U.S. Army
Fort Monmouth, New Jersey

Remedial Investigation Report Addendum

M-14 Landfill

Fort Monmouth, New Jersey

January 2011
Revised June 2011

REMEDIAL INVESTIGATION REPORT ADDENDUM
FOR M 14 LANDFILL
FORT MONMOUTH, NEW JERSEY

PREPARED FOR:

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TETRA TECH EM INC. PROJECT NO. 103G1058223

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ACRONYMS AND ABBREVIATIONS

µg/L	Micrograms per liter
bgs	Below ground surface
AMC	U.S. Army Material Command
BEE	Baseline Ecological Evaluation
BRAC	Base Realignment and Closure
Brinkerhoff	Brinkerhoff Environmental Services, Inc.
CECOM	U.S. Army Communications and Electronics Command
COC	Contaminant of Concern
DPW	Directorate of Public Works
DRMR	Division of Remediation Management and Response
DSHW	Division of Solid Hazardous Waste
FMETL	Fort Monmouth Environmental Testing Laboratory
ft	Foot or feet
FTMM	Fort Monmouth
GWQS	Ground Water Quality Standards
IGWSCC	Impact to Ground Water Soil Cleanup Criteria
MBC	Maximum Background Concentration
MDL	Method Detection Limit
MODFLOW	Modular finite-difference Flow model
ND	Non-detect
NFA	No Further Action
NJAC	New Jersey Administrative Code
NJDEP	New Jersey Department of Environmental Protection
NRDCSCC	Non-Residential Direct Contact Soil Cleanup Criteria
NSS	Near Surface Soils
PCB	Polychlorinated Biphenyl
PDB	Passive Diffusion Bag
PPE	Personal Protective Equipment
ppm	Parts per million
PQL	Practical Quantitation Limit
PVC	Polyvinyl Chloride
QA/QC	Quality Assurance/Quality Control
RDCSCC	Residential Direct Contact Soil Cleanup Criteria
RI	Remedial Investigation
RIR	Remedial Investigation Report
RIRA	Remedial Investigation Report Addendum
SI	Site Investigation
SIR	Site Investigation Report
SOP	Standard Operating Procedure
SQE	Sediment Quality Evaluation
SRP	Site Remediation Program
SRS	Site Remediation Standards
SVOC	Semivolatile Organic Compound
SWQS	Surface Water Quality Standards

SWS	Surface Water Sample
TAL	Target Analyte List
TCL	Target Compound List
Tetra Tech	Tetra Tech EM, Inc.
TIC	Tentatively Identified Compound
Versar	Versar, Inc.
VOC	Volatile Organic Compound
Weston	Roy F. Weston, Inc.

EXECUTIVE SUMMARY

Tetra Tech EM Inc. (Tetra Tech) has been contracted by the U.S. Army Garrison Fort Monmouth Directorate of Public Works (DPW) to prepare a Remedial Investigation Report Addendum (RIRA) to document soil, ground water and surface water conditions at M-14 site (M-14), located in the Main Post of Fort Monmouth, New Jersey. This report addresses the remedial investigation (RI) activities performed at this site to determine soil, ground water, and surface water conditions from April 2001 through August 2010. RI activities performed at M-14include landfill delineation activities, monitoring well installations, quarterly ground water and surface water sampling, and a sensitive receptor survey.

In December 2008, a landfill boundary delineation expanded the extent of M-14. In addition to the trench excavations, the DPW collected soil samples in an effort to better define the boundary limits of M-14and to characterize near-surface soil quality conditions between the landfill (non-residential) and single-family structures (residential area). The surficial soil analytical results indicate that six SVOCs [benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene] and two metals (arsenic and lead) were detected at concentrations greater than established NJDEP NRDCSRS and MBCs for the soils at the Main Post of FTMM.

To determine potential contaminants of concern (COC) currently in ground water at M-14, the past eight quarterly sampling events were evaluated. Based on the magnitude of the exceedances, the frequency of occurrences, no volatile organic compounds (VOC) are considered COCs at M-14. M-14
The metals arsenic and lead were detected in surface water in concentrations exceeding NJDEP SWQS. The concentrations of lead however, did not exceed the maximum background concentration (MBC) of 10 micrograms per liter (µg/L). Therefore lead is not a COC. The presence of arsenic at concentrations greater than the MBC for surface water in both ground water and surface water may signify the migration of arsenic into the nearby surface water body (Husky Brook) at M-14. This situation requires further evaluation and continued monitoring of both surface water and ground water for arsenic. Therefore, arsenic is considered a COC for surface water for M-14.

To address soil surficial contamination, hot-spot removals are recommended prior to placement of soil cover where surface contamination is found to be one order of magnitude greater than the NRDCSRS. An additional 1-foot to 1.5-feet of certified clean soil cover (a “soil cap”), depending on the depth at which contamination was found, is recommended to be placed over the soil borings where any SVOC and/or metal concentrations exceed NRDCSRS and MBC. Further, in accordance with the NJDEP requirements, it is recommended that additional certified clean soil cover over soil boring locations that do not have the minimum two-feet of cover. Continued monitoring of arsenic in surface water is recommended at M-14. Lastly, a deed notice is recommended to be filed to document the presence of the waste deposits and contaminated soil on site.

1.0 INTRODUCTION

Tetra Tech EM Inc. (Tetra Tech) has been contracted by the U.S. Army Garrison, Fort Monmouth Directorate of Public Works (DPW) to prepare a Remedial Investigation Report Addendum (RIRA) to document conditions at M-14 site (M-14), located in the Main Post Area of Fort Monmouth, New Jersey. This report addresses the remedial investigation activities performed at the site to determine soil, ground water, and surface water conditions from April 2001 through August 2010.

This section describes the objectives and organization of this RIRA.

1.1 OBJECTIVES

The objectives of this RIRA are to update aquifer chemical and physical characteristics, surficial soil conditions and to determine the requirement for further remedial activities at M-14. The remedial investigation was conducted in accordance with New Jersey Department of Environmental Protection's (NJDEP) Technical Requirements for Site Remediation (July 1999), New Jersey Administrative Code (NJAC) 7:26E, et seq.

This RIRA is an addendum to Versar, Inc.'s (Versar) August 2005 Remedial Investigation Report (RIR), which details activities including the implementation of a long-term monitoring program, subsurface soil and hydrogeologic investigations, and ground water sampling and analyses conducted to support and expand the results and findings of the site investigation (SI) performed by Roy F. Weston (Weston) in 1995. Versar's August 2005 RIR included the results of remedial investigation activities performed from June 1997 through January 2001. This RIR is included in **Appendix A.**

The remedial investigation and subsequent preparation of the RIRA included:

- Characterization of ground water and surface water quality through quarterly ground water and surface water sampling events conducted from April 2001 through August 2010.
- Installation of three additional monitoring wells in July 2010 to address NJDEP's July 25, 2007 correspondence.
- Comparison of the results of the ground water and surface water quality monitoring programs with the NJDEP Ground Water Quality Standards (GWQS) and Surface Water Quality Standards (SWQS).
- Investigation and evaluation of the designated aquifer uses, the associated aquifer classification, and the appropriate ground water quality standard for ground water resources beneath M-14. NJDEP GWQS specify the appropriate quality standard and designated uses for ground water and also outline technical and general policies to ensure that the designated uses can be adequately protected.
- Supplemental near-surface soil sampling and trench excavation investigation as part of a landfill boundary delineation project. As a result of this investigation, the existing landfill boundaries have been expanded.

- Development of a ground water flow and transport model for M-14 based on the hydrogeologic data, field investigation programs and technical research to evaluate the migration of potential contaminants of concern (COC) beneath the site
- Determination of the need for continued monitoring for arsenic contamination in surface water based on the results of field and laboratory investigations and the hydrogeologic conditions at the site.
- Characterization of the surficial soils that cover the historic fill areas.
- Determination of the remedial action to address contamination of surficial soils.

1.2 REPORT ORGANIZATION

This report is organized to minimize repetition. **Section 2.0** provides background information and a general description of M-14 located in the Main Post area of Fort Monmouth. **Section 3.0** describes and summarizes all previously reported investigative and remedial actions at M-14. **Section 4.0** provides reference for a detailed physical description of the site. **Section 5.0** summarizes the soil, surface water and ground water chemical characterization of M-14. **Section 6.0** discusses the updated ground water model for the site. Conclusions and recommendations for M-14 are presented in **Section 7.0**. References cited in this report and following Section 7.0.

2.0 SITE BACKGROUND AND ENVIRONMENTAL SETTING

This section summarizes background information and describes the environmental setting of the area surrounding M-14. A more thorough description of the site is provided in Versar's 2005 RIR (**Appendix A**), which includes additional historical background information and detailed environmental setting information such as regional and local geology, hydrogeology, soils, topography, and drainage in the vicinity of M-14.

Specifically, this section describes the site and its location, summarizes site background information, presents current site conditions, and portrays the environmental setting of M-14 at the Fort Monmouth installation.

2.1 SITE LOCATION AND DESCRIPTION

Fort Monmouth military installation is located in the central-eastern portion of New Jersey in Monmouth County, approximately 45 miles south of New York City and 70 miles northeast of Philadelphia (**Figure 2-1**). The Main Post encompasses approximately 630 acres and is bordered to the north by Parkers Creek, to the northeast by New Jersey Transit Railroad, to the east by State Highway 35, to the south/southeast by Oceanport Creek, and to the south by residential areas.. The Main Post currently provides administrative, training, and housing support functions, as well as providing many of the community facilities for Fort Monmouth. The primary mission of Fort Monmouth is to provide command, administrative, and logistical support for U.S. Army Headquarters' Communications and Electronics Command (CECOM). CECOM is a major subordinate command of the U.S. Army Materiel Command (AMC) and is the host tenant at Fort Monmouth.

M-14 occupies approximately 6.9 acres (300,000 square feet) on the Main Post of Fort Monmouth and is bordered by Murphy Drive to the east, Husky Brook and the M-12 Landfill to the south, and Gosselin Ave and residential properties to the west and north (**Figure 2-2**). M-14 was used primarily from 1965 to 1966 for the disposal of building rubble. The top cover is composed of dredging soils from Husky Brook Lake. The bank of Husky Brook contains trees, bramble, and small shrub vegetation upstream and large rocks downstream of M-14.

