Final Second Five-Year Review Report for the Hudson River PCBs Superfund Site

APPENDIX 7

CAPPING EVALUATION

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Louis Berger US, Inc.

April 2019

FINAL SECOND FIVE-YEAR REVIEW REPORT FOR THE HUDSON RIVER PCBs SUPERFUND SITE

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1 BACKGROUND

This appendix summarizes the findings of bathymetric surveys and related investigations required by the Consent Decree to evaluate the stability and effectiveness of sub-aqueous caps constructed in the Upper Hudson River. The sub-aqueous caps were constructed by the General Electric Company (GE) to isolate residual sediment polychlorinated biphenyl (PCB) contamination following dredging in specific certification units (CUs).

The Statement of Work (SOW) included in the 2006 Consent Decree, and updated in 2010 for Phase 2, requires GE to develop an Operations, Maintenance and Monitoring (OM&M) Plan for both Phase 1 and Phase 2 dredging activities (United States vs. General Electric, 2006). The SOW lays out specific objectives for monitoring and maintenance of installed subaqueous caps, including:

1. Determine whether the physical integrity of individual cap layers/components has been maintained;
2. Determine whether the chemical isolation effectiveness of the cap component for chemical isolation has been maintained; and
3. Determine whether there is a need for additional protective measures and institutional controls (*e.g.*, additional controls for caps in the navigation channel, notifications to boaters regarding actions in capped areas, etc.).

The monitoring activities designed to address these objectives are to be carried out at specified intervals (described in detail in Section 2 below) for 30 years with respect to the Phase 1 caps, or in perpetuity for Phase 2 caps (for Phase 2 caps, chemical isolation layer monitoring may be terminated after 30 years, or the United States Environmental Protection Agency's (EPA's) direction). The first OM&M Plan was released in 2011, and covered monitoring activities for caps installed in the 2009 construction season, *i.e.*, areas dredged during Phase 1 (General Electric 2011k). Subsequent OM&M Plans were submitted following each year of Phase 2 dredging, and similarly described plans for activities related to stabilization of caps and shorelines.

This appendix serves as an overview of cap monitoring information presented in the various OM&M documents submitted to EPA between 2011 and 2015. Complete details regarding OM&M activities, including shoreline stabilization activities not covered in this appendix, can be found in the Phase 1 and Phase 2 OM&M documents (General Electric 2011k, 2012g, 2013n; 2014f; 2015g; 2016g; EPA, 2005, 2010g).

2 OVERVIEW OF CAP CONSTRUCTION AND MONITORING

In accordance with the SOW and based upon EPA approval, caps with various component layers and thicknesses were installed during Phase 1 and Phase 2 remediation. Details regarding the various cap types can be found in the Phase 2 Year 1 OM&M report (General Electric 2012g). Cap design and configuration were based on river flow velocity and degree of residual contamination within a specific CU. For example, Type A Isolation Caps, placed over areas with lower residual PCB concentrations (greater than 1 milligram per kilogram (mg/kg) but less than or equal to 6 mg/kg average Tri+ surface PCBs[1]), were designed to withstand a 10-year recurrence interval flow event [*e.g.*, 34,500 cubic feet per second (cfs) at Fort Edward]. Type B Isolation Caps, placed over areas with higher residual PCB concentrations (greater than 6 mg/kg average Tri+ surface PCBs), were designed to withstand a 100-year recurrence interval flow event (*e.g.*, 47,300 cfs at Fort Edward).

To confirm the proper placement of the cap components, construction Quality Control (QC) activities were performed. Representative samples of cap materials were collected throughout cap placement operations and tested for physical and chemical characteristics consistent with the design specifications. In addition, post-placement bathymetric surveys were performed to document the top elevation of caps to confirm that the thickness and horizontal extent of the placed cap materials met the design requirements. Further, the surveyed, as-built conditions of each cap were reviewed and approved by EPA as part of the process for CU Backfill/Engineered Cap Completion Approval.

As required by the SOW, including the OM&M Scope (Attachment E to the SOW), the OM&M cap stability monitoring program consists of the following activities:

[1] Tri + PCBs represents the sum of all measured PCB congeners with three or more chlorine atoms per molecule. PCBs are a group of chemicals consisting of 209 individual compounds known as congeners. The congeners can have from one to ten chlorine atoms per molecule, each with its own set of chemical properties.

- A baseline bathymetric survey conducted just after placement of the cap (post-placement survey), followed by another bathymetric survey in the subsequent year (Year 1 survey).
- Tier 1 bathymetric surveys conducted 5 and 10 years after initial cap placement, and then at intervals of 10 years in perpetuity (30 years for caps installed in Phase 1). Tier 1 bathymetric surveys are intended to determine if the caps have remained in place over time (compared to the documented baseline conditions). Specifically, these surveys are intended to evaluate whether there has been a measurable loss of cap material.
    - Measurable Loss is defined as a loss of more than 3 inches of cap thickness over a contiguous 4,000 square foot (sf) area or a contiguous area representing over 20 percent of the cap area, whichever is less, considering the accuracy of the measurement technique and the nature of the cap surface.
    - If a Measurable Loss of cap material is observed during the Tier 1 bathymetric surveys, follow-up visual (and, as necessary, physical) investigations are to be conducted to confirm whether there has been a Significant Loss of cap material. In accordance with the SOW, a Significant Loss of cap material is defined by the same criterion as a Measurable Loss; however, the additional lines of evidence serve to confirm the observed loss. If the investigations confirm a Significant Loss, affected areas of the cap will be repaired, as necessary.
- 'High-flow' bathymetric surveys to be conducted as soon as possible following a 100-year flood event.
- Chemical Isolation monitoring to be conducted at selected 'sentinel areas,' as described in Section 5.2 of this appendix.

3 SURVEY DATA AND METHODS

Multi-beam hydrographic surveys are the preferred method of surveying capped areas, although in shallow areas single-beam bathymetric and/or topographic land survey techniques were permitted as necessary to supplement the multi-beam bathymetric survey data. The surveys completed to date consist of the following:

- Baseline post-placement surveys were conducted immediately after each cap was constructed to check that it met design specifications.
- Year 1 surveys were conducted during the year following cap placement for all capped areas.
    - The Year 1 survey for areas capped during Phase 1 dredging was conducted in 2010.
    - Year 1 surveys for areas capped during Phase 2 dredging activities were conducted in 2012, 2013, 2014, 2015, and 2016. Table A7-1 provides information on the OM&M cap stability surveys carried out during Phase 2 dredging.
- High Flow survey - a High Flow survey of Phase 1 caps installed in 2009 was performed in June 2011, following a 100-year flood event that occurred in April 2011.
- Tier 1 surveys - two 5-year recurrence Tier 1 surveys were completed to-date: in 2014, the 5-year Tier 1 survey was carried out in the areas dredged as part of Phase 1 (2009), and in 2016, the 5-year Tier 1 Survey was carried out for areas dredged during Phase 2 Year 1 (2011).
- In 2014, an additional survey was conducted for caps in CU-14 and CU-15, which were repaired due to damage caused by a boat anchor and a tug boat sinking on top of a cap.

While the Year 1 surveys provided a basis to evaluate short-term cap stability, the two 5-year Tier 1 surveys conducted in 2014 and 2016 provide a basis for evaluation of longer-term cap stability. In addition, Hurricane Irene passed through New England in August 2011. As the Phase 1 caps were installed in 2009 and resurveyed in 2014, a comparison of

the Phase 1 baseline and Tier 1 surveys provides insight into how well the Phase 1 caps withstood 100-year flood conditions (April 2011) and a second significant precipitation event (August 2011).

4 RESULTS AND DISCUSSION

4.1 Short-term Cap Stability (Comparison of Baseline and Year 1 Surveys)

As described above, a Year 1 survey was performed to determine whether any Measurable Loss occurred during the year following the placement of cap material. EPA analyzed bathymetric survey maps produced by GE for each of the Year 1 surveys conducted, and did not identify any capped areas that underwent Measurable Loss as defined in Section 2 of this appendix. EPA's analysis indicates that during the first year following cap placement, cap material remained stable as defined in the OM&M documents, and confirmed GE's results that no Measurable Loss occurred during the first year following placement of the cap.

