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Dear Mr. Lim and Mr. Pinaud:

AFCEC is hereby submitting the Final Supplemental Remedial Investigation (RI) Report for 1,4-Dioxane at Chemical Spill-20 (CS-20).

The Draft Supplemental RI report was submitted on 27 Jun 2016 and comments were due on 18 Jul 2016. EPA submitted comments on 21 Jul 2016 and MassDEP submitted a concurrence letter (no comments) on 26 Jul 2016. AFCEC submitted a Response to Comments Letter (RCL) on 01 Sep 2016 which documented discussions held during the 14 Jul 2016 Technical Update meeting whereby the agencies agreed to conduct interim monitoring prior to finalizing the Draft Supplemental RI. EPA concurred with the RCL on 22 Sep 2016. The interim monitoring program was completed between Mar 2017 and May 2019 and AFCEC presented the data to EPA and MassDEP at Technical Update meetings. At the end of the interim monitoring period, AFCEC submitted an RCL #2 on 14 Nov 2019; comments were due on 27 Nov 2019. EPA concurred with the RCL #2 on 2 Dec 2019. MassDEP has offered no additional comments despite AFCEC’s continued requests for input.

As of 29 Jan 2020, AFCEC has not received MassDEP’s position. AFCEC believes we have developed a solid conceptual site model that is protective of human health and the environment and, with EPA concurrence on the RCL, is hereby finalizing the Supplemental RI. This report summarizes the findings of the RI and includes the data collected during the interim monitoring period. This report also updates the screening level for the assessment of 1,4-dioxane groundwater data to a risk-based concentration (RBC) of 0.46 ug/L which was specified by the EPA in a comment letter on the Draft Explanation of Significant Differences for 1,4-Dioxane in
Groundwater at Chemical Spill-10. The EPA’s process relies on the calculation of an RBC where applicable or relevant and appropriate requirement-based standards do not exist. The RBC of 0.46 µg/L replaces the Massachusetts Department of Environmental Protection (MassDEP) Massachusetts Contingency Plan (MCP) Method-1 Groundwater-1 (GW-1) standard of 0.3 µg/L that was used to assess groundwater data in the Draft Supplemental RI Report.

If you have any questions, please contact me at (508)968-4670 x 5613 or email rose.forbes@us.af.mil.

Sincerely,

ROSE FORBES, P.E.
Remediation Program Manager

c: Jen DeAngelis, AFCEC/CZOE
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Bob Lim, EPA (1 bound, 1 CD)
Leonard Pinaud, MassDEP (1 bound, 1 CD)
Marc Nascarella, MassDPH (1 bound, 1 CD)
CH2M Doc. Ctl. & Distribution
Final Supplemental Remedial Investigation Report for 1,4-Dioxane at Chemical Spill-20, Joint Base Cape Cod, MA

January 2020

Prepared for:
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<tr>
<td>AFCEC</td>
<td>Air Force Civil Engineer Center</td>
</tr>
<tr>
<td>AFCEE</td>
<td>Air Force Center for Engineering and the Environment</td>
</tr>
<tr>
<td>atm m³/M</td>
<td>atmosphere-cubic meter per mole</td>
</tr>
<tr>
<td>BRL</td>
<td>below the reporting limit</td>
</tr>
<tr>
<td>CERCLA</td>
<td>Comprehensive Environmental Response, Compensation, and Liability Act</td>
</tr>
<tr>
<td>COC</td>
<td>contaminant of concern</td>
</tr>
<tr>
<td>CS</td>
<td>Chemical Spill</td>
</tr>
<tr>
<td>CSM</td>
<td>conceptual site model</td>
</tr>
<tr>
<td>CWMA</td>
<td>Crane Wildlife Management Area</td>
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<td>ESD</td>
<td>Explanation of Significant Difference</td>
</tr>
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<td>U.S. Environmental Protection Agency</td>
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<tr>
<td>foc</td>
<td>fraction organic carbon</td>
</tr>
<tr>
<td>FS</td>
<td>Fuel Spill</td>
</tr>
<tr>
<td>ft/ft/day</td>
<td>feet per day</td>
</tr>
<tr>
<td>°F</td>
<td>degrees Fahrenheit</td>
</tr>
<tr>
<td>GAC</td>
<td>granular activated carbon</td>
</tr>
<tr>
<td>gpm</td>
<td>gallons per minute</td>
</tr>
<tr>
<td>GW-1</td>
<td>Groundwater-1</td>
</tr>
<tr>
<td>HATF</td>
<td>Hunter Avenue Treatment Facility</td>
</tr>
<tr>
<td>in.</td>
<td>inch</td>
</tr>
<tr>
<td>IRP</td>
<td>Installation Restoration Program</td>
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<tr>
<td>JBCC</td>
<td>Joint Base Cape Cod</td>
</tr>
<tr>
<td>Kd</td>
<td>distribution coefficient</td>
</tr>
<tr>
<td>Kh</td>
<td>Henry’s law constant</td>
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ACRONYMS AND ABBREVIATIONS

Koc  soil organic carbon partition coefficient
LUC  Land Use Control
MassDEP  Massachusetts Department of Environmental Protection
MCL  Maximum Contaminant Level
MCP  Massachusetts Contingency Plan
MDFW  Massachusetts Division of Fisheries and Wildlife
MMR  Massachusetts Military Reservation
MNA  monitored natural attenuation
MPP  Mashpee Pitted Plain
msl  mean sea level
PCE  tetrachloroethene
PWSW  public water supply well
RAO  remedial action objective
RBC  risk-based concentration
RI  Remedial Investigation
RL  reporting limit
ROD  Record of Decision
SPEIM  System Performance and Ecological Impact Monitoring
UCMR  Unregulated Contaminant Monitoring Rule
USAF  U.S. Air Force
VI  vapor intrusion
VISL  Vapor Intrusion Screening Level
µg/L  micrograms per liter
1,1-DCE  1,1-dichloroethene
1,1,1-TCA  1,1,1-trichloroethane
1.0 INTRODUCTION

This Final Supplemental Remedial Investigation Report for 1,4-Dioxane at Chemical Spill-20, Joint Base Cape Cod, MA has been prepared for the Air Force Civil Engineer Center (AFCEC) as part of the U.S. Air Force (USAF) Installation Restoration Program (IRP) under contract number FA8903-08-D-8769 (Task Order 376). This report summarizes the findings of the Supplemental Remedial Investigation (RI) for 1,4-dioxane at the Chemical Spill-20 (CS-20) plume at the Joint Base Cape Cod (JBCC), Massachusetts (Figures 1-1 and 1-2). In addition to the data collected during the Supplemental RI (August 2015 through May 2016), this final report also presents data collected during an interim monitoring program (AFCEC 2017) which was completed between March 2017 and May 2019.

This final report also updates the screening level for the assessment of 1,4-dioxane groundwater data to a risk-based concentration (RBC) of 0.46 micrograms per liter (µg/L) which was specified by the EPA in a comment letter on the Draft Explanation of Significant Differences for 1,4-Dioxane in Groundwater at Chemical Spill-10 (EPA 2019a). The EPA’s Superfund process relies on the calculation of an RBC where applicable or relevant and appropriate requirement-based standards do not exist. The RBC of 0.46 µg/L replaces the Massachusetts Department of Environmental Protection (MassDEP) Massachusetts Contingency Plan (MCP) Method-1 Groundwater-1 (GW-1) standard of 0.3 µg/L that was used to assess groundwater data in the Draft Supplemental RI Report.

This document was prepared in accordance with the U.S. Environmental Protection Agency (EPA) RI guidance (EPA 1988) and in compliance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980. In accordance with Executive Order 12580, the USAF is the lead agency for remedial actions at JBCC (formerly known as Massachusetts Military Reservation [MMR]) and this document is being issued by the USAF as the lead agency. JBCC was formally added to the National Priorities List in 1989, and the Comprehensive Environmental Response, Compensation, and Liability Information System number for the JBCC/MMR site is MA2570024487.
1.1 SUPPLEMENTAL RI OBJECTIVES

The objectives of the Supplemental RI are to characterize the nature and extent of 1,4-dioxane in CS-20 groundwater, evaluate its fate and transport, and determine if potentially unacceptable risks to human health and the environment exist from exposure to 1,4-dioxane in groundwater that would warrant remedial action. The data were also used to assess whether additional remedial alternatives and/or treatment options need to be considered, and whether the existing selected remedy for the CS-20 plume in the 2000 Record of Decision (ROD) (AFCEE 2000) requires modification.

A work plan that describes the actions that would be taken to complete Supplemental RI/Feasibility Study reports for 1,4-dioxane in groundwater at the CS-20 plume was submitted in March 2016 (AFCEC 2016b). Any changes made during the field investigation are documented in this report.

1.2 SITE DESCRIPTION, BACKGROUND, AND REMEDIAL STATUS

This section presents a summary of the conceptual site model (CSM), the existing remedy presented in the ROD, and current remedial status for the CS-20 plume and is based on the current understanding of site history and conditions. The CS-20 plume is currently in the Remedial Action – Operations phase of the CERCLA cleanup process.

The majority of the former CS-20 groundwater plume is located south of JBCC in Falmouth, Massachusetts (Figure 1-2). The land above the northern portion of the former CS-20 plume (i.e., north of Route 151) is undeveloped woodlands used for recreational purposes (hiking, biking, hunting, etc.) within the Crane Wildlife Management Area (CWMA), which is managed by the Massachusetts Division of Fisheries and Wildlife (MDFW). The land above the southern portion of the former CS-20 plume is residential.

The former CS-20 plume is detached from an unknown source area that was located on JBCC and is a dilute dissolved-phase groundwater plume currently defined as the extent of groundwater containing tetrachloroethene (PCE), the CS-20 contaminant of concern (COC), at concentrations exceeding the Maximum Contaminant Level (MCL) of 5 µg/L.
The maximum historic PCE concentration detected at CS-20 was 98 µg/L in 2005 and the maximum PCE concentration detected at CS-20 in 2015 was 6.7 µg/L at monitoring well 69MW1422 (AFCEC 2016c). The 2015 CS-20 plume delineation was comprised of two individual lobes with approximately 6,700 feet (ft) between the trailing edge and leading edge of the plume and had a maximum width of approximately 500 ft and was up to 40 ft thick in the aquifer from approximately 145 to 185 ft below ground surface. The footprint of the 2015 CS-20 plume lobes occupied approximately 19 acres. The 2015 CS-20 plume boundary is used in this document as a location reference but by 2016 only one well had PCE concentrations above the MCL of 5 µg/L (69MW1422) and the CS-20 PCE plume has not been delineated since 2016 (AFCEC 2016a, 2019).

The former CS-20 groundwater plume is one of the four Southwest Plumes which also include CS-4, CS-21, and Fuel Spill-29 (FS-29) (Figure 1-2). The FS-29 plume is also no longer delineated and the FS-29 remedial system was shut down in September 2010 having remediated the aquifer within its capture zone. Groundwater extracted from extraction wells located within each of the Southwest Plumes is treated at a centrally-located treatment plant referred to as the Hunter Avenue Treatment Facility (HATF).

The following remedial action objectives (RAOs) were developed for the CS-20 groundwater plume (AFCEE 2000, 2011):

- Prevent residential exposure to CS-20 groundwater with PCE concentrations greater than the MCL of 5 µg/L.
- Restore useable groundwaters to their beneficial uses wherever practicable, within a time frame that is reasonable given the particular circumstances of the site.

The selected remedy for CS-20 groundwater in the ROD (AFCEE 2000) included the following components:

- The design, construction, and operation of a treatment system to hydraulically capture and treat plume contaminants,
- Institutional controls to mitigate exposure to humans from Southwest Plume groundwater contaminants. In 1999, the Falmouth Board of Health adopted water well regulations to minimize the risk of exposure to groundwater contamination,
- Engineering controls to mitigate exposure to humans from Southwest Plumes groundwater contaminants. Residents potentially impacted by the plume are connected to a public water supply, and
• Plume monitoring, performance monitoring of the treatment system, and ecological sampling to monitor the impacts of the system on the environment.

Since the remedy was selected in 2000, the following changes have occurred:

• The Wellfield Design (AFCEE 2004) presented the plan to treat the four Southwest Plumes (CS-4, CS-20, CS-21, and FS-29) via granular activated carbon (GAC) at a centrally located treatment plant (HATF) on JBCC.

• The institutional controls described in the ROD were further developed as described in the Southwest Plumes Explanation of Significant Difference (ESD) (AFCEE 2008). The Southwest Plumes ESD provides a more thorough description of the Land Use Control (LUC) Program, including a private well verification program that has been instituted for all JBCC groundwater sites. The purpose of the private well verification program was to identify all private wells near the JBCC plume, and if present, complete a protectiveness determination. In addition, the Southwest Plumes ESD indicated that the final remedial design allowed groundwater contamination in the downgradient leading edge of CS-20 to reach cleanup levels through natural attenuation instead of through active treatment. The LUC boundaries for CS-20 and the other Southwest Plumes which define the area where private well outreach and protectiveness determinations have been completed are presented in Figure 1-2.

• The 2011 ESD for the IRP groundwater plumes (AFCEE 2011) clarified the inclusion of monitored natural attenuation (MNA) as a component of the selected pump and treat remedy for CS-20, slightly modified the phrasing of the RAOs, and added text regarding the JBCC three-step process to achieve site closure.

The final design for the CS-20 remedial system consisted of two extraction wells that began operation on 11 January 2006 with a design extraction rate of 775 gallons per minute (gpm) (425 gpm at 81EW0001 and 350 gpm at 81EW0002) (AFCEE 2008). The CS-20 extraction wells were installed as part of the Southwest Plumes remedial system, which was designed to collectively remediate the CS-4, CS-20, CS-21, and FS-29 groundwater plumes (AFCEE 2004). The contaminated groundwater was captured by extraction wells in each plume, treated by GAC at the HATF, and the treated water was returned to the aquifer through reinjection wells, an infiltration trench, and an infiltration gallery (Figure 1-2).

