Phase V Status & Remedial Monitoring Report

RTN 4-3024222
Former Bird Machine Company Site
Walpole, Massachusetts

Prepared for:

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ACRONYMS

AMEC	AMEC Environment & Infrastructure, Inc.
bgs	Below ground surface
BHI	Baker Hughes Inc.
BMC	Bird Machine Company
BWSC	Bureau of Waste Site Cleanup
CAM	Compendium of Analytical Methods
cfs	Cubic feet per second
CMR	Code of Massachusetts Regulations
COC	Contaminants of Concern
CSA	Comprehensive Site Assessment
cVOC	Chlorinated Volatile Organic Compounds
DCB	1,4-dichlorobenzene
DCE	Dichloroethene
DDA	Demolition Debris Area
DO	Dissolved Oxygen
EPC	Exposure Point Concentration
EPH	Extractable Petroleum Hydrocarbons
Fe2	Ferrous Iron
FIR	Final Inspection Report (310 CMR 40.0878)
ft	Feet
H&S	Health and Safety
HASP	Health and Safety Plan
HSM	Health and Safety Manager
ISCO	In-Situ Chemical Oxidation
LRA3	Lead Release Area 3
LSP	Licensed Site Professional
MassDEP	Massachusetts Department of Environmental Protection
MBA	Manufacturing Building Area
MCP	Massachusetts Contingency Plan
mg/kg	Milligrams per kilogram
mg/L	Milligrams per liter
MMCL	Massachusetts Maximum Contaminant Level for drinking water
MNA	Monitored Natural Attenuation
mV	Millivolts
NAPL	Non-aqueous phase liquid
ND	Not Detected by laboratory analysis
NSR	No Significant Risk
OHM	Oil or Hazardous Material
OMM	Operation, Maintenance, and Monitoring
ORP	Oxidation-Reduction Potential
OSHA	U.S. Occupational Safety & Health Administration
OSWER	U.S Office of Solid Waste and Emergency Response

ACRONYMS (continued)

P&T	Pump and Treat
PID	Photoionization Detector
ppb	Parts per billion (for groundwater, micrograms per liter)
PPE	Personnel Protective Equipment
RAM	Release Abatement Measure
RAP	Remedial Action Plan
RC	Reportable Concentration
RD	Reductive Dechlorination
RMR	Remedial Monitoring Report
ROS	Remedy Operation Status
RTN	Release Tracking Number
SRS	South Rail Spur
SSO	Site Safety Officer
SVOC	Semivolatile Organic Compound
TCB	1,2,4-Trichlorobenzene
TCE	Trichloroethene
USEPA	United States Environmental Protection Agency
USGS	U.S. Geological Survey
VC	Vinyl Chloride
VOC	Volatile Organic Compounds
Weston	Weston Solutions, Inc.

Executive Summary

On behalf of Baker Hughes, Inc. (BHI), Amec Foster Wheeler Environment & Infrastructure, Inc. (Amec Foster Wheeler), formerly AMEC Environment & Infrastructure, Inc. (AMEC), completed this Phase V Status and Remedial Monitoring Report (RMR) for the former Bird Machine Company (BMC) Site located in Walpole, Massachusetts. BHI is submitting this RMR pursuant to 310 CMR 40.0890 of the Massachusetts Contingency Plan (MCP). This RMR documents the operation of a Comprehensive Remedial Action that is expected to be a Permanent Solution for the Site, and that was installed as described in the Phase IV Final Inspection Report (FIR; AMEC 2012). A Permanent Solution will achieve a condition of No Significant Risk (NSR) for current and reasonably foreseeable site uses. As documented in the Class C-2 Response Action Outcome (RAO) Statement submitted to the Massachusetts Department of Environmental Protection (MassDEP) on December 16, 2011, the Site already achieves the requirements of a Temporary Solution (AMEC 2011a).

Release Abatement Measures (RAMs) have been conducted at several locations between 2005 and 2011 to reduce the mass and concentrations of contaminants at the Site. The Phase II Comprehensive Site Assessment (CSA) reports (AMEC 2011b, AMEC 2011c) indicate that a condition of NSR exists for all areas of the Site except groundwater, where some monitoring well concentrations exceed drinking water criteria (Massachusetts Maximum Contaminant Levels or MMCLs). It is unlikely that groundwater at the Site will be used for drinking water, but the Site is within a Potential Drinking Water Source Area designated by the Town of Walpole (Walpole 2007). Considering this designation, groundwater at the Site is categorized as GW-1 under the MCP. The CSA reports found no current pathway between Site contaminants and the Town's water supply wells to the northeast, but the potential for contaminant movement from a portion of the Site warrants further monitoring. Background information including a description of RAMs and Site characteristics is summarized in Section 1 of this RMR.

Areas of groundwater contamination exceeding MMCLs have been identified for arsenic, chlorinated Volatile Organic Compounds (cVOCs), and 1,4-dichlorobenzene (DCB). A Monitored Natural Attenuation (MNA) remedy consisting of active monitoring of natural processes was selected to achieve cleanup goals, and was installed in accordance with Phase IV of the MCP. MNA is considered an Active Remedial Monitoring Program under the MCP and has been designed and constructed to provide a Permanent Solution that achieves a condition of NSR, as described in the FIR (AMEC 2012).

The August 2013 Phase V Status and Remedial Monitoring Report (RMR; AMEC 2013) coincided with one year of initial process monitoring as described in the FIR (AMEC 2012). At that time, it was determined that initial process monitoring had confirmed that key MNA processes were underway and a transition to long-term performance monitoring was appropriate. Long-term monitoring is designed to confirm that site conditions remain suitable for MNA, and that overall contaminant concentrations and mass are decreasing within a reasonable timeframe.

The long-term monitoring program includes continued quarterly sampling at six locations within the plumes that have had significant fluctuations in recent contaminant concentrations above the MMCLs. Semiannual sampling is performed for nine other wells within the horizontal and vertical extent of the plume areas where previous quarterly sampling shows little variation in concentrations. Annual sampling is performed for 23 wells along the plume lateral or vertical edges where concentrations are below MMCLs. Analytes for long-term monitoring consists of the contaminants exceeding MMCLs and their primary breakdown products. The current OMM program for long-term monitoring is summarized in **Table 1**.

Wells sampled during the March 2015 round included the subset of wells sampled on a quarterly basis. Wells sampled during the June 2015 round included the subset of wells sampled on a quarterly, semi-annual, and annual basis.

Section 1 of this report provides background information for the site. Section 2 describes monitoring procedures, and Section 3 documents any modifications from the plans presented in the FIR. Section 4 of this RMR provides monitoring results and evaluations of MNA effectiveness, and Section 5 includes an updated Conceptual Site Model (CSM) and recommendations for future monitoring. This RMR documents that a remedial monitoring well network to support an Active Remedial Monitoring Program is being operated in accordance with the plans and specifications presented in the FIR.

1.0 Site Background

Amec Foster Wheeler completed this Phase V Status Report & RMR for the former BMC Site located in Walpole, Massachusetts on behalf of BHI. This document is submitted pursuant to 310 CMR 40.0892 of the MCP. This Report documents operation and implementation of MNA, an Active Remedial Monitoring Program, which is the selected Permanent Solution for the Site. The Site location is indicated in **Figure 1**, and following is general information pertaining to the MCP status.

Release Tracking Number (RTN):	RTN 4-3024222
Tier Classification:	Tier IB
Site Address:	100 Neponset Street Walpole, Massachusetts 02071-1037
Person Undertaking Response Actions:	Baker Process Inc. 2929 Allen Pkwy Ste 2100 Houston TX 77019-7111 Contact: Mr. Chris Clodfelter Phone: 713-439-8329
Licensed Site Professional:	Kim M. Henry, LSP (License # 7122) Amec Foster Wheeler Environment & Infrastructure, Inc. 271 Mill Road Chelmsford, Massachusetts 01824 Phone: 978-692-9090

A Tier 1B Permit Application was submitted to the MassDEP on January 10, 2008, including a revised Tier Classification and updated Phase I information combining several linked sites under the subject RTN. Tier 1B permit #W204776 for this RTN was effective on February 28, 2008, and expired on February 28, 2013. Because Remedy Operation Status (ROS; AMEC, 2013b) was achieved and a ROS Opinion filed with the MassDEP on February 13, 2013, renewal of the permit was not required under the MCP.

This RMR is organized as follows:

- Section 1 – Site Background
- Section 2 – Operation, Maintenance, and Monitoring
- Section 3 – OMM Modifications Since the Preceding Report
- Section 4 – Evaluation of Effectiveness
- Section 5 – Recommendations and Updated CSM
- Section 6 – References

The remainder of Section 1 summarizes site characteristics, release history, and response actions. Section 2 describes monitoring procedures, and Section 3 documents any modifications from the plans presented in the FIR. Section 4 provides monitoring results and evaluations of MNA effectiveness, and Section 5 includes an updated CSM and recommendations for future monitoring. Section 6 provides references for this report.

1.1 Disposal Site Description

The Site, defined in the MCP as the area where the release "has come to be located," is in the central portion of the 108-acre Property. The approximate universal transverse mercator coordinates for the Site are 4,664,600 North and 312,700 East (World Geodetic System 1984/North American Datum 1983), based on the United States Geological Survey (USGS) Franklin Quadrangle Map, 1987. The Site Location Map, **Figure 1**, shows the regional location of the Site and positions of the nearest municipal water supply wells. Access to the property and Site is obtained via Neponset Street; this road and other Site features are depicted on an aerial photo in **Figure 2**. The Neponset River flows around the Site from the south to the northeast. Ruckaduck Pond is located to the west and was formerly used for water power, with dams maintaining an elevation several feet above the downstream river. An outlet from Ruckaduck Pond (formerly used to power a turbine) traverses the Site through an underground pipe, returning to the river on the east side.

As documented in the Phase II CSA, historical maps [including Sanborn Library, LLC Fire Insurance (Sanborn) Maps] were reviewed to determine the previous owner/operators of the property and the operations history. The Property appears to have been developed by 1832 with a "shingle mill" and two houses south of the Site, and a small pond in the present location of Ruckaduck Pond. A map dated 1852 indicates "Smith’s Mill" and three houses in the same area. A map dated 1888 indicates the Walpole Emery Mill in the same area, and Old Colony Railroad in its present location along the western edge of the Site. Sanborn maps from 1918 indicate that a railroad spur and three "factory" buildings had been constructed, and an open channel or “tailrace” had been constructed downstream of one of the factory buildings to convey water used for powering machinery back to the Neponset River. The BMC reportedly started operations at the property in 1919.

The 1927 and 1944 Sanborn Fire Insurance Maps indicate larger industrial buildings at the property, including a machine shop, casting shed, lumber shed, assembling, welding shop, and office. A 1940 USGS Topographic Map contains more detailed topography in the vicinity of the Site, indicates the boundary of the Cedar Swamp, and shows Cedar Swamp Brook. Historical aerial photographs and facility plans from 1931 to 1978 indicate that the Neponset River was rerouted at different times to facilitate the expansion of buildings and the addition of new ones. The open tailrace channel was filled in and replaced with a buried 24-inch concrete pipe in 1966. The industrial buildings on the Property were expanded several times in the 1960s and 1970s.

BMC primarily manufactured and repaired industrial centrifuges on the Property. BHI acquired BMC in 1989. BMC became an operating unit within Baker Process, Inc., a wholly-owned subsidiary of Baker Hughes Incorporated. Baker Hughes Process Systems, Inc. is the present owner of the Property. Manufacturing operations at the Property were discontinued in 2004, and most buildings associated with the former BMC were demolished by 2008. There is typically one worker at the Property, a security guard. Current human receptors at the Site are limited to occasional trespassers. The Property is zoned Limited Manufacturing, which allows a wide range of commercial, institutional, and residential uses. The Property is also grandfathered for industrial use.

Existing site features are indicated in **Figure 3** and include: a fire pump house (building no. 9), garage (19), and guard shack (21); floors and frost walls of demolished buildings 1, 3, 5, 20, 22, and 23; frost walls of demolished buildings 4, 4A, 6A, 7A, 8, 8A, 12, and 15; and pavement around the former buildings except where it was removed for RAM excavations. Figure 3 also shows remaining subsurface drains that lead to outfalls in the Neponset River. These drains were connected to the former buildings (roof drains or sanitary lines) or to surface catch basins, a few of which still remain as indicated in the figure. Note that the drain line connecting the pond and the river was installed within a former masonry-lined tail race; the masonry was observed in place near the southeast wall of former building 1 during building demolitions, and may still exist on either side of the drain in other areas. Figure 3 shows several subsurface structures which were left in place following building demolition: a 10,000-gallon concrete wastewater sump that was cleaned and filled with sand; several sections of Transite pipe encased in concrete; a 5,000-gallon steel wastewater tank that was closed in place near former building 4 by filling with concrete; and a reinforced-concrete base for a wastewater pump station adjacent to the 5,000-gallon tank. The RAM excavation areas in Figure 3, and the areas above the structures left in place, have been filled to grade with sandy soil.

The area surrounding the property has a mixture of residential and recreational (undeveloped forests and wetlands) uses. There are 273 residences with an estimated 743 residents located within ½-mile of the Site (Weston, 2005). There are presently no inhabited houses or private water supply wells within 500 feet (ft) of the Site. There are no schools, daycare centers, playgrounds, or parks within 500 ft of the Site. The 1987 USGS Franklin quadrangle map depicts the Boyden School located approximately 0.35 mile southeast of the Property, and 0.5 miles southeast of the Site. The nearest public water supply wells are slightly over 1 mile northeast of the Site as indicated in **Figure 1**.

1.2 Release History and response Actions

The Site includes multiple RTNs due to the discovery of various releases at the property during past investigations. Timing of releases is not well known, and the Site was used for manufacturing from at least 1832 to 2004. The RTNs were linked together to facilitate administrative compliance with MCP requirements. Three exposure areas were identified and evaluated in the October 2011 Phase II CSA Report (AMEC 2011b): the Manufacturing Building Area (MBA), the Lead Release Area 3 (LRA3), and the South Rail Spur (SRS). A separate exposure area was addressed in the December 2011 Phase II CSA Addendum (AMEC 2011c); the Demolition Debris Area (DDA). All four areas are indicated in **Figure 2**. Release Abatement Measures (RAMs) were conducted at several locations within the DDA, MBA, and LRA3 to reduce the mass and concentrations of contaminants at the Site. The CSAs indicate that a condition of No Significant Risk exists for all areas of the Site except groundwater within the MBA, where some monitoring well concentrations exceed drinking water criteria.

The remaining contamination at MBA includes metals (primarily antimony, barium, lead, nickel, and zinc) and Extractable Petroleum Hydrocarbon (EPH) compounds in soil. The concentrations of metals and Semivolatile Organic Compounds (SVOCs) have been reduced significantly by soil excavation RAMs. The remaining elevated concentrations in soil are under and around the former locations of manufacturing buildings. These soil concentrations were found to pose No Significant Risk for current and future foreseeable uses of the Site.

