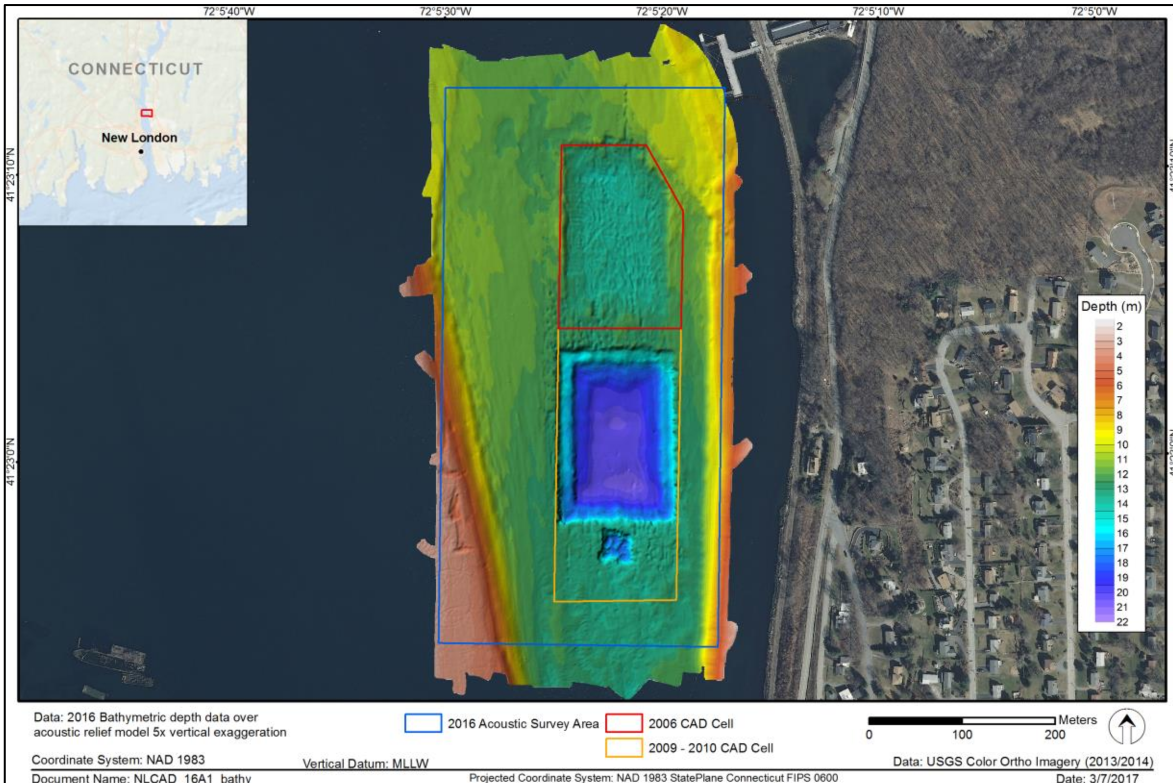
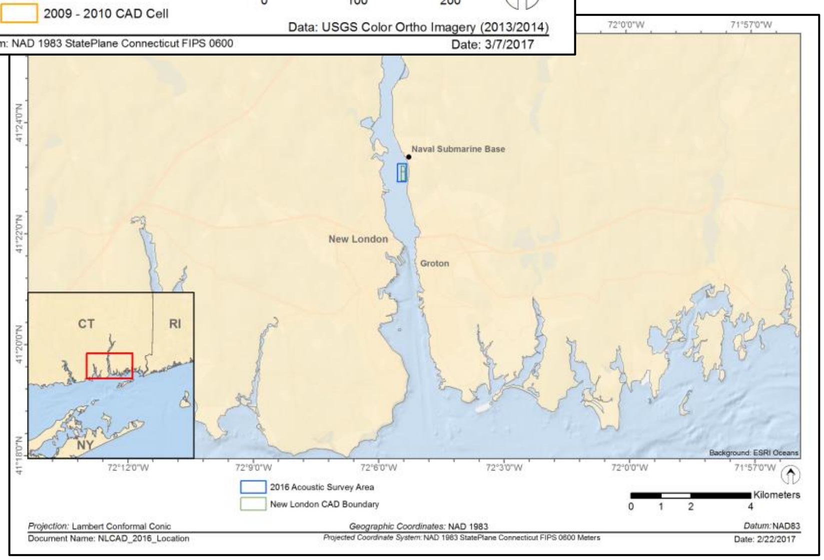
Data Summary Report for the Baseline Monitoring Survey at the New London Confined Aquatic Disposal Cell Site – October 2016

Disposal Area Monitoring System DAMOS





DAMOS

DISPOSAL AREA MONITORING SYSTEM

Data Summary Report

DR 2016-03

October 2017

US Army Corps of Engineers®

New England District

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Note on units of this report: As a scientific data summary, information and data are presented in the metric system. However, given the prevalence of English units in the dredging industry of the United States, conversions to English units are provided for general information in Section 1. A table of common conversions can be found in Appendix A.

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LIST OF ACRONYMS

ASCII	American Standard Code for Information Interchange
CAD	Confined Aquatic Disposal
CCOM	Center for Coastal and Ocean Mapping
DAMOS	Disposal Area Monitoring System
FIPS	Federal Information Processing Standard
GIS	Graphic information system
GPS	Global positioning system
MBES	Multibeam echo sounder
MLLW	Mean lower low water
MRU	Motion Reference UnitNAD North American Datum
NAE	New England District
NLCAD	New London CAD Cell Site
NOAA	National Oceanic and Atmospheric Administration
NOS	National Ocean Service
NTRIP	Network transport of RTCM data over IP
PV	Plan-view
RTCM	Radio Technical Commission for Maritime Services
RTK	Real time kinematic GPS
SHP	Shapefile or geospatial data file
SOP	Standard Operating Procedures
SVP	Sound Velocity Profile
SPI	Sediment-profile Imaging
TIF	Tagged image file
TIN	Triangulated irregular network
USACE	U.S. Army Corps of Engineers

1.0 INTRODUCTION

A monitoring survey was conducted at the New London Confined Aquatic Disposal (NLCAD) Cell Site in October 2016 as part of the U.S. Army Corps of Engineers (USACE) New England District (NAE) Disposal Area Monitoring System (DAMOS) Program. DAMOS is a comprehensive monitoring and management program designed and conducted to address environmental concerns surrounding the placement of dredged material at aquatic disposal sites throughout the New England region. An overview of the DAMOS Program and the NLCAD Cell Site is provided below.

1.1 Overview of the DAMOS Program

The DAMOS Program features a tiered management protocol designed to ensure that any potential adverse environmental impacts associated with dredged material disposal are promptly identified and addressed (Germano et al. 1994). For over 39 years, the DAMOS Program has collected and evaluated disposal site data throughout New England. Based on these data, patterns of physical, chemical, and biological responses of seafloor environments to dredged material disposal activity have been documented (Fredette and French 2004).

DAMOS monitoring surveys fall into two general categories: confirmatory studies and focused studies. The data collected and evaluated during these studies provide answers to strategic management questions in determining the next step in the disposal site management process to guide the management of disposal activities at existing sites, plan for use of future sites, and evaluate the long-term status of historic sites.

Confirmatory studies are designed to test hypotheses related to expected physical and ecological response patterns following placement of dredged material on the seafloor at established, active disposal sites. Two primary goals of DAMOS confirmatory monitoring surveys are to document the physical location and stability of dredged material placed into the aquatic environment and to evaluate the biological recovery of the benthic community following placement of dredged material. Several survey techniques are employed in order to characterize these responses to dredged material placement. Sequential acoustic monitoring surveys (including bathymetric, acoustic backscatter, and side-scan sonar data collection) are performed to characterize the height and spread of discrete dredged material deposits or mounds created at open water sites as well as the accumulation/consolidation of dredged material into confined aquatic disposal cells.

Sediment-profile (SPI) and plan-view (PV) imaging surveys are often performed in confirmatory studies to provide further physical characterization of the material and to support evaluation of seafloor (benthic) habitat conditions and recovery over time. Each type of data collection activity is conducted periodically at disposal sites and the conditions found after a defined period of disposal activity are compared with the long-term data set at specific sites to determine the next step in the disposal site management process (Germano et al. 1994).

Focused studies are periodically undertaken within the DAMOS Program to evaluate inactive or historical disposal sites and contribute to the development of dredged material placement and monitoring techniques. Focused DAMOS monitoring surveys may also feature additional types of data collection activities as deemed appropriate to achieve specific survey objectives, such as subbottom profiling, towed video, sediment coring, or grab sampling.

The 2016 NLCAD Cell Site investigation was considered part of a focused study to track long-term stability of the confined aquatic disposal (CAD) cells given their location within a working harbor. The objective was to characterize the harbor topography and surficial features over the two existing CAD cells by completing a multibeam bathymetric survey.

1.2 Introduction to the New London Confined Aquatic Disposal Cell Site

The NLCAD Cell Site is one of several CAD cell sites in New England. The site is located in the Federal Navigation Channel of the Thames River, immediately south of the Naval Submarine Base, in New London, Connecticut (Figure 1-1). The CAD cells are located approximately 7.5 km (4.7 mi) upstream of where the river enters Long Island Sound (USACE 2012). The site consists of two cells; 2006 CAD cell (previously termed “Pier 6” cell) to the north, and 2009-2010 CAD cell (previously termed “maintenance dredged material” cell) to the south (Figure 1-2).

