National Aeronautics and
Space Administration

Ames Research Center
Moffett Field, CA 94035-1000

September 18, 2025

Reply to Attn of: JQ: 213-7

Ms. Yvonne Fong (*pdf via email*)
Moffett Field Project Manager
U.S. Environmental Protection Agency Region 9
75 Hawthorne Street (SFD-8-3)
San Francisco, CA 94105

Ms. Mary Snow, P.E. (*pdf via email*)
Moffett Field Project Manager
San Francisco Bay Regional Water Quality Control Board
1515 Clay Street, 14th Floor
Oakland, CA 94612

SUBJECT: NASA Ames Research Center
Final Five-Year Review Report
Installation Restoration (IR) Sites 1, 22, 26, NASA Regional Groundwater Remediation Program, NASA Vapor Intrusion Area of Responsibility, and NASA Land Use Controls

Dear Ms. Fong and Ms. Snow:

NASA Ames is pleased to submit the referenced report for your review. The changes in the document are in response to your comments received on October 16, 2024, December 30, 2024, January 7, 2025, March 17, 2025, and April 29, 2025. The document has been signed by the Acting Chief of the Environmental Management Division.

Please contact me at 650-604-1406 or garrett.michael.turner@nasa.gov with any questions.

Sincerely,

Garrett Michael
Turner
Digitally signed by Garrett Michael Turner
Date: 2025.09.18 15:17:24 -07'00'

Garrett Michael Turner, P.E.
Restoration Project Manager
Environmental Management Division

Enclosure

cc: (electronically)
L. Jones, US EPA
A. Lee, US EPA
D. Darrow, US Navy
213-7\B. Moody
202A-4\D. Hymer
T20G-4\B. Reddig

FINAL FIVE-YEAR REVIEW REPORT

INSTALLATION RESTORATION SITES 1, 22, 26, NASA REGIONAL GROUNDWATER REMEDIATION PROGRAM, NASA VAPOR INTRUSION AREA OF RESPONSIBILITY, AND NASA LAND USE CONTROLS

NASA AMES RESEARCH CENTER,

MOFFETT FIELD, CALIFORNIA

August 2025

Prepared for:

National Aeronautics and Space Administration
Ames Research Center
Moffett Field, CA

Prepared Under:

Contract GS00Q14OADS144
Task Order 80ARC020F0036

Prepared by:

BB&E
NASA Ames Research Center
Moffett Field, California 94035-1000

National Aeronautics and Space Administration

ENVIRONMENTAL SUPPORT SERVICES CONTRACT GS00Q14OADS144

FINAL FIVE-YEAR REVIEW REPORT

INSTALLATION RESTORATION SITES 1, 22, 26, NASA REGIONAL GROUNDWATER REMEDIATION PROGRAM, NASA VAPOR INTRUSION AREA OF RESPONSIBILITY, AND NASA LAND USE CONTROLS

CDRL 14-001

Prepared for:
Environmental Management Division
NASA Ames Research Center
M/S 213-7
Building N213, Room 109C
Moffett Field, CA 94035-0001

AUGUST 2025

BB&E
CONSULTING ENGINEERS
& PROFESSIONALS

Final Five-Year Review Report
Naval Air Station Moffett Field Superfund Site
Installation Restoration (IR)
Sites 1, 22, 26, NASA Regional Groundwater Remediation Program (RGRP), NASA Vapor Intrusion (VI) Area of Responsibility (AOR), and NASA Land Use Controls (LUCs)

Prepared by
NASA Ames Research Center

Bridget Moody Digitally signed by Bridget Moody
Date: 2025.09.18 14:34:45 -07'00'

REVIEW AND APPROVAL

Bridget D. Moody
Acting Chief, Environmental Management Division

EXECUTIVE SUMMARY

The National Aeronautics and Space Administration (NASA) has conducted this Five-Year Review (FYR) for Sites 1, 22, 26, NASA Regional Groundwater Remediation Program (RGRP; comprised of the former Navy Site 28/West-Side Aquifers Treatment System [WATS] and NASA Groundwater Area of Responsibility [AOR]/Groundwater Treatment System [GWTS]), NASA Vapor Intrusion (VI) AOR, and NASA Land Use Controls (LUCs) located at NASA Ames Research Center (NASA Ames), near Mountain View, California, as required by the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Section (§)121(c), as amended, and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) Part 300.430(f)(4)(ii) of the Code of Federal Regulations (CFR). The report has been prepared in accordance with the United States Environmental Protection Agency (EPA) Comprehensive Five-Year Review Guidance (EPA, 2001).

The purpose of this FYR is to evaluate the implementation and performance of the selected remedies at Sites 1, 22, 26, NASA RGRP, NASA VI AOR, and NASA LUCs, including evaluating whether the selected remedies remain or will be protective of human health and the environment. This FYR is required for Sites 1 and 22 because hazardous substances, pollutants, or contaminants remain at the sites above levels that allow for unlimited use and unrestricted exposure, and their Records of Decision (RODs) were signed after October 17, 1986 (the effective date of the Superfund Amendments and Reauthorization Act [SARA]). This FYR is an EPA statutory review as hazardous substances, pollutants, or contaminants remain at the sites above levels that allow for unlimited use and unrestricted exposure and achieving the remedial action objectives (RAOs) and remediation goals (RGs) will take longer than five years. **Table ES-1** (below) correlates and summarizes sites and areas that have transitioned from the Navy to NASA that are addressed in this FYR.

This is the fifth FYR for Sites 22, and 26, and the sixth FYR for Site 1. This is the first FYR for NASA RGRP, NASA VI AOR, and NASA LUCs; and the first time Sites 1, 22, and 26 with NASA RGRP, NASA VI AOR, and NASA LUCs have been combined and reported by NASA per the Memorandum of Understanding that conveyed responsibility of operations and maintenance (O&M) and long-term monitoring (LTM) from the Navy to NASA on October 1, 2016. The EPA has directed NASA that the review period for this FYR is from 2019 to 2023.

This review included a document and data review, site inspections, personnel interviews, and regulatory agency comments. The methods, findings, conclusions, and recommendations identified during the review are presented in this report.

Table ES-1

Summary of 2019-2023 NASA FYR (Site 1, Site 22, Site 26, NASA RGRP, NASA VI AOR, and NASA LUCs)

FYR Site	CERCLA Operable Unit (OU)	Regulatory Driver	Date of NASA Responsibility
Site 1	OU 1, Installation Restoration (IR) Site 1	OU1 Record of Decision (ROD); 1997	NASA assumed Site 1 operations and maintenance, monitoring, and reporting (OMMR) responsibilities from the Navy on October 1, 2016. *Note: The IR Site 2 landfill was excavated in 1997, and approximately 23,000 cubic yards of refuse were transferred to the IR Site 1 landfill and consolidated with the IR Site 1 landfill contents. Three years of post-excavation monitoring showed that groundwater had not been adversely affected by these activities at IR Site 2, and groundwater monitoring was discontinued with concurrence from EPA and the State of California Regional Water Quality Control Board, San Francisco Bay Region (Water Board). No further action is required at the IR Site 2 former landfill.*
Site 22	NA, IR Site 22	Site 22 ROD, 2002	NASA assumed Site 22 OMMR responsibilities from the Navy on October 1, 2016.
Site 26	OU5, IR Site 26	OU5 ROD, 1996 Site 26 ROD Amendment, 2014	NASA assumed Site 26 OMMR responsibilities from the Navy on October 1, 2021.
NASA RGRP	OU4, IR Site 28	MEW ROD, 1989 MEW ROD Explanation of Significant Difference (ESD), 1990 MEW ROD ESD, 1996 Navy Federal Facility Agreement (FFA),1989 Navy FFA Amendment, 1993 MEW ROD Amendment, 2010	NASA assumed Site 28/WATS OMMR responsibilities from the Navy on October 1, 2016. NASA became responsible for the NASA Groundwater AOR upon signing the Allocation & Settlement Agreement in 1998. The execution of the FFA on November 14, 2014, formalized NASA responsibility of achieving RAOs for RGRP.

FYR Site	CERCLA Operable Unit (OU)	Regulatory Driver	Date of NASA Responsibility
	NA, NASA Groundwater AOR	MEW ROD, 1989 Allocation & Settlement Agreement, 1998 NASA FFA, 2014	NASA has been reporting on the NASA RGRP (combined NASA Groundwater AOR and Site 28) since 2017.
NASA VI AOR	NA, VI Study Area	VI Amendment to MEW ROD, 2010 NASA FFA, 2014	August 16, 2010, MEW ROD Amendment address VI risk and abatement not addressed in 1989 ROD.
LUCs	NA, Site 1, Site 14 South*, Site 22, Site 26, Site 28/WATS Area, Site 29 (Hangar 1, Former Naval Air Station (NAS) Moffett Field Area of MEW Regional Plume, and Former NAS Moffett Field Area of MEW Regional Plume VI Study Area	NASA FFA, 2014 Final OU1 ROD, 1997 NFA for USTs 19 and 20, Site 14 South, 2022 Final Site 22 ROD, 2002 Site 26 ROD Amendment, 2014 Site 26 Memo to File for Non-Significant Modification to Final ROD Amendment 2021 Final LTM Plan for NTCRA for PCB Contamination at IR 29 (Hangar 1) MEW ROD, 1989 VI Amendment to MEW ROD, 2010	November 14, 2014, FFA formalized NASA's obligation to implement LUCs to ensure the protectiveness of both NASA response actions and CERCLA response actions conducted by the Navy and the MEW potentially responsible parties (PRPs) on NASA Ames.

**Site 14 South is not a CERCLA site. It is a petroleum-impacted site overseen by the California Regional Water Board.*

Summary Forms

The following EPA Five-Year Review Summary Form provides additional information on the review assessment results and the future effectiveness of the remedies implemented at Sites 1, 22, 26, NASA RGRP, NASA VI AOR, and NASA LUCs.

SUMMARY FORM
FIVE-YEAR REVIEW
NASA AMES RESEARCH CENTER, MOFFETT FIELD, CALIFORNIA

SITE IDENTIFICATION		
Site name: Sites 1, 22, 26, NASA RGRP, NASA VI AOR, and NASA LUCs		
U.S. EPA ID: CA2170090078		
Site areas addressed in this FYR: Sites 1, 22, 26, NASA RGRP, NASA VI AOR, and NASA LUCs		
Region: 9	**State:** CA	**City / County:** Moffett Field / Santa Clara County
SITE STATUS		
NPL status: ☒ Final ☐Deleted ☐Other (specify)		
Remediation status (choose all that apply): ☐Under Construction ☒Operating (Biostimulation/bioaugmentation, MNA, and ICs) ☐Complete System Off		
Multiple OUs? ☒YES ☐NO	**Construction completion date:** Site 1, 11/16/1998; Site 22, 8/3/2003; Site 26, 1/26/1999. *Note: While construction for specific sites/OUs has been completed, the overall Site-wide (fence-to-fence) construction was not completed during this review period.*	
Has the site(s) been put into reuse? ☒YES (Site 22 underlies the putting greens and fairways of holes 6 and 7 of The Golf Club at Moffett Field, which is operated by a lessee to NASA Ames Research Center at Moffett Field.) ☒NO (Sites 1, 26, NASA RGRP, and NASA VI AOR)		
REVIEW STATUS		
Lead agency: ☐U.S. EPA ☐State ☐Tribe ☒Other Federal Agency (NASA)		
Author name: Garrett Michael Turner, P.E.		
Author title: Restoration Program Manager	**Author affiliation:** Environmental Management Division, NASA Ames Research Center	
Review period: 11/16/2023 to 02/12/2025		
Date(s) of inspection: Site 1, 02/07/2024; Site 22, 02/07/2024; Site 26, 03/27/2024; NASA RGRP, 02/08/2024; NASA VI AOR, 01/24/2024; and NASA LUCs, Q1 2024 and ongoing.		
Type of review: ☐Post-SARA ☐NPL Removal Only ☐Pre-SARA ☐NPL State/Tribe-lead ☒ NPL-Remedial Action Site ☐Regional Discretion		
Review number: ☒1 (first) NASA RGRP, NASA VI AOR, and NASA LUCs ☐2 (second) ☐3 (third) ☒ Other (specify): fifth (Sites 22 and 26) and sixth (Site 1)		

REVIEW STATUS – CONTINUED
Triggering Action ☐Actual RA On-site Construction at OU# ___________________ ☐Actual RA Start at OU# ___________________ ☐Construction Completion ___________________ ☐Previous FYR Report ☒Other *(specify)* EPA Concurrence Letter dated 8/7/2020 stating that next FYR trigger due date would be 2/12/2025.
Triggering action dates: Site 1 – 2/12/2020; Site 22 and Site 26 – 02/12/2020; NASA RGRP, NASA VI AOR, and NASA LUCs – 2/12/2020
Due date *(five years after triggering action date)*: 2/12/2025

Issues:

PFAS detected in the groundwater samples collected at Sites 1 (and 2), 22, 26, 28, and NASA RGRP at varying concentrations during the 2023 PFAS SI.

Site 1

PFAS detected in the groundwater samples collected at Sites 1 and 2 at varying concentrations during the 2023 PFAS SI.

Site 22

PFAS detected in the groundwater samples collected at Site 22 at varying concentrations during the 2023 PFAS SI.

Site 26

PFAS detected in the groundwater samples collected at Site 26 at varying concentrations during the 2023 PFAS SI.

NASA RGRP and VI AOR

PFAS detected in the groundwater samples collected within this area at varying concentrations during the 2023 PFAS SI.

NASA GWTS and WATS effluent should be monitored and the data evaluated to determine if any discharges of PFAS-impacted effluent are occurring and redistributing PFAS.

To ensure long-term protectiveness of each remedy, the following recommendations and follow-up actions listed below must be taken:

Site 1

To ensure long-term protectiveness, additional sampling for PFAS (per- and polyfluoroalkyl substances) should be performed to further assess potential risk is needed.

Site 22

To ensure long-term protectiveness, additional sampling for PFAS (per- and polyfluoroalkyl substances) should be performed to further assess potential risk is needed.

Site 26

To ensure long-term protectiveness, additional sampling for PFAS (per- and polyfluoroalkyl substances) should be performed to further assess potential risk is needed.

NASA RGRP and VI AOR

To ensure long-term protectiveness, additional sampling for PFAS (per- and polyfluoroalkyl substances) should be performed to further assess potential risk is needed.

NASA GWTS and WATS groundwater extraction systems' effluent should be monitored, and the data evaluated to determine if any discharges of PFAS-impacted effluent are occurring and redistributing PFAS.

Protectiveness Statements:

Site 1

The remedy for Site 1 is currently protective of human health and the environment because potential exposure pathways are incomplete, groundwater contaminant concentrations are stable, pumping from Building 191 continues to maintain the preferred groundwater flow direction, landfill gas is not migrating from the landfill, and the landfill cap is functioning as intended. To ensure long-term protectiveness, additional sampling for PFAS (per- and polyfluoroalkyl substances) should be performed to further assess potential risk is needed.

Site 22

The remedy for Site 22 is currently protective of human health and the environment because potential exposure pathways are incomplete, groundwater contaminant concentrations do not indicate any leaching or releases from the landfill, pumping from Building 191 continues to maintain the preferred groundwater flow direction, landfill gas is not migrating from the landfill, and the biotic barrier is functioning as intended. To ensure long-term protectiveness, additional sampling for PFAS (per- and polyfluoroalkyl substances should be performed to further assess potential risk is needed.

Site 26

The remedy for Site 26 is currently protective of human health and the environment because groundwater contaminant plumes are stable or decreasing, and land use controls are in place to prevent access to contaminated groundwater and minimize future potential vapor intrusion risk. To ensure long-term protectiveness, additional sampling for PFAS (per- and polyfluoroalkyl substances) should be performed to further assess potential risk is needed.

NASA RGRP and VI AOR

The groundwater remedy for the NASA RGRP and the vapor intrusion remedy for the NASA VI AOR are protective of human health and the environment because there is no direct exposure to contamination. Governmental controls are in place to prevent access to contaminated groundwater. The vapor intrusion control systems, monitoring program, and institutional controls are in place to minimize exposure risk from vapor intrusion. To ensure long-term protectiveness, additional sampling for PFAS (per- and polyfluoroalkyl substances) should be performed to further assess potential risk is needed. Additionally, for the remedy to be protective in the long-term, alternative groundwater cleanup technologies should be selected to accelerate the reduction of the source of vapor intrusion.

Regional Water Board Position

The Regional Water Board’s position on the protectiveness determination of the remedy at Site 1, Site 22, Site 26, NASA RGRP, and NASA VI AOR is “Deferred Protectiveness” with respect to PFAS in soil and groundwater. However, NASA’s position is that a Short-term Protective determination is applicable because there is no known risk from PFAS contamination in soil. Additionally, ICs are in place to prevent access to contaminated groundwater. Based on the findings documented in the PFAS SI Report, further investigation of PFAS is needed to further assess potential risk and to ensure long-term protectiveness.

Other Findings:

Site 1

Burrowing mammal management is and will continue to be a critical O&M issue at Site 1 and the current level of management is not indefinitely sustainable or cost-effective.

The use of certain dissolved metals as monitoring parameters (MPs)/chemicals of concern (COCs), that occur naturally at elevated levels, has required additional and extraneous sampling and reporting activities.

Optimization of groundwater sampling at Site 1 should be consistent with other NASA Ames sites for cost savings. MEW Parties and NASA have recently adopted the HydraSleeve™ sampling method for the NASA RGRP, Site 26, and MEW PRP wells. Site 1 should be evaluated for adopting the HydraSleeve™ sampling method as soon as practicable.

Site 22

Optimization of groundwater sampling at Site 1 should be consistent with other NASA Ames sites for cost savings. MEW Parties and NASA have recently adopted the HydraSleeve™ sampling method for the NASA RGRP, Site 26, and MEW PRP wells. Site 1 should be evaluated for adopting the HydraSleeve™ sampling method as soon as practicable.

Site 26

Annual LTM performed by NASA (2021-2023) following the Navy's 2019 EAB/ISCR implementation indicates that minimal matrix diffusion is occurring with sufficient source zone reduction. This allows MNA to be an appropriate long-term remedy such that biennial sampling would be sufficient. MNA data should be reviewed to transition from LTM of comprehensive well network to using select, optimized wells for annual LTM or, if substantiated, biennial LTM.

NASA RGRP and VI AOR

Reduction of dissolved COCs has yielded lower mass removal rates at some locations and reduced cost effectiveness.

Continued mass removal optimization through maximizing groundwater extraction for each extraction system at high-concentration locations should be pursued.

The current site conceptual model for the RGRP is incomplete and should be updated.

More frequent well redevelopment and conveyance line flushing will be required in future years to sustain design efficiency.

The lack of cleanouts in both system's conveyance piping limits the reach and effectiveness of maintenance activities (conveyance line flushing, etc.).