Groundwater sampling indicates that elevated concentrations of arsenic and cVOCs are present in the area adjoining the river downgradient of the manufacturing buildings, and chlorobenzenes in a single well in the North Parking area. Groundwater concentrations in these areas exceed drinking water criteria. The updated extent of these exceedances is provided in Section 4 based on the results of quarterly monitoring. It is unlikely that groundwater at the Site will be used for drinking water, but the Site is within a Potential Drinking Water Source Area designated by the Town of Walpole (Walpole 2007). Considering this designation, groundwater at the Site is categorized as GW-1 under the MCP.

1.3 Hydrogeological Characteristics

The southeastern portion of the Site includes sand and gravel fill in depths of up to 10 feet, generally thickest where the Neponset River was rerouted. Beneath the fill layer, a 5-foot to 10-foot thick silty sand layer is present, which thins to a few feet in the west where bedrock is at a depth of 10 feet or less. The bedrock surface slopes downward to the east and is typically 20 to 30 feet deep near the river. Where bedrock deepens, the silty sand is underlain by a coarser silty sand and gravel in thicknesses of up to 20 feet. Cross sections including the latest contaminant findings are presented in Section 4.

The majority of borings at the Site were not cored into rock, and drilling refusals are generally interpreted as the bedrock surface unless inconsistent with borings that were cored or hammered to confirm rock. A bedrock low of about 45 ft below ground surface (bgs) occurs in the east-center of the Site near monitoring well MW-708. Bedrock cored during the FIR monitoring well installations consisted of two distinct rock types, conglomerate and shale. The interpreted bedrock surface map is provided in **Figure 4**.

Bedrock at MW-702 to the northwest and MW-710 to the east consisted of alternating layers of consolidated to unconsolidated conglomerate containing a mixture of angular to rounded boulders and sand. The layers consisted of approximately 5-foot thick consolidated rock alternating with approximately 3-foot thick unconsolidated boulders and sand. These alternating layers are consistent with highly fractured and weathered conglomerate material having been repeatedly faulted and folded. Bedrock at MW-708, a few hundred feet west of MW-710, consisted of slightly weathered shale in approximately 2-centimeter thick bedding layers. These layers were oriented vertically, suggesting previous faulting and folding in the area.

The water table beneath the Site occurs approximately 3 to 5 ft bgs in either fill or sand. Bedrock is believed to impede vertical flow as it is generally less transmissive than the shallow sand aquifer, depending on competency. Groundwater in the sand aquifer appears to be discharging to the Neponset River or its associated wetlands during much of the year. The water table in the areas adjacent to the River is less than 1 foot bgs. The horizontal direction of groundwater flow is toward the River from both sides. The vertical direction of flow is upward, discharging to the River. Vertical flow in the vicinity of Ruckaduck Pond is expected to be downward since the dam impounds surface water at an elevation above the water table. Mapped shallow and deep piezometric surfaces for the recent quarterly monitoring events are presented in Section 4.

Groundwater flow directions in specific areas of the MBA vary depending on water table conditions. Groundwater elevations were mapped for monitoring events in October 2006, July 2008, and April 2009 in the Remedial Action Plan (RAP; AMEC 2011d), and based on river flow records these three times appear to represent a range of typical median, low, and high water tables, respectively. Significant changes in the water table surface are apparent between the three events, particularly in the southeast portion of the Site. Aside from precipitation and river flow, another difference between the events was that in 2006 the MBA buildings and pavement were still intact; while in 2007 the buildings were demolished and some pavement removed resulting in the present Site conditions. Removal of the impervious structures may have affected infiltration patterns. Lateral groundwater seepage velocities in the sandy soils are estimated to range between 0.1 and 0.9 feet per day in the MBA, based on these three mapped events.

2.0 Operation, Maintenance, and Monitoring [310 CMR 40.0892(2)(A)]

The MNA remedy consists of an Active Remedial Monitoring Program as defined at 310 CMR 40.0006. The type and frequency of Operation, Maintenance, and Monitoring (OMM) under this program are summarized in the following sub-sections.

2.1 Monitoring Network Design and Operation

The locations of monitoring wells are indicated in **Figure 5**. Initial process monitoring was conducted in the first year of OMM (August 2012 – August 2013) through quarterly sampling and measurements of water levels in the monitoring wells and river. Analytical parameters for the current reporting period are summarized in **Table 2**. Monitoring well road boxes and protective covers will be inspected and maintained as needed during sampling events. Monitoring wells will be redeveloped if needed based on observations during purging and sampling.

Groundwater sampling at wells and temporary screens is performed with low-flow sampling techniques using a peristaltic pump. The pump is equipped with dedicated polyethylene tubing. The pump intake is lowered slowly into the well to the approximate center of the saturated screen section, and remains at least two feet above the bottom of the well to prevent the disturbance of any sediment which may be present. The water level is measured and recorded before starting the pump. Sampling records from previously sampled wells are reviewed in order to determine initial flow rates, or purging will be started at flow rates of approximately 0.2 to 0.5 liters per minute. The flow rate is adjusted to ensure that little or no drawdown (less than 0.3 feet) occurs in the well. If this level of drawdown cannot be sustained, the pumping rate is reduced to the minimum capabilities of the pump to avoid pumping the well dry. The level of the water is not allowed to drop below the intake on the pump to avoid the possible entrainment of air into the sample. If the recharge rate is very low, sampling commences as soon as the well has recharged to a sufficient level to purge one system volume (volume of pump and tubing) and then the appropriate volume of sample is collected.

During the purging of the well, the field parameters (pH, temperature, conductivity, dissolved oxygen, redox potential and turbidity) are monitored every 3 to 5 minutes, or as appropriate, using a flow-through cell, until the parameters stabilize. Field parameters are considered stabilized when, for three consecutive readings, the temperature is within ± 3%, pH is within ± 0.1, dissolved oxygen is within ± 10% or changes less than 0.3 mg/L, redox potential is within ± 10 mV, conductivity is within ± 3%, and turbidity is within ± 10%. An attempt is made to purge the well until turbidity of the purged water is less than 5 nephelometric turbidity units (ntu).

After purging is completed, groundwater samples are pumped directly into the proper sample containers. All sample containers are filled by allowing the pump discharge to flow gently down the inside of the container with minimal turbulence. Samples requiring dissolved constituent analysis are collected by pumping water through a new 0.45 µm filter into the appropriate sample container using a peristaltic pump and new silicone tubing. Sample containers, preservatives, volumes, hold times, and shipping requirements are summarized in **Table 2**. Each sample is labeled and placed into a cooler with ice for shipment to the laboratory. Sampling activities are documented using pre-printed field data sheets to record well purging and any field screening results. Purge water is collected until sampling is complete, then returned to the monitoring well in accordance with the MCP.

2.2 Control of OHM Spills and Accidents

Site activities consist of groundwater sampling and analysis and water table measurements. Limited amounts of Oil or Hazardous Material (OHM) are associated with these activities, mainly consisting of petroleum or lubricants in vehicles or generators. Equipment containing OHM is operated in paved areas to the extent possible. Safe engineering and construction practices are implemented during for all phases of work, as described in the Health and Safety Plan in the FIR.

Spills of OHM will be reported and addressed in accordance with the MCP. Any impacted material resulting from a spill of machine oil or other hazardous substances will be placed in 55-gallon waste disposal drums or other approved containers for waste characterization, off-site transportation, and disposal. Equipment that comes in contact with contaminant residuals in soil or groundwater will be decontaminated before leaving the Site. Any wash water used will be managed as described in Section 2.3. No spills of OHM occurred during the current reporting period.

2.3 Waste Management

Minimal soil and water waste are generated during field activities at the site. Excess groundwater collected during sampling is poured back into the boring or well from which it was obtained as required by MassDEP. Development water that cannot be returned to the boring or well, and all decontamination water and spill wastes are containerized and characterized for disposal at a licensed offsite waste facility. When waste is generated from site activities, characterization and disposal are conducted within 90 days of generation.

2.4 Measures to Avoid Adverse Impacts

Field crews periodically traverse and work within wooded and wetland areas east of the Neponset River to sample four monitoring well locations. The well locations are accessed on foot to minimize adverse impacts to these sensitive areas.

2.5 Permits, Licenses and Approvals

No federal permits or approvals are required to implement OMM activities. The work is conducted under the direction of a Licensed Site Professional under the MCP as indicated in Section 1, and is subject to the Public Involvement requirements of the MCP. The public notification letter for this report is provided in **Appendix A**. The BWSC Transmittal Form required under the MCP will be provided in **Appendix B** in the paper copy of this RMR, following final eDEP submittal.

Monitoring well installations within 100-foot wetland buffers and 200-foot Riverfront Area buffers were subject to the wetland protection requirements of the Walpole Conservation Commission and complied with their Order of Conditions. Ongoing site activities, which consist only of monitoring well sampling and gauging, are not subject to Conservation Commission requirements. All waste materials generated during response actions that cannot be reused are transported to appropriately licensed disposal facilities, in accordance with state and federal regulations.

3.0 OMM Modifications Since the Preceding Report [310 CMR 40.0892(3)(B)]

The August 2013 Phase V Status and Remedial Monitoring Report (RMR; AMEC 2013) coincided with one year of initial process monitoring as described in the FIR (AMEC 2012). At that time, it was determined that initial process monitoring had confirmed that key MNA processes were underway and a transition to long-term performance monitoring was appropriate. Long-term monitoring is designed to confirm that site conditions remain suitable for MNA, and that overall contaminant concentrations and mass are decreasing within a reasonable timeframe.

The long-term monitoring program includes continued quarterly sampling at 6 locations within the plumes that have had significant fluctuations in recent contaminant concentrations above the MMCLs. Semiannual sampling is performed for 9 other wells within the horizontal and vertical extent of the plume areas where previous quarterly sampling shows little variation in concentrations. Annual sampling is performed for 23 wells along the plume lateral or vertical edges where concentrations are below MMCLs. Analytes for long-term monitoring consist of the contaminants exceeding MMCLs and their primary breakdown products. The current OMM program for long-term monitoring is summarized in **Table 1**. This semi-annual report documents the seventh and eighth rounds of sampling since the implementation of OMM modifications presented in the August 2013 RMR.

Wells sampled during the March round included the subset of wells sampled on a quarterly basis. Wells sampled during the June round included the subset of wells sampled on a quarterly, semi-annual, and annual basis.

Recommendations for any future modifications, based on the results in Section 4, are provided in Section 5 of this report.

4.0 Evaluations of Effectiveness [310 CMR 40.0892(2)(B)]

MNA is expected to reduce concentrations of contaminants to below drinking water standards in the shallow sand aquifer at the Site, and to achieve or approach background levels. For the purpose of Presumptive Certainty in achieving or approaching background, in accordance with MassDEP Policy WSC-04-160, it is assumed that the background level of arsenic is approached at a level of 5 ppb which is one-half of the MMCL criterion for this contaminant. Similarly for cVOCs and chlorobenzenes, background would be approached at one-half of the MMCL standards: 35 ppb for TCB; 2.5 ppb for PCE, TCE, or DCB; and 1 ppb for VC.

The principal MNA processes are expected to include desorption, dilution, and biodegradation, considering site conditions described in the CSA (AMEC 2011c). The Site has relatively fast groundwater flow with seepage velocities estimated in the range of 37 to 330 ft/yr through sandy material. Neponset River flow is estimated at 200 to 400 times greater than the groundwater discharge, based on estimates in the CSA. Anaerobic conditions and dechlorination products are observed in wells having organic contaminants. Because releases are believed to be at least decades old, plumes of contaminants likely have achieved steady state or declining concentrations. However, source removals in portions of the vadose and saturated zones during 2005 – 2008 may have affected hydrogeology and plume stability in some areas. Therefore, in the absence of any continuing sources, contaminants sorbed to the aquifer matrix are expected to continue desorbing to groundwater, biodegrading (for organics) in the aquifer, and discharging to the river. Plumes appear to be relatively dilute based on low ratios of contaminant maximum concentrations to solubilities (<0.08%), and plume widths are generally less than 200 feet.

MNA effectiveness will be demonstrated through declining contaminant concentrations and reduced plume size within a reasonable timeframe, and persistence of site conditions favorable to MNA processes. Data analysis includes graphic or tabular displays of the following measurements for COCs and geochemical indicators:

- groundwater flow directions
- groundwater and surface water flow rates
- plume extent (horizontal & vertical)
- concentrations versus time

Data analysis includes evaluation of plume stability and loss of contaminant mass, and where possible estimates of remediation times. Evaluation of progress in achieving cleanup goals can be difficult due to subsurface and/or measurement variability, and seasonal or storm-related variations in groundwater movement. Therefore, multiple lines of evidence will be used to reduce uncertainty in evaluating the overall effectiveness. Following the evaluations in this section, the CSM will be updated in Section 5 as needed to ensure that it considers all viable hypotheses for explaining the data.

4.1 Flow Rates

Water table measurements were collected at shallow and deep (above bedrock) wells at the beginning of each monitoring event, on March 25 and June 1, 2015. Shallow and deep water table contours were prepared for these two dates and are provided in **Figures 6 and 7**. Neponset River flows at the nearest stream gauge in Norwood MA are indicated in the right panel of **Figure 8**.

During the March 25, 2015 synoptic water level round, discharge rates in the Neponset River averaged approximately 68 cubic feet per second (cfs), which is 36 cfs below long-term median values for that date. During the June 1, 2015 water level round, discharge rates in the Neponset River increased from 29 cfs to 67 cfs as the day progressed. This increase corresponded with precipitation throughout the day, which totaled 0.27 inches. The average discharge on June 1, 2015 was approximately 39 cfs, only 1 cfs below long-term medial values for that date. While discharge rates for both rounds were slightly below long-term trends, the relative flow rates (in spring compared to summer), were characteristic of seasonal conditions.

The shallow water table measurements in March averaged one to two feet higher in elevation than in June, which correlates with an upward trend in river flows during March and a downward trend in June. The long-term median data in **Figure 8** suggest that river flow is typically increasing in March and is near, or at the annual high. By June river elevations are typically decreasing from the spring high water levels, but have not reached annual low conditions, which are typically observed in July or August.

The latest results show an inflection of the shallow water table downward at MW-714S, which is more pronounced compared to the previous report. The slight mounding of the shallow water table in the area between MB-MW-365 and MW-712S, and the slight downward inflection historically observed at MB-MW-367 were more apparent in March 2015 compared to the June 2015 synoptic gauging rounds. The upward vertical gradient typically observed at MW-714, was measured during the two most recent gauging rounds. This location had a downward vertical gradient observed for the first time during the two preceding synoptic gauging events in September and December 2014. The shallow water table contours in this area may reflect varying degrees of infiltration through surficial fill due to variations in fill material and degree of compaction, or greater infiltration in low areas where runoff ponds.