1.3 New London Harbor CAD Cell Construction Sequence

Construction of CAD cells in New London began in October 2006 with the removal of 167,800 m^3 (219,500 y^3) of material from the harbor’s bottom. The cell was capped immediately after being filled with dredged silt and clay from neighboring piers. A second CAD cell was constructed in the winter of 2009-2010, directly south of the original cell (USACE 2012).

1.4 Previous Monitoring Events at New London Harbor CAD Cell Site

In October 2009 a baseline study was conducted at the NLCAD Cell Site as part of a larger investigation of four New England Harbors. The 2009 survey included a bathymetric survey, a sediment-profile and plan-view survey, and a towed underwater video survey of the NLCAD Cell Site. At the time of the survey the second cell (2009-2010) had yet to be constructed, however the survey covered both cells. Additional construction related bathymetric surveys were also conducted for Cell 2006 (Table 1-1).

1.5 2016 Survey Objectives

The 2016 survey was designed as a focused survey to track long-term stability of the CAD cells 2006 and 2009-10. The objectives of the survey were to:

- characterize the harbor topography and surficial features over the two existing CAD cells by completing a multibeam bathymetric survey, and
- Using the baseline multibeam data, calculate any remaining capacity of the cells assuming they would be filled to within 1 m (~3 ft) of the surrounding harbor bottom.

Table 1.1. Summary of Previous Investigations at NLCAD Cell Site (USACE 2012)

Date	Time Period	Study Type
October 2006	Post-construction survey of the 2006 cell	Bathymetric Survey
November 2006	Post-disposal survey of the 2006 cell	Bathymetric Survey
November 2006	Post-capping survey of the 2006 cell	Bathymetric Survey
December 2007	One year post-construction survey of the 2006 cell	Bathymetric Survey
October 2009	Pre-construction survey of the 2009-2010 cell	Bathymetric Survey 25-Station Sediment-Profile Imaging Survey Towed Underwater Video

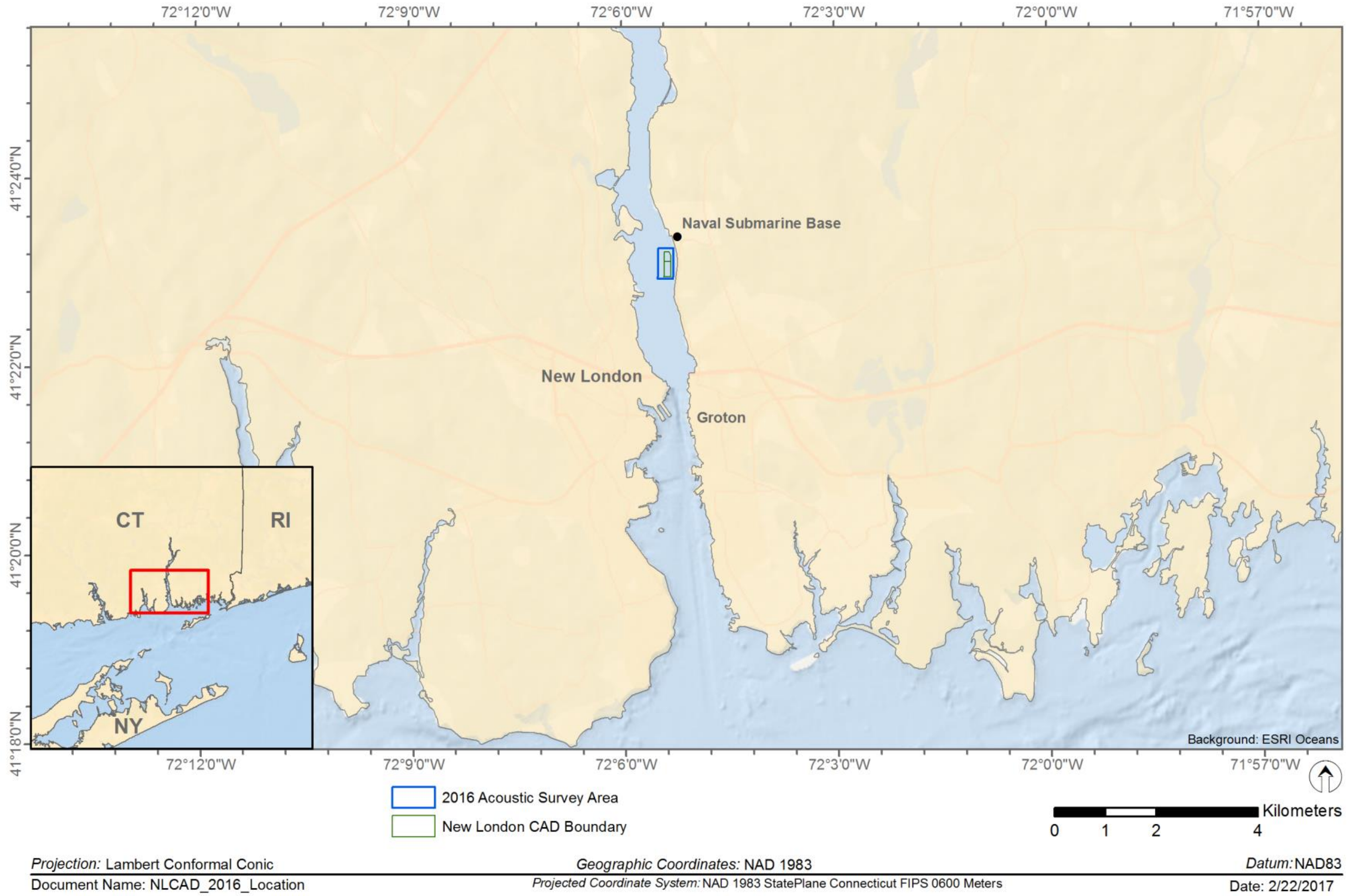


Figure 1-1. Location of the New London CAD Cell Site (NLCAD)

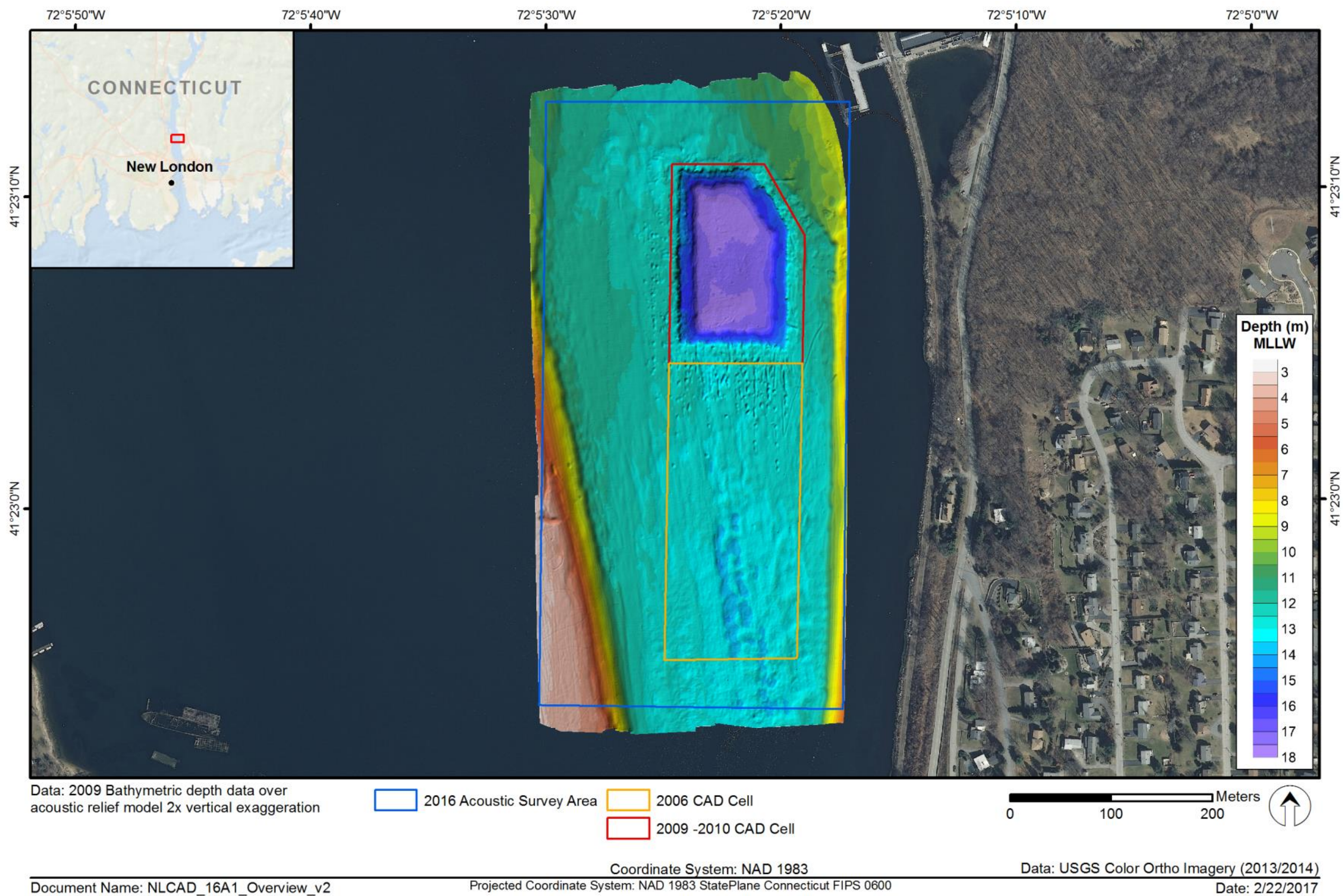


Figure 1-2. Overview and NLCAD 2016 acoustic survey area

2.0 METHODS

The October 2016 survey at the NLCAD Cell Site was conducted by a team of investigators from INSPIRE Environmental and CR Environmental including certified hydrographer Christopher Wright aboard the 25-foot *R/V Cyprinodon*. The acoustic survey was conducted 11-12 October 2016. An overview of the methods used to collect, process, and analyze the survey data is provided below. Detailed Standard Operating Procedures (SOPs) for data collection and processing are available in the Quality Assurance Project Plan for the DAMOS Program (Battelle 2015).