Tier 3A buildings are currently sampled for VI COCs annually as a NASA standard of practice for demonstrative remedy implementation and protectiveness. The EPA requires NASA to sample for VI COCs biennially. NASA should evaluate historical data, building/structure occupancy, and VI sample locations to identify which buildings/structures should be VI sampled annually versus biennially.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

Acronyms and Abbreviations

µg/L	micrograms per liter
1,1-DCA	1,1-dichloroethane
1,1-DCE	1,1-dichloroethene
1,1,1-TCA	1,1,1-trichloroethane
1,2-DCA	1,2-dichloroethane
1,2-DCB	1,2-dichlorobenzene
1,2-DCE	1,2-dichloroethene
ACC	ACC Environmental Consultants
AMEC	AMEC Environment and Infrastructure, Inc.
AOPC	Areas of Potential Concern
AOR	Area of Responsibility
APTIM	Aptim Federal Services, LLC (formerly CB&I)
ARAR	Applicable or Relevant and Appropriate Requirement
ARC	Ames Research Center
Army	United States Department of the Army
ART	Adapting to Rising Tides Program
AST	aboveground storage tank
AWQC	ambient water quality criteria
Basin Plan	San Francisco Bay Water Quality Control Plan
BB&E	BB&E, Inc.
BCDC	San Francisco Bay Conservation and Development Commission
bgs	below ground surface
CAMU	Corrective Action Management Unit
CB&I	CB&I Federal Services, LLC (now APTIM)
CCL	calculated concentration limit
CCSF	City and County of San Francisco
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
cis-1,2-DCE	cis-1,2-dichlorethene
COC	chemical of concern
COPC	chemical of potential concern
CPC	Capital Planning Committee
cVOC	chlorinated volatile organic compound
CY	cubic yards
DCE	dichloroethylene
DC&E	Design, Community & Environment (now PlaceWorks, Inc.)
DEH	Department of Environmental Health
DHC	*Dehalococcoides*

Acronyms and Abbreviations

EAB	enhanced anaerobic bioremediation
EATS	East-Side Aquifer Treatment System
EC	Engineering Control
EHC®	A proprietary substrate consisting of plant material and zero-valent iron
EKI	EKI Environment & Water, Inc. (formerly Erler & Kalinowski, Inc.)
EPA	United States Environmental Protection Agency
ERA	ecological risk assessment
ERD	Environmental Resources Document
ERT	Earth Resources Technology, Inc.
ESA	Earth Sciences Associates, Inc.
ESD	Explanation of Significant Difference
ESI	Expanded PFAS Site Inspection
EVO	emulsified vegetable oil
FFA	Federal Facility Agreement
FFS	Focused Feasibility Study
FS	Feasibility Study
ft/ft	feet per foot
FWEC	Foster Wheeler Environmental Corporation, Inc.
FYR	Five Year Review
GAC	granular activated carbon
GIS	Geographic Information System
gpm	gallons per minute
GWTS	groundwater treatment system
HHRA	human health risk assessment
HVAC	heating, ventilation, and air conditioning
IC	institutional control
IMP	Implementation and Monitoring Plan
IR	Installation Restoration
ISCR	in-situ chemical reduction
ITC	International Technology Corporation
JMM	James M. Montgomery, Consulting Engineers, Inc.
KEMRON	KEMRON Environmental Services, Inc.
LDS	Leisnoi Diversified Services, LLC
LTM	long-term monitoring
LTMP	Long-Term Management Plan
LUC	land use control
MCL	maximum contaminant level

Acronyms and Abbreviations

MEW	Middlefield-Ellis-Whisman
MFA	Moffett Federal Airfield
mg/L	milligrams per liter
mm	millimeters
MNA	monitored natural attenuation
Moffett Field	Former Naval Air Station Moffett Field
MP	monitoring parameter
msl	mean sea level
MTC	Metropolitan Transportation Commission
NAS	Naval Air Station
NASA	National Aeronautics and Space Administration
NASA Ames	NASA Ames Research Center
Navy	Department of the Navy
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NEESA	Naval Energy and Environmental Support Activity
NFA	no further action
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NRC	National Resource Council
NRP	NASA Research Park
NTCRA	Non-Time-Critical Removal Action
O&M	operations and maintenance
OMMR	operations and maintenance, monitoring, and reporting
OTIE	Oneida Total Integrated Enterprises
OU	Operable Unit
PCB	polychlorinated biphenyl
PCE	tetrachloroethene
POC	point of compliance
PP	Proposed Plan
ppb	parts per billion
PRC	PRC Environmental Management, Inc.
PRP	primary responsible party
PV	Planetary Ventures, Inc.
RA	remedial action
RAO	Remedial Action Objective
RD	remedial design
REC	Record of Environmental Consideration
RG	Remediation Goal

Acronyms and Abbreviations

RGRP	Regional Groundwater Remediation Program
RI	Remedial Investigation
ROD	Record of Decision
SARA	Superfund Amendments and Reauthorization Act
SCVWD	Santa Clara Valley Water District
SES-Tech	SES-Tech Remediation Services
SOW	Statement of Work
SVOC	semi-volatile organic compound
SWRCB	State Water Resources Control Board
SWRP	Storm Water Retention Pond
TBC	to be considered
TCE	trichloroethene
TDS	total dissolved solid
TIA	Traffic Island Area
trans-1,2-DCE	trans-1,2-dichloroethene
TtEC	Tetra Tech EC, Inc.
TtEMI	Tetra Tech EM, Inc.
TtFW	Tetra Tech FW, Inc.
USACE	United States Army Corps of Engineers
USFWS	United States Fish and Wildlife Service
UST	underground storage tank
VC	vinyl chloride
VI	vapor intrusion
VOC	volatile organic compound
Water Board	California Regional Water Quality Control Board, San Francisco Bay Region
WATS	West-Side Aquifers Treatment System

1 INTRODUCTION

On behalf of the National Aeronautics and Space Administration (NASA) Ames Research Center (NASA Ames), BB&E, Inc. (BB&E) has conducted a Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Five Year Review (FYR) for Installation Restoration (IR) Sites 1, 22, 26, NASA Regional Groundwater Remediation Program (RGRP; comprised of former Department of the Navy [Navy] Site 28/ West-Side Aquifers Treatment System [WATS] and NASA Groundwater Area of Responsibility [AOR]/groundwater treatment system [GWTS]), NASA Vapor Intrusion (VI) AOR, and NASA Land Use Controls (LUCs) at NASA Ames (including the former NAS Moffett Field), near Mountain View, California. The report has been prepared in accordance with the following guidance documents:

- United States Environmental Protection Agency (EPA) *Comprehensive Five-Year Review Guidance* (EPA, 2001),
- EPA *Recommended Evaluation of Institutional Controls: Supplement to Comprehensive Five-Year Review Guidance* (EPA, 2011),
- EPA *Clarifying the Use of Protectiveness Determinations for Comprehensive Environmental Response, Compensation, and Liability Act Five-Year Reviews* (EPA, 2012), and
- EPA *Five-Year Review Recommended Template* (EPA, 2016).

1.1 Purpose

The purpose of this FYR is to evaluate whether the implementation and performance of the remedy for NASA's sites and areas of responsibility are currently and will continue to be protective of human health and the environment and assess the progress of the recommendations made since the last FYR. The methods, findings, and conclusions identified during the review are presented in this FYR report. The report also identifies issues found during this FYR and offers recommendations to address them. The review is not intended to reconsider decisions made during selection of the remedies, but rather to evaluate implementation and performance of the selected remedies only.

1.2 Five-Year Review Authority

NASA is authorized to conduct the FYR for Sites 1, 22, 26, NASA RGRP, NASA VI AOR, and NASA LUCs in accordance with CERCLA Section (§) 121 and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP).

The NCP in Title 40 Code of Federal Regulations (CFR) § 300.430(f)(4)(ii) states:

> *If a remedial action is selected that results in hazardous substances, pollutants, or contaminants remaining at the site above levels that allow for unlimited use and unrestricted exposure, the lead agency shall review such action no less often than every five years after the initiation of the selected remedial action.*

This FYR for Site 1, 22, 26, NASA RGRP, NASA VI AOR, and NASA LUCs summarizes the work conducted by NASA in collaboration with regulatory agencies, including the EPA, California Regional Water Quality Control Board, San Francisco Bay Region

(Water Board), and NASA Ames tenants. The trigger action for this FYR is the EPA Concurrence Letter dated 8/7/2020 stating that the next FYR trigger due date would be 2/12/2025.

1.3 Five-Year Review Approach

This is the sixth FYR for Site 1, the fifth FYR for Sites 22 and 26, and the first FYR for NASA RGRP, NASA VI AOR, and NASA LUCs. A statutory FYR is required for Sites 1, 22, and 26 because: 1) ongoing and completed RAs will leave contaminants in place above concentrations that allow unlimited use and unrestricted exposure of the land, and 2) the Records of Decision (RODs) were signed on or after October 17, 1986 (the effective date of the SARA).

This FYR includes all sites within the CERCLA process where a RA has been taken or is underway. **Table 1-1** summarizes the CERCLA status of Sites 1, 22, 26, NASA RGRP, NASA VI AOR, and NASA LUCs within the CERCLA process at the former NAS Moffett Field.

Table 1-1

FYR CERCLA Status of NASA Sites and Areas of Responsibility

CERCLA Operable Unit (OU)	Site Number	Site Name	FYR Status
1	1	Runway Landfill	Transferred from the Navy to NASA in 2016. Sixth FYR (this review). Annual reporting and operations and maintenance (O&M) by NASA are ongoing. *Note: The IR Site 2 landfill was excavated in 1997, and approximately 23,000 cubic yards of refuse were transferred to the IR Site 1 landfill and consolidated with the IR Site 1 landfill contents. Three years of post-excavation monitoring showed that groundwater had not been adversely affected by these activities at IR Site 2, and groundwater monitoring was discontinued with concurrence from EPA and the State of California Regional Water Quality Control Board, San Francisco Bay Region (Water Board). No further action is required at the IR Site 2 former landfill.*

CERCLA Operable Unit (OU)	Site Number	Site Name	FYR Status
N/A	22	Site 22 Landfill	Transferred from the Navy to NASA in 2016. Fifth FYR in August 2020. Annual reporting and O&M are ongoing by NASA.
5	26	Site 26 Southern Plume	Transferred from the Navy to NASA in 2021. Fifth FYR in August 2020. The East-Side Aquifer Treatment System (EATS) has been offline since July 2003. Navy completed a Focused Feasibility Study (FFS) and Proposed Plan (PP) evaluating alternative effective treatments. The ROD Amendment was signed by the Agencies on September 30, 2014, removing groundwater extraction and treatment as a remedy, and replacing the remedy with biostimulation/bioaugmentation, monitored natural attenuation (MNA), and ICs. Biostimulation/bioaugmentation implementation was completed in 2019. Annual reporting and O&M are ongoing by NASA.
N/A	Commingled groundwater plume within the central portion of NASA Ames	NASA RGRP	First FYR (this review). The commingled groundwater plume on NASA Ames is part of the Middlefield-Ellis-Whisman (MEW) Regional Plume, which is being remediated pursuant to the 1989 MEW ROD issued by the EPA and two subsequent Explanations of Significant Difference (ESDs). The NASA RGRP area consists of the Site 28/WATS and NASA Groundwater AOR/GWTS.
N/A	VI Study Area	NASA VI AOR	First FYR (this review). NASA performs site inspections, indoor air quality testing, and reporting. and is responsible for maintaining LUCs and/or implementing them with new construction through NASA reviewed and approved construction permits.

CERCLA Operable Unit (OU)	Site Number	Site Name	FYR Status
N/A	1, 14 South*, 22, 26, 29 (Hangar 1), NASA RGRP, and NASA VI AOR	NASA LUCs	First FYR (this review). Annual groundwater monitoring and reporting is ongoing by NASA. NASA performs site inspections and tenants are responsible for maintaining LUCs and/or implementing them with new construction through NASA reviewed and approved construction permits.

**Site 14 South is not a CERCLA site. It is a petroleum-impacted site overseen by the California Regional Water Board.*

1.4 Consideration and Planning for Climate Change

NASA FYR sites should consider potential impacts from projected sea level rise and other anticipated impacts from climate change. Planning for these potential impacts may consider costs associated with stabilization and maintenance, rebuilding/replacement, and relocation (NRC, 1987). As of this FYR, the regional relative sea level trend in San Francisco Bay, California ranges from 0.051 inches/year (in/yr) to 0.078 in/yr ±0.0067 in/yr at a 95% confidence interval (CI) based on monthly mean sea level data collected from 1897 to 2023 (NOAA, 2023). Models based on current projections of global sea level rise indicate that the San Francisco Bay Area is anticipated to experience approximately 6 to 10 inches of localized sea level rise by 2030 and upwards of 13 to 23 inches of sea level rise by 2050 (BCDC ART, 2020). There are regular seasonal fluctuations from coastal ocean temperatures, salinity, wind, atmospheric pressure, and ocean currents (e.g., astronomical influences, atmospheric rivers, storm surges/winter storms, King Tides, large-scale climate cycles such as El Niño Southern Oscillation, etc.). Current sea level rise in the San Francisco Bay Area has caused an increase in the severity and frequency of major flooding events.

Other than tsunamis, tides and ocean swells will have the largest influence on coastal water levels at the local and regional scale (Sweet et al., 2022; CPC, 2020). The water levels in the San Francisco Bay are highly dynamic and have a daily tidal range of approximately 6 feet (USACE, 2024). Consequential impacts of sea level rise will include inundation and erosion of coastal beaches and cliffs that accelerates further shoreline recession, in addition to rising groundwater levels, which may cause flooding further inland/away from the immediate coastline. Additional resources that are threatened by sea level rise include transportation infrastructure (e.g., roadways and bridges), electric utility systems and power plants, stormwater systems and wastewater treatment plants and outfalls, groundwater aquifers, and natural features (e.g., wetlands, marshes, and fisheries; Heberger et al., 2012).

Wind-driven waves, typically 3 to 5 feet high, affect coastal water levels on a local scale and based on a peer review of relevant data to the south end of the San Francisco Bay, the dominant local winds blow to the north and high winds influence ocean swells and waves surges are directed into Central Bay and towards the northern bays (e.g., San Pablo). There are generally southeasterly winds from South Bay to Central Bay, and these wind-driven waves migrate from the southeast towards the northwest, away from the proximity of ARC.

Based on the models, the San Francisco Bay Area will be impacted by 12-24" rise in sea level (during 50-year and 100-year King Tide storm surge), with a corresponding ~6-10 ft storm surge flooding depth (BCDC ART, 2020). If sea level rises by 6 inches, a 1% annual exceedance probability (AEP) water level (100-year water level) will become a ~4% AEP water level (about 25-year water level) in the Bay (USACE, 2024; Vandever et al., 2017; CCSF, 2020). If sea levels rise by 24 inches, Bay Area coastal communities could experience multiple flood events, in addition to 90 to 150 days of high tide flooding, each year (Ghanbari et al., 2019; Sidder, 2019).

Twenty years from the end of this FYR period (2043), sea level rise impacts associated with climate change on the ARC may require mitigation for increased resilience to sea level rise and increased storm severity. Mitigation will likely be required for areas and lagoons adjacent to South Bay and proximal (inland) areas to South Bay to accommodate for erosion, flooding, salt/brackish water intrusion, and increased groundwater levels. It is recommended that a sea level rise and flood strategy for the FYR sites be developed and implement deployable flood protection and adaptation measures, as outlined in **Table 1-2**.

Table 1-2

Planning Considerations for Adaptation to Anticipated Sea Level Change

Risk Category	Potential Impacts Posed	Potential Mitigation
Flooding and rising sea levels impact shorelines	• Widespread shoreline erosion and inundation.	Stabilize the shoreline (e.g., beach nourishment, new augmented coastal/levee armoring, bulkheading).
Sea water intrusion on wetlands and marshes	• Loss of wetlands, transformation to open sea water and wave action. • Ecological impacts of decreased freshwater and increased brackish/salt water. • Salinity intrusion into groundwater supplies.	Implement shoreline protection and ecological preservation/restoration to preserve critical ecological systems. Incorporate engineering response to increase salt wedge management by modifying the elevation of the aquifer connections to the estuary to reduce the landward penetration of the salt wedge.

Risk Category	Potential Impacts Posed	Potential Mitigation
Flooding and rising groundwater levels for groundwater and wastewater treatment plants	• Flooding could cause damage to stormwater and groundwater management and treatment systems; may cause untreated discharges from these systems. • Rising sea water levels could interfere/impair with discharge from outfalls/outlet sited on the existing sea levels along the South Bay.	Modify or construct new systems as appropriate. Implement pump systems and/or raise existing horizontal levee systems for wave attenuation and storm buffering, and to consider freeboard on levee system. Increase levee height/armament. Increase pumping and discharge capacity and operating redundancy at Building 191 pumphouse. Modify subgrade sewer infrastructure (e.g., sewers, catch basins, outfalls, etc.). Consider rising groundwater levels and changes in corrosion rates. Sensitivity calculations should be made prior to making the final design selections to consider sea level change during the structure's designed service life.
Transportation and infrastructure	• Sea level rise and wave surges flooding existing infrastructure.	Transportation and infrastructure planners should design projects that incorporate nature-based flood protection into roads, utilities, and other projects in public areas. The levels of highways and railroads may have to be raised incrementally by re-ballasting or adding pavement as required to manage costs.

Table 1-3

Potential Site Mitigation for Adaptation to Anticipated Sea Level Change

Site Number	Site Name	Potential Mitigation
1	Runway Landfill	• Stabilize the shoreline (e.g., beach nourishment, new augmented coastal/levee armoring, bulkheading). • Implement shoreline protection and ecological preservation/restoration to preserve critical ecological systems. • Incorporate engineering response to increase salt wedge management by modifying the elevation of the aquifer connections to the

Site Number	Site Name	Potential Mitigation
		estuary to reduce the landward penetration of the salt wedge. • Construct a horizontal levee system for wave attenuation and storm buffering, and to consider freeboard on levee system. • Increase pumping and discharge capacity and operating redundancy at Building 191 pumphouse. Modify subgrade sewer infrastructure changes in corrosion rates. • Consider additional monitor wells with shallower screen levels to address rising groundwater levels. • Design life calculations should be made prior to final design selections to consider sea level change during the structure’s designed service life.
22	Site 22 Landfill	• Stabilize the shoreline (e.g., beach nourishment, new augmented coastal/levee armoring, bulkheading). • Implement shoreline protection and ecological preservation/restoration to preserve critical ecological systems. • Incorporate engineering response to increase salt wedge management by modifying the elevation of the aquifer connections to the estuary to reduce the landward penetration of the salt wedge. • Construct a horizontal levee system for wave attenuation and storm buffering, and to consider freeboard on levee system. • Consider additional monitor wells with shallower screen levels to address rising groundwater levels. • Design life calculations should be made prior to final design selections to consider sea level change during the structure’s designed service life.
26	Site 26 Southern Plume	• Incorporate engineering response to increase salt wedge management by modifying the elevation of the aquifer connections to the estuary to reduce the landward penetration of the salt wedge.