Lateral hydraulic gradients were calculated for the area between MW-711 and MW-709, which is near the center of the cVOC plume where it discharges to the river. Lateral gradients for shallow wells across the top of the aquifer were 0.018 ft/ft in March and 0.008 ft/ft in June. Lateral gradients for deep wells across the bottom of the aquifer were 0.005 ft/ft in March and 0.003 ft/ft in June.

The lateral seepage velocity was calculated for the bottom of the aquifer in this same area near the center of the cVOC plume, which is the depth where the majority of contaminants are present. The bottom of the aquifer in this area consists of silty sand and gravel, which is comparable to the aquifer material at DD-MW-201 where hydraulic conductivity was measured during the DDA Phase II investigations (Weston 2007a). Based on the above lateral gradients, and the measured hydraulic conductivity of 13 ft/day for silty sand & gravel at DD-MW-201, and assuming an effective porosity of 0.23, the lateral seepage velocity at the bottom of the aquifer in this area is estimated to average 0.21 ft/day for the monitoring period.

Where shallow and deep well couplets are present, the difference in piezometric surfaces were calculated to determine the vertical component of flow between the shallow and deep aquifers. **Figures 6a** and **7a** show the vertical flow direction at shallow and deep well pairs using up and down arrows, or "=" for a neutral flow direction (a difference of 0.04 feet or less). **Figures 6b** and **7b** show vertical component of flow between bedrock and deep overburden wells. In general, water table elevation data obtained from water level measurements from the same date (e.g. same quarterly gauging round) suggest the following vertical flow directions:

- Slight upward flow in the northern part of the site where the aquifer is thinner;
- Upward flow at MW-709 and MW-710 where the cVOC plume discharges to the River;

- Slightly downward flow at LR-MW-122 at the downgradient edge of the arsenic plume; in the central area, except at MW-714 and MW-713; and
- Variable vertical flow in the central portion of the site where infiltration of precipitation affects hydrogeologic conditions.

Where bedrock and deep overburden well couplets exist, the difference in piezometric surfaces was calculated to determine the vertical component of flow between the bedrock and deep overburden aquifers. Measurements obtained during the March and June 2015 synoptic gauging events indicate that upward vertical gradients were present at MW-702B in the north, downward to neutral vertical gradients at MW-708B in the central area, and neutral vertical gradients at MW-710B near the river. During the March gauging round, the piezometric surface in wells screened in bedrock was -0.40 feet at MW-702B (downward vertical flow), 0.25 feet at MW-708B (upward vertical flow), and +0.04 feet at MW-710B (neutral vertical flow), when compared to the head in wells screened in the deep overburden aquifer (**Figure 6b**). During the June gauging round, the piezometric surface in wells screened in bedrock was -0.44 feet at MW-702B (downward vertical flow), -0.01 feet at MW-708B (neutral vertical flow), and 0.00 feet at MW-710B (neutral vertical flow), when compared to wells screened in the deep overburden aquifer (**Figure 7b**).

4.2 Contaminant Extent

This section of the RMR documents the latest findings regarding the extent of groundwater contamination. Sampling logs are provided in **Appendix C**, and complete laboratory results (including non-detects) are provided in tabular form in **Appendix D**. Summaries of detections are provided for COCs in **Table 3**. Table 3 includes recent historic results (since installation of new wells in June 2012) for comparison to the latest results; results from the current reporting period are shown in black font, while older results are shown in grey. Horizontal extents are illustrated in **Figure 9**, and vertical extents are shown in **Figures 10 to 13**.

Evaluations of contaminant concentration trends over time and distance are presented in Section 4.3 and 4.4. The concentrations listed parenthetically in the following text are for the most recent (June 2015) sampling round unless otherwise specified.

4.2.1 Horizontal Extent of Contamination

Wells sampled during the current reporting period encompassed wells sampled on a Quarterly basis (March and June), on a semi-annual basis (June), and on an annual basis (June). Wells sampled during the previous reporting period included those sampled quarterly (September and December), and semi-annually (December).

<u>Chlorobenzene Results</u>

Quarterly sampling and analysis of DCB and TCB was conducted in March and June at MW-702B and NP-MW-601. Annual sampling and analysis of DCB and TCB was conducted in June at MW-700S, MW-701S, MW-702D, NP-MW-602, and NP-MW-603. DCB and TCB detections are summarized below relative to their respective 5 ppb and 70 ppb MMCLs.

- MW-702B; Below the MMCL for DCB (4.7 ppb) and TCB (50 ppb) in March, and DCB (2.2 ppb) and TCB (25 ppb) in June.
- NP-MW-601; Below the MMCL for DCB (3.8 ppb) and TCB (38 ppb) in March, and DCB (3.9 ppb) and TCB (44 ppb) in June.

Sample results from MW-700s, MW-701S, MW-702D, NP-MW-602, and NP-MW-603 were non-detect for DCB and TCB during the current reporting period.

The DCB/TCB plume is centered around wells NP-MW-601 and MW-702. While the overall shape of the plume boundary remains unchanged compared to the previous Phase V Status Report, the DCB/TCB plume boundary on **Figure 9** has been changed to a dashed line to represent chlorobenzene concentrations below the MMCL at MW-702B and NP-MW-601.

In general, chlorobenzene concentrations during the current reporting period were slightly lower than average conditions with no MMCL exceedances. No new detections of chlorobenzenes were observed at monitoring wells outside the horizontal and vertical extent of the chlorobenzene plume, which suggests that the plume is not expanding. The overall downward trend of DCB and TCB at NP-MW-601 and MW-702B over the past several years may indicate that MNA is diminishing the mass of chlorobenzenes and reducing the overall plume size. Temporal trends of chlorobenzene concentrations are discussed in detail in Section 4.3.

<u>Arsenic Results</u>

Quarterly sampling and analysis of arsenic was conducted in March and June at MW-706S. Semi-annual sampling and analysis of arsenic was conducted in June at LR-MW-122. Annual sampling and analysis of arsenic was conducted in June at LR-MW-121, MB-MW-371, MW-703S, and MW-705S. Arsenic detections are summarized below relative to the 10 ppb MMCL:

- MW-706S; Above the MMCL in March (79.9 ppb), below the MMCL in June (2.6 ppb).
- LR-MW-122; Above the MMCL in June (22.7 ppb).
- MB-MW-371; Below the MMCL in June (0.7 ppb).
- MW-703S; Below the MMCL in June (1.6 ppb).

Sample results from LR-MW-121 and MW-705S were non-detect for arsenic during the current reporting period.

The arsenic plume is centered around LR-MW-122, MW-703, and MW-706. The lateral and trailing edges of the plume have been changed to a dashed line on **Figure 9** to represent concentrations below the MMCLs at MW-703S and MW-706S during the June round. Because arsenic concentrations at LR-MW-122 were above the MMCL in June, the leading edge of the plume boundary will remain a solid line to depict this condition.

Except for the spike in arsenic concentrations observed at MW-706S during the March round, arsenic concentrations were typical of long-term trends at wells sampled during the current reporting period. No new detections of arsenic were observed at monitoring wells outside the horizontal and vertical extents of the plume, which suggests that the plume is stable and not expanding. Temporal trends of arsenic concentrations are discussed in detail in Section 4.3.

<u>cVOC Results</u>

Sampling and analysis of cVOCs was conducted in March (quarterly) and June (semi-annually and annually) from the wells shown on Table 1. cVOC detections are summarized below relative to the 5 ppb MMCL for PCE and TCE, and the 2 ppb MMCL for VC:

- MB-MW-362; exceedances of PCE (9.5 ppb) and TCE (11 ppb) during the June round; VC (ND) was below the MMCL.
- MB-MW-374; exceedances of PCE (66 ppb), TCE (15 ppb), and VC (7.8 ppb) in March, and PCE (40 ppb), TCE (16 ppb) and VC (4.9 ppb) in June.
- MW-704S; PCE (3.4 ppb), TCE (1.8 ppb) and VC (ND) all were below the MMCL.

- MW-704D; PCE (1.4 ppb), TCE (ND) and VC (ND) were all below the MMCL during the June round.
- MW-707D; exceedance of PCE (5.3 ppb) during the June round; TCE (3.2 ppb) and VC (1.4 ppb) were below the MMCL.
- MW-709S; exceedances of PCE (110 ppb), TCE (70 ppb), and VC (15 ppb) in March, and PCE (88 ppb), TCE (53 ppb) and VC (10 ppb) in June.
- MW-709D; exceedance of PCE (5.5 ppb) during the June round; TCE (1.8 ppb) and VC (ND) were below the MMCL.
- MW-710S; exceedances of PCE (8.4 ppb) and TCE (5.9 ppb) during the June round; VC (1.2 ppb) was below the MMCL.
- MW-710M; exceedances of PCE (11 ppb) and TCE (5.2 ppb) during the June round; VC (ND) was below the MMCL.
- MW-711D; PCE (4.2 ppb), TCE (1.9 ppb) and VC (ND) were all below the MMCL during the June round.
- MW-713S; PCE (ND), TCE (ND) and VC (1.8 ppb) were all below the MMCL during the June round.
- MW-713D; exceedance of PCE (9.2 ppb) during the June round; TCE (4.9 ppb) and VC (ND) were below the MMCL.
- MW-714S; exceedances of PCE (51 ppb), TCE (54 ppb), and VC (3.1 ppb) in March, and TCE (13 ppb) and VC (2.9 ppb) in June. PCE (2.4 ppb) was below the MMCL during the June round.
- MW-714D; PCE (1.3 ppb), TCE (ND) and VC (ND) were all below the MMCL during the June round.

Samples results from LR-MW-124, LR-MW-129, MB-MW-360, MB-MW-361, MB-MW-363, MW-708B, MW-708D, MW-710D, MW-711S, MW-712S, and MW-715S were non-detect for PCE, TCE, and VC during the current reporting period.

There are two cVOC plumes as depicted on **Figure 9**; a smaller plume centered around MW-707, and a large plume centered around MW-704, MW-709, MW-712, and MW-714. The smaller cVOC plume is surrounded by a solid boundary line to represent the PCE exceedance over the MMCL at MW-707. The larger plume is surrounded by a plume boundary line that is dashed where cVOCs are present below the MMCL (i.e. MW-711 and MW-704) and solid where cVOCs exceed the MMCL (i.e. MW-709, MW-713, MW-714S, MB-MW-362).

In general, concentrations of cVOCs observed during the current reporting period were consistent with long-term trends. A noticeable spike in PCE and TCE concentrations were observed at MW-714S during the March round; however by June, concentrations returned to typical conditions. Temporal trends of cVOCs concentrations are discussed in detail in Section 4.3.

4.2.2 Vertical Extent of Contamination

The vertical extent of groundwater contamination is indicated in Figure 10 for DCB, and in Figures 11 to 13 for cVOCs, using cross-sections along the lines indicated in Figure 9. Arsenic extent above the MMCL has been identified as a shallow plume based on monitoring wells and Geoprobe results, as described in the FIR.

DCB results suggest that chlorobenzene contamination above MMCLs is historically present within the relatively thin (12-foot thick) overburden sandy aquifer at monitoring well NP-MW-601, and shallow bedrock well MW-702B. During the current reporting period, the concentration of DCB remained below the MMCL at NP-MW-601 during both the March (3.8 ppb) and June

(3.9ppb) rounds, and at MW-702B during both the March (4.7 ppb) and June (2.2 ppb) sampling rounds. Because TCB and DCB were below the MMCL at MW-702B and NP-MW-601 during the current reporting period, the vertical extent of DCB has been removed from **Figure 10**.

The vertical extents of PCE and other cVOCs are indicated in Figures 11 to 13. The estimated area of cVOCs depicted on **Figure 11** was changed slightly from the previous RMR to represent cVOC concentrations below the MMCL at MW-714 during the June round. Similarly, the estimated area of cVOCs depicted **on Figure 12** and **13** was changed slightly to represent cVOC concentrations below the MMCL at MW-711 during the June round. Note the horizontal scales differ on these cross-sections but the vertical scales are the same. Extent of contamination is drawn to include all well screens where March or June samples had contaminants exceeding the MMCLs. Compared to the depiction in the FIR, the vertical extent is similar in terms of the majority of contamination above MMCLs occurring 10 or more feet below the water table within the site, and surfacing along the eastern edge in the area of the river. The water table elevation has been updated to represent conditions observed during the latest (June 2015) synoptic gauging round.

4.3 Concentrations Over Time

Plots of contaminant concentrations over time at monitoring wells with current or historic MMCL exceedances are presented in **Figures 14 and 15** for DCB/TCB; **Figures 16 and 17** for arsenic; and **Figures 18 to 28** for cVOCs. Note that results for new monitoring wells cover only a three-year duration, therefore limited conclusions regarding trends are possible for these new wells. Additional sampling data will be added to the plots in future semiannual reports. Results are discussed by contaminant type in the following paragraphs.

DCB/TCB measurements are available since June 2006 at NP-MW-601 (**Figure 14**). In general concentrations of DCB and TCB at this well have fluctuated, with the average TCB concentrations below the 70 ppb MMCL, and average DCB concentrations slightly above the 5 ppb MMCL. Concentrations of TCB and DCB were below the 70 ppb and 5 ppb respective MMCLs during the March and June rounds at NP-MW-601.

Concentrations of DCB/TCB have been monitored at MW-702B since June 2012 (**Figure 15**). Since this time, chlorobenzenes have shown a slight overall decrease in concentration, ranging between 25-72 ppb for TCB, and 2.2-7.0 ppb for DCB. The concentrations observed during the June sampling round were the lowest concentrations observed to date for both TCB (25 ppb) and DCB (2.2 ppb), which are below background concentrations.

Arsenic results measurements are available since June 2006 at LR-MW-122 (**Figure 16**), and since June 2012 at MW-706S (**Figure 17**). During this period arsenic has been detected in the range of 1.1 to 22.7 ppb except for August 2006 and July 2010 (34 ppb and 75 ppb, respectively) at LR-MW-122. Arsenic concentrations at this location increased to 22.7 ppb during the June round, from the historic low of 1.1 ppm during the December 2014 round. Since installation in 2012, arsenic concentrations at MW-706S are typically observed near the MMCL, except during the September 2012 (86.6 ppb) and March 2015 (79.9 ppb) rounds. Overall long term trends at both locations show a slight overall decrease in concentration with respect to time.

cVOC measurements are available since June 2007 for LR-MW-129, since July 2008 for MB-MW-362, and since April 2009 for MB-MW-374. Trends of individual cVOC analytes (PCE, TCE, and VC) were generally consistent for a given well, and are plotted on **Figures 18** to **20**. Concentrations of cVOCs in LR-MW-129 declined rapidly over the initial year (2007-2008); and all analytes were not detectable at the laboratory reporting limit for the past several years. Concentrations at MB-MW-362 show a sharp increase between late 2009 and mid-2010, and then a decline to the recent concentrations (PCE = 9.5 ppb and TCE=11 ppb) in June 2015.