The predicted remedial system shutdown date (when the last operational CS-20 extraction well is shut off) and expected aquifer restoration timeframe (when PCE concentrations drop below the MCL throughout the plume) presented in the ROD was approximately 24 years after system startup (AFCEE 2000), which equates to approximately 2030. Based
on contaminant transport modeling completed in 2013, PCE concentrations in the uncaptured leading edge of the former CS-20 plume were predicted to decrease below the MCL through natural attenuation by approximately 2024 (AFCEC 2013b).

Plume cleanup at CS-20 progressed faster than predicted and CS-20 extraction well 81EW0001 was turned off on 11 July 2014 (AFCEC 2014b) and CS-20 extraction well 81EW0002 was turned off on 25 September 2015 (AFCEC 2016c) as a result of remedial system optimization efforts. Since the CS-20 extraction wells are no longer operational, the remedy at CS-20 transitioned to the MNA and LUC components. System Performance and Ecological Impact Monitoring (SPEIM) data indicate that the current cleanup standard (the MCL for PCE) has been achieved throughout the plume. PCE concentrations in only one CS-20 monitoring well (69MW1422) exceeded the MCL in 2018 and PCE was not detected at that location when sampled in 2019. This restoration timeframe is several years ahead of the most recent modeling prediction of 2024 for aquifer restoration for the existing COC (PCE) (AFCEC 2016c) and approximately 10 years before the restoration timeframe estimated in the ROD which was approximately 2030 (AFCEE 2000).

1.3 INITIAL INVESTIGATION FOR 1,4-DIOXANE

The primary industrial use of 1,4-dioxane was to stabilize solvents, particularly 1,1,1-trichloroethane (TCA), which is less chemically stable than other common solvents such as PCE and trichloroethene. Therefore, 1,4-dioxane is commonly associated with 1,1,1-TCA, or its breakdown product 1,1-dichloroethene (DCE). Both 1,1,1-TCA and 1,1-DCE have been detected in CS-20 monitoring wells in the past (AFCEC 2014a). 1,4-Dioxane has also been used in printing and textiles (e.g., polyester); household cleaners and detergents; cosmetics; paints, varnishes, and paint remover; industrial processing of fats and oils; pharmaceuticals; and the chemical industry. The initial recommendation to perform sampling for 1,4-dioxane at the CS-20 chlorinated solvent plume was presented in the Final 4th Five-Year Review, 2007-2012 Massachusetts Military Reservation (MMR) Superfund Site Otis Air National Guard Base, MA (AFCEC 2013a).

A presence/absence (Site Inspection equivalent) 1,4-dioxane field investigation at the CS-20 plume was completed between October 2013 and June 2014 (Figure 1-3 and
Table 1-1). These results are summarized in the 1,4-Dioxane Monitoring Well Sample Results Data Presentation Project Note (AFCEC 2014a) and are presented on Figure 1-3 and summarized in Table 1-1. The RBC of 0.46 µg/L replaces the MassDEP MCP GW-1 standard of 0.3 µg/L that was used to assess groundwater data in the 1,4-Dioxane Monitoring Well Sample Results Data Presentation Project Note (AFCEC 2014a).

The initial 1,4-dioxane sampling effort for the CS-20 plume included: the CS-20 influent and effluent plant sampling ports, the two CS-20 extraction wells (when they were still operating), five CS-20 monitoring wells located within the CS-20 plume migration pathway, and one private residential well used as a drinking water supply that is in the CS-20 LUC monitoring program. 1,4-Dioxane was detected at concentrations that were below the reporting limit (BRL) of 0.15 µg/L in the combined CS-20/CS-4 influent ports and the CS-20 extraction wells and 1,4-dioxane was not detected in the CS-20 combined effluent port. The detection of BRL concentrations at both CS-20 extraction wells confirmed the presence of 1,4-dioxane within the CS-20 plume even though 1,4-dioxane was not detected in the two monitoring wells located in the main body of the plume. 1,4-Dioxane was detected above the RBC of 0.46 µg/L in one monitoring well located in the uncaptured leading edge of the plume (Figure 1-3) at a concentration of 0.783 µg/L (81MW0013B) and concentrations in the other two leading edge wells were BRL (81MW0019A) and 0.298 µg/L (81MW0018A). Both 1,1,1-TCA and 1,1-DCE had been historically detected in these wells where 1,4-dioxane was observed. 1,4-Dioxane was not detected in the private residential well that is used as a potable water supply.

1.4 REPORT ORGANIZATION

This Supplemental RI report consists of six sections and four appendices. The Supplemental RI objectives, site description, background, operational history, and regulatory status are presented in Section 1. Physical characteristics of the site, including climate, geology, hydrogeology, hydrology, and land use are presented in Section 2. Supplemental RI field sampling approach and rationale, 1,4-dioxane interim monitoring results, nature and extent of 1,4-dioxane in groundwater, and the fate and transport of 1,4-dioxane are presented in Section 3. The risk evaluation for 1,4-dioxane is presented in
Section 4. A summary of the RI findings and conclusions is presented in Section 5. References are included in Section 6.

CS-20 Supplemental RI information from JBCC emerging contaminants Technical Update Meeting presentations that were presented to the regulatory agencies during the completion of the field investigation are included in Appendix A. The data summary report for the Supplemental RI analytical data is included in Appendix B-1 and the data summary report for the 1,4-dioxane interim monitoring program analytical data is included in Appendix B-2. Supporting documentation for the risk assessment is included in Appendix C.
2.0 PHYSICAL CHARACTERISTICS

This section presents information on the physical characteristics in the former CS-20 plume area including climate, geology, hydrogeology, hydrology, and land use.

2.1 CLIMATE

The former CS-20 plume area is located in the upper western portion of Cape Cod which has a humid continental climate influenced by the proximity to the Atlantic Ocean, resulting in warmer winters and cooler summers than areas further inland. The average annual temperature is approximately 50 degrees Fahrenheit (°F), with the coldest temperatures in February ranging from approximately 23 to 38 °F and the warmest temperatures in July ranging from approximately 63 to 78°F. Total annual precipitation is approximately 47.8 inches (in.), with precipitation fairly evenly distributed throughout the year at 4 in. per month, and a variation from 2 to 4.8 in. per month. The least precipitation typically occurs during June. Prevailing winds are the northwest from November to March at an average of 12 miles per hour and from the southwest from April to October at an average of 9 miles per hour.

2.2 GEOLOGY

The unconsolidated overburden sediment beneath JBCC and adjacent areas was deposited during late-stage Pleistocene glaciation. The former CS-20 plume area, and the majority of JBCC and the areas to the south between the JBCC boundary and Vineyard Sound, lie within the broad glacial outwash plain referred to as the Mashpee Pitted Plain (MPP) (Figure 2-1). The MPP is comprised of poorly graded, medium to coarse-grained sand with well-graded gravel, and occasional local, discontinuous lenses of fine-grained silty sands, silts, and clays. Underlying the MPP in most areas are silty glaciolacustrine sediments and basal till, although in some areas coarse-grained MPP deposits directly overlie bedrock. In general, this sequence of glacial deposits that comprise the overburden ranges in thickness from 70 ft near the Cape Cod Canal, which is located near the northwest corner of JBCC, to approximately 300 ft below JBCC, to more than 400 ft along Vineyard Sound located approximately six miles to the south. The total thickness of unconsolidated
deposits in the former CS-20 plume area ranges from 240 to 310 ft (AFCEE 2012b). The bedrock surface forms the bottom of the aquifer and has been identified as a granite or gneiss in the area of the former CS-20 plume.

2.3 HYDROGEOLOGY/HYDROLOGY

The single groundwater flow system that underlies western Cape Cod is known as the Sagamore Lens. This sole-source aquifer is primarily unconfined and is recharged by infiltration of precipitation at a rate of approximately 30 in. per year. Overall the aquifer is considered homogenous and isotropic; locally, however, heterogeneous and anisotropic conditions occur. Groundwater flow paths dip gradually, as indicated by gradually deepening contaminant plumes, into the aquifer instead of following a strictly horizontal flow path. This is attributed to accretion of recharge from precipitation at the aquifer surface rather than density differences between uncontaminated water and water containing dissolved chemicals.

Surface water bodies in the vicinity of the former CS-20 plume include Deep Pond, which is a kettle pond located near the distal end of the PCE plume, and a small unnamed wetland on the southwestern side of the plume (Figure 1-2). Surface water bodies on Cape Cod are generally an expression of the water table and are hydraulically connected with the aquifer. Groundwater enters the upgradient portion of the pond, flows through the pond, and exits on the downgradient portion of the pond.

Groundwater flow in the CS-20 area is generally to the south-southwest. Flow within the aquifer is predominantly horizontal, with a horizontal component of hydraulic gradient in the vicinity of the former CS-20 plume ranging from approximately 0.0011 to 0.0019 ft per ft (AFCEE 1999). The depth to groundwater in the vicinity of the former CS-20 plume ranges from less than a few feet near Deep Pond and the wetland to approximately 60 ft below ground surface in the northern portion of the plume below the CWMA; the elevation of the water table within the former CS-20 plume area ranges from approximately 55 ft mean sea level (msl) in the north to approximately 38 ft msl in the south. Water table
elevations typically fluctuate from 1 to 4 ft per year in the area of the former CS-20 plume (AFCEE 2012b).

The saturated aquifer thickness varies from 200 to 260 ft in the CS-20 area; the bedrock surface forms the bottom of the aquifer. The former CS-20 groundwater plume is overlain by a lens of uncontaminated groundwater that is up to 140 ft thick (AFCEC 2015). Aquifer materials consist primarily of medium- and coarse-grained sands. However, low hydraulic conductivity silts and high hydraulic conductivity gravels do exist in the aquifer; therefore hydraulic conductivity values range from 1 to 390 ft per day (ft/day) in the CS-20 area. Using a porosity of 0.24 and the range of horizontal hydraulic gradients within the CS-20 area, the average linear groundwater velocities typically range from a low of approximately 0.004 ft/day for the lower hydraulic conductivity units to approximately 5 ft/day in the areas of higher hydraulic conductivity aquifer materials and steeper gradients (AFCEE 1999).

2.4 LAND USE

The land above the northern portion of the former CS-20 plume (i.e., north of Route 151) is undeveloped woodlands used for recreational purposes (hiking, biking, hunting, etc.) within the CWMA, which is managed by the MDFW (Figure 2-2). The land above the southern portion of the former CS-20 plume is residential and one Town of Falmouth water supply well, the Crooked Pond public water supply well (PWSW), is located approximately 5,000 ft to the south of the leading edge of the former CS-20 plume. Based on contaminant transport modeling, the CS-20 PCE plume was not expected to migrate beyond Deep Pond and no impacts to the PWSW were anticipated (AFCEC 2013b). This PWSW was sampled for 1,4-dioxane by the Town of Falmouth in August 2013 under the Unregulated Contaminant Monitoring Rule (UCMR) 3 and 1,4-dioxane was not detected.

As part of the LUC process specified in the ESD (AFCEE 2011), a private well verification survey was completed for the Southwest Plumes (including CS-20) between April 2009 and August 2011 (AFCEE 2012c). The survey identified a total of 67 properties associated with CS-20 that have one or more private wells that are used as a non-potable water source.
One residential well that is used as a drinking water source was identified in the CS-20 area. This residential well was monitored annually for volatile organic compounds as part of the existing remedy; PCE, 1,1,1-TCA, and 1,1-DCE were not detected in this well and monitoring was discontinued. No private wells that were identified present an unacceptable exposure risk from PCE in CS-20 groundwater. As discussed in Section 1.3, this private well was also sampled for 1,4-dioxane analysis in June 2014 and 1,4-dioxane was not detected.
3.0 SUPPLEMENTAL RI FIELD PROGRAM AND RESULTS

This section includes a summary of the Supplemental RI field sampling approach and rationale, nature and extent of 1,4-dioxane detections in groundwater, results of the 1,4-dioxane interim monitoring program, and the fate and transport of 1,4-dioxane in the CS-20 plume area. Sampling locations are presented on Figure 3-1 and monitoring well construction and location information is included in Table 3-1. Groundwater sampling results are presented in comparison to the RBC of 0.46 µg/L for 1,4-dioxane and are included in Tables 3-2 and 3-3. Maps showing the distribution of 1,4-dioxane detections in groundwater collected during the Supplemental RI and the interim monitoring program are included in Figures 3-2 and 3-3 and the vertical distribution of 1,4-dioxane detections in the CS-20 area are presented in two cross-sectional views (Figures 3-4, 3-5, and 3-6).

3.1 SUPPLEMENTAL RI FIELD PROGRAM APPROACH AND RATIONALE

Based on many years of characterization and monitoring, the groundwater flow field at the former CS-20 plume area is well understood. It is expected that the 1,4-dioxane migrated in groundwater on the same flow path as the former CS-20 PCE plume. Therefore, existing monitoring wells that are used (or have been used in the past) to monitor the former CS-20 PCE plume are well situated to further delineate the extent of 1,4-dioxane to expand upon the data collected during the initial sampling effort (AFCEC 2014a). These Supplemental RI sampling locations were selected based on historic 1,1,1-TCA and 1,1-DCE detections, historic plume monitoring data, initial 1,4-dioxane sampling results, and an assessment of the groundwater flow field. The initial dataset used in the Supplemental RI included 1,4-dioxane results from the sampling of 32 monitoring wells, two extraction wells, two treatment plant ports, one private drinking water well currently in the CS-20 LUC program, and one surface water sample located in Deep Pond (Figure 3-1 and Table 3-1). As presented in Section 1.0, the Supplemental RI dataset was expanded through use of the 1,4-dioxane data collected during the interim monitoring program. The Crooked Pond PWSW, which is located downgradient of the former CS-20 plume, was also sampled for 1,4-dioxane by the Town of Falmouth in August 2013 as part of UCMR 3 and the results were provided to AFCEC.
The CS-20 Supplemental RI sampling program was presented in the *Final Supplemental Remedial Investigation/Feasibility Study Work Plan for 1,4-Dioxane at Chemical Spill-10, Chemical Spill-20, and Landfill-1, Joint Base Cape Cod, MA* (AFCEC 2016b). After receiving results from the initial RI sampling effort, one additional monitoring well was added to the program for further delineation and four monitoring wells with the highest concentrations were resampled. The initial presence/absence (Site Inspection equivalent) investigation was completed between October 2013 and June 2014 (AFCEC 2014a), the Supplemental RI field investigation was completed between August 2015 and May 2016, and the 1,4-dioxane interim monitoring program was completed between March 2017 and May 2019. Analytical results were presented to the regulatory agencies at several Technical Update Meetings (*Appendix A*) and any modifications to the ongoing field program were discussed with the regulatory agencies during those meetings.