4.2 Cap Stability under High Flow Conditions (April 2011 100-year Flood)

As per the OM&M documents, a Tier 1 survey of installed caps is to be conducted as soon as practical following a 100-year flood event. In April 2011, a 100-year flood event occurred, with mean daily discharge reaching a maximum of 47,100 cfs on April 29, 2011. In response to this event, a Tier 1 high flow survey of Phase 1 caps installed in 2009 was performed in June 2011.

The 2011 Tier 1 high flow survey data were compared with the 2009 post-placement survey data to determine whether any Measurable Loss of cap material had occurred (Table A7-2a and Figures A7-1a-i). Results of the bathymetric comparison indicate that the 100-year flood produced depositional conditions in the areas of the river that were capped in Phase 1, and no Measurable Loss was identified. Our analysis confirmed GE's results that no measurable loss occurred during the 100-year flood. For engineered caps in CU-1 through CU-8 and CU-18, the percentage of total capped area that experienced deposition between 2009 and 2011 ranged between 85 and 100 percent. Similarly, the volume of sediment deposited on caps between 2009 and 2011 was substantially greater than the volume of sediment eroded during this time period.

To further gauge the impact of the 2011 high flow event, the net amount of sediment accumulation (*i.e.*, the volume of sediment deposited on caps minus the volume of sediment eroded from caps) was calculated for Phase 1 capped areas over three distinct periods:

i. Between the 2009 post-placement and the 2010 Year 1 surveys,
ii. Between the 2010 Year 1 survey and the 2011 High Flow survey, and
iii. Between the 2011 High Flow survey and the 2014 5-year Tier 1 survey (Table A7-2b).

This calculation provides a means of comparing the amount of sediment deposited (or eroded) between survey years. The results indicate that between 2009 and 2010, all CUs were net depositional. Between 2010 and 2011 (the interval that included the April 2011 100-year flood), all capped areas continued to be net depositional, although the volume deposited was lower than that deposited between 2009 and 2010 (with the exception of CU-5 and CU-8 (the erosion within CU-5 capped area equates to an average depth of erosion of 0.2 inches over its entire area, while the erosion within CU-8 capped areas equates to an average depth of erosion of 0.7 inches over its entire area). This comparison indicates that the 100-year flood did produce substantially higher rates of deposition (compared to the 2009-2010 interval), with the possible exception of CU-1, which gained the largest amount of sediment (net sediment deposition of 15,800 cubic yards; equates to an average depth of deposition of 36 inches over the area of CU-1). It should be noted that access dredging in portions of CU-1 in 2015 removed some of the sediment overburden that had accumulated onto of the CU-1 caps since placement in 2009.

While the 2010 and 2011 bathymetric surveys only provide “snapshots in time” of Phase 1 cap bathymetry, there was only an approximately two-month time lag between the April 2011 100-year flood event and the 2011 high flow bathymetric survey. As such, it is unlikely that any areas of measurable loss were created in Phase 1 cap areas due to the 100-year flood that could have subsequently been refilled with sediment prior to the June 2011 bathymetric survey. In fact, sediment deposited on the Phase 1 caps between 2009 and

2010, as indicated in Table A7-b2, protected the actual cap material during the 100-year flood.

Between 2011 and 2014, the majority of the capped areas continued to be depositional, with net accumulation rates generally comparable to the 2009-2010 and 2010-2011 time periods. The CU-7 and CU-8 capped areas exhibited some net erosion (570 and 100 cubic yards for CU-7 and CU-8, respectively). This equates to an average depth of erosion of 2.5 and 0.3 inches over the areas of CU-7 and CU-8, respectively. These two CUs are adjacent to bridge footings, which may alter water flow velocity, resulting in localized scour.

Given the volume of sediment deposited between the 2009 and 2011 Phase 1 cap surveys, the bathymetric survey comparison results indicate that the Phase 1 capped areas were nearly all net depositional, and that the caps withstood the 100-year flood condition in April of 2011 without Measurable Loss.

4.3 Longer-term Cap Stability (Comparison of Baseline and Tier 1 Surveys)

While the bathymetric data for the 2016 Tier 1 survey have not been finalized by GE, the 2014 Phase 1 5-year Tier 1 bathymetric survey results were available for evaluation. As noted above, comparison of the 2014 Tier 1 bathymetry and the 2009 post-placement bathymetry for Phase 1 capped areas provides the longest time period over which to assess the stability of the caps. A comparison of the 2009 baseline elevations and the 2014 Tier 1 elevations indicated that the Phase 1 area caps have remained intact and have been net depositional in nature (Table A7-3 and Figures A7-2a-i). Bathymetric change analysis in the Phase 1 capped areas indicates recent deposition of sediment occurred on the cap surfaces, and confirmed that the Phase 1 capped areas have not experienced Measurable Loss of cap material as defined in the OM&M documents.

5 CONCLUSIONS AND ONGOING MONITORING

Comparison of bathymetric surveys conducted post-placement of the cap material and one year after placement indicate that the caps remained stable over this time period. A Tier 1 High Flow bathymetric survey was conducted in 2011 shortly after a 100-year flood event that occurred in April 2011. A comparison of the Phase 1 2010 Year 1 survey and the 2011 High Flow survey indicated that the caps remained intact and capped areas were predominately depositional areas, with the exception of slight erosion in CU-5 and CU-8. The occurrence of the 2011 100-year flood just prior to Phase 2 dredging activities provided an early "stress test" of cap stability and the ability of the caps to withstand a 100-year flood event. Based on EPA's analysis (which confirms GE's previous results), the caps withstood the 100-year flood with minimal erosion, and importantly, no measurable loss of cap material. Further, data indicating natural deposition of sediment on top of cap materials provides further confidence in cap stability moving forward. However, the OM&M program was specifically designed to detect erosion of cap material, and there are robust provisions in place for cap integrity investigations (as described in Section 5.1) in the event that a cap does experience measurable loss of material, including the use of submersible cameras and divers to investigate any detected measurable loss, and the requirement that GE maintain and repair, as needed, the Phase 1 caps for 30 years and the Phase 2 caps in perpetuity.

For Phase 1 cap material that was surveyed as part of the 2014 5-year Tier 1 survey, analysis of bathymetric change indicated that the capped areas were net depositional between 2009 and 2014. Future 5-year Tier 1 surveys will be conducted in 2017, 2018, 2019, and 2020, and will provide further data on the stability of caps in River Section 2 and River Section 3. Moving forward, if any future Tier 1 survey detects measurable loss, regardless of the mechanism of cap disturbance (*e.g.*, high flow events, disturbance of material by boat prop wash, etc.), GE is responsible for maintaining the integrity and stability of the caps in perpetuity (30 years for Phase 1 caps). In addition to the Tier 1 bathymetric surveys, GE is required to monitor the ability of the caps to chemically isolate

the capped sediment from the overlying sediment and water column (as described in Section 5.2). Ongoing monitoring efforts are summarized in the sections that follow.

5.1 Tier 1 and Tier 2 Bathymetric Surveys

Tier 1 bathymetric surveys of the dredged areas will be carried out at intervals of 5 and 10 years after cap placement, then every 10 years in perpetuity, or as otherwise agreed to with EPA. Phase 2 Years 2, 3, 4 and 5 will have their first Tier 1 surveys conducted in 2017, 2018, 2019, and 2020, respectively. Due to safety concerns, CU-60, which was dredged in 2015 (Phase 2 Year 5), will have a Tier 1 survey conducted on a portion of the cap and the remainder of the capped area initially will be visually surveyed from shore for signs of erosion. In the event that a flood event with a magnitude at or exceeding that of a 100-year flood event occurs during the monitoring period in the immediate vicinity of the capped area, the OM&M plan requires that potentially affected caps also be inspected through a bathymetric survey as soon as is practical after that event.