2.1 Navigation and On-Board Data Acquisition

Navigation for the acoustic survey was accomplished using a Hemisphere VS-330 RTK GPS which received base station correction through the Keynet NTRIP broadcast. Horizontal position accuracy in fixed RTK mode was approximately 1 cm, vertical (tidal) accuracy was approximately 2 cm. The GPS system was interfaced to a laptop computer running HYPACK MAX® hydrographic survey software. HYPACK MAX® recorded vessel position and GPS satellite quality and provided a steering display for the vessel captain to accurately maintain the position of the vessel along pre-established survey transects.

On the *Cyprinodon*, vessel heading measurements were provided by an IxBlue Octans III fiber optic gyrocompass. A dual-antenna Hemisphere VS-110 Crescent Digital compass was mobilized as a backup.

2.2 Acoustic Survey

The acoustic survey included multibeam bathymetric, backscatter, and side-scan sonar data collection. The bathymetric data provided measurements of water depth that, when processed, were used to map the seafloor topography. Backscatter and side-scan sonar data provided images that supported the characterization of surface sediment texture and roughness. Each of these acoustic data types is useful for assessing dredged material placement and surface sediment features.

2.2.1 Acoustic Survey Planning

The acoustic survey area at the NLCAD Cell Site (Figure 1-2) had water depths ranging from 3 m to 18 m in 2009. The acoustic survey featured a high spatial resolution survey of 2 CAD cells (2006 CAD cell, and 2009-2010 CAD cell) covering an approximate 300 × 600 m area in New London Harbor (Figure 1-2).

INSPIRE hydrographers obtained site coordinates, imported them to geographic information system (GIS) software, and created maps to aid planning. Base bathymetric data from previous surveys were used to calculate the transect separation required to obtain full bottom coverage using an assumed beam angle limit of 90-degrees (45 degrees to port, 45 degrees to starboard). Transects spaced 15-20 m apart and cross-lines spaced 100-150 m apart were created to meet conservative beam angle constraints (Figure 2-1). The proposed survey area and design were then reviewed and approved by NAE scientists.

2.2.2 Acoustic Data Collection

Data layers generated by the survey included bathymetric, acoustic backscatter, and side-scan sonar and were collected using an R2Sonic 2022 broadband multibeam echo sounder (MBES). This 200-400 kHz system forms up to 256 1-2° beams (frequency dependent) distributed equiangularly or equidistantly across a 10 - 160° swath. The MBES system was operated using a transmit frequency of 200 kHz to facilitate comparisons with previous survey data while maximizing bathymetric resolution. The MBES transducer was mounted amidships to the port rail of the survey vessel using a high strength adjustable boom. The primary GPS antenna was mounted on the transducer boom. The transducer depth below the water surface (draft) and antenna height were checked and recorded at the beginning and end of data acquisition, and the draft was confirmed using the "bar check" method.

An IxBlue Octans III motion reference unit (MRU) was interfaced to the MBES topside processor and to the acquisition computer. Precise linear offsets between the MRU and MBES were recorded and applied during acquisition. Depth and backscatter data were synchronized using pulse-per-second timing and transmitted to the HYPACK MAX® acquisition computer via Ethernet communications. Several patch tests were conducted during the survey to allow computation of angular offsets between the MBES system components.

The system was calibrated for local water mass speed of sound by performing sound velocity profile (SVP) casts at frequent intervals throughout each survey day using an AML, Inc. Minos-X profiling instrument.

2.2.3 Bathymetric Data Processing

Bathymetric data were processed by the certified hydrographer using HYPACK HYSWEEP® software. Processing components are described below and included:

- Adjustment of data for tidal elevation fluctuations
- Correction of ray bending (refraction) due to density variation in the water column
- Removal of spurious points associated with water column interference or system errors
- Development of a grid surface representing depth solutions
- Statistical estimation of sounding solution uncertainty
- Generation of data visualization products

Tidal adjustments were accomplished using RTK GPS. Water surface elevations derived using RTK were adjusted to Mean Lower Low Water (MLLW) elevations using NOAA's VDATUM Model. Processed RTK tide data were successfully ground-truthed against a data series acquired using a digital water level recorder installed at a surveyed control point established by USACE for bathymetric surveys.

Correction of sounding depth and position (range and azimuth) for refraction due to water column stratification was conducted using a series of nine sound-velocity profiles acquired by the survey team. Data artifacts associated with refraction remain in the bathymetric surface model at a relatively fine scale (generally less than 5 cm) relative to the survey depth.

Data were filtered to accept only beams falling within an angular limit of 60° to minimize refraction artifacts. Spurious sounding solutions were rejected based on the careful examination of data on a sweep-specific basis.

The R2Sonics 2022 MBES system was operated at 200 kHz. At this frequency the system has a published beam width of 2.0°. Assuming a mean depth of 6 m and a maximum beam angle of 60°, the maximum diameter of the beam footprint was calculated at approximately 0.4 × 0.8 m (0.35 m^2). Mid-swath data would have a resolution of 0.07 m^2. Data were reduced to a cell (grid) size of 0.5 × 0.5 m, acknowledging the system's fine range resolution while accommodating beam position uncertainty. This data reduction was accomplished by calculating and exporting the average elevation for each cell in accordance with USACE recommendations (USACE 2013).

Statistical analysis of data as summarized on Table 2-1 showed negligible tide bias and vertical uncertainty substantially lower than values recommended by USACE (2013) or NOAA (2015). Note that the most stringent National Ocean Service (NOS) standard for this project depth (Special Order 1A) would call for a 95^{th} percentile confidence interval (95% CI) of 0.27 m at the maximum site depth (13.6 m) and 0.25 m at the average site depth (6.1 m).

Reduced data were exported in ASCII text format with fields for Easting, Northing, and MLLW Elevation (meters). All data were projected to the Connecticut State Plane FIPS 0600, NAD83 (metric). A variety of data visualizations were generated using a combination of ESRI ArcMap (V.10.1) and Golden Software Surfer (V.13). Visualizations and data products included:

- ASCII data files of all processed soundings including MLLW depths and elevations
- Contours of seabed elevation (25-cm, 50-cm and 1.0-m intervals) in a geospatial data file (SHP) format suitable for plotting using GIS and computer-aided design software
- 3-dimensional surface maps of the seabed created using 5× vertical exaggeration and artificial illumination to highlight fine-scale features not visible on contour layers delivered in grid and tagged image file (TIF) formats, and
- An acoustic relief map of the survey area created using 5× vertical exaggeration, delivered in georeferenced TIF format.

2.2.4 Backscatter Data Processing

Backscatter data were extracted from cleaned MBES TruePix formatted files then used to provide an estimation of surface sediment texture based on seabed surface roughness. Mosaics of backscatter data were created using HYPACK®'s implementation of GeoCoder software developed by scientists at the University of New Hampshire's NOAA Center for Coastal and Ocean Mapping (UNH/NOAA CCOM). Seamless mosaics of unfiltered backscatter data were developed and exported in grayscale TIF format. Backscatter data were also exported in ASCII format with fields for Easting, Northing, and backscatter (dB). A Gaussian filter was applied to backscatter data to minimize nadir artifacts and the filtered data were used to develop backscatter values on a 0.5-m grid. The grid was exported to an ESRI binary GRD format to facilitate comparison with other data layers.

2.2.5 Side-Scan Sonar Data Processing

Side-scan sonar data were processed using Chesapeake Technology, Inc. SonarWiz software. Seamless mosaics of side-scan sonar data were developed and exported in grayscale TIF format using a resolution of 0.3 m per pixel.

2.2.6 Acoustic Data Analysis

Bathymetric contour lines and acoustic relief models were generated from grids and displayed using GIS. The backscatter mosaics and filtered backscatter grid were combined with acoustic relief models in GIS to facilitate visualization of relationships between acoustic datasets. This is done by rendering images and color-coded grids with sufficient transparency to allow three-dimensional acoustic relief model to be visible underneath.

2.3 Remaining Cell Capacity Calculation

CAD cell volumes and remaining capacities were calculated by constructing triangulated irregular network (TIN) surface models for each cell using processed ASCII point data (binned as described in Section 2.2.3), then computing the volumes and planar areas above and below discreet 20-cm elevation intervals within vertical prisms. Prism geometry was defined by digital polygons provided by USACE and, where applicable, alternate boundaries digitized based on the observed footprint of each cell's excavation. TIN-based volume calculations are recommended by EM 1110-2-1003 (30 Nov 13, 10-30(d)).

TIN models honor each sounding solution without introducing minor uncertainties associated with grid interpolations. A TIN model consists of a series of triangles constructed between corrected sounding points that exactly honors the elevation and position of each point.