Site Number	Site Name	Potential Mitigation
		• Construct a horizontal levee system for wave attenuation and storm buffering, and to consider freeboard on levee system. • Consider additional monitor wells with shallower screen levels to address rising groundwater levels. • Design life calculations should be made prior to final design selections to consider sea level change during the structure's designed service life.
Commingled groundwater plume within the central portion of NASA Ames	NASA RGRP	• Incorporate engineering response to increase salt wedge management by modifying the elevation of the aquifer connections to the estuary to reduce the landward penetration of the salt wedge. • Construct a horizontal levee system for wave attenuation and storm buffering, and to consider freeboard on levee system. • Consider additional monitor wells with shallower screen levels to address rising groundwater levels. • Design life calculations should be made prior to final design selections to consider sea level change during the structure's designed service life.
28 and associated buildings within AOR	NASA VI AOR	• Construct a horizontal levee system for wave attenuation and storm buffering, and to consider freeboard on levee system. • Design life calculations should be made prior to final design selections to consider sea level change during the structure's designed service life.
1, 14 South*, 22, 26, 29 (Hangar 1), NASA RGRP, and NASA VI AOR	NASA LUCs	• Update the NASA LUC Implementation and Monitoring Plan based on site mitigation implementation for continued protectiveness.

**Site 14 South is not a CERCLA site. It is a petroleum-impacted site overseen by the California Regional Water Board.*

2 BACKGROUND

This section describes potential threats posed to the public and environment that were identified when the RODs for Sites 1, 22, 26, NASA RGRP, NASA VI AOR, and NASA LUCs were developed. For each site, physical characteristics, land and resource use, and history of contamination are summarized. Because the sites are in the same general vicinity, the sites share the same general physical characteristics and area land uses.

NASA Ames is located near the south end of San Francisco Bay in California, three miles north of downtown Mountain View (**Figure 1**). Part of the current NASA Ames was originally Moffett Field and was established as a military facility in 1931, when the United States government acquired 1,000 acres from the neighboring cities of Sunnyvale and Mountain View. Between 1935 and 1941, the Navy transferred operations of Moffett Field to the War Department under the control of the United States Department of the Army (Army) Air Corps. In 1941, control of the facility was returned to the Navy. Congress initially established Ames on August 9, 1939, as the Ames Aeronautical Laboratory, an element of the National Advisory Committee for Aeronautics (NACA). The Ames Aeronautical Laboratory's initial purpose was to conduct research and develop technology for use by military aircraft manufacturers. Upon the creation of NASA in 1958, NACA and all its laboratories were merged into this new agency. The Ames Aeronautical Laboratory was renamed Ames Research Center and was designated as a NASA field center.

In 1930, in one of the first cooperative regional economic development campaigns, Santa Clara, San Mateo, San Francisco, and Alameda Counties set up a joint program to identify a site for a new Navy base, purchase it, and donate it to the Navy. The counties' goal was to establish a west coast Naval Air Station (NAS). On December 12, 1930, this goal was realized when President Herbert Hoover signed the bill allowing the Navy to accept the site and appropriating $5 million for construction. The base officially opened in 1933. On April 12, 1933, the base was commissioned as NAS Sunnyvale. In 1942, the station was named "Moffett Field" in honor of Rear Admiral William A. Moffett.

In October 1991, Congress and President Bush accepted the recommendations of the Base Closure and Realignment Commission (BRAC) to disestablish NAS Moffett Field. Because the availability of the airfield has become essential to Ames Research Center's (ARC) mission, the BRAC recommended that the site remain a federal property and that the Department of Defense (DOD) negotiate a transfer of responsibility for the airfield to NASA. NAS Moffett Field was closed as a military base on July 1, 1994, and the property was transferred to NASA Ames. It did not include the family housing areas and several related facilities located near Onizuka Air Station, which were retained by the DOD for administration.

The area formerly known as NAS Moffett Field was known for a time as Moffett Federal Airfield (MFA). The former NAS Moffett Field now includes the two planning areas known as the NASA Research Park (NRP) and the Eastside/Airfield as well as the current and former military housing areas at Wescoat Village, Orion Park, and Shenandoah Park that transferred directly to the Air Force and then to the United States Department of the Army (Army). Further, NAS Moffett Field also included several holes in the City of Sunnyvale Golf Course, located to the south across U.S. Highway 101. This land provides a clear zone for the airfield.

NASA Ames is bounded by United States Fish and Wildlife Service (USFWS) property (former salt evaporation ponds) to the north, a Lockheed Martin Aerospace Facility to the east, U.S. Highway 101 and residential areas to the south, and Stevens Creek to the west.

NASA Ames is relatively flat, ranging from two feet below to 36 feet above mean sea level (msl). A sizable portion of NASA Ames is situated on previously submerged land or marshlands that have been backfilled to existing elevations. Wetlands located in the northern portion of NASA Ames are natural surface water. Surface drainage near NASA Ames includes Stevens Creek to the west and Coyote Creek and Guadalupe Slough to the east (Foster Wheeler Environmental Corporation, Inc. [FWEC], 2002).

The San Francisco Bay Water Quality Control Plan (Basin Plan) of 2013 (Water Board, 2013) identifies potential and beneficial uses of groundwater in the region. NASA Ames is located at the northern end of the Santa Clara Basin where beneficial use of groundwater (municipal and domestic, industrial process, industrial service, and agricultural water supply) is listed in the Basin Plan.

Regionally, the Santa Clara Valley contains interbedded alluvial, fluvial, and estuarine deposits to a maximum depth of 1,500 feet (Iwamura, 1980). Locally, these sediments consist of varying combinations of clay, silt, sand, and gravel that represent the interfingering of estuarine and alluvial depositional environments during the late Pleistocene and Holocene epochs. The fluvial sediments were derived from the Santa Cruz highlands west of the basin and deposited on an alluvial plain bounded by alluvial fan deposits to the west and baylands to the northeast (Iwamura, 1980). The heterogeneity of channel and interchannel sediments deposited in the fluvial depositional environment has been evident in subsurface explorations at NASA Ames. These sediments most likely were deposited during the Holocene period when global sea levels rose to their present elevation (Navy, 2002).

This FYR uses NASA/MEW nomenclature (upper and lower portion of the A Aquifer, B Aquifer, and C Aquifer). The A, B, and C Aquifers overlie what has been identified as the Deep Aquifer. The aquifer and aquitard descriptions are based on existing data and lithologic interpretation of soil borings. **Table 2-1** presents the aquifer zones and their approximate depths (BB&E, Inc. [BB&E], 2024). Additional information can be found below in Section 2.4.1.

Table 2-1

Aquifer Zones

Aquifer	Aquifer Zone	Approximate Depth (feet below ground surface [bgs])
A	A/A1 Aquifer Zone (upper portion of A aquifer)	3 to 35
	A2/B1 Aquifer Zone (lower portion of A aquifer)	25 to 70
Aquitard	A/B Aquitard	50 to 90
B	B2 Aquifer Zone (middle portion of B aquifer)	55 to 120
	B2/B3 Aquitard	95 to 135
	B3 Aquifer Zone (lower portion of B aquifer)	95 to 150
Aquitard	B/C Aquitard	130 to 160
C	C Aquifer Zone	150 to 230
Deep	Deep Aquifer Zone	Generally deeper than 225

2.1 Site 1

This section discusses the site characteristics and history of Site 1. Site 2 is discussed in this section because RAs at Site 2 impacted Site 1.

2.1.1 Physical Characteristics

Sites 1 and 2 are in the northern portion of NASA Ames (**Figure 1**). Site 2 is a former landfill; the waste material was removed and transferred to Site 1 as part of remedy implementation. The former Site 2 landfill was closed with no further action (NFA) status in 2003.

Site 1 is in the northernmost portion of NASA Ames and encompasses approximately 12 acres. The closed landfill is flat on the west side with an elevation of approximately seven feet above msl. It is mounded on the eastern side where the elevation is approximately 23 feet above msl at the apex. Two culverts drain surface water from the site toward the south and west.

A silty clay aquitard several feet thick exists below the Site 1 former landfill and above the uppermost aquifer zone. The thickness of this aquitard varies, and it is not known conclusively whether this aquitard is continuous beneath the landfill. The stratigraphy beneath the aquitard consists of silty sand or sand and gravel deposits separated by low-permeability silts and clays. Since the former landfill is relatively isolated from surrounding water bodies by low-permeability barriers, elevated water levels are maintained. Potential for flow from the landfill to the other bodies exists, but actual flow is limited or constrained by these low permeability lithologies (Navy, 1997).

Based on information obtained during the review period and from groundwater gauging data collected in October 2023, depth to groundwater at Site 1 is between approximately 1.74 feet below msl in the northern portion of the landfill to approximately 2.89 feet below msl in the southern portion of the landfill. In general, groundwater in the upper portion of the A aquifer zone beneath the Site 1 former landfill flows north to south; however, the regional gradient is south to north toward San Francisco Bay. The southward gradient at Site 1 is opposite from the regional gradient because of pumping of the storm drainage system associated with Building 191 (located south of Site 1). The pump station influences groundwater gradients because the drainage system that feeds the pump station is below the water table in some areas. Should pumping at Building 191 cease, the northern area of Moffett Federal Airfield, including Site 1, may be prone to flooding (Navy, 1997).

The following remedies were implemented for Site 1:

- Site 1 was capped with a multi-layer cover.
- Groundwater and landfill gas monitoring was performed and continues to be performed at Site 1.
- A subsurface groundwater collection trench was installed along the northern border of the Site 1 to intercept any potential future migration of leachate before it reaches surface water.
- Post-closure maintenance activities were conducted and continue to be conducted at Site 1.
- A passive gas-venting trench was installed along the western boundary of Site 1 to prevent potential off-site and subsurface migration of landfill gases.
- Institutional controls (ICs) were implemented to maintain the integrity of the Site 1 landfill cap and to prevent disturbances or excavation of waste materials.

The components of the remedy have been completed in accordance with the requirements of the ROD. The biotic barrier at Site 1 was completed in 1998. The landfill cap is functioning as designed and continues to prevent human and animal exposure to landfill contaminants.

NASA and the Santa Clara County Department of Environmental Health (DEH) conduct site visits and perform quarterly inspections at Site 1 as part of the institutional control (IC) implementation measure. To meet the EPA annual reporting requirement, NASA provides annual reports that detail the effectiveness of IC monitoring and implementation. IC implementation at the Site 1 landfill has been completed because LUCs for this site have been incorporated into the construction permitting process and lease provisions. These requirements also have been incorporated into NASA's Environmental Resources Document (ERD; NASA, 2015).

2.1.2 Land and Resource Use

Land use at Site 1 is specified in the NASA-prepared *Moffett Field Comprehensive Use Plan* (NASA, 1994). The plan states that the primary uses for this area are an airfield clearance zone and open space with limited access and preserved in its natural state because of safety interests. Future land use for Site 1 was not provided in NASA's 2002 *NASA Ames Development Plan, Final Programmatic Environmental Impact Statement (EIS)* (Design, Community & Environment [DC&E], 2002). No plans currently exist for this property to change ownership. The nearest residential area is located more than 1.5 miles to the south-southwest (upgradient). The Water Board defines the criteria for drinking water sources as groundwater with total dissolved solids (TDS) lower than 3,000 milligrams per liter (mg/L) and can support a pumping yield of at least 200 gallons per day (California State Water Resources Control Board [SWRCB], 2006). Groundwater at Site 1 is not currently used as a drinking water supply, and it is not expected to be a drinking water supply in the future because of the following factors: it does not meet state drinking water standards, saltwater intrusion, and subsidence that has occurred from groundwater pumping in the past. No drinking water or production wells are in the area. None of the beneficial uses of groundwater (municipal or domestic, industrial process, industrial, and agricultural water supply) are identified in the Basin Plan of 2013 (Water Board, 2013) as an existing use at Site 1.

2.1.3 History of Contamination

Site 1 was operated as a landfill from the mid-1960s until the late 1970s and subsequently used as a pistol range. Detailed operation records for Site 1 were not maintained, but a solid waste facility permit was obtained from Santa Clara County in 1979. This permit states that the landfill operated as a sanitary landfill and that it received waste such as cardboard, lawn cuttings, pruning, wood waste, and asbestos insulation wrapped in double- plastic bags. According to civilian and military personnel interviews, the landfill received domestic refuse, as well as waste from maintenance and military operations. Maintenance and military operations waste included scrap equipment, paint and paint thinners, solvents, lacquer, ash, asbestos, jet fuels, waste oil, fuel filters (containing fuel sludge, lead compounds, and rust), transformer oil and filters, and polychlorinated biphenyl (PCB)-contaminated sawdust; however, data obtained during field investigations support the information found in the permit and indicate that Site 1 was operated much like a solid waste landfill (Navy, 1997).

According to the Remedial Investigation (RI) Report, Site 1 waste depth ranged from two to 21 feet below msl, but typically from eight to 12 feet below msl (International Technology Corporation [ITC], 1993a) with 0.5 to seven feet of gravelly sand final cover material.

The total waste volume at Site 1 at the time was estimated to be approximately 423,000 cubic yards (CY; Navy, 1997).

Although former Site 2 landfill operation records were not maintained, it is understood the landfill operated from the 1940s until approximately 1952 (ITC, 1993) and received domestic refuse, as well as wastes from maintenance and military operations, such as scrap equipment, paint and paint thinners, solvents, lacquer, oil, fuel filters, and sawdust contaminated with PCBs. Although no disposal records for the landfill exist, the Feasibility Study (FS) conservatively estimated that the total maximum volume of refuse at Site 2 was estimated to be approximately 169,400 CY (Navy, 1997). As part of the remedy implementation for Sites 1 and 2 the consolidation of landfill waste from the former Site 2 landfill into Site 1 landfill was performed.

2.2 Site 22

This section discusses the site characteristics and history of Site 22.

2.2.1 Physical Characteristics

Site 22 is a closed landfill located in the northeastern corner of NASA Ames (**Figure 1**) and encompasses approximately 9.4 acres with an estimated waste volume of 92,000 CY. Site 22 waste is understood to be domestic waste, as confirmed from exploratory trenching (Navy, 2002). Site 22 currently underlies the putting greens and fairways of holes 6 and 7 of The Golf Club at Moffett Field, operated and maintained by a NASA tenant.

Adjacent properties include North Patrol Road bordered by USFWS property to the north, East Patrol Road bordered by a Lockheed Martin facility to the east, and the remainder of The Golf Club at Moffett Field to the south and west. A ditch on the northern edge of the landfill, beyond North Patrol Road, drains surface water to the west.

The stratigraphy around the Site 22 former landfill consists predominantly of clay and silty clay with discontinuous sand and silt intervals. Because of the discontinuous sand and silt intervals, interconnection is limited between groundwater and surface water as well as between groundwater and the North Patrol Road ditch. Hydraulic interconnection between groundwater and the North Patrol Road ditch is also impeded by the relatively low hydraulic conductivity of clay/silty clay. Physical and chemical data indicate that interconnection between the perched landfill leachate and shallow groundwater is also limited due to the predominance of clay and clayey silt beneath and around the landfill (Navy, 2002).

Regional groundwater flow in the vicinity of Site 22 is to the north toward San Francisco Bay. However, groundwater flow beneath Site 22 differs from the regional flow due to pumping activities associated with Building 191 which lowers the water table west of the site. As a result, groundwater flow from the Site 22 landfill is generally to the west toward Building 191 (FWEC, 2003). Based on information obtained during the review period and groundwater gauging data collected in October 2023, the groundwater showed a west to northwest flow direction in the western portion of the site and an east to northeast flow direction in the eastern portion of the site. Groundwater elevations at Site 22 in October 2023 were between 2.2 feet below msl in the central portion of the site, three feet below msl on the western portion of the site, and 2.5 feet below msl on the eastern portion of the site.

Site 22 is a closed landfill situated where The Golf Club at Moffett Field is located. In 2002, the Navy and regulatory agencies signed the ROD for the Site 22 landfill (Navy, 2002), and the following remedies were implemented:

- A biotic barrier was installed in 2003 to prevent burrowing animals from disturbing the subsurface contamination.
- Surface water flow was managed across the site to prevent ponding of water on the Site 22 landfill and to improve precipitation runoff to reduce water infiltration into the subsurface.

- ICs were implemented to maintain the integrity of the landfill cover and biotic barrier and to prevent disturbances or excavation of waste materials.
- Groundwater and landfill gas were and continue to be monitored in the vicinity of the site.

The components of the remedy have been completed in accordance with the requirements of the ROD. The Site 22 biotic barrier is functioning as designed and prevents human and animal exposure to landfill contaminants. While not specified as ICs in the ROD, the biotic barrier and landfill-regrading activities to prevent ponding of water are considered ICs at Site 22.

The Santa Clara County DEH conduct site visits and quarterly inspections as part of IC implementation measures. To meet the EPA annual reporting requirement, NASA provides annual reports, which include quarterly inspection reports for Site 22 that detail the effectiveness of IC monitoring and implementation. IC implementation at Site 22 has been completed because LUCs for this site have been incorporated into the NASA permitting process and lease provisions. These requirements have been incorporated into NASA's ERD (NASA, 2015).

Groundwater monitoring data at Site 22 indicates that pesticides, semi-volatile organic compounds (SVOCs), and volatile organic compounds (VOCs) do not appear to be affecting the shallow aquifer based on the infrequent, low, and trace concentrations of these detected contaminants. Landfill gas monitoring at Site 22 shows that landfill gas is not migrating off-site from the landfill. Required maintenance of the biotic barrier includes backfilling shallow, small-diameter holes made by burrowing animals. Site 22 underlies a portion of The Golf Club at Moffett Field. The Golf Club at Moffett Field maintains the course features of Site 22.

This FYR found that the remedy for Site 22 is currently protective of human health and the environment because potential exposure pathways are incomplete, groundwater contaminant concentrations are stable, pumping from Building 191 continues to maintain the preferred groundwater flow direction, landfill gas is not migrating from the landfill, and the biotic barrier is functioning as intended. To ensure long-term protectiveness of the remedy, the following action must be taken:

- Maintain groundwater monitoring, methane monitoring, and LUC inspections,
- Continue burrowing mammal management activities in coordination with the regulatory agencies to avoid and minimize impacts to special status species.
- LUCs have been incorporated into NASA’s ERD (NASA, 2015). Report completion and documentation of this task to the regulatory agencies.

2.2.2 Land and Resource Use

Land use at Site 22 is specified in NASA’s 2002 *NASA Ames Development Plan, Final Programmatic EIS* (DC&E, 2002). Site 22 currently underlies the putting greens and fairways of holes 6 and 7 of The Golf Club at Moffett Field, which is operated by a NASA tenant. Before completion of the remedy, soil borings and trenching indicated that most of Site 22 is covered by approximately 1.5 feet of soil; however, soil thicknesses varied in a few areas to less than one foot. The Golf Club at Moffett Field has been maintained and operated for over 40 years. The nearest residential area is located more than 1.5 miles to the southwest (upgradient).

