ONONDAGA LAKE CAPPING, DREDGING, HABITAT AND PROFUNDAL ZONE (SMU 8) FINAL DESIGN

METRO OUTFALL VICINITY DESIGN ADDENDUM

Prepared for:

Honeywell

301 Plainfield Road, Suite 330
Syracuse, NY 13212

Prepared by:

PARSONS

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ANCHOR QEA

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OCTOBER 2014

SUMMARY OF DESIGN REVISIONS

This addendum provides revisions associated with the cap design in the vicinity of the Onondaga County Metropolitan Wastewater Treatment Plant (Metro) Deepwater Outfall to ensure it is not impacted as a result of sediment capping. The outfall extends from the shoreline through the south corner of Remediation Area E and into Remediation Area D. The outfall pipeline is referred to as Outfall 1 (Subaqueous Conduit) on the historical Metro design detail drawings. It is a 60-inch (in.) inner diameter pipe of reinforced concrete construction with 6-in. thick pipe walls for a total outer diameter of 72 in. The pipe consists of 20-ft. lengths clamp-bolted together and sealed.

According to the 1922 design drawings for this outfall, approximately 1,350 ft. of the outfall lies within a channel that was dredged as part of the construction. The final 900 ft. length is supported with timber frames spaced every 20 ft., which are pile-supported to an unknown depth. The dispersion section has pipe support structures that are spaced every 4 ft. and is also underlain by a 20-ft. wide apron of rock protection. The current condition of the outfall is unknown. Most of the pipeline is buried beneath sediment that has accumulated since its construction.

To avoid having an adverse effect on the outfall, the Final Design included a dredging offset of 25 ft. from the outfall. The Final Design assumed a cap would be placed over the outfall pipeline, and included a 25-ft. capping offset in the area around the discharge end of the pipe. The Final Design also indicated that the remedial approach in the vicinity of this outfall would be re-evaluated based on additional consultation with Onondaga County.

Based on discussions with Onondaga County subsequent to the Final Design, it is now understood that this discharge is active during Metro high flow conditions and the pipeline's integrity must remain intact. Placing capping material on top of the pipeline could put stress on the pipe, as well as result in settlement of the underlying sediment which could result in impacts to the pipeline. Therefore, a revised capping and dredging design has been developed for this area.

Factors considered during the development of a dredging and capping approach in the vicinity of this pipeline that will minimize the potential impacts to the pipeline include:

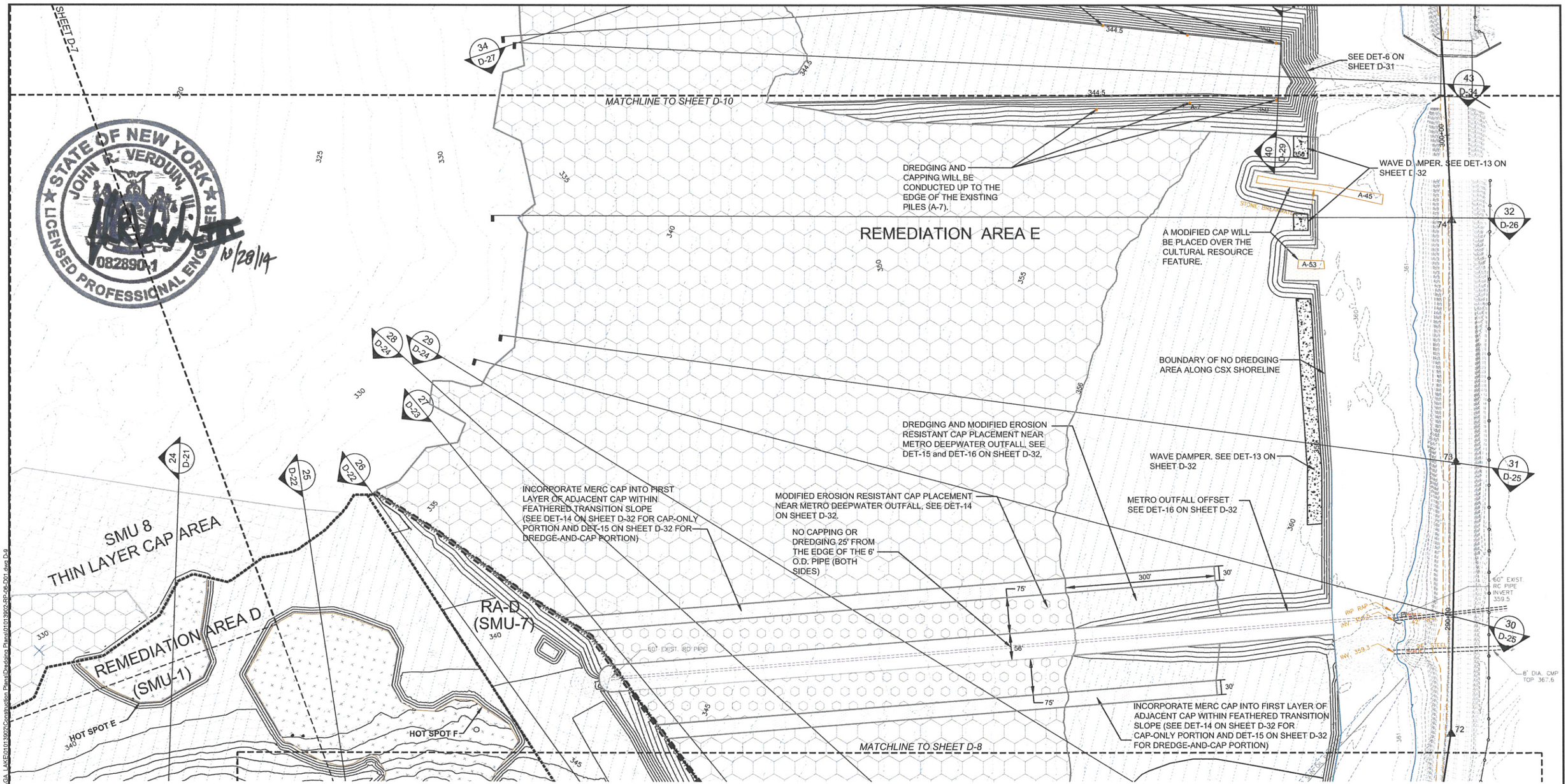
- The pipe was installed in the 1920's and its current condition is unknown.
- The lengths and conditions of the support piles are unknown.
- The tolerance of the pipe for settlement is unknown.
- The subsurface stratigraphy and geotechnical properties of the deep sediments/soils underlying the pipeline are not well defined.

- Both primary and secondary settlement were considered. However, there is inherent difficulty/uncertainty in predicting the timeframe and magnitude of secondary compression of earthen materials due to loading.

Even with a 25-ft capping offset from the pipeline, settlement of sediments under the pipeline could occur due to the weight of a full-thickness cap such that the integrity of the pipeline could be impacted based on detailed geotechnical settlement analysis. Therefore, the revised design in the vicinity of the deepwater outfall pipeline includes:

- No dredging or capping within 25 ft. of the pipeline.
- A modified erosion-resistant cap in the zone between 25 ft. and 100 ft. of the pipeline in areas where there is minimal or no dredging prior to capping. This cap will consist of 6 inches of gravely sand, which is the maximum cap thickness and coarsest substrate that can be applied in this area based on cap stability considerations (Attachment 1). This will help reduce scour and resuspension of underlying sediments due to wind/wave action, but will not be coarse enough to meet the predicted erosive force of a 100-year storm event, which is the design basis for the surrounding area. Due to the reduced cap thickness, the cap surface elevation in this area will be approximately 2 ft. lower than the surrounding cap elevation, which will reduce erosive forces in this area.
- Portions of the modified erosion-resistant cap are within the cap area where granular activated carbon (GAC) was included in the chemical isolation layer in the original design. Revised cap chemical isolation layer modeling was completed based on a cap thickness of 6 inches, resulting in the revised GAC application rates listed in Table 3 in Attachment 2. Details pertaining to the revised modeling in this area are also provided in Attachment 2.
- In areas where the modified erosion-resistant cap will be placed, the cap will transition from the modified cap to the full thickness cap beyond 100 ft. of the pipeline with incremental increases in cap thickness to avoid significant differential cap loading in the transition zone.

The total area adjacent to the pipeline that will not be capped is approximately 1.9 acres. The area where the modified erosion-resistant cap will be places is approximately 4.3 acres. The revised capping plan is presented in the attached revised design sheets. Monitoring, maintenance, contingency actions and institutional controls will be addressed in consultation with NYSDEC during finalization of the Onondaga Lake Operations and Maintenance Scoping Document.



LEGEND:

- LIMITS OF DREDGING AND CAPPING
- LIMITS OF CAP ONLY
- HOT SPOT
- THIN LAYER CAP
- LIMITS OF MERC CAP FEATHERED TRANSITION
- LIMITS OF MODIFIED CAP FOR CULTURAL RESOURCES
- PROJECT BASELINE
- EXISTING CONTOUR
- PROPOSED DREDGING CONTOUR
- SHORELINE (ELEV. 362.5)
- REMEDIATION AREA BOUNDARY
- SMU BOUNDARY
- CROSS SECTION LOCATION AND DESIGNATION
- CULTURAL RESOURCES
- LIMITS OF MODIFIED EROSION RESISTANT CAP IN CAP ONLY AREA
- LIMITS OF MODIFIED EROSION RESISTANT CAP IN DREDGE AND CAP AREA

BASELINE COORDINATES		
POINT #	NORTHING	EASTING
72	1116827.31	927868.29
73	1117307.31	928159.49
74	1117742.79	928403.32

0 100 200
SCALE IN FEET

NOTE:
SEE SHEET D-IDX FOR GENERAL NOTES AND LEGEND.