Samples were analyzed at ALS Environmental Laboratory, located in Kelso, Washington, which is an Air Force Environmental Laboratory Accreditation Program certified laboratory. Laboratory analysis of the groundwater samples collected provided the necessary data to meet Supplemental RI work plan data quality objectives and allowed comparison to the RBC of 0.46 µg/L for 1,4-dioxane. A project-specific method reporting limit (RL) that ranged between 0.15 µg/L and 0.2 µg/L was used to maintain consistency with 1,4-dioxane results previously reported by AFCEC as well as the MassDEP. All field activities, laboratory analyses, and reporting were completed in accordance with the *Final Supplemental Remedial Investigation/Feasibility Study Work plan for 1,4-Dioxane at Chemical Spill-10, Chemical Spill-20, and Landfill-1, Joint Base Cape Cod, MA* (AFCEC 2016b). The data summary reports for the analytical data reported in this Supplemental RI are included in *Appendix B-1* (Supplemental RI data) and *Appendix B-2* (1,4-dioxane interim monitoring program data), and it was concluded the analytical data collected are of suitable quality to support the objectives presented in the work plan.
3.2 NATURE AND EXTENT OF 1,4-DIOXANE DATA COLLECTED DURING SUPPLEMENTAL RI

Thirty-two monitoring wells were sampled in the former CS-20 plume area during the Site Inspection equivalent and Supplemental RI and 1,4-dioxane was detected at concentrations exceeding the RBC in two monitoring wells, 69MW1422 and 81MW0013B (Table 3-2). Monitoring well 69MW1422 is located in the central portion of the former CS-20 plume area near extraction well 81EW0001 (Figure 3-2) and 1,4-dioxane concentrations in this well decreased from 0.73 µg/L in August 2015 to 0.48 µg/L in April 2016. Monitoring well 81MW0013B is located in the former CS-20 leading edge lobe (Figure 3-2) and 1,4-dioxane concentrations in this well decreased from 0.783 µg/L in March 2014 to BRL of 0.15 µg/L in April 2016.

1,4-Dioxane was detected above the RL but below the RBC in two monitoring wells located near the former CS-20 leading edge lobe, 81MW0018A and 81MW0018B (Figure 3-2). 1,4-Dioxane concentrations in both of these wells also decreased when resampled, from 0.298 µg/L in March 2014 to BRL in April 2016 (81MW0018A) and from 0.26 µg/L in August 2015 to 0.17 µg/L in April 2016 (81MW0018B) (Table 3-2).

1,4-Dioxane was detected below the reporting limit of 0.15 µg/L in nine wells and was not detected in 19 of the 32 wells sampled, the private residential well used as a drinking water supply (RS0034GALL), or the downgradient Crooked Pond PWSW (69PWS50066).

A very low estimated concentration of 1,4-dioxane (0.025J µg/L) (Appendix B-1) reported BRL was detected in the surface water sample collected from Deep Pond (69SWDP01).

The extent of 1,4-dioxane in the former CS-20 plume area that exceeded the RBC is defined by a solitary detection at monitoring well 69MW1422. It is noted that some of the most elevated historic detections of 1,1,1-TCA and 1,1-DCE were reported at this monitoring well in 1999/2000 (AFCEC 2014a). This 1,4-dioxane detection is located approximately 80 ft below the water table within a fine to silty sand lithologic unit (Figure 3-6). Based on current 1,4-dioxane results, lithology, and historic CS-20 PCE concentration trends in
the area (AFCEE 2012b, 2016a, and 2019), this area of 1,4-dioxane is limited in extent and is located in a relatively low hydraulic conductivity aquifer unit.

### 3.3 1,4-DIOXANE INTERIM MONITORING PROGRAM RESULTS

Since the 1,4-dioxane detections at CS-20 were limited in extent and concentrations were expected to decrease, a recommendation to implement a 1,4-dioxane interim monitoring program (AFCEC 2017) was presented in the Draft Supplemental RI Report.

The CS-20 1,4-dioxane monitoring plan was summarized in the *CS-20 1,4-Dioxane Interim Monitoring Program Project Note* which was submitted in March 2017 (AFCEC 2017). Eight CS-20 monitoring wells were sampled for a total of four events between March 2017 and May 2019. The CS-20 interim 1,4-dioxane monitoring network is presented on Figure-3-3, well construction information is included in Table 3-1, and monitoring results are summarized in Table 3-3.

1,4-Dioxane concentrations generally decreased at the wells included in the interim monitoring network. By October 2018, 1,4-dioxane was no longer detected in seven of the eight wells monitored, confirming the expectation that concentrations would decrease over time through attenuation. 1,4-Dioxane concentrations in the remaining well 69MW1422, fluctuated, decreasing from 0.73 µg/L in August 2015 to 0.2 µg/L in November 2017 and 0.28 µg/L in November 2018 (both below the RBC); the 1,4-dioxane concentration at 69MW1422 then increased to 0.7 µg/L in May 2019. The average 1,4-dioxane concentration in this well throughout the interim monitoring period is 0.41 µg/L which is below the RBC of 0.46 µg/L.

Monitoring well 69MW1422 is screened within a fine to silty sand lithologic unit and residual concentrations have been observed to be more persistent in finer grained sediments. Groundwater concentrations in monitoring wells screened in similar lithologic units at JBCC have been observed to fluctuate over time as concentrations slowly attenuate. The PCE concentration was observed to be more persistent in this well when compared to
other nearby monitoring locations and recently decreased from above the MCL of 5 µg/L in April 2018 to not detected in April 2019 (AFCEC 2019).

### 3.4 FATE AND TRANSPORT OF 1,4-DIOXANE

The mobility and persistence of 1,4-dioxane is influenced by the chemical’s interaction with the environment. Pertinent physical and chemical properties for 1,4-dioxane are listed in Table 3-4 and are described as follows:

- **Volatilization** occurs when a compound transfers from the aqueous phase to the gas phase. Measures of a chemical’s tendency to volatilize from water and soil moisture include its vapor pressure and Henry’s law constant (Kh). Compounds with Kh values higher than $10^{-3}$ atmosphere-cubic meter per mole (atm m³/M) are expected to volatilize readily from water to air, whereas those with Kh values lower than $10^{-6}$ atm-m³/M are relatively nonvolatile. Compounds with Kh values in between this range are expected to be moderately volatile. At a given temperature, the higher the vapor pressure of a compound, the higher the volatility of that compound. The Kh value of 1,4-dioxane at 25 degrees Celsius is $4.82 \times 10^{-6}$ which is indicative of low volatility. However, as described in Section 4.1, 1,4-dioxane is considered sufficiently volatile that exposure to 1,4-dioxane vapors should be considered in the risk assessment.

- **Sorption** occurs when a constituent adheres to and becomes associated with solid particles in the geologic formation. The subsurface materials likely to sorb chemicals are clays and organic matter. At the former CS-20 plume area, the hydrogeological unit where 1,4-dioxane is present in groundwater generally consists of fine to silty sand with little to no organic carbon which is not likely to sorb chemicals. The conventional measure of sorption is the distribution coefficient (Kd), which can be estimated as the product of the soil organic carbon partition coefficient (Koc) of the chemical and the fraction organic carbon (foc) in the soil. The Koc value of 1,4-dioxane is 0.72 milliliters per gram, which is indicative of low tendency to adsorb and consequentially higher mobility.

- **Solubility** is a measure of the degree to which a constituent will dissolve in water. Highly soluble chemicals are more likely to be leached from soil by precipitation or runoff that infiltrates into the subsurface. 1,4-Dioxane is considered to be miscible in water, with an estimated solubility of 1,000,000 milligram per liter; thereby readily leaching from soil into groundwater and remaining in a dissolved state.

- **Degradation** is the deterioration or destruction of a chemical, either biologically (through biodegradation) or abiotically (through such processes as abiotic reduction, hydrolysis, or photolysis). Biodegradation of chemicals by microbial organisms occurs through metabolic and co-metabolic (e.g., enzymatic) processes. The rate of degradation is dependent on the chemical, biological, and physical conditions of the medium in which the contaminant is located. Limited evidence exists for 1,4-dioxane biodegradation under anaerobic conditions (Shen et al, 2008), however, the CS-20
aquifer is aerobic. Under aerobic conditions, ample evidence exists of biodegradation of 1,4-dioxane (Mahendra and Alvarez-Cohen 2006; Kim et al, 2009; Huang et al, 2014), both metabolically and co-metabolically. Enhancement of the bioremediation process has been shown to be effective under specific conditions utilizing propane, butane, or methane (Li et al, 2016; Mora et al, 2012). Intrinsic biodegradation (e.g., biological natural attenuation) of 1,4-dioxane has also been demonstrated successfully at a number of sites (Chiang et al, 2012; Li et al, 2016; Adamson et al, 2015), and in some cases the demonstration of effectiveness has led to acceptance of monitored natural attenuation as the final remedy for a site (Chiang et al, 2008).

Following its release at the ground or near ground surface, 1,4-dioxane would have vertically migrated through the unsaturated, vadose zone. If 1,4-dioxane had initially sorbed to soil, this chemical would have dissolved into infiltrating water from precipitation and leached into groundwater quite readily due to its high aqueous solubility. Once in groundwater, the 1,4-dioxane would travel on the same flow path and likely concurrent with the former CS-20 PCE plume (as well as the 1,1,1-TCA and 1,1-DCE), in a generally south-southwest direction, and would be transported through advection and dispersion with natural attenuation processes (degradation, dispersion, dilution, sorption, and volatilization) reducing the mass, volume, and concentration. This decrease in 1,4-dioxane concentrations was observed in the resampling of the four CS-20 monitoring wells with the highest historical concentrations during the Supplemental RI (Table 3-2) and in seven of the eight monitoring wells sampled during the interim monitoring program (Table 3-3). Significant decreases in concentration (up to 80 percent) were observed within a two-year period. The area where 1,4-dioxane remains (near 69MW1422) is located within a fine to silty sand unit and is expected to continue to decrease through natural attention processes (probably dominated by dilution and dispersion) similar to the observed trend in PCE concentrations at this well (AFCEC 2016a and 2019).
4.0 RISK ASSESSMENT

The baseline risk assessment completed for CS-20 as part of the Final Southwest Operable Unit Remedial Investigation (AFCEE 1999) identified PCE as the groundwater COC. Potential exposure risks to PCE contaminated groundwater are being successfully managed through the LUC Program and remedial actions intended to achieve the RAO of restoring the aquifer are ongoing and progressing ahead of the timeframe estimated at the time of the remedy selection. This Supplemental RI is being performed to evaluate the nature and extent and potential risks of exposure to 1,4-dioxane at CS-20.

4.1 HUMAN HEALTH EVALUATION

4.1.1 Exposure Assessment

The current and potential future exposure pathways associated with CS-20 are summarized in the Human Health and Ecological Conceptual Exposure Model (Figure 4-1). The soil exposure pathway is not complete and has been eliminated from further consideration because there are no known sources of soil contamination at CS-20 (AFCEE 2012b). The current and potential future exposure pathways to groundwater for residential household uses and to Deep Pond surface water for recreational uses at CS-20 are considered complete. However, LUCs are in place that successfully manage the exposure risks to PCE contaminated groundwater at CS-20 and given the understanding of the nature and extent of 1,4-dioxane at CS-20 presented in Section 3.0, current exposure to 1,4-dioxane in groundwater is not likely.

A vapor intrusion (VI) assessment was completed in 2012 for all JBCC IRP groundwater plumes, and results indicated an incomplete pathway for VI at the CS-20 PCE plume (AFCEE 2012a) based on the presence of a clean water lens above the plume. The results from the 2012 VI evaluation are applicable to 1,4-dioxane at CS-20 since all detections of 1,4-dioxane at CS-20 are coincidental with the former PCE plume. However, as indicated in the Final Supplemental Remedial Investigation/Feasibility Study Work Plan for 1,4-Dioxane at CS-10, CS-20, and LF-1, JBCC, MA (AFEC 2016c), a qualitative
screening of potential VI risk has been completed by comparing 1,4-dioxane groundwater concentrations to VI screening values.

4.1.2 Human Health Screening Approach

As discussed in the work plan (AFCEC 2016c), this human health risk evaluation includes a comparison of groundwater sampling results for 1,4-dioxane to the RBC of 0.46 µg/L for a residential use exposure scenario including ingestion, dermal contact, and inhalation. A qualitative screening of potential VI risk is provided by comparing 1,4-dioxane groundwater concentrations to a VI screening value for 1,4-dioxane calculated using EPA’s Vapor Intrusion Screening Level (VISL) Calculator tool (EPA 2019b).