2.2 SITE BACKGROUND

This section summarizes background information presented in reports summarizing previous site work performed at M-14.

2.2.1 1995 Site Investigation Report

In 1994, Weston conducted site investigation activities at M-14, including a geophysical investigation, surface water sampling, well installation and sampling, ground water monitoring, and tidal monitoring. The results of this field work were included in the December 1995 Site Investigation Report (SIR). The December 1995 SIR was used as the basis for the supplemental remedial investigations conducted by Versar at M-14, and summarized in Versar's August 2005 RIR **(Section 2.2.4)**.

In 1994, the ground water monitoring program at M-14 consisted of quarterly monitoring of six on-site ground water monitoring wells: five installed in the southern portion of the site along Husky Brook, and one installed in the northwestern section of the site. According to the December 1995 SIR, the ground water and surface water sample results for M-14 indicated that no COCs were detected at concentrations greater than the NJDEP GWQS or SWQS. The December 1995 SIR recommended that because the site was historically used as a landfill, the DPW should implement a long-term ground water monitoring program at M-14 (Weston 1995).

2.2.2 2003 Remedial Investigation Report Sediment Quality Evaluation

In October 2003, Versar submitted a RIR and Sediment Quality Evaluation (SQE) for work performed at the M-12 and M-14 landfills in April 2000 (**Appendix A**). DPW initiated a sediment sampling investigation to evaluate potential impacts to stream sediments in creeks and/or brooks running adjacent to the Main Post and Charles Wood (CW-3A only) landfill sites. This investigation combined the M-12 and M-14 Landfills together as one site. The M-12/M-14 Landfill was included in the sediment sampling program to supplement previous findings by Weston related to soil, surface water, and ground water (Versar 2003).

To determine potential polychlorinated biphenyl- (PCB) related impacts to sediments in Husky Brook, DPW obtained 25 sediment samples from the surface and near-surface sediments of Husky Brook on April 10, 2000, including two duplicate samples for quality assurance and quality control (QA/QC) purposes. The samples were obtained from the area along the 1,700-foot portion of Husky Brook that flows through the M-12/M-14 Landfill. All 25 sediment samples were analyzed for PCBs and compared to the sediment sampling guidance concentrations defined in the NJDEP Guidance for Sediment Quality Evaluations (NJDEP 1998).

As presented in Section 3.0 of the October 2003 RIR SQE, the data indicated that, with the exception of one anomalous detection of PCBs in a duplicate sample, no PCBs were detected in any of the 25 samples obtained from Husky Brook. Based on NJDEP's guidance criteria, the results indicated that no PCB-related contaminants are impacting sediments in Husky Brook. In addition, no potential exists for long-term adverse benthic effects in Husky Brook associated with the M-12/M-14 Landfill. A No Further Action (NFA) determination was recommended for the M-12/M-14 Landfill related to potential PCB impacts to the sediments of Husky Brook.

2.2.3 2004 Remedial Investigation Report for Near-Surface Soils

On behalf of DPW, Versar characterized the near-surface soils at the MW-14 Landfill to demonstrate compliance equivalence of the existing soil cover over the landfill with respect to the U.S. Solid Waste Disposal Act of 1965 (**Appendix A**). Versar advanced 119 borings from 6 to 24 inches in depth at strategic locations across the site. A total of 238 soil samples was collected from December 1998 to January 1999. All soil samples were analyzed for target compound list (TCL) organics and target analyte list (TAL) metals. The results are presented in Versar's March 2004 Remedial Investigation Report for Near-Surface Soils (NSS) for M-14 (Versar 2004).

As stated in this report, concentrations of semi-volatile organic compounds (SVOC), pesticides, and metals were detected exceeding the NJDEP Residential Direct-Contact Soil Cleanup Criteria (RDCSCC). In all cases, further analysis of the analytical results did not define a source area or level of contamination that necessitated the identification and evaluation of potential remedial actions. Where applicable and appropriate, the data were evaluated utilizing the compliance averaging approach to determine compliance with NJDEP RDCSCC. In most cases, either the calculated compliance average was less than the respective RDCSCC or the exceedance was considered marginal. However, to address the exceedances of analytes that did not meet cleanup criteria in the near surface soils, DPW proposed incorporating a document equivalent to a Declaration of Environmental Restriction (DER) into the Fort Monmouth Master Plan for soils at the site. Given the inactive and undisturbed status of the landfill; the continued performance of long-term surface water and ground water monitoring proximate to M-14; the minimal potential for environmental and/or human health impacts; the lack of ground water uses at or downgradient of the site; and the distribution, occurrence, and relatively low concentrations of COCs, the U.S. Army requested a NFA determination for these parameters in soils at M-14.

2.2.4 2005 Remedial Investigation Report

Following Weston's December 1995 SIR, DPW continued quarterly ground water sampling at M-14, as discussed in Versar's August 2005 Remedial Investigation Report (Versar 2005) (**Appendix A**).

Ground water samples were collected during 16 rounds of sampling from June 1997 to January 2001 and were analyzed for volatile organic compounds (VOC), semivolatile organic compounds (SVOCs), pesticides, PCBs and TAL metals. Samples collected during two additional rounds of sampling using low-flow methodology were analyzed for TAL metals. A total of 115 samples were collected as part of the ground water sampling program during this period. Based on the results of the ground water quality evaluation, no SVOCs, pesticides, or PCBs were detected in ground water at M-14 greater than the NJDEP GWQS. One VOC (tert-butyl-alcohol) was detected greater than the NJDEP GWQS in one well during one round of ground water sampling. This detection was considered isolated and of marginal concentration. A total of 12 metals were detected in ground water samples collected from M-14 at concentrations exceeding the NJDEP GWQS. However, none of these metals were considered in Versar's August 2005 RIR to be COCs in site ground water based on the process of elimination via categorization of background metals, reduction in concentration or non-detection of samples by low-flow sampling, and elimination of isolated or marginal detections.

Based on the results of the remedial investigation ground water sampling during this period, Versar concluded in their August 2005 RIR that no COCs existed within the ground water, and an NFA was recommended for ground water at M-14.

In addition to the ground water sampling, a quarterly surface water sampling program was conducted by the DPW at M-14 during the same period to determine whether contamination of ground water at M-14 had impacted nearby surface water (Husky Brook). Surface water samples were collected during 22 quarterly sampling events and analyzed for VOCs plus 15 tentatively identified compound (TIC) parameters and various wet chemistry parameters. A total of 65

surface water samples was collected from three stream locations (SS-9, SS-19, and SS-12). One COC was identified within the surface water samples (methylene chloride); however, this COC was considered a common laboratory contaminant.

2.2.5 2004 Reduction of Ground Water Analysis for M-14 Landfill

In November 2004, DPW requested a reduction in ground water analysis for samples collected from M-14 based on the results of long-term monitoring. The results indicated that SVOCs, pesticides, and PCBs had not been detected in site ground water in concentrations exceeding the NJDEP GWQS in any on-site monitoring well since 2001. Subsequently, NJDEP approved the reduction of ground water analysis to VOCs and TAL metals only, via electronic correspondence dated November 16, 2004 **(Appendix B).**

2.2.6 2007 NJDEP Response Comments

On July 25, 2007, the NJDEP Division of Remediation Management and Response (DRMR) sent DPW a correspondence which included comments on the following three reports prepared by Versar for M-14 **(Appendix B)**:

- Remedial Investigation Report, M-14 Landfill, dated August 12, 2005
- Remedial Investigation Report for Near Surface Soils, M-14 Landfill, dated March 17, 2004
- Remedial Investigation Report and Sediment Quality Evaluation, M-12/M-14 Landfill, dated October 15, 2003

NJDEP comments from the July 25, 2007 correspondence are summarized in the following sections.

2.2.6.1 M-12 and M-14 Recognized as One Site

NJDEP provided comments on the M-12 and M-14 landfills together, as NJDEP considers these landfills essentially one site separated by Husky Brook, which runs between the two landfills. NJDEP further stated that the U.S. Army also has recognized these sites as essentially one site with regards to the sediment quality evaluation, and to a lesser extent regarding the surface water evaluation. Additionally, NJDEP stated that the soil and ground water sampling results from both landfills are similar, and the respective RIRs have concluded that shallow ground water beneath both landfills flows toward Husky Brook.

2.2.6.2 Work Plan Submittal

NJDEP stated that the U.S. Army should submit a comprehensive investigation work plan for NJDEP review and approval prior to initiating any of the additional sampling requested in the July 25, 2007 comment letter. The work plan was recommended to ensure that NJDEP and the U.S. Army would be in complete agreement on all details prior to sampling.

2.2.6.3 Landfill Boundary Delineation

Based on a review of aerial photographs, NJDEP identified potential disposal areas outside the existing landfill boundaries. As such, NJDEP requested that the U.S. Army review and revisit (if appropriate) the delineation of all landfill areas at Fort Monmouth, including M-12 and M-14. NJDEP further stated that test pitting to verify geophysical results of landfill boundary delineation would be good practice, and verifying landfill boundaries prior to closing and transfer of Fort Monmouth would be in the Army's best interest.

2.2.6.4 Surface Soils

According to NJDEP, the results of the surface soil sampling indicated that soil in the 0 to12-inch surface interval contains SVOCs and metals in concentrations exceeding the NJDEP RDCSCC throughout the M-12 Landfill and in two distinct areas of M-14. Therefore, these surface soils posed a potential direct-contact threat, and remedial action was required to minimize or eliminate the threat. Depending on the location and extent of the soil contamination exceeding the RDCSCC, targeted soil excavations may be feasible. At a minimum, engineering controls such as additional soil cover, fencing, and warning signs would be required, in conjunction with a deed notice.

NJDEP further stated that in Versar's M-14 RIR for Near-Surface Soils, compliance averaging of soil sample results was done incorrectly in several cases. Also, averaging was applied to arsenic and several polyaromatic hydrocarbons (PAH), which the NJDEP does not allow because the health-based Soil Cleanup Criteria (SCC) is less than the RDCSCC.