ANCHOR QEA

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REVISIONS

REV	DATE	BY	APP'D	DESCRIPTION
0	03/05/12	WJD	JRV	ISSUED FOR CONSTRUCTION
1	08/07/13	WJD	JRV	ADDED CULTURAL RESOURCE A13 AND 25-FT NO CAP BUFFER
2	10/23/14	WJD	JRV	REVISED REMEDIATION AREA E

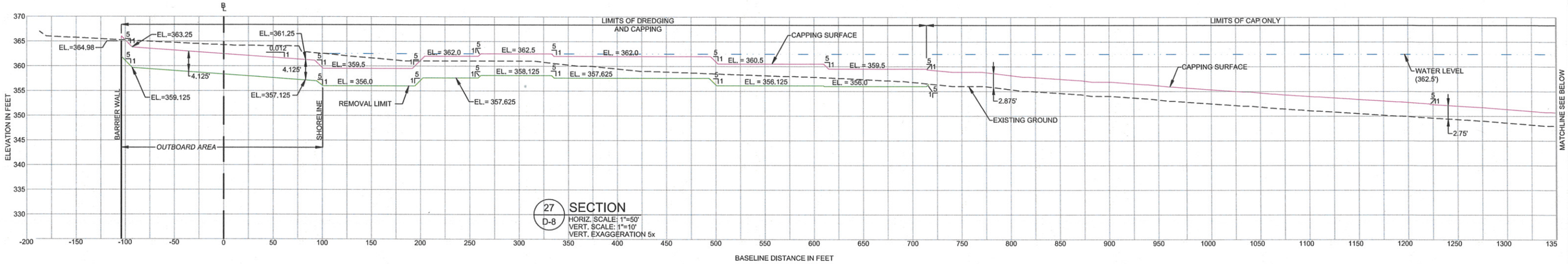
DESIGNED BY: K. POWELL / W. DINICOLA
DRAWN BY: G. HOWELL
CHECKED BY: P. LaROSA / D. SMITH
APPROVED BY: J. VERDUIN
SCALE: AS NOTED
DATE: MARCH 5, 2012

ONONDAGA LAKE CAPPING, DREDGING, HABITAT AND PROFUNDAL ZONE (SMU 8) FINAL DESIGN

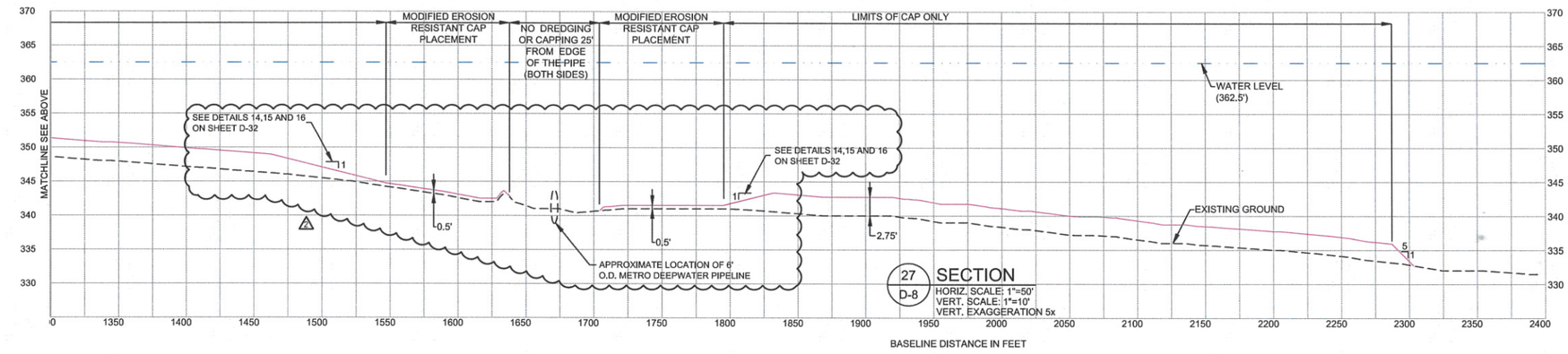
REMEDIATION AREA D & E DREDGING AND CAPPING PLAN

D-9

SHEET NO. 11 OF 35



27 / D-8 **SECTION**
HORIZ. SCALE: 1"=50'
VERT. SCALE: 1"=10'
VERT. EXAGGERATION 5x



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VERT. SCALE: 1"=10'
VERT. EXAGGERATION 5x

NOTES:
1. SEE SHEET D-IDX FOR GENERAL NOTES AND LEGEND.
2. WATER LEVEL 362.5 FT NAVD 88 IS THE AVERAGE LAKE LEVEL DURING AQUATIC PLANT GROWING SEASON.
3. THE TYPICAL DREDGING AND CAPPING SLOPE FOR EDGES AND TRANSITIONS IS 5H:1V.
4. CAP THICKNESS AND ELEVATION ARE BASED ON MAXIMUM OVER-PLACEMENT WITHOUT SETTLEMENT CONSIDERATIONS FOR HABITAT MODULES 5 AND 6 IN PORTIONS OF REMEDIATION AREAS C AND D CORRESPONDING TO THE FIRST YEAR OF CAPPING. CAP THICKNESS AND ELEVATION ARE BASED ON MEAN OVER-PLACEMENT WITHOUT SETTLEMENT FOR ALL REMAINING AREAS.

STATE OF NEW YORK ★ JOHN R. VERDUIN, III ★ 082890-1 ★ LICENSED PROFESSIONAL ENGINEER
10/28/14

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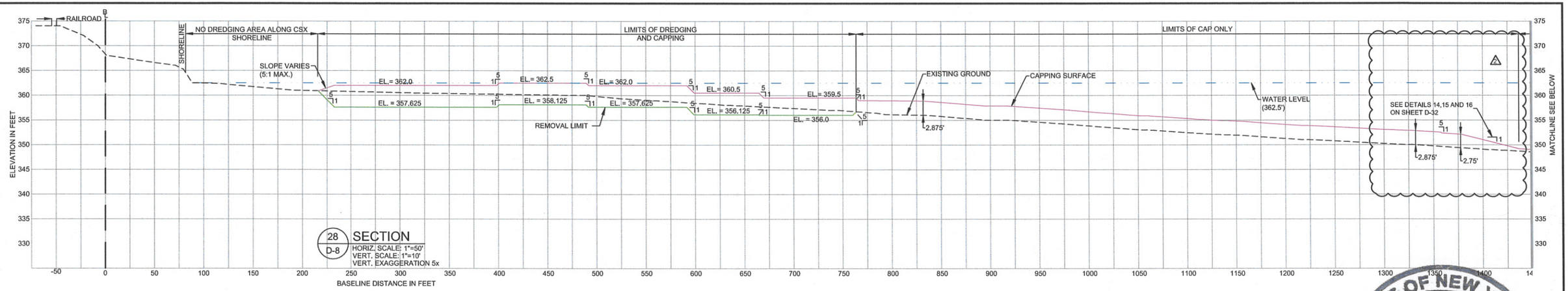
ONONDAGA LAKE CAPPING, DREDGING, HABITAT AND PROFUNDAL ZONE (SMU 8) FINAL DESIGN

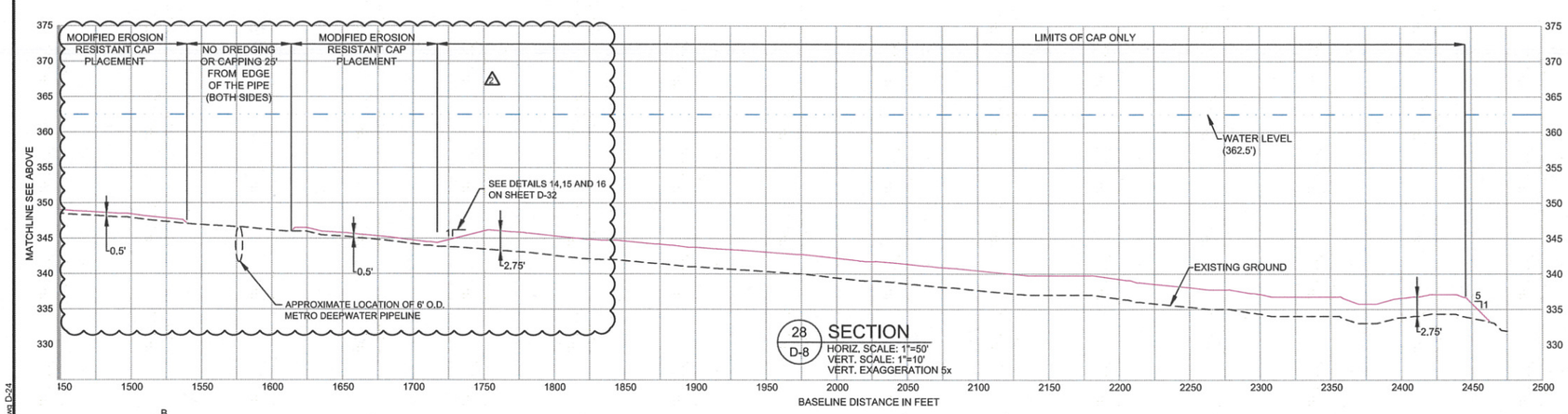
REMEDIATION AREA E DREDGING AND CAPPING CROSS SECTION 27

D-23

SHEET NO. 25 OF 35



28 / D-8 SECTION
HORIZ. SCALE: 1"=50'
VERT. SCALE: 1"=10'
VERT. EXAGGERATION 5x



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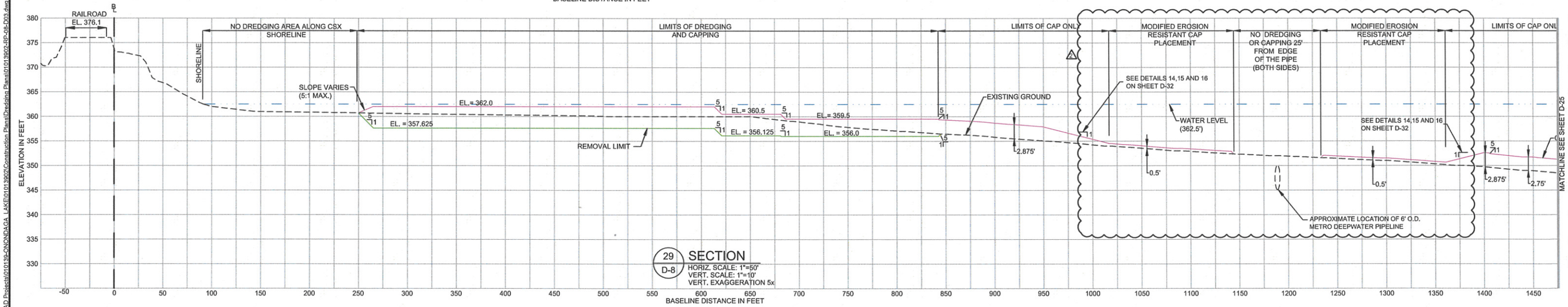

29 / D-8 SECTION
HORIZ. SCALE: 1"=50'
VERT. SCALE: 1"=10'
VERT. EXAGGERATION 5x

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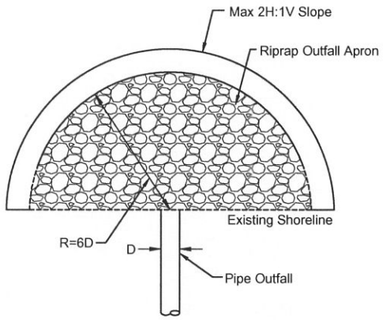
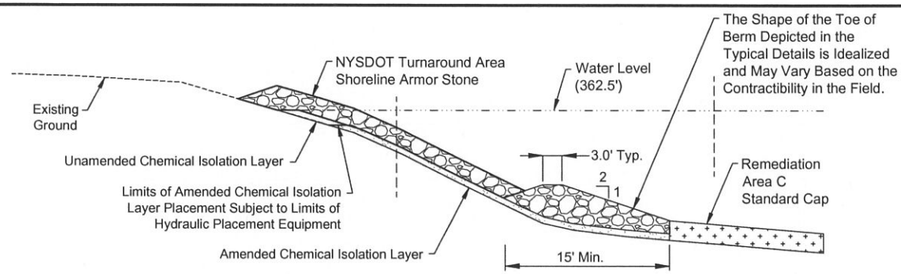
REMEDIATION AREA E
DREDGING AND CAPPING CROSS SECTIONS 28 & 29