Concentrations at MB-MW-374 were near MMCL criteria until mid-2010, then generally increased between mid-2010 and June 2015. Since 2011, PCE has fluctuated between 16 ppb and 72 ppb, TCE between 6 ppb and 16 ppb, and VC between 1.4ppb and 10 ppb. During the June 2015 round at MB-MW-374, concentrations of PCE (40 ppb), TCE (16 ppb) and VC (4.9 ppb) were consistent with average conditions over the past several years.

Concentrations of cVOCs at the new wells with MMCL exceedances generally showed the following trends over the approximate three years of measurements to date, as indicated in **Figures 21-28**:

- Flat with concentrations near MMCL criteria at MW-704S. PCE, the only contaminant with historic concentrations above the MMCL, fell below the MMCL for the first time during the June 2014 (4.8 ppb) monitoring round, and remained below the MMCL during all subsequent rounds, including during the current monitoring period (3.4 ppb in June);
- Fluctuating concentrations above MMCL criteria at MW-709S.
- Flat with concentrations near MMCL criteria at MW-709D;
- Flat with concentrations slightly above MMCL criteria at MW-710S;
- Flat with concentrations slightly above MMCL criteria at MW-710M;
- Slightly increasing then decreasing with concentrations near, to below the MMCL criteria at MW-711D;
- Flat with concentrations near MMCL criteria at MW-713D, with slightly increasing trends for PCE and TCE over the past several monitoring rounds; and
- Sharply fluctuating concentrations of PCE and TCE at MW-714S. PCE concentrations range from ND to 84 ppb, and ND to 54 ppb for TCE. VC has slightly fluctuating concentrations near the MMCL.

4.4 Concentrations Over Distance

Average concentrations of cVOCs were plotted along two potential groundwater flow paths for the recent measurements at new wells. The first flow path is from MW-711D to MW-709 to MW-704, a distance of 290 feet. The results for shallow and deep screens at the latter two locations were averaged; the resulting PCE, TCE, and VC concentrations are presented in **Figures 29, 30, and 31** respectively. Because of recent modifications to the sampling frequency of wells in the monitoring program, concentration vs. distance plots are only displayed for the annual sampling round conducted in June of each year. This also helps to visualize the long-term trends as the continuously increasing number of sampling rounds and data points have recently made these figures difficult to interpret.

Over the length of the MW-711-709-704 flow path, PCE, TCE and VC generally increase in concentration between MW-711 and MW-709, then decline in concentration between MW-709 and MW-704. Since June 2013, the overall shape of the concentration versus distance plot remains consistent, with declining concentrations of cVOCs at each well every year. Concentrations of all three analytes are near the MMCL at both the upgradient and downgradient wells for each event depicted. Excluding the June 2012 rounds, the highest cVOC concentrations are observed at the midpoint of the flow path. Over time, it is expected that PCE, TCE, and VC concentrations will continue to decline with an expected flattening of the concentration versus distance curve as the elevated concentrations at MW-709 continue to degrade and discharge to the Neponset River.

The second flow path is from MB-MW-374 to MW-713D, a distance of 151 feet; the PCE, TCE, and VC concentrations are presented in **Figures 32, 33, and 34** respectively. Again, because of recent modifications to the sampling frequency of wells in the monitoring program and the density of the data points depicted on these figures, concentration vs. distance plots are only displayed for the annual sampling round conducted in June of each year.

The June 2012 data suggests an overall increasing concentration of TCE and VC over this flow path. The three subsequent June sampling events show an overall decreasing concentration of TCE and VC over this same flow path. All four June rounds depicted (2012 through 2015) show an overall decreasing concentration of PCE between MB-MW-374 and MW-713. Concentrations of all three analytes are near the MMCL at the downgradient well for each event.

4.5 Estimates of Mass Loss & Plume Stability

MNA is expected to reduce concentrations of contaminants at this site principally by the processes of desorption, dilution, and biodegradation. These processes are expected to be interrelated, for example increased precipitation may speed both desorption of contaminants from the aquifer matrix to groundwater, and dilution due to greater groundwater discharge to the river and increased surface water flow. Note that an increase in the rate of desorption of contaminants may increase groundwater concentrations in some areas in the short term, as greater mass is being removed from the solid aquifer matrix. Fluctuations in desorption may result from changes in water table elevation or gradient, including preferential flow paths along infrastructure or geologic anomalies below the water table.

Evaluation of contaminant mass loss and plume stability considers the above evaluations of COC extent in Section 4.2 and changes in concentrations over time discussed in Section 4.3. These evaluations also consider the groundwater flow conditions described in Section 4.1, and are presented below by analyte type. Any changes to the Conceptual Site Model (CSM) and MNA program based on this evaluation are indicated below, and summarized in Section 5.

The DCB/TCB plume at NP-MW-601 and MW-702B shows evidence of mass loss based on the presence of daughter products. DCB is an anaerobic degradation intermediate of TCB, and the maxima for both compounds have coincided in time. DO and ORP results have historically been low at these two wells, indicating anaerobic conditions. Recent concentrations of parent and daughter COCs are decreasing, suggesting dilution and degradation processes are continuing to reduce the overall mass of contaminants at this location. Plume shape appears to be stable and is oriented around two wells about 60 feet apart, in line with groundwater flow. No significant changes in groundwater flow conditions were noted for this area. TCB results have recently showed a downward trend at NP-MW-601. If this trend continues, background concentrations of TCB and DCB may consistently be achieved in as little as two to five years; however given longer-term fluctuations, this recent trend may not continue. Pending further results to evaluate this trend, the CSM at this location does not warrant changes. Although only three years of data exist for MW-702B, a downward trend is apparent for both DCB and TCB. TCB and DCB concentrations during the most recent round (June 2015) at MW-702B were below background concentrations. Future forecasting of this trend line at this location suggests that average DCB and TCB concentrations may consistently achieve background concentrations in the next several years. However, this prediction assumes that TCB and DCB concentrations at upgradient well NP-MW-601 does not add significant mass to MW-702B.

Evaluation of the arsenic plume surrounding MW-706S suffers from a relatively short (three year) duration of measurements, but results at this plume center well are consistent with the long-term trends for downgradient well LR-MW-122. Results at both wells indicate that arsenic concentrations may fluctuate from about 80 ppb to levels just below the 10 ppb MMCL criterion, but with the exception of the March 2015 results (79.9 ppb) recently have been around the MMCL. Mass loss is expected as groundwater in the plume area discharges into surface waters of the Neponset River and associated wetlands. Plume shape appears to be stable or thinning and is oriented around two wells about 100 feet apart, in line with groundwater flow. The trailing edge of the plume is depicted as dashed on **Figure 9** to represent concentrations below the MMCL at the upgradient well locations. No significant changes in groundwater flow conditions were noted for this area. Remediation times of five to ten years are expected based on the short-term and long-term fluctuations in concentrations observed at MW-706S and LR-MW-122, respectively. There are no significant changes to the CSM at this location.

The overall cVOC plume shape is unchanged from the previous reporting period. The northern and a portion of the western edge of the plume boundary have been dashed on **Figure 9** to represent current PCE concentrations below the MMCL at the cross- and downgradient ends of the plume. In general, average concentrations of PCE and daughter products have increased at some interior monitoring points (i.e. MB-MW-374) and decreased at others (i.e. MB-MW-362) over the past several years, and appear to be relatively unchanged over much of the plume. A trend of increasing PCE concentration at upgradient well MW-714S that started in late 2012 was interrupted by a significant drop during the September 2013 sampling round, rebounded during the December 2013/January 2014 round, then decreased rapidly again during the first three quarters of 2014. Concentrations of PCE and TCE at this well spiked during the March 2015 sampling round, but returned to average concentrations by June 2015. VC remained stable at this well during the current reporting period. cVOC concentrations for the deep well (MW-714D) at this location have generally remained below the MMCL criteria; TCE and VC were non-detect during the most recent monitoring round, while PCE was detected at a concentration below background.

Additional mass loss is expected as groundwater in the plume area discharges into surface waters of the Neponset River and associated wetlands. Groundwater flow conditions are similar to historical conditions.

5.0 Recommendations and CSM [310 CMR 40.0892(2)(D)]

5.1 Conceptual Site Model

Groundwater data collected during the current reporting period are generally consistent with historic conditions, and do not warrant changes to the Conceptual Site Model. The current CSM for the site is discussed below.

The estimated areas of groundwater contamination exceeding MMCLs are indicated in **Figures 9** and **10-13**. Arsenic contamination is observed at the water table, DCB contamination is near the bottom of a thin (12-foot thick) sand aquifer and in the underlying shallow bedrock, and PCE contamination is in the deepest part of the sand aquifer (up to 35 ft bgs). The Neponset River appears to be a groundwater discharge area based on measured horizontal and vertical gradients around the Site. PCE and TCE have been identified at one monitoring location east of the river, at higher concentrations in the shallow compared to the deep screen, and appear to be discharging to surface water in this area. Sediment and surface water concentrations in the river suggest that the contaminant discharge from groundwater to the river has not resulted in measurable concentrations of contaminants in the river. A CSA completed for the river where it borders the Site found a condition of No Significant Risk for river receptors (Weston 2007b).

The CSAs for the Site (AMEC 2011b, AMEC 2011c) found no current pathway between Site contaminants and the Town's water supply wells located 1.2 miles to the northeast (**Figure 1**), but the potential for movement in this direction warrants monitoring. The town supply wells draw water from surficial sands and gravel above bedrock, in the High Yield (>300 gpm) aquifer mapped by USGS northeast of the Site. The bedrock surface in the supply well area is 62 to 80 feet bgs, compared to 10 to 40 feet bgs at the Site; bedrock slopes downward to the northeast along the river valley. The potential for contaminant migration to the Town's supply wells would appear to be greatest for non-aqueous phase liquid (NAPL) chlorinated organic compounds which are denser than water, but NAPL has not been observed at the Site. The chlorinated organic compounds encountered at the BMC site have been in the dissolved phase rather than NAPL. In this dissolved form the density contrast has no effect on migration, compared to advection, dispersion, and other processes. Dissolved phase concentrations at the BMC site do not suggest the presence of NAPL.

No significant sources of groundwater contaminants are known to remain at the Site. Source control has occurred through soil excavation RAMs in the areas in and upgradient from arsenic and some cVOC groundwater contamination. The RAM around Building 6/6A, upgradient from arsenic detected in LR-MW-122, included the removal of soil having arsenic above background levels. The RAM around Building 7A/7C and LRA 2, upgradient from cVOCs detected in LR-MW-129, included removing soil with metals and oily contamination that was not known to contain cVOCs. Above-ground structures and below-ground tanks associated with former manufacturing operations have been removed as of early 2008, and it is possible that these structures included source materials. Except for arsenic, groundwater contaminants are generally found below the water table, which suggests that there are no continuing releases from the surface or shallow soils.

The installed well network and sampling procedures described in this report meet the design requirements identified in the FIR. Monitoring wells are focused along plume centerlines and discharge areas. Monitoring locations include shallow, deep, and bedrock screens as appropriate to measure changes in nature and extent of contaminants.

5.2 OMM Revisions or Corrective Measures

MNA will be continued as a Permanent Solution if evaluations of site data demonstrate that natural attenuation is occurring at rates that will achieve drinking water standards and approach background levels in a reasonable timeframe. In the RAP, this timeframe was identified as up to 10 years for MNA. Determination of satisfactory reductions in concentrations considers multiple lines of evidence including temporal trends in individual wells, estimates of mass reduction, and distribution of contaminants and geochemical conditions. The data presented in this report indicate that natural attenuation is occurring in the areas of MMCL exceedances. No significant changes in the CSM are warranted based on the latest measurements, and the estimated remediation timeframe of 10 years from 2012 is assumed to be the same.

The August 2013 semiannual RMR coincided with one year of initial process monitoring as described in the FIR (AMEC 2012). Initial process monitoring had confirmed that key MNA processes were underway and that a transition to long-term performance monitoring was appropriate. Long-term monitoring is designed to confirm that site conditions remain suitable for MNA, and that overall contaminant concentrations and mass are decreasing within a reasonable timeframe. This is the third semiannual RMR to be submitted since the long-term monitoring program was implemented. As discussed in Section 3.0, long-term monitoring consists of continued quarterly sampling at six locations within the plumes that have had significant fluctuations in recent contaminant concentrations above the MMCLs. Semiannual sampling is performed for 9 other wells within the horizontal and vertical extent of the plume areas where previous quarterly sampling shows little variation in concentrations. Annual sampling is performed for 23 wells along the plume lateral or vertical edges where concentrations are below MMCLs. Analytes for long-term monitoring consist of the contaminants exceeding MMCLs and their primary breakdown products. The long-term monitoring schedule is presented in **Table 1**. Water levels at all of the monitoring wells, including those sampled on a semi-annual or annual basis, continue to be gauged on a quarterly basis. The results for this monitoring period do not suggest the need for changes to OMM at this time.

If MNA measurements suggest that some portions of the Site will not achieve a Permanent Solution, then supplemental MCP documents for design and construction of contingent remedies will be prepared. The following types of measurements will be considered as evidence of the need for contingent remedies:

- Contaminant concentrations exhibit an increasing trend not expected based on monitoring to date,
- Near-source wells exhibit large concentration increases indicative of a new or renewed release,
- Contaminants are identified in monitoring wells located outside the original plume boundary or other specified compliance boundary,
- Contaminant concentrations are not decreasing at a rate necessary to meet the remediation objectives,
- Changes in land and/or ground-water use will adversely affect the protectiveness of the MNA remedy, and
- Contaminants are identified in locations posing unacceptable risk to human or ecological receptors.

Multiple lines of evidence will be used to determine the need for contingent remedies, to account for the uncertainty associated with variability in subsurface conditions. The evaluations of these types of measurements will be conducted in accordance with USEPA guidance for performance monitoring of MNA (EPA 2004).

5.3 Remedy Operation Status

Remedy Operation Status was achieved in February 2013. Based on the data presented in this RMR and the conclusions summarized in Sections 5.1 and 5.2, MNA is still considered a viable Permanent Solution for the Site and meets the requirements for Remedy Operation Status.

6.0 References

AMEC 2013. Phase V Status and Remedial Monitoring Report, Prepared by AMEC Environment &Infrastructure, Inc. for Baker Hughes Inc. Final, August, 2013.

AMEC 2013a. Phase V Status and Remedial Monitoring Report, Prepared by AMEC Environment &Infrastructure, Inc. for Baker Hughes Inc. Final, August 2013.

AMEC 2013b. Remedy Operation Status Opinion, Former Bird Machine Company Site. Prepared by AMEC Environment &Infrastructure, Inc. for Baker Hughes Inc. Final, February 13, 2013.

AMEC 2012. Phase IV Final Inspection Report, Former Bird Machine Company Site. Prepared by AMEC Earth & Environmental Inc. for Baker Hughes Inc. Final, August 2012.