4.1.3 Human Health Screening Results

A comparison of 1,4-dioxane groundwater sampling results to the RBC of 0.46 µg/L is provided in Table 4-1. The most recent sampling results indicate that 1,4-dioxane is detected at a concentration greater than the RBC of 0.46 µg/L in just one monitoring well, 69MW1422 (Figures 3-2 and 3-3), which was last sampled in May 2019. However, the 1,4-dioxane concentration at this well was below the RBC during the two prior sampling events completed in November 2017 and November 2018. The heterogeneous nature of the 1,4-dioxane that remains in this area is related to the silty nature of the aquifer materials. Since it is unlikely that a future residential well would be screened in this silty sand unit (i.e., a non-productive portion of the aquifer), the remaining 1,4-dioxane observed at monitoring well 69MW1422 (where the average concentration over the past four sampling events is also below the RBC of 0.46 µg/L) does not constitute a potential risk to residents through a drinking water exposure pathway under a reasonably foreseeable future use.

A very low estimated concentration of 1,4-dioxane (0.025J µg/L) (Appendix B-1) reported BRL (Table 4-1) was detected in the surface water sample collected from Deep Pond (69SWDP01). Since this concentration is below the RBC of 0.46 µg/L and is considered suitable to drink, recreational use of Deep Pond such as wading and swimming is not an issue with regards to 1,4-dioxane. In addition, given the lack of 1,4-dioxane detections at
concentrations above the RBC of 0.46 µg/L in groundwater near Deep Pond, it is unlikely that future concentrations of 1,4-dioxane in the surface water of Deep Pond will approach or exceed 0.46 µg/L. These results indicate no unacceptable risk to current and/or future residents from exposure to Deep Pond surface water.

Although a clean water lens is present above the CS-20 1,4-dioxane groundwater detections which indicates an incomplete pathway for VI, an EPA VISL calculation for 1,4-dioxane at CS-20 was completed. The input parameters for the EPA VISL calculator include the following (with the chosen parameters in parenthesis): exposure scenario (residential), the target risk for carcinogens (1x10⁻⁶), the target hazard quotient (1), and the average groundwater temperature (20 degrees centigrade). Given those preceding input parameters, the EPA VISL for 1,4-dioxane at CS-20 was calculated to be 3,700 µg/L in groundwater (Appendix C). In other words, the EPA VISL indicates it would take a 1,4-dioxane concentration of 3,700 µg/L in groundwater at the water table to create a VI issue at CS-20. As shown in Table 4-1, no 1,4-dioxane concentrations exceed the EPA VISL of 3,700 µg/L, indicating that VI risks related to 1,4-dioxane at CS-20 is not a concern at present nor is it expected to be in the future.

4.2 ECOLOGICAL RISK EVALUATION

4.2.1 Exposure Assessment

The current and potential future ecological exposure pathways to Deep Pond surface water are complete at CS-20 (Figure 4-1).

4.2.2 Ecological Screening Approach

As detailed in the work plan (AFCEC 2016b), a quantitative screening of ecological risk associated with 1,4-dioxane is provided by comparing surface water sampling results to the EPA Region 5 ecological screening value of 22,000 µg/L (EPA 2003).
4.2.3 Ecological Screening Results

A comparison of Deep Pond surface water sampling results to available ecological screening values indicates that the 2016 1,4-dioxane concentration (BRL) is well below the EPA Region 5 ecological screening value of 22,000 µg/L (Table 4-1). Given that the highest historic 1,4-dioxane concentrations in CS-20 groundwater are below 1 µg/L, it is unlikely that surface water 1,4-dioxane concentrations will exceed the EPA Region 5 screening value of 22,000 µg/L in the future, indicating no current or future risk to ecological receptors at CS-20 from 1,4-dioxane.
5.0 SUMMARY AND CONCLUSIONS

The former CS-20 plume, which detached from an unknown source area that was located on JBCC, was a dilute dissolved-phase groundwater plume defined as the extent of groundwater containing PCE, the CS-20 COC, at concentrations exceeding the MCL of 5 µg/L (AFCEE 2000). This Supplemental RI was completed to determine the nature and extent of 1,4-dioxane in groundwater at CS-20, evaluate its fate and transport, and determine if potentially unacceptable risks to human health and the environment exist from exposure to 1,4-dioxane in groundwater that would warrant remedial action.

The initial recommendation to perform sampling for 1,4-dioxane was presented in the Final 4th Five-Year Review, 2007-2012 Massachusetts Military Reservation (MMR) Superfund Site Otis Air National Guard Base, MA (AFCEC 2013a). A presence/absence (Site Inspection equivalent) 1,4-dioxane field investigation was completed between October 2013 and June 2014 and confirmed that 1,4-dioxane is present at the CS-20 plume and additional investigation was recommended (AFCEC 2014a).

The Supplemental RI field program for 1,4-dioxane was completed between August 2015 and May 2016 and resulted in a 1,4-dioxane dataset from 32 monitoring wells, two extraction wells, two treatment plant ports, one residential well used for drinking water in the existing CS-20 LUC program, and one surface water sample located in Deep Pond (Figure 3-1 and Table 3-1). One PWSW located downgradient of the former CS-20 plume was also sampled for 1,4-dioxane by the Town of Falmouth in August 2013 and the results were provided to AFCEC; 1,4-dioxane was not detected.

1,4-Dioxane was detected at concentrations exceeding the RBC in two monitoring wells (69MW1422 and 81MW0013B) and was detected above the RL in two additional wells (81MW0018A and 81MW0018B). These four wells were resampled in May 2016 and concentrations in all four well decreased (Table 3-2).

Since the 1,4-dioxane in groundwater at CS-20 was very limited in extent and concentrations were expected to decrease similar to the observed long-term trend for PCE,
a recommendation to implement a 1,4-dioxane interim monitoring program (AFCEC 2017) was presented in the Draft Supplemental RI Report. Eight CS-20 monitoring wells were sampled for a total of four events between March 2017 and May 2019 (Figure 3-3 and Table 3-3). 1,4-Dioxane concentrations generally decreased during the interim monitoring period and by October 2018 1,4-dioxane was not detected in seven of the eight wells being monitored. 1,4-Dioxane concentrations in the remaining well (69MW1422) fluctuated, decreasing below the RBC in November 2017 (0.2 µg/L) and November 2018 (0.28 µg/L) and then increased to 0.7 µg/L in May 2019.

1,4-Dioxane concentrations are limited in extent to detections at only one monitoring well (69MW1422) and this monitoring well is screened approximately 80 ft below the water table within a fine to silty sand lithologic unit (Figure 3-6). In general, contaminant concentrations are more persistent in finer grainer aquifer materials and groundwater concentrations in monitoring wells screened in similar fine-grained lithologic units at JBCC have been observed to fluctuate over time as concentrations slowly attenuate. The average 1,4-dioxane concentration in groundwater at this well throughout the interim monitoring period is 0.41 µg/L which is below the RBC of 0.46 µg/L and concentrations in this area are expected to continue to decrease through the processes of natural attenuation similar to the PCE concentration trend observed at this well (AFCEC 2016a and 2019).

The baseline risk assessment completed for CS-20 as part of the Final Southwest Operable Unit Remedial Investigation (AFCEE 1999) identified PCE as the groundwater COC. The human health risk evaluation for 1,4-dioxane in this Supplemental RI involved comparing groundwater sampling results for 1,4-dioxane to the RBC of 0.46 µg/L for a residential drinking water exposure scenario and completing a qualitative screening of potential VI risk by comparing 1,4-dioxane groundwater concentrations to the calculated EPA VISL of 3,700 µg/L. In addition, ecological risks were evaluated by comparing 1,4-dioxane surface water sampling results to the EPA Region 5 ecological screening value of 22,000 µg/L.

The screening-level human health risk assessment concluded there is no unacceptable risk to current or future residents. 1,4-Dioxane is limited in extent and remains in one monitoring well (69MW1422) at concentrations above the RBC of 0.46 µg/L (based on the
most recent sampling event in May 2019). This well is screened within a fine to silty sand lithologic unit and it is unreasonable to expect that this portion of the aquifer would be used for a future drinking water supply. In addition, the average 1,4-dioxane concentration at this monitoring well during the interim monitoring period (March 2017 to May 2019), which would be representative of a longer-term exposure, is below the RBC of 0.46 µg/L. VI related to 1,4-dioxane at CS-20 is not a concern and there is no unacceptable risk to current and/or future residents from exposure to Deep Pond surface water. In addition, Deep Pond surface water concentrations are well below the ecological screening value for 1,4-dioxane.

Based on the conclusions of the screening-level risk assessment, 1,4-dioxane should not be considered a COC at CS-20 and a Fact Sheet should be prepared documenting that no further action is needed for 1,4-dioxane at CS-20.
6.0 REFERENCES


_____. 2017 (March). Chemical Spill-20 1,4-Dioxane Interim Monitoring Program Project Note. 658003-EC-CS20-PRJNOT-001. Prepared by CH2M for AFCEC/JBCC, Installation Restoration Program, Otis Air National Guard Base, MA.


_____. 2016b (March). Final Supplemental Remedial Investigation/Feasibility Study Work Plan for 1,4-Dioxane at Chemical Spill-10, Chemical Spill-20, and Landfill-1, Joint Base Cape Cod, MA. 658003-EC-Multiple-QAPP-001. Prepared by CH2M for AFCEC/JBCC, Installation Restoration Program, Otis Air National Guard Base, MA.


_____. 2014a (August). 1,4-Dioxane Monitoring Well Sample Results Data Presentation Project Note. 473147-SPEIM-MULTIPLE-PRJNOT-007. Prepared by CH2M HILL for AFCEC/JBCC, Installation Restoration Program, Otis Air National Guard Base, MA.


U.S. Environmental Protection Agency (EPA). 2019a (October). Letter from Robert Lim (EPA) to Rose Forbes (AFCEC) regarding comments on the Draft Explanation of Significant Differences for 1,4-Dioxane in Groundwater at Chemical Spill-10, Joint Base Cape Cod, MA.


FIGURES
FIGURE 1-1
JOINT BASE CAPE COD, MASSACHUSETTS
AFCEC - Joint Base Cape Cod
Final Supplemental Remedial Investigation Report for 1,4-Dioxane at CS-20, JBCC, MA

Legend

Joint Base Cape Cod
Former 2015 CS-20 Plume Boundary
(No Longer Delineated)

Data Source: AFCEC, September 2019
JBCC Boundary From Massachusetts Air National Guard 2011
CS-20 1,4-DIOXANE PRESENCE/ABSENCE RESULTS
AFCEC - Joint Base Cape Cod
Final Supplemental Remedial Investigation Report for 1,4-Dioxane at CSI-20, JBCC, MA

FIGURE 1-3

1,4-Dioxane Detections in Groundwater:
- No Detections
- Detection Below or at EPA RBC
- Detection Above EPA RBC

1,4-Dioxane EPA RBC = 0.46 µg/L

Legend
- Extraction Well
- Joint Base Cape Cod Boundary
- Former 2015 CS-20 Plume Boundary (No Longer Delineated)
- Bog/Wetland
FIGURE 2-1

REGIONAL SURFICIAL GEOLOGY
AFCEC - Joint Base Cape Cod
Final Supplemental Remedial Investigation Report for 1,4-Dioxane at CS-20, JBCC, MA
FIGURE 2-2
CS-20 AREA MAP

AFCEC - Joint Base Cape Cod
Final Supplemental Remedial Investigation
Report for 1,4-Dioxane at CS-20, JBCC, MA

Legend

- Joint Base Cape Cod Boundary
- Former 2015 CS-20 Plume Boundary (No Longer Delineated)
- Crane Wildlife Management Area

Data Source: AFCEC, September 2019
JBCC Boundary from Massachusetts Air National Guard 2011
2018 Aerial Imagery © Google
FIGURE 3-2

CS-20 1,4-DIOXANE DETECTIONS IN GROUNDWATER - SUPPLEMENTAL RI

AFCEC - Joint Base Cape Cod
Final Supplemental Remedial Investigation Report for 1,4-Dioxane at CS-20, JBCC, MA

1,4-Dioxane Detections in Groundwater:
- No Detections
- Detection Below or at EPA RBC
- Detection Above EPA RBC

1,4-Dioxane EPA RBC = 0.46 µg/L

Legend
- Joint Base Cape Cod
- Former 2015 CS-20 Plume Boundary (No Longer Delineated)
- Infiltration Gallery/Trench
- Treatment System Pipeline
- Bog/Wetland
- Extraction Well (Off)

Data Source: AFCEC, September 2019
JBCC Boundary from Massachusetts Air National Guard 2011

Monitoring/Extraction/Residential Well
Public Water Supply Well

No Detections
Detection Below or at EPA RBC
Detection Above EPA RBC

69PWS50066
69MW1507
81MW0001A,B
81MW0003A,B
81MW0004A
81MW0005A,B
81EW0001
69MW1422
81MW0012A
81MW0011A,B
32MW2002
81MW0006A,B
81MW0016A
81MW0019A,B,C
81MW0018A,B
81EW0002
81MW0015A,B
81MW0017A,B
81MW0013A,B
81MW0010B,C
81MW0007A
81MW0008A,B
81MW0005A,B
81MW0002A
81MW0003A
69PWS50066
69MW1503A
81MW0004A
69MW1523
69PWS50066
69PWS50066
FIGURE 3-3
CS-20 1,4-DIOXANE DETECTIONS IN GROUNDWATER - INTERIM MONITORING NETWORK
AFCEC - Joint Base Cape Cod
Final Supplemental Remedial Investigation Report for 1,4-Dioxane at CS-20, JBCC, MA

Data Source: AFCEC, September 2019
JBCC Boundary from Massachusetts Air National Guard 2011

Legend
- Joint Base Cape Cod Boundary
- Former 2015 CS-20 Plume Boundary (No Longer Delineated)
- Bog/Wetland

1,4-Dioxane Detections in Groundwater:
- Green dot: No Detection
- Red dot: Detection Above EPA RBC
1,4-Dioxane EPA RBC = 0.46 µg/L
FIGURE 3-4
CS-20 LINES OF CROSS-SECTION
AFCEC - Joint Base Cape Cod

Legend
- Extraction Well (Off)
- Monitoring Well
- Joint Base Cape Cod Boundary
- Former 2015 CS-20 Plume Boundary (No Longer Delineated)
- Other Plume Boundary (Dashed Where Inferred)

Data Source: AFCEC, September 2019
JBCC Boundary from Massachusetts Air National Guard 2011

Final Supplemental Remedial Investigation Report for 1,4-Dioxane at CS-20, JBCC, MA
FIGURE 4-1

CS-20 HUMAN HEALTH AND ECOLOGICAL CONCEPTUAL EXPOSURE MODEL
AFCEC - Joint Base Cape Cod
Final Supplemental Remedial Investigation Report for 1,4-Dioxane at CS-20, JBCC, MA

1 The source area was not found.
2 The vapor intrusion pathway was found to be incomplete in the Final 2011 Vapor Intrusion Technical Memorandum (AFCEE 2012a).