As described in Section 2.0, quantitative guidance was provided to assess the potential of measurable loss of cap material. If measurable loss is documented via bathymetric survey, Tier 2 monitoring will commence in those locations. Tier 2 monitoring will initially consist of a visual investigation to confirm the condition of the cap. The visual investigation, as described in the OM&M documents, may consist of a survey using an underwater camera, a survey using side-scan sonar, or a visual investigation conducted on-site by a diver. The goal of the visual investigation will be to determine the condition of the cap and to further confirm whether Significant Loss has occurred. Visual observations of the size and type of surface materials present and notes regarding any visual signs of cap material disturbance or loss at the location will be made. The size and type of surface materials present will be qualitatively compared with the size and type of materials present at adjacent cap locations where a Measurable Loss has not been identified, and any differences shall be noted. If the visual investigation confirms Significant Loss of the cap armor material, then a physical investigation will be conducted consisting of the collection of cores from the isolation layer for visual evaluation of any potential loss in isolation layer thickness. The information

obtained from the isolation layer cores will also be used to help determine the type of repair needed.

If the Tier 2 monitoring investigations confirm that there is in fact a Significant Loss, those sections of the cap exhibiting the loss will be repaired as set forth in the OM&M documents. In any areas of Significant Loss, if the thickness of cap materials exceeds the design prism thickness, such excess material thickness will be considered in the determining the need for and the extent and timing of repairs. If a Significant Loss of a particular cap type is identified in any monitoring event, all caps of the same (or lesser) type that were installed in a similar physical setting, but not monitored in that event, will be reviewed to determine if there is more widespread damage.

5.2 Chemical Isolation Layer Monitoring

The effectiveness of the Phase 2 caps with respect to chemical isolation will be evaluated via a limited coring program in selected areas referred to as "sentinel areas." The sentinel areas will be chosen from areas with a higher concentration range of PCBs underlying the cap, as well as areas that exhibit critical conditions that may exist in certain reaches of the river (*e.g.*, high groundwater upwelling rates). EPA will select up to six sentinel areas for chemical isolation monitoring and provide GE with the boundaries of the capped areas selected as part of the development of the final OM&M plan. The monitoring program will generate data to verify the basic design assumptions for the caps with regard to prevention of contaminant migration upward and through the cap.

Chemical isolation monitoring will be carried out by GE. The initial chemical isolation monitoring effort will occur in the 10th year following construction of the first sentinel cap area among those selected for monitoring, or as soon as practical after a 100-year flood event, whichever is earlier. Monitoring of all sentinel cap areas will be conducted in the same year. Subsequent efforts will be conducted at 10-year intervals or as soon as practical after a 100-year flood event, whichever is earlier, and this chemical isolation layer monitoring may be terminated after 30 years, or at EPA's discretion, at a time when the monitoring results are determined by EPA to confirm design predictions.

Each monitoring effort will consist of the collection of a minimum of 20 cores per sentinel area. Cores will be advanced through the cap and a minimum of 2 feet into the underlying sediments, to native clay, or bedrock, whichever is reached first. Cores will be segmented for analysis based on visual inspection. A minimum of two core segments will be collected for analysis from within the chemical isolation layer of the cap, one in the upper 3 inches of the isolation layer and one from 3 inches to 6 inches above the bottom of the chemical isolation layer. These core segments, plus one from the upper portion of the underlying sediments, will be analyzed for PCBs. Results of the analysis will be compared to baseline information collected at the completion of cap construction. The results will be reported to EPA within 15 days of sample collection.

Before collecting cores at each sentinel area, GE will review record drawings for that sentinel area and will conduct a visual investigation of the area to be cored. Based on this review and other information, GE will develop coring methods for each sentinel area on a case-by-case basis and will review the coring methods to be used with EPA before conducting the coring.

6 REFERENCES

EPA. 2005. Attachment E to Statement of Work, Operations, Maintenance and Monitoring Scope, September 2005.

_____. 2010g. Attachment E to Statement of Work, Operations, Maintenance and Monitoring Scope for Phase 2 of the Remedial Action, December 2010.

General Electric. 2011k. Hudson River PCBs Site Operation, Maintenance, and Monitoring Plan for Phase 1 Caps and Habitat Replacement/Reconstruction. Prepared by Parsons Corp for General Electric Company, Revised. September 2011.

_____. 2012g. Hudson River PCBs Site Operation, Maintenance, and Monitoring Plan for Phase 2 Year 1 Caps and Habitat Replacement/Reconstruction. Prepared for General Electric Company by Parsons Corp. April 2012.

_____. 2013n. Hudson River PCBs Site Operation, Maintenance, and Monitoring Plan for 2012 Caps and Habitat Replacement/Reconstruction. Prepared for General Electric Company by Anchor QEA and Parsons Corp. August 2013.

_____. 2014f. Hudson River PCBs Site Operation, Maintenance, and Monitoring Plan for 2013 Caps and Habitat Replacement/Reconstruction. Prepared for General Electric Company by Anchor QEA and Parsons Corp. March 2014.

_____. 2015g. Hudson River PCBs Site Operation, Maintenance, and Monitoring Plan for 2014 Caps and Habitat Replacement/Reconstruction, Prepared for General Electric Company by Anchor QEA and Parsons Corp. September 2015.

_____. 2016g. Hudson River PCBs Site Operation, Maintenance, and Monitoring Plan for 2015 Caps and Habitat Replacement/Reconstruction. Prepared for General Electric Company by Anchor QEA and Parsons Corp. 2016.

United States v. General Electric Company, Consent Decree Civ. No. 05-cv-1270 (N.D.N.Y. November 2, 2006).

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APPENDIX 7

CAPPING EVALUATION

Tables and Figures

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April 2019

Table A7-1. OM&M cap stability surveys conducted during Phase 1 and Phase 2 dredging years

Dredging Activity	Year Dredged	Post-placement Survey	Year 1 Survey	5-year Tier 1 Survey	10-year Tier 1 Survey	Additional Tier 1 Surveys
Phase 1	2009	**2009**	**2010**	**2014**	2024	Every 10 years until 30 years after installation.
Phase 2 Year 1	2011	**2011**	**2012**	**2016**	2026	Every 10 years in perpetuity.
Phase 2 Year 2	2012	**2012**	**2013**	2017	2027	
Phase 2 Year 3	2013	**2013**	**2014**	2018	2028	
Phase 2 Year 4	2014	**2014**	**2015**	2019	2029	
Phase 2 Year 5	2015	**2015**	**2016**	2020	2030	

Note: Bold indicates that the survey has been conducted.

Table A7-2a. Phase 1 cap stability surveys conducted following the April 2011 100-year flood event (2009 post-placement survey vs. 2011 High Flow Tier-1 Survey)

Certification Unit	Area Capped (acres)	Total area Capped with >3" of deposition between 2009 and 2011 surveys (%)	Total area capped with >3" of erosion between 2009 and 2011 surveys (%)	Total area capped with >3" of erosion between 2009 and 2011 surveys (ft^2)	Largest Contiguous Area Capped with >3" of erosion between 2009 and 2011 surveys (ft^2)	Volume of Deposited Sediment between 2009 and 2011 surveys (cy)	Volume of Eroded Sediment between 2009 and 2011 surveys (cy)
CU-1	3.31	64	<1	483	141	16294	10
CU-2	3.43	70	1	1642	176	4770	30
CU-3	1.22	83	<1	57	9	3340	1
CU-4	3.55	51	1	1734	529	5715	24
CU-5	0.70	99	<1	5	3	4210	0
CU-6	1.33	72	1	781	88	1384	12
CU-7	0.94	87	<1	152	42	3770	2
CU-8	1.47	79	1	413	58	4431	6
CU-18	1.11	20	1	416	49	254	10

[1]: The net volume of sediment is calculated by differencing the volume of gross deposition greater than 3 inches and the volume of gross erosion greater than 3 inches that occurred between the respective years indicated.

[3]: Negative numbers indicate net erosion of sediments between survey years.