Table 2-1. Accuracy and Uncertainty Analysis of Bathymetric Data

		Results (m)				
Survey Date	**Quality Control Metric**	**Mean**	**95% Uncertainty**	**Range**		
10/12/2016	Cross-Line Swath Comparisons	-0.01	0.11			
	Within Cell Uncertainty	0.04	0.10	0.00	-	1.55
	Beam Angle Uncertainty (0 - 60d)	-0.01	0.10	0.08	-	0.14

Notes:
1. The mean of cross-line nadir and full swath comparisons are indicators of tide bias.
2. 95% uncertainty values were calculated using the sums of mean differences and standard deviations expressed at the 2-sigma level.
3. Within cell uncertainty values include biases and random errors.
4. Beam angle uncertainty was assessed by comparing cross-line data (60-degree swath limit) with a reference surface created using mainstay transect data.
5. Swath and cell based comparisons were conducted using 0.5 m x 0.5 m cell averages. These analyses do not exclude sounding variability associated with terrain slopes and objects (e.g., pilings, debris).

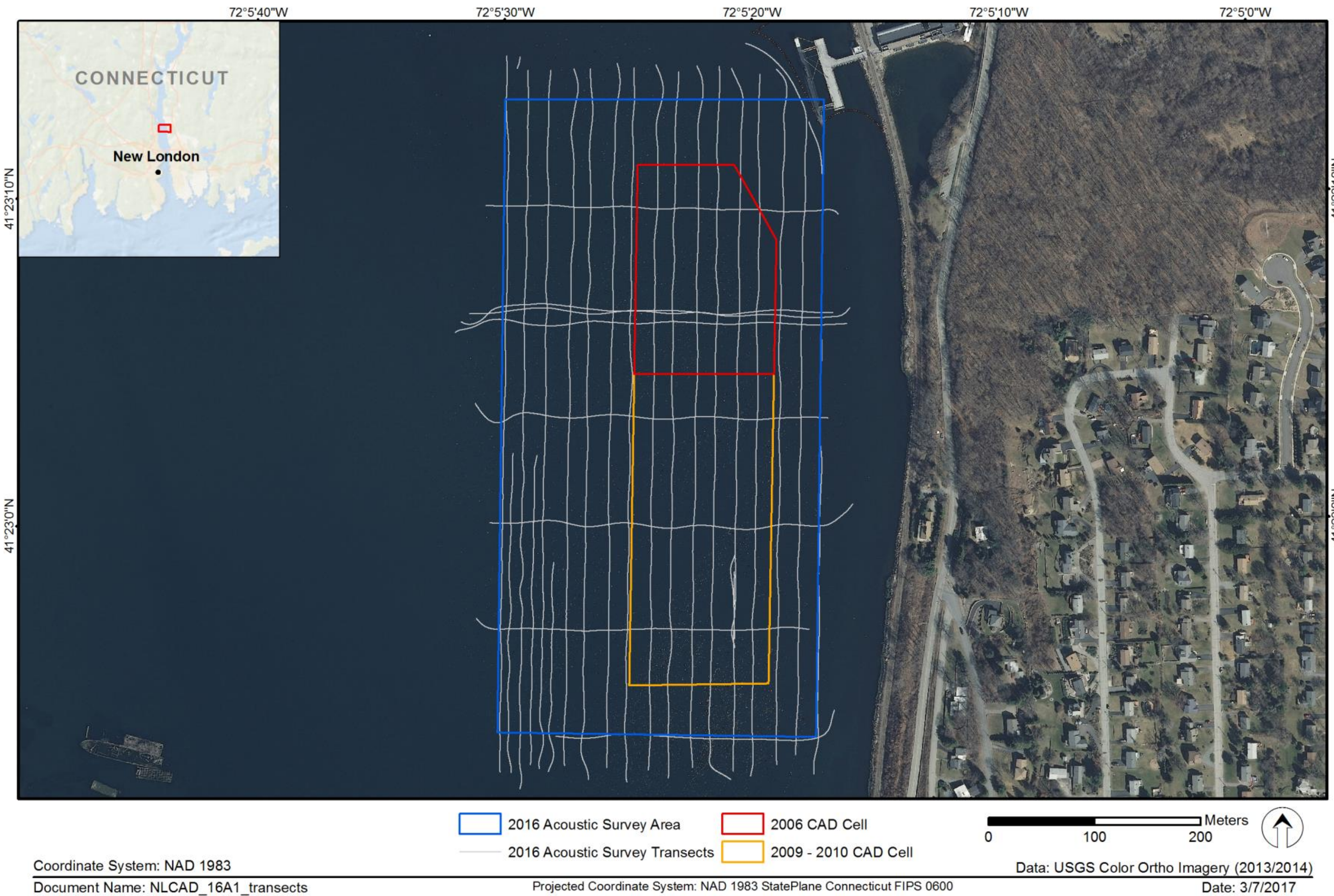


Figure 2-1. NLCAD 2016 acoustic survey area and tracklines

3.0 ACOUSTIC RESULTS

The results of the acoustic survey conducted in October 2016 to characterize seafloor topography and sediment surface features over the NLCAD Cell Site are presented in this section.

3.1 Bathymetry

The October 2016 New London CAD survey covered approximately 300 x 600 m area on the eastern bank of the Thames River, south of the Naval Submarine Base. Survey tracklines were run over the 2006 and 2009-2010 CAD cells (Figure 2-1). Depths over the entire survey area ranged from 3.2 to 21.1 m below MLLW (Figure 3-1). The survey area had slopes to the east and southwest that rapidly descended to 12 m below MLLW. The deepest areas were found in two rectangular depressions in the 2009-2010 CAD cell. Depths in the large rectangular depression to the north had depths of 12.2 to 21.2 m below MLLW and the smaller rectangular depression to the south had depths of 13.2 to 18.2 m below MLLW. Outside of these two depressions depths in the CAD cells were consistently in the 12 to 13 m below MLLW range. Depth decreased gradually northwest and north east of the CAD cells.

Multibeam bathymetric data rendered as an acoustic relief model provided a more detailed representation of the fine-scale topography of the cells and of the entire site (Figure 3-2). These data show curved marks in the 2006 CAD cell consistent with the removal or mechanical smoothing of material but only a few marks within the 2009-2010 CAD cell. The marks were not visible in the 2009 survey (Figure 1-2). Very small (2.5 to 4 m in diameter) circular pits are located along the southern and western boundaries of the cells consistent with spud piles from a dredge. Outside of the rectangular depressions in the 2009-2010 CAD cell the surface is pitted with irregular marks consistent with limited dredging that continue downriver. Circular scar marks are seen on the southwestern bank of the survey area consistent with anchor drag marks. Multibeam bathymetric data rendered as a color scale by elevation over an acoustic relief model (grayscale with hill-shading) provided additional representation of cell topographic lows and of the entire site (Figure 3-3).

3.2 Backscatter and Side-Scan Sonar

A mosaic of unfiltered backscatter data for the NLCAD Cell Site (Figure 3-4) generally revealed coarser surfaces having a stronger acoustic return at the northern extent of the 2009-2010 CAD cell and to the south of the cell. Coarser surfaces were also seen on the bank in the southwest of the survey area. Finer sediments with a weaker acoustic return (darker gray) were found outside of these areas.

Filtered backscatter results were processed into a grid file and presented in a quantitative form where backscatter intensity values were assigned a color (Figure 3-5). In this filtered and gridded display, the finer-scale details were less visible, but the relative intensity of backscatter returns was easier to discern. Stronger returns, associated with coarser surfaces were seen on the northern border and to the south of the large rectangular depression in the 2009-2010 CAD cell. Finer sediments were present in the 2006 CAD cell and the 2009-2010 CAD cell. Side-scan sonar results provided a high-resolution acoustic representation of the seafloor surface in a mosaic of the site (Figure 3-6).

3.3 Comparison with Previous Bathymetry

The multibeam data from the 2016 survey were compared with multibeam data collected in October of 2009 (Figure 3-7). A subtraction of the bottom elevations in the 2009 survey from the 2016 elevations captured the apparent changes in bathymetry since the 2009 survey (Figure 3-8). Elevations in the 2006 CAD cell increased by 0.5 m to 5 m, suggesting that the cell has been filled since the 2009 survey. The surface of this cell was marked by curved troughs that were not present after the cell was constructed and must represent placement activities (compare Figure 3-7 and 3-8).

In the 2009-2010 CAD cell, elevations decreased consistent with the two rectangular depressions observed in the 2016 bathymetry, suggesting that the cell has been excavated since the 2009 survey. Small circular depth increases were seen to the north and south of the large rectangular depression in the 2009-2010 CAD cell, suggesting the placement of material in these areas. Some slight depth decreases were also seen outside of the 2006 CAD cell.

3.4 Cell Capacity

The NLCAD cells have remaining capacity of approximately 151,830 m^3 (Table 3-1) if filled to within one meter of the surrounding harbor bottom. A complete set of capacity reports is presented in Appendix B.