2.2.6.5 Surface Water and Sediments

NJDEP required a Baseline Ecological Evaluation (BEE) to determine whether receptors, especially within Husky Brook, have been impacted by contaminants from the M-12 and M-14 landfills.

NJDEP described collection and analysis of additional sediment samples for full TCL plus 30 and .TAL metals analyses. Sampling locations would include one upgradient, one downgradient, two locations along the landfills (at least one on each side of the tributary that splits the M-12 Landfill), and one from the tributary that splits the M-12 Landfill.

NJDEP noted that surface water sample (SWS) location #12, which is in Husky Brook Pond and was used as an upgradient sampling location in the M-14 RIR, should be used in the future as a point upgradient of both landfills.

NJDEP also recommended that because of the presence of measurable VOCs in surface water samples, additional surface water samples should be collected along Husky Brook in conjunction with the sediment sampling for TCL plus 30 and TAL metals. Passive diffusion bags (PDB) collect samples for VOC analysis and were to be deployed in the sediments to monitor shallow ground water discharging to Husky Brook. In addition, NJDEP requested that DPW evaluate

any U.S. Army property upgradient of the M-12 and M-14 Landfills that could be sources of VOCs in Husky Brook.

2.2.6.6 Ground Water

In the comment letter, NJDEP stated that an NFA determination could not be issued for ground water because of the following concerns and deficiencies:

- One upgradient background well must be installed and sampled for each landfill to provide data for remedial decision making. The background wells should be near the landfills, but in areas that were clearly not impacted by the landfills. Samples from the background wells should be analyzed for TAL metals only.

- An additional round of samples must be collected from all wells to provide data for remedial decision making because the existing wells at both landfills may not have been sampled since 2001. Analyses should be TCL VOCs, TCL SVOCs, and TAL metals.

- Approximately four wells, including an upgradient well, should be installed in the western portion of M-14. Samples collected from these wells should be analyzed for TCL plus 30 and TAL metals.

- Paper copies of all sampling documentation (such as ground water field parameters and low-flow sampling sheets) must be submitted in summary tables in reports.

This RIRA summarizes the results from the work performed as mandated by NJDEP in the comment letter.

2.2.7 Aerial Photograph Site Analysis - Main Post: 1940-1974

DPW performed an Aerial Photograph Site Analysis of the Main Post of Fort Monmouth in 2010. Information regarding M-14 observed on each figure studied as part of the analysis are presented below and found in **Appendix C**.

Figure 4: May 2, 1957: A 1957 aerial photograph of Fort Monmouth reveals that additional buildings had been constructed on the eastern side of the Main Post near the main gate, as well as an oval running track towards the center of the southern portion of the post. An incinerator is depicted in the southeast corner of the post boundary off of Main Street. In the photograph, the M-3, M-4, M-5, and M-8 landfills are clearly visible on the northeastern portion of the post, and the M-12 and M-14 landfills are clearly visible towards the center of the post. A small probable magazine area is noted on the figure, located slightly north of the current M-2 landfill area on the southwestern section of the post. The surrounding area appears to be more developed, with less open space and additional residential housing.

Figure 6: May 13, 1963: Changes in this aerial photograph are primarily noted in the M-3, M4, M-5, and M-8 landfills, which consolidate all of the landfills into one area labeled “Site 1.” An L-shaped wall appears to divide the M-8 and M-5 landfills. Possible debris and rubble and light-

toned surface are noted in the northwest portion of the M-5 landfill. The M-2 landfill is labeled as "Site 2 Poss Landfill," and seems to be fully delineated. A small fill area is depicted behind the Gosselin housing area within the vicinity of the current M-14 landfill.

Figure 7: December 6, 1969: The 1969 photograph of Fort Monmouth shows several new buildings that still remain today: the theater (Building 1215), bowling alley (Building 689), and Buildings 361, 362, and 363. The "Site 1" area that encompasses the M-3, M-4, M-5, and M-8 landfills shows a defined boundary for M8 and is now labeled as a landfill. Three new fill areas have been noted on the figure: (1) an area located within a small section of the current M-18 landfill; (2) an additional fill area in the western portion of the M-12 landfill; and (3) a small fill area located south of the 750 area. On the Oceanport Avenue section of Main Post, a tank cluster is identified behind the Building 116 warehouse.

Figure 8: March 13, 1974: The 1974 photograph of Fort Monmouth reveals minor changes to the installation. The figure depicts the Main Post from M-2 and M-3 landfills to the Oceanport Avenue area. The M-2, M-3, M-8, M-18, and M-12 landfills seem to be undisturbed and vegetated. The M-8 landfill appears to still be active.

2.2.7 Landfill Delineation Project, Fort Monmouth, New Jersey

On August 1, 2008, DPW presented to the NJDEP Site Remediation Program (SRP) for approval a landfill delineation study involving advancement of test pits and soil borings to confirm the boundaries of nine solid waste landfills at FTMM, including M-14 Landfill. The NJDEP SRP reviewed and approved the DPW's study according to a letter dated August 19, 2008 (NJDEP 2008) (**Appendix B**).

2.2.8 2009 Regulatory Approach to Fort Monmouth Landfills

According to this letter from the NJDEP SRP, the Army and NJDEP have been involved in discussions pertaining to soil cover requirements for the FTMM landfills since at least 1996 (NJDEP 2009). A well-vegetated soil cover approximately 1 foot thick exists on the surface of the great majority of the nine landfills, but areas of exposed waste deposits are present on some of the landfills. NJDEP stated that surface soils on all the landfills contain contaminants at concentrations exceeding New Jersey Soil Remediation Standards (SRS) including for the M-12/M-14 landfills. However, in many locations, the soil contaminants are indicative of historical fill. NJDEP stated that in locations where SRSs are exceeded, the SRP would accept placement of an additional 1-foot-thick clean soil cover to eliminate direct contact threat. Existing areas of exposed waste deposits must either be removed or properly re-graded and covered with 1 to 2 feet of clean soil cover. The SRP also stated that it would verify that the NJDEP Division of Solid and Hazardous Waste (DSHW) would accept 1 additional foot of soil cover as a proper final cover for the landfills.

The NJDEP DSHW requires evaluation of the landfills for methane gas generation and installation of passive or active gas venting systems as necessary. NJDEP stated that FTMM must perform a methane gas evaluation for each landfill or present existing documentation and data that conclusively show absence of subsurface methane gas at each landfill. In addition,

deed notices would be required for all landfills due to the documented presence of waste deposits, even if NFA status would be achieved. The NJDEP letter of February 24, 2009, appears in **Appendix B**.

2.2.9 2010 Sanitary Landfill Minor Disruption Approval

In September 2010, NJDEP granted FTMM Sanitary Landfill Minor Disruption approval (permit no. LCB100002) for the performance of on-going remedial investigation and remedial activities pertaining to the nine inactive landfill sites located throughout the FTMM army base (**Appendix B**). The minor disruption activities approved include soil borings, soil sampling, test pits, piezometer and monitoring well installation, injection of chemical and biological oxidation stimulants for ground water remediation and methane gas surveys. The approval was granted with a five-year expiration.

2.2.10 2010 NJDEP Regulatory Requirements for Fort Monmouth Landfills

In a letter dated November 2010, NJDEP SRS provided Attachment 1 *NJDEP Regulatory Approach – Fort Monmouth Landfills* (**Appendix B**). The letter indicates the NJDEP Solid and Hazardous Waste Program (SHWP) has determined that NJDEP SRP will assume the lead regulatory role for NJDEP. Attachment 1 provides a summary and discussion of all NJDEP regulatory requirements for the Fort Monmouth Landfills including: 1) Surface water and sediment; 2) Landfill cover/ surface soils; 3) Methane Gas; 4) Deed Notices and 5) Operation and Maintenance (NJDEP, 2010).

2.2.11 Public Notification

In accordance with the Notification and Public Outreach Rule of the NJDEP Technical Requirements for Site Remediation (TRSR) (N.J.A.C. 7:26E-1.4), Fort Monmouth established a Restoration Advisory Board (RAB) in 2006 with representatives from the local municipalities who represent a variety of interests and viewpoints. The RAB acts as a focal point to exchange information between Fort Monmouth and the local communities regarding environmental and restoration activities and meets on a quarterly basis to review and comment on on-going environmental work. The meetings are open to the public and are advertised in local newspapers. All environmental projects subject to the NJDEP TRSR are presented at the RAB.

Although the Public Notification requirements were amended in 2009 with the implementation of signs or periodic letters to inform the public of on-going environmental work, on June 17, 2010, Fort Monmouth requested that the NJDEP grant approval of an alternate notification and public outreach plan utilizing the existing RAB and document repository of Fort Monmouth environmental reports, which is accessible to the public. The NJDEP response indicated that the alternative plan provided adequate public notice and complied with the intent of 7:26E-1.4; NJDEP approved the request on June 24, 2010.

Public notification documentation is presented in **Appendix D**.

2.2.12 Baseline Ecological Evaluation (BEE)

Shaw Environmental, Inc. was contracted by the Army to conduct a BEE for Fort Monmouth's Main Post and Charles Wood Areas. Sampling of multiple media was conducted in 2010, the results of which are not available for discussion herein. The final BEE will be submitted to the NJDEP under separate cover in June 2011.

2.3 CURRENT CONDITIONS

On October 21, 2010, Tetra Tech conducted a site walk to assess current conditions at M-14. The site is located on the north side of Husky Brook, and consists of an open field with some trees. At the time of the walkthrough, the area was landscaped, with the grass cut and the trees pruned. A playground formerly existed on the eastern side of the site, but was completely removed following the evaluation of surface soil sampling results, collected May 29, 2009. A nature trail has been constructed that runs through the center of the property and across Husky Brook.

General utilities servicing M-14 Landfill are depicted on **Figure 2-3**. Wetlands present on site are depicted on **Figure 2-4**.

2.4 ENVIRONMENTAL SETTING

The description of the geological/hydrogeological setting of M-14 is presented in the 2005 RIR (**Appendix A**). Included is a description of the regional geology and hydrogeology of the area surrounding FTMM and the Main Post and Charles Wood areas.