Groundwater at Site 22 is considered not potable for human or animal consumption because it does not meet state drinking water standards (Navy, 2002). As of this FYR, no local wells or known natural seeps or springs exist where groundwater could be withdrawn for local consumption, and the shallow aquifer underlying Site 22 does not supply water to local or municipal wells. Groundwater at Site 22 is not and will not likely be used as a source of drinking water or for other beneficial use in the future (TtEC, 2005).

2.2.3 History of Contamination

Site 22 was used as an active landfill from 1950 through 1967. Because operating records do not exist for Site 22, the landfill's history was compiled from reviewing aerial photographs and historical maps of the area and interviewing base personnel. Base personnel reported that Site 22 was used as a municipal landfill after the landfill at Site 2 was closed. Visual characterization of waste excavated at Site 2 confirmed that Site 2 contained primarily domestic waste; therefore, it was expected (and later confirmed) that Site 22 also contained domestic waste. When the landfill was covered with soil, it was not intended as the landfill's "cap" required by current regulations but placed to allow for landscaping and use as a The Golf Club at Moffett Field (Navy, 2002). In 1973, Site 22 was converted into holes 6 and 7 of The Golf Club at Moffett Field (Navy, 2002).

2.3 Site 26

This section discusses the site characteristics and history of Site 26, as presented in the ROD Amendment (Navy, 2014), unless otherwise cited.

2.3.1 Physical Characteristics

Site 26 originally consisted of a northern and southern chlorinated volatile organic compound (cVOC) groundwater plume located east of the Moffett Field runways. The northern plume was present in an area where TDS in groundwater are at concentrations above 3,000 mg/L which meets one of the criteria identified in the State Water Resources Control Board (SWRCB) Resolution 88-63 (Sources of Drinking Water Policy). No action other than continued groundwater monitoring was the selected remedy for the northern plume in the OU5 ROD; therefore, the northern plume did not require remediation. Only remnants of the southern plume are currently observed. VOC contaminants (**Figure 2**) were found to impact the upper portion of the A Aquifer (Navy, 1996). Following implementation of a RA from 2001 to 2003 and a series of treatability studies in 2009 through 2011, VOC concentrations and plume footprint in the southern plume were reduced (Navy, 2014). Six cVOCs were identified as chemicals of concern (COCs) in the ROD for the groundwater plume at Site 26: tetrachloroethene (PCE) and trichloroethene (TCE) and their daughter products cis-1,2-dichloroethene (cis-1,2-DCE); 1,1-dichloroethene (1,1-DCE); and vinyl chloride (VC); and non-daughter product 1,2-dichloroethane (1,2-DCA) (Navy, 1996 and Navy, 2014).

Site 26 is in the northeast portion of NASA Ames and is bordered by the airfield runways to the west, Hangars 2 and 3 to the south, East Patrol Road to the east, and The Golf Club at Moffett Field to the north. Site 26 topography is relatively flat (Navy, 1996) and subsurface soils consist of mostly fine-grained material from near ground surface to the investigated depth of 250 feet bgs.

Laterally and vertically, discontinuous lenses of coarse-grained sediments are evident to approximately 35 feet bgs. Only the shallow A Aquifer (which extends from 0 to 55 feet bgs and an average depth to groundwater of approximately eight feet bgs) beneath the site is impacted with VOCs.

Groundwater flow in the A Aquifer at the site is generally north/northwest. There is also a slight upward hydraulic gradient which drives groundwater flow from the lower portion to the upper portion of the A Aquifer. Similarly, there is a predominant upward hydraulic gradient driving groundwater flow from the deeper, B Aquifer to the lower portion of the shallower A Aquifer. Groundwater flow direction at Site 26 is to the north. Water levels and groundwater flow in the A aquifer zone were influenced locally by the EATS extraction wells when it operated from January 1999 to July 2003. In addition, the Building 191 lift station and its associated drainage network influence groundwater flow in the A aquifer zone (Navy, 2005a).

Site 26 consists of cVOC groundwater plumes located east of the Moffett Field runways. In 1996, the Navy signed the ROD for Site 26 (Navy, 1996). The ROD divided Site 26 into northern and southern groundwater contaminant plumes. Groundwater monitoring was the only action required for the northern plume because the groundwater is not a current or potential source of drinking water and does not pose an unacceptable risk to human health or the environment (Navy, 1996). The remedy selected and implemented for the southern plume at Site 26 includes:

- Extracting and treating groundwater so that concentrations of COCs are reduced to drinking water maximum contaminant levels (MCL) by the EATS.
- Conducting groundwater monitoring.
- Implementing ICs to prevent human exposure to or ingestion of contaminated groundwater.

COCs identified in the ROD include TCE; 1,2-dichloroethene (1,2-DCE); PCE; VC; 1,1-DCE; and 1,2-dichloroethane.

To extract and treat groundwater, the Navy began construction of the EATS in July 1997. Between January 1999 and July 2003, the EATS processed 67,050,786 gallons of extracted groundwater and removed 23.65 pounds of VOCs. In 2003, the EATS was shut down to evaluate its efficiency, the stability of the plume, and conditions for natural attenuation, and to determine whether the pump-and-treat remedy would achieve the groundwater cleanup standards identified in the ROD.

After the shutdown of the EATS, concentrations of COCs in the groundwater continued to be above the MCLs. During the shutdown, it was determined that the EATS, under its current configuration, would not attain cleanup standards within the 50-year timeframe originally projected in the ROD. As a result, between 2003 and 2010, the Navy performed remedy optimization, including several pilot scale treatability tests at Site 26. Alternative remedial technologies and the current pump-and treat remedy were evaluated in a FFS for Site 26 (Shaw Environmental, Inc., 2012). A replacement remedy was selected, presented in a PP, and documented in a ROD Amendment (Navy, 2014).

The selected remedy, documented in the ROD Amendment (Navy, 2014), replaces the current remedy at Site 26 for the southern plume and consists of targeted in situ biostimulation/bioaugmentation treatment in the portions of the groundwater plume with the highest remaining concentrations of COCs, MNA, and ICs. The remedy for the northern portion of the plume will remain as described in the ROD. The main components of the selected remedy include:

- Treating groundwater by injecting a biostimulation/bioaugmentation nutrient mixture (dechlorinating bacteria and nutrients) into groundwater to enhance and accelerate biodegradation of the COCs.
- Monitoring groundwater in new and existing wells to verify COC degradation rates, evaluate MNA effectiveness, and estimate cleanup times throughout the plume.
- Implementing LUCs that will: 1) prohibit access to groundwater except for treatment and dewatering until cleanup levels are met, and 2) notify and require property owners and developers that any new building planned for construction over the groundwater plume at Site 26 be designed and constructed in a manner that will mitigate potential unacceptable health risks from VI.

IC implementation at Site 26 has been completed because NASA has placed restrictions on domestic use of groundwater in its land use planning documents.

The remedy at Site 26 evaluated during this FYR cycle was found to be currently protective of human health and the environment because groundwater contaminant plumes are stable or decreasing and potential exposure pathways are incomplete. To ensure long-term protectiveness of the remedy, the following actions must be taken:

- Report the impacts of the Navy’s implementation in 2019 of the selected remedy as described in the Site 26 ROD Amendment (Navy, 2014) for meeting the project Remedial Action Objectives (RAOs) by protecting human health and environmental receptors and maintaining present and future beneficial groundwater uses.
- Report completion and documentation of the incorporation of LUCs into NASA's ERD (NASA, 2015) to EPA and the Water Board.

2.3.2 Land and Resource Use

Land use is specified in NASA’s 2002 *NASA Ames Development Plan, Final Programmatic EIS* (DC&E, 2002). Access and development in the Site 26 area is restricted to the east, west, and south because of safety considerations related to munitions storage and airfield operations; as such, a change in land use is not planned. Access from the north where The Golf Club at Moffett Field is located is not restricted.

The closest residential area is approximately one mile southwest (upgradient) of Site 26 (Navy, 1996).

Groundwater in the Site 26 southern plume meets state criteria for potable use and is therefore considered a potential drinking water source. However, no drinking water wells are in the Site 26 area and future use of groundwater as a drinking water supply is not anticipated. If Site 26 groundwater were to be used as a future drinking water supply, then it would require treatment due to ambient concentrations of naturally occurring metals that exceed state drinking water standards (Navy, 1996). Because TDS levels in groundwater within the upper portion of the A Aquifer at the northern end of NASA Ames exceed the Water Board’s TDS limit, which includes the Site 26 northern plume, groundwater in this area is not considered a potential drinking water source.

2.3.3 History of Contamination

Site 26 is associated with historical activities at Hangars 2 and 3, the former industrial wastewater-holding ponds, several underground storage tanks (USTs), and the runway apron. The construction of the hangars was completed in 1942. Unpaved areas at the corner of Hangars 2 and 3 were reportedly used to dispose of liquid waste. Hangar 3 contained an Aircraft Intermediate Maintenance Department power plant shop in the northeast corner. The former industrial wastewater-holding ponds were located northeast of Hangar 3 and used from 1968 to 1978. These ponds were unlined and received wastewater from aircraft washing, ground support equipment maintenance, and the hangars. The wastewater was held in the ponds, treated, and discharged to sanitary sewers (Navy, 2014).

2.4 NASA Regional Groundwater Remediation Program

This section discusses the site characteristics and history of the NASA RGRP. The NASA RGRP area consists of the Site 28/WATS and the NASA Groundwater AOR/GWTS.

2.4.1 Physical Characteristics

The NASA RGRP is a commingled groundwater plume within the central portion of NASA Ames (**Figure 1**). The groundwater plume resulted primarily from off-site upgradient sources, the MEW Superfund site and the Naval Air Station Moffett Field Superfund site.

The NASA RGRP is in the northern portion of the Santa Clara Valley Groundwater Sub-basin (Santa Clara Valley Water District [SCVWD], 2001). The hydrostratigraphy in this part of the sub-basin is divided into upper and lower water-bearing zones, separated by an extensive regional aquitard (SCVWD, 1989). As shown in **Table 2-1**, the upper water-bearing zone is subdivided into two water-bearing zones: the A Zone and the B Zone, which are separated by the A/B Aquitard. The A Zone is further subdivided into two zones (A1 and A2 Zones), and the B Zone is further subdivided into three zones (B1, B2, and B3 Zones). Because the A/B Aquitard is not continuous, the A2 and B1 Aquifers are generally referred to as a single A2/B1 unit. The lower water-bearing zone occurs below a depth of about 150 feet bgs and is subdivided into the C Zone (which extends to about 230 feet bgs) and the Deep Zone. The aquitard separating the upper and lower water-bearing zones (B/C Aquitard) is the major confining layer beneath NASA Ames. Groundwater at the site generally flows north- northeast in both the A1 and A2/B1 Aquifers. The overall gradient across the NASA RGRP area is approximately 0.0040 feet per foot (ft/ft) in the A1 Aquifer and 0.0036 ft/ft in the A2/B1 Aquifer (BB&E, 2022).

The NASA RGRP is underlain by VOC-impacted groundwater within the A1 and A2/B1 Aquifers, west of the runways. The MEW ROD identifies the following COCs within the NASA RGRP: chloroform; 1,2-dichlorobenzene (1,2-DCB); 1,1-dichloroethane (1,1-DCA); 1,1-DCE; cis-1,2-DCE; Freon 113; phenol; PCE; 1,1,1-trichloroethane (1,1,1-TCA); TCE; and VC. The MEW ROD selected TCE as the indicator chemical for groundwater cleanup based on the assumption that achieving the cleanup goal for TCE would result in cleanup of the other site contaminants. The TCE groundwater cleanup goals specified by the 1989 MEW ROD are 5 micrograms per liter (µg/L) for the shallow aquifers and 0.8 µg/L for the deep aquifers. In 1996 EPA's ESD subsequently clarified that cleanup must remediate all COCs to their respective Applicable or Relevant and Appropriate Requirements (ARARs).

The commingled groundwater plume on NASA Ames is part of the MEW Regional Plume, which is being remediated pursuant to the 1989 MEW ROD issued by the EPA and two subsequent ESDs. As described in the MEW ROD, groundwater cleanup included initial actions, which have been completed, and the current long-term remedial phase. The VOCs addressed in the MEW ROD are assigned to both facility-specific and regional responsibilities. Each of the MEW primary responsible parties (PRPs) is responsible for the investigation, remediation, and source control of VOCs in soil and groundwater at its facility-specific properties south of Highway 101. The MEW PRPs are jointly responsible, through the RGRP, for the remediation of VOCs in groundwater that have bypassed the source control areas and are not being captured by the facility-specific source control systems or that cannot be attributed to a sole source (EPA, 2004). Also shown in **Figure 2** are the Orion Park plume located along the western edge of NASA Ames and the Site 26 plume located on the east side of Moffett Field.

In 1998, NASA entered into an Allocation and Settlement Agreement for MEW Remedial Program Management Between NASA and Fairchild Semiconductor Corporation, Raytheon Company, and Intel Corporation (NASA, 1998), which pertained to requirements established under the MEW ROD. Under this Agreement, various geographical divisions of responsibility, COCs, and treatment system design, installation, and O&M responsibilities were allocated among the MEW Companies, Navy, and NASA under the MEW ROD. NASA RGRP Groundwater AOR to the MEW Regional Plume is shown in **Figure 2**. In 2015, NASA entered into the NASA Moffett Federal Facility Agreement (FFA) with the EPA and San Francisco Bay Regional Water Quality Control Board (EPA, 2015). The groundwater cleanup and reporting responsibilities pertaining to NASA under the Allocation and Settlement Agreement and MEW ROD were incorporated into the NASA Moffett FFA.

The Navy's 1993 amendment to the 1990 Navy Moffett FFA (EPA, 1990) adopted the MEW ROD for Site 28 to address historical Navy source areas to the MEW Regional Plume in the shallow aquifers. The WATS is the groundwater treatment system implemented by the Navy in 1998 under the MEW ROD and Navy Moffett FFA to treat historical Navy source areas to groundwater contamination at Site 28 that have commingled with the MEW Regional Plume (EPA 1989).

On October 1, 2016, NASA assumed operations and maintenance, monitoring, and reporting (OMMR) responsibilities for the Site 28 WATS Area. The Navy retains responsibility to address the Navy source areas that have contributed to groundwater contamination at Site 28, including deeper aquifers. Before the transfer of WATS to NASA, NASA only sampled the NASA Groundwater AOR from 1999 to 2016. After the transfer, starting in 2017, NASA began sampling and reporting both the NASA Groundwater AOR and Site 28 as one entity known as the NASA RGRP.

2.4.2 Land and Resource Use

Land use in the NASA RGRP is specified in NASA's 2002 *NASA Ames Development Plan, Final Programmatic EIS* (DC&E, 2002) and includes airfield operations, administrative offices, research and development facilities, operations and maintenance facilities, undeveloped land/burrowing owl habitat, and various storage building. Several operations and maintenance facilities are located within the Site 28 area. Hangar 1 and several of the surrounding buildings are part of the Historic District established in 1994 (NASA, 1994).

WATS is located within NASA's redevelopment area. Future land use is described in the *NASA Ames Development Plan, Final Programmatic EIS* (DC&E, 2002). The WATS area is within portions of two planning areas: the NRP and the Ames Campus. New educational, office, research and development, museum, conference center, housing, and retail space is planned for NRP, and plans include demolition of non-historic structures (DC&E, 2002). Two proposed residential developments are being considered within the NRP over areas of the regional plume with high concentrations of contaminants. The developments include the Mountain View Housing Venture, LLC (between 1,900 and 2,078 dwelling units) and the University of California Berkeley's Berkeley Space Center (partially residential with unspecified number of dwelling units). High-density office, research, and development space is planned for the Ames Campus (DC&E, 2002). There are currently no plans for this land to change ownership.

The NASA RGRP is in the South Bay Groundwater Basin where the Water Board has determined that the criteria for drinking water sources are applicable. The criteria are defined as groundwater with TDS lower than 3,000 mg/L that is capable of pumping at least 200 gallons per day (California SWRCB, 1998). Groundwater within the NASA RGRP meets these criteria and is considered a potential drinking water source. However, there are no drinking water wells within the NASA RGRP. NASA controls future potential consumption of groundwater in the redevelopment areas through clauses in tenant leases prohibiting potable uses of the groundwater (NASA, 2002).

2.4.3 History of Contamination

The MEW PRPs, Navy, and NASA released VOCs to the environment, which combined with plumes from local sources have commingled to form a regional plume (**Figure 1**). The MEW ROD (EPA, 1989) states that during 1981 and 1982, preliminary investigations of MEW facilities indicated significant contaminant concentrations in soil and groundwater (Navy, 2005b).

VOCs and cVOCs are the primary COCs identified in the WATS area. Four areas within the WATS area were identified as potential sources of VOC or fuel-related groundwater contamination: Building 29, Building 31, former Building 88, and the Hangar 1 former aircraft wash rack (Tetra Tech EM, Inc. [TtEMI], 2001a). The potential VOC source areas are complex to evaluate because these local potential sources lie within the area of the MEW regional VOC plume. PCE impacts can be directly associated with former Building 88 and subsequent migration to the Traffic Island Area (TIA). Fuel-related contaminants are attributed to a few petroleum sites, including USTs and sumps in the WATS area.

VOCs are found in the A1 and A2 aquifer zones to maximum depths of about 35 and 77 feet, respectively. The most frequently occurring VOCs detected in the groundwater within the WATS area are the chlorinated solvents TCE and cis-1,2-DCE, with lesser amounts of PCE and VC. Cis-1,2-DCE and VC are found commingled with TCE and PCE and are likely reductive dechlorination products from their natural degradation. In addition to the on-site sources discussed above, TCE and its degradation products historically migrated into the WATS area from upgradient MEW sources, and current data indicate migration continues (BB&E, 2022).

NASA Ames operates the NASA GWTS within NASA Groundwater AOR to the MEW Regional Plume. The WATS was installed and operated by the Navy to address Navy source areas associated with the Navy's Site 28 Area. On October 1, 2016, NASA assumed operational, maintenance, monitoring and reporting responsibilities for the Navy's Site 28 WATS Area. In 2017, NASA combined the reporting of the NASA Groundwater AOR with the Navy's Site 28 Area and referred to as the NASA RGRP (**Figure 2**).

The NASA GWTS was designed to address two areas that were discussed in the *Proposed Locations of NASA Ames Groundwater Extraction Wells in the VTOL Pad and South Navy Warehouse Areas* (Erler & Kalinowski, Inc., 1995). The first area of concern is located south of the former Navy Warehouse (building N144), between buildings N240 and N259. Although no soil source area was identified during groundwater investigations conducted in 1994, contouring of TCE concentrations in groundwater in this area suggested a potential source area of TCE contamination in the A1 Aquifer (**Figure 3**). However, plume mapping and concentration data indicate that the plume in this area is a continuation of the Regional Plume. NASA extraction wells NASA-1A and NASA-2A were installed in the A1 Aquifer to address this area. Pumping from NASA-2A was suspended on April 28, 2009, with approval from the EPA and Water Board.