D-24

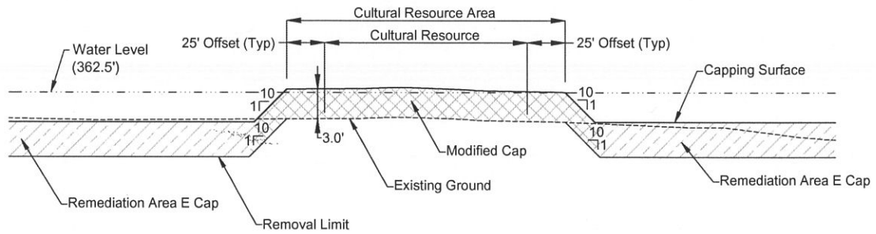
SHEET NO. 26 OF 35



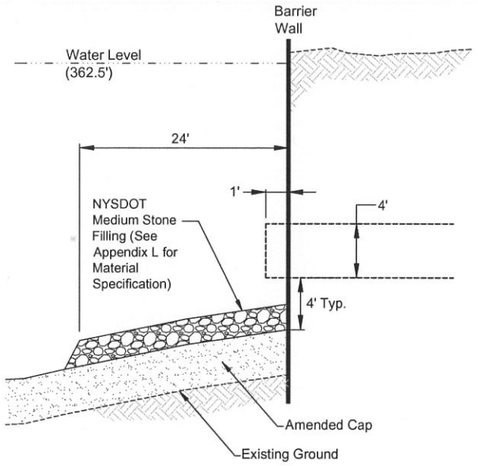
DET-8
Outfall Scour Protection - Plan View
(TYP.)
Not to Scale



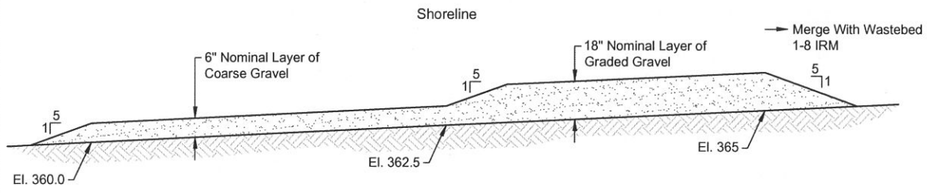
DET-11
NYSDOT Turnaround Cap Detail
(TYP.)
Not to Scale



DET-12
Typical Detail Cross Section of Cultural Resources Modified Cap in Dredge Areas
(TYP.)
Not to Scale

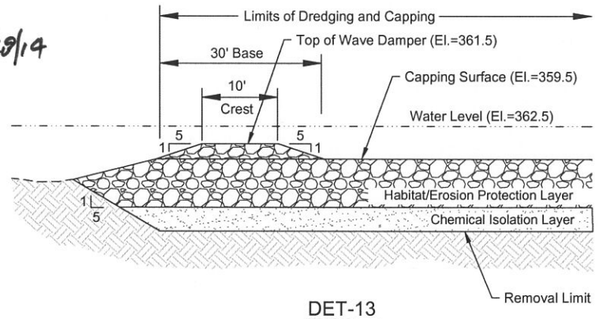


DET-9
48-Inch Stormwater Outfall Scour Protection
(TYP.)
Not to Scale

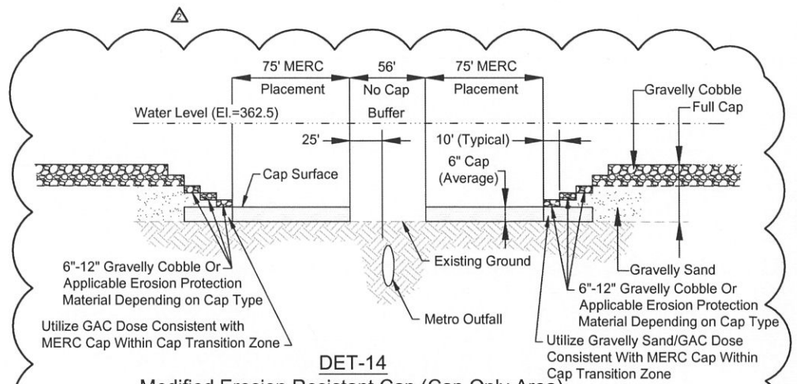


DET-10
Shoreline Stabilization
(TYP.)
Not to Scale

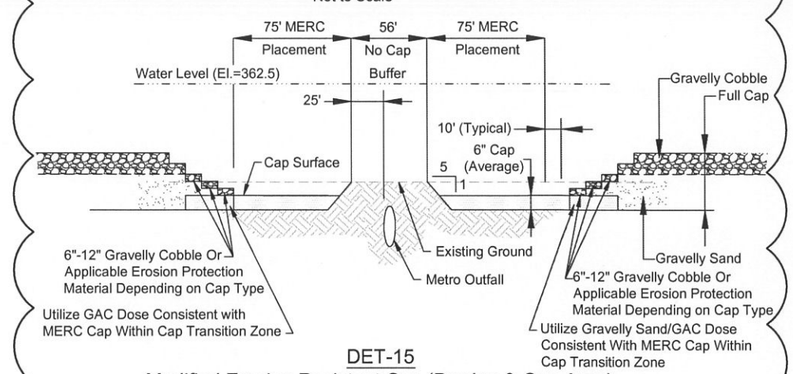
NOTE: THE FOLLOWING CROSS SECTIONS ARE FOR ILLUSTRATIVE PURPOSES ONLY



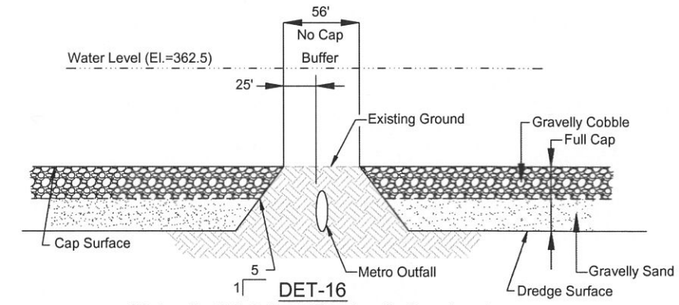
DET-13
Remediation Area E Wave Damper
(TYP.)
Not to Scale



DET-14
Modified Erosion Resistant Cap (Cap Only Area)
(TYP.)
Not to Scale



DET-15
Modified Erosion Resistant Cap (Dredge & Cap Area)
(TYP.)
Not to Scale



DET-16
Metro Outfall Offset (Dredge & Cap Area)
(TYP.)
Not to Scale

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ONONDAGA LAKE CAPPING, DREDGING, HABITAT AND PROFUNDAL ZONE (SMU 8) FINAL DESIGN

TYPICAL DETAILS AND NOTES

D-32

SHEET NO. 34 OF 35

ATTACHMENT 1
MODIFIED EROSION RESISTANT CAP
SETTLEMENT ANALYSIS

ANCHOR QEA

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MEMORANDUM

To:	Ed Glaza, P.E. Parsons	**Date:**	October 9, 2014
From:	Paul LaRosa P.E., John Verduin P.E., and Jeff Warren P.E. (WA), Anchor QEA Engineering, PLLC	**Project:**	130139-01.06
Re:	Metro Deepwater Outfall Settlement Evaluation		

1 INTRODUCTION

This memorandum describes the methods used to determine design offsets with respect to cap-induced settlement evaluations for remedial action adjacent to the Metropolitan Syracuse Wastewater Treatment Plant (Metro) Deepwater Outfall (referred to as "the Outfall" for the rest of this document). Minimum dredge offsets for the Outfall were previously established in the *Onondaga Lake Capping, Dredging, Habitat, and Profundal Zone Final Design* (Final Design) Report (Parsons and Anchor QEA 2012) based on operational considerations of dredge equipment.

Due to thick deposits of compressible sediments adjacent to and underlying the Outfall and uncertainties in the construction and condition of the Outfall, settlement evaluations were performed to determine dredging and capping offsets that will result in a low risk of unacceptable differential settlement of sediments underlying the Outfall.

The location of the Outfall is shown on Figure 1. The alignment and elevation of the Outfall is shown on Figure 2. Characteristics of the Outfall are described in detail in section 7.2.2.5 of the Final Design Report (Parsons and Anchor QEA 2012):

> *"A discharge pipeline from Metro extends from the shoreline through the south corner of Remediation Area E and into Remediation Area D. This discharge is not currently active, however, the option to initiate use in the future must be considered, and the pipeline's integrity must remain intact.*
>
> *The pipeline is referred to as Outfall 1 (Subaqueous Conduit) on the historical Metro design detail drawings. It is a 60-in. inner diameter pipe of reinforced concrete*

construction with 6-in. thick pipe walls for a total outer diameter of 72 in. The pipe consists of 20 ft. lengths clamp bolted together and sealed.

According to design drawings for this outfall, approximately 1,350 ft. of the outfall lies within a channel that was dredged as part of the construction. The final 900 ft. length is supported with timber frames spaced every 20 ft. which are pile-supported to an unknown depth. The dispersion section has pipe support structures that are spaced every 4 ft. and is also underlain by a 20 ft. wide apron of rock protection.

The cap design over the Metro deepwater outfall may be modified based on additional consultation with Onondaga County, and, if appropriate, would be revised in a subsequent design addendum subject to review and approval by NYSDEC."

2 UNCERTAINTIES AND DISCUSSIONS WITH METRO

Based on discussions between Parsons and Metro in November and December of 2013, it is understood that capping and dredging operations should be designed so as not to disturb the Outfall because the Outfall is periodically active and there are no current plans for replacement or a change in operations. The following uncertainties are considered:

- The existing condition of the Outfall is unknown. Based on design drawings provided by Metro during the design phase, it is assumed that the Outfall was constructed in the 1920s; thus, significant deterioration of the Outfall is possible. No recent survey of the pipeline is available to evaluate the condition of the Outfall. The majority of the Outfall is buried beneath the sediment surface; therefore, no exterior inspection is possible.
- For the pile-supported section of the Outfall, pile lengths and conditions are unknown. The pile lengths were not specified on the Outfall design drawings.
- The tolerance of Outfall for settlement is unknown; assumed tolerances are discussed in Section 4.4.
- Subsurface stratigraphy and geotechnical properties are not defined at regular intervals along the alignment of the Outfall (i.e., at every pipe joint or near pile supports).
- No explorations or data were collected specifically for the settlement evaluation of the Outfall; instead data available from pre-design investigation phases were used to provide an estimate of subsurface conditions.