Table A7-2b. Phase 1 cap net deposition rates between 2009 and 2014

Certification Unit	Area Capped (acres)	Net volume of sediment deposited between 2009 and 2010 surveys (cy)[1]	Net volume of sediment deposited between 2010 and 2011 (cy)[1,3]	Net volume of sediment deposited between 2011 and 2014 (cy)[1,3]
CU-1	3.31	681	15825	3393
CU-2	3.43	2458	2027	2958
CU-3	1.22	2568	730	1671
CU-4	3.55	4503	1211	4247
CU-5	0.70	4209	-19	140
CU-6	1.33	831	469	96
CU-7	0.94	3600	124	-475
CU-8	1.47	4641	-141	-40
CU-18	1.11	168	12	371

[1]: The net volume of sediment is calculated by differencing the volume of gross deposition greater than 3 inches and the volume of gross erosion greater than 3 inches that occurred between the respective years indicated.

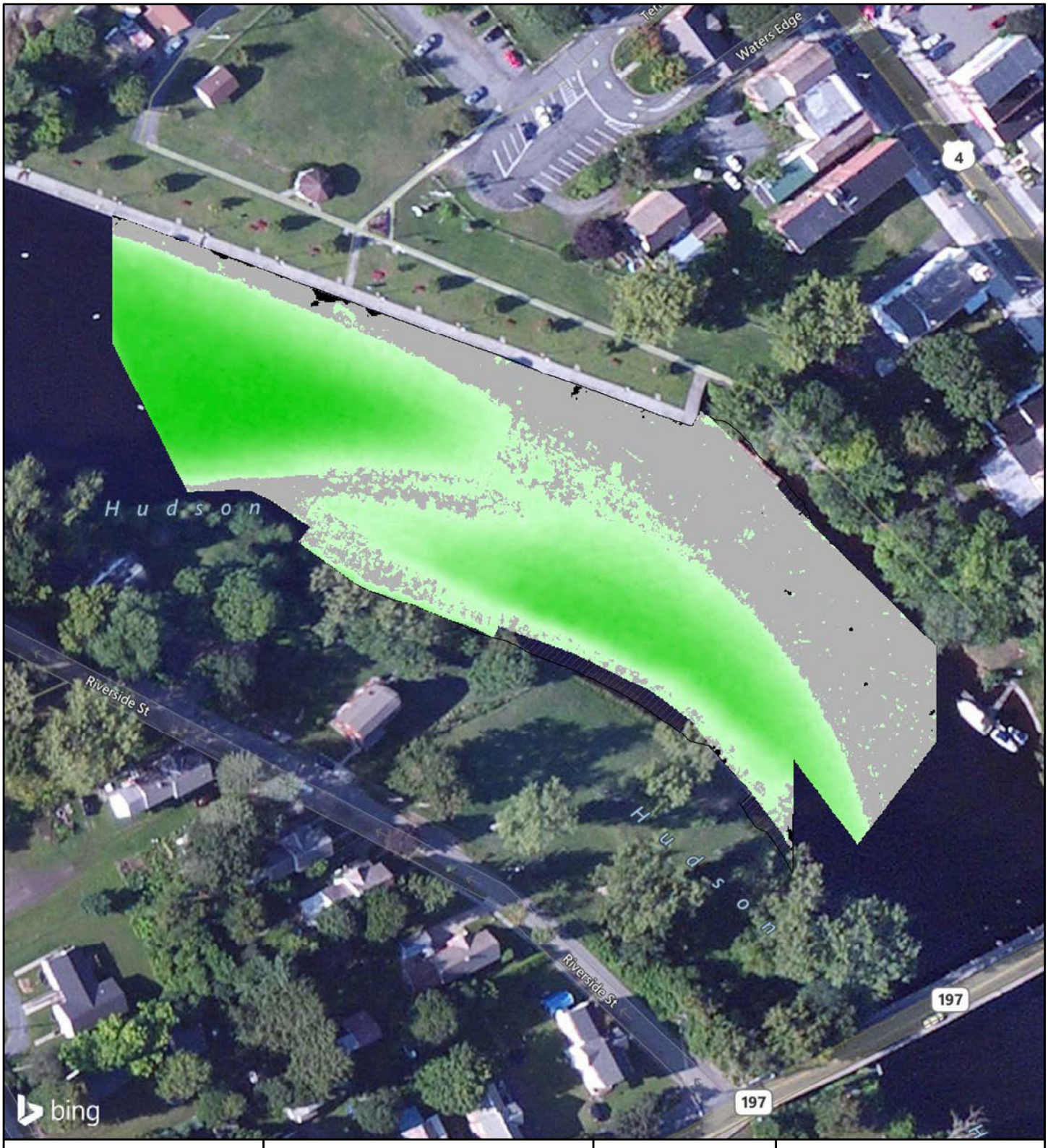
[3]: Negative numbers indicate net erosion of sediments between survey years.

Table A7-3. Phase 1 5-year cap stability (2009 post-placement survey vs. 2014 Tier-1 survey)

Certification Unit	Area Capped (acres)	Total area Capped with >3" of deposition between 2009 and 2014 surveys (%)	Total area capped with >3" of erosion between 2009 and 2014 surveys (%)	Total area capped with >3" of erosion between 2009 and 2014 surveys (ft2)	Largest Contiguous Area Capped with >3" of erosion between 2009 and 2014 surveys (ft2)	Volume of Deposited Sediment between 2009 and 2014 surveys (cy)	Volume of Eroded Sediment between 2009 and 2014 surveys (cy)
CU-1	3.31	95	<1	448	220	19463	14
CU-2	3.43	97	<1	1056	127	7376	21
CU-3	1.22	>99	<1	1	1	4527	<1
CU-4	3.55	97	<1	26	9	9690	<1
CU-5	0.70	99	<1	3	2	4253	<1
CU-6	1.33	77	5	2794	777	1546	85
CU-7	0.94	86	3	1285	401	3772	41
CU-8	1.47	78	5	2959	858	4704	89
CU-18	1.11	58	1	348	27	519	6

[1]: The net volume of sediment is calculated by differencing the volume of gross deposition greater than 3 inches and the volume of gross erosion greater than 3 inches that occurred between the respective years indicated.

[3]: Negative numbers indicate net erosion of sediments between survey years.



Sediment Deposition (ft)

12.45

0.25

3" Erosion to 3" Depo.

>3" Erosion

Mile Markers

Certification Units

Total area capped: 3.31 acres
Area capped with >3" deposition: 64%
Area capped with >3" erosion: <1%

No Measurable Loss in CU-1

Coordinate System:
NAD 1983 StatePlane
New York Central FIPS 3101 (ft)

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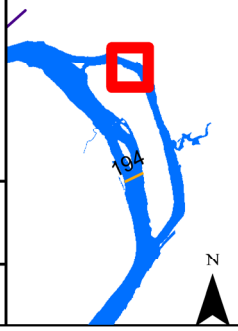

Figure A7-1a. CU-1 Bathymetric Comparison 2009 Cap Reference Survey vs. 2011 High Flow Survey

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0 50 100 Feet

Value

12.45

0.25

3" Erosion to 3" Depo.

>3" Erosion

Mile Markers

Certification Units

Total area capped: 3.43 acres
Area capped with >3" deposition: 70%
Area capped with >3" erosion: 1%

No Measurable Loss in CU-2

Coordinate System:
NAD 1983 StatePlane
New York Central FIPS 3101 (ft)

April 2019

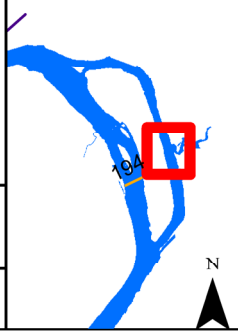


Figure A7-1b. CU-2 Bathymetric Comparison 2009 Cap Reference Survey vs. 2011 High Flow Survey

Louis Berger

0 50 100 Feet

Sediment Deposition (ft)

12.45

0.25

3" Erosion to 3" Depo.

