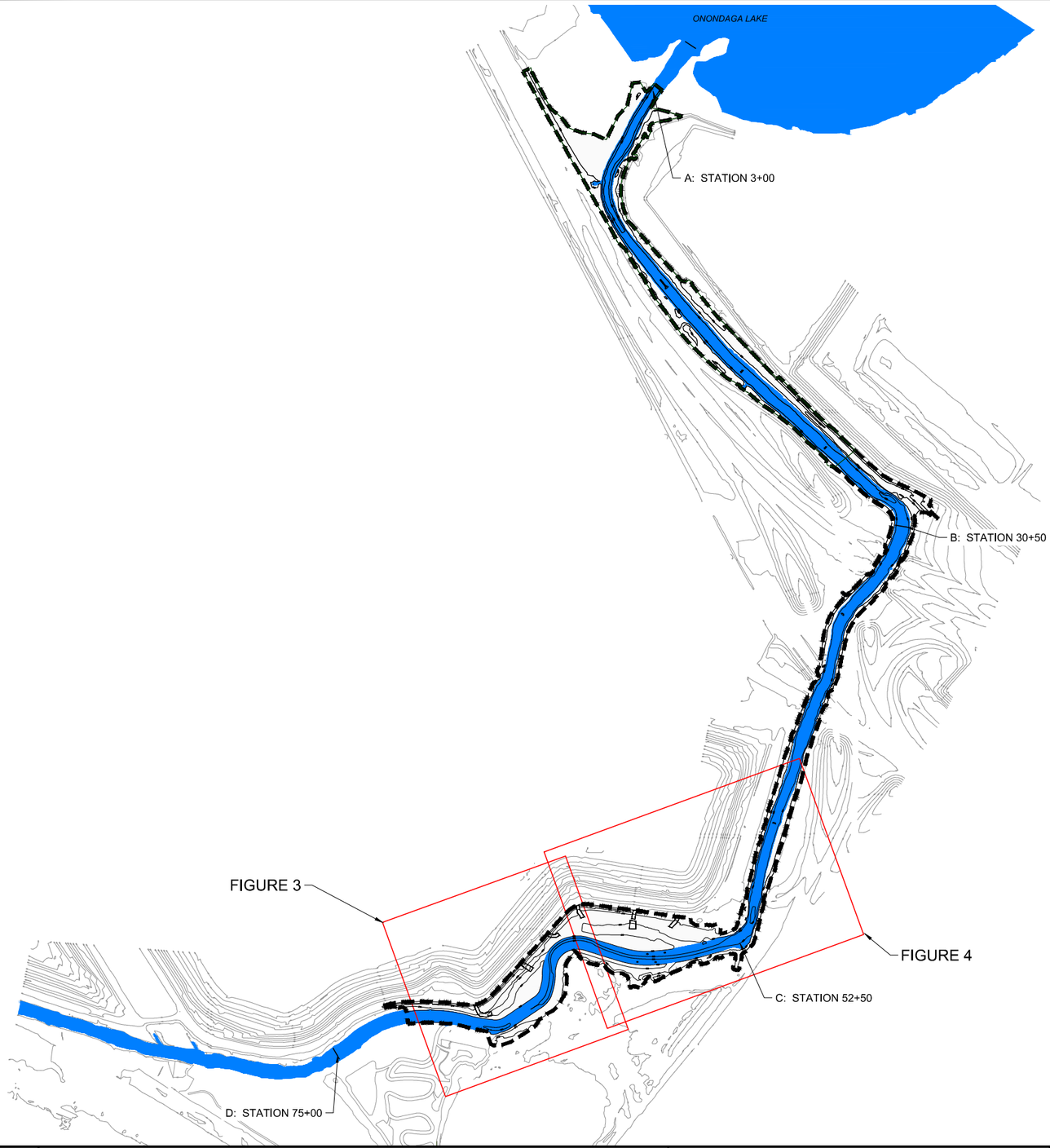
DESIGNED BY: R. DAVIS, J. GAFFNEY
DRAWN BY: E. PIPKIN, D. GAFFNEY
CHECKED BY: T. DRURY, R. DAVIS
APPROVED BY: -
SCALE: AS SHOWN
DATE: 06/19/2012