3 SUBSURFACE CONDITIONS

Subsurface conditions in the vicinity of the Outfall were evaluated as part of the Cap Induced Settlement Evaluation (Appendix E, Anchor QEA 2012). Because no new subsurface information was collected in the vicinity of the Outfall after the Final Design, the interpreted subsurface conditions presented in Appendix E were used for this evaluation. Cone penetrometer data collected to support design refinements during construction were considered, but because consolidation properties were not directly measured, the data only provide general information on sediment characterization and were not specifically used for the settlement calculations.

Figure 3 presents the locations of explorations advanced during the design phase within Remediation Area E and the alignments of interpreted geologic profiles in the vicinity of the Outfall (cross sections I-I' and J-J'). Two cross sections, depicted on Figure 4 (I-I') and Figure 5 (J-J') were developed for the Final Design. These cross sections are relevant to the subsurface stratigraphy in the vicinity of the Outfall.

Subsurface conditions in Remediation Area E are described further in Appendix E:

> *"**Remediation Area E:** Figure 13 presents the locations of explorations advanced within Remediation Area E. Three cross-sections, depicted on Figure 14 (I-I'), Figure 15 (J-J'), and Figure 16 (K-K'), were developed to illustrate the subsurface stratigraphy in Remediation Area E. The generalized subsurface profile includes a surficial layer approximately 10 to 20 feet thick, consisting of fine to medium sand in the nearshore region, which grades to black silt with decreasing amounts of fine sand with distance from shore. The thickness of the sand layer was observed to decrease with distance from shore and transitions from primarily sand in the most nearshore explorations to silt with some fine sand, and then eventually to just silt in the offshore portion of Remediation E.*
>
> *Beneath the surficial layer of silt and fine sand is a layer of organic silt and clay that extends to the bottom of most explorations conducted within Remediation Area E (approximately 30 to 40 feet below the mudline). This organic silt layer appears consistent with the lacustrine (natural Lake sediments) deposit noted on two historical deep boring logs from Remediation Area D (B-76-1 and B-76-2—not shown on figures) and a deep historical boring (TH-305) on the shoreline of Remediation*

Area E completed for the design of the sewage treatment plant. In boring TH-305, the lacustrine deposit was observed to extend to approximately 130 feet below the shoreline elevation, with underlying sandy silt. Given that the ground surface near this boring is approximately 20 feet higher than the average mudline within the Lake in Remediation Area E, the depth to the underlying silt and sand layer, which is expected to serve as a subsurface drainage layer (i.e., doubly drained), was assumed to be approximately 110 feet in the eastern portion of Remediation Area E. Based on deep borings advanced in Remediation Area D, the lacustrine deposit on the western side of Remediation Area E (bordering Remediation Area D; see Section I-I' Figure 14) was assumed to extend between approximately 100 and 150 feet below the mudline before transitioning to underlying glacial soils. However, since the underlying glacial soils were described as clay and silt on the historical boring logs, this layer was not assumed to provide for drainage on the western side of Remediation Area E. These assumptions for thickness of the lacustrine deposit are expected to be conservative relative to the time rate of settlement, which is highly dependent on the drainage distance for porewater expelled during consolidation. Therefore, the durations predicted for settlement to occur in Remediation Area E may be overestimated, as discussed in Table 1.

In the western portion of Remediation Area E (along the boundary with Remediation Area D), a thin (approximately 3-feet-thick) surficial layer of very soft organic silt overlies the soil profile described above (see Section I-I' on Figure 14)."

4 SETTLEMENT EVALUATION

4.1 General

With the exception of the induced stress at depth ($\Delta\sigma_z$) and the thickness of the sediments expected to experience changes in stress, methods of settlement evaluation for the Outfall are consistent with the methods presented in Appendix E. This section presents a brief review of the methods used to estimate primary and secondary consolidation, and the modifications to the evaluation as compared to Appendix E.

4.1 Primary Consolidation

The magnitude and rate of primary consolidation is a function of the following:

- Change in vertical effective stress
- Thickness of the compressible deposit
- Depth of the compressible deposit (vertical effective stress)
- Length of the drainage path
- Characteristics intrinsic to the sediments (consolidation ratio, coefficient of consolidation, and permeability)

For conservatism, all sediments were assumed to be normally consolidated. As such, primary consolidation was estimated by the following equation:

$$\Delta \boldsymbol{H} = \boldsymbol{H}\frac{\boldsymbol{C_C}}{\boldsymbol{1+e_o}}\boldsymbol{log}\left(\frac{\boldsymbol{\sigma'_o+\Delta\sigma_Z}}{\boldsymbol{\sigma'_o}}\right) \qquad \text{(Equation 4-1, Appendix E)}$$

where:

ΔH = settlement of sub-layer
H = initial thickness of sub-layer
C_C = compression index
σ'_o = initial effective stress prior to cap placement at mid-height of layer
$\Delta\sigma_Z$ = change in effective stress as a result of cap placement at mid-height of layer
e_o = initial void ratio at effective stress of existing conditions (as predicted using consolidation results)

For each consolidation case evaluated, the major geologic units were broken up into sub-layers. The induced stress applied to each sub-layer was computed as a function of the depth to the midpoint of the sub-layer, the thickness of the cap applied, and three-dimensional effects relating to the offset distance assumed.

4.2 Secondary Compression

The natural process of secondary compression, sometimes referred to as "creep" is described in Appendix E. Unlike primary consolidation, secondary compression is independent of the magnitude of the change in induced stress. In theory, secondary compression is a process that occurs without terminus. The initiation of creep is difficult to determine, but it is typically assumed to initiate when 90 percent of primary consolidation is complete. Due to

the simplicity of the theory and inherent difficulties in estimating secondary compression, engineering judgment is required to interpret the results. In general, secondary compression is typically only considered when thick deposits of organic sediments are present, which is the condition beneath the Outfall.

Due to the collection primarily of disturbed sediment samples, and the soft nature of shallow sediments, only Seepage Induced Consolidation Tests were performed in Remediation Area E during the pre-design investigation. As such, secondary compression characteristics were not directly available from laboratory testing and secondary compression indices were estimated based on empirical correlations to Atterberg limits and moisture content. The secondary compression indices used were compared with literature values for organic soils and determined to be within a reasonable range.

Secondary consolidation was estimated by the following equation:

$$\boldsymbol{\delta_S = C_{\alpha\epsilon} H \, log\left(\frac{t}{t_p}\right)} \qquad \text{(Equation 4-4, Appendix E)}$$

where:

δ_S	=	estimated settlement due to secondary compression
H	=	initial thickness of layer
t	=	time after application of load, assumed to be 30 years for this evaluation
t_p	=	time required to complete consolidation settlement; in theory, this is infinite but it is assumed to occur when 90% of the primary consolidation is complete
$C_{\alpha\epsilon}$	=	modified secondary compression index

4.3 Modifications to Consolidation Analyses

Consolidation estimates presented in Appendix E assume that the dredge and cap area for each Habitat Module is of infinite areal extent, and that dredge and cap thickness are constant. For each consolidation case evaluated, the result of this simplifying assumption is that $\Delta\sigma_z$ is constant with depth.

For areas where dredging and capping offsets are incorporated (e.g., 25 feet along both sides of the Outfall), the assumptions used in Appendix E would over predict the actual induced stresses at depth because no load is placed directly over the offset area. Figure 6 presents a conceptual sketch of the area to be evaluated and the differences in the induced stress profile as compared to the induced stress profile using assumptions from Appendix E.

To estimate the induced stress at depth along the alignment of the Outfall, two methods were used:

1. SETTLE 3D
2. The Newmark Method and superposition

SETTLE 3D

Using established input parameters for Remediation Area E, Geosyntec Consultants estimated consolidation using the computer program SETTLE 3D. SETTLE 3D is a three-dimensional program for the analysis of vertical consolidation and settlement under foundations, embankments, and surface loads (Roc Science 2014).

Newmark Method

The Newmark solution (1935) was adapted from Boussinesq equations to estimate the induced stress at depth beneath the corner of a rectangular footing (Coduto 1999). Using the principles of superposition, profiles of induced stress were developed for key locations along the alignment of Outfall. Figure 7 presents the locations of these estimates of induced stress (settlement evaluations).

For a particular offset, the induced stress estimated from SETTLE 3D and the Newmark Method were determined to be similar.

4.4 Tolerable Deflection

Tolerances for settlement of the Outfall were not provided by Metro. In order to determine reasonable offsets for the Outfall, the amount of tolerable settlement was estimated using guidance for rigid conduits (Bjerrum 1963). As described in DM 7.1 (NAVFAC 1982), tolerable settlement is described in terms of the angular deformation between two pipe sections. For pipe lengths of 20 feet (based on the Outfall design drawings), a differential

settlement between two pipe sections of approximately 3.7 inches would result in an angular deformation equal to 1 degree, the maximum recommended by the guidance. Given uncertainties, including the age and likely deteriorated condition of the Outfall, a maximum tolerable differential settlement of 2 inches was selected. This maximum tolerable differential settlement was used for design offsets and is equivalent to a factor of safety of approximately 2. Differential settlement is further discussed in Section 6.

5 RESULTS

Table 1 summarizes the input parameters and results of the settlement evaluations for each settlement evaluation location shown on Figure 7. For each location, a sensitivity analysis was performed with a range of cap thickness and horizontal offset distances for capping to determine the most appropriate remedial design. Table 2 presents a summary of the sensitivity evaluation. The results indicate that within the area designated as cap-only and extending approximately 300 feet shoreward into the dredge-and-cap area (see Figure 7), a 6-inch-thick modified erosion resistant cap placed between 25 and 100 feet laterally from the Outfall, with transition to a full-thickness cap beyond 100 feet, is expected to result in settlement less than the assumed tolerance of 2 inches. Table 2 also indicates that the use of a thicker modified erosion-resistant cap, or transition to the full thickness cap closer to the Outfall than 100 feet, will result in settlements greater than the assumed tolerance.

Within the 200-foot-long portion along the length along the pipeline closest to shore within the dredge-and-cap area, the dredge depth is approximately equal to or greater than the cap thickness; therefore, the resulting induced stress would result in a low potential for settlement and thus no capping offset is required. Outboard of this (i.e., within the remaining 300-foot-length of the dredge-and-cap area), the dredge cut is less than the cap thickness; therefore, stresses and induced settlement potential increase. Thus, the 100-foot offset where a 6-inch-thick cap will be placed is appropriate for the offshore 300-foot-long portion of the dredge-and-cap area. Settlement evaluations at locations #3 and #4 (See Figure 7 and Table 1) illustrate this.

Using a 6-inch-thick cap within a 100-foot offset, primary consolidation as a result of capping adjacent to the Outfall was predicted to result in settlements of 1 to 2 inches, depending on the area evaluated. In some areas, the majority of this settlement is predicted to take more than 30 years to occur. In other areas, this settlement may occur in 1 to 3 years.