Table 3-1. Remaining Capacity of New London CAD Cells

Cell ID	Depth of Surrounding Harbor Bottom (m) below MLLW	Remaining Capacity if Filled to within 1 m of Surrounding Harbor Bottom (m^3)
2006	11	27,285
2009-2010 (large rectangular depression in the northern portion of the cell)	12	121,785
2009-2010 (small rectangular depression in the southern portion of the cell)	13	2,761

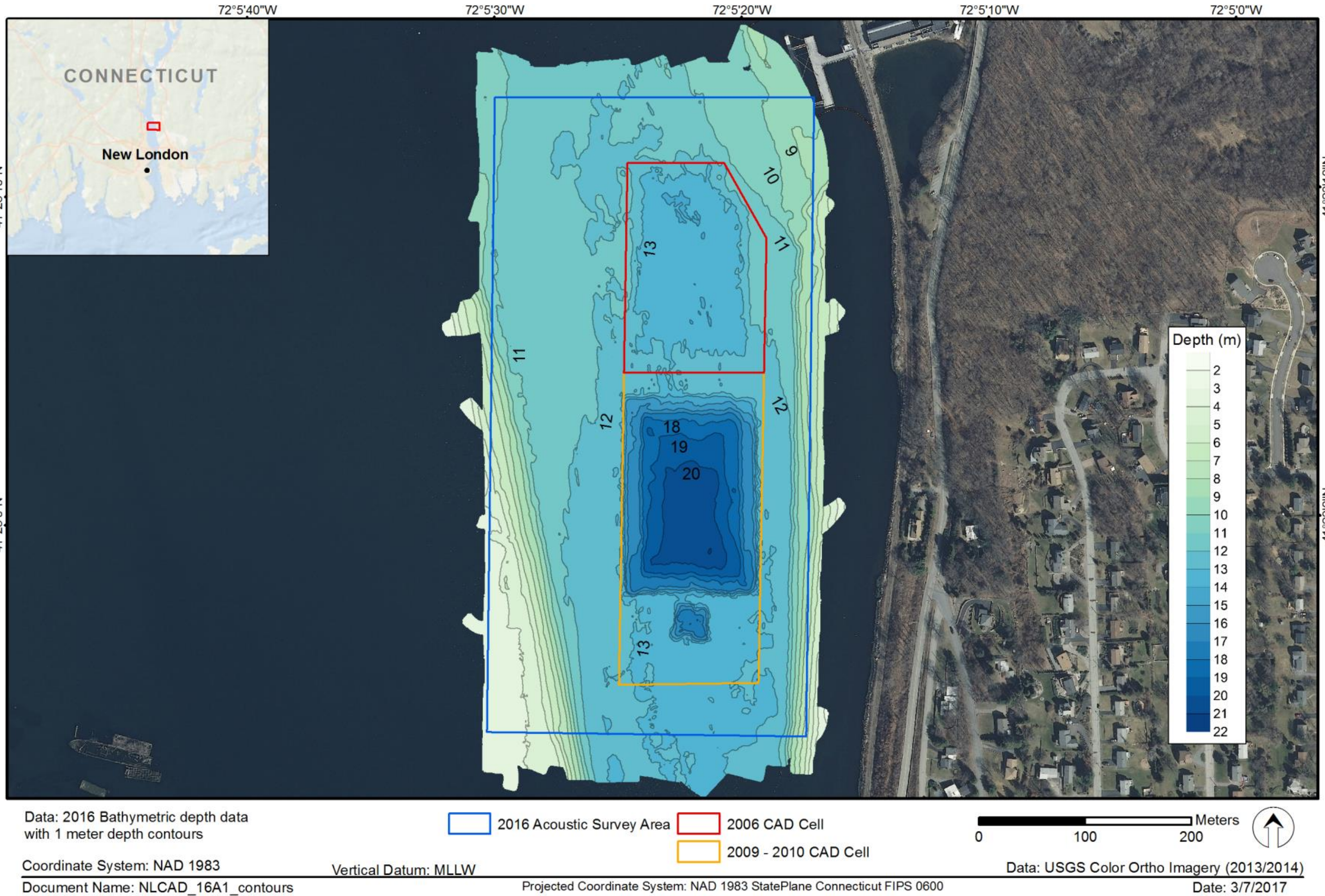


Figure 3-1. Bathymetric contour map of NLCAD Cell Site – November 2016