AMEC 2011a. Response Action Outcome Statement for RTN 4-3024222, Former Bird Machine Company Site. Prepared by AMEC Earth & Environmental Inc. for Baker Hughes Inc. Final, December 2011.

AMEC 2011b. Phase II Comprehensive Site Assessment Report for RTN 4-3024222, Former Bird Machine Company Site. Prepared by AMEC Earth & Environmental Inc. for Baker Hughes Inc. Final, October 2011.

AMEC 2011c. Phase II Comprehensive Site Assessment Addendum for RTN 4-3024222, Former Bird Machine Company Site. Prepared by AMEC Earth & Environmental Inc. for Baker Hughes Inc. Final, December 2011.

AMEC 2011d. Phase III Remedial Action Plan for RTN 4-3024222, Former Bird Machine Company Site. Prepared by AMEC Earth & Environmental Inc. for Baker Hughes Inc. Final, December 2011.

USGS 2015. Gauging Data at USGS Station 01105000, Neponset River at Norwood, MA. National Water Information System. http:nwis.waterdata.usgs.gov. August 2015.

Walpole 2007. Letter from John Spillane, Chairman, Town of Walpole Board of Water & Sewer Commissioners, to Dina Kuykendall, BHI. October 25, 2007.

Weston 2005. Phase I Initial Site Investigation Report for RTN 3-0024222, Bird Machine Company Manufacturing Building Area. Prepared by Weston Solutions Inc. for Baker Process Inc. September 14, 2005.

Weston 2007a. Phase II Comprehensive Site Assessment for Demolition Debris Area, RTN 4-3024105. Prepared by Weston Solutions Inc. for Baker Process Inc. July 30, 2007.

Weston 2007b. Phase II Comprehensive Site Assessment for Release of Hydrocarbons to the Neponset River Site, RTN 4-3023575. Prepared by Weston Solutions Inc. for Baker Process Inc. January 25, 2007.

Figures

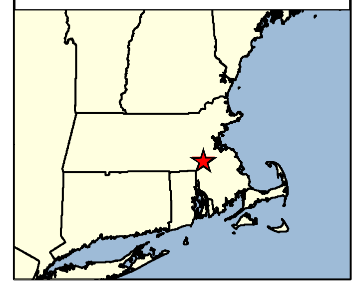
FIGURE 1

SITE LOCATION MAP

Former Bird Machine Company

100 Neponset Street
Walpole, MA

Location of Site



Source: Topo quad provided by National Geographic TOPO! Series: 2008
Town Supply Wells by MassGIS, 2012.

0 2,000 Feet

amec foster wheeler
AMEC Foster Wheeler
Environment & Infrastructure, Inc.
271 Mill Road
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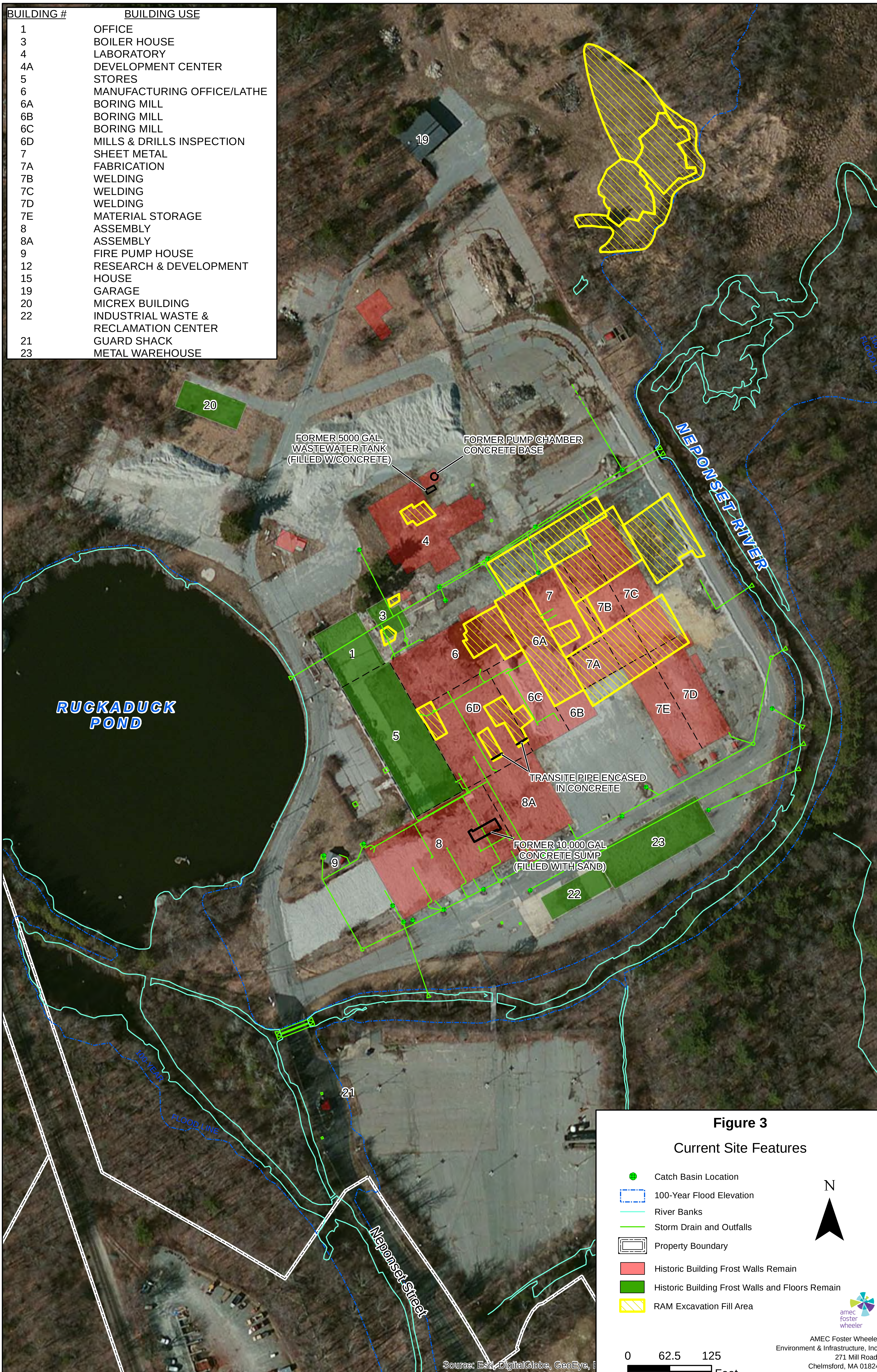
H:\BirdMachineCo\Task12\MXD\SiteMap.mxd January 22, 2015 DWN: andrew.nelson CHKD: AKN

Figure 2

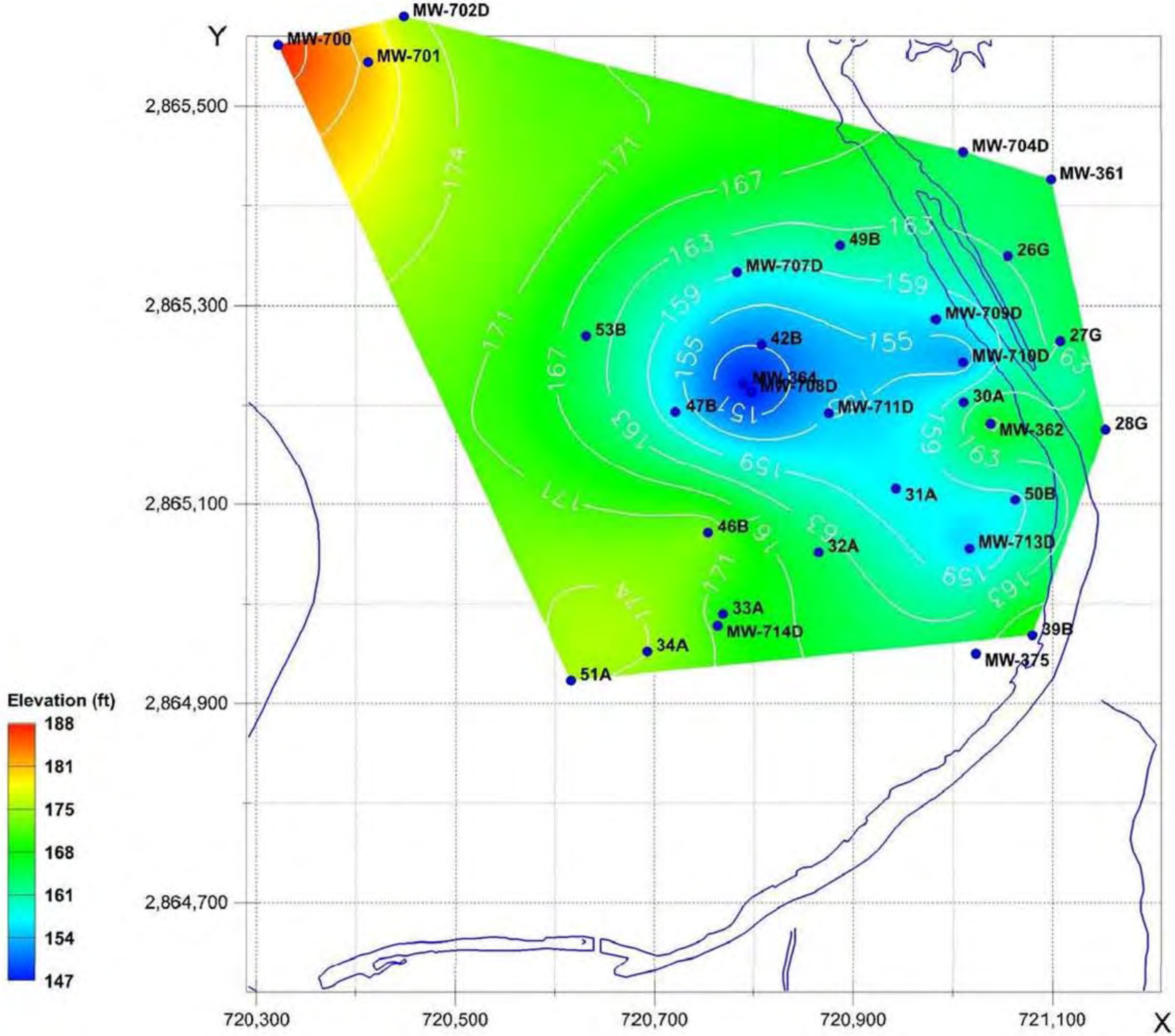
Disposal Site Boundary, Former Bird Machine Company

H:\BirdMachineCo\Task18\MXD\Figure2_DisposalSiteBoundary.mxd January 22, 2015 DWN: andrew.nelson CHKD: AKN



H:\BirdMachineCo\Task17\MXD\Figure3.mxd January 22, 2015 DWN: andrew.nelson CHKD: AKN

Source: Building data from Weston Solutions. Imagery provided by ESRI, 2012.



Bedrock Elevations From Drilling

Bird Machine Company

100 Neponset Street
Walpole, MA

Location of Site

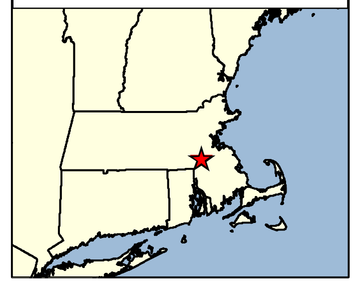


Figure 4

Source: MassGIS, 2001.

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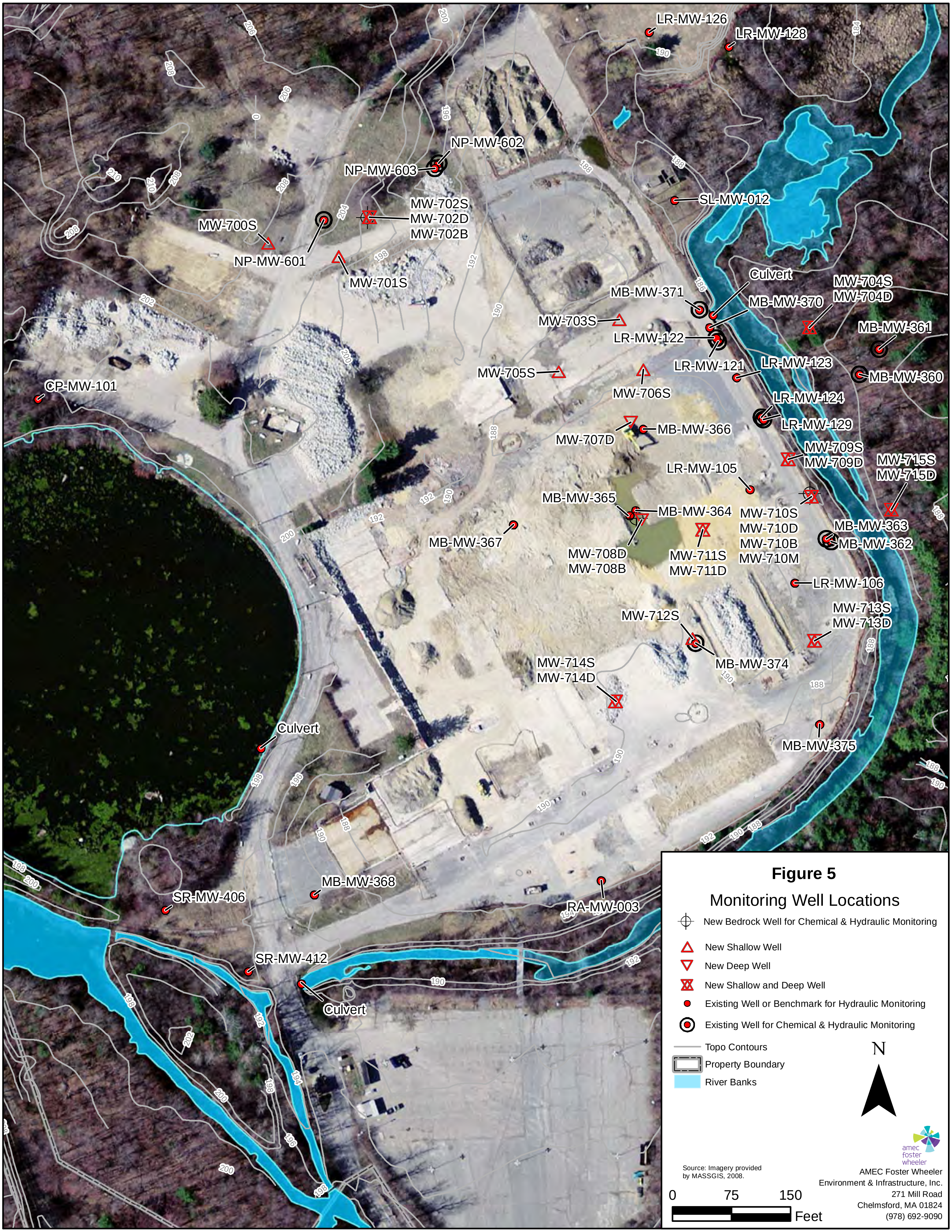
H:\BirdMachineCo\Task19\MXD\Figure4_BedrockElevationsFromDrilling.mxd January 22, 2015 DWN: andrew.nelson CHKD: AKN