>3" Erosion

Mile Markers

Certification Units

Total area capped: 1.22 acres
Area capped with >3" deposition: 83%
Area capped with >3" erosion: <1%

No Measurable Loss in CU-3

Coordinate System:
NAD 1983 StatePlane
New York Central FIPS 3101 (ft)

April 2019

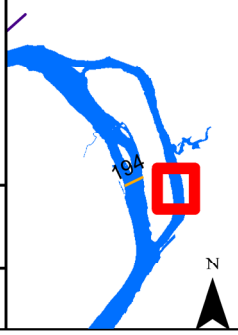
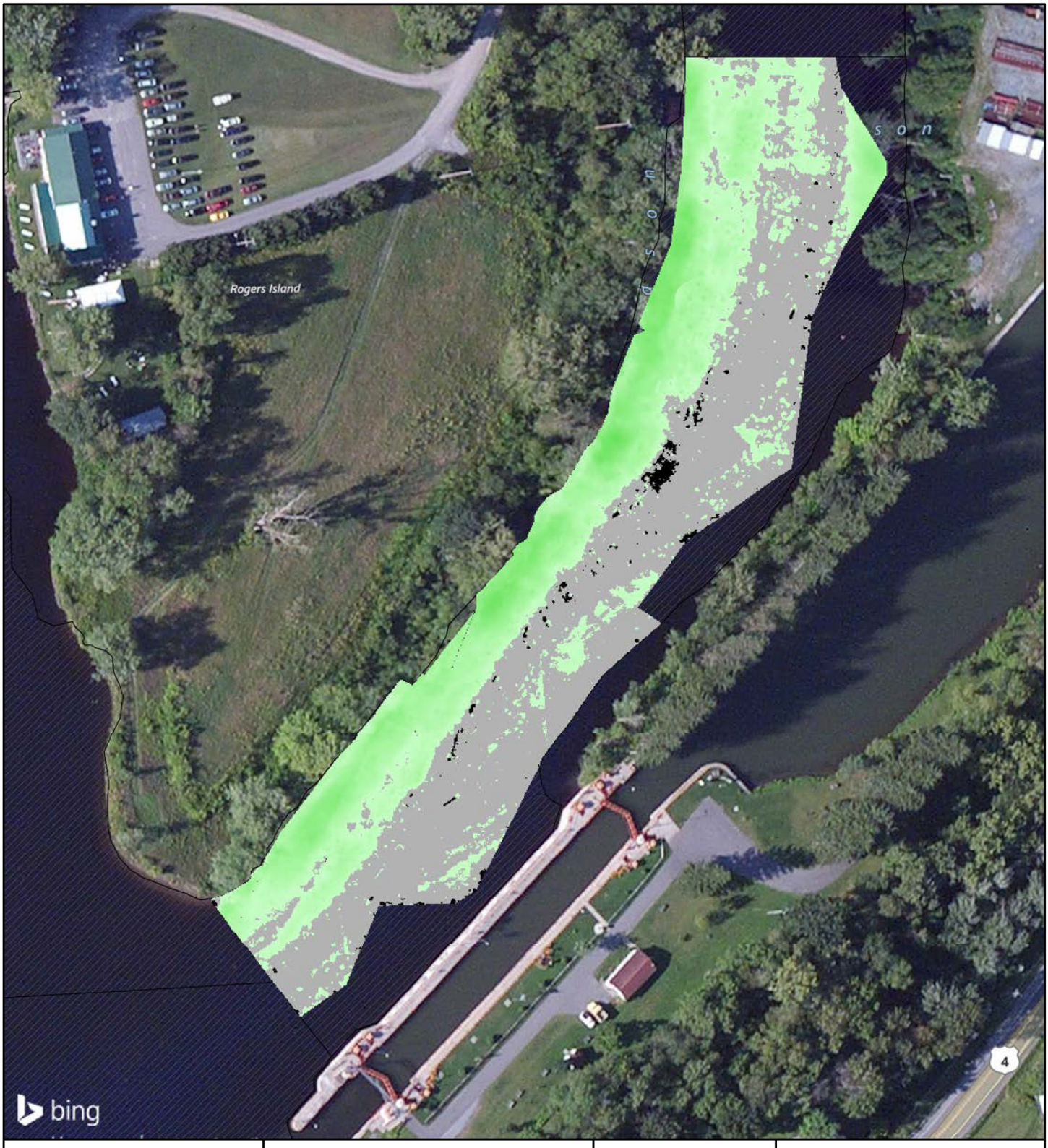


Figure A7-1c. CU-3 Bathymetric Comparison 2009 Cap Reference Survey vs. 2011 High Flow Survey

Louis Berger

0 50 100 Feet



Sediment Deposition (ft)

12.45

0.25

3" Erosion to 3" Depo.

>3" Erosion

Mile Markers

Certification Units

Total area capped: 3.55 acres
Area capped with >3" deposition: 51%
Area capped with >3" erosion: 1%

No Measurable Loss in CU-4

Coordinate System:
NAD 1983 StatePlane
New York Central FIPS 3101 (ft)

April 2019

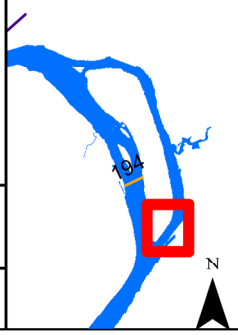


Figure A7-1d. CU-4 Bathymetric Comparison 2009 Cap Reference Survey vs. 2011 High Flow Survey

Louis Berger

0 50 100 Feet

Sediment Deposition (ft)

12.45

0.25

3" Erosion to 3" Depo.

>3" Erosion

Mile Markers

Certification Units

Total area capped: 0.7 acres
Area capped with >3" deposition: 99%
Area capped with >3" erosion: <1%

No Measurable Loss in CU-5

Coordinate System:
NAD 1983 StatePlane
New York Central FIPS 3101 (ft)

April 2019

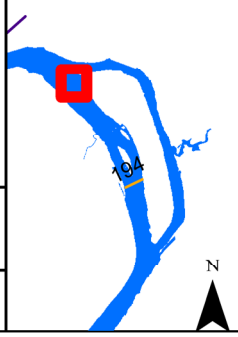


Figure A7-1e. CU-5 Bathymetric Comparison 2009 Cap Reference Survey vs. 2011 High Flow Survey

Louis Berger

0 50 100 Feet

Sediment Deposition (ft)

12.45

0.25

3" Erosion to 3" Depo.

>3" Erosion

Mile Markers

Certification Units

Total area capped: 1.33 acres
Area capped with >3" deposition: 72%
Area capped with >3" erosion: 1%

No Measurable Loss in CU-6

Coordinate System:
NAD 1983 StatePlane
New York Central FIPS 3101 (ft)