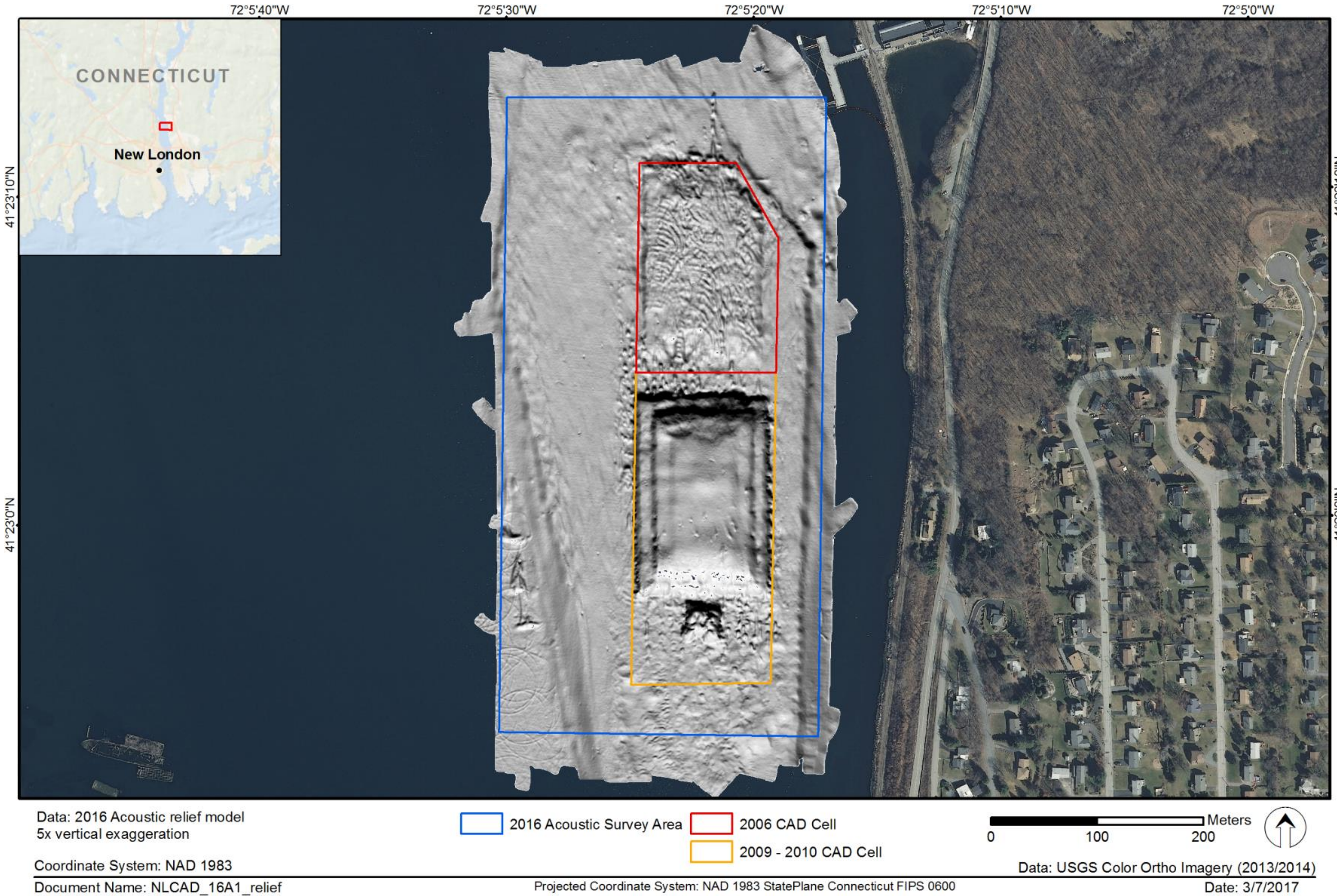


Figure 3-2. Acoustic relief map (hill-shaded) of NLCAD Cell Site – November 2016

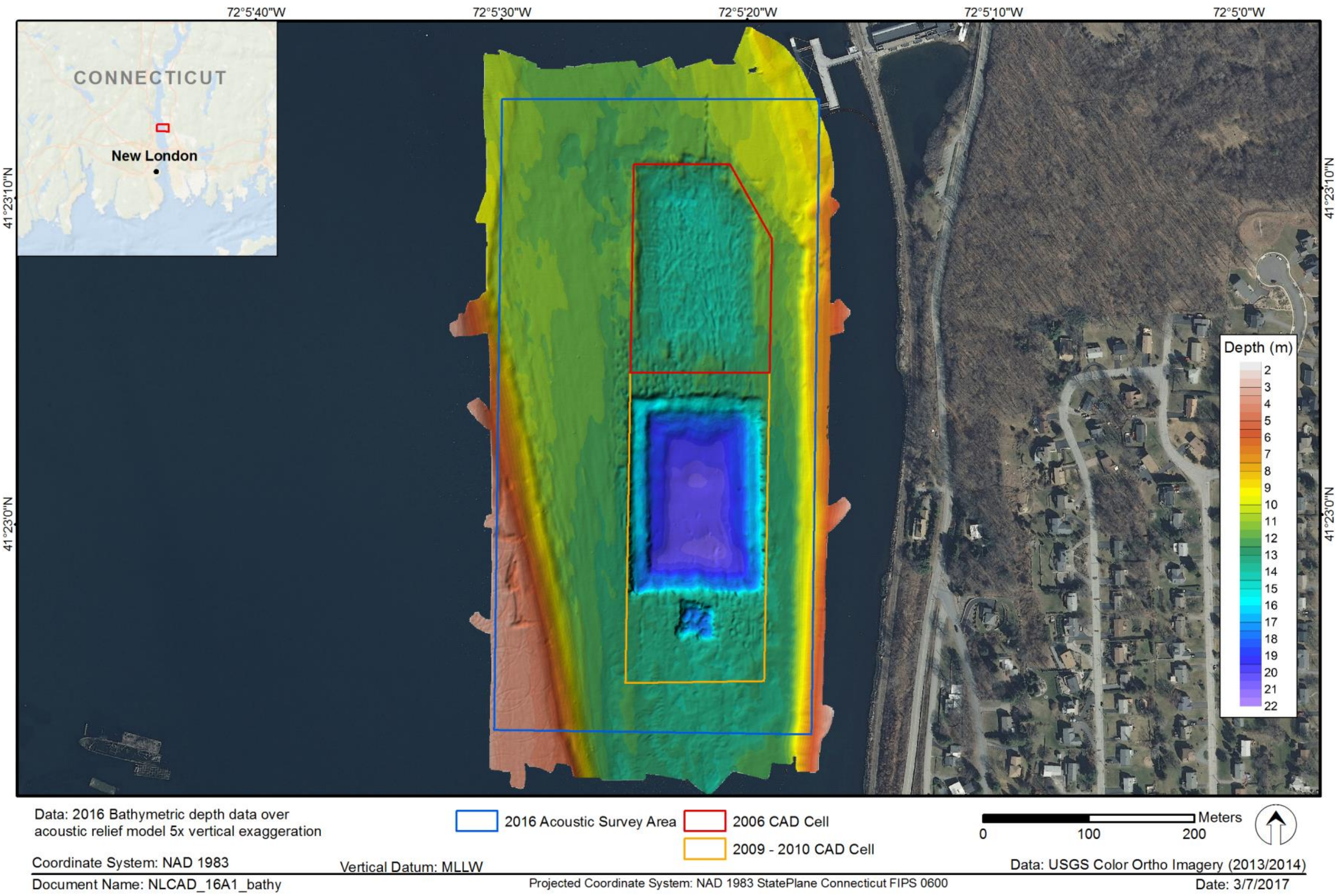


Figure 3-3. Bathymetric depth data over acoustic relief model of NLCAD Cell Site – November 2016

Figure 3-4. Mosaic of unfiltered backscatter data of NLCAD Cell Site – November 2016

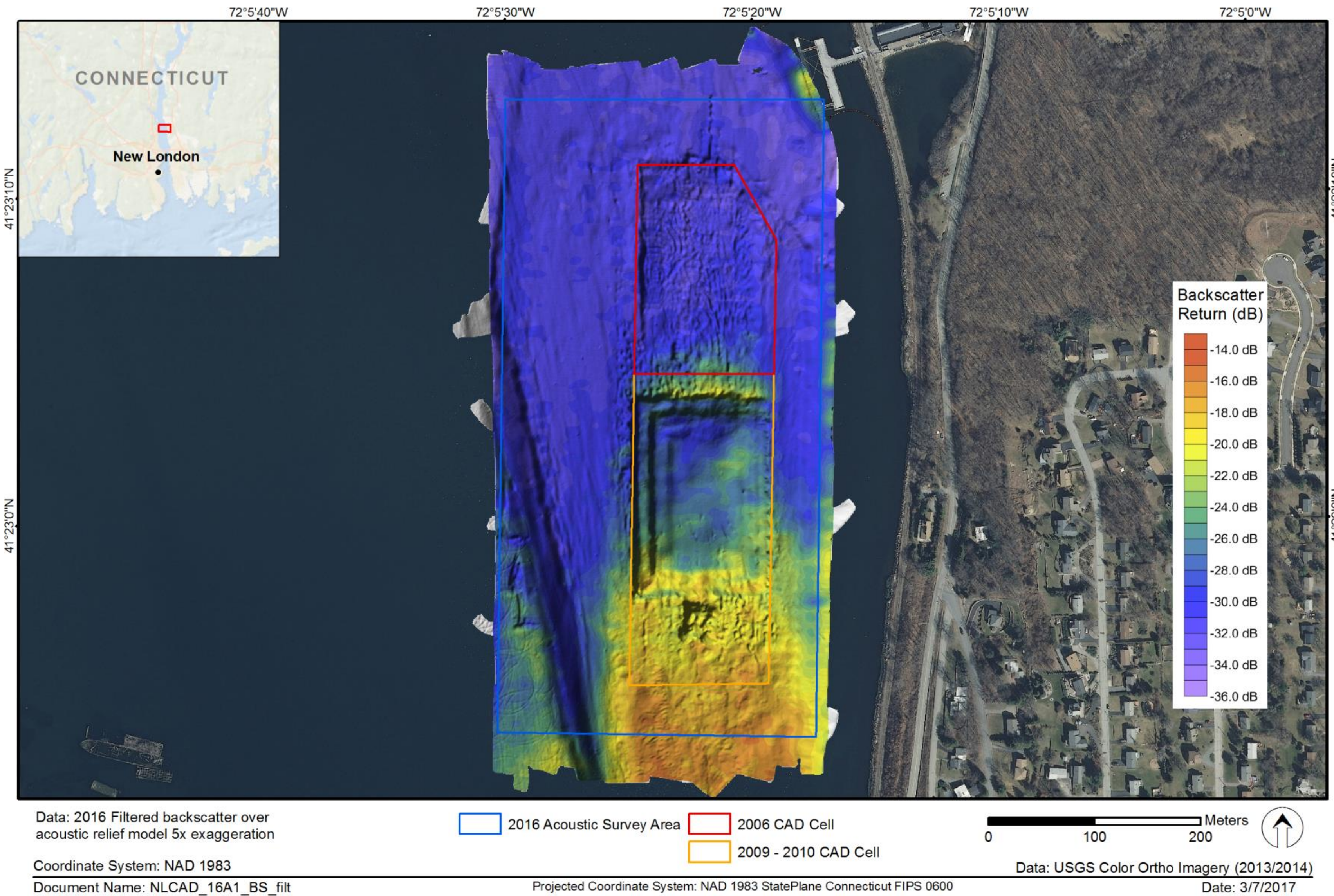


Figure 3-5. Filtered backscatter over acoustic relief model of NLCAD Cell Site – November 2016