As a result of the predicted range in time to reach 90% of primary consolidation, secondary compression was predicted to range from 0 to 15 inches. As a result of the uncertainties discussed in Section 4.2, and conservative assumption regarding the thickness of the underlying organic soils (organic sediments are assumed to be thick), the secondary compression presented here may be conservative, and was not included in differential settlement calculations (as discussed in Section 6).

6 DIFFERENTIAL SETTLEMENT

Differential settlement occurs when loading, or sediment properties change rapidly over short distances. If severe enough, the resulting change in ground profile can damage structures.

Engineering judgment is required in interpreting primary consolidation and secondary compression results, and estimating the potential for differential settlement. As discussed previously, secondary compression is difficult to predict due to simplicities of the theory. For example, the magnitude of induced stress does not theoretically impact the magnitude of the secondary compression. In theory, slight changes in stress can trigger secondary compression to great depths. In practice, primary consolidation is often the greater concern when evaluating differential settlements. Furthermore, it is not anticipated that naturally deposited lake sediments will vary significantly (sediment thickness and coefficient of secondary consolidation) over the span of a few pipe joints (one pipe joint is 20 feet long for the Outfall).

Because primary consolidation is estimated to range from 1 to 2 inches, it is believed that the design offsets described in Section 7 will result in a low risk of differential settlement greater than the assumed tolerable limit (2 inches).

7 OFFSET RECOMMENDATIONS

Based on the preceding differential settlement evaluations, the revised dredging and capping design in the vicinity of the Outfall includes the following components (Figure 7):

- A 25-foot No-Dredge and No-Cap offset will be incorporated for the entire length of the Outfall for both sides. This offset is measured from the edge of the Outfall.

Including the width of the Outfall (6-foot diameter), this creates a 56-foot-wide No-Dredge and No-Cap area perpendicular to the alignment of the Outfall. Additional offsets are discussed below.

- A Modified Erosion Resistant Cap (MERC) will be placed at a horizontal distance of 25 feet to 100 feet from the edge of the Outfall along most of the length of the Outfall (Figure 7).
- Where a MERC is incorporated, transition to a full thickness cap will begin at a distance of 100 feet from the edge of the Outfall, and include a gradual buildup of the cap layers (referred to as "feathered edges"), consistent with the recommended capping approach for Remediation Area E.
- In the dredge-and-cap area nearshore, dredging will initiate at a slope of 5 horizontal to 1 vertical and will continue to the required dredge elevation. Dredging will initiate at a distance of 25 feet from the edge of the Outfall.

8 REFERENCES

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Table 1
Summary of Inputs and Results for Metro Deepwater Outfall Design Offsets (As Presented in Figure 7)

Settlement Evaluation[1]	Habitat Module[2] (Water Depth, feet)	Cross Section[3]	Consolidation Case[4]	Input Parameters[5]										Estimated Total Primary Consolidation (inches)	Time to 90% of Primary Consolidation (years)	Estimated Total Secondary Consolidation (inches)
						SICT Parameters					Oedometer Parameters	Thickness (ft)	Buoyant Weight (pcf)			
				Sediment Units	Sample Location (depth) for Consolidation Parameters	A (-)	B (-)	Z (kPa)	C (m/sec)	D (-)	$C_{\alpha\epsilon}$					
1	Module 1 (-20 to -30 ft)	I-I'	2	Organic SILT	70031 (0-3.3')	4.7	-0.194	0.109	8.1E-11	3.74	0.012	3	22	1.6	3	10
				SILT & Fine SAND	70006 (10-12')	2.74	-0.091	0.065	5.6E-09	3.25	0.006	15	33			
				Organic SILT	60016 (14-16')	3.49	-0.195	2.19	5.3E-09	3.34	0.008	112	36			
		J-J'	1	Soft SILT	60056 (0.5-3.3')	4.15	-0.202	0.15	1.7E-10	3.79	0.013	10	21	2.0	17	3
				Medium Stiff CLAY	60061 (13.2-16.5')	3.46	-0.178	0.091	4.8E-10	4.17	0.009	115	32			
2	Module 2 (-7 to -20 ft)	I-I'	2	Organic SILT	70031 (0-3.3')	4.7	-0.194	0.109	8.1E-11	3.74	0.0123	3	22	1.7	3	10
				SILT & Fine SAND	70006 (10-12')	2.74	-0.091	0.065	5.6E-09	3.25	0.0060	15	33			
				Organic SILT	60016 (14-16')	3.49	-0.195	2.19	5.3E-09	3.34	0.0084	112	36			
		J-J'	1	Soft SILT	60056 (0.5-3.3')	4.15	-0.202	0.15	1.7E-10	3.79	0.013	10	21	2.0	16	3
				Medium Stiff CLAY	60061 (13.2-16.5')	3.46	-0.178	0.091	4.8E-10	4.17	0.009	115	32			
3	Module 3B (-3 to -7 ft)	I-I'	2	Organic SILT	70031 (0-3.3')	4.7	-0.194	0.109	8.1E-11	3.74	0.012	3	22	1.4	30	0
				SILT & Fine SAND	70006 (10-12')	2.74	-0.091	0.065	5.6E-09	3.25	0.006	12	33			
				SILT & CLAY	70022 (13.2-16.5')	3.28	-0.146	0.028	2.3E-10	4.82	0.009	115	31			
		J-J'	3	Soft SILT	60056 (0.5-3.3')	4.15	-0.202	0.150	1.7E-10	3.79	0.013	7	21	1.3	30	0
				SILT & CLAY	60061 (13.2-16.5')	3.46	-0.178	0.091	4.80E-10	4.17	0.009	118	32			
4	3B (-2 to -3 ft)	I-I'	2	Organic SILT	70031 (0-3.3')	4.7	-0.194	0.109	8.1E-11	3.74	0.012	3	22	1.1	30	0
				SILT & Fine SAND	70006 (10-12')	2.74	-0.091	0.065	5.6E-09	3.25	0.006	12	33			
				SILT & CLAY	70022 (13.2-16.5')	3.28	-0.146	0.028	2.3E-10	4.82	0.009	115	31			
	5B (-0.5 to -2 ft)	I-I'	3	Organic SILT	70006 (2-4')	2.64	-0.194	0.943	6.9E-09	4.05	0.008	3	37	0.8	1	15
				SILT & Fine SAND	70006 (10-12')	2.74	-0.091	0.065	5.6E-09	3.25	0.006	12	33			
				Organic SILT	60016 (14-16')	3.66	-0.09	0.027	2.8E-09	3.98	0.008	115	28			

Notes:

The consolidation cases chosen for this evaluation were selected from Appendix E (Anchor QEA 2012) by choosing the input parameters, which resulted in more conservative (greater magnitude) estimates for Primary Consolidation. Figure 7 shows the Design Offsets used to evaluate the induced stress at each location.

1 Settlement evaluations used the input parameters as presented in Appendix E (Anchor QEA 2012).

2 Habitat modules are based on water depths.

3 Cross sections I-I' and J-J' are presented on Figures 4 and 5.

4 The evaluation cases referenced are consistent with those presented in Appendix E (Anchor QEA 2012).

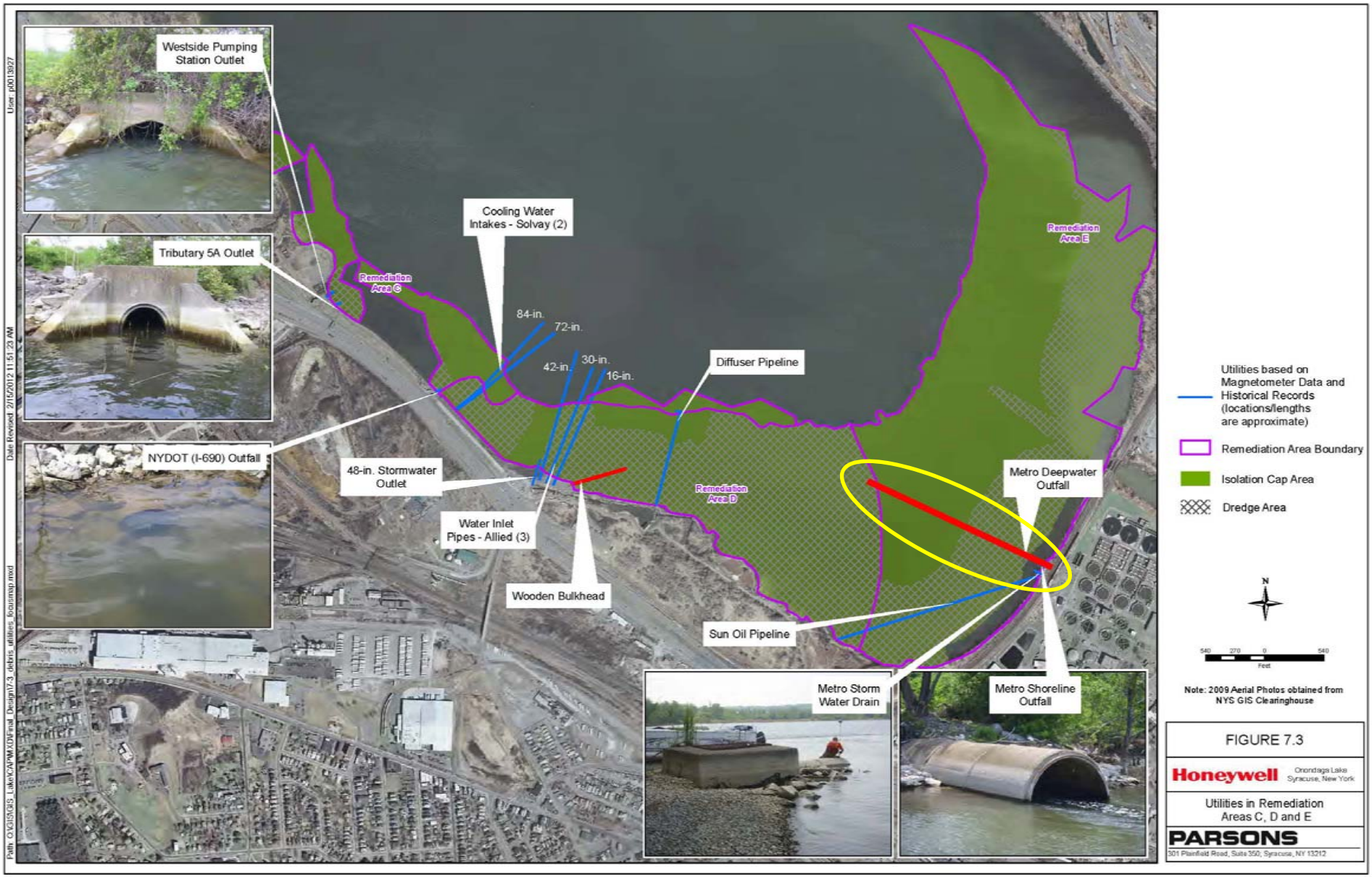
5 The input parameters are consistent with those presented in Appendix E (Anchor QEA 2012).