1 The source area was not found.
2 The vapor intrusion pathway was found to be incomplete in the Final 2011 Vapor Intrusion Technical Memorandum (AFCEE 2012a).
TABLES
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<thead>
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<th>Location Description</th>
<th>Location Identification</th>
<th>Date Sampled</th>
<th>1,4-Dioxane (µg/L)</th>
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Data Source: AFCEC, January 2020

Notes:
- **Bold** value indicates an exceedance of the RBC for 1,4-dioxane.
- 1,4-Dioxane by U.S. Environmental Protection Agency Method 8270D-SIM: MDL = 0.075 µg/L; RL = 0.15 µg/L.

Key:
- BRL = below reporting limit
- ND = not detected
- CS-20 = Chemical Spill-20
- RBC = risk-based concentration
- JBCC = Joint Base Cape Cod
- RL = reporting limit
- LUC = Land Use Control
- µg/L = micrograms per liter
- MDL = method detection limit
### Table 3-1
CS-20 1,4-Dioxane Sample Locations and Well Construction Information
Final Supplemental Remedial Investigation Report for 1,4-Dioxane at CS-20, JBCC, MA

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<th>Easting (ft)</th>
<th>Surface Elevation (ft msl)</th>
<th>Midscreen Elevation (ft msl)</th>
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<th>Top Screen Elevation (ft msl)</th>
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Data Source: AFCEC, January 2020

Key:
- **bgs** = below ground surface
- **msl** = mean sea level
- **CS-20** = Chemical Spill-20
- **NA** = not applicable
- **ft** = feet
- **JBCC** = Joint Base Cape Cod
## Table 3-2
CS-20 1,4-Dioxane Supplemental RI Results
Final Supplemental Remedial Investigation Report for 1,4-Dioxane at CS-20, JBCC, MA

<table>
<thead>
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<th>RBC = 0.46</th>
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Data Source: AFCEC, January 2020

Note:
- **Bold** value indicates an exceedance of the RBC of 0.46 µg/L for 1,4-dioxane.

Key:
- BRL = below the reporting limit of 0.15 µg/L
- RBC = risk-based concentration
- CS-20 = Chemical Spill-20
- RI = Remedial Investigation
- JBCC = Joint Base Cape Cod
- µg/L = micrograms per liter
- ND = not detected
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Data Source: AFCEC, January 2020

Note:

**Bold** value indicates an exceedance of the RBC for 1,4-dioxane.

Key:

- **BRL** = below the reporting limit
- **ND** = not detected
- **CS-20** = Chemical Spill-20
- **RBC** = risk-based concentration
- **J** = estimated concentration
- **µg/L** = micrograms per liter
- **LTM** = long term monitoring
Table 3-4
Physical and Chemical Properties for 1,4-Dioxane
Final Supplemental Remedial Investigation Report for 1,4-Dioxane at CS-20, JBCC, MA

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<th>Density (g/cm³)</th>
<th>Water Solubility (mg/L)</th>
<th>Vapor Pressure (mm Hg)</th>
<th>$K_h$ (atm-m³/mole)</th>
<th>Log BCF (—)</th>
<th>$K_{oc}$ (mL/g)</th>
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Data Sources:
1. U.S. Environmental Protection Agency, Technical Fact Sheet - 1,4-Dioxane (January 2014).

Key:
- atm-m³ = atmosphere-cubic meter
- BCF = bioconcentration factor
- cm³ = cubic centimeter
- CS-20 = Chemical Spill-20
- g = gram
- JBCC = Joint Base Cape Cod
- $K_h$ = Henry’s law constant
- $K_{oc}$ = organic carbon partition coefficient
- mg/L = milligrams per liter
- mL/g = milliliters per gram
- mm Hg = millimeters of mercury
Table 4-1
CS-20 1,4-Dioxane Monitoring Results vs Risk Screening Values
Final Supplemental Remedial Investigation Report for 1,4-Dioxane at CS-20, JBCC, MA

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Final Supplemental Remedial Investigation Report for 1,4-Dioxane at CS-20, JBCC, MA

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<td>No</td>
<td>N/A</td>
</tr>
<tr>
<td>81MW0018B</td>
<td>11/8/2017</td>
<td>ND</td>
<td>No</td>
<td>N/A</td>
</tr>
<tr>
<td>81MW0018B</td>
<td>10/30/2018</td>
<td>ND</td>
<td>No</td>
<td>N/A</td>
</tr>
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<td>ND</td>
<td>No</td>
<td>N/A</td>
</tr>
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<td>81MW0019A</td>
<td>8/24/2015</td>
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<td>No</td>
<td>N/A</td>
</tr>
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<td>81MW0019A</td>
<td>3/22/2017</td>
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<td>11/8/2017</td>
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<td>N/A</td>
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<td>No</td>
<td>N/A</td>
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<td>81MW0019A</td>
<td>4/30/2019</td>
<td>ND</td>
<td>No</td>
<td>N/A</td>
</tr>
<tr>
<td>81MW0019B</td>
<td>8/24/2015</td>
<td>ND</td>
<td>No</td>
<td>N/A</td>
</tr>
<tr>
<td>81MW0019C</td>
<td>3/5/2014</td>
<td>BRL</td>
<td>No</td>
<td>N/A</td>
</tr>
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<td>81MW0019C</td>
<td>3/23/2017</td>
<td>BRL</td>
<td>No</td>
<td>N/A</td>
</tr>
<tr>
<td>81MW0019C</td>
<td>11/9/2017</td>
<td>ND</td>
<td>No</td>
<td>N/A</td>
</tr>
<tr>
<td>81MW0019C</td>
<td>11/30/2018</td>
<td>ND</td>
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<td>N/A</td>
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<tr>
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<td>5/2/2019</td>
<td>ND</td>
<td>No</td>
<td>N/A</td>
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</tbody>
</table>

### Surface Monitoring Results

<table>
<thead>
<tr>
<th>Deep Pond</th>
<th>Date</th>
<th>Method</th>
<th>ND/A</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4/21/2016</td>
<td>BRL</td>
<td>N/A</td>
<td>No</td>
</tr>
</tbody>
</table>

Data Source: AFCEC, January 2020

Notes:

**Bold** value indicates an exceedance of the RBC for 1,4-dioxane.

Surface water sampling results are compared to the EPA Region 5 ecological screening value of 22,000 µg/L. This ecological screening value is N/A for comparison to groundwater results.

Key:

- BRL = below the reporting limit of 0.15 µg/L
- ND = not detected
- RBC = risk-based concentration
- CS-20 = Chemical Spill-20
- VI = vapor intrusion
- EPA = U.S. Environmental Protection Agency
- VISL = Vapor Intrusion Screening Level
- JBCC = Joint Base Cape Cod
- N/A = not applicable
- µg/L = microgram per liter
APPENDIX A

Reporting and Communication during Supplemental RI

Emerging Contaminants Updates

24 September 2015 Technical Update Meeting
14 October 2015 JBCC Cleanup Team Meeting
19 November 2015 Technical Update Meeting
11 February 2016 Technical Update Meeting
21 April 2016 Technical Update Meeting
19 July 2017 Technical Update Meeting
07 December 2017 Technical Update Meeting
13 June 2019 Technical Update Meeting
28 August 2019 Technical Update Meeting
14 November 2019 Technical Update Meeting
Emerging Contaminants Update
24 September 2015 Technical Update Meeting
CS-20 Sampling Program (Figures 13 and 14):

• The initial (presence/absence) 1,4-dioxane sampling effort included: plant influent and plant effluent, two extraction wells, five monitoring wells, and one LUC residential well (Figure 13).

• Began sampling CS-20 wells on 03 August 2015; 21 of the 26 monitoring wells have been sampled to date.

• Validated analytical results have been received for 14 locations and 1,4-dioxane concentrations ranged from ND to 0.73 µg/L (Figure 14).

• Concentrations in one monitoring well exceeded the MCP GW-1 standard of 0.3 µg/L for 1,4-dioxane (0.73 µg/L at 69MW1422) (Figure 14).
FIGURE 13
CS-20 1,4-DIOXANE
PRESENCE/ABSENCE RESULTS
AFCEC - Joint Base Cape Cod
24 September 2015 Technical Update Meeting

Legend

- Joint Base Cape Cod Boundary
- Plume Boundary (Dashed Where Inferred)
- Bog/Wetland
- Extraction Well

1,4-Dioxane Detections in Groundwater:
- No Detections
- Detection Below or at MCP GW-1
- Detection Above MCP GW-1

1,4-Dioxane MCP GW-1 = 0.3 µg/L

Note: Location identifiers with an "RS" prefix represent private residential wells.
CS-20 1,4-DIOXANE DETECTIONS IN GROUNDWATER

Data Source: AFCEC, September 2015
JBCC Boundary from Massachusetts Air National Guard 2011

FIGURE 14

1,4-Dioxane Detections in Groundwater/Surface Water:
- No Detections
- Detection Below or at MCP GW-1
- Detection Above MCP GW-1

1,4-Dioxane MCP GW-1 = 0.3 µg/L

Legend
- Joint Base Cape Cod
- CS-20 Plume Boundary
- Infiltration Gallery/Trench
- Treatment System Pipeline
- Monitoring Well
- Extraction Well (On)
- Reinjection Well (On)
- ND
- Groundwater Results (µg/L)
- Not Detected
<table>
<thead>
<tr>
<th>Location</th>
<th>Northing (ft)</th>
<th>Easting (ft)</th>
<th>Midscreen Elevation (ft msl)</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>32MW2002</td>
<td>231808</td>
<td>852193</td>
<td>-153.83</td>
<td>Near extraction well 81EW0002.</td>
</tr>
<tr>
<td>69MW1422</td>
<td>233119</td>
<td>853259</td>
<td>-133.31</td>
<td>Near extraction well 81EW0001.</td>
</tr>
<tr>
<td>69MW1503A</td>
<td>236782</td>
<td>855160</td>
<td>-69.00</td>
<td>Upgradient and/or trailing edge.</td>
</tr>
<tr>
<td>69MW1507</td>
<td>229258</td>
<td>851288</td>
<td>-87.57</td>
<td>Downgradient of treatment system.</td>
</tr>
<tr>
<td>69MW1523</td>
<td>234785</td>
<td>854907</td>
<td>-100.78</td>
<td>Upgradient and/or trailing edge.</td>
</tr>
<tr>
<td>69MW1517B</td>
<td>234133</td>
<td>853782</td>
<td>-45.78</td>
<td>North of 81EW0001.</td>
</tr>
<tr>
<td>69SWDP01</td>
<td>229171</td>
<td>851471</td>
<td>N/A</td>
<td>Deep Pond surface water sample.</td>
</tr>
<tr>
<td>81MW0001A</td>
<td>237419</td>
<td>855575</td>
<td>-62.43</td>
<td>Upgradient and/or trailing edge.</td>
</tr>
<tr>
<td>81MW0003A</td>
<td>235694</td>
<td>854897</td>
<td>-58.60</td>
<td>Upgradient and/or trailing edge.</td>
</tr>
<tr>
<td>81MW0004A</td>
<td>235806</td>
<td>855669</td>
<td>-47.02</td>
<td>Upgradient and/or trailing edge.</td>
</tr>
<tr>
<td>81MW0005A</td>
<td>235230</td>
<td>854337</td>
<td>-97.50</td>
<td>Upgradient and/or trailing edge.</td>
</tr>
<tr>
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<td>235230</td>
<td>854336</td>
<td>-72.50</td>
<td>Upgradient and/or trailing edge.</td>
</tr>
<tr>
<td>81MW0006A</td>
<td>234277</td>
<td>853357</td>
<td>-132.52</td>
<td>North of 81EW0001.</td>
</tr>
<tr>
<td>81MW0006B</td>
<td>234277</td>
<td>853357</td>
<td>-62.52</td>
<td>North of 81EW0001.</td>
</tr>
<tr>
<td>81MW0007A</td>
<td>233991</td>
<td>854138</td>
<td>-139.88</td>
<td>North of 81EW0001.</td>
</tr>
<tr>
<td>81MW0008A</td>
<td>233373</td>
<td>852962</td>
<td>-164.76</td>
<td>Near extraction well 81EW0001.</td>
</tr>
<tr>
<td>81MW0008B</td>
<td>233372</td>
<td>852962</td>
<td>-125.26</td>
<td>Near extraction well 81EW0001.</td>
</tr>
<tr>
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<td>232886</td>
<td>853404</td>
<td>-53.00</td>
<td>Near extraction well 81EW0001.</td>
</tr>
<tr>
<td>81MW0011B</td>
<td>232371</td>
<td>852960</td>
<td>-48.36</td>
<td>North of 81EW0002.</td>
</tr>
<tr>
<td>81MW0012A</td>
<td>232761</td>
<td>852386</td>
<td>-125.40</td>
<td>North of 81EW0002.</td>
</tr>
<tr>
<td>81MW0013A</td>
<td>230153</td>
<td>851780</td>
<td>-89.66</td>
<td>Downgradient of treatment system.</td>
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<tr>
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<td>852280</td>
<td>-52.20</td>
<td>Near extraction well 81EW0002.</td>
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<td>-146.89</td>
<td>Near extraction well 81EW0002.</td>
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<td>852591</td>
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</tr>
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<td>-198.58</td>
<td>Downgradient of treatment system.</td>
</tr>
<tr>
<td>81MW0019B</td>
<td>234001</td>
<td>848990</td>
<td>-112.50</td>
<td>Downgradient of treatment system.</td>
</tr>
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<td>85PLT01002</td>
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<td>N/A</td>
<td>N/A</td>
<td>CS-4/CS-20 Influent.</td>
</tr>
<tr>
<td>85PLT01003</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>Combined CS-4/CS-20 Effluent.</td>
</tr>
</tbody>
</table>

Data Source: AFCEC, September 2015

Key:
CS = Chemical Spill
ft = feet
msl = mean sea level
N/A = not applicable
Emerging Contaminants Update
14 October 2015 JBCC Cleanup Team Meeting
Emerging Contaminants Update

Rose Forbes, AFCEC
Mary O’Reilly, CH2M
JBCC Cleanup Team Meeting
October 14, 2015
CS-20 Sampling Program (Figures 9 and 10):

• The initial SI Equivalent 1,4-dioxane sampling effort (Figure 9) in 2013/2014 included:
  – plant influent and plant effluent,
  – two extraction wells,
  – five monitoring wells,
  – and one private residential well.