The second area is downgradient of Navy Site 8 North, near the southwest corner of the Vertical Take-Off and Landing (VTOL) pad. As documented in the *Center-Wide Sampling and Analysis Program, Volume VII: Work Plan for Area of Investigation 7* (Erler & Kalinowski, Inc., 1994), the likely source of any solvent contamination to groundwater in this area was from chemicals previously located at the Navy Site 8 storage areas. In 1994, NASA removed solvent-contaminated soil exceeding cleanup levels by excavating over 3,000 CY of soil (*Site 8-North Soil Excavation & Source Removal*; NASA, 1994). NASA extraction wells NASA-3A and NASA-4A were installed in the A1 Aquifer to address residual groundwater contamination downgradient of this area. Wells NASA-3A and NASA-4A were installed in 2000 and groundwater extraction began in late 2001. Pumping from NASA-4A was suspended on April 28, 2009, with approval from the EPA and Water Board. The effectiveness of the remedy is monitored using a network of RGRP monitoring wells. In the past, NASA has sampled 13 NASA RGRP and five MEW RGRP groundwater monitoring wells (on behalf of the MEW Parties) annually (in September) and NASA's two operating extraction wells quarterly.

Figure 2 shows the recent approximate plume boundary, which generally has not changed since the startup of WATS on November 26, 1998. The PCE and VC plumes are entirely within the boundaries of the TCE and cis-1,2-DCE plumes in the WATS area (FWEC, 2003b). Evaluation of data from WATS monitoring wells has shown that, in addition to TCE, cis-1,2-DCE is a significant component of the mass underlying the site (FWEC, 2002). For the WATS area, the TCE and cis-1,2-DCE occur most frequently and are considered indicator parameters for WATS (FWEC, 2002). Contaminant concentrations generally have remained the same or have decreased since the startup of WATS. The mean TCE concentrations for the A1 and A2 aquifer zones also show a decrease for 1999, 2000, and 2001 (FWEC, 2003b). However, the mean cis-1,2-DCE concentrations for the A1 and A2 aquifer zones remained relatively unchanged for 1999, 2000, and 2001 (FWEC, 2003b).

Former Navy Site 28

This section discusses the site characteristics and history of former Navy Site 28. NASA assumed OMMR responsibilities for the former Navy Site 28 in 2016 and incorporated the sampling and reporting into the NASA RGRP program along with the NASA Groundwater AOR in 2017. Site 28 background is presented for context within the NASA RGRP and will not be addressed separately going forward.

Physical Characteristics

The former Navy Site 28 is underlain by cVOC groundwater plumes that impact the upper and lower portions of the A Aquifer and possibly the upper portion of the B Aquifer, west of the Moffett Field runways. The most frequently occurring cVOCs detected in the groundwater are TCE and cis-1,2-DCE with PCE and VC reported over a smaller areal extent (Navy, 2005b).

The Site 28 stratigraphy consists of discontinuous sand and gravel channels and discontinuous clay layers bounded by silty sands, sandy silts, and silts. There is a hydraulic connection between the upper and lower portions of the A Aquifer, and locally there is not a continuous aquitard that separates them. The hydraulic connection between the upper and lower portions of the A Aquifer has an impact on capture zones, chemical transport, and the interpretation of plumes (Tetra Tech FW, Inc. [TtFW], 2005). The B aquifer zone is present below the A/B Aquitard and extends up to 160 feet bgs. The B aquifer zone is divided into two permeable zones: an upper zone referred to as the B2 aquifer zone and a lower zone referred to as the B3 aquifer zone that are separated by a laterally discontinuous and variable thickness aquitard (referred to as the B2/B3 Aquitard) encountered at depths ranging from 95 to 130 feet bgs. The B3 Aquifer lies beneath the B2 Aquifer and extends to 160 feet bgs (see **Table 2-1**; CB&I Federal Services, LLC [CB&I], 2014).

Groundwater flows generally to the north-northeast in the upper and lower portions of the A Aquifer west of the runways at Moffett Field (SES-Tech Remediation Services

[SES-Tech], 2009). Navy, and MEW extraction wells influence local groundwater levels, flow directions, and hydraulic gradients (Navy, 2005b).

History of Contamination

Building 29, Building 31, former Building 88, the TIA, and the Hangar 1 former aircraft wash rack are areas within Site 28 that have been identified as potential sources of VOC or fuel-related groundwater contamination (TtEMI, 2001a).

The primary petroleum site area within Site 28 was Site 9, which includes Buildings 29 and 31. Building 29 was part of the former fuel farm that was in service from the 1940s until 1964 (Earth Sciences Associates, Inc. [ESA] and James M. Montgomery, Consulting Engineers, Inc. [JMM], 1986) where 13 USTs and one aboveground storage tank (AST) and associated sumps were removed in July 1993 (TtEMI, 2001a). These former fuel farm tanks contained aviation gasoline, fuel and lubrication oils, and jet fuels. Building 31 was part of the former Naval Exchange gasoline station. The Building 31 area contained four USTs (three gasoline storage tanks and one waste oil tank), which were removed in October 1990 (TtEMI, 2001a).

Former Building 88 and the Hangar 1 former aircraft wash rack were suspected sources of VOC contamination in the upper and lower portions of the A Aquifer (TtEMI, 2001a). Former Building 88 was located southwest of Hangar 1. Sump 66 was removed in May 1990 followed by the demolition of Building 88 and removal of Tank 68 and Sump 91 in June 1994 as part of Navy's source control activities (TtEMI, 2001a). Residual PCE contamination in the Former Building 88 Area and TIA are an ongoing PCE source of groundwater contamination in the upper and lower portions of the A Aquifer (TtEC, 2008) for the Navy. Historical drycleaning activities conducted at former Building 88 were determined to be the source of PCE along with Building 88's associated sewer line.

The former aircraft wash rack area is approximately 250 feet south of Hangar 1. The former wash rack was used to clean aircraft and consisted of a 90-foot by 100-foot section of pavement sloped to central catchment basin 297A. Effluent from the catchment basin was routed under Cody Road to Sump 25 oil-water separator, which, in turn, discharged to the sanitary sewer system. Sump 25 was a 2,000-gallon concrete, dual-chamber oil-water separator that used an oil skimmer system for oil recovery. Sump 25 received concurrence from the Water Board for NFA for petroleum hydrocarbons on December 8, 2011.

2.5 NASA Vapor Intrusion Area of Responsibility

This section discusses the site characteristics and history of NASA VI AOR.

2.5.1 Physical Characteristics

The NASA VI AOR is in the northern portion of the Santa Clara Valley Groundwater Sub-basin (SCVWD, 2001) (**Figure 1**). The hydrostratigraphy in this part of the sub-basin is divided into upper and lower water-bearing zones, separated by an extensive regional aquitard (SCVWD, 1989).

The NASA VI AOR is defined by groundwater contamination beneath NASA Ames primarily from the MEW Superfund site and former NAS Moffett Field Superfund Site.

NASA Ames, the Navy, and the MEW PRPs are each responsible for the remediation of a portion of this commingled groundwater contamination plume (EPA, 1989).

2.5.2 Land and Resource Use

Land use in the NASA VI AOR area is specified in NASA's 2002 *NASA Ames Development Plan, Final Programmatic EIS* (DC&E, 2002) and currently includes administrative offices, research and development facilities, operations and maintenance facilities, undeveloped land/burrowing owl habitat, and various storage buildings (**Figure 3**).

2.5.3 History of Contamination

Groundwater contamination is present beneath NASA Ames primarily from upgradient sources. The groundwater contamination resulted from releases from the MEW Superfund site and former NAS Moffett Field Superfund Site. The commingled groundwater contamination is referred to as the "Regional Plume." In June 1989, EPA Region 9 issued a ROD under CERCLA selecting the groundwater cleanup remedy for the MEW Site. NASA Ames, the Navy, and the MEW PRPs are each responsible for remediation and receptor exposure of a portion of the plume and assigned VI AORs are shown on **Figure 3** (EPA, 1989).

In August 2010, the EPA amended the MEW Site 1989 ROD in accordance with CERCLA and NCP to address health risks associated with long-term exposure to TCE and other MEW Site chemicals of potential concern (COPCs) through the VI pathway in current and future buildings overlying the shallow subsurface contamination at the MEW Site. Subsequently, the EPA selected a remedy for the VI pathway to prevent subsurface volatile contaminants in groundwater from migrating into indoor air or accumulating in enclosed building spaces at levels exceeding its indoor air cleanup criteria for long-term exposure for residential and commercial buildings (EPA, 2010). NASA's portion of the VI Study Area is the VI AOR (**Figure 3**).

The ROD Amendment selected a remedy for the VI pathway to prevent subsurface volatile contaminants in groundwater from migrating into indoor air or accumulating in enclosed building spaces at levels exceeding its indoor air cleanup criteria for long-term exposure for residential and commercial buildings. The ROD Amendment defines the VI AOR where TCE concentrations in shallow groundwater are greater than 5 µg/L or parts per billion (ppb).

The 2010 ROD Amendment provides a tiering system to determine the appropriate response action for each building/property within the NASA VI AOR. The tiering system for existing buildings is based on indoor air sampling with or without heating, ventilation, and air conditioning (HVAC) system in place and other lines of evidence. TCE is the primary COC for the VI pathway, along with PCE; cis-1,2-DCE; trans-1,2-dichloroethene (trans-1,2-DCE); VC; 1,1-DCA; and 1,1-DCE. To determine the appropriate tier and corresponding response action for the occupied buildings within the NASA VI AOR, NASA performs regular (typically biennially) indoor air and background air sampling with analysis for the COCs, with TCE as the primary COC for the VI pathway evaluation.

In September 2011, in coordination with the MEW PRPs, NASA Ames, and the Navy, EPA developed the Statement of Work (SOW) for the VI remedial design (RD) and remedial action (RA). Pursuant to an agreement among NASA Ames, Navy, and the MEW PRPs, each entity is responsible for implementing the VI Remedy in its designated AOR, as depicted on **Figure 3** (EPA, 2011).

2.6 NASA Land Use Controls

This section discusses the site characteristics and history of NASA LUCs.

In 2015, NASA entered the NASA Moffett FFA with EPA Region IX and the Water Board. Pursuant to the FFA, NASA Ames is the lead federal agency to conduct response actions in accordance with CERCLA on NASA Ames (EPA, 2015). NASA is also responsible for LUCs implementation to ensure the protectiveness of both NASA Ames and CERCLA response actions conducted by the Navy and MEW PRPs on NASA Ames. The sites in which NASA Ames has LUC responsibilities subject to the FFA are Sites 1, 22, 26, 28, 29 (Hangar 1), Former NAS Moffett Field Area of MEW Regional Plume - Groundwater, and Former NAS Moffett Field Area of MEW Regional Plume Vapor Intrusion. In June 2023, NASA updated its LUC (IMP) to include former Navy Site 14. Site 14 South was closed under the UST Low-Threat Closure Policy Guidelines (Water Board, 2012), with the Navy receiving Uniform Case Closure and NFA notification from the Water Board on September 15, 2022, and provided the required LUCs for Site 14 South.

LUCs are engineered, non-engineered, and institutional (e.g., deed restrictions, permits, easements) controls undertaken to reduce environmental/health risk or protect the integrity of response actions. LUCs can be used before, during, and after active treatment and monitoring are used in response actions.

NASA Ames has responsibility for LUCs arising from response actions undertaken by NASA at sites for which NASA is the source of contamination and the Navy and MEW PRPs on NASA Ames that require implementation of LUCs to be fully protective of human health and the environment. These LUCs are documented in the RODs (except for the Water Board assigned LUCs for Site 14 South), approved by EPA and the Water Board. In addition to specific LUCs that are established for response actions at individual sites, as property custodian, NASA Ames' general LUC responsibilities for NASA and other Responsible Parties' response actions include:

- Provide reasonable site access for response action implementation and regulatory agency oversight;
- Prevent alteration of, interference with, or damage to response actions by NASA, NASA contractors, or tenants;
- Prevent activities and land use(s) inconsistent with LUCs;
- Obtain concurrence from EPA and the Water Board, with notification to PRPs, to modify or terminate any LUCs; and
- Incorporate LUC requirements in NASA Ames land planning documents, contracts, leases, agreements, and deed covenants.

2.6.1 Physical Characteristics

The NASA LUCs is in the northern portion of the Santa Clara Valley Groundwater Sub-basin (SCVWD, 2001). The hydrostratigraphy in this part of the sub-basin is divided into upper and lower water-bearing zones, separated by an extensive regional aquitard (SCVWD, 1989). The physical characteristics of each LUC area are summarized below.

2.6.2 Land and Resource Use

Land use in the NASA LUC areas are specified in NASA's 2002 *NASA Ames Development Plan, Final Programmatic EIS* (DC&E, 2002). Specifically, NASA Ames is responsible for the LUCs for Site 1 (closed landfill), Site 14 (groundwater), Site 22 (closed landfill), Site 26 (groundwater), Site 28 (groundwater), Site 29 (coating materials), Former NAS Moffett Field Area of MEW Regional Plume - Groundwater, and Former NAS Moffett Field Area of MEW Regional Plume Vapor Intrusion Study Area (**Figure 1** and **Figure 3**).

2.6.3 History of Contamination

Site 1

Site 1 is a closed landfill of approximately 12 acres located in the northernmost portion of NASA Ames to the north of the airfield. In 1991, the nearby former Site 2 landfill was administratively combined with the Site 1 landfill for regulatory oversight and remedy implementation purposes. The 1997 Navy ROD for Site 1 and 2 presented the Navy's selected remedy to address potential exposure to the contents of the landfills and production of leachate from rain infiltration (PRC Environmental Management, Inc. [PRC], 1997). In the 1997 Navy ROD, Site 1 was designated as a corrective action management unit (CAMU) to allow waste from Site 2 to be removed and placed into Site 1. Approximately 23,000 CY of waste from Site 2 were transferred and consolidated within Site 1. Site 1 was then capped with a multilayer cover consisting of a 1-foot-thick low permeability clay layer, a 10-ounce geotextile fabric biotic barrier, and a vegetative cover consisting of a 1-foot-thick compacted soil vegetated with grass.

The 1997 Navy ROD specified LUCs to maintain the protectiveness of the remedy, including restricting cap disturbances, maintaining fencing and signage, continuing operation of the Building 191 lift station, and restricting domestic groundwater use. (PRC, 1997). In 2003, the EPA and the Water Board approved clean closure of Site 2, allowing unrestricted use of the Site 2 area.

Site 14 South

Site 14 South was formerly an unmanned, self-service fuel station operated by NASA Ames (previously operated by the Navy) and is located southwest of the intersection of Cody Road and Ellis Street at NASA Ames (**Figure 1**). Site 14 South encompasses approximately one acre and is almost entirely paved with asphalt or concrete.

The site previously contained two 5,000-gallon USTs (Tanks 19 and 20) containing unleaded gasoline that were removed by the Navy in 1986. The Navy was the lead agency administrating Site remediation to facilitate closure of Moffett Field Site 14 South and it is Department of Defense (DoD) policy to achieve Site closure with the agreement of local regulatory authorities. During replacement of the fuel tanks in 1986, a release was detected in the tank pit of former Tanks 19 and 20. Between 1986 and 2016, numerous investigations, removal actions, and in-situ remediation activities were instituted by the Navy. In November 2019, the Navy submitted the closure report recommending NFA for Tanks 19 and 20 and Site 14 South (Battelle, 2019).

As a follow-up action to facilitate site closure, NASA removed two 12,000-gallon fiberglass USTs (numbered 70 and 71 by the Navy and renumbered as 431 and 432 by NASA) and associated piping and distribution lines at Site 14 South in February 2020. These USTs contained unleaded gasoline and bio-diesel fuel. Tanks 431 and 432 were found to be intact when removed; and the soil surrounding these USTs was unimpacted. A grab groundwater sample from the excavation had elevated concentrations of diesel, indicating an upgradient source of hydrocarbons (suspected to be previously removed USTs 19 and 20). Additional groundwater investigations in the area demonstrated that grab sample data was not representative of groundwater conditions around former USTs 431 and 432; therefore, no further remediation was required beyond the previously completed actions and approved by the Water Board in January 2020. Site 14 has been closed with NFA deemed necessary under the UST Low-Threat Closure Policy Guidelines (Water Board, 2012) governed by the Water Board. The Navy received Uniform Case Closure and NFA notifications from the Water Board on September 15, 2022, and provided the required LUCs for Site 14 South.

Site 22

Site 22 is a former landfill located in the northeastern portion of NASA Ames (**Figure 1**). The 2002 Navy ROD presented the Navy's selected remedy consisting of a landfill cover (consisting of a 6-inch foundation layer, a biotic barrier comprised of a 12-inch layer of 4- to 8-inch cobblestone capped with a concrete and sand slurry mix, a 6-inch coarse granular 3/8-inch pea gravel drainage layer, an 8-ounce geotextile fabric layer, and an 8-inch topsoil layer capped with a 4-inch layer of sand),groundwater monitoring, landfill gas monitoring and LUCs. LUCs include maintaining the structural aspects of the cap, maintaining vegetation, topsoil, irrigation system, surface contours and surrounding surface water drainage, preventing use of site groundwater, continuing operation of the Building 191 lift station, and restricting residential use of the site.

Site 26

Site 26 is located east of the airfield that consists of two, cVOC groundwater plumes (northern and southern plumes) that have impacted the upper portion of the A Aquifer (**Figure 1**). Since the northern plume is in an area where high TDS concentrations preclude use of groundwater as a possible drinking water source (State Water Resources Control Board Resolution 88-63, 2006), the Navy selected groundwater monitoring as the only required action for the Northern Plume in the 1996 Navy ROD (Navy, 1996 and EPA, 1996).

The 1996 Navy ROD remedy selected and implemented for the southern plume specified groundwater extraction and treatment, groundwater monitoring, and ICs to prevent exposure to, or ingestion of, contaminated groundwater by restricting domestic groundwater use. The Navy operated a groundwater extraction and treatment system from 1999 to 2003 for Site 26. The 2014 Navy ROD Amendment changed the Site 26 southern plume remedy to targeted in situ biostimulation/bioaugmentation with MNA and ICs, including restricting domestic groundwater use and addressing VI in new construction or modifications to existing structures.

Site 28

WATS is a groundwater remediation system located on the west side of the runways, west of Hangar 1 (**Figure 1**), which was installed by the Navy to clean up VOCs and petroleum hydrocarbons in the AI and A2 aquifer zones. Plumes from local Moffett sources have commingled with a regional VOC plume, and the WATS treats part of the regional plume. MEW Companies, the Navy, and NASA contributed to the regional VOC plume.

The WATS treats groundwater in the WATS area, which is generally bounded by Hangar 1 to the east, McCord Avenue to the west, King Road to the north, and a line approximately 300 feet south of Wescoat Road to the south. Additional details are included in the 2005 Five-Year Review for Moffett Field (Navy, 2005b).