April 2019

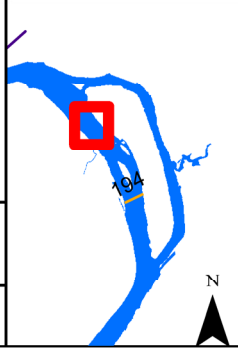
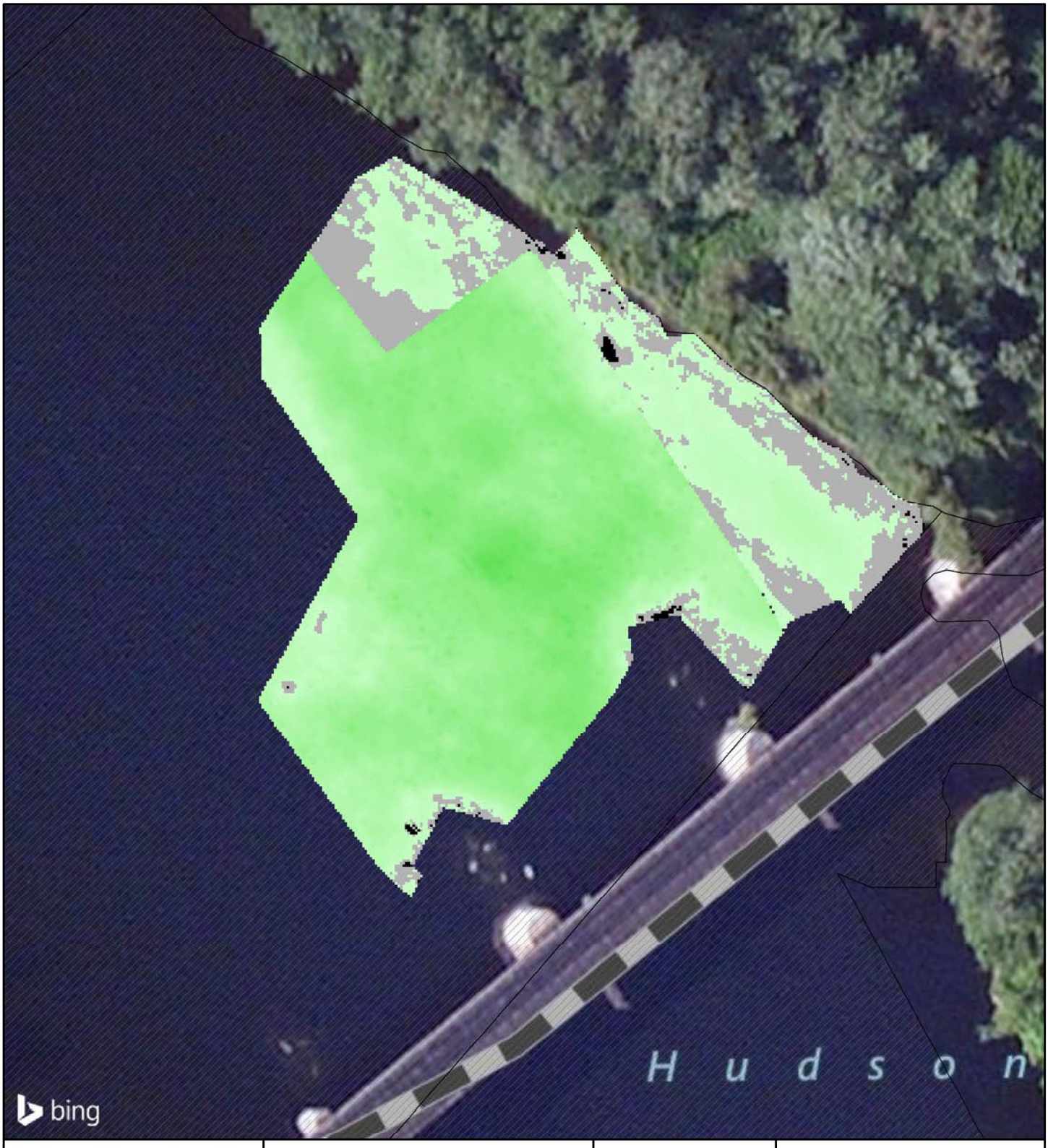


Figure A7-1f. CU-6 Bathymetric Comparison 2009 Cap Reference Survey vs. 2011 High Flow Survey

Louis Berger

0 50 100 Feet



Sediment Deposition (ft)

12.45

0.25

3" Erosion to 3" Depo.

>3" Erosion

Mile Markers

Certification Units

Total area capped: 0.94 acres
Area capped with >3" deposition: 87%
Area capped with >3" erosion: <1%

No Measurable Loss in CU-7

Coordinate System:
NAD 1983 StatePlane
New York Central FIPS 3101 (ft)

April 2019

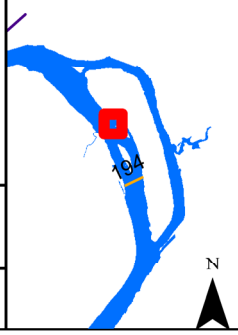


Figure A7-1g. CU-7 Bathymetric Comparison 2009 Cap Reference Survey vs. 2011 High Flow Survey

Louis Berger

0 50 100 Feet

Sediment Deposition (ft)

12.45

0.25

3" Erosion to 3" Depo.

>3" Erosion

Mile Markers

Certification Units

Total area capped: 1.47 acres
Area capped with >3" deposition: 79%
Area capped with >3" erosion: 1%

No Measurable Loss in CU-8

Coordinate System:
NAD 1983 StatePlane
New York Central FIPS 3101 (ft)

April 2019

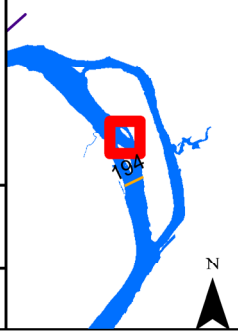
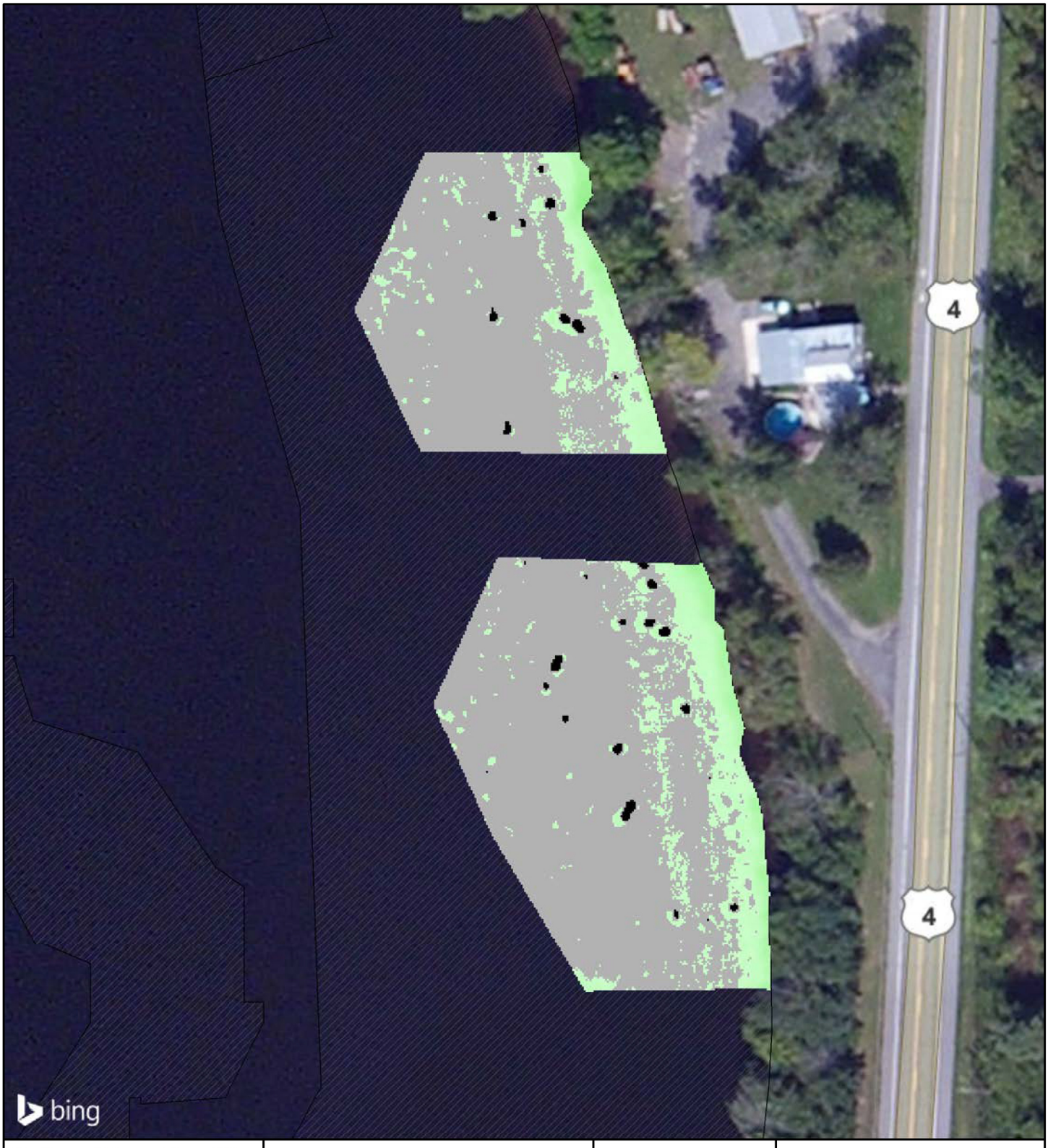


Figure A7-1h. CU-8 Bathymetric Comparison 2009 Cap Reference Survey vs. 2011 High Flow Survey

Louis Berger

0 50 100 Feet



Sediment Deposition (ft)

12.45

0.25

3" Erosion to 3" Depo.