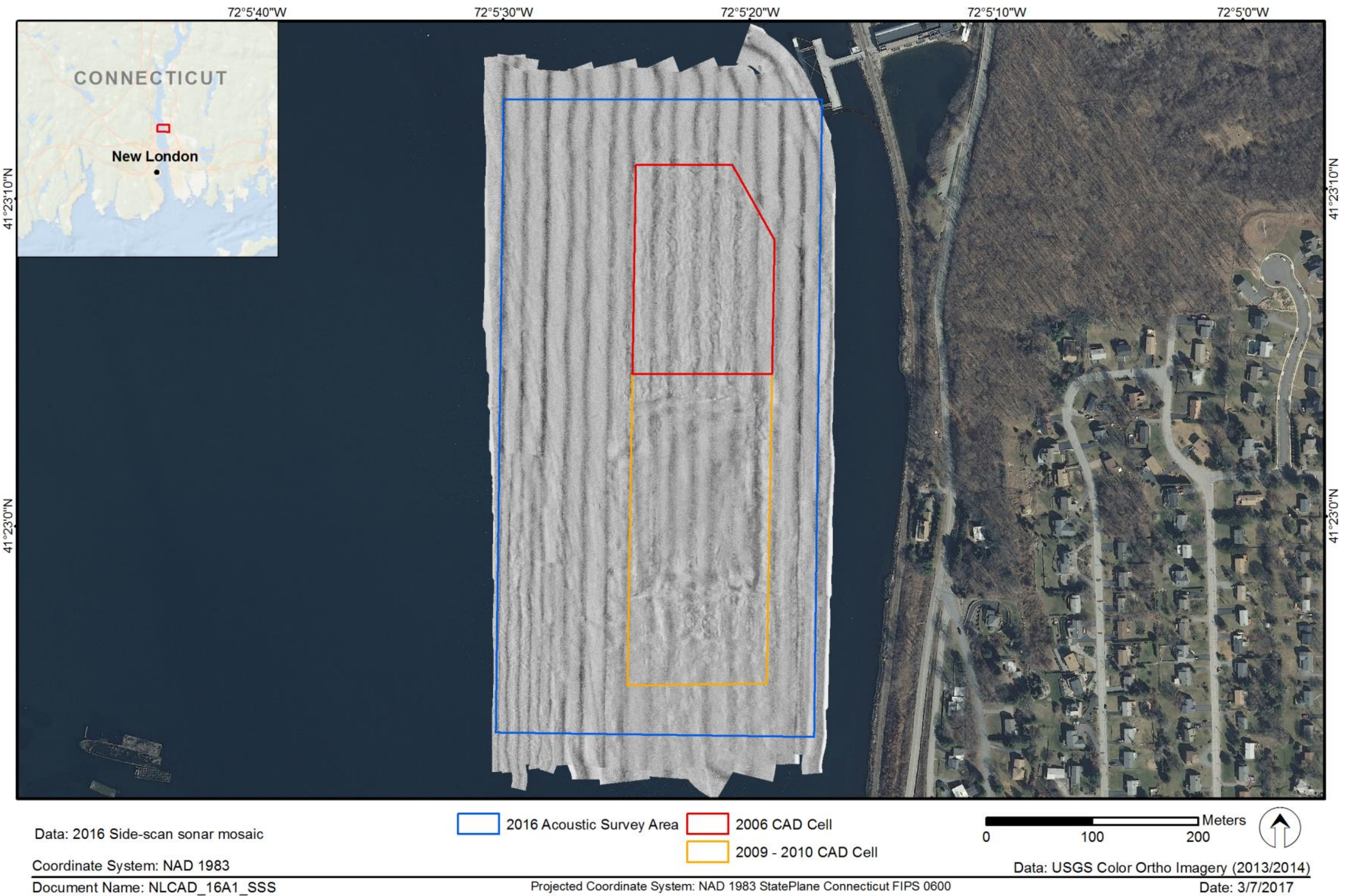


Figure 3-6. Side-scan mosaic of NLCAD Cell Site – November 2016

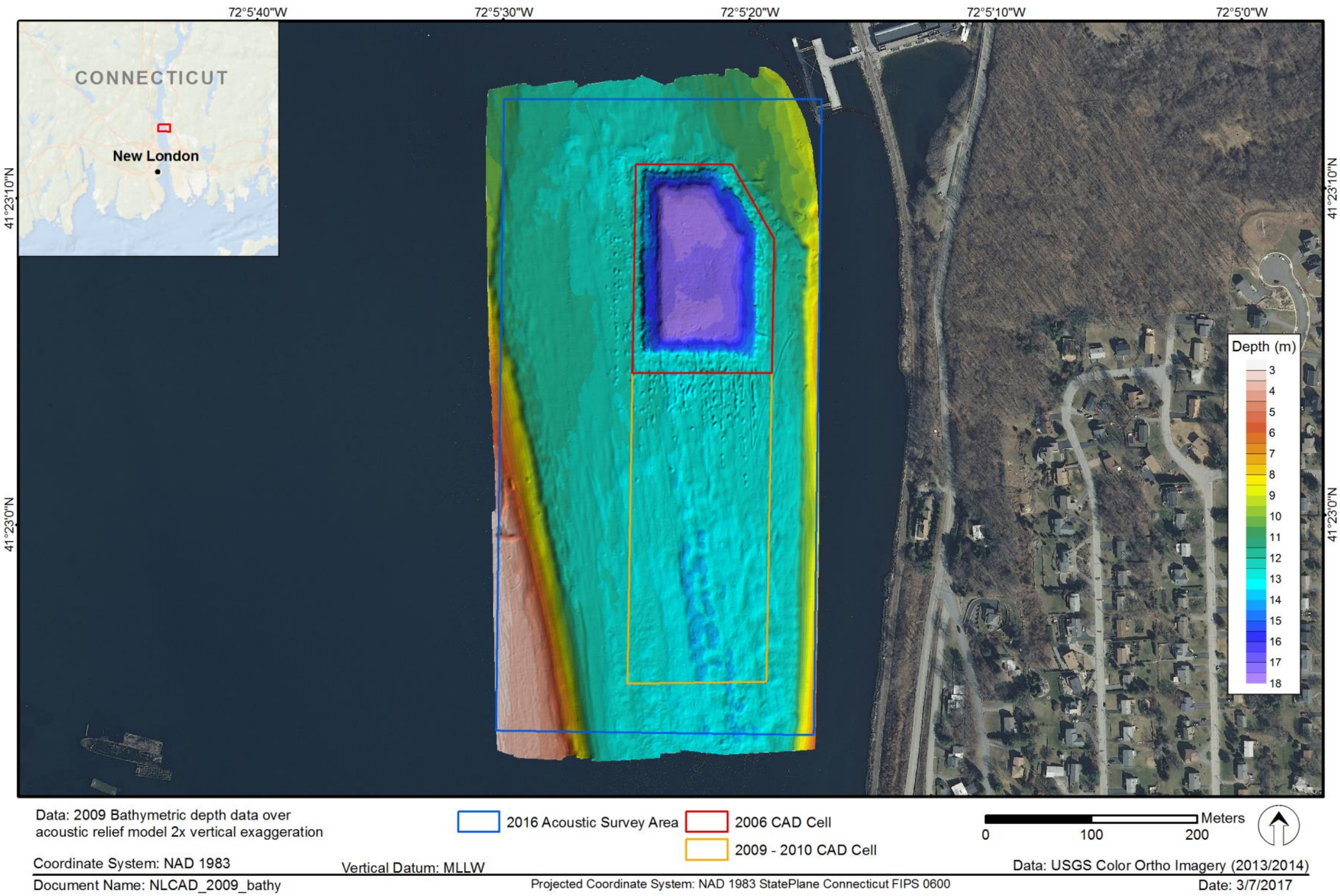


Figure 3-7. Bathymetric depth data over acoustic relief model of NLCAD Cell Site – October 2009

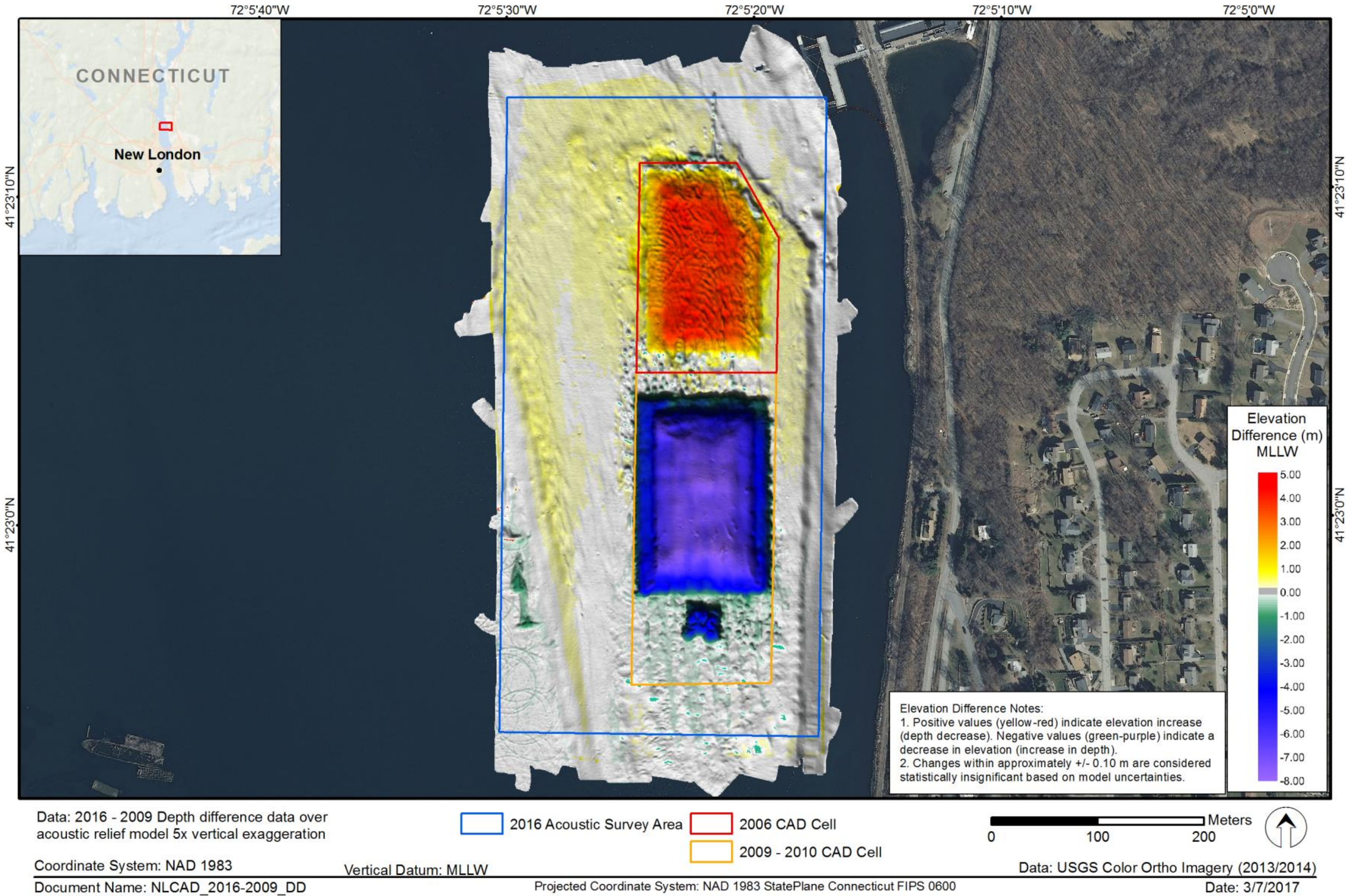


Figure 3-8. NLCAD Cells elevation difference: 2016 vs. 2009

4.0 SUMMARY

The objective of the survey was to:

- Characterize the harbor topography and surficial features over the two existing CAD cells by completing a multibeam bathymetric survey
- Determine remaining cell capacity

Observed surficial features in the survey areas were consistent with dredging and placement activities in and around the CAD cells.

Elevation changes at the New London CAD cells were measured by subtracting the 2009 bathymetric survey data from the 2016 bathymetric survey data.

CAD Cell 2006

- Elevations increased by 0.5 m to 5 m, suggesting that the cell has been filled since the time of the 2009 survey
- Remaining cell capacity if filled to within 1 m of surrounding harbor bottom was 27,285 m^3

CAD Cell 2009-2010

- Elevations decreased consistent with the two rectangular depressions observed in the 2016 bathymetry, suggesting that the cell has been excavated since the 2009 survey
- Remaining cell capacity if both depressions filled to within 1 m of surrounding harbor bottom was 123,546 m^3.