2.4.1 Regional and Local Geology

Monmouth County lies within the New Jersey Section of the Atlantic Coastal Plain physiographic province. The M-14 Landfill site is located in what may be referred to as the Outer Coastal Plain subprovince, or the Outer Lowlands. The geologic map of New Jersey is provided as Figure 2-4 of the 2005 RIR (**Appendix A**).

As presented in the Weston SI, the boring logs from monitoring well installations at M-14 indicate that the lithology consists of a thin soil cover (0.4 feet) underlain by alternating layers of reworked sand, silt, trace of clay and gravel with broken concrete gravel pieces with interbedded plant/root fragments. Borehole logs also represent a lithology consisting of a gray-green silty fine to coarse grained sand. Ground water saturation was observed 4-6 feet bgs at each well location during drilling activities at M-14. Water-level elevation data collected during the Weston SI indicate that local ground water flow is south toward Husky Brook (Versar, 2005).

2.4.2 Hydrogeology

A description of the hydrology of the site is provided in Section 2.4.2 of the 2005 RIR (**Appendix A**). The site is underlain by a Class III-A aquifer. The primary designated use for Class III-A ground water is the release or transmittal of ground water to adjacent classification

areas and surface water, as relevant. Secondary designated uses in Class III-A include any reasonable use.

Shallow ground water may be locally influenced within the Main Post Area by the following factors:

- Tidal influence (based on proximity to the Atlantic Ocean, rivers, and tributaries)
- Topography
- Nature of the fill material within the Main Post Area
- Presence of clay and silt lenses in the natural overburden deposits
- Local ground water recharge areas (e.g., streams, lakes)
- Roadways, utility conduits and stormwater culverts

Due to the fluvial nature of the overburden deposits (e.g., sand and clay lenses), shallow ground water flow direction is best determined on a case-by-case basis. The ground water flow in the vicinity of the M-14 Landfill is assumed to be south toward Husky Brook (Versar, 2005).

2.4.3 Soils

A description of the soils in the vicinity of M14 is provided in Section 2.4.4 of the 2005 RIR (**Appendix A**). According to the 2004 RIR, the soils in the vicinity of M-14 are classified as UD- Udorthents – smoothed.

2.4.4 Topography and Surface Drainage

A description of the topography and surface draining in the vicinity of Site 108 is provided in Section 2.4.5 of the 2005 RIR (**Appendix A**). According to the 2005 RIR, M-14 is located on the floodplain of Mill Creek. The USGS topographic map (**Figure 2-1**) shows that the land surface of the site is relatively flat at an elevation of less than 20 feet above mean sea level (amsl). M-14 is located north of the Husky Brook. Surface water runoff from the M-14 Landfill site is likely to flow south into the Husky Brook.

3.0 SITE ACTIVITIES

Fort Monmouth DPW has conducted remedial investigation activities at M-14, including landfill delineation activities, supplemental soil sampling, monitoring well installations, quarterly ground water sampling, and a sensitive receptor survey based on the earlier results and findings of Versar's October 2003 RIR SQE, March 2004 RIR NSS, and August 2005 RIR, and previous work conducted at M-14 by Weston in 1995. The purpose of this supplemental investigation was to define the areal extent of potential pollutants and evaluate impacts to ground water in the vicinity of M-14, and to address comments from NJDEP's July 25, 2007 correspondence. Remedial investigation activities documented in this report were performed from April 2001 through August 2010. These activities were managed by the Fort Monmouth DPW and performed by various DPW contractors.

The details of remedial investigation activities that occurred at M-14 - including soil sample collection activities, landfill delineation activities, monitoring well installation activities, surface water sampling activities, ground water sampling activities, ground water depth measurements, and sensitive receptor/well surveys - are described in the following sections.

3.1 SOIL SAMPLE COLLECTION ACTIVITIES

DPW is currently preparing a response to the July 25, 2007 NJDEP correspondence which commented that Versar's approach to compliance averaging of soil sample results was conducted incorrectly in several cases. Furthermore, an area west of M-14 has been assessed via near-surface soil sampling and analysis in preparation of the construction of a proposed children's play area. The results indicated that soil within this area contain contaminants at concentrations exceeding the NJDEP RDCSRS (**Table 3-1**). Therefore, no construction in this area will occur.

3.2 LANDFILL DELINEATION ACTIVITIES

In December 2008, DPW conducted a landfill boundary delineation to determine the exact aerial extent of M-14. Trench excavations were performed at a total of 31 locations along M-14 boundary (**Figure 3-1**). Trench logs and a photographic documentation log depicting trenching activities are included in **Appendix F**. Based on the results of the trench excavation, the landfill boundaries were expanded to include areas where landfilled materials were not previously encountered. A record of the materials observed in the trenches has been tabulated and included in **Table 3-2**.

In addition to excavating trenches, DPW collected soil samples in an effort to better define the boundaries of M-14 and to characterize near-surface soil quality conditions between the landfill (non-residential) and single-family structures (residential area) to the north. FTMM DPW characterized the near-surface soils using 203 soil borings installed at strategic locations over the site. DPW installed soil borings and collected soil samples from December 28, 1998 to May 13, 2010 (**Figure 3-2**). All soil samples were analyzed for Semi-volatile Organic Compounds (SVOCs), Volatile Organic Compounds (VOCs), Pesticides, Polychlorinated biphenyls (PCBs), and Total Analyte List (TAL) metals.

FTMM DPW installed the soil borings in accordance to the NJDEP Technical Requirements for Site Remediation (N.J.A.C. 26:E) to characterize near surface soil and assess potential risk to human health or the environment. Soil boring activities were managed by FTMM DPW and performed by TECOM-Vinnell Services (TVS).

All soil sampling activities, including waste disposal, were conducted in accordance with applicable Fort Monmouth Standard Operating Procedures (**Appendix G**), which comply with the most current version of the NJDEP's Field Sampling and Procedures Manual.

Samples were collected using a two-inch Geoprobe® Macrocore sampler. A total of 518 samples was collected from 203 soil borings. The soil boring locations were located in and around M-14 as identified in the 1995 Weston SI report. The locations of the borings were established in a grid-like pattern within the previously designated boundaries of M-14. Each soil sample, except those prepared for VOC analysis, were collected between zero and 12 inches bgs. VOC samples were collected at approximately 24 inches bgs since surface soils would not be expected to retain volatile constituents over time.

Laboratory analyses of the samples collected were conducted at Fort Monmouth Environmental Testing Laboratory (FMETL), a New Jersey certified laboratory. A summary of the soil sample collection information and analyses performed is provided in **Table 3-3**.

3.3 SURFACE WATER SAMPLING ACTIVITIES

DPW conducted surface water sampling at M-14 from March 2003 through September 2010. 124 surface water samples were collected over 31 rounds of sampling from four distinct surface water sampling collection points (SS-09, SS-11, SS-12 and SS-19). **Figure 3-3** depicts the locations of the surface water sample collection points at M-14. The samples were analyzed by Fort Monmouth Environmental Testing Laboratory (FMETL) for VOCs plus 15 TICs in accordance with U.S. Environmental Protection Agency (EPA) Methods 601 and 602 (purgeable halocarbons and aromatics, respectively), TAL metals, and various wet chemistry parameters. The results of these analyses are discussed in **Section 3.4**.

Sampling equipment was thoroughly decontaminated before and after each use in accordance with the Fort Monmouth Standard Sampling Operating Procedure (DPW 1997) **(Appendix G)**. The surface water samples were collected and immediately placed in laboratory-supplied bottleware. Sample containers were labeled, sealed, packed in ice, and transported to the FMETL in accordance with proper chain-of-custody procedures. Copies of the chain-of-custody forms for the laboratory analyses are presented in **Appendix H**.

3.4 MONITORING WELL INSTALLATION ACTIVITIES

Three additional monitoring wells were installed in the vicinity of M-14 in July 2010 (M14MW18 and M14MW25) and October 2010 (M14 MW26) 2010 to address NJDEP's July 25, 2007 comments. These wells are located along the western border of M-14 (**Figure 3-4)** and serve as upgradient background wells for the landfill. Samples from these wells were collected

and analyzed for TCL plus 30 and TAL metals; results are discussed in **Section 3.5.** Boring logs and monitoring well construction diagrams for wells within M-14 are included in **Appendix I.**

3.5 GROUND WATER SAMPLING ACTIVITIES

As part of the remedial investigation of M-14, quarterly ground water sampling was conducted from April 2001 through August 2010. Sampling activities were performed in accordance with the Fort Monmouth Standard Sampling Operating Procedure (DPW 1997). Laboratory analyses of the samples collected at M-14 were conducted at the FMETL, a New Jersey certified laboratory (Certification No. 13461).

This section describes the quarterly ground water sampling conducted by the DPW at M-14 from the second quarter of 2001 through the third quarter of 2010. During this period, ground water samples were collected during 38 quarterly sampling events. Ground water samples collected from April 2001 to November 2004 were analyzed for TCL plus 30 (VOCs plus 15 TICs and SVOCs plus 15 TICs), pesticides and PCBs, and TAL metals by FMETL using EPA Methods 624, 625, 608, 3113B, and 3111D (or 3120B and 3112B). From November 2004 through August 2010, ground water was analyzed for VOCs and TAL metals only. Three low-flow sampling rounds for TAL metals were conducted on March 31, June 7, 2010, and September 8, 2010.

The waste types generated by the remedial activities included three-gallon polyethylene pails, polyethylene tubing, Teflon® bailers, mason string, and personal protective equipment (PPE). The pails were recycled, and the other materials were disposed of in accordance with the *Fort Monmouth Solid Waste Management Plan*

A total of 266 ground water samples, including 37 duplicate samples for quality assurance and quality control (QA/QC) purposes, was collected from seven monitoring wells (M14MW19 through M14MW25) from April 2001 to August 2010. The additional three monitoring wells, M14MW18, M14MW25 and M14MW26, were installed by DPW in July and October 2010, and will be incorporated into the quarterly ground water monitoring program. Data from these three wells is not yet available.