• Began sampling CS-20 wells on 03 August 2015; 21 of the 26 monitoring wells have been sampled to date.

• Validated analytical results have been received for 14 locations and 1,4-dioxane concentrations ranged from ND to 0.73 µg/L (Figure 10).

• Concentrations in two monitoring wells exceeded the MCP GW-1 standard of 0.3 µg/L for 1,4-dioxane (Figure 9 and Figure 10).
FIGURE 9
CS-20 1,4-DIOXANE SITE INSPECTION EQUIVALENT RESULTS (2013 - 2014)
AFCEC - Joint Base Cape Cod
14 October 2015 JBCCCT Meeting

Legend

- Joint Base Cape Cod Boundary
- Plume Boundary (Dashed Where Inferred)
- Bog/Wetland
- Extraction Well

1,4-Dioxane Detections in Groundwater:
- No Detections
- Detection Below or at MCP GW-1
- Detection Above MCP GW-1

1,4-Dioxane MCP GW-1 = 0.3 µg/L

Note: Location identifiers with an "RS" prefix represent private residential wells.
**FIGURE 10**

**CS-20 1,4-DIOXANE DETECTIONS IN GROUNDWATER (2015)**

AFCEC - Joint Base Cape Cod

14 October 2015 JBCCCT Meeting

---

1,4-Dioxane Detections in Groundwater/Surface Water:
- No Detections
- Detection Below or at MCP GW-1
- Detection Above MCP GW-1

1,4-Dioxane MCP GW-1 = 0.3 µg/L

---

**Legend**
- Joint Base Cape Cod
- CS-20 Plume Boundary
- Infiltration Gallery/Trench
- Treatment System Pipeline
- Monitoring Well

- Extraction Well (On)
- Extraction Well (Off)
- Reinjection Well (On)
- ND (Not Detected)

Data Source: AFCEC, October 2015

JBCC Boundary from Massachusetts Air National Guard 2011
Emerging Contaminants Update
19 November 2015 Technical Update Meeting
CS-20 Sampling Program (Figure 10 and Table 4):

- Began sampling CS-20 wells on 03 August 2015; 21 of the 26 monitoring wells have been sampled to date.

- Validated analytical results have been received for all 21 locations and 1,4-dioxane concentrations ranged from ND to 0.73 µg/L (Table 4).

- Concentrations in one monitoring well exceeded the MCP GW-1 standard of 0.3 µg/L for 1,4-dioxane (0.73 µg/L at 69MW1422) (Figure 10).

- Concentrations in one additional CS-20 well sampled during the initial Site Inspection (SI) Equivalent sampling effort in 2013/2014 exceeded the MCP GW-1 standard of 0.3 µg/L for 1,4-dioxane (0.783 µg/L at 81MW0013B) (Figure 10 and Table 4).
CS-20 1,4-DIOXANE DETECTIONS IN GROUNDWATER (2015)

AFCEC - Joint Base Cape Cod
19 November 2015 Technical Update Meeting

FIGURE 10

1,4-Dioxane Detections in Groundwater/Surface Water:
- No Detections
- Detection Below or at MCP GW-1
- Detection Above MCP GW-1

1,4-Dioxane MCP GW-1 = 0.3 µg/L

Data Source: AFCEC, November 2015
JBCC Boundary from Massachusetts Air National Guard 2011
Table 4
Chemical Spill-20 1,4-Dioxane Monitoring Results
19 November 2015 Technical Update Meeting

<table>
<thead>
<tr>
<th>Location</th>
<th>Date</th>
<th>1,4-Dioxane (µg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>69MW1422</td>
<td>8/26/2015</td>
<td>0.73</td>
</tr>
<tr>
<td>69MW1503A</td>
<td>8/4/2015</td>
<td>ND</td>
</tr>
<tr>
<td>69MW1507</td>
<td>9/11/2015</td>
<td>ND</td>
</tr>
<tr>
<td>69MW1517A</td>
<td>3/20/2014</td>
<td>ND</td>
</tr>
<tr>
<td>69MW1517B</td>
<td>9/14/2015</td>
<td>0.047</td>
</tr>
<tr>
<td>69MW1523</td>
<td>8/4/2015</td>
<td>ND</td>
</tr>
<tr>
<td>81EW0001</td>
<td>12/3/2013</td>
<td>BRL</td>
</tr>
<tr>
<td>81EW0002</td>
<td>12/3/2013</td>
<td>BRL</td>
</tr>
<tr>
<td>81MW0001A</td>
<td>8/3/2015</td>
<td>ND</td>
</tr>
<tr>
<td>81MW0003A</td>
<td>8/14/2015</td>
<td>ND</td>
</tr>
<tr>
<td>81MW0004A</td>
<td>8/14/2015</td>
<td>ND</td>
</tr>
<tr>
<td>81MW0005A</td>
<td>8/13/2015</td>
<td>ND</td>
</tr>
<tr>
<td>81MW0006B</td>
<td>8/20/2015</td>
<td>ND</td>
</tr>
<tr>
<td>81MW0006B</td>
<td>8/20/2015</td>
<td>0.095</td>
</tr>
<tr>
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<td>9/17/2015</td>
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</tr>
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<tr>
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</tr>
<tr>
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<td>8/26/2015</td>
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</tr>
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<td>81MW0011A</td>
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<td>ND</td>
</tr>
<tr>
<td>81MW0011B</td>
<td>9/16/2015</td>
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</tr>
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<td>81MW0012A</td>
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<td>8/5/2015</td>
<td>0.26</td>
</tr>
<tr>
<td>81MW0019A</td>
<td>8/24/2015</td>
<td>ND</td>
</tr>
<tr>
<td>81MW0019B</td>
<td>8/24/2015</td>
<td>ND</td>
</tr>
<tr>
<td>81MW0019C</td>
<td>3/5/2014</td>
<td>BRL</td>
</tr>
</tbody>
</table>

Data Source: AFCEC, November 2015

Note:
**Bold** value indicates an exceedance of the MCP GW-1 standard for 1,4-dioxane.

Key:
- BRL = below the reporting period
- MCP = Massachusetts Contingency Plan
- GW-1 = MCP Method 1 Groundwater-1 Standard
- ND = not detected
- J = estimated value
- µg/L = micrograms per liter
Emerging Contaminants Update
11 February 2016 Technical Update Meeting
Emerging Contaminants Update
11 February 2016 Technical Update Meeting

CS-20 Sampling Program (Figure 14):

• Completed sampling the CS-20 monitoring wells on 28 January 2016.

• Validated analytical results have been received for 21 of the 26 locations and results were presented at the 19 November 2015 Technical Update Meeting.
  
  – 1,4-dioxane concentrations ranged from ND to 0.73 µg/L.
  
  – Concentrations in one monitoring well exceeded the MCP GW-1 standard of 0.3 µg/L for 1,4-dioxane (0.73 µg/L at 69MW1422).
  
  – Concentrations in one additional CS-20 well sampled during the initial SI Equivalent sampling effort in 2013/2014 exceeded the MCP GW-1 standard of 0.3 µg/L for 1,4-dioxane (0.783 µg/L at 81MW0013B).
FIGURE 14

CS-20 1,4-DIOXANE DETECTIONS IN GROUNDWATER

AFCEC - Joint Base Cape Cod
11 February 2016 Technical Update Meeting

1,4-Dioxane MCP GW-1 = 0.3 µg/L

Data Source: AFCEC, February 2016
JBCC Boundary from Massachusetts Air National Guard 2011

Legend

Joint Base Cape Cod
CS-20 Plume Boundary
(Dashed Where Inferred)
Infiltration Gallery/Trench
Treatment System Pipeline
Bog/Wetland
Extraction Well (Off)

Path: Y:\Figures\General\2016\Emerg_Contaminants\Tech_Update\February\GIS\Arcmap\EC_11Feb16_TechUpdate_Fig14_PWS.mxd Date: 2/10/2016 Time: 11:24:00 AM User: JMESSNE1
Emerging Contaminants Update
21 April 2016 Technical Update Meeting
Emerging Contaminants Update  
21 April 2016 Technical Update Meeting  

**CS-20 Sampling Program (Figure 6 and Table 6):**

- Completed sampling the CS-20 monitoring wells on 28 January 2016.
  - 1,4-dioxane concentrations ranged from ND to 0.73 µg/L.
  - Concentrations in one monitoring well exceeded the MCP GW-1 standard of 0.3 µg/L for 1,4-dioxane (0.73 µg/L at 69MW1422).
  - Concentrations in one additional CS-20 well sampled during the initial SI equivalent sampling effort in 2013/2014 exceeded the MCP GW-1 standard of 0.3 µg/L for 1,4-dioxane (0.783 µg/L at 81MW0013B).
- Regulatory path forward for CS-20 based on these results.
**FIGURE 6**

**CS-20 1,4-DIOXANE DETECTIONS IN GROUNDWATER**

AFCEC - Joint Base Cape Cod
21 April 2016 Technical Update Meeting

---

**Joint Base Cape Cod**

**CS-20 Plume Boundary**

(Dashed Where Inferred)

**Infiltration Gallery/Trench**

**Treatment System Pipeline**

**Bog/Wetland**

**Extraction Well (Off)**

---

1,4-Dioxane Detections in Groundwater:

- **No Detections**
- **Detection Below or at MCP GW-1**
- **Detection Above MCP GW-1**

1,4-Dioxane MCP GW-1 = 0.3 µg/L
<table>
<thead>
<tr>
<th>Location</th>
<th>Date</th>
<th>1,4-Dioxane (µg/L)</th>
<th>Key</th>
</tr>
</thead>
<tbody>
<tr>
<td>32MW2002</td>
<td>1/27/2016</td>
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<td>69MW1422</td>
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<td>0.73</td>
<td></td>
</tr>
<tr>
<td>69MW1503A</td>
<td>8/4/2015</td>
<td>ND</td>
<td></td>
</tr>
<tr>
<td>69MW1507</td>
<td>9/11/2015</td>
<td>ND</td>
<td></td>
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<tr>
<td>69MW1517A</td>
<td>3/20/2014</td>
<td>ND</td>
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<td>9/14/2015</td>
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<td></td>
</tr>
<tr>
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<td>8/19/2013</td>
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<td>81MW0011B</td>
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<td>81MW0018B</td>
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<td></td>
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<tr>
<td>81MW0019A</td>
<td>8/24/2015</td>
<td>ND</td>
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<td>RS0034GALL</td>
<td>6/30/2014</td>
<td>ND</td>
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</tbody>
</table>

Data Source: AFCEC, April 2016

**Note:** Bold value indicates an exceedance of the MCP GW-1 standard for 1,4-dioxane.

**Key:**
- BRL = below the reporting period of 0.15 µg/L
- MCP = Massachusetts Contingency Plan
- GW-1 = MCP Method 1 Groundwater-1 Standard
- ND = not detected
- J = estimated value
- µg/L = micrograms per liter
Emerging Contaminants Update
19 July 2017 Technical Update Meeting
Supplemental RI/FS Sampling:

**CS-20**

- Completed the first CS-20 1,4-Dioxane Interim Monitoring sampling event. Eight wells were sampled between 16 and 27 March 2017. 1,4-Dioxane concentrations in all eight wells decreased.

- 1,4-Dioxane concentrations in only one well (69MW1422 at 0.46 micrograms per liter [µg/L]) exceed the Massachusetts Contingency Plan Groundwater-1 standard of 0.3 µg/L.