5.0 DATA TRANSMITTAL

Data transmittal to support this data report will be provided as a separate deliverable for inclusion in a Technical Support Notebook. The data submittal will include:

- Scope of Work
- Raw and processed acoustic survey data
- Survey field logs
- Report figures and associated files, including an ArcGIS geo-database
- Electronic copies of all data and final products

6.0 REFERENCES

Battelle. 2015. Quality Assurance Project Plan (QAPP) for the Disposal Area Monitoring Study (DAMOS) Program. Prepared by Battelle, Norwell, MA. Submitted to U.S. Army Corps of Engineers, New England District, Concord, MA, 50 pp.

Fredette, T. J.; French, G. T. 2004. Understanding the physical and environmental consequences of dredged material disposal: history in New England and current perspectives. Mar. Pollut. Bull. 49:93–102.

Germano, J. D.; Rhoads, D. C.; Lunz, J. D. 1994. An Integrated, Tiered Approach to Monitoring and Management of Dredged Material Disposal Sites in the New England Regions. DAMOS Contribution No. 87. U.S. Army Corps of Engineers, New England Division, Waltham, MA, 67 pp.

National Oceanic and Atmospheric Administration (NOAA). 2015. NOS Hydrographic Surveys Specifications and Deliverables. May 2015.

USACE. 2012. Monitoring Surveys of New England CAD Cells, October 2009. DAMOS Contribution No. 185. U.S. Army Corps of Engineers, New England District, Concord, MA, 151 pp.

USACE. 2013. Engineering and Design Hydrographic Surveying. EM1110-2-1003.

APPENDIX A

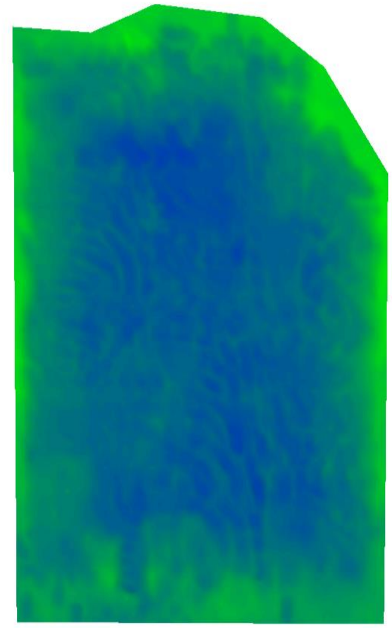
TABLE OF COMMON CONVERSIONS

Metric Unit Conversion to English Unit		English Unit Conversion to Metric Unit	
1 meter 1 m	3.2808 ft	1 foot 1 ft	0.3048 m
1 square meter 1 m^2	10.7639 ft^2	1 square foot 1 ft^2	0.0929 m^2
1 kilometer 1 km	0.6214 mi	1 mile 1 mi	1.6093 km
1 cubic meter 1 m^3	1.3080 yd^3	1 cubic yard 1 yd^3	0.7646 m^3
1 centimeter 1 cm	0.3937 in	1 inch 1 in	2.54 cm

APPENDIX B

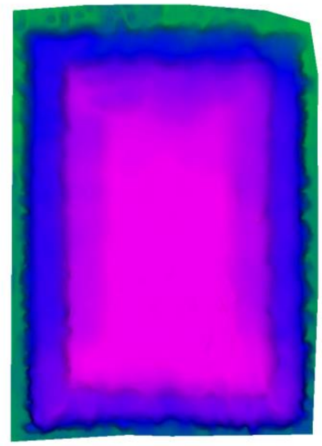
CAPACITY REPORTS FOR NEW LONDON CAD CELL SITE

New London
CAD Cell Capacity Report
CAD Cell: 2006
Level unit: Meter
Volume unit: Cubic Meter
TIN vs Level Volume Totals



Level (MLLW)	Volume Above	Area Above	Volume Below	Area Below
-11	0	0	50,203	23,551
-11.2	1	16	45,494	23,534
-11.4	18	212	40,801	23,339
-11.6	115	727	36,188	22,824
-11.8	315	1,302	31,678	22,249
-12	633	1,878	**27,285**	21,673
-12.2	1,067	2,469	23,009	21,082
-12.4	1,631	3,262	18,863	20,289
-12.6	2,404	4,527	14,926	19,024
-12.8	3,461	6,073	11,273	17,477
-13	4,880	8,288	7,981	15,263
-13.2	6,809	10,940	5,200	12,611
-13.4	9,239	13,289	2,920	10,262
-13.6	12,192	16,748	1,163	6,802
-13.8	16,013	21,233	274	2,318
-14	20,488	23,096	39	455
-14.2	25,160	23,526	0	25
-14.4	29,870	23,551	0	0

New London
CAD Cell Capacity Report
CAD Cell: 2009-2010 North Cell
(large rectangular depression in the northern portion of the cell)



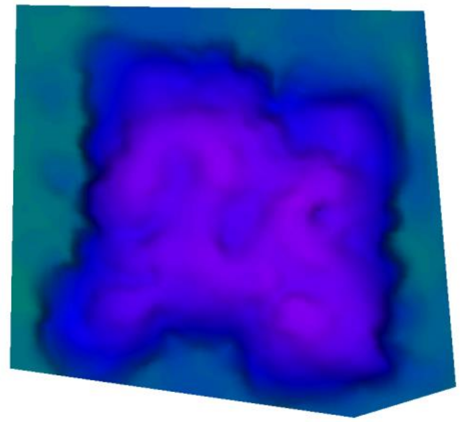
Level unit: Meter
Volume unit: Cubic Meter
TIN vs Level Volume Totals

Level (MLLW)	Volume Above	Area Above	Volume Below	Area Below
-12	0	0	148,536	27,467
-12.2	0	1	143,042	27,466
-12.4	11	170	137,560	27,297
-12.6	104	831	132,159	26,636
-12.8	336	1,488	126,898	25,979
-13	717	2,313	**121,785**	25,154
-13.2	1,237	2,843	116,812	24,624
-13.4	1,846	3,232	111,927	24,235
-13.6	2,523	3,533	107,111	23,934
-13.8	3,259	3,833	102,354	23,634
-14	4,058	4,148	97,659	23,319
-14.2	4,918	4,450	93,026	23,017
-14.4	5,837	4,741	88,451	22,726
-14.6	6,814	5,032	83,935	22,435
-14.8	7,851	5,336	79,478	22,131
-15	8,951	5,677	75,085	21,790
-15.2	10,122	6,025	70,763	21,442
-15.4	11,360	6,355	66,507	21,112
-15.6	12,665	6,703	62,319	20,764
-15.8	14,044	7,102	58,205	20,365
-16	15,514	7,640	54,181	19,827
-16.2	17,098	8,213	50,272	19,254
-16.4	18,798	8,808	46,478	18,659
-16.6	20,641	9,640	42,828	17,827
-16.8	22,657	10,507	39,351	16,960
-17	24,815	11,050	36,016	16,417
-17.2	27,075	11,545	32,782	15,922
-17.4	29,437	12,094	29,650	15,373
-17.6	31,916	12,694	26,635	14,773
-17.8	34,514	13,289	23,740	14,178
-18	37,231	13,870	20,964	13,597
-18.2	40,059	14,420	18,299	13,047
-18.4	43,005	15,038	15,751	12,429
-18.6	46,084	15,806	13,337	11,661

Level (MLLW)	Volume Above	Area Above	Volume Below	Area Below
-18.8	49,338	16,712	11,097	10,756
-19	52,771	17,664	9,037	9,804
-19.2	56,401	18,597	7,174	8,870
-19.4	60,196	19,352	5,475	8,115
-19.6	64,146	20,165	3,932	7,302
-19.8	68,279	21,233	2,572	6,234
-20	72,651	22,474	1,450	4,993
-20.2	77,330	24,524	635	2,944
-20.4	82,430	26,139	242	1,328
-20.6	87,742	26,939	60	528
-20.8	93,184	27,361	9	106
-21	98,669	27,457	1	10
-21.2	104,162	27,467	0	0

New London
CAD Cell Capacity Report
CAD Cell: 2009-2010 South Cell
(small rectangular depression in the southern portion of the cell)

Level unit: Meter
Volume unit: Cubic Meter
TIN vs Level Volume Totals



Level (MLLW)	Volume Above	Area Above	Volume Below	Area Below
-13	0	0	4,338	1,795
-13.2	0	9	3,979	1,786
-13.4	13	141	3,633	1,654
-13.6	54	271	3,314	1,525
-13.8	123	414	3,024	1,382
-14	219	541	**2,761**	1,255
-14.2	339	639	2,522	1,156
-14.4	472	689	2,296	1,107
-14.6	614	733	2,079	1,062
-14.8	765	776	1,870	1,020
-15	924	818	1,671	977
-15.2	1,092	860	1,480	935
-15.4	1,268	903	1,297	892
-15.6	1,454	951	1,123	845
-15.8	1,649	998	959	798
-16	1,853	1,046	804	750
-16.2	2,067	1,100	659	695
-16.4	2,293	1,156	526	639
-16.6	2,530	1,215	404	580
-16.8	2,779	1,277	294	518
-17	3,041	1,343	197	452
-17.2	3,318	1,434	115	362
-17.4	3,616	1,545	53	250
-17.6	3,938	1,673	17	123
-17.8	4,283	1,760	2	35
-18	4,640	1,794	0	1
-18.2	4,999	1,795	0	0