Copies of the chain-of-custody forms for the laboratory analyses and laboratory data sheets are presented in **Appendix J**. Analytical data were validated for laboratory issues and the data validation packages for the 4th Quarter 2009 and 2nd Quarter 2010 sampling events is provided in **Appendix K**. A summary of the ground water sampling activities, including sampling rounds, well IDs, sample IDs, sampling locations, collection/analysis dates, analytical parameters, and analysis methods, is provided in the laboratory data package in **Appendix J**. The results of these analyses are discussed in **Section 5.5**.

As discussed in the Weston December 1995 SIR and Versar's August 2005 RIR, several natural and anthropogenic factors contribute to the wide range in concentrations of metals in soils, which further impact the concentration of metals in ground water. Soils derived from the glauconitic sands contain abundant aluminum, calcium, potassium, iron, magnesium, and manganese (among others), which are likely to be present at elevated concentrations in the ground water, particularly when sediments are entrained in the collected ground water samples. Low-flow

sampling methodology has been employed at the site in the past to reduce the presence of entrained sediment and has generally yielded substantial reductions in the dissolved-phase concentrations of metals, such as arsenic, antimony, beryllium, cadmium, chromium, cobalt, lead, mercury, selenium, silver, thallium, and vanadium at Fort Monmouth sites. Decreases in the concentrations of metals characteristic of glauconitic sand have been historically observed. These included aluminum, barium, calcium, copper, iron, magnesium, manganese, nickel, potassium, sodium, and zinc.

Two rounds of low-flow sampling (Low-flow #3 and Low-flow #4) were conducted on March 31, 2010 and June 4, 2010. A total of 12 samples were collected from 6 wells (M14MW19 through M14MW24) and analyzed for TAL metals to determine whether elevated metals concentrations observed in the ground water samples at M-14 are caused by entrained soil particles (i.e., high turbidity) rather than dissolved-phased ground water constituents. The samples were analyzed by FMETL for TAL metals in accordance with EPA Methods 3120B and 3112B. The results of these analyses are discussed in **Section 5.5**.

Sampling equipment was thoroughly decontaminated before and after each use, in accordance with the Fort Monmouth Standard Sampling Operating Procedure (DPW 1997). Following collection, the ground water samples were immediately placed in laboratory-supplied bottleware. The sample containers were labeled, sealed, packed in ice, and transported to the FMETL in accordance with proper chain-of-custody procedures.

3.6 GROUND WATER DEPTH MEASUREMENTS

During each of the ground water monitoring rounds, depth-to-water measurements in each of the monitoring wells were recorded with an accuracy of 0.01 foot. These depth-to-ground water measurements, recorded from April 2001 through August 2010, are presented in **Table 3-4**. The ground water elevation at each well was calculated by subtracting the measured depth to ground water from the elevation of the top of the well casing. The ground water elevations are discussed in **Section 6.0**.

3.7 OFFSITE RECEPTOR EVALUATION

A visual and documentary search of sensitive populations was performed by the FTMM DPW and its subcontractor to identify any potentially sensitive populations within 200 feet of the FTMM boundary. The identification of said populations accords with NJDEP statutory requirement.

Although the identified populations are within 200 feet of the FTMM boundary, all of the environmentally impacted locations are at a distance from the fence line that exceeds the 200-foot buffer established by NJDEP (**Figure 3-5**).

In addition to sensitive receptors, the DPW included in the search all identified off-site wells within 2,000 feet of the FTMM perimeter. No production wells were identified within 2,000 feet of the FTMM boundary. The majority of off-site wells are monitoring wells associated with various remedial activities. A ground water model has been developed for FTMM, with the

overall ground water flow pattern for the Main Post being easterly with a localized northeasterly component. FTMM is bounded by surface water bodies to the east and northeast that mitigate any potential impacts from FTMM onto any domestic and/or irrigation wells located to the east or northeast of the Main Post.

Surface water bodies interact with ground water at FTMM. The interaction takes place in three basic ways: (1) streams gain water from inflow of ground water through the Streambed, (2) they lose water to ground water by outflow through the streambed, or (3) they do both, gaining in some reaches and losing in other reaches. When ground water discharges into a surface water body, the altitude of the ground water table in the vicinity of the creek must be higher than the altitude of the stream-water surface. Conversely, for surface water to seep to ground water, the altitude of the water table in the vicinity of the stream must be lower than the altitude of the stream-water surface. The surface water bodies at FTMM (Oceanport and Parkers Creeks) may be gaining or losing depending upon the tidal cycle. Throughout the entire tidal cycle, however, the net result is ground water inflow into the creeks, albeit at low flow rates.

A copy of the offsite receptor evaluation report and survey form (Tetra Tech 2010) are provided in **Appendix L.**

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4.0 SITE PHYSICAL CHARACTERISTICS

Geologic and hydrogeologic characterization of M-14 was performed as part of the Weston SIR and Versar RIR. Detailed discussions of the physical properties of the unconsolidated soil, bedrock, and ground water underlying M-14 area are included in these reports, found in **Appendix A**.

4.1 GROUND WATER FLOW DIRECTION

Ground water contour maps were generated based on ground water depth measurements from quarters one through three of 2010 ground water sampling rounds (**Figures 4-1 to 4-3**). Ground water underlying M-14 Landfill flows toward Husky Brook. Ground water measurements collected from March 2009 to September 2010 are included in **Table 3-4.**

4.2 GLAUCONITIC SOIL AND METALS EVALUATION

A Basewide Glauconitic Investigation Report was completed by DPW in March 2011 and a Background Metals Evaluation was prepared by Brinkerhoff for DPW in May 2011. Both documents indicate the potential for soil particles present in ground water samples which are potentially affecting the metals analysis results in ground water samples collected from the overall FTMM site. Additional ground water sampling including the comparison of filtered and unfiltered samples results has been proposed to determine the potential affect of soil particles on metals analysis results. Results and conclusions from these future sampling events will be provided to NJDEP under separate cover.

The Basewide Glauconitic Investigation Report and the Background Metals Evaluation Report are provided in **Appendix E.**

5.0 SITE CHEMICAL CHARACTERIZATION

This section includes a discussion of the chemical characterization of M-14 based on the various samples collected and analyzed during 38 quarterly rounds of ground water monitoring well sampling, including two low-flow sampling rounds. Specifically, this section summarizes near-surface soil sampling results, surface water sampling results and contaminants of concern, and ground water sampling results and contaminants of concern.

Ground water monitoring well sampling was conducted from April 2001 to August 2010. DPW personnel were responsible for the collection of samples during this remedial investigation. Sample analyses were performed by FMETL.

5.1 SOIL SAMPLING RESULTS

A total of 518 soil samples was collected from 203 soil borings (B1-B119, C01-C31, D01-D40, Playground 1A – 9A, and Mulch-1 – 4) at M-14 from December 23, 1998 to May 13, 2010. The results were compared to the Soil Remediation Standards (N.J.A.C. 7:26D), which were revised November 4, 2009, per Attachment 1 of NJDEP's Regulatory Approach to Fort Monmouth Landfills (NJDEP, 2010). The soil analytical results are presented by analyte (VOCs, SVOCs, pesticides, PCBs, and metals) and the analytical results are compared to the NJDEP NRDCSRS. All soil sample results are expressed in milligrams per kilogram (mg/kg), equivalent to parts per million (ppm). Analytical data for M-14 are presented in **Table 5-1**. Concentrations that exceeded their respective NRDCSRS are highlighted in red in **Table 5-1** and illustrated on **Figures 5-1 through 5-3**.

5.1.1 VOCs

The soil samples to be analyzed for VOC were collected from M-14 at a depth of 24 inches bgs. **Table 5-1** presents the results of the laboratory analysis for VOCs. Five VOCs were detected in 49 soil samples. No VOC concentrations exceeded the NJDEP NRDCSRS at M-14.

5.1.2 SVOCs

The soil samples to be analyzed for SVOC were collected from M-14 a depth range of six to 24 inches bgs. A total of 23 SVOCs was detected in site soil borings. Six of the SVOCs were detected at concentrations exceeding their respective NJDEP NRDCSRS in at least one sample (benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene). These analytical results are summarized in **Tables 5-1 through 5-3**.

Benzo(a)anthracene was detected at concentrations exceeding the NRDCSRS of 2 mg/kg in six samples. Concentrations ranged from 2.4 mg/kg at B-8 (6-12") and B-114 (6-12") to 27 mg/kg at B-60 (6-12").

Benzo(a)pyrene was detected at concentrations exceeding the NRDCSRS of 0.2 mg/kg in 20 samples. Concentrations ranged from 0.24 mg/kg at B-11 (6-12") and B-43 (6-12") to 26 mg/kg at B-60 (6-12").

Benzo(b)fluoranthene was detected at concentrations exceeding the NRDCSRS of 2 mg/kg in six samples. Concentrations ranged from 2 mg/kg at B-112 (6-12") to 23 mg/kg at B-60 (6-12").

Benzo(k)fluoranthene was detected at concentrations exceeding the NRDCSRS of 23 mg/kg in one sample location at a concentration of 25 mg/kg at B-60 (6-12").

Dibenz(a,h)anthracene was detected at concentrations exceeding the NRDCSRS of 0.2 mg/kg in seven samples. Concentrations ranged from 0.21 mg/kg at B-25 (6-12") to 2.05 mg/kg at D-05 (0-6").

Indeno(1,2,3-cd)pyrene was detected at concentrations exceeding the NRDCSRS of 2 mg/kg in three samples. Concentrations ranged from 4.1 mg/kg at D-05 (0-6") to 13 mg/kg at B-60 (6-12").

5.1.3 Metals

The soil samples to be analyzed for Metals were collected from M-14 a depth range of six to 24 inches bgs. A total of 23 metals was detected in site soil borings. Two of the metals were detected at concentrations exceeding their respective NJDEP NRDCSRS in at least one sample (arsenic and lead). These analytical results are summarized in **Tables 5-1 through 5-3**.

Arsenic was detected at concentrations exceeding the NRDCSRS of 19 mg/kg in 58 samples. Concentrations ranged from 19.2 mg/kg at C-11 (0-6") to 168 mg/kg at B-28 (6-12").

Lead was detected at concentrations exceeding the NRDCSRS of 800 mg/kg in one sample location at a concentration of 946 mg/kg at D-37 (0-6").