Table 2
Sensitivity Evaluation of Capping and Dredging Offsets

Settlement Evaluation[1]	Habitat Module[2] (Water Depth, feet)	Cross Section[3]	Consolidation Case[4]	Estimated Total Primary Consolidation (inches)					
				MERC Applied from 25 to 100 feet from Outfall			6-inch-thick MERC		
				6-inch-thick MERC	9-inch-thick MERC	12-inch-thick MERC	MERC applied from 25 to 100 feet	MERC applied from 25 to 75 feet	MERC applied from 25 to 50 feet
1	Module 1 (-20 to -30 ft)	I-I'	2	**1.6**	2.0	2.3	**1.6**	3.0	2.1
		J-J'	1	**2.0**	2.5	3.0	**2.0**	2.5	3.5
2	Module 2 (-7 to -20 ft)	I-I'	2	**1.7**	2.0	2.4	**1.7**	2.1	3.1
		J-J'	1	**2.0**	2.6	3.1	**2.0**	2.5	3.5
3	Module 3B (-3 to -7 ft)	I-I'	2	**1.4**	1.8	2.2	**1.4**	1.7	2.3
		J-J'	3	**1.3**	1.6	2.5	**1.3**	1.9	2.6
4	3B (-2 to -3 ft)	I-I'	2	**1.1**	N/A[5]	N/A[5]	**1.1**	N/A[5]	N/A[5]
	5B (-0.5 to -2 ft)	I-I'	3	**0.8**	N/A[5]	N/A[5]	**0.8**	N/A[5]	N/A[5]

Notes:
MERC - Modified Erosion Resistant Cap
Bold values - estimated primary settlement for the selected design offsets
Shading - a value greater than the tolerable differential settlement (greater than 2 inches)
This table presents sensitivity evaluations and resulting settlement estimates for a range of MERC thicknesses and horizontal offsets for dredging and capping.
1 Settlement evaluations used the input parameters as presented in Appendix E (Anchor QEA 2012).
2 Habitat modules are based on water depths.
3 Cross sections I-I' and J-J' are presented on Figures 4 and 5.
4 The evaluation cases referenced are consistent with those presented in Appendix E (Anchor QEA 2012).
5 The MERC is not placed in this portion of the Dredge and Cap area. The effects of modifying the MERC in other areas of the outfall will have negligible effects on induced stress and consolidationation estimates in this area.

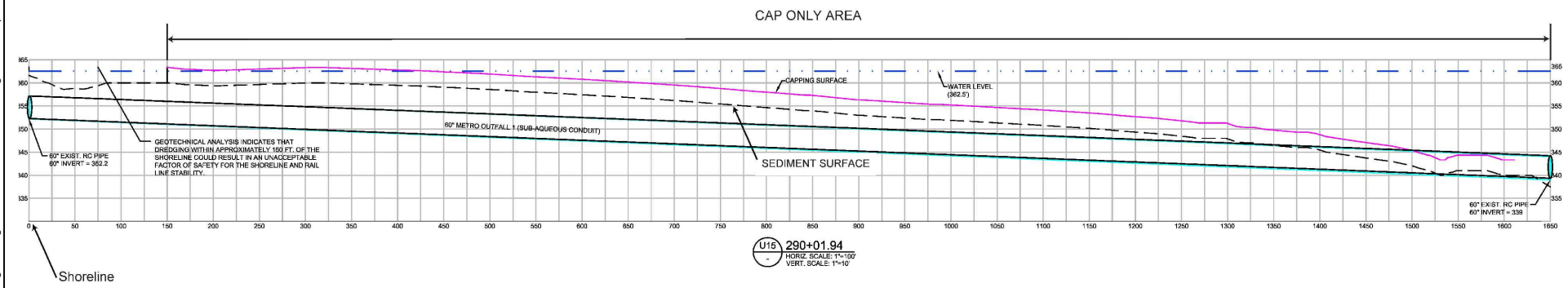
FIGURES



SOURCE: Onondaga Lake Capping, Dredging, Habitat, and Profundal Zone Final Design (Parsons and Anchor QEA 2012)

Figure 1
Vicinity Map
Metro Deepwater Outfall Settlement Evaluation
Onondaga Lake

ANCHOR QEA



SOURCE: Onondaga Lake Capping, Dredging, Habitat, and Profundal Zone Final Design (Parsons and Anchor QEA 2012)

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Figure 2
Plan View Map of Remediation Area E
Metro Deepwater Outfall Settlement Evaluation
Onondaga Lake

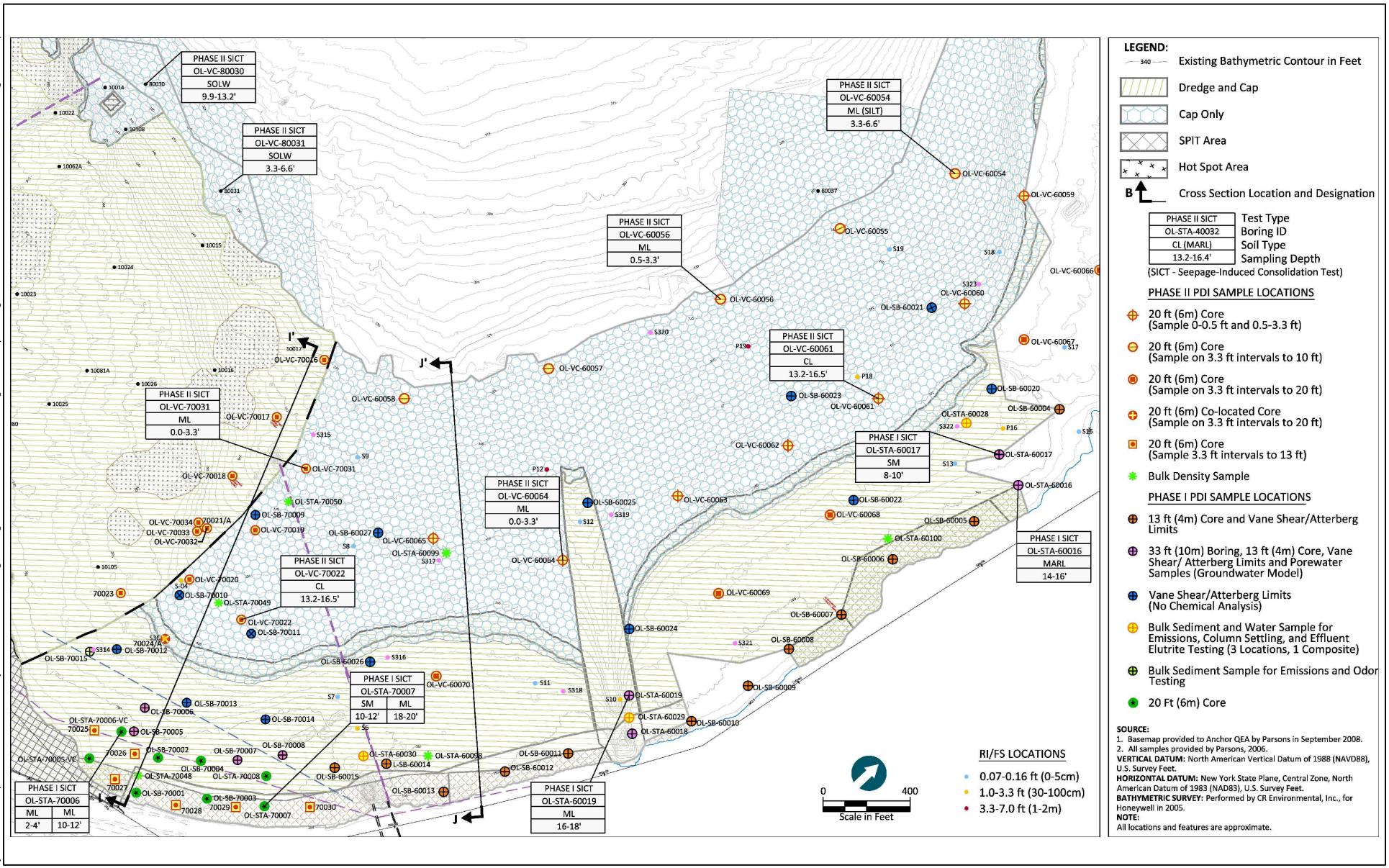

Figure 3
Plan View Map of Remediation Area E
Metro Deepwater Outfall Settlement Evaluation
Onondaga Lake

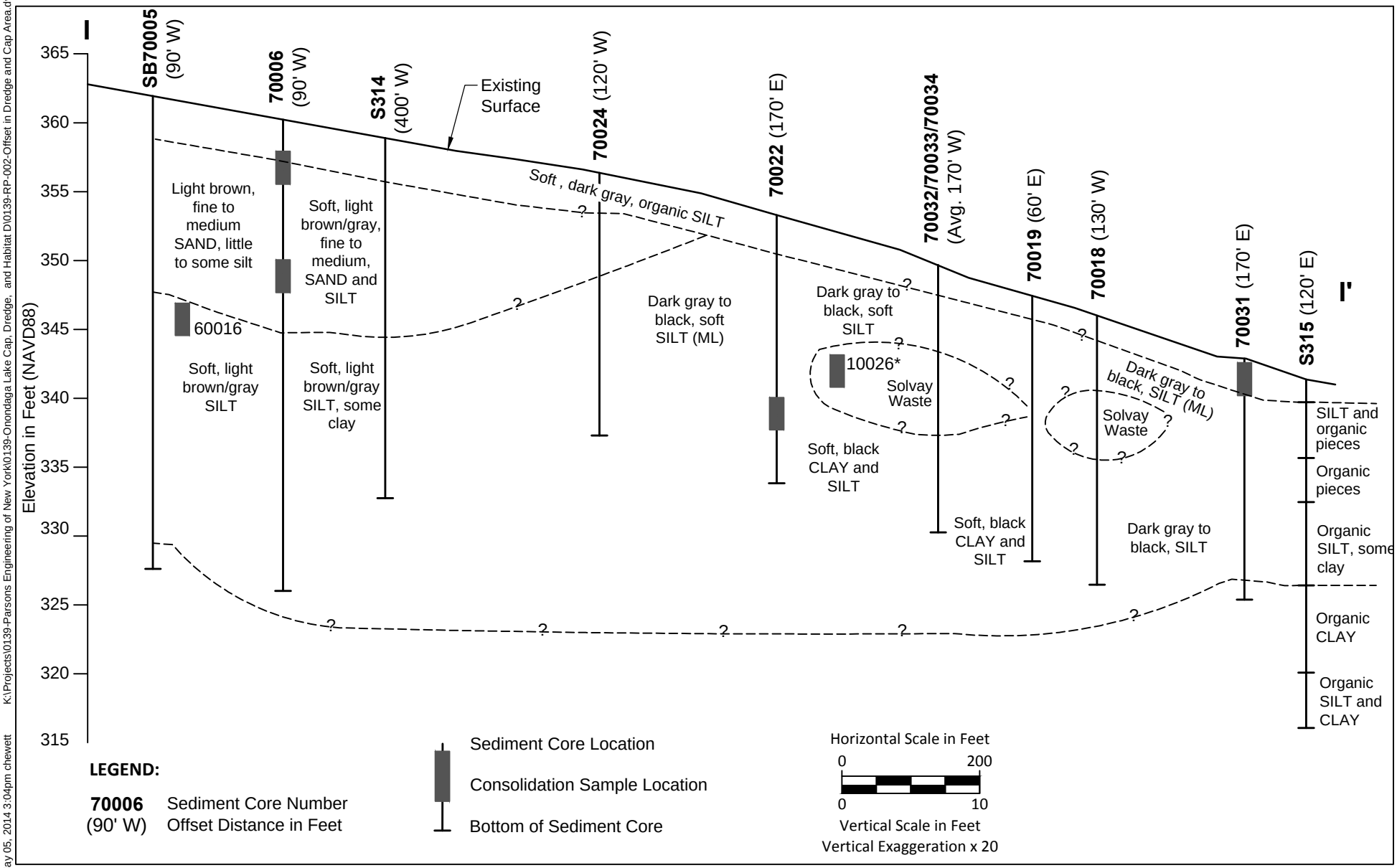

Figure 4
Typical Cross Section I-I' – Remediation Area E
Metro Deepwater Outfall Settlement Evaluation
Onondaga Lake