- 1,4-Dioxane concentrations in all other wells are below the reporting limit of 0.15 µg/L or not detected.
FIGURE 1
CS-20 1,4-DIOXANE
INTERIM MONITORING NETWORK
AFCEC - Joint Base Cape Cod
19 July 2017 Technical Update Meeting
### Table 1
CS-20 Interim LTM 1,4-Dioxane Sampling Results
19 July 2017 Technical Update Meeting

<table>
<thead>
<tr>
<th>Location</th>
<th>Date</th>
<th>1,4-Dioxane (µg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>32MW2002</td>
<td>1/27/2016</td>
<td>BRL</td>
</tr>
<tr>
<td>32MW2002</td>
<td>3/16/2017</td>
<td>ND</td>
</tr>
<tr>
<td>69MW1422</td>
<td>8/26/2015</td>
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</tr>
<tr>
<td>69MW1422</td>
<td>4/26/2016</td>
<td>0.48</td>
</tr>
<tr>
<td>69MW1422</td>
<td>3/27/2017</td>
<td>0.46</td>
</tr>
<tr>
<td>81MW0011A</td>
<td>3/19/2014</td>
<td>ND</td>
</tr>
<tr>
<td>81MW0011A</td>
<td>3/22/2017</td>
<td>ND</td>
</tr>
<tr>
<td>81MW0013B</td>
<td>3/5/2014</td>
<td>0.783</td>
</tr>
<tr>
<td>81MW0013B</td>
<td>4/26/2016</td>
<td>BRL</td>
</tr>
<tr>
<td>81MW0013B</td>
<td>3/16/2017</td>
<td>BRL</td>
</tr>
<tr>
<td>81MW0018A</td>
<td>3/5/2014</td>
<td>0.298</td>
</tr>
<tr>
<td>81MW0018A</td>
<td>4/26/2016</td>
<td>BRL</td>
</tr>
<tr>
<td>81MW0018A</td>
<td>3/16/2017</td>
<td>ND</td>
</tr>
<tr>
<td>81MW0018B</td>
<td>8/5/2015</td>
<td>0.26</td>
</tr>
<tr>
<td>81MW0018B</td>
<td>4/26/2016</td>
<td>0.17</td>
</tr>
<tr>
<td>81MW0018B</td>
<td>3/16/2017</td>
<td>BRL</td>
</tr>
<tr>
<td>81MW0019A</td>
<td>8/24/2015</td>
<td>ND</td>
</tr>
<tr>
<td>81MW0019A</td>
<td>3/22/2017</td>
<td>ND</td>
</tr>
<tr>
<td>81MW0019C</td>
<td>3/5/2014</td>
<td>BRL</td>
</tr>
<tr>
<td>81MW0019C</td>
<td>3/23/2017</td>
<td>BRL</td>
</tr>
</tbody>
</table>

Data Source: AFCEC, July 2017

Note:

**Bold** value indicates an exceedance of the MCP GW-1 standard.

Key:

- **BRL** = below the reporting limit of 0.15 µg/L
- **GW-1** = MCP Method 1 Groundwater-1 Standard
- **MCP** = Massachusetts Contingency Plan
- **ND** = not detected
- **µg/L** = micrograms per liter
Emerging Contaminants Update
07 December 2017 Technical Update Meeting
Supplemental RI/FS Sampling:

**CS-10 (Table 8)**
- The CS-10 In-Plume plant influent and effluent ports were sampled for 1,4-dioxane on 19 October 2017; 1,4-dioxane was not detected in any of the influent or effluent ports.

**CS-20 (Figure 6 and Table 9)**
- The second CS-20 semiannual 1,4-dioxane interim sampling event was completed between 08 and 09 November 2017; concentrations in all eight wells are below the MCP GW-1 standard of 0.3 µg/L.
FIGURE 6

CS-20 1,4-DIOXANE
INTERIM MONITORING NETWORK
AFCEC - Joint Base Cape Cod
07 December 2017 Technical Update Meeting
### Table 9
CS-20 Interim LTM 1,4-Dioxane Sampling Results
07 December 2017 Technical Update Meeting

<table>
<thead>
<tr>
<th>Location</th>
<th>Date</th>
<th>1,4-Dioxane (µg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>32MW2002</td>
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<td>BRL</td>
</tr>
<tr>
<td>32MW2002</td>
<td>3/16/2017</td>
<td>ND</td>
</tr>
<tr>
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<td>11/9/2017</td>
<td>BRL</td>
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<td>69MW1422</td>
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<tr>
<td>69MW1422</td>
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<td>69MW1422</td>
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<td>0.20 J</td>
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<td>ND</td>
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<td>ND</td>
</tr>
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<td>81MW0011A</td>
<td>11/8/2017</td>
<td>BRL</td>
</tr>
<tr>
<td>81MW0013B</td>
<td>3/5/2014</td>
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<td>81MW0013B</td>
<td>4/26/2016</td>
<td>BRL</td>
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<td>BRL</td>
</tr>
<tr>
<td>81MW0013B</td>
<td>11/9/2017</td>
<td>ND</td>
</tr>
<tr>
<td>81MW0018A</td>
<td>3/5/2014</td>
<td>0.298</td>
</tr>
<tr>
<td>81MW0018A</td>
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<td>3/16/2017</td>
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<td>81MW0018A</td>
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<td>81MW0018B</td>
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<tr>
<td>81MW0018B</td>
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<td>ND</td>
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<td>81MW0019A</td>
<td>8/24/2015</td>
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<td>ND</td>
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<tr>
<td>81MW0019A</td>
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<td>ND</td>
</tr>
<tr>
<td>81MW0019C</td>
<td>3/5/2014</td>
<td>BRL</td>
</tr>
<tr>
<td>81MW0019C</td>
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<td>BRL</td>
</tr>
<tr>
<td>81MW0019C</td>
<td>11/9/2017</td>
<td>ND</td>
</tr>
</tbody>
</table>

Data Source: AFCEC, December 2017

Note:
**Bold** value indicates an exceedance of the MCP GW-1 standard.

Key:
- BRL = below the reporting limit of 0.15 µg/L
- CS-20 = Chemical Spill-20
- GW-1 = MCP Method 1 Groundwater-1 Standard
- J = estimated concentration
- LTM = long term monitoring
- MCP = Massachusetts Contingency Plan
- ND = not detected
- µg/L = micrograms per liter
Emerging Contaminants Update
13 June 2019 Technical Update Meeting
Emerging Contaminants Update  
13 June 2019 Technical Update Meeting

Reporting (Figures 1a and 1b and Tables 1a and 1b):

Chemical Spill-10 (CS-10)

• The *Draft Explanation of Significant Differences for 1,4-Dioxane at Chemical Spill-10, Joint Base Cape Cod, MA* was submitted on 12 December 2018.
  – Received MassDEP comments on 09 January 2019; waiting on EPA comments.

Chemical Spill-20 (CS-20)

• Finalization of the *Draft Supplemental Remedial Investigation Report for 1,4-Dioxane at Chemical Spill-20, Joint Base Cape Cod, MA* will be completed after the CS-20 1,4-Dioxane Interim Monitoring Program is completed.
  – Last sampling event was completed on 02 May 2019.
  – 1,4-Dioxane concentrations in 69MW1422 increased from 0.28 to 0.7 micrograms per liter (µg/L), which is above the Massachusetts Contingency Plan (MCP) Groundwater-1 (GW-1) standard of 0.3 µg/L, all other wells have been nondetect for two or more sampling events (Figures 1a and 1b and Tables 1a and 1b).
  – Since there is only one well with 1,4-dioxane concentrations above the GW-1 standard and all other wells are nondetect, contamination is limited in extent and 1,4-dioxane should not be considered a contaminant of concern (COC) at CS-20.
  – Proceed with the path forward for finalizing the Supplemental Remedial Investigation (RI), which includes documenting that 1,4-dioxane will not be added as a COC.
FIGURE 1a

CS-20 SUPPLEMENTAL RI
1,4-DIOXANE DETECTIONS IN GROUNDWATER
AFCEC - Joint Base Cape Cod
13 June 2019 Technical Update Meeting

1,4-Dioxane Detections in Groundwater:
- No Detections
- Detection Below or at MCP GW-1
- Detection Above MCP GW-1

1,4-Dioxane MCP GW-1 = 0.3 µg/L
1,4-Dioxane Detections in Groundwater:

- No Detection
- Detection Above MCP GW-1

1,4-Dioxane MCP GW-1 = 0.3 µg/L

**FIGURE 1b**

CS-20 1,4-DIOXANE INTERIM MONITORING NETWORK
AFCEC - Joint Base Cape Cod
13 June 2019 Technical Update Meeting
Emerging Contaminants Update
28 August 2019 Technical Update Meeting
Emerging Contaminants Update
28 August 2019 Technical Update Meeting

**Reporting:**

**Chemical Spill-10 (CS-10)**

- The *Draft Explanation of Significant Differences for 1,4-Dioxane at Chemical Spill-10, Joint Base Cape Cod, MA* was submitted on 12 December 2018.
  - Received MassDEP comments on 09 January 2019; and received EPA comments on 21 August 2019; RCL is in preparation.

**Chemical Spill-20 (CS-20) (Figure 1)**

- Finalization of the *Draft Supplemental Remedial Investigation Report for 1,4-Dioxane at Chemical Spill-20, Joint Base Cape Cod, MA* will be completed after the CS-20 1,4-Dioxane Interim Monitoring Program is completed.
  - There is only one well with 1,4-dioxane concentrations above the Massachusetts Contingency Plan (MCP) Groundwater-1 (GW-1) standard of 0.3 micrograms per liter (µg/L) and all other wells are nondetect, therefore, contamination is limited in extent and 1,4-dioxane should not be considered a contaminant of concern (COC) at CS-20.
  - Data and path forward for finalizing the Supplemental Remedial Investigation (RI), which includes documenting that 1,4-dioxane will not be added as a COC were presented at the 13 June 2019 Technical Update Meeting.
  - Waiting on EPA data review before proceeding with the path forward; no comments were received by MassDEP at the 13 June 2019 Technical Update Meeting.
FIGURE 1
CS-20 1,4-DIOXANE INTERIM MONITORING NETWORK
AFCEC - Joint Base Cape Cod
28 August 2019 Technical Update Meeting

1,4-Dioxane Detections in Groundwater:
- No Detection
- Detection Above MCP GW-1

1,4-Dioxane MCP GW-1 = 0.3 µg/L

Legend
- Joint Base Cape Cod Boundary
- 2015 Plume Boundary (No Longer Delineated)
- Bog/Wetland

Data Source: AFCEC, August 2019
JBCC Boundary from Massachusetts Air National Guard 2011
Emerging Contaminants Update
14 November 2019 Technical Update Meeting
Emerging Contaminants Update
14 November 2019 Technical Update Meeting

Reporting:

Chemical Spill-10 (CS-10)

- The *Draft Explanation of Significant Differences for 1,4-Dioxane at Chemical Spill-10, Joint Base Cape Cod, MA* was submitted on 12 Dec 2018.
  - Received MassDEP comments on 09 Jan 2019 and EPA comments on 21 Aug 2019 and submitted the response to comment letter (RCL) on 16 Sep 2019. Concurrence/comments were due 07 Oct 2019.

Chemical Spill-20 (CS-20)

- RCL2 for the *Draft Supplemental Remedial Investigation Report for 1,4-Dioxane at Chemical Spill-20, Joint Base Cape Cod, MA* will be submitted on 14 Nov 2019. Since there are many changes to the 2016 Draft Supplemental Remedial Investigation (RI) report the RCL2 includes a redline-strikeout version of the Draft Final Supplemental RI report. Revisions include:
  - Addition of the interim monitoring program results.
  - Change in the screening level for the assessment of 1,4-dioxane groundwater data to a risk-based concentration (RBC) of 0.46 micrograms per liter (µg/L).
  - Recommendation that 1,4-dioxane should not be considered a contaminant of concern (COC) and a Fact Sheet should be prepared documenting that no further action is needed for 1,4-dioxane at CS-20.
Emerging Contaminants Update
14 November 2019 Technical Update Meeting

Path Forward:

• Continue TTRS RI field program and Valley Farm Road private well sampling program.
• Continue AV Supplemental RI field program and private well sampling program.
• Continue Flight Line Expanded SI field program.
• Continue providing bottled water to residences with exceedances of the LHA and evaluating filtration systems and/or municipal water connections as further response actions.
• Receive agency comments/concurrence on the RCL2 for the Draft CS-20 Supplemental RI and finalize the report.
• Receive agency comments/concurrence on the RCL for the Draft CS-10 Explanation of Significant Differences and finalize the report.
• Begin preparation of the Draft Supplemental Feasibility Study Report for 1,4-Dioxane and PFAS at Landfill-1 after the standards are clearly defined; request FFA milestone extension.
• Present sample results and field program updates to the agencies at Technical Update Meetings and to the public at future JBCC Cleanup Team Meetings.
**APPENDIX B-1**

Data Summary Report for Supplemental RI Results
Appendix B-1
Data Summary Report for Supplemental RI Results
Final Supplemental Remedial Investigation Report for 1,4-Dioxane at CS-20, JBCC, MA

INTRODUCTION

The objective of this data summary report (DSR) is to assess the data quality of analytical results for samples collected for the 1,4-dioxane Supplemental Remedial Investigation at the Chemical Spill-20 (CS-20) site for the Joint Base Cape Cod (JBCC), Task Order 376 as presented in the Final Supplemental Remedial Investigation Report for 1,4-Dioxane at Chemical Spill-20, JBCC, MA. This report is intended as a general data quality assessment designed to summarize data issues.

ANALYTICAL DATA

This DSR covers 39 groundwater samples with three field groundwater duplicate samples and three wastewater samples with no field quality control (QC) samples taken. Field duplicates are not required for treatment facility wastewater samples. These samples were reported under 20 sample delivery groups. Samples were collected between 25 October 2013 and 25 May 2016. The analyses were performed by Australian Laboratory Services (ALS), Kelso, Washington and Alpha Analytical, Westborough Massachusetts. Samples were collected and delivered by Federal Express to ALS overnight services and delivered by courier to Alpha Analytical. Samples were analyzed for the analytes/methods provided in Table B-1.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Method</th>
<th>Laboratory</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,4-Dioxane by selected ion mode, isotopic dilution gas chromatography mass spectrometry</td>
<td>SW8270 SIM</td>
<td>ALS and Alpha Analytical</td>
</tr>
</tbody>
</table>

The data were assessed using the UFP Federal Policy-Quality Assurance Project Plan (UFP-QAPP). The assessment included a review of the following:

• Chain-of-Custody documentation
• Holding time compliance
• Required QC samples at the specified frequencies
• Method blanks and field blanks
• Laboratory control spiking samples
• Surrogate spike recoveries
• Internal standards
• Matrix spike/matrix spike duplicate (MS/MSD) samples on a site/location basis
• Initial and continuing calibration information and other method-specific criteria as defined by the QAPP

Data were carried through data validation as described in the QAPP and data flags were assigned according to the QAPP. These flags, and the reason for each flag, were entered into the electronic database. Multiple flags are routinely applied to specific sample method/matrix/analyte combinations, but there is only one final flag. A final flag is applied to the data, and is the most conservative of the applied validation flags. The final flag also includes matrix and blank sample impacts.