NINEMILE CREEK
CHANNEL & HABITAT RESTORATION
(NOT TO BE USED FOR CONSTRUCTION)

100% DESIGN
SITE OVERVIEW

FIGURE NO.
1

Jun 19, 2012 12:17pm dgaffney B:\Projects\Honeywell\Nine Mile Creek (090139-01)\NMC_100pct_Design\CADD\Figures\Appendix_E\090139-01-NINEMILE-95% DRAFT DESIGN REPORT\fig 1-2.dwg 1-NINEMILE PLAN ALL



0 300 600
SCALE IN FEET

LEGEND:

- APPROX. LIMITS OF GRADING
- FINISHED GRADE MAJOR CONTOUR
- OPEN WATER

NOTES:

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3. VERTICAL DATUM: NAVD 88 (FT).
4. CONTOURS ARE 5' INTERVAL.

ONE INCH
AT FULL SIZE, IF NOT ONE INCH SCALE ACCORDINGLY

ANCHOR QEA

DESIGNED BY: R. DAVIS, J. GAFFNEY
DRAWN BY: E. PIPKIN, D. GAFFNEY
CHECKED BY: T. DRURY, R. DAVIS
APPROVED BY: -
SCALE: AS SHOWN
DATE: 06/19/2012

NINEMILE CREEK
CHANNEL & HABITAT RESTORATION
(NOT TO BE USED FOR CONSTRUCTION)

100% DESIGN
CHANNEL STATIONING

FIGURE NO.
2

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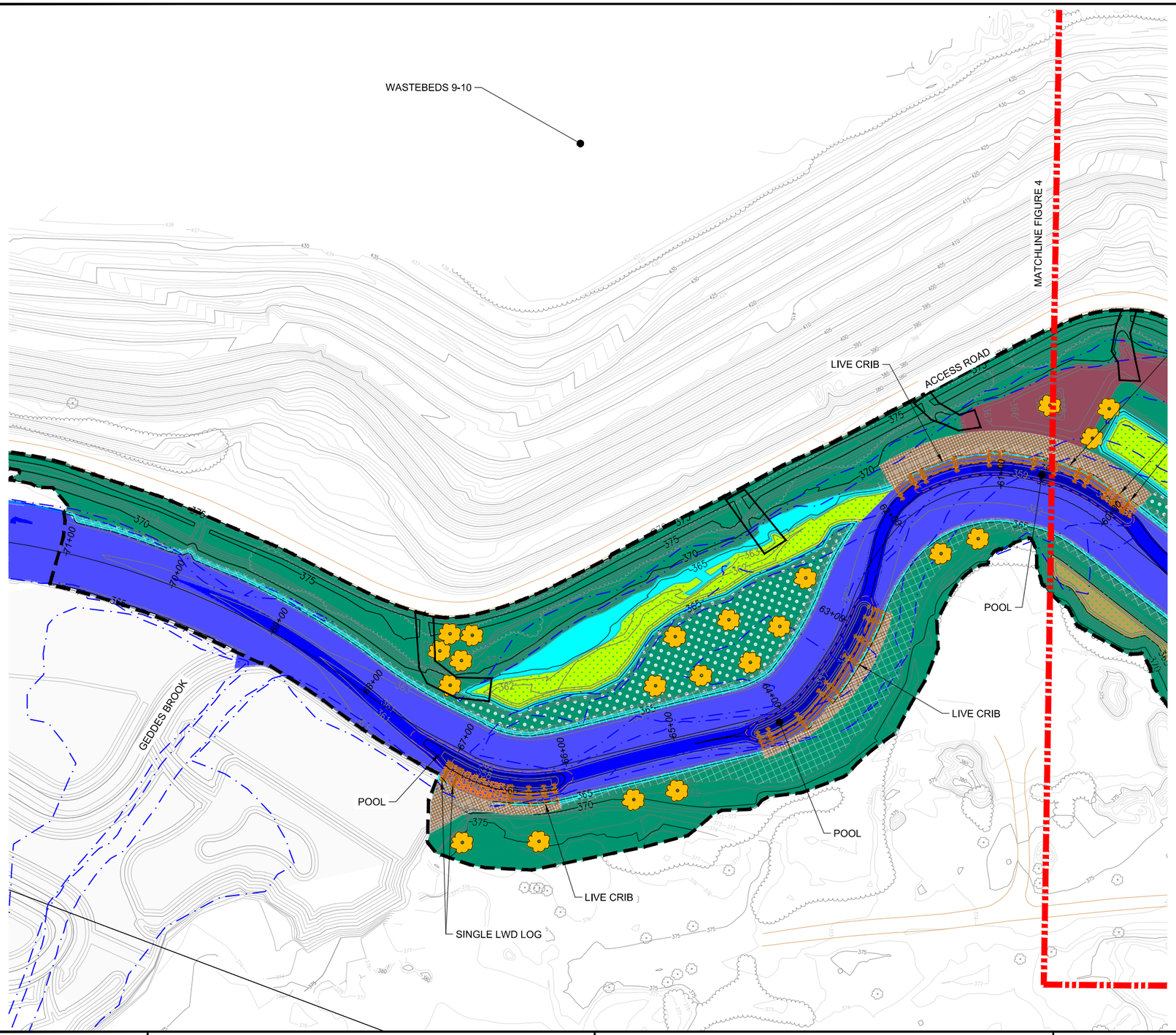