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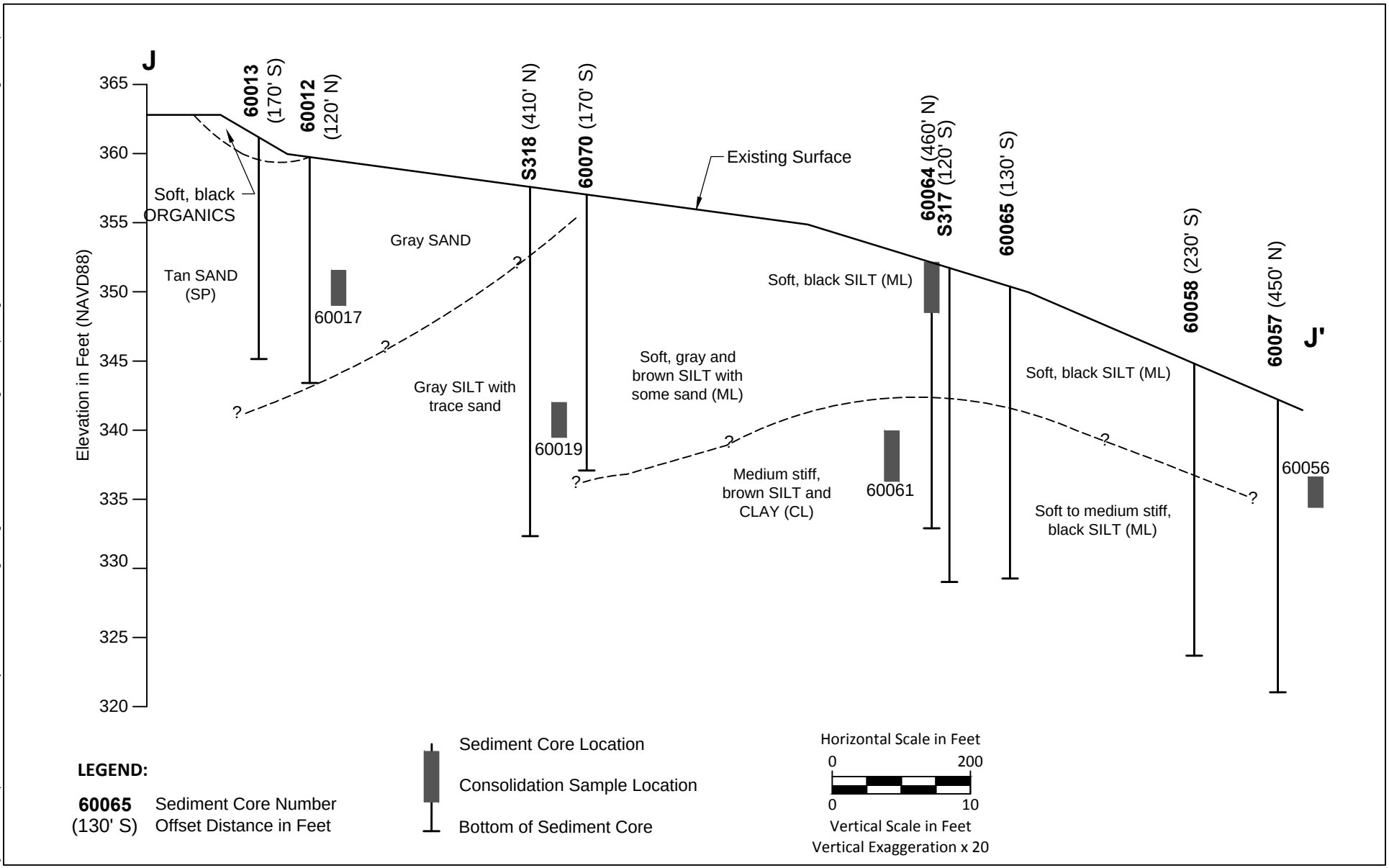

Figure 5
Typical Cross Section J-J' – Remediation Area E
Metro Deepwater Outfall Settlement Evaluation
Onondaga Lake

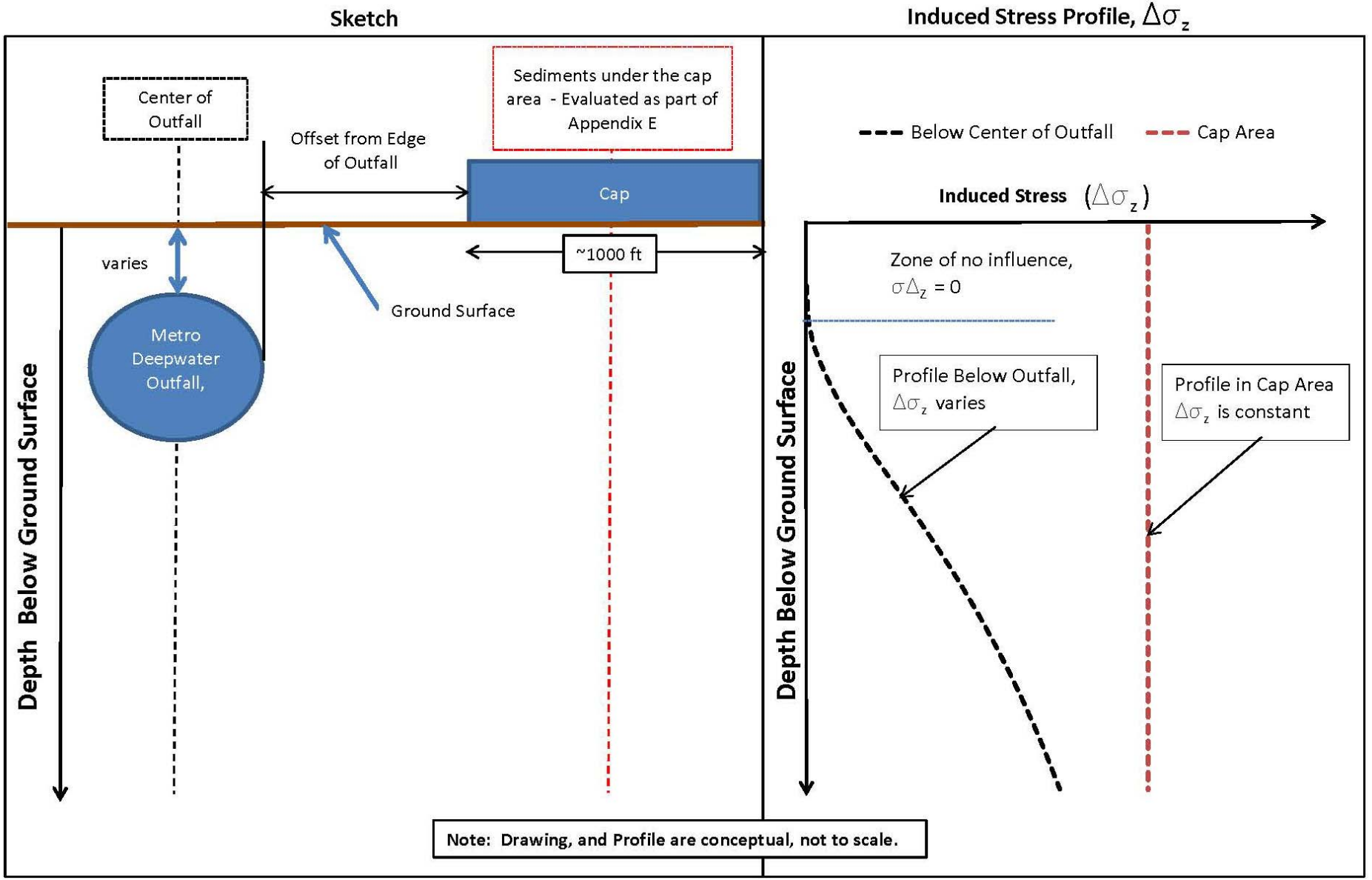

Figure 6
Induced Stress at Depth
Metro Deepwater Outfall Settlement Evaluation
Onondaga Lake