The data flags used for this data set are listed in the QAPP and are defined as follows:

• J = Analyte was present but the reported value may not be accurate or precise (estimated).
• U = Analyte was detected but qualified as a non-detected result based on blank contamination.
• UJ = Analyte was not detected and the specified detection limit may not be accurate or precise (estimated).
FINDINGS

The summaries of the data validation findings are contained in the following subsections and Table B-2.

Holding Times

All holding time criteria were met. No holding time flags were applied.

Calibration

Initial and continuing calibrations and second source checks were analyzed as required in every analytical batch and were in control.

Method Blanks

Method blanks were analyzed at the required frequency for each method and were in control with one exception of a blank detected less than the limit of quantitations (LOQ). The sample result was flagged as a nondetected result at the LOQ.

Field Blanks

Equipment blanks were collected and analyzed at the required frequency. There was one equipment blank with a low level detected result but was associated with non-detected data and no sample results were flagged.

Field Duplicates

Field duplicates were collected as required, and precision was acceptable.

Matrix Spike Samples

MS/MSDs were collected at the required frequency and provided acceptable accuracy and precision.


**Surrogates**

Surrogate recoveries were in control overall. There was one sample (CHPQ01507-O0815) where the surrogate spike was recovered marginally low, 68 percent vs. a lower control limit of 70 percent and the nondetected result was flagged “UJ”.

**Laboratory Control Samples**

Laboratory control sample/laboratory control sample duplicates (LCS/LCSD) were analyzed as required and were in control.

**Internal Standards**

Internal standards were in control.

**Sample Preservation**

All samples were correctly preserved.

**Performance Evaluation Samples**

In March of 2016, CH2M submitted a blind performance evaluation (PE) sample to the laboratory (ALS) for analysis of 1,4-dioxane. The table below provides a comparison of PE results obtained by ALS against the certified values provided by the PE vendor, ERA of Denver Colorado. The results from ALS are very close to the certified values and well within the acceptance ranges provided by our PE vendor.

<table>
<thead>
<tr>
<th></th>
<th>Certified Value (µg/L)</th>
<th>Laboratory Result (µg/L)</th>
<th>% Difference</th>
<th>Acceptance Limits µg/L</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,4-Dioxane</td>
<td>0.792</td>
<td>0.750</td>
<td>5</td>
<td>0.554 - 1.03</td>
</tr>
</tbody>
</table>

Notes:

Certified Value and Acceptance Limits were provided by the PE Vendor, ERA.
Analyte free source water was used to construct PE samples, which was confirmed through analysis of a source water blank.
µg/L = micrograms per liter
Chain of Custody

No chain of custody anomalies were noted in the review.

Overall Assessment

The goal of this assessment is to demonstrate that a sufficient number of representative samples were collected and the resulting analytical data can be used to support the decision-making process. The procedures for assessing the precision, accuracy, representativeness, completeness, and comparability parameters (PARCC) are addressed in the QAPP. The following summary highlights the PARCC findings for the above-defined events:

1. The completeness goal for valid usable data is 95 percent for aqueous samples. Completeness for aqueous samples was 100 percent.

2. The routinely acceptable performance of field and laboratory QC indicators (field duplicates, field blanks, laboratory blanks, MS/MSDs, surrogate spikes, LCS, and calibrations) shows that the precision and accuracy of the data met project objectives.

3. Sample results are representative and comparable to field conditions because the field sampling and laboratory analyses were performed using standardized and documented procedures as defined in project documents. In addition, all results were reported with industry standard units.
# Table B-2
Validation Flags$^a$

<table>
<thead>
<tr>
<th>Field ID</th>
<th>Method</th>
<th>Analyte</th>
<th>Final Result (µg/L)</th>
<th>Final Flag</th>
<th>Reason</th>
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</thead>
<tbody>
<tr>
<td>CHPQ01507-O0815</td>
<td>SW8270 SIM</td>
<td>1,4-Dioxane</td>
<td>0.02</td>
<td>UJ</td>
<td>SUR&lt;LCL</td>
</tr>
<tr>
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<td>SW8270 SIM</td>
<td>1,4-Dioxane</td>
<td>0.15</td>
<td>U</td>
<td>LB&lt;RL</td>
</tr>
</tbody>
</table>

$^a$ Field samples and field duplicates only.

Key:
- LB<RL = the method blank had a detection less than the limit of quantitations
- Sur<LCL = Surrogate recovery less than lower limit
- U = nondetected result after validation due to blank contamination
- UJ = estimated nondetect
- µg/L = micrograms per liter
APPENDIX B-2

Data Summary Report for Interim Monitoring Results
INTRODUCTION

The objective of this data summary report (DSR) is to assess the data quality of analytical results for samples collected for the 1,4-Dioxane Interim Monitoring Program at the CS-20 Site for the Joint Base Cape Cod (JBCC), as presented in the Final Supplemental Remedial Investigation Report for 1,4-Dioxane at Chemical Spill 20, Joint Base Cape Cod, MA. This report is intended as a general data quality assessment designed to summarize data issues.

ANALYTICAL DATA

This DSR covers 32 groundwater samples with one field duplicate, one equipment blank and one matrix spike/matrix spike duplicate sample taken. These samples were reported under nine sample delivery groups. Samples were collected between 06 March 2017 and 02 May 2019. The analyses were performed by Australian Laboratory Services (ALS), Kelso, Washington and Eurofins Lancaster, Lancaster, Pennsylvania. Samples were collected and delivered by Fed Ex using overnight services. Samples were analyzed for the analytes/method provided in Table B-1.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Method</th>
<th>Laboratory</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,4-Dioxane by selected ion mode, isotopic dilution gas chromatography mass spectrometry</td>
<td>SW8270 SIM</td>
<td>ALS and Eurofins Lancaster</td>
</tr>
</tbody>
</table>

- The data were assessed using the UFP Federal Policy-Quality Assurance Project Plan (UFP-QAPP)^1. The assessment included a review of the following:
  - Chain-of-Custody documentation
  - Holding time compliance

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• Required QC samples at the specified frequencies
• Method blanks and field blanks
• Laboratory control spiking samples
• Surrogate spike recoveries
• Internal standards
• Matrix spike/matrix spike duplicate (MS/MSD) samples on a site/location basis
• Initial and continuing calibration information and other method-specific criteria as defined by the QAPP

Data were carried through data validation as described in the QAPP and data flags were assigned according to the QAPP. These flags, and the reason for each flag, were entered into the electronic database. Multiple flags are routinely applied to specific sample method/matrix/analyte combinations, but there is only one final flag. A final flag is applied to the data and is the most conservative of the applied validation flags. The final flag also includes matrix and blank sample impacts.

The data flags used for this data set are listed in the QAPP and are defined as follows:

• J = Analyte was present, but the reported value may not be accurate or precise (estimated).
• U = Analyte was detected but qualified as a non-detected result based on blank contamination.
• UJ = Analyte was not detected, and the specified detection limit may not be accurate or precise (estimated).
• US = Analyte was not detected, and the specified detection limit may not be accurate or precise (estimated). Result is considered screening level data quality.

FINDINGS

The summaries of the data validation findings are contained in the following subsections and Table B-2.
Holding Times

All holding time criteria were met. No holding time flags were applied.

Calibration

Initial and continuing calibrations and second source checks were analyzed as required in every analytical batch and were in control.

Method Blanks

Method blanks were analyzed at the required frequency and were in control with two exceptions of a blank detected less than the LOQ. The sample results were flagged as a nondetected results at the LOQ.

Field Blanks

One equipment blank was collected. No sample data required qualification.

Field Duplicates

One field duplicate pair was collected. No sample data required qualification.

Matrix Spike Samples

MS/MSDs were collected at the required frequency and provided acceptable accuracy and precision. One sample result was flagged “J” as an estimated concentrations for marginally low MS recovery.

Surrogates

Surrogate spikes were analyzed as required and were in control.
Laboratory Control Samples

Laboratory control sample/laboratory control sample duplicates (LCS/LCSD) were analyzed as required and were in control.

Internal Standards

Internal standards were in control.

Sample Preservation

All samples were correctly preserved overall however there are five samples that arrived in one shipping cooler with an internal temperature measured above the required 6 degrees celsius. The temperature was recorded at 7.1 degrees celsius. Samples were flagged “UJ” and are considered estimated concentrations.

Chain of Custody

No chain of custody anomalies were noted in the review.

Sample Preparation

Two samples contained levels of sediment in the samples that required use of a centrifuge to allow the water to be decanted off for sample preparation. Samples are flagged “US” and are considered estimated concentrations, screening level data quality.

Overall Assessment

The goal of this assessment is to demonstrate that a sufficient number of representative samples were collected, and the resulting analytical data can be used to support the decision-making process. The procedures for assessing the precision, accuracy, representativeness, completeness, and comparability parameters (PARCC) are addressed in the QAPP. The following summary highlights the PARCC findings for the above-defined events:
1. The completeness goal for valid usable data is 95 percent for aqueous samples. Completeness for aqueous samples was 100 percent.

2. The routinely acceptable performance of field and laboratory QC indicators show that the precision and accuracy of the data met project objectives.

3. Sample results are representative and comparable to field conditions because the field sampling and laboratory analyses were performed using standardized and documented procedures as defined in project documents. In addition, all results were reported within industry standard units.
### Table B-2
Validation Flags

<table>
<thead>
<tr>
<th>Field ID</th>
<th>Method</th>
<th>Analyte</th>
<th>Final Result (µg/L)</th>
<th>Final Flag</th>
<th>Reason</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHPQ0018A-S0217</td>
<td>SW8270D SIM</td>
<td>1,4-DIOXANE</td>
<td>0.15</td>
<td>U</td>
<td>LB&lt;RL</td>
</tr>
<tr>
<td>CHPQ02002-S0217</td>
<td>SW8270D SIM</td>
<td>1,4-DIOXANE</td>
<td>0.15</td>
<td>U</td>
<td>LB&lt;RL</td>
</tr>
<tr>
<td>CHPQ01422-S0217P</td>
<td>SW8270D SIM</td>
<td>1,4-DIOXANE</td>
<td>0.46</td>
<td>J</td>
<td>MS&lt;LCL</td>
</tr>
<tr>
<td>CHPQ0013B-S0419</td>
<td>SW8270D SIM</td>
<td>1,4-DIOXANE</td>
<td>0.2</td>
<td>UJ</td>
<td>TEMP&gt;6C</td>
</tr>
<tr>
<td>CHPQ02002-S0419</td>
<td>SW8270D SIM</td>
<td>1,4-DIOXANE</td>
<td>0.2</td>
<td>UJ</td>
<td>TEMP&gt;6C</td>
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<td>Matrix Lab Centrifuge</td>
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<td>Matrix Lab Centrifuge</td>
</tr>
</tbody>
</table>

*Field samples and field duplicates only.

Key:
- LB<RL = the method blank had a detection less than the LOQ
- MS<LCL = Matrix spike recovery less than lower limit
- Matrix Lab Centrifuge = sample was centrifuged during sample preparation to address sediment in the sample
- Temp>6C = shipping cooler temperature out of control
- J = estimated detection
- U = nondetected result after validation due to blank contamination
- UJ = estimated nondetect
- US = estimated nondetect, screening level data quality
- µg/L = micrograms per liter
APPENDIX C

Supporting Documentation for the Risk Assessment
### Appendix C

Resident Vapor Intrusion Screening Levels (VISL)

Final Supplemental Remedial Investigation Report for 1,4-Dioxane at CS-20, JBCC, MA

| Chemical | CAS Number | Does the chemical meet the definition for volatility? | Does the chemical have inhalation toxicity data? | Is the chemical sufficiently volatile and toxic to pose inhalation risk via vapor intrusion from soil source? | Target Subslab and near-source soil gas concentration (TCR=1E-06 or THQ=1) | Target Groundwater Concentration (MCL?) | Pure Phase Vapor Concentration (µg/m³) | Maximum Groundwater Vapor Concentration (µg/m³) | Temperature for Maximum Groundwater Vapor Concentration (°C) | Lower Explosive Limit LEL (%) | IUR Ref. | IUR Ref. (µg/m³) | RfC Ref. | RfC Ref. (µg/m³) | Mutagenic Indicator | Carcinogenic VISL TCR=1E-06 Cgw (µg/L) | Noncarcinogenic VISL THQ=1 Cgw (µg/L) |
|----------|------------|-----------------------------------------------------|-----------------------------------------------|-------------------------------------------------|------------------------------------------------------------------------------|------------------------------------------|-----------------------------------------|-------------------------------------------------|-------------------------------------------------|-------------------------------|-----------|----------------|---------|----------------|----------------|----------------------|---------------------|---------------------|
| Dioxane, 1,4- | 123-91-1 | Yes | Yes | Yes | Yes | 0.562 | CA | 18.7 | 3000 | -- | 180000000 | 193200000 | 20 | 3 | CRC89 | 0.000005 | I | 0.03 | I | No | 0.562 | 31.3 |

Key:

°C = degrees Celsius

CA = California Environmental Protection Agency/Office of Environmental Health Hazard Assessment assessments. Available online at: [http://www.oehha.ca.gov/ChemiDB/index.asp](http://www.oehha.ca.gov/ChemiDB/index.asp)

CAS = Chemical abstract service number

HLC = Henry's Law Constant


IUR = inhalation unit risk

JBCC = Joint Base Cape Cod

LEL = lower explosive limit

MCL = Maximum Contaminant Level

NLH = national

PPTV = Provisional Peer-Reviewed Toxicity Value. Available online at: [http://www.epa.gov/nln/ntrl/index.html](http://www.epa.gov/nln/ntrl/index.html)

RfC = reference concentration

RI = Remedial Investigation

TCR = target concentration

THQ = target hazard quotient for non-carcinogens

VISL = Vapor Intrusion Screening Level

VP = vapor pressure

µg/L = microgram per liter

µg/m³ = microgram per cubic meter