5.2 CONTAMINANTS OF CONCERN IN SOIL

In order to determine potential COCs in soil, the first step was to identify exceedances of the NJDEP NRDCSRS in soil samples collected at the site. These exceedances are presented in **Section 5-1** above and summarized in **Tables 5-2 and 5-3 and Figures 5-1 through 5-3**.

The comparison of each exceedance to established maximum background concentrations (MBC) at the Main Post were then used, when appropriate, to eliminate or identify analytes as COCs. If a concentration exceeded both the regulatory standard and the MBC for the Main Post, the analyte was classified as a COC.

No VOCs, pesticides or PCBs were detected at concentrations greater than NRDCSRS; therefore VOCs, pesticides and PCBs are not considered COCs at M-14.

23 SVOCs and 23 metals were detected in site soil borings. Six of the 23 SVOCs detected [benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene] were detected at concentrations exceeding NJDEP NRDCSRS. Two of the 23 metals detected (arsenic and lead) were detected at concentrations exceeding NJDEP NRDCSRS.

The six SVOCs [benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene] are considered COCs for M-4 Landfill. These SVOCs exceed both their respective NRDCSRS and MBC established for soils at the Main Post:

- ***Benzo(a)anthracene*** is considered a COC because it was detected at concentrations greater than the MBC of 0.65 mg/kg in six of the six samples where benzo(a)anthracene exceeded NJDEP NRDCSRS (2 mg/kg).
- ***Benzo(a)pyrene*** is considered a COC because it was detected at concentrations greater than the MBC of 0.6 mg/kg in 10 of the 21 samples where benzo(a)pyrene exceeded NJDEP NRDCSRS (0.2 mg/kg).
- ***Benzo(b)fluoranthene*** is considered a COC because it was detected at concentrations exceeding the MBC of 0.9 mg/kg in six samples where benzo(b)fluoranthene exceeded NJDEP NRDCSRS.
- ***Benzo(k)fluoranthene*** was detected in only one sample at a concentration greater than the NJDEP NRDCSRS and the MBC of 0.43 mg/kg. Due to the infrequency and magnitude of exceedance in soil samples, benzo(k)fluoranthene is not considered to be a COC.
- ***Dibenz(a,h)anthracene*** is considered a COC because it was detected at concentrations greater than the MBC of 0.079 mg/kg in seven samples where dibenz(a,h)anthracene exceeded NJDEP NRDCSRS.
- ***Indeno(1,2,3-cd)pyrene*** is considered a COC because it was detected at concentrations greater than the MBC of 0.46 mg/kg in three samples where indeno(1,2,3-cd)pyrene exceeded NJDEP NRDCSRS.

The two metals (arsenic and lead) are considered COCs for M-14 Landfill. These metals concentrations exceeded both their respective NRDCSRS and MBC established for soils at the Main Post of FTMM. Arsenic and lead are common background constituents in Monmouth County and site specific soils and elevated concentrations of these metals were observed in soil samples collected at Fort Monmouth. The soil analytical results for these two metals were compared to their respective MBCs of 22.9 mg/kg (arsenic) and 19.5 mg/kg (lead).

- ***Arsenic*** is considered to be a COC because arsenic was detected at concentrations greater than the MBC of 22.9 mg/kg in 32 out of 58 samples where detections exceeded NJDEP NRDCSRS.

- ***Lead*** was detected in only one sample at a concentrations greater than the NJDEP NRDCSRS and the MBC. Due to the infrequency and magnitude of exceedance in the soil samples, lead is not considered to be a COC.

5.3 QUALITY ASSURANCE/QUALITY CONTROL - SOIL

Quality assurance/quality control (QA/QC) samples including samples duplicates, field blanks and trip blanks, were collected in accordance with the version of the NJDEP *Field Sampling Procedures Manual* in effect at the time sampling was conducted There was no evidence of any QA/QC issues identified based on the results of the QA/QC sample results.

5.4 SURFACE WATER SAMPLING RESULTS

At total of 31 rounds of surface water sampling (a total of 124 surface water samples) was conducted from March 2003 through September 2010 at four surface water sample collection points (SS-09, SS-11, SS-12 and SS-19) at M-14. The samples were analyzed by FMETL for VOC plus15, TAL metals, and various wet chemistry parameters. Surface water samples were not analyzed for SVOCs, pesticides, or PCBs, as discussed in Versar's August 2005 RIR.

This section discusses potential COCs in surface water, and their impact on surface water quality at M-14. The laboratory analytical results for stream sampling are summarized in **Table 5-4**. The results were compared to the NJDEP SWQS and MBCs identified in Weston's December 1995 SIR **(Appendix A)**. Analytes detected at concentrations greater than their respective NJDEP cleanup criterion are highlighted in gray shading and bold typeface in **Table 5-4**. The laboratory chain-of-custody forms for surface water samples are provided in **Appendix H**.

In order to define the current surface water quality at M-14, the following discussion will concentrate on the most recent eight quarters of sampling, conducted from December 2008 to September 2010. **Figure 3-3** depicts the most recent contaminant distribution for surface water within the area of M-14.

The constituents detected in surface water samples collected during the most recent eight quarters of sampling at concentrations that exceed NJDEP SWQS are discussed below.

5.4.1 VOCs

Vinyl chloride was detected at concentrations greater than the NJDEP SWQS of 0.082 micrograms per liter (µg/L) in three separate rounds of sampling conducted at one surface water sampling location. Vinyl chloride was detected at concentrations greater than the SWQS at SS-11 with concentrations ranging from 0.3 µg/L in sampling round 53 to 0.76 µg/L in sampling round 54.

Bromodichloromethane was detected at a concentration greater than the NJDEP SWQS of 2.49 µg/L in one round of sampling condcuted at two surface water sampling locations. Bromodichloromethane was detected at concentrations exceeding the SWQS in sampling round 55 at concentrations of 1.03 µg/L at SS-19 and 1.08 µg/L at SS-12.

5.4.2 Metals

Arsenic was detected at concentrations greater than the NJDEP SWQS of 0.017 µg/L in each of the most recent eight quarters of sampling conducted at three surface water sampling locations. Arsenic was detected at concentrations exceeding the SWQS with concentrations ranging from 0.750 µg/L in sampling round #54 at SS-19 to 69.2 µg/L in sampling round #50 at SS-11. Arsenic was also detected at concentrations greater than its surface water MBC of 2.6 µg/L in nine rounds of sampling between SS-09, SS-11, and SS-19 during the most recent eight quarters of sampling.

Lead was detected at a concentration greater than the NJDEP SWQS of 5.0 µg/L in one round of sampling #50 conducted at three surface water sampling locations. Lead was at concentrations ranging from 5.47 µg/L at SS-11 to 9.2 µg/L at SS-09. These concentrations are less than the surface water MBC of 10 µg/L for lead.

5.4.3 pH

pH was measured outside the acceptable NJDEP SWQS range of 6.5-8.5 in three rounds of sampling collected at three surface water sampling locations. The pH ranged from 6.00 in sampling round #56 at SS-12 to 6.49 in sampling round #53 at SS-09.

5.5 CONTAMINANTS OF CONCERN IN SURFACE WATER

To determine the potential COCs in surface water at M-14, exceedances of the NJDEP SWQS were identified in surface water samples collected from the site. These exceedances are presented in **Tables 5-4 and 5-5**. In addition, the magnitude and frequency of the exceedances and comparisons to established background concentrations were used to eliminate or identify analytes as COCs. **Table 5-5** summarizes the process used to identify COCs in surface water at M-14.

In accordance with NJDEP's July 25, 2007 correspondence, DPW used SS-12 as an upgradient sampling location for M-14. It is the contention of the DPW that the concentrations of the two VOCs exceeding the NJDEP SWQS in the surface water samples are from a source upgradient of M-14 beyond the boundary of Fort Monmouth. No similar constituents were detected in ground water at M-14 during prior sampling events. Therefore, the VOC constituents detected in surface water at M-14 are not identified as COCs.

A total of four pH measurements collected from surface water at M-14 were outside the acceptable range for NJDEP SWQS. The pH measurements at these locations have historically fluctuated between a high of 8.77 in sampling round #47 at SS-12 to a low of 5.74 in sampling round #26 at SS-09. This fluctuation between high and low pH is indicative of either measurement error or natural pH variation. Therefore, pH is not identified as a COC for M-14.

The metals arsenic and lead were detected in surface water in concentrations exceeding NJDEP SWQS. However, because the two concentrations of lead are not greater than the surface water

MBC of 10 µg/L, lead is not considered a COC. The presence of arsenic greater than the MBC for surface water in both ground water and surface water may signify the migration of arsenic into the nearby surface water body (Husky Brook) at M-14. Arsenic is therefore a COC for surface water for M-14. This situation requires further evaluation and continued monitoring of both surface water and ground water for arsenic.

Based on the magnitude of the exceedances, the frequency of occurrences, and the wide-ranging results, one metal (arsenic) is identified as a COC in surface water at M-14. No other COCs were identified in surface water at M-14. The concentrations of arsenic in surface water at M-14 are summarized on **Figure 3-3** and in **Table 5-5**.

The method detection limits (MDL) for each non-detect (ND) sampling result are included in the laboratory data packages found in **Appendix H.** The method detection limit for each analysis is included in the laboratory data packages.

5.6 GROUND WATER SAMPLE RESULTS

This section presents a discussion of the results of laboratory analyses performed for the 38 rounds of ground water samples collected from April 2001 through August 2010 from the seven monitoring wells (M14MW19 through M14MW25). These 38 rounds are a combination of 36 quarterly rounds collected from M14MW19 through M14MW25 and two low-flow rounds (Low-flow #3 and Low-flow #4) conducted on March 31 2010 and June 4, 2010. As discussed in **Section 2.2.3**, a low-flow sampling methodology was proposed for use by the DPW and accepted by the NJDEP to assess the impact of suspended sediments on the dissolved-phase metals concentrations at M-14 during the second and third quarterly sampling rounds of 2010. In addition, ground water monitoring wells M14MW18 and M14MW26 were installed in July and October 2010, respectively. At this time, no data from these wells are available.