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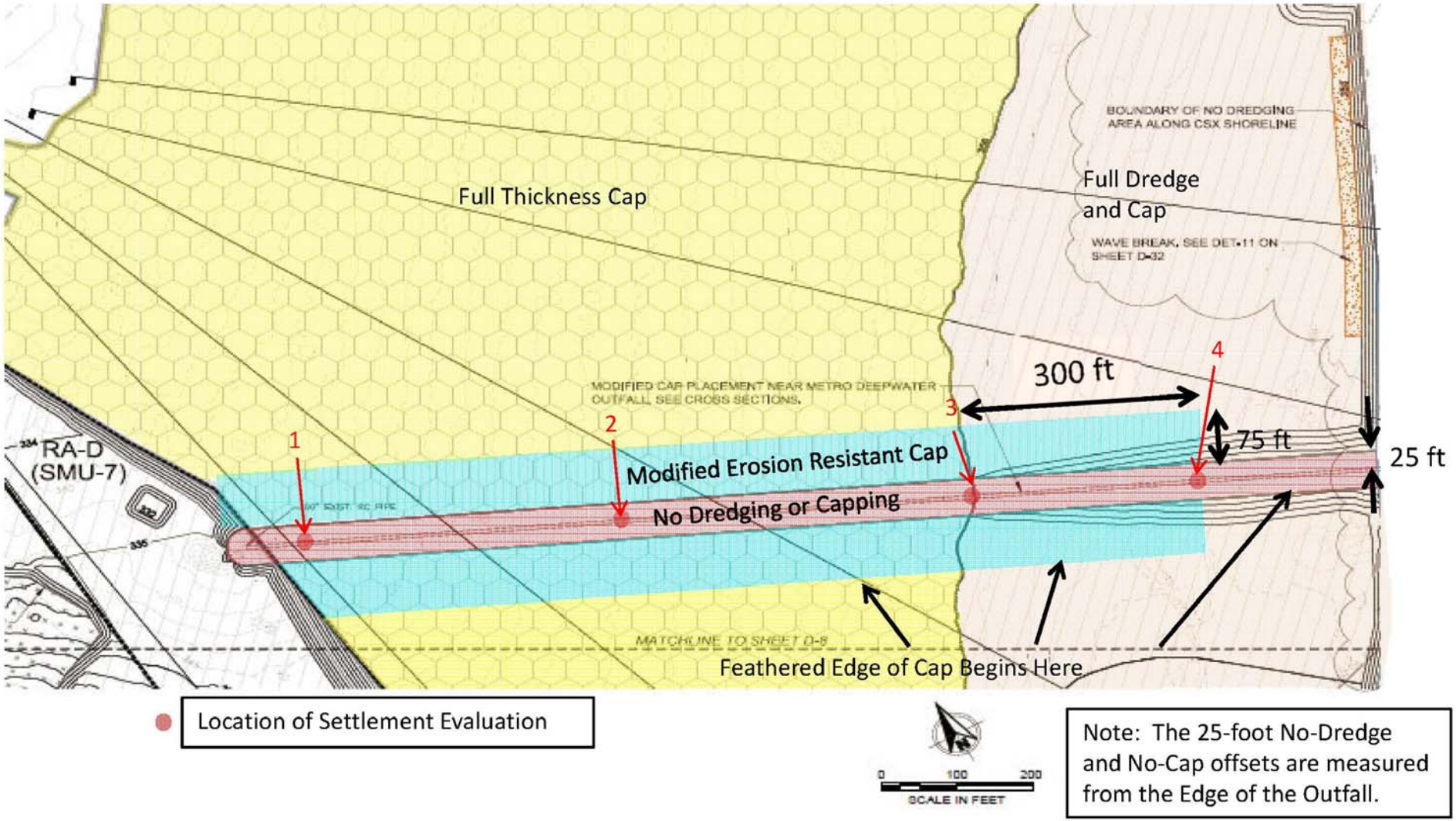

Figure 7
Plan View of Design Offsets
Metro Deepwater Outfall Settlement Evaluation
Onondaga Lake

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ATTACHMENT 2
MODIFIED EROSION RESISTANT CAP
CHEMICAL ISOLATION LAYER MODELING

ANCHOR QEA

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MEMORANDUM

To:	Ed Glaza, Parsons	**Date:**	August 28, 2014
From:	Deirdre Reidy and Kevin Russell, Anchor QEA	**Project:**	120139-01.03
Cc:	Paul LaRosa, Anchor QEA		
Re:	Isolation Cap Modeling in Area of Metro Pipeline		

Due to stability concerns in the vicinity of the Metropolitan Syracuse Wastewater Treatment Plant (Metro) outfall pipeline, a modified cap consisting of a single 6-inch-thick layer of sand amended with granular activated carbon (GAC) will be constructed in portions of Model Areas E1, E2, and E3. Chemical isolation cap modeling was conducted to assess the GAC application rates required for the modified cap in these areas. Consistent with the procedures followed for the final design (Parsons and Anchor QEA 2012), steady-state modeling was first performed for the modified cap thickness of 6 inches, with no GAC amendment. In this analysis, compliance with design standards (i.e., probable effects concentrations [PECs] and sediment screening concentrations [SSCs]) was assessed at the midpoint of the cap layer because the compliance points used in the final design are not applicable for this configuration (i.e., compliance was previously assessed at the bottom of the habitat layer, which does not exist in this case, or at the bottom of the bioturbation zone, which is now the sediment/cap interface). This compliance point is representative of the depth-averaged chemical concentrations to which benthic organisms may be exposed. Table 1 lists the chemicals that are predicted to exceed their respective PEC/SSC at steady state for the modified cap (the results from the final design are also included for comparison purposes).

Table 1
Steady-state Model Results for 6-inch Modified Cap in Portions of Remediation Area E Near the Metro Pipeline Compared with the Final Design Steady-state Model Results[1]

Chemical	Model Area E1		Model Area E2		Model Area E3	
	Final Design	6-inch Modified Cap	Final Design	6-inch Modified Cap	Final Design	6-inch Modified Cap
Benzene						
Toluene						
Ethylbenzene			Exceedance	Exceedance	Exceedance	Exceedance
Xylenes			Exceedance	Exceedance	Exceedance	Exceedance
Chlorobenzenes			Exceedance	Exceedance		Exceedance
Dichlorobenzenes		Exceedance	Exceedance	Exceedance		Exceedance
Trichlorobenzenes		Exceedance	Exceedance	Exceedance		Exceedance
Naphthalene		Exceedance	Exceedance	Exceedance	Exceedance	Exceedance
Phenol						
Mercury	Exceedance	Exceedance	Exceedance	Exceedance	Exceedance	Exceedance
Total PCB		Exceedance		Exceedance		Exceedance
Fluorene		Exceedance	Exceedance	Exceedance		Exceedance
Phenanthrene		Exceedance		Exceedance		Exceedance
Acenaphthene		Exceedance		Exceedance		Exceedance
Acenaphthylene				Exceedance		Exceedance
Anthracene		Exceedance		Exceedance		Exceedance
Pyrene		Exceedance		Exceedance		Exceedance
Benzo(a)anthracene		Exceedance		Exceedance		Exceedance
Benzo(b)fluoranthene		Exceedance		Exceedance		Exceedance
Benzo(k)fluoranthene		Exceedance		Exceedance		Exceedance
Chrysene		Exceedance		Exceedance		Exceedance

Table 1
Steady-state Model Results for 6-inch Modified Cap in Portions of Remediation Area E Near the Metro Pipeline Compared with the Final Design Steady-state Model Results[1]

Chemical	Model Area E1		Model Area E2		Model Area E3	
	Final Design	6-inch Modified Cap	Final Design	6-inch Modified Cap	Final Design	6-inch Modified Cap
Fluoranthene		Exceedance		Exceedance		Exceedance
Benzo(a)pyrene		Exceedance		Exceedance		Exceedance
Dibenz(a,h)anthracene		Exceedance		Exceedance		Exceedance
Indeno(1,2,3-cd)pyrene		Exceedance		Exceedance		Exceedance
Benzo(g,h,i)perylene		Exceedance		Exceedance		Exceedance

Note:
1 Steady-state modeling is based on simulating a sand-only cap with maximum porewater concentrations.

As expected, due to the reduced thickness, more chemicals were predicted to exceed the standards at steady state for the modified cap with no GAC amendment as compared to the final design steady-state results.

Again following the procedures used in the final design, the chemicals that did not meet the PEC/SSC at steady state were evaluated with the transient numerical model, including simulating amendment of the sand with GAC. All chemicals were simulated using the 95th percentile porewater concentrations, consistent with cap modeling completed as part of the final design. The compliance point for this modified cap (described above) is within the GAC-amended sand layer; therefore, it is not appropriate to assess compliance based on sorbed-phase concentrations because that would include contaminants adsorbed to the GAC. To avoid this, PEC-equivalent porewater values were developed based on chemical-specific partition coefficients and the habitat restoration layer total organic carbon (TOC) value of 4.6% used for these areas for the final design. Table 2 lists the PEC-equivalent porewater value for each chemical and model area in the case of mercury, given that partition coefficients for this chemical varied by area in the final design.

Table 2
PEC-equivalent Porewater Concentration

Chemical	PEC (µg/kg)	PEC-equivalent Porewater Concentration (µg/L)
Chlorobenzene	428	50.4
Dichlorobenzenes	239	12.0
Ethybenzene	176	9.92
Naphthalene	917	68.1
Xylene	561	36.3
Trichlorobenzene	347	6.78
PCB	295	0.005
Fluorene	264	0.383
Phenanthrene	543	0.423
Acenaphthene	861	0.883
Acenaphthylene	1301	3.28
Anthracene	207	0.161
Pyrene	344	0.036
Benzo(a)anthracene	192	0.010

Table 2
PEC-equivalent Porewater Concentration

Chemical	PEC (µg/kg)	PEC-equivalent Porewater Concentration (µg/L)
Benzo(b)fluoranthene	908	0.018
Benzo(k)fluoranthene	203	0.004
Chrysene	253	0.005
Fluoranthene	1436	0.203
Benzo(a)pyrene	146	0.003
Dibenz(a,h)anthracene	157	0.001
Indeno(1,2,3-cd)pyrene	183	0.004
Benzo(g,h,i)perylene	780	0.003
Mercury (Model Area E1)	2200	1.08
Mercury (Model Area E2)	2200	0.367
Mercury (Model Area E3)	2200	1.30

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The model-predicted porewater concentrations at the midpoint of the "active" layer of modified cap were compared to these PEC-equivalent porewater values to assess compliance in this evaluation. The transient numerical modeling was conducted starting with the minimal practical GAC application rate of 0.1 lb/sf and the application rate was increased as necessary to meet the porewater-equivalent PEC/SSC. The bioturbation zone and the "active layer" are separate in the numerical model; therefore, the model does not allow simulation of bioturbation within the GAC-amended layer. Bioturbation would tend to average the chemical concentrations over the 6-inch cap thickness, likely with relatively minor impacts on predicted concentrations at the modified cap's mid-thickness compliance point evaluated in this analysis. In addition, the numerical model requires a thickness to be specified for each model layer; thus, in order to configure the model to only simulate the chemical isolation layer, a nominally small thickness (1 cm) was specified for each of the other layers—the bioturbation zone, habitat restoration layer, and foundation layer. The properties of these other layers (i.e., TOC) were specified so that sorption would be negligible; therefore, the model layer configuration was specified so that the 6-inch, GAC-amended layer was the only sorptive layer in the model, and bioturbation was not accounted for in this layer. The results of the GAC application rates developed based on this numerical modeling are shown in Table 3.

Table 3
Transient Numerical Model Results

Model Area	Final Design GAC Application Rate (lb/sf)	GAC Application Rate (lb/sf)	Driving Chemical
E1	0	0.1	--
E2	0.27	0.7	Dichlorobenzenes
E3	0.008	0.3	Naphthalene

Notes:
1 Compliance point is at a depth of 9.62 cm, which is the midpoint of the active layer (accounts for the nominal thickness of the habitat restoration layer and bioturbation zone [2 cm] and half the active layer thickness [7.62 cm]).
2 '--' indicates all chemicals met the porewater-equivalent PEC/SSC at the minimum GAC application rate evaluated (i.e., iterative modeling to determine design GAC application rate, through which the driving chemical is identified, was not performed).

REFERENCES

Parsons and Anchor QEA (Anchor QEA, LLC), 2012. *Onondaga Lake Capping, Dredging, Habitat and Profundal Zone (SMU 8) Final Design. Appendix B – Cap Modeling.* Prepared for Honeywell. March 2012.