H:\BirdMachineCo\Task18\MXD\Fig5_MW_Locations.mxd January 22, 2015 DWN: andrew.nelson CHKD: JDP

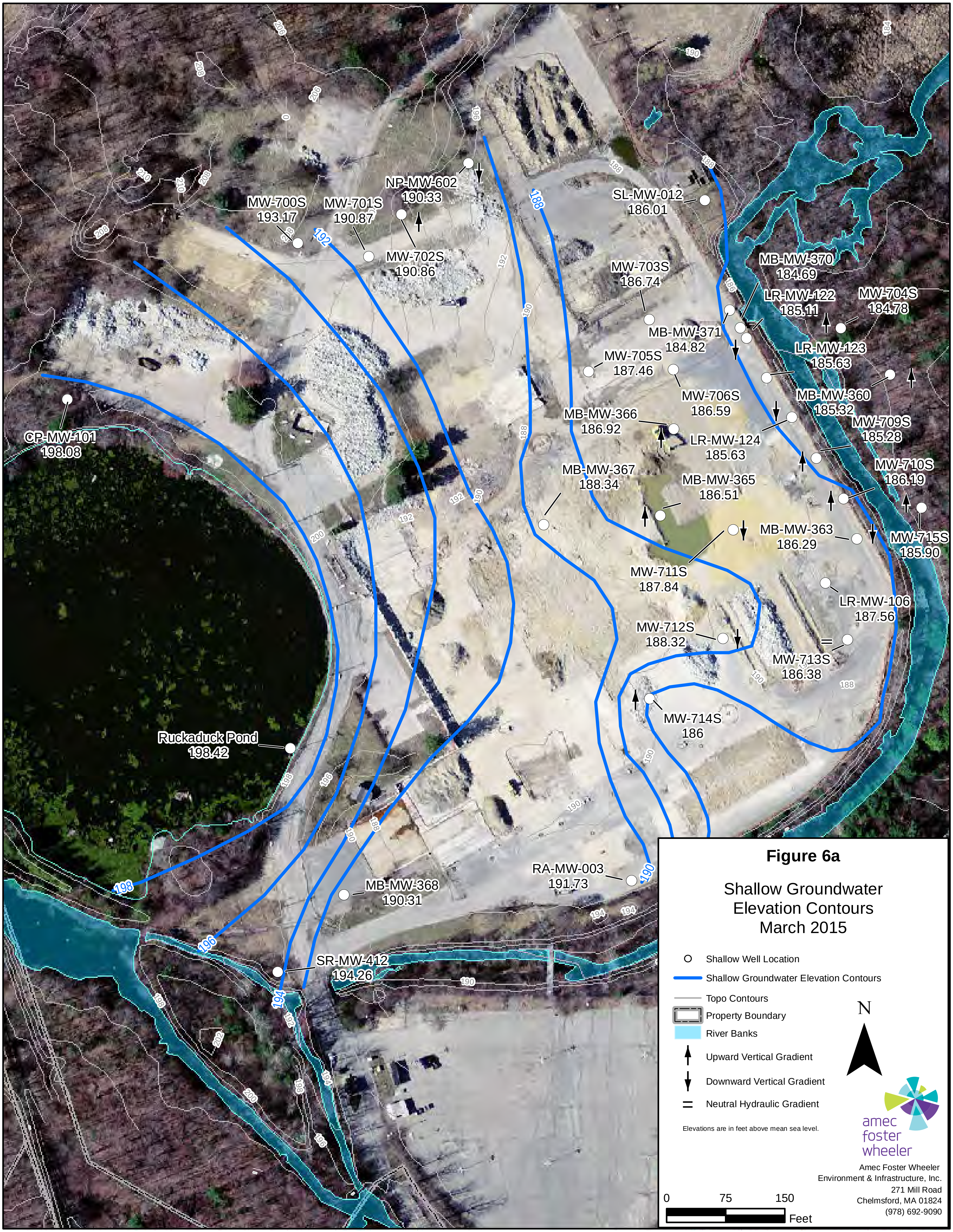
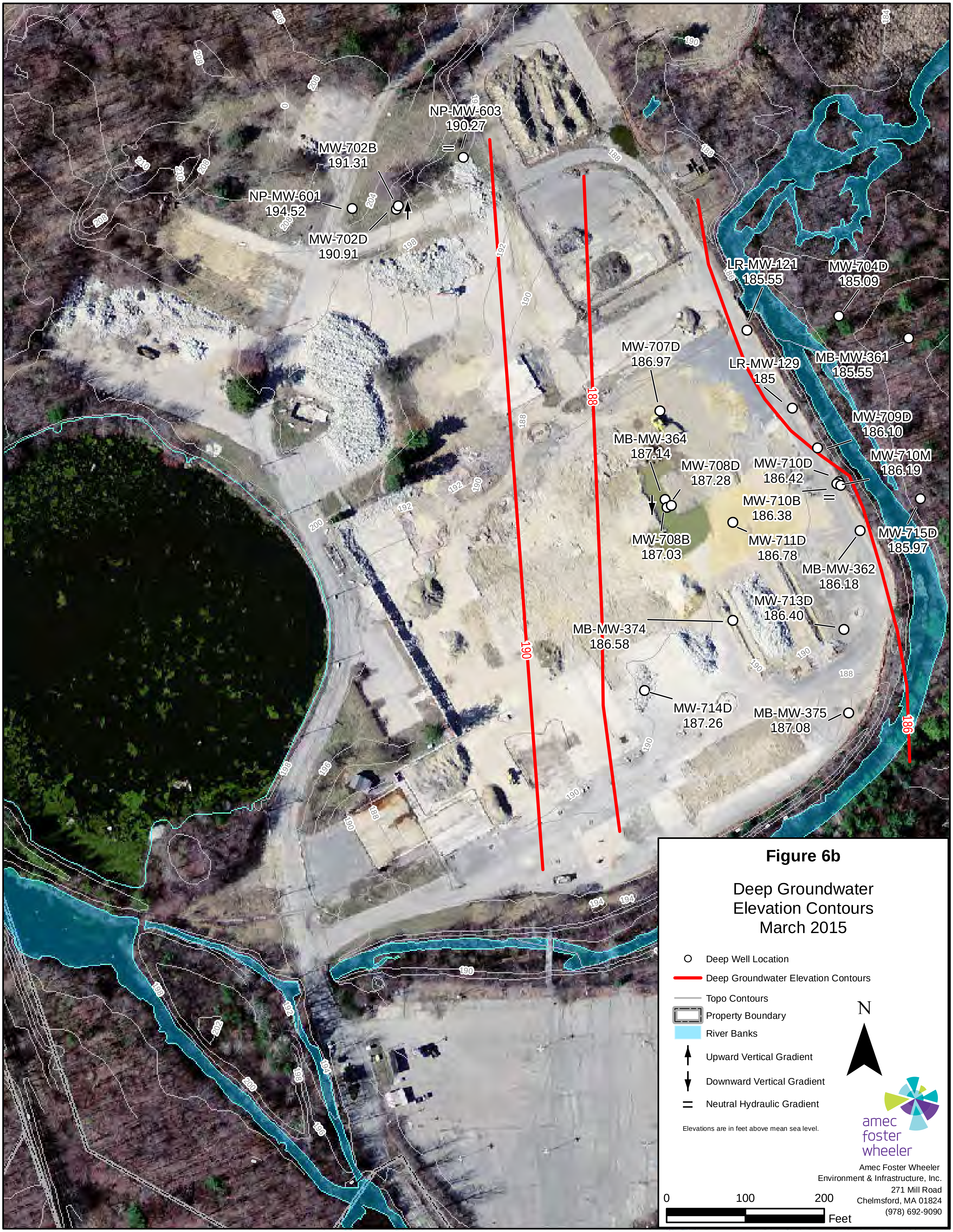


Figure 6a

Shallow Groundwater Elevation Contours
March 2015

H:\BirdMachineCo\Task19\MXD\Shallow_Groundwater_Contours_March2015.mxd August 11, 2015 DWN: emily.gardiner CHKD: AKN

Source: Imagery provided by MASSGIS, 2008.



H:\BirdMachineCo\Task19\MXD\Deep_Groundwater_Contours_March2015.mxd August 11, 2015 DWN: emily.gardiner CHKD: AKN

Source: Imagery provided by MASSGIS, 2008.