Site 29 (Hangar 1)

Site 29 (Hangar 1) is located on the west side of the airfield and consists of the Hangar 1 aboveground structure, concrete floor, small areas of exposed soil on the east side of the structure and surrounding storm water drainage system (**Figure 1**). The building materials and paint used to construct Hangar 1 contained PCBs, asbestos, lead, and zinc. Contaminants released from these materials migrated into the environment around the hangar and entered the storm drain system. In 2003, NASA and the Navy removed contaminated sediment from the storm water collection trench surrounding the hangar and applied a temporary coating to prevent migration of PCBs from the exterior surfaces of the hangar. In 2010, the Navy conducted a Non-Time-Critical Removal Action (NTCRA) to remove the hangar siding and coat the steel frame and other exposed surfaces. In 2013, the Navy finalized an After-Action Completion Report and Long-Term Management Plan (LTMP) for Site 29 to address long-term maintenance of the coating, which includes LUCs to protect the coating remedy from site activities and use, ensure building inhabitants are notified of potential exposure hazards, address worker exposure hazards, and require post-construction repairs over the coating for building modifications (AMEC Environment & Infrastructure, Inc [AMEC], 2013).

The LTMP identifies the following actions for the long-term management phase of the NTCRA for Site 29 Hangar 1: 1) coating inspections and maintenance, 2) implementation of ICs, and 3) sampling of sediment from the storm drain system surrounding the hangar.

The Navy completed the first NTCRA in 2013 and conducted site monitoring in 2014 and 2015. NASA Ames has conducted site management since October 2015, when NASA Ames assumed lead agency responsibility for the site. In 2018, NASA Ames conducted long-term management activities to maintain ICs for the site and monitor the storm drain system for site COCs. Beginning in 2018, NASA Ames has conducted quarterly inspections and sampling at the storm drain system surrounding the hangar.

The coating on the ground and mezzanine levels of the hangar structure was visually screened in April 2014 by Planetary Ventures, Inc. (PV; ACC, 2015) in support of

NASA's November 2014 lease agreement with PV for the Moffett Federal Airfield (MFA) Leasehold. In September 2014, the Navy completed spot repairs to the coating on the ground and mezzanine levels of the hangar structure (AMEC, 2014).

In June 2017, PV concluded testing methods to remove the coating and underlying paint from the hangar structure (ACC, 2017). Based on the pilot study results, PV agreed to implement a second NTCRA to remove the coating under the terms of the NASA-PV lease agreement for the MFA Leasehold and PV's 2017 Bona Fide Prospective Purchaser Agreement and Order on Consent with EPA. In late August/early September 2019, a General Coating Conditions Assessment was completed. The *Final Hangar 1 Engineering Evaluation/Cost Analysis*, (EKI Environment & Water, Inc. [EKI], 2019) was approved in December 2019, *Final Hangar 1 Action Memorandum* (EKI, 2020) was approved in November 2020, and the *Final Hangar 1 NTCRA Work Plan* (EKI, 2022) was approved in March 2022. Full-scale abatement and recoating activities began in May 2022 (BB&E, 2023b).

Former NAS Moffett Field Area of MEW Regional Plume

In accordance with the 1989 MEW Study Area ROD, the MEW PRPs, Navy, and NASA have been addressing the MEW Regional Plume and source areas commingled with the MEW Regional Plume at NASA Ames by operating groundwater extraction and treatment systems. The extent of the MEW Regional Plume is the area of TCE groundwater concentrations greater than 5 µg/L in the shallow aquifers and greater than 0.8 µg/L in the deep aquifers (EPA, 1989). Pursuant to an agreement among NASA, Navy, and the MEW PRPs, each entity implements the groundwater remedy in its respective designated groundwater geographic AOR. There are no LUCs selected for groundwater in the 1989 MEW Study Area ROD; however, NASA has implemented groundwater LUCs associated with the MEW Regional Plume on NASA Ames. Additionally, VI LUCs apply to this area and are described in Section 2.5.

Former NAS Moffett Field Area of MEW Regional Plume VI Study Area

EPA amended the 1989 MEW Study Area ROD to select a VI remedy for the MEW Superfund Site in the 2010 MEW VI ROD Amendment. The source of VI associated with the MEW Regional Plume in buildings at NASA Ames is from cVOCs in shallow groundwater. The VI Study Area is generally defined as the area where TCE concentrations in shallow groundwater are greater than 5 µg/L. In 2011, EPA worked with the MEW PRPs, NASA, and Navy to develop the SOW for the VI RD and RA. Pursuant to an agreement among NASA, Navy, and the MEW PRPs, each entity is responsible for implementing the VI remedy in it designated VI geographic AOR on NASA Ames. The area on NASA Ames subject to the 2010 MEW VI ROD Amendment and the LUC boundary is shown on **Figure 3** (Former NAS Moffett Field Area of MEW Regional Plume VI Study Area & LUC Boundary). NASA Ames maintains LUCs associated with the 2010 MEW VI ROD Amendment on NASA Ames, which include incorporating requirements for VI ECs in future construction (or modifications to existing buildings) and in permitting and building design processes, establishing Recorded Agreements to ensure installation and operation of VI ECs, providing information on VI to future owners, and providing information regarding building and occupancy changes to EPA.

3 RESPONSE ACTION SUMMARY

This section discusses remedy selection, implementation, and O&M to achieve protection of human health and the environment. NASA's Ames *Moffett Field Comprehensive Use Plan* (NASA, 1994) is consistent with the applicable remedy for continued use of these sites and areas on NASA Ames.

3.1 Site 1

3.1.1 Basis for Taking Action

Site 1 and Site 2 were initially identified and characterized as two separate sites. But as more characterization data was collected it was determined the former Site 2 landfill waste would be consolidated under a landfill cap at Site 1. The following history documents the action taken which led to the consolidation of waste from Site 2 to Site 1, the Site 1 ROD, and the closure of Site 2.

Site characterization at Sites 1 and 2 detected VOCs in the landfill refuse and perimeter soils. SVOCs, PCBs, and metals were also detected in landfill soils (PRC, 1995). VOCs, SVOCs, and metals were also detected in the landfill leachate samples. Radiological surveys did not detect radioactive materials above background concentrations at Sites 1 and 2. Low contaminant concentrations detected in samples of leachate, surface debris, and soils at both sites supported use of the EPA presumptive remedy (containment) for landfills (Navy, 1997). The EPA established that engineered containment could be used at landfills where the waste posed a relatively low long-term threat and treatment would be impracticable, thus not requiring a complete characterization of Site 1.

Post-RI activities were performed at Site 2 to define the extent of buried material prior to its relocation in the Site 1 landfill. Site 2 waste was removed and placed in Site 1 during construction of the remedy from July 1997 to November 1998. Site 2 was subsequently closed after the implementation of the remedy.

Chemical data from groundwater samples collected in association with the RI and FS reports at the landfill perimeter indicated that the Site 1 landfill was not significantly impacting groundwater. A human health risk assessment (HHRA) was conducted for Site 1 (ITC, 1993). A streamlined ecological assessment was conducted for Site 1 due to exposure pathways for ecological receptors being determined to be incomplete. The streamlined ecological assessment for Site 1 found that no threatened and endangered species or special status species were known to inhabit Site 1.

3.1.2 Remedy Selection

The Site 1 ROD was signed in 1997 and the selected remedy is as follows:

- Consolidate wastes from the Site 2 landfill into the Site 1 landfill.
- Place a cap and cover over Site 1.
- Perform groundwater monitoring at Site 1.
- Install a subsurface groundwater collection trench along the northern border of Site 1 to intercept potential future leachate migration before it discharges to surface water.

- Perform landfill gas monitoring at Site 1.
- Install a passive gas-venting trench along the western boundary of Site 1 to prevent potential subsurface migration of landfill gases off-site.
- Conduct post-closure maintenance activities at Site 1.
- Implement ICs.

3.1.3 Remedy Implementation

Landfill Closures

The excavation and transfer of waste from Site 2 to Site 1 began on July 28, 1997. Approximately 23,000 CY of waste were transferred from Site 2 to Site 1 from July through August 1997.

After waste was removed from Site 2 and transferred to Site 1, Site 2 was closed with unrestricted use controls.

The Site 1 landfill cap, consisting of a 1-foot-thick low permeability clay layer, a 10-ounce geotextile fabric biotic barrier, and a vegetative cover consisting of a 1-foot-thick compacted soil vegetated with grass., was completed in 1998. A groundwater collection trench was constructed across the northern boundary of the landfill as a contingency measure intended to act as a control system should the need arise to manage contaminated groundwater migrating off-site. Groundwater monitoring wells were installed along the landfill perimeter (TtFW, 2004b). A gas-venting trench was installed across the western boundary of the landfill and several gas-venting wells were installed within the landfill to allow landfill gas to passively vent to atmosphere.

Groundwater Monitoring

A long-term groundwater monitoring plan was developed as part of the remedy. Groundwater sampling was performed on a quarterly basis at Site 1 from January 2002 to November 2004 in accordance with the *Site 1 Landfill Final Closure Plan and Post-Closure Maintenance Plan* (TtEMI, 1998). In January 2005, the groundwater monitoring schedule was amended to semiannual in accordance with the *Final Site 1 Landfill Post-Closure Long-Term Monitoring Plan* (TtFW, 2005).

Shallow groundwater flow direction is confirmed to be from the north to south across the Site 1 landfill based on groundwater elevation data collected from 2004 through 2023. This flow direction is opposite from the likely regional groundwater gradient of south to north toward San Francisco Bay due to the stormwater drainage system pumping at Building 191, southeast of the landfill. The COCs in groundwater at the Site 1 Landfill include dissolved metals, PCBs, pesticides, VOCs, and SVOCs. Monitoring parameters (MPs) include physical and analytical parameters that are subsets of the COCs. The analytical MPs include selected metals, VOCs, pesticides, and SVOCs. The objective of the MPs was to select a subset of the COCs that, if a release from the landfill occurred, would be representative and detected in the groundwater monitoring wells (TtFW, 2004b).

Regularly scheduled groundwater sampling data of the MPs were compared with the respective calculated concentration limits (CCLs) to determine if there was an exceedance. If downgradient analytical data are lower than or equal to the respective CCLs, NFA was necessary. If the concentration of a downgradient analyte is greater than its CCL, a statistical evaluation is required to assess whether a release has occurred (OTIE, 2014).

Landfill Gas Monitoring

Landfill gas (methane) monitoring is performed in accordance with the *Site 1 Landfill Final Closure Plan and Post-Closure Maintenance Plan* (TtEMI, 1998), the *Post-Closure Monitoring (Site 1) and Groundwater Monitoring (Site 2) Sampling and Analysis Plan* (ITC, 2000), *Final Sampling and Analysis Plan Addendum* (FWEC, 2001), and the *Final Site 1 Landfill Post-Closure Long-Term Monitoring Plan* (TtFW, 2005).

The Site 1 gas monitoring network consists of 19 passive gas vents, four landfill gas monitoring wells, and 21 monitoring locations located around the perimeter of the site. Landfill gas is monitored quarterly to confirm that concentrations remain below five percent by volume in air at the site boundary.

Institutional Controls

NASA has incorporated ICs required by the ROD for Site 1into its land use planning document, the NASA Ames ERD. NASA's Facilities Group has incorporated LUCs for Site 1 into its permitting process and lease provisions and maintains copies of environmental records for the Site 1 landfill remedy. NASA conducts site visits and quarterly inspections as part of IC implementation and continues to maintain and operate the Building 191 pumping station as part of its stormwater drainage and conveyance system and provides annual reports to the agencies that detail the effectiveness of IC monitoring and implementation.

Remedy O&M

Landfill inspections are performed as prescribed by the *Site 1 Landfill Post-Closure Long-Term Monitoring Plan* (TtFW, 2005). Maintenance activities that are performed based on the findings of the inspections include typical cap maintenance, vegetation management, sign maintenance, and erosion control. Landfill settlement surveying is performed every five years. Additionally, monitoring is performed on raptor perches and controls performed to deter mammal burrowing, which includes quarterly inspections by the Santa Clara County DEH. NASA has performed inspections weekly by a NASA wildlife biologist due to the frequency of mammal burrowing activity. Methane measurements, water level measurements, and groundwater samples are collected at Site 1 semiannually. Annual reports are submitted to EPA and the Water Board summarizing Site 1 maintenance activities and groundwater and gas monitoring data.

3.2 Site 22

3.2.1 Basis for Taking Action

The Site 22 landfill was characterized during various investigations since the early 1990s and included soil and groundwater sampling, a landfill gas survey, exploratory trenching, and aquifer testing (slug tests). VOCs, SVOCs, PCBs, and metals were detected in the landfill waste. Neither VOCs nor PCBs were detected above contract required quantitation limits in perimeter soils. However, several SVOCs were detected in perimeter soils (PRC, 1995). VOCs, cVOCs, one SVOC, and metals were detected in leachate samples. PCBs were not detected in leachate samples (PRC, 1995). Low contaminant concentrations found in samples of leachate, groundwater, soil, and landfill gas at Site 22 supported use of the EPA presumptive remedy (containment) for landfills (Navy, 2002).

Chemical analyses of groundwater samples from wells surrounding the landfill indicate sporadic detections of organic constituents in perimeter wells; these may have originated from the landfill because of the presence of groundwater within the refuse. Total petroleum hydrocarbon constituents were not detected more than one time, and neither VOCs nor SVOCs were detected at concentrations significantly above ambient water quality criteria (AWQC). Results from the analysis of groundwater samples did not indicate significant or consistent chemical releases from the landfill (Navy, 2002). Metals detected in some perimeter groundwater wells exceeded AWQC, but the results were not significantly different from background concentrations.

VOCs and SVOCs were detected in landfill leachate wells. Two pesticides detected in a landfill leachate sample were detected infrequently and at low concentrations (Navy, 2002).

The landfill gas survey found no indications of off-site migration of landfill gases, no detectable concentrations of non-methane hydrocarbons migrating to the atmosphere from the landfill, and no significant subsurface gas migration beyond the perimeter of the landfill (Navy, 2002).

As part of the additional investigation, exploratory trenches were excavated to further evaluate the vertical and horizontal extent of refuse within the landfill. The exploratory trenching uncovered municipal wastes such as old tires, newspapers, vacuum tubes, and shampoo bottles. Based on the results of the trenching, the estimated extent of the landfill was approximately 9.4 acres, and the estimated refuse volume was approximately 92,000 CY.

A HHRA was conducted as part of the RI and indicated that total carcinogenic risks and noncarcinogenic hazard indices for recreational and occupational exposures were within EPA target risk levels. Risks associated with soil gas exposure or methane hazards were not found. An ecological risk assessment (ERA) selected the burrowing owl as an indicator species, a representative measurement endpoint receptor. The ERA concluded that chemical concentrations at the Site 22 landfill did not appear to adversely affect the burrowing owl community and did not identify risks to ecological receptors.

3.2.2 Remedy Selection

The Site 22 ROD was signed in 2002 by the Navy, EPA, and Water Board (Navy, 2002). The RAO identified in the ROD was to protect human health and the environment by preventing contact with landfill refuse. The major components of the selected response action to achieve the RAO are:

- Install a biotic barrier to prevent burrowing animals from uncovering the subsurface contamination.

- Manage surface water flow across the site to prevent ponding of water on the landfill cover and to improve precipitation runoff to reduce water infiltration into the subsurface.
- Implement ICs to maintain the integrity of the barrier and to prevent disturbances or excavation of waste materials.
- Monitor groundwater and gas in the vicinity of the site.

For IC implementation, the ROD documents identify the following requirements as elements of the selected response action for the Site 22 landfill (Navy, 2002):

- Protection of the structural aspects of the landfill cover.
- Prohibition of alterations of the drainage patterns or modification of surface contours.
- Establishment of specific boundaries for the extent of the landfill.
- Prohibition of extraction of groundwater from the site.
- Prohibition of residential land use.
- Requirement of regulatory approval for consideration of alternative land uses.
- Indication of parties responsible for ongoing operations, maintenance, and monitoring activities for the site.
- Requirement of annual reporting to the EPA regarding the implementation, monitoring, and efficacy of the ICs.
- Requirement that a transfer of the site to a non-federal entity includes a restrictive covenant conveying the property with ICs in place.

3.2.3 Remedy Implementation

Construction of the remedy began in January 2003 and was completed August 2003. Details regarding the implementation of the selected remedy are documented in the *Final Remedial Action Report for Installation Restoration Site 22 Landfill* (TtFW, 2004a).

Landfill Cover

The installation of the Site 22 landfill cover provides a barrier that prevents human exposure to landfill contents. The Site 22 landfill cover consists (from bottom to top) of a 6-inch foundation layer, a biotic barrier composed of a 12-inch layer of 4- to 8-inch cobblestone capped with a concrete and sand slurry mix, a 6-inch coarse granular 3/8-inch pea gravel drainage layer, an 8-ounce geotextile fabric layer, and an 8-inch topsoil layer capped with a 4-inch layer of sand (FWEC, 2003a). A subsurface drainage system was installed above the biotic barrier to redirect water infiltration of the upper layers toward the northern and southern boundaries of the Site 22 landfill. On the northern side of the site, surface runoff and subsurface water discharge to the new drainage swale, that flows into the North Patrol Road ditch through two culverts. On the southern side of the site, surface runoff and subsurface water are directed to existing golf water hazards outside of the landfill limits. Completed topography directs sheet-flow water in the same directions and toward the east.

Groundwater Monitoring

A long-term groundwater monitoring plan has been implemented on a semiannual basis at Site 22 in accordance with the *Final Post-Construction Operations, Maintenance, and Monitoring Plan* (FWEC, 2003a) and the *Final Site 22 Post-Construction Operations, Maintenance, and Monitoring Plan Addendum* (TtEC, 2007). The groundwater monitoring network consists of ten wells screened in the upper portion of the A Aquifer and located upgradient and downgradient of the landfill.

The Site 22 ROD required development of CCLs for COCs as part of the groundwater monitoring program (Navy, 2002). Analytical MPs are a subset of the COCs at Site 22 and are cis-1,2-DCE; chloroform; TCE; and xylenes based on the frequency of detection and/or properties of each compound. The CCLs were proposed in the *Final Site 22 Post-Construction Operations, Maintenance, and Monitoring Plan Addendum* (TtEC, 2007) based on exposure pathways and potential groundwater use at the site and were developed using AWQC and surface water screening criteria that are protective of aquatic organisms. The CCLs are used in the evaluation of groundwater data collected from the monitoring wells at Site 22.

Regularly scheduled groundwater sampling data of the MPs were compared with the respective CCLs to determine if there was an exceedance. If downgradient analytical data are lower than or equal to the respective CCLs, NFA was necessary. If the concentration of a downgradient analyte is greater than its CCL, a statistical evaluation is required to assess whether a release has occurred (OTIE, 2014).