>3" Erosion

Mile Markers

Certification Units

Total area capped: 1.11 acres
Area capped with >3" deposition: 20%
Area capped with >3" erosion: 1%
No Measurable Loss in CU-18

Coordinate System:
NAD 1983 StatePlane
New York Central FIPS 3101 (ft)

April 2019

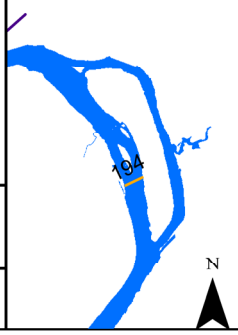


Figure A7-1i. CU-18 Bathymetric Comparison 2009 Cap Reference Survey vs. 2011 High Flow Survey

Louis Berger

0 50 100 Feet

Sediment Deposition (ft)

12.45

0.25

3" Erosion to 3" Depo.

>3" Erosion

Hudson River Boundary

Certification Units

Total area capped: 3.31 acres
Area capped with >3" deposition: 95%
Area capped with >3" erosion: <1%

No Measurable Loss in CU-1

Coordinate System:
NAD 1983 StatePlane
New York Central FIPS 3101 (ft)

April 2019

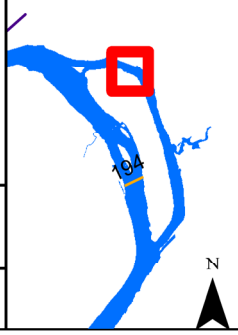
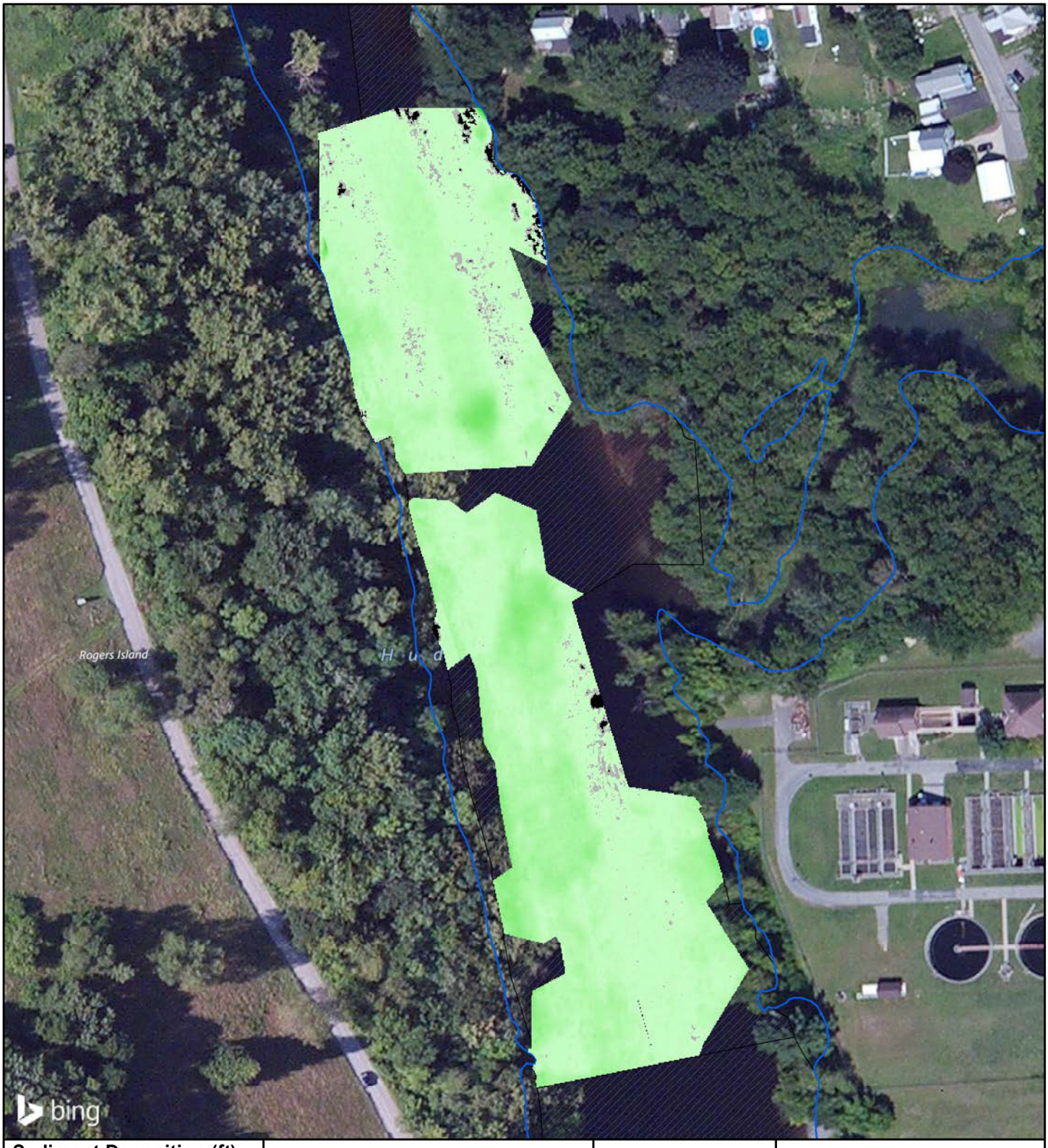


Figure A7-2a. CU-1 Bathymetric Comparison 2009 Cap Reference Survey vs. 2014 Five-Year Tier 1 Survey

Louis Berger

0 50 100 Feet



Sediment Deposition (ft)

12.45

0.25

3" Erosion to 3" Depo.

>3" Erosion

Hudson River Boundary

Certification Units

Total area capped: 3.43 acres
Area capped with >3" deposition: 97%
Area capped with >3" erosion: <1%

No Measurable Loss in CU-2

Coordinate System:
NAD 1983 StatePlane
New York Central FIPS 3101 (ft)

April 2019

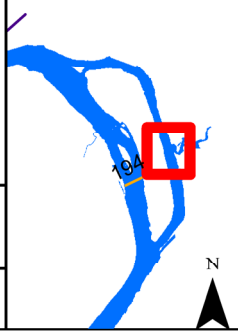


Figure A7-2b. CU-2 Bathymetric Comparison 2009 Cap Reference Survey vs. 2014 Five-Year Tier 1 Survey

Louis Berger

0 50 100 Feet

Sediment Deposition (ft)

12.45

0.25

3" Erosion to 3" Depo.

>3" Erosion

Hudson River Boundary

Certification Units

Total area capped: 1.22 acres
Area capped with >3" deposition: >99%
Area capped with >3" erosion: <1%

No Measurable Loss in CU-3

Coordinate System:
NAD 1983 StatePlane
New York Central FIPS 3101 (ft)

April 2019

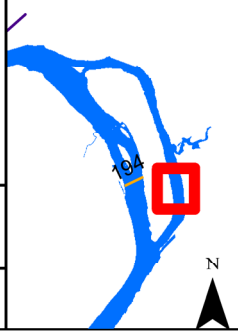


Figure A7-2c. CU-3 Bathymetric Comparison 2009 Cap Reference Survey vs. 2014 Five-Year Tier 1 Survey

Louis Berger

0 50 100 Feet

Sediment Deposition (ft)

12.45

0.25

3" Erosion to 3" Depo.

>3" Erosion

Hudson River Boundary

Certification Units

Total area capped: 3.55 acres
Area capped with >3" deposition: 97%
Area capped with <1% erosion: <1%

No Measurable Loss in CU-4

Coordinate System:
NAD 1983 StatePlane
New York Central FIPS 3101 (ft)

April 2019

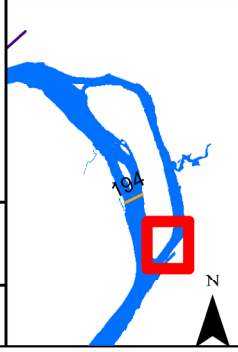


Figure A7-2d. CU-4 Bathymetric Comparison 2009 Cap Reference Survey vs. 2014 Five-Year Tier 1 Survey

Louis Berger

0 50 100 Feet

Sediment Deposition (ft)

12.45

0.25

3" Erosion to 3" Depo.