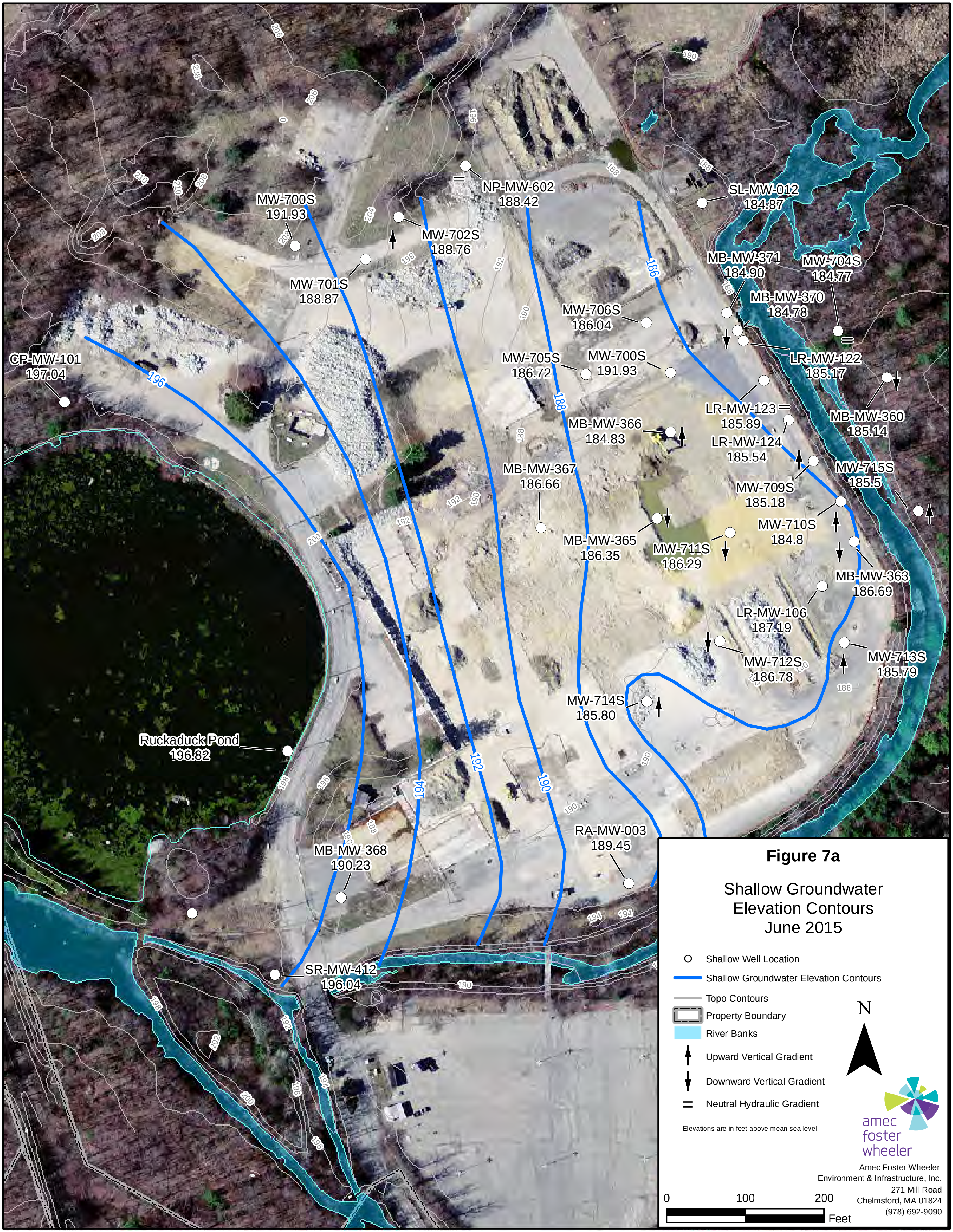


Figure 7a
Shallow Groundwater Elevation Contours
June 2015
Shallow Well Location
Shallow Groundwater Elevation Contours
Topo Contours
Property Boundary
River Banks
Upward Vertical Gradient
Downward Vertical Gradient
Neutral Hydraulic Gradient
Elevations are in feet above mean sea level.
N
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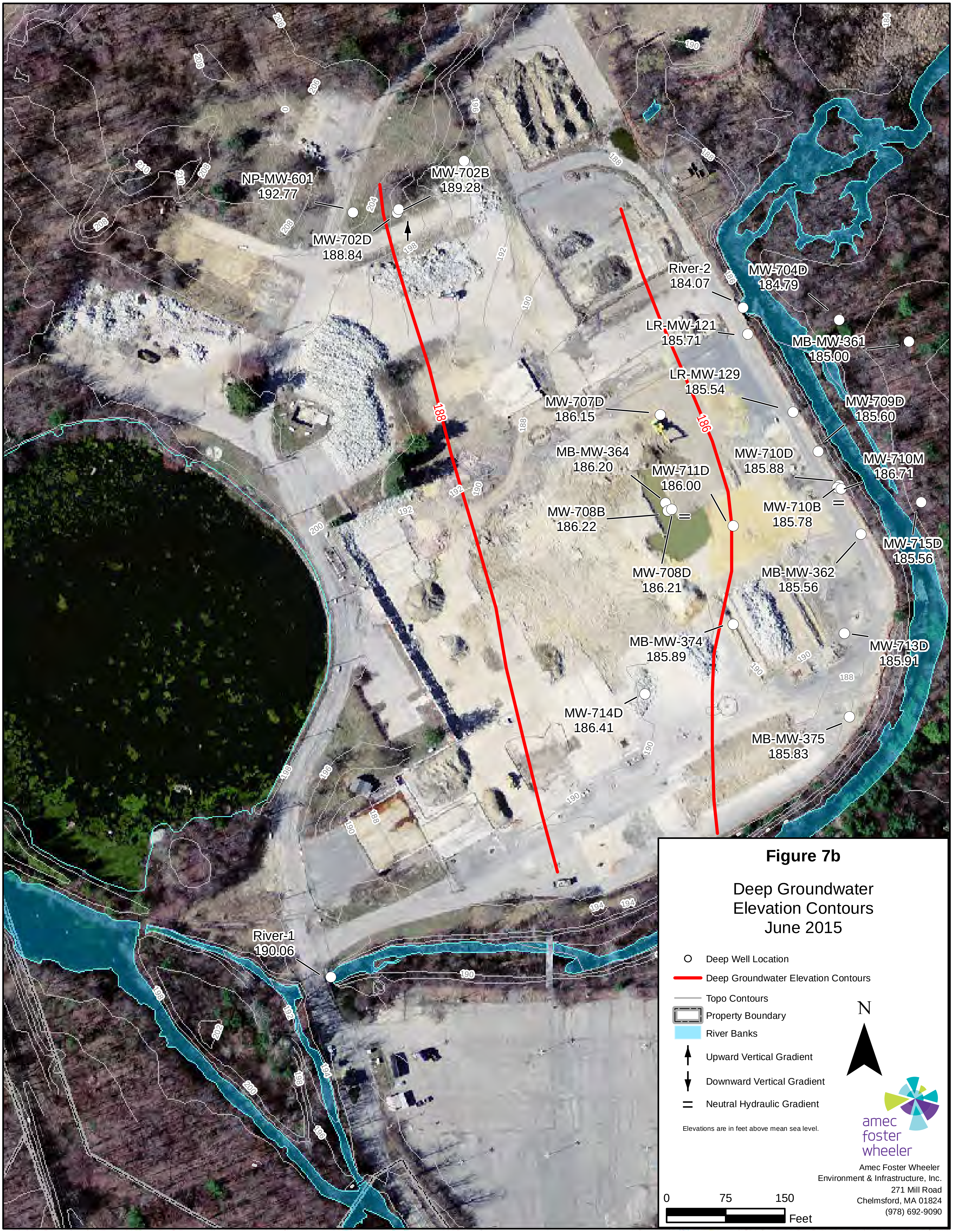
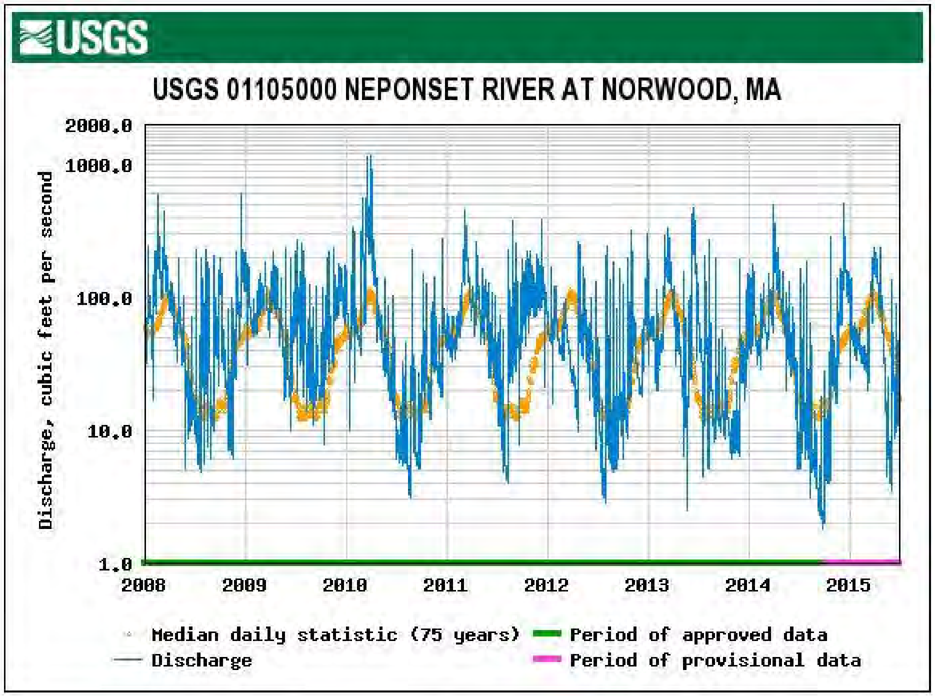
(978) 692-9090
0 100 200
Feet
NP-MW-602 188.42
SL-MW-012 184.87
MW-700S 191.93
MW-702S 188.76
MW-701S 188.87
MB-MW-371 184.90
MW-704S 184.77
MB-MW-370 184.78
MW-706S 186.04
CP-MW-101 197.04
MW-705S 186.72
MW-700S 191.93
LR-MW-122 185.17
LR-MW-123 185.89
MB-MW-360 185.14
MB-MW-366 184.83
LR-MW-124 185.54
MB-MW-367 186.66
MW-715S 185.5
MW-709S 185.18
MW-710S 184.8
MB-MW-365 186.35
MW-711S 186.29
MB-MW-363 186.69
LR-MW-106 187.19
MW-712S 186.78
MW-713S 185.79
MW-714S 185.80
Ruckaduck Pond 196.82
RA-MW-003 189.45
MB-MW-368 190.23
SR-MW-412 196.04
196
194
192
190
188
186

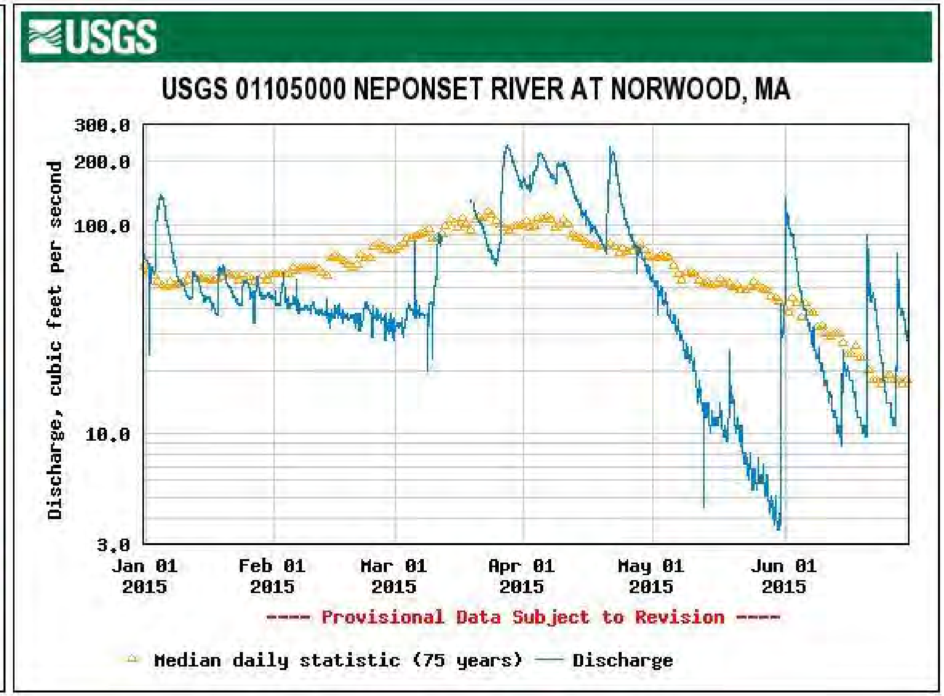


Source: Imagery provided by MASSGIS, 2008.

Figure 8. USGS Hydrographs of the Neponset River

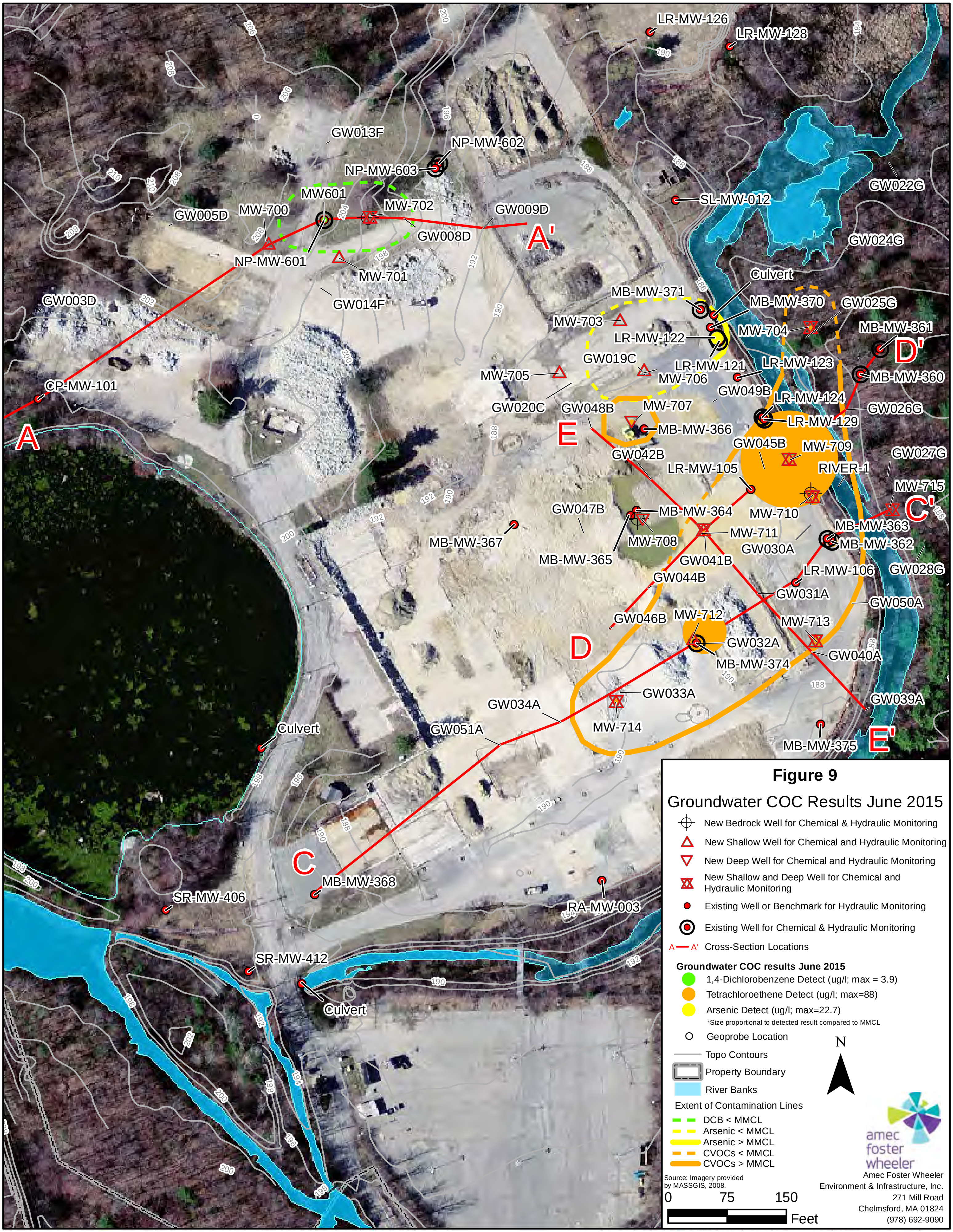


2008 to 2015 Daily Discharge

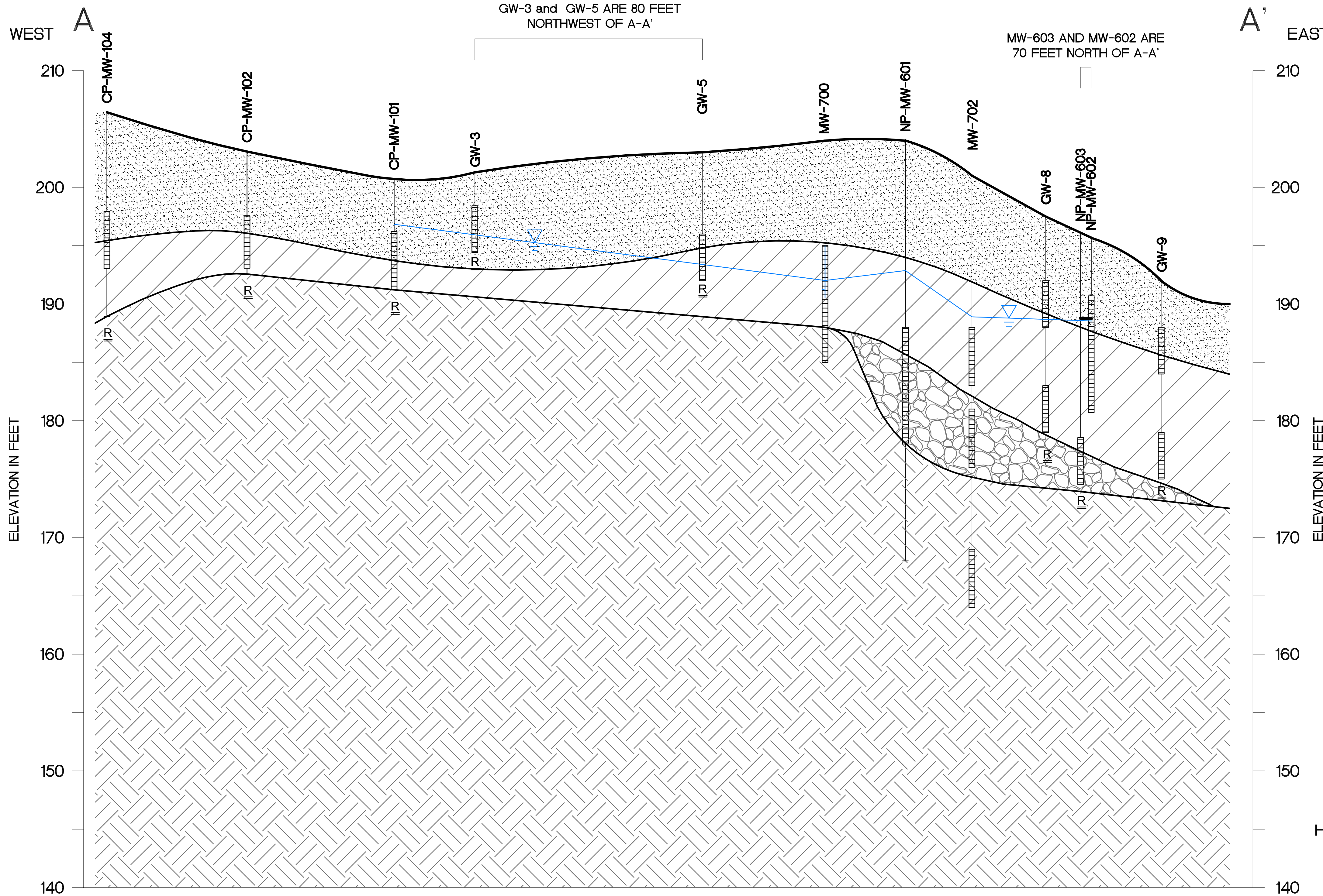


2015 Daily Discharge

http:nwis.waterdata.usgs.gov



H:\BirdMachineCo\Task19\MXD\Fig9_Lateral_Extent_of_Groundwater_COCs_June 2015_V2.mxd August 11, 2015 DWN: emily.gardiner CHKD: JDP



PROFILE A-A'

HORIZONTAL SCALE: 1" = 100'

0 100' 200'

0 10' 20'