Landfill Gas Monitoring

Methane monitoring at Site 22 is conducted in accordance with the *Final Post-Construction Operations, Maintenance, and Monitoring Plan* (FWEC, 2003a) and the *Final Site 22 Post-Construction Operations, Maintenance, and Monitoring Plan Addendum* (TtEC, 2007) to protect public health and safety and the environment by demonstrating that methane migration is not occurring in the vadose zone. The Site 22 methane monitoring network consists of four landfill gas monitoring wells, 15 tree well methane monitoring points, and 13 perimeter monitoring locations.

Tree wells were installed following the placement of the biotic barrier and prior to the placement of the irrigation system. Tree wells consist of a 6-foot-diameter plastic liner extending from the final ground surface into the foundation layer. They were installed to allow trees to be planted at The Golf Club at Moffett Field without jeopardizing the integrity of the biotic barrier (TtFW, 2004a).

Methane is monitored to confirm that concentrations of methane remain below five percent by volume in air at the site boundary. An exceedance of the criterion will be considered verified if methane concentrations for an individual landfill gas monitoring well, a tree well located at the boundary, or a perimeter surface monitoring station are above five percent by volume for any two out of three consecutive quarters. If methane concentrations are confirmed, EPA, Water Board, and Santa Clara County DEH will be notified.

Institutional Controls

NASA has incorporated ICs required by the Site 22 ROD into its land use planning document. In addition, NASA's Facilities Group has incorporated LUCs for Site 22 into its permitting process and lease provisions and maintains copies of environmental records for the remedy. NASA conducts site visits and quarterly inspections as part of IC implementation and continues to maintain and operate the Building 191 pumping station as part of its stormwater drainage and conveyance system to prevent major flooding at the landfill during storm events. NASA provides annual reports to the agencies that detail the effectiveness of IC monitoring and implementation.

3.2.4 Remedy O&M

The remedy O&M at Site 22 has been performed in accordance with the *Final Post-Construction Operations, Maintenance, and Monitoring Plan* (FWEC, 2003a) and the *Final Site 22 Post-Construction Operations, Maintenance, and Monitoring Plan Addendum* (TtEC, 2007). Landfill settlement markers were installed in January 2004 and surveyed every five years to assess stability and movement of the landfill's cover. Groundwater sampling, water level monitoring, landfill gas monitoring, and landfill inspections are performed on a semiannual basis and annual reports are submitted to EPA and the Water Board. The Santa Clara County DEH inspects Site 22 quarterly to check the integrity of the landfill cover. Additional inspections are periodically conducted by the Golf Course at Moffett Field to assess burrowing animal activity and site hydrology. Maintenance issues identified by Santa Clara County DEH are addressed during the maintenance activities.

Quarterly maintenance activities performed at Site 22 are as follows:

- **Landfill Cover Integrity:** Activities include inspecting vegetation cover, animal burrows, erosion, fissures, breaches, manmade disturbance, presence of new deep-rooted (shrubs and trees) vegetation, and condition of existing deep-rooted vegetation.
- **Drainage Systems Integrity:** Activities include checking for slumping or vegetation in drainage channels, vegetation and soil accumulation in drop-ins and pipe inlets, and existence of or damage to drop-in or pipe inlet guards.
- **Vegetation Monitor and Control:** Activities include mowing and related vegetation controls. The vegetation at Site 22 is maintained by The Golf Club at Moffett Field management (NASA tenant).

3.3 Site 26

3.3.1 Basis for Taking Action

Contaminants identified in the RI in the Site 26 aquifers include cVOCs, VOCs, petroleum hydrocarbons, SVOCs, and metals (Navy, 1996). The HHRA indicated that all potential residential exposure pathways associated with groundwater exposure at Site 26 are incomplete and that occupational exposure is the most likely exposure scenario. The HHRA found that occupational exposure to groundwater did not present significant risks to site workers and therefore a potential future residential use scenario was used to select COCs and Remediation Goals (RGs; Navy, 1996). Demolition of

Hangar 3, which is within the LUC boundary of Navy Site 26, is currently in progress. Vapor intrusion at MFA Leasehold was addressed in Environmental Issues Management Plan, MFA Leasehold, Former NAS Moffett Field, California (Erler & Kalinowski, Inc., 2017) and Memorandum to File for Non-Significant Modification to Final Record of Decision Amendment for Installation Restoration Site 26 (Navy, 2021). The COC concentrations in groundwater at Site 26 are lower than those used in the HHRA.

3.3.2 Remedy Selection

In 1996, the Site 26 ROD was signed, and the remedy selected was extraction and treatment of groundwater, ICs and MNA which lead to the installation of the former EATS. As mentioned in Section 2.3.1, the EATS operated from 1999 to 2003 to address impacted groundwater through extraction and treatment.

In 2014, the 1996 ROD was amended to change the remedy to biostimulation/ bioaugmentation, ICs, and MNA monitoring. The EATS was dismantled in 2017 after the 2014 Site 26 ROD Amendment was adopted.

There is also a slight upward hydraulic gradient of the site groundwater which drives groundwater flow from the lower portion to the upper portion of the A Aquifer. Similarly, there is a predominant upward hydraulic gradient driving groundwater flow from the deeper, B Aquifer to the lower portion of the shallower A Aquifer. These upward hydraulic gradients reduce the potential of site contaminants from migrating vertically down in the aquifer. Groundwater flow direction at Site 26 is to the north.

3.3.3 Remedy Implementation

The Navy began construction of the EATS in July 1997. Construction was completed in January 1999 and the EATS operated until 2003 and was dismantled in 2017. When operational, the EATS consisted of five extraction wells that extracted and treated groundwater using an air stripper and liquid-phase granular activated carbon (GAC) vessels. The treated water was discharged to the stormwater system in accordance with the National Pollutant Discharge Elimination System (NPDES) general permit. The EATS processed approximately 67,050,786 gallons of groundwater and removed 23.65 pounds of VOCs while in operation.

The Navy completed treatability studies using in-situ treatment with Hydrogen Release Compound® in 2005 and EHC® in 2009-2010 to dechlorinate cVOCs. With concurrence from EPA and the Water Board, the Navy proposed a plan in April 2013 to modify the current remedy to optimize groundwater cleanup using biostimulation/ bioaugmentation, MNA, and ICs at IR Site 26. The PP was adopted as the 2014 Site 26 ROD Amendment in September 2014.

The Navy prepared a RA Work Plan that was implemented in 2019 with the injection of emulsified vegetable oil (EVO) and *Dehalococcoides* (DHC) microorganisms into the three areas to enhance ongoing in situ bioremediation. Annual groundwater monitoring for VOCs continued during implementation of the remedy. The Navy shifted to long-term monitoring (LTM) in 2020 after completion of the in situ and performance monitoring phases of the RA Work Plan.

Institutional Controls

ICs specified in the 2014 Site 26 ROD Amendment include prohibiting access to groundwater except for treatment and dewatering until cleanup levels are met, notifying property owners and developers, and requiring that any new building planned for construction over the groundwater plume at Site 26 be designed and constructed in a manner that will mitigate potential unacceptable health risks from VI or evaluate and demonstrate that there are not potential unacceptable VI risks prior to construction. ICs will remain in effect until cleanup standards have been met in groundwater underlying the site. In addition, the ICs no longer include a requirement to continue O&M of the Building 191 pump station and storm water drainage system; however, it is still an IC for both Sites 1 and 22.

NASA Environmental Management has revised its ERD to include groundwater use restrictions, as specified in the Site 26 ROD, into NASA's planning documents.

Groundwater Monitoring

As part of the remedy, NASA performs LTM of the groundwater plume at Site 26 and prepares an annual report. The objective of the LTM is to document that MNA is continuing. The LTM program includes assessing well conditions, gauging groundwater levels, measuring groundwater field parameters, and collecting and analyzing groundwater samples from 17 of the 29 Site 26 LTM wells for select VOCs in accordance with the LTM Plan (KEMRON Environmental Services, Inc. [KEMRON], 2018). An additional 12 wells are sampled on a biennial basis.

3.3.4 Remedy O&M

The 2014 Site 26 ROD Amendment changed the 1996 Site 26 ROD remedy of extraction and treatment of groundwater with the EATS, ICs, and MNA monitoring to biostimulation/bioaugmentation, ICs, and MNA.

Biostimulation / Bioaugmentation

The Navy is responsible for achieving groundwater cleanup standards. Since the 2014 Site 26 ROD Amendment, the Navy has performed an injection of EVO and DHC in the first quarter of 2019. NASA's LTM at Site 26, which began in 2021 after assuming OMMR responsibilities from the Navy, has documented that between 2019 and 2020, there was significant reduction in the areal extent of the COC plume as a direct result of the 2019 EVO/DHC injections. The injections resulted in a rapid decline in PCE; TCE; cis-1,2-DCE; and VC distribution between 2020 and 2022.

Institutional Controls

The 2014 Site 26 ROD Amendment prohibits access to groundwater except for treatment and dewatering and notifying property owners and developers and requiring that any new building planned for construction over the groundwater plume at IR Site 26 be designed and constructed in a manner that will mitigate potential unacceptable health risks from VI or evaluate and demonstrate that there are not potential unacceptable VI risks prior to construction. ICs will remain in effect until cleanup standards have been met in groundwater underlying the site. The ICs no longer include a requirement to continue operation and maintenance of the Building 191 pump station and storm water drainage system.

NASA conducts quarterly (or more frequently, as needed) site inspections of the continued maintenance of LUCs. An annual LUC report is prepared in accordance with the NASA Moffett FFA Site Management Plan schedule that addresses the continued implementation and adequacy of LUCs for the site. The inspections use a checklist to document reviews and updates and note any deficiencies and corrective actions undertaken.

The 2023 Site 26 Annual LUC Report indicated that all LUCs are being maintained and no evidence of domestic groundwater use has occurred at the site. Proposed modifications to Hangar 3, which is within the LUC boundary of Site 26, have been on hold due to unsafe conditions inside the hangar. Demolition of the hangar was completed in December 2024, with site restoration being completed in March 2025.. VI at MFA Leasehold was addressed in *Environmental Issues Management Plan, MFA Leasehold, Former NAS Moffett Field, California* (Erler & Kalinowski, Inc, 2017) and *Memorandum to File for Non-Significant Modification to Final Record of Decision Amendment for Installation Restoration Site 26* (Navy, 2021).

Monitored Natural Attenuation

Groundwater is gauged, sampled, and reported annually in accordance with the *Draft Final Long-Term Monitoring Plan, Remedial Action for IR Site 26* (KEMRON, 2018) and *Draft Final 2020 Long-Term Monitoring Report, Installation Restoration Site 26* (Leisnoi Diversified Services, LLC [LDS]/KEMRON, 2021).

3.4 NASA RGRP

The NASA RGRP is a commingled groundwater plume within the central portion of NASA Ames (**Figure 1**). The groundwater plume resulted primarily from off-site upgradient sources (the MEW Superfund site) and from previous Navy operations at Moffett Field. The RGRP includes Site 28/WATS and NASA Groundwater AOR/GWTS per the Allocation and Settlement Agreement.

In 1998, NASA entered into an Allocation and Settlement Agreement for MEW Remedial Program Management Between NASA and Fairchild Semiconductor Corporation, Raytheon Company, and Intel Corporation (NASA, 1998), which pertained to requirements established under the MEW ROD. Under this Agreement, various geographical divisions of responsibility, COCs, and treatment system design, installation, and O&M responsibilities were allocated among the parties (MEW, Navy, and NASA). NASA Ames Groundwater AOR to the MEW Regional Plume is shown in **Figure 1**. In 2015, NASA entered the NASA Moffett FFA with EPA and the Water Board (EPA, 2015), which includes the groundwater cleanup and reporting responsibilities pertaining to NASA under the Allocation and Settlement Agreement, and the MEW ROD requirements were incorporated into the NASA Moffett FFA.

In 2017, NASA combined the reporting of the NASA Ames Groundwater AOR with the former Navy Site 28 WATS Area, which combined is referred to as the NASA RGRP.

3.4.1 Initial Response

The initial response included site characterization, consisting of the *Initial Assessment Study in* 1984 (Naval Energy and Environmental Support Activity [NEESA], 1984), *Confirmation Study* (ESA and JMM, 1986), and Phase I RI (ITC, 1991). In October 1992, EPA determined that the west-side aquifers were affected by the MEW Regional Plume. As a result, EPA determined that west-side aquifers were subject to the 1989 MEW ROD directing remediation of the aquifers; therefore, the Navy agreed to adopt the MEW ROD in a December 1993 amendment to their FFA. This amendment specifies that the Navy agrees to remediate the source control removal areas in accordance with the MEW ROD for contamination attributable to Navy sources. The contaminated medium at WATS is the groundwater in the A1 and A2 aquifer zones. Because the Navy adopted the MEW ROD, an RI/FS and associated risk assessments were not completed.

Initial response actions by the Navy included removal of ASTs, USTs, and sumps associated with potential sources, removal of VOC-impacted soils, and removal of approximately four million gallons of PCE-impacted water in the WATS area. Source control measures were also implemented in 1994 to provide hydraulic control and treatment of sources with the installation of WATS and GWTS (NASA operated systems). There are three systems installed including the MEW GWTS to extract, treat, and contain impacted groundwater from the commingled plume (within the RGRP AOR).

3.4.2 Basis for Taking Action

Site characterization found VOCs primarily present in the upper and lower portions of the A Aquifer with cVOCs detected most frequently within Site 28. Additionally, VOCs have historically migrated into the Site 28 area from upgradient MEW sources associated with the MEW Regional Plume (**Figure 1**). An environmental assessment prepared by EPA as part of the MEW RI/FS was used to evaluate threats to human health and the environment. The Environmental Assessment noted that most COCs present in groundwater and subsurface soils were VOCs and cVOCs. The Environmental Assessment concluded that exposure to contaminated groundwater posed the greatest public health concern since COCs are not present at elevated levels in surface soils and COC exposure to flora and fauna was negligible (EPA, 1989).

Since the 1989 MEW ROD, the toxicity of TCE and its VI potential into buildings overlying shallow groundwater contamination is a new concern. In August 2010, EPA amended the MEW ROD to select a remedy for the VI pathway to prevent groundwater VOCs from migrating into indoor air or accumulating in enclosed building spaces that exceed indoor air cleanup criteria for long-term exposure for residential and commercial buildings (EPA, 2010). The Navy is responsible for implementing the VI remedy identified in the MEW ROD Amendment within the area of Moffett Field that is impacted by Navy sources (Navy Area) which includes areas of Site 28 where TCE concentrations in shallow groundwater are greater than 5 µg/L. For NASA, this area of responsibility is the VI AOR discussed in Section 3.5 below.

3.4.3 Remedy Selection

The RGRP remedy is specified in the 1989 MEW ROD (EPA, 1989), two subsequent ESDs (EPA, 1990, 1996), and the 2015 NASA Moffett FFA and consists of groundwater extraction and treatment with the objective of mass removal and hydraulic containment of VOC-contaminated groundwater. The RGRP remedy is designed to protect local water supplies by remediating and controlling groundwater that contains elevated concentrations of MEW COCs, including the control of the discharge of treated groundwater to surface water.

In the northern portion of the NASA RGRP area, the NASA GWTS treats groundwater pumped from two extraction wells located within the NASA Groundwater AOR. In the southern portion of the NASA RGRP area, nine extraction wells located within Site 28 pump water to the WATS. WATS is a groundwater treatment system located on the west side of the runways, west of Hangar 1, which was installed to clean up VOCs and petroleum hydrocarbons in the A1 and A2 aquifer zones. Plumes from local Moffett sources have commingled with a Regional Plume. VOCs were released to the environment by the MEW PRPs, the Navy, and NASA at or near Moffett Field. Since April 2023, the WATS also receives partially treated groundwater from the Navy's temporary groundwater pretreatment system, which receives groundwater from three extraction wells located in the TIA and Building 88 areas at the upgradient edge of Site 28.The Navy's temporary groundwater pretreatment system was removed from service in August 2024, after the required upgrades to the WATS treatment capability were completed and the untreated groundwater from the TIA wells was routed directly into the WATS.

3.4.4 Remedy Implementation

Groundwater Extraction and Treatment

In accordance with the MEW ROD, the Navy installed and operated WATS from November 1998 through September 2016 as an integral component of the RGRP. (NASA assumed OMMR responsibilities on October 1, 2016). WATS is a groundwater treatment system located on the west side of the runways, west of Hangar 1, which was installed by the Navy to clean up VOCs and petroleum hydrocarbons in the A1 and A2 aquifer zones. WATS construction began in July 1997, and operation started in November 1998. Groundwater extraction, treatment, and monitoring are ongoing. Four areas within the WATS area were identified as potential sources of VOC or fuel-related groundwater contamination: Building 29, Building 31, former Building 88, and the Hangar 1 former aircraft wash rack (TtEMI, 2001b). In addition, ICs have been implemented to prevent exposure to or ingestion of contaminated groundwater.

The remedial objective of NASA's GWTS is treatment and hydraulic containment of VOC-contaminated groundwater downgradient from known and/or suspected sources located within NASA's AOR to the MEW RGRP. The NASA GWTS was designed to address two areas that were discussed in the *Proposed Locations of NASA Ames Groundwater Extraction Wells in the VTOL Pad and South Navy Warehouse Areas* (Erler & Kalinowski, Inc., 1995). The first area of concern is located south of the former Navy Warehouse (building N144), between buildings N240 and N259. Although no soil source area was identified during groundwater investigations conducted in 1994, contouring of TCE concentrations in groundwater in this area suggested a potential source area of TCE contamination in the A1 Aquifer. However, recent plume mapping and concentration data indicate that the plume in this area is a continuation of the Regional Plume. NASA extraction wells NASA-1A and NASA-2A were installed in the A1 Aquifer to address this area in 2000 and groundwater extraction was initiated in late 2001. Pumping from NASA-2A was suspended on April 28, 2009, with approval from the EPA and Water Board.

The second area is located downgradient of Navy Site 8 North, near the southwest corner of the Vertical Take-Off and Landing (VTOL) pad. As documented in the *Center-Wide Sampling and Analysis Program, Volume VII: Work Plan for Area of Investigation7* (Erler & Kalinowski, Inc., 1994), the likely source of any solvent contamination to groundwater in this area was from chemicals previously located at the Navy Site 8 storage areas. In 1994, NASA removed solvent-contaminated soil exceeding cleanup levels by excavating over 3,000 CY of soil (*Site 8-North Soil Excavation & Source Removal* (NASA, 1994). NASA extraction wells NASA-3A and NASA-4A were installed in the A1 Aquifer to address residual groundwater contamination downgradient of this area in 2000 and groundwater extraction began in late 2001. Pumping from NASA-4A was suspended on April 28, 2009, with approval from the EPA and Water Board.

Groundwater Monitoring

The effectiveness of the remedy is monitored using a network of RGRP monitoring wells. As part of the long-term RGRP groundwater monitoring program, NASA samples 130 RGRP monitoring wells. NASA also participates with the MEW Companies in the annual RGRP water level gauging event and measures the groundwater elevation of 289 wells.