Ground water samples were collected and analyzed for VOCs plus 15 TICs, SVOCs plus 25 TICs, pesticides, PCBs, and TAL metals from April 2001 through August 2004. Upon approval from NJDEP's in November 2004 (as discussed in **Section 3**), ground water samples were collected from M14MW19 through M14MW25 and analyzed for VOCs and TAL metals only through August 2010.

As discussed in Versar's August 2005 RIR, Fort Monmouth is underlain by a Class III-A aquifer. The appropriate ground water quality criteria for Class III-A are the criteria for the most stringent classification for vertically or horizontally adjacent ground waters that are not Class III-A (NJAC 7:9-6.7e). Ground water analytical results were compared against the higher of the NJDEP Practical Quantitation Limits (PQL) and the NJDEP GWQS for Class II-A aquifers (NJAC 7:9-6, Table 1). Analytes detected in ground water samples collected from M-14 at concentrations greater than the NJDEP criteria are bold and highlighted in **Table 5-6**. The chain-of-custody forms for ground water samples and laboratory data sheets are provided in **Appendix J**. **Figure 5-4** depicts the contaminant distribution for ground water within the area of M-14.

During the 38 quarterly sampling events conducted from April 2001 to August 2010, a total of 41 samples contained detectable concentrations of five VOCs in site ground water. Three of

these samples contained one VOC (chlorobenzene) in one monitoring well (M14MW22) at concentrations exceeding NJDEP GWQS. A total of 11 samples contained detectable concentrations of five SVOCs in site ground water. One sample from M14MW24 contained an estimated amount of the SVOC pentachlorophenol at a concentration exceeding its respective NJDEP GWQS. A total of 19 samples contained detectable concentrations of seven pesticides in site ground water. None of these pesticides were detected at concentrations exceeding NJDEP GWQS. No PCBs were detected in site ground water.

Eight of the 12 metals detected in site ground water (antimony, arsenic, beryllium, cadmium, lead, nickel, selenium, and thallium) were detected at concentrations that exceeded their respective GWQS in at least one sample.

This section discusses analytical results for VOCs and metals detected at concentrations exceeding the NJDEP GWQS. In order to define the current ground water quality beneath M-14, analytical results from the most recent eight quarters of sampling, conducted from October 2008 to August 2010, are summarized in the following sections.

5.6.1 VOCs

During the eight quarterly sampling events conducted from October 2008 to August 2010, a total of six samples (five from M14MW22 and one from M14MW23) contained detectable concentrations of four VOCs (chlorobenzene; 1,4-dichlorobenzene; methylene chloride; and *tert*-butyl alcohol) in site ground water. None of these concentrations exceeded NJDEP GWQS. No TICs were detected greater than the appropriate NJDEP GWQS at the site (500 µg/L for total TICs and 100 µg/L for an individual compound).

5.6.2 Metals

During the past eight quarterly sampling events conducted from October 2008 to August 2010, eight metals were detected in ground water samples at concentrations greater than their respective NJDEP GWQS.

Antimony was detected at concentrations exceeding the GWQS of 6 µg/L in five rounds of sampling conducted at six monitoring well locations. Concentrations ranged from 6.5 µg/L (Low-flow #4 – round 55) in M14MW21 to 23.1 µg/L (sampling round 38) in M14MW24.

Arsenic was detected at concentrations exceeding the GWQS of 3 µg/L in seven rounds of sampling conducted at seven monitoring well locations. Concentrations ranged from 3.27 µg/L (sampling round 49) in M14MW24 to 95.6 µg/L (sampling round 38) in M14MW24.

Beryllium was detected at a concentration exceeding the GWQS of 1 µg/L in only one round of sampling (1.09 µg/L in sampling round 38) conducted at one monitoring well location (M14MW23).

Cadmium was detected at concentrations exceeding the GWQS of 4 µg/L in three rounds of sampling conducted at two monitoring well locations. Concentrations ranged from 5.82 µg/L (sampling round 42) in M14MW23 to 145 µg/L (sampling round 56) in M14MW22.

Lead was detected at concentrations exceeding the GWQS of 5 µg/L in three rounds of sampling conducted at four monitoring well locations. Concentrations ranged from 5.41 µg/L (sampling round 39) in M14MW24 to 9.96 µg/L (sampling round 50) in M14MW22.

Nickel was detected at a concentration exceeding the GWQS of 100 µg/L in only one round of sampling conducted at one monitoring well location. Nickel was detected at 205 µg/L (sampling round 56) in M14MW22.

Selenium was detected at concentrations exceeding the GWQS of 40 µg/L in five rounds of sampling conducted at six monitoring well locations. Concentrations ranged from 41.2 µg/L (sampling round 55) in M14MW19 to 119 µg/L (sampling round 44) in M14MW24.

Thallium was detected at concentrations exceeding the GWQS of 2 µg/L in one round of sampling conducted at two monitoring well locations. Concentrations were 2.03 µg/L (sampling round 38) in M12MW23 and 4.02 µg/L (sampling round 37) in M14MW24.

5.7 CONTAMINANTS OF CONCERN IN GROUND WATER

Several factors were used to eliminate or identify analytes as COCs. These factors include the magnitude and frequency of the exceedances of the NJDEP GWQS in monitoring well samples collected at the site during the past eight quarterly sampling events, comparisons to low-flow sample results (for metals only), and comparisons to established background concentrations (see **Section 5.5**). **Table 5-7** summarizes the process used to identify COCs in ground water at M-14.

No VOCs were detected at concentrations exceeding the GWQS during the past eight quarterly sampling events. Therefore, no VOCs are considered COCs at M-14.

Samples were not analyzed for SVOCs, pesticides, and PCBs in accordance with the NJDEP correspondence dated November 2004 **(Appendix B).**

A total of eight metals was detected in ground water at M-14 at concentrations exceeding the NJDEP GWQS (antimony, arsenic, beryllium, cadmium, lead, nickel, selenium, and thallium) during the last eight quarterly sampling events. The evaluation of each of these metals as a potential contaminant of concern is discussed below.

As discussed in **Section 3.5**, a low-flow sampling methodology was proposed for use by the DPW and accepted by the NJDEP to assess the impact of suspended sediments on the dissolved-phase metals concentrations at M-14. The eight different metals detected in M-14 ground water at concentrations exceeding the NJDEP GWQS were divided into background and non-native metals. The indigenous metals were then compared to the Main Post MBCs identified in the 1995 Weston SIR and presented in **Table 5-7**.

Four of the eight metals detected in M-14 ground water at concentrations exceededing GWQS (antimony, beryllium, lead, and thallium) are considered common background constituents in Monmouth County soils. The water chemistry in this area is affected by glauconitic sediments (such as Red Bank, Tinton and Hornerstown sands) underlying the site (Versar 2005). Elevated concentrations of these metals are routinely observed in ground water samples collected at Fort Monmouth. Based on this information, the ground water analytical results for these four metals were compared to their respective MBCs of 20.7 µg/L (antimony), 2.1 µg/L (beryllium), 22.7 µg/L (lead), and 5.5 µg/L (thallium) as follows:

- Antimony is considered a potential COC because antimony was detected at concentrations greater than both GWQS and MBC.
- Beryllium is not considered to be a COC because beryllium was not detected at concentrations exceeding the MBC.
- Lead is not considered to be a COC because lead has not been detected at concentrations exceeding the MBC.
- Thallium is not considered to be a COC because thallium was not detected at concentrations exceeding the MBC.

A total of four non-native metals detected in ground water samples exceeded the GWQS (arsenic, cadmium, nickel, and selenium). These metals, in addition to antimony, were compared to sample results collected during the low-flow sampling rounds.

Two separate rounds of sampling (March 31, 2010 and June 7, 2010) were performed during the quarterly ground water sampling program using a low-flow ground water sampling technique, as discussed in **Section 3.5**. This technique was used to determine whether the detected metal concentrations observed in the ground water samples are a function of entrained sediments suspended in the ground water during the course of well purging and sampling activities, or an accurate representation of dissolved-phase aquifer/ground water conditions. These comparisons provided the following results:

- Antimony is not considered to be a COC because antimony was not detected at concentrations exceeding the MBC in low-flow ground water sampling rounds.
- Arsenic is not considered to be a COC because arsenic was not detected at concentrations exceeding the MBC in low-flow ground water sampling rounds.
- Cadmium is not considered to be a COC because cadmium was not detected at concentrations exceeding the MBC in low-flow ground water sampling rounds.
- Nickel is not considered to be a COC because nickel was not detected during the low-flow ground water sampling rounds. In addition, in the one instance where nickel exceeded GWQS, the concentration was only marginally greater than the MBC.
- Selenium concentrations exceeded the GWQS and MBC in samples collected during both of the low-flow sampling rounds. Based on these results, selenium is considered to be a potential COC at M-14.

Based on the magnitude of the exceedances and the frequency of occurrences, no metal is identified as a COC at M-14. No other COCs were identified in ground water at M-14. The concentration of selenium in ground water at M-14 is summarized in **Table 5-6**.

6.0 CONTAMINANT MIGRATION AND GROUND WATER USE DESIGNATION

This section describes the ground water modeling conducted for M-14.

6.1 Ground Water Modeling

Brinkerhoff Environmental Services, Inc. (Brinkerhoff), prepared the MODFLOW Ground water Modeling Report, dated June 10, 2010 (**Appendix N)**. The report summarizes the site-wide ground water models that Brinkerhoff developed and refined for both the Main Post and the Charles Wood Area. This section summarizes the tidal evaluation and ground water flow study discussed in Brinkerhoff's June 2010 MODFLOW Ground water Modeling Report (Brinkerhoff 2010).

6.1.1 Tidal Evaluation

As part of the ground water modeling project, Brinkerhoff performed a preliminary tidal evaluation of select monitoring wells throughout the Main Post of Fort Monmouth. The study locations were mutually selected by Brinkerhoff and representatives of Fort Monmouth to represent an overall profile for the Main Post area. On September 29, 2009, wireless data loggers were placed into each of the 25 predetermined ground water monitoring wells targeted for the study. Two ground water monitoring wells within M-14 area (M14MW20 and M14MW24) were utilized as part of the tidal evaluation. Data was collected for approximately 30 days.