>3" Erosion

Hudson River Boundary

Certification Units

Total area capped: 0.7 acres
Area capped with >3" deposition: 99%
Area capped with >3" erosion: <1%

No Measurable Loss in CU-5

Coordinate System:
NAD 1983 StatePlane
New York Central FIPS 3101 (ft)

April 2019

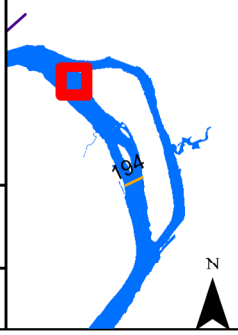


Figure A7-2e. CU-5 Bathymetric Comparison 2009 Cap Reference Survey vs. 2014 Five-Year Tier 1 Survey

Louis Berger

0 50 100 Feet

Sediment Deposition (ft)

12.45

0.25

3" Erosion to 3" Depo.

>3" Erosion

Hudson River Boundary

Certification Units

Total area capped: 1.33 acres
Area capped with >3" deposition: 77%
Area capped with >3" erosion: 5%

No Measurable Loss in CU-6

Coordinate System:
NAD 1983 StatePlane
New York Central FIPS 3101 (ft)

April 2019

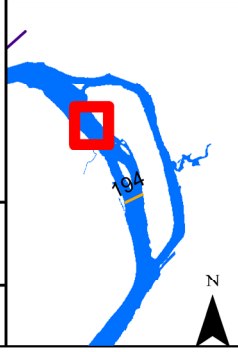
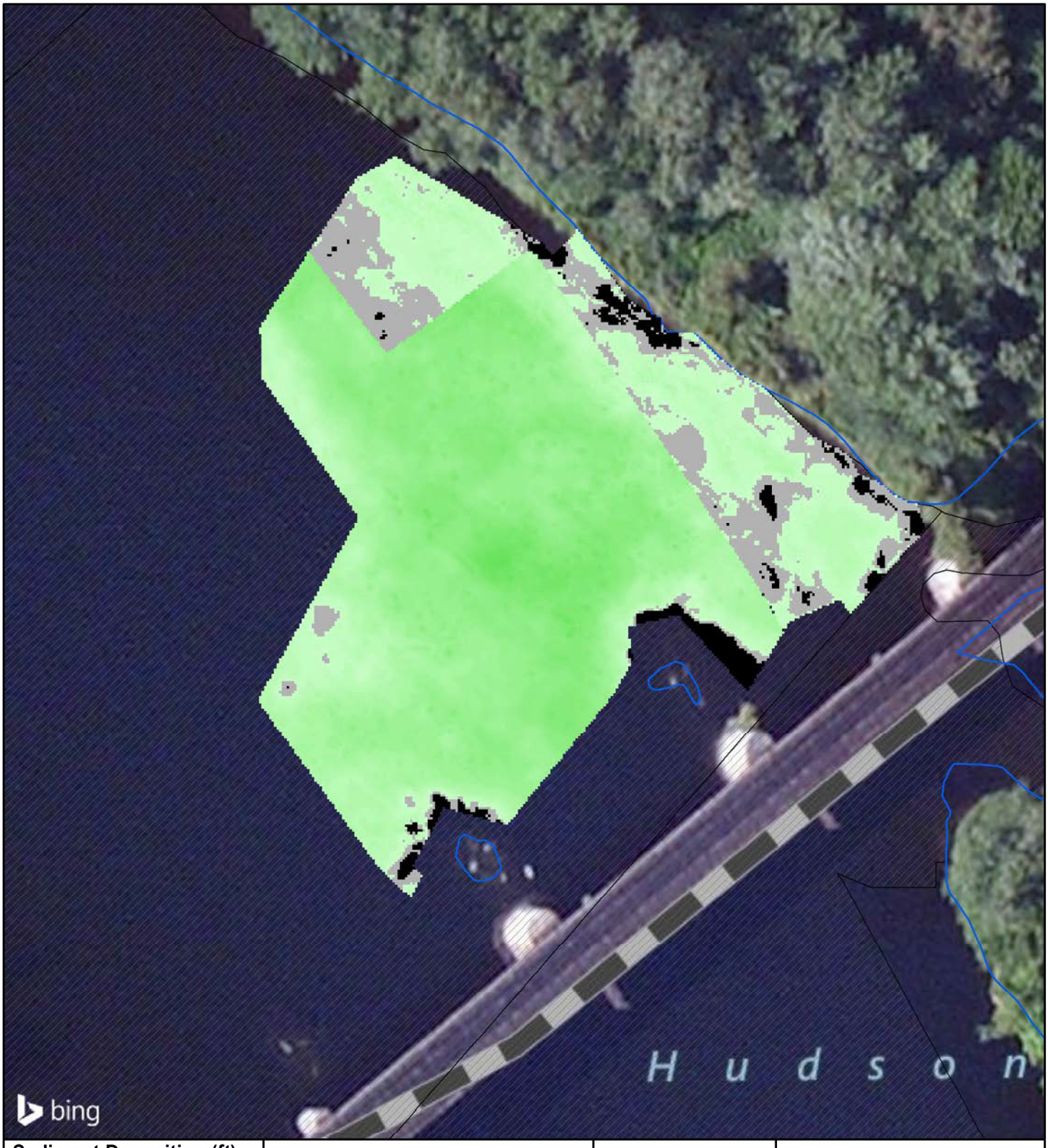


Figure A7-2f. CU-6 Bathymetric Comparison 2009 Cap Reference Survey vs. 2014 Five-Year Tier 1 Survey

Louis Berger

0 50 100 Feet



Sediment Deposition (ft)

12.45

0.25

3" Erosion to 3" Depo.

>3" Erosion

Hudson River Boundary

Certification Units

Total area capped: 0.94 acres
Area capped with >3" deposition: 86%
Area capped with >3" erosion: 3%

No Measurable Loss in CU-7

Coordinate System:
NAD 1983 StatePlane
New York Central FIPS 3101 (ft)

April 2019

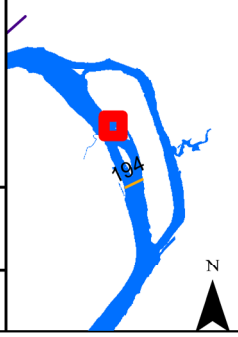


Figure A7-2g. CU-7 Bathymetric Comparison 2009 Cap Reference Survey vs. 2014 Five-Year Tier 1 Survey

Louis Berger

0 25 50 Feet

Sediment Deposition (ft)

12.45

0.25

3" Erosion to 3" Depo.

>3" Erosion

Hudson River Boundary

Certification Units

Total area capped: 1.47 acres
Area capped with >3" deposition: 78%
Area capped with >3" erosion: 5%

No Measurable Loss in CU-8

Coordinate System:
NAD 1983 StatePlane
New York Central FIPS 3101 (ft)

April 2019

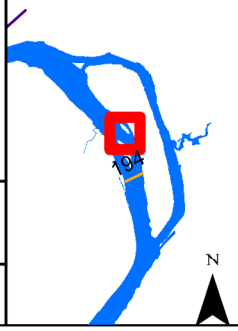


Figure A7-2h. CU-8 Bathymetric Comparison 2009 Cap Reference Survey vs. 2014 Five-Year Tier 1 Survey

Louis Berger

0 50 100 Feet

Sediment Deposition (ft)

12.45

0.25

3" Erosion to 3" Depo.

>3" Erosion

Hudson River Boundary

Certification Units

Total area capped: 1.11 acres
Area capped with >3" deposition: 58%
Area capped with >3" erosion: 1%
No Measurable Loss in CU-18

Coordinate System:
NAD 1983 StatePlane
New York Central FIPS 3101 (ft)

April 2019

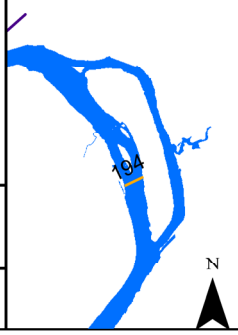


Figure A7-2i. CU-18 Bathymetric Comparison 2009 Cap Reference Survey vs. 2014 Five-Year Tier 1 Survey

Louis Berger

0 25 50 Feet