On February 13, 2015, Geosyntec submitted the *Request for Reduction in Groundwater Monitoring Frequency* to EPA, which presented an evaluation of historical monitoring data and a request to reduce the groundwater gauging frequency to an annual basis and the groundwater sampling frequency to a biennial basis. In March 2016, EPA conditionally approved the request in a letter titled *Conditional Approval –Trial Reduction of Groundwater Monitoring Frequency*). The trial reduction calls for annual water level gauging in September and biennial groundwater sampling in September/October of even years.

3.4.5 Remedy O&M

NASA GWTS

The NASA GWTS began operation in 2001 and currently treats up to 20 gallons per minute (gpm) of water extracted from A1 Aquifer wells, NASA-1A, and NASA-3A. Groundwater extraction from wells NASA-2A and NASA-4A was suspended in 2009. Extracted groundwater is treated with two 5,000-pound GAC vessels operating in series. Treated groundwater is then discharged to Stevens Creek.

During this FYR period (2019-2023), the NASA GWTS treated approximately 30 million gallons of groundwater and removed 8 pounds of total VOCs. The extraction rate averaged over the five-year period was 11.3 gpm and the average operating time of the treatment system was 98.4%.

WATS

During 2021, the pump rates for WATS extraction wells and sumps were periodically adjusted following system rehabilitation and pump replacements to expand the area of capture and increase COC mass removal. The VOCs removed from the A1 and A2/B1 Aquifers at Site 28 predominantly include PCE; TCE; cis-1,2-DCE; and VC and represent approximately 97 percent of VOCs removed.

During this FYR period (2019-2023), the WATS treated approximately 116 million gallons of groundwater and removed 578 pounds of total VOCs. The extraction rate averaged over the five-year period was 44.3 gpm and the average operating time of the treatment system was 83.8%.

3.5 NASA VI AOR

3.5.1 Basis for Taking Action

In August 2010, EPA amended the MEW Site 1989 ROD to address health risks associated with long-term exposure to TCE and other MEW Site COPCs through the VI pathway in current and future buildings overlying the shallow subsurface contamination at the MEW Site. The ROD Amendment defines the VI Study Area as the area where TCE concentrations in shallow groundwater are greater than 5 µg/L or ppb. EPA selected a remedy for the VI pathway to prevent subsurface volatile contaminants in groundwater from migrating into indoor air or accumulating in enclosed building spaces at levels exceeding its indoor air cleanup criteria for long-term exposure for residential and commercial buildings (EPA, 2010).

It should be noted that the boundaries for NASA's RGRP and VI AOR are similar, but not identical. The groundwater remedy in the NASA RGRP in Site 28 is NASA's responsibility while the VI remedy in Site 28 remains the Navy's responsibility until the Navy has an operating remedy in place. The NASA VI AOR is downgradient of Site 28. Any NASA structures that reside over the regional plume fall under NASA's VI AOR area and NASA is responsible for ensuring that tenants are in compliance with VI requirements. This excludes Buildings N210, N239, N239A, N243, and N243A; these are the responsibility of the Navy VI AOR.

3.5.2 Remedy Selection

The 2010 ROD Amendment selected a remedy for the VI pathway to prevent subsurface volatile contaminants in groundwater from migrating into indoor air or accumulating in enclosed building spaces at levels exceeding its indoor air cleanup criteria for long-term exposure for residential and commercial buildings. TCE is the primary COC for the VI pathway, along with PCE; dichloroethylene (DCE); VC; 1,1-DCA; and 1,1-DCE (EPA, 2010). In September 2011, in coordination with the MEW, NASA Ames, and the Navy, EPA developed the SOW for the VI Remedy RD and RA. Pursuant to an agreement among NASA Ames, Navy, and the MEW, each entity is responsible for implementing the VI Remedy in its designated AOR (**Figure 3**; ERT, 2017).

The remedy provides ICs to: 1) ensure the operation and monitoring of ECs used to prevent levels of site COCs associated with the VI pathway from exceeding indoor air cleanup levels; 2) ensure that the appropriate ECs are incorporated, where necessary, into new building development at the site; and 3) provide information to building owners and tenants regarding the appropriate VI remedy for each building. The remedy also provides a tiering system to determine the appropriate response action for each building/property within the VI Study Area based on indoor air sampling with or without a HVAC system in place and other lines of evidence.

3.5.3 Remedy Implementation

LTM of the NASA VI AOR includes building surveys and the collection of a series of indoor and outdoor air samples for those buildings/structures with the NASA VI AOR is based on the *Draft Building-Specific Vapor Intrusion Sampling Plan, 2024 Long-Term Monitoring Sampling Event* (BB&E, 2023b). Building surveys were conducted prior to each round of indoor air sampling activity to identify each building's structural condition, observe the ventilation system and use by the building occupants, observe operational procedures in laboratory and maintenance areas, and gather information about building use schedules. Indoor air sampling was performed in 2012 (Phase I), 2015 (Phase II), 2016 (Phase III; Earth Resources Technology, Inc. [ERT], 2017), 2018 (ERT, 2019; Site 28; NOREAS, Inc., 2019), and 2020 (ERT, 2020). The building surveys and previous indoor air sampling results were used to select potential sampling locations within each building for the long-term indoor VI monitoring plan.

The buildings were tiered using the indoor air sampling results and Tables 6A and 6B of the 2010 ROD Amendment was used to determine the need for a response action in accordance with the Response Action Tiering System per the *Draft Building-Specific Vapor Intrusion Long-Term Monitoring Plan* (ERT, 2017). Indoor air quality results for COCs were compared to the 2010 ROD Amendment cleanup levels and to ambient outdoor air concentration ranges with consideration of whether an air quality engineering control (EC) is in place (ERT, 2017) to determine each building's tier.

3.5.4 Remedy O&M

The *Draft Building-Specific Vapor Intrusion Long-Term Monitoring Plan* (ERT, 2017) evaluated and tiered the buildings in the NASA VI AOR for response action in accordance with the Response Action Tiering System per the 2010 ROD Amendment. Buildings classified as Tier 3A require biennial evaluation and sampling. Buildings classified as Tier 3B require sampling once every five years. The tiering recommendations will remain the same until subsequent sample data indicates otherwise (BB&E, 2023a).

3.6 NASA LUCs

3.6.1 Basis for Taking Action

In 2015, NASA entered the NASA Moffett FFA with EPA and the Water Board. Pursuant to the FFA, as lead federal agency, NASA Ames conducts response actions in accordance with CERCLA. NASA Ames also implements LUCs to ensure the protectiveness of both NASA Ames response actions and CERCLA response actions conducted by the Navy and the MEW PRPs.

NASA Ames has responsibility for LUCs arising from the following:

- Response actions undertaken by NASA at sites for which NASA is the source of contamination; and
- Response actions undertaken by Responsible Parties (Navy and MEW Companies) on NASA Ames that require implementation of LUCs to be fully protective of human health and the environment. Such LUCs are documented in the RODs and approved by EPA and the Water Board.

In addition to specific LUCs that are established for response actions at individual sites, as property custodian, NASA Ames' general LUC responsibilities for NASA and other Responsible Parties' response actions include:

- Provide reasonable site access for response action implementation and regulatory agency oversight;
- Prevent alteration of, interference with, or damage to response actions by NASA, NASA contractors, or tenants;
- Prevent activities and land use inconsistent with LUCs;
- Obtain concurrence from EPA and the Water Board, with notification to Responsible Parties, to modify or terminate any LUCs; and
- Incorporate LUC requirements in NASA Ames land planning documents, contracts, leases, agreements, and deed covenants.

3.6.2 Remedy Selection

NASA Ames has LUC responsibilities subject to the NASA Moffett FFA for the following sites:

- Navy Site 1 Landfill,
- Navy Site 22 Landfill,
- Navy Site 26,
- Navy Site 28,
- Navy Site 29 Hangar 1,
- Former NAS Moffett Field Area of MEW Regional Plume (Groundwater), and
- Former NAS Moffett Field Area of MEW Regional Plume VI Study Area.

In June 2023, NASA updated its LUC Implementation and Monitoring Plan to include former Navy Site 14. Site 14 South was closed under the UST Low-Threat Closure Policy Guidelines (Water Board, 2012), with the Navy receiving Uniform Case Closure and NFA notification from the Water Board on September 15, 2022, and provided the required LUCs for Site 14 South.

3.6.3 Remedy Implementation

NASA Ames identifies new LUCs, facilitates implementation of LUCs, communicates LUCs requirements to NASA Ames organizations, contractors, and tenants, maintains the Geographic Information System (GIS)-based LUCs map, monitors the maintenance of LUCs, and reports to EPA and the Water Board on continued implementation of LUCs pursuant to the NASA Moffett FFA. All NASA Ames organizations, contractors, and tenants are responsible for complying with and maintaining LUCs as described in the implementing mechanisms. NASA implements LUCs per the NASA Moffett FFA through the following mechanisms:

- NASA Ames LUCs IMP Update
- NASA Ames Development Plan Final Programmatic Environmental Impact Statement
- NASA Ames ERD
- NASA Ames Center Master Plan
- NASA Procedural Directive 8500.1, NASA Environmental Management
- Ames Procedural Requirements 8500.1, Ames Environmental Procedural Requirements
- Ames Policy Directive 8822.1, NRP Design Review Program
- Ames Procedural Directive 8829.1, NASA Ames Construction Permits
- Environmental Issues Management Plan
- NASA Ames Leases
- LUCs Map

LUC inspections are conducted to visually observe the continued maintenance of LUCs at NASA Ames. Inspections are conducted quarterly by Santa Clara County DEH inspects Site 1 and 22 or more frequently, as needed, by NASA (Site 1) and a NASA tenant (Site 22).

3.6.4 Remedy O&M

LUC inspections are conducted to visually observe the continued maintenance of LUCs at NASA Ames per the 2023 IMP Update. NASA Ames Environmental Management Division conducts regularly scheduled site inspections quarterly, or more frequently as needed, to visually observe the continued maintenance of LUCs. Inspection observations are recorded on LUC checklists. The LUC checklist includes two observational categories: “In Compliance”, which indicates that no issues were observed, or “Action Needed”, which means the condition noted was not in compliance. Items marked as “Action Needed” will be addressed as soon as possible.

An annual LUC report is prepared in accordance with the NASA Moffett FFA Site Management Plan schedule. The annual report addresses the continued implementation and adequacy of LUCs for each site, including the results of inspections (including inspection checklists), document reviews and updates, and any noted deficiencies and corrective actions taken.

4 PROGRESS SINCE LAST REVIEW

This section summarizes the progress of remedy implementation at Sites 1, 22, and 26 since the previous FYR reports (BB&E, 2020 and Navy, 2020) were prepared. This is the first FYR for the NASA RGRP, NASA VI AOR, and NASA LUCs under the responsibility of NASA and progress of remedy implementation is summarized for the last five years performed by NASA and others. The following sections discuss the status of recommendations and follow-up actions that the previous FYR report specified as necessary to maintain protectiveness of the remedy at each site.

Groundwater samples were collected at 26 Areas of Potential Concern (AOPCs) across Moffett Field, including Site 1, Site 2, Site 22, Site 26, NASA RGRP, and Site 28 during the 2023 PFAS SI. PFAS was detected in groundwater samples at varying concentrations at the AOPCs. Some of the PFAS concentrations detected in groundwater exceeded the 2022 EPA RSLs and/or the California RWB groundwater ESLs. Pertinent information from the 2023 SI, including the **Executive Summary** and Conclusions Sections, along with supporting data **Tables 5-2, 5-4,** and **5-7** and figures are included in **Appendix E**. The 2023 SI recommended that additional investigations be performed to evaluate the horizontal and vertical extents of PFAS in groundwater, routine monitoring of the treated effluent from the groundwater systems, and further evaluation of surface water impacts.

As of 2024, NASA's Expanded PFAS Site Inspection (ESI) is ongoing and will not be completed during this FYR review period. Therefore, no data or information regarding any preliminary findings on the nature and extent of PFAS can be incorporated in this FYR.

As summarized in **Appendix E, Table 5-2**, PFAS were detected at a high frequency in certain soil samples. Notably, of the PFAS with established screening levels, PFOA and PFHxS were detected in 25 of the 28 collected soil samples and PFOS was detected in 23 of the 28 samples. PFOS was present in 15 of the samples at concentrations exceeding the residential RSL and PFOA was present in three of the samples at concentrations exceeding the residential RSL.

Similarly, certain PFAS analytes in groundwater samples (**Appendix E, Table 5-4**) were detected at high frequencies. Notably, of the PFAS with established screening levels, PFHxS was detected in 75 of the 79 collected groundwater samples, while PFBS, PFOA and PFOS were detected in 71 of the 79 samples. The groundwater RSL was also exceeded at high frequencies in certain PFAS analytes, mostly notably PFOS (59 samples), PFOA (53 samples), and PFHxS (42 samples).

4.1 Progress for Site 1

This section and **Table 4-1** present the recommendations and follow-up actions from the fifth FYR for Site 1 signed in June 2020. The previous FYR for Site 1 indicated that no issues and follow-up actions were noted; however, to improve performance, several recommendations were noted. **Table 4-1** indicates the status of these recommendations and follow-up actions since the 2020 FYR.

Table 4-1

Status of Site 1 Previous FYR Recommendations

Recommendations	Status of Previous FYR Recommendations
Perform landfill inspections on a quarterly basis to ensure that any burrows discovered from burrowing animals are backfilled to prevent exposing landfill wastes.	Recommendation addressed – Landfill inspections are conducted quarterly, and any burrowing activity is noted. The burrowing mammal management program was implemented in 2017 and is ongoing with success; results are summarized in the annual Site 1 reports.
Calculate a revised barium CCL screening level for the three downgradient point of compliance (POC) monitoring wells (W1-1R, W1-15, and W1-19) on an annual basis utilizing the 95% upper confidence limit of historical barium concentrations in these wells.	Recommendation addressed – Statistical evaluations of the barium sampling data were performed in 2022 and 2023. The results of the statistical evaluation concluded that there is no release from within the landfill and that NFA is required. Further evaluation of the applicability of naturally occurring metals as indicators of releases from the landfill should be performed.
Enforcing land use restrictions by not allowing any activities that would compromise the integrity of the landfill cap at Site 1.	Recommendation addressed – Landfill inspections are conducted quarterly and periodically to ensure the ICs are being implemented and landfill cap integrity is not compromised. The inspection results are summarized in the annual Site 1 reports.
Evaluate potential sea level rise effects on remedy when considering future planning.	Recommendation addressed – An evaluation of the sea level rise effects based on future planning for the Site 1 groundwater is presented in Section 1.4. Additional considerations may include pumping capacity modifications to Building 191 pumphouse.

4.2 Progress for Site 22

This section and **Table 4-2** present the recommendations and follow-up actions from the fourth FYR for Site 22 completed in June 2020. The previous FYR for Site 22 indicated that no issues and follow-up actions were noted; however, to improve performance, several recommendations were made. **Table 4-2** indicates the status of these recommendations and follow-up actions since the 2020 FYR.

Table 4-2

Status of Site 22 Previous FYR Recommendations

Recommendations	Status of Previous FYR Recommendations
Perform landfill inspections on a quarterly basis to ensure that any burrows discovered from burrowing animals are backfilled to prevent exposing landfill wastes.	Recommendation addressed – Landfill inspections are conducted quarterly, and any burrowing activity is noted. The burrowing mammal management program was implemented in 2017 and is ongoing with success; results are summarized in the annual Site 22 reports.
Enforcing land use restrictions by not allowing any activities that would compromise the integrity of the landfill cap at Site 22.	Recommendation addressed – Landfill inspections are conducted quarterly and periodically to ensure the ICs are compliant and the landfill cap integrity is not comprised. The results of these inspections are summarized in the annual Site 22 reports.
Evaluate potential sea level rise effects on the Site 22 remedy when considering future planning.	Recommendation addressed – An evaluation of the sea level rise effects based on future planning for the Site 22 groundwater is presented in Section 1.4. Additional considerations may include pumping capacity modifications to Building 191 pumphouse.

4.3 Progress for Site 26

This section and **Table 4-3** present the issues, recommendations, and follow-up actions from the third FYR for Site 26 completed in August 2020. The Navy 2020 Site 26 FYR identified two issues. The issues and status of the issues are provided on **Table 4-3**.

Table 4-3

Status of Site 26 Previous FYR Issues and Recommendations

Recommendations	Status of Previous FYR Recommendations
Soil gas exceeding indoor air screening levels for VOCs was detected beneath Hangar 2 and 3 during a sub-slab soil gas investigation (EKI, 2014). The cVOC soil gas screening values were exceeded at one or more locations at Hangar 2 and 3.	Recommendation addressed – Groundwater and soil gas data collected from Hangar 2 and Hangar 3 perimeter did not indicate any new unknown groundwater sources requiring additional RAs to meet the RAO in the ROD Amendment.
The current LUC area boundary for Site 26 does not fully capture the complete Hangar 2 and 3 footprints. In addition, the results from the recommended soil gas and groundwater investigation may influence the current groundwater plume dimensions.	Recommendation addressed – Groundwater and soil gas data collected from Hangar 2 and from the perimeter of indicated the LUC boundary needed to be revised to remain protective. The LUC boundary was revised to include the entirety of Hangars 2 and 3 through a Memorandum to File as a Non-significant Modification to the Final ROD Amendment.

4.4 Progress for NASA RGRP

This is the first NASA FYR for the NASA RGRP; however, EPA and the Navy have completed multiple FYRs for the MEW Superfund Site which includes the NASA RGRP.

4.4.1 WATS

This section and **Table 4-4** present the issues, recommendations, and follow-up actions from the third FYR for Site 28 signed in August 2020 as well as from the fourth EPA FYR for the NASA Groundwater AOR signed in 2019.

Table 4-4

Status of WATS Previous FYR Review Issues and Recommendations

Issue	Recommendations and Follow-up Actions	Status of Previous FYR Recommendations
Additional PCE sources have been identified in the TIA and downgradient of former Building 88 area.	Source removal by excavation near 28SI-16 and the TIA, install A zone extraction well within the excavation footprint, install extraction well screened in the lower A/B1 or B2 Aquifer, for source reduction and control of downward vertical migration of COCs. Additional extraction well recommended to reduce PCE sources migrating downgradient of former Building 88 area.	Issue addressed – NASA anticipates the Navy's 2019 enhanced anaerobic bioremediation (EAB) / in-situ chemical reduction (ISCR) effort and three additional extraction wells will continue to have a notable impact on the distribution of COCs and the extent of hydraulic containment within Site 28.
Low operating performance of Source Control Extraction Well EA1-1.	Replace A-zone source control extraction well EA1-1 which has pumped significantly less than other upper A Aquifer source control extraction wells since the startup of WATS in 1998.	Issue addressed – Part of Navy's TIA remediation decommissioned and replaced EA1-1 extraction well to improve recovery for the Navy's