According to the Brinkerhoff report, although an underlying rhythmic cycle appears to be present in the vicinity of M-14, the fluctuations may represent changes in hydraulic gradient and not tidal fluctuations. These changes appear to be exaggerated at intervals of low tide when the difference is the greatest between the ground water elevation in the well and the corresponding surface water. This effect appears to be muted during high tide when the difference is less significant (Brinkerhoff 2010).

6.1.2 Ground Water Flow

According to the modeling report, the suggested ground water flow directions indicated by the ground water flow model are generally consistent with those seen in previous ground water investigations and are also favorable when compared to ground water contour maps prepared using field depth-to-water measurements collected on January 28, 2010. The ground water contour map illustrating January 2010 measurements at M-14 that was created as part of the ground water modeling report is presented as **Figure 4-1**. The ground water contour map suggests that ground water at the site flows toward Husky Brook to the south and east (Brinkerhoff 2010).

In general, ground water flows from areas of relatively high topographic elevations toward lower topographic elevations where site surface water features are present. The MODFLOW simulation shows that the central portion of the Main Post is a relatively high ground water

divide, being that this portion of Fort Monmouth is almost completely surrounded by low-elevation surface water. The Main Post area can be characterized as having a small hydraulic gradient. When combined with the low hydraulic conductivity of the aquifer materials, this translates into very slow ground water migration. Particle markers, which represent typical travel paths and speeds for water molecules in the system, indicate extremely long travel times. In several areas of the Main Post, representative markers did not reach the nearest surface water sink within the 200-year travel time shown. As a result of the slow ground water velocity, recharge to the aquifer from rainfall, although very limited, has the effect of adding a downward component to the ground water flow (Brinkerhoff 2010).

The physical conditions of the site would likely contribute to ground water contaminant plumes with a dominant elongation in a downgradient direction. Vertical contaminant migration would typically be heavily impeded by the fine-grained aquifer materials present at depth (Brinkerhoff 2010).

7.0 CONCLUSIONS AND RECOMMENDATIONS

This section summarizes conclusions and recommendations for M-14, and addresses the remedial action work plan for the site.

Fort Monmouth DPW has conducted remedial investigation activities at M-14, including supplemental soil sampling, landfill delineation activities, monitoring well installations, quarterly ground water and surface water sampling, and a sensitive receptor survey based on the earlier results and findings of Versar's October 2003 RIR SQE, March 2004 RIR NSS, and August 2005 RIR, and previous work conducted at M-14 by Weston in 1995. The purpose of the supplemental investigations was to define the areal extent of potential pollutants, evaluate impacts to ground water and surface water in the vicinity of M-14, and address comments from NJDEP's July 25, 2007 correspondence. Remedial investigation activities documented in this report were performed from April 2001 through August 2010. These activities were managed by the Fort Monmouth DPW and performed by various DPW contractors.

7.1 SOIL CONCLUSIONS AND RECOMMENDATIONS

The surficial soil analytical results indicate that six SVOCs [benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene]_and two metals (arsenic and lead) were detected at concentrations greater than established NJDEP NRDCSRS and MBCs for the soils at the Main Post of FTMM at 63 soil boring locations(**Figures 5-1 through 5-3**).

An additional 1-foot to 1.5-feet of certified clean soil cover (a "soil cap"), depending on the depth at which contamination was found, is recommended to be placed over the soil borings where any SVOC and/or metal concentrations exceed NRDCSRS and MBC. This will provide a total of two-feet of clean soil as a remedial action and engineering control to address the contamination of surficial soils and prevent exposure. This action will be properly designed and constructed to allow proper drainage, to facilitate the growth of vegetation and to ensure that the soil cover is durable. Additionally, hot-spot removals are recommended prior to placement of soil cover where surface contamination contains contaminant concentrations one order of magnitude greater than the NRDCSRS at the following soil boring locations: B-60, B-76, B-112, B-114, D-05 (**Table 5-2 and Figure 5-3**). This remedial action is in agreement with NJDEP's 2010 Regulatory Requirements for Fort Monmouth Landfills (NJDEP, 2010).

Further, in accordance with the NJDEP requirements, it is recommended that additional certified clean soil cover over soil boring locations that do not have the minimum two-feet of cover. This would involve soil boring locations: B-48, B-53, B-69, B-70, B-94, B-105, B-117. As above, this action will be properly designed and constructed to allow proper drainage, to facilitate the growth of vegetation and to ensure that the soil cover is durable.

Lastly, a deed notice is recommended to be filed to document the presence of the waste deposits and contaminated soil on site, as per the agreement with NJDEP's Regulatory Requirements for Fort Monmouth Landfills (NJDEP, 2010).

7.2 SURFCAE WATER CONCLUSIONS AND RECOMMENDATIONS

Two VOCs (vinyl chloride and bromochloromethane) and two metals (arsenic and lead) were detected in surface water at concentrations exceeding NJDEP SWQS. It is the contention of the DPW that the concentrations of the two VOCs detected greater than the NJDEP SWQS in the surface water samples are from a source upgradient of M-14 beyond the boundary of Fort Monmouth. No similar constituents were detected in ground water at M-14 in prior sampling events. Therefore, the VOC constituents detected in surface water at M-14 are not identified as COCs. Lead concentrations in surface water did not exceed the MBC of 10 µg/L; therefore, lead is not considered a COC for surface water. The presence of arsenic greater than the MBC for surface water in both ground water and surface water samples may signify the migration of arsenic into the nearby surface water body (Husky Brook) at M-14. Arsenic is considered a COC for surface water for M-14. This situation requires further evaluation and continued monitoring of both surface water and ground water for arsenic.

Brinkerhoff developed and refined the site-wide ground water models for both the Main Post and the Charles Wood areas of Fort Monmouth. According to their report, the Main Post area can be characterized as having a small hydraulic gradient. The combination of small hydraulic gradient and low hydraulic conductivity of the aquifer materials translates into very slow ground water migration. They conclude the physical conditions of the site would likely contribute to ground water contaminant plumes with a dominant elongation in a downgradient direction. Vertical contaminant migration would typically be heavily impeded by the fine-grained aquifer materials present at depth (Brinkerhoff 2010). These results concur with results previously presented in Versar's August 2005 RIR, which indicated that arsenic and lead migration would be minimal due to low hydraulic conductivity and strong retardation by the soils.

Continued monitoring of surface water is recommended with regard to arsenic contamination in surface water at M-14. Based on the results of the remedial investigation activities described in this RIRA, continued surface water monitoring at M-14 is warranted. No changes to the existing quarterly surface water sampling programs are required at this time.

7.3 GROUND WATER CONCLUSIONS AND RECOMMENDATIONS

During the 38 quarterly sampling events conducted from April 2001 to August 2010, 41 samples contained detectable concentrations of five VOCs in site ground water. Three of these samples contained one VOC (chlorobenzene) at concentrations exceeding NJDEP GWQS. 11 samples contained detectable concentrations of five SVOCs in site ground water. One of these samples contained a SVOC (pentachlorophenol) at an estimated concentration exceeding its respective NJDEP GWQS. 19 samples contained detectable concentrations of seven pesticides in site ground water; however, these pesticides were not detected at concentrations exceeding NJDEP GWQS. No PCBs were detected in site ground water.

A total of 12 metals was detected in site ground water. Eight of the 12 detected metals (antimony, arsenic, beryllium, cadmium, lead, nickel, selenium, and thallium) were detected at concentrations that exceeded their respective GWQS in at least one sample.

To determine potential COCs currently in ground water at M-14, the past eight quarterly sampling events were evaluated. No VOCs were detected at concentrations exceeding GWQS during these sampling events; therefore no VOCs are considered COCs at M-14. Based on the magnitude of the exceedances and the frequency of occurrences, no metals are identified as a COC in ground water at M-14.

Based on the results of the remedial investigation activities described in this RIRA, continued ground water monitoring at M-14 is not warranted. No changes to the existing quarterly ground water sampling programs are required at this time.

REFERENCES

Brinkerhoff Environmental Services, Inc. (Brinkerhoff). 2010. MODFLOW Ground water Modeling Report. June 10.

Brinkerhoff Environmental Services, Inc. (Brinkerhoff). 2011. Metals Background Evaluation. May.

Environmental Data Resources, Inc. (EDR). 2010. Offsite Receptor Report. October 13.

New Jersey Department of Environmental Protection.(NJDEP). 1998. Guidance for Sediment Quality Evaluations. November.

NJDEP. 1999. Technical Requirements for Site Remediation. N.J.A.C. 7:26E, et seq. July

NJDEP. 2007. M-12 and M-14 Landfills, Fort Monmouth, New Jersey. July 25.

NJDEP. 2009. Letter regarding *Regulatory Approach to Fort Monmouth Landfills*. From Mr. Larry Quinn, Site Manager, NJDEP Bureau of Investigation, Design and Construction. To Mr. Joseph Fallon, FTMM DPW. February 24.

NJDEP. 2010. Letter regarding NJDEP Regulatory Requirements for Fort Monmouth Landfills. From Edward Putnam, Assistant Director, NJDEP. To Mr. Joseph Fallon, Directorate of Public Works, FTMM DPW. November 10.

Tetra Tech, Inc. 2010. *Chenanga Technology Services Corporation (CTSC) Purchase Order Number C09-20652 – Office Receptor Evaluation Report for Fort Monmouth Main Post and the Charles Wood Area*. December 8.

U.S. Army Garrison, Fort Monmouth, Directorate of Public Works (DPW). 1997. Fort Monmouth Standard Sampling Operating Procedure, New Jersey. December.

Versar, Inc. (Versar). 2003. Remedial Investigation Report and Sediment Quality Evaluation Report for the M-12/M-14 Landfill. October 15.

Versar. 2004. Remedial Investigation Report for Near Surface Soils at M-14. March 17.

Versar. 2005. Remedial Investigation Report M-14 Landfill. August 12.

Roy F. Weston, Inc. (Weston). 1995. Site Investigation Report – Main Post and Charles Wood Areas, Fort Monmouth, New Jersey. December.

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2010 MODFLOW Ground Water Modeling (Summary Report)