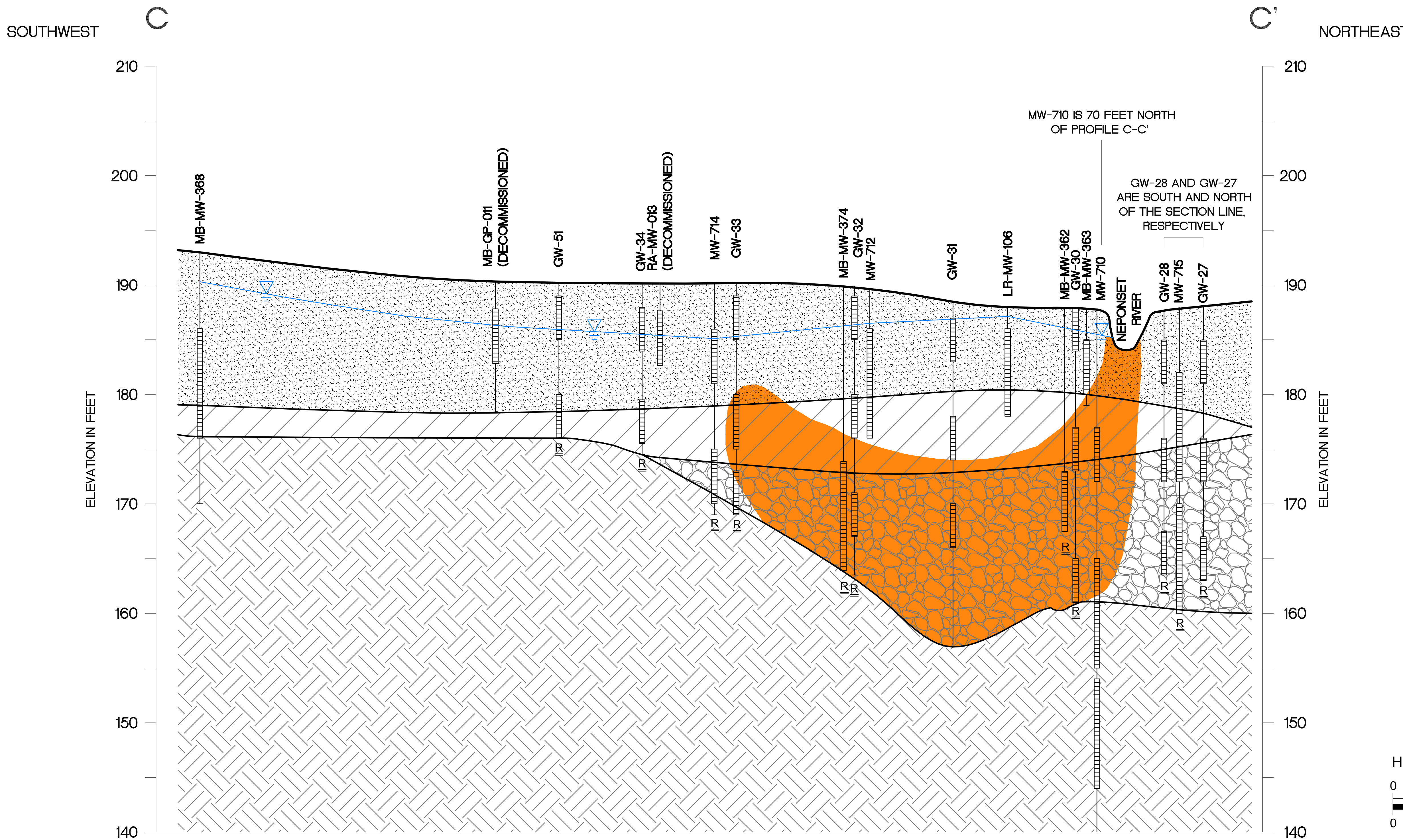
VERTICAL SCALE: 1" = 10'

SAND	GW-3 TEMPORARY GROUNDWATER MONITORING POINT
SILTY SAND	MB-MW-125 MONITORING WELL LOCATION
SILTY SAND & GRAVEL	JUNE 2015 GROUNDWATER LEVEL
BEDROCK	SOIL HORIZON TRANSITION
	GROUND SURFACE
	MONITORING WELL SCREEN
	R REFUSAL

GEOLOGIC CROSS SECTION A-A'
BIRD MACHINE
WALPOLE, MASSACHUSETTS

amec foster wheeler
ENVIRONMENT & INFRASTRUCTURE
271 MILL ROAD
CHELMSFORD, MA 01824

DRAWN BY: DED
REVIEWED BY: CK
DATE: 08/06/15
FIGURE 10



PROFILE C - C'

HORIZONTAL SCALE: 1" = 100'

0 100' 200'

0 10' 20'

VERTICAL SCALE: 1" = 10'

SAND

SILTY SAND

SILTY SAND & GRAVEL

BEDROCK

ESTIMATED AREA OF CVOCS > MMCL

GW-3 TEMPORARY GROUNDWATER MONITORING POINT

MB-MW-125 MONITORING WELL LOCATION

JUNE 2015 GROUNDWATER LEVEL

SOIL HORIZON TRANSITION

GROUND SURFACE

MONITORING WELL SCREEN

R REFUSAL

GEOLOGIC CROSS SECTION C-C'
BIRD MACHINE
WALPOLE, MASSACHUSETTS

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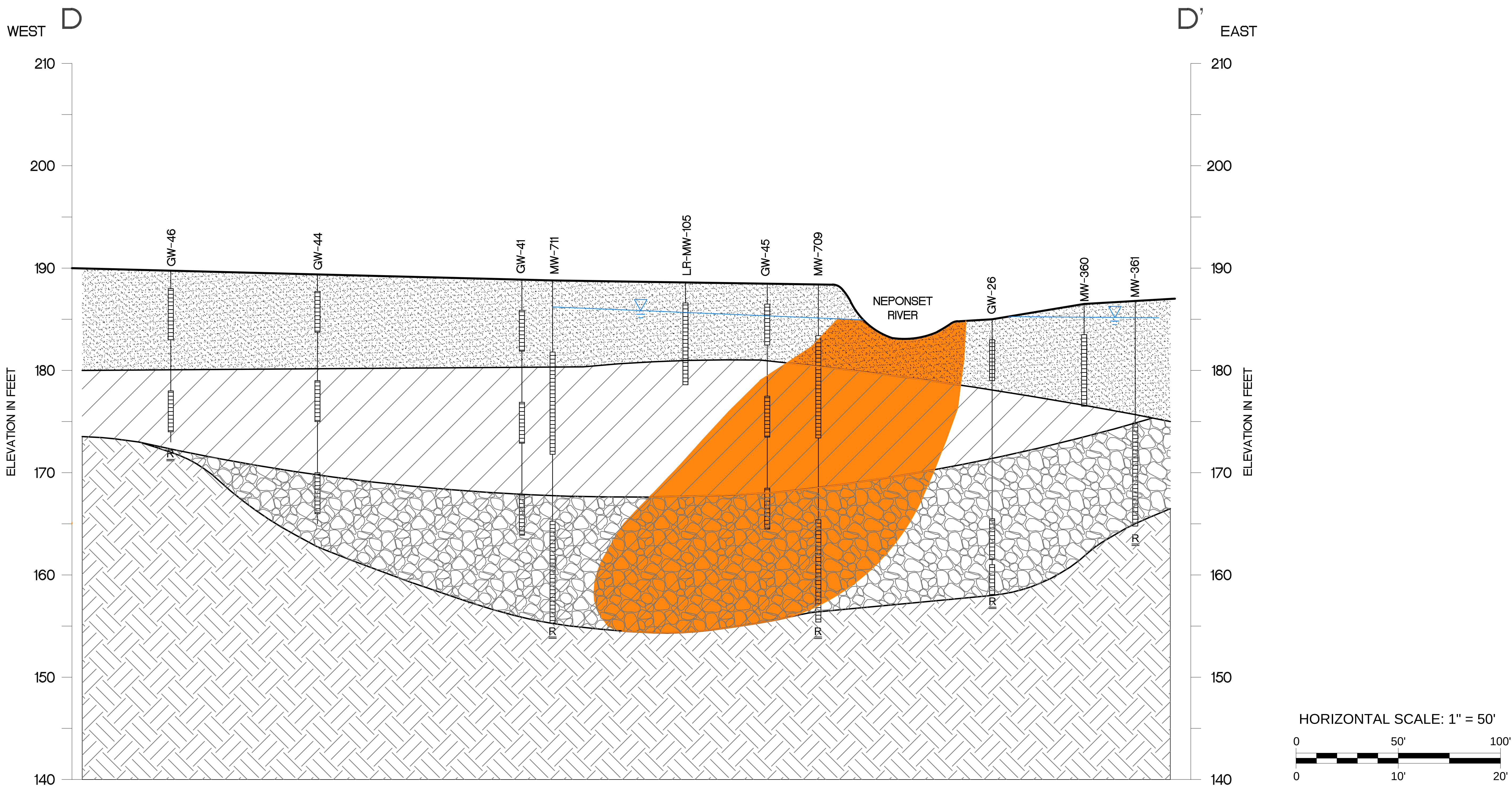
DRAWN BY: DED	DATE:	FIGURE 11
REVIEWED BY: CK	08/06/15	



PROFILE D - D'

SAND	
SILTY SAND	
SILTY SAND & GRAVEL	
BEDROCK	
	ESTIMATED AREA OF CVOCS > MMCL
GW-3	TEMPORARY GROUNDWATER MONITORING POINT
MB-MW-125	MONITORING WELL LOCATION
	JUNE 2015 GROUNDWATER LEVEL
	SOIL HORIZON TRANSITION
	GROUND SURFACE
	MONITORING WELL SCREEN
R	REFUSAL

GEOLOGIC CROSS SECTION D-D'
BIRD MACHINE
WALPOLE, MASSACHUSETTS

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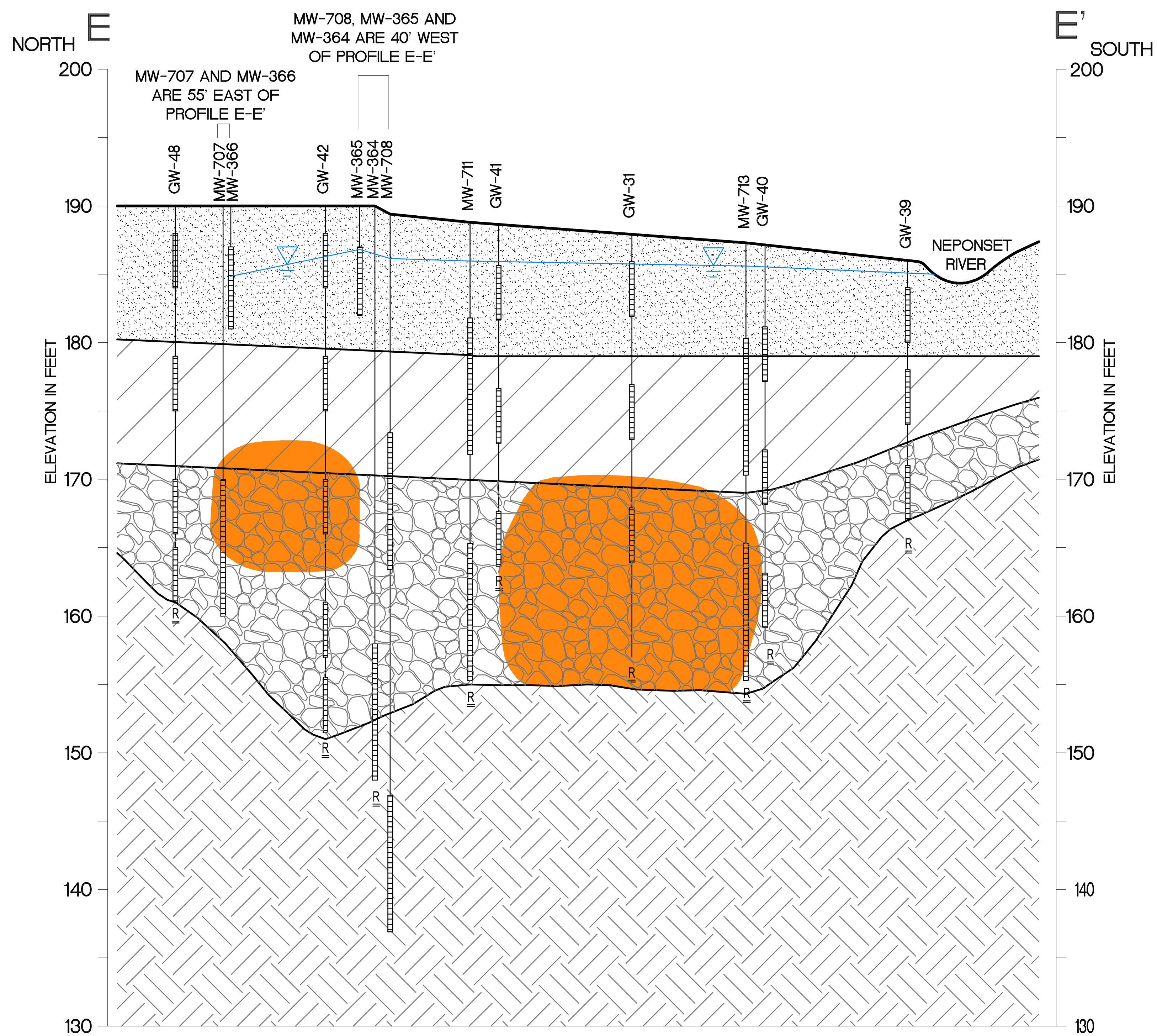
CHELMSFORD, MA 01824

DRAWN BY: DED
REVIEWED BY: CK
DATE: 08/06/15

FIGURE 12



PROFILE E - E'

HORIZONTAL SCALE: 1" = 100'

0 100' 200'

0 10' 20'

VERTICAL SCALE: 1" = 10'

	ESTIMATED AREA OF CVOCS > MMCL		
	GW-3	TEMPORARY GROUNDWATER MONITORING POINT	
SAND	MB-MW-125	MONITORING WELL LOCATION	
SILTY SAND		JUNE 2015 GROUNDWATER LEVEL	MONITORING WELL SCREEN
SILTY SAND & GRAVEL		SOIL HORIZON TRANSITION	
BEDROCK		GROUND SURFACE	R REFUSAL

GEOLOGIC CROSS SECTION E-E'
BIRD MACHINE
WALPOLE, MASSACHUSETTS

amec foster wheeler

ENVIRONMENT & INFRASTRUCTURE
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DRAWN BY: DED	DATE:	FIGURE 13
REVIEWED BY: CK	08/06/15	

FILE: C:\Users\dana.dempsey\Documents\BIRD MACHINE\2015-08-06\Bird Machine 11X17 Size Cross Sections 2015-01-20.dwg BY: dana.dempsey