LEGEND:

- APPROX. LIMITS OF GRADING
- FINISHED GRADE MAJOR CONTOUR
- FINISHED GRADE MINOR CONTOUR
- EXISTING GRADE MAJOR CONTOUR
- EXISTING GRADE MINOR CONTOUR
- EXISTING TREE LINE
- EXISTING DELINEATED WETLAND BOUNDARIES
- PROPOSED POOL EXTENT
- SOIL WRAPS
- LIGHT STONE FILLING MATERIAL
- APPROX. EXTENT OF STORMWATER OUTFALL PROTECTION FEATURES
- BIO-DEGRADABLE RECP
- EMERGENT WETLAND (ZONE B1e)
- FORESTED WETLAND (ZONE B1f)
- FORESTED UPLAND (ZONE A1a)
- FORESTED UPLAND MIX (ZONE A1b)
- RED MAPLE/HARDWOOD SWAMP OR WOODS
- RIVERINE FRINGING WETLAND (ZONE A2)
- PROPOSED LARGE TREE
- LONG TERM MEDIAN (180 cfs) FLOW DEPTHS
  - 0-2FT
  - 2-4 FT
  - 4-6 FT
  - 6-8 FT
  - >8 FT

0 50 100
SCALE IN FEET

NOTES:

1. FIGURES ARE FOR REPRESENTATION ONLY. NOT FOR CONSTRUCTION.
2. HORIZONTAL DATUM: NY STATE PLANE CENTRAL ZONE (FT).
3. VERTICAL DATUM: NAVD 88 (FT).
4. CONTOURS ARE 1' INTERVAL.

ONE INCH
AT FULL SIZE, IF NOT ONE INCH SCALE ACCORDINGLY

ANCHOR QEA

DESIGNED BY: R. DAVIS, J. GAFFNEY
DRAWN BY: E. PIPKIN, D. GAFFNEY
CHECKED BY: T. DRURY, R. DAVIS
APPROVED BY: -
SCALE: AS SHOWN
DATE: 06/19/2012

NINEMILE CREEK
CHANNEL & HABITAT RESTORATION
(NOT TO BE USED FOR CONSTRUCTION)

100% DESIGN
STA 71+00 TO STA 60+00

FIGURE NO.
3

Jun 19, 2012 12:20pm dgaffney B:\Projects\Honeywell\Nine Mile Creek (090139-01)\NMC_100pct_Design\CADD\Figures\Appendix_E\090139-01-NINEMILE-95% DRAFT DESIGN REPORT-Fig 3-4.dwg 3-NINEMILE PLAN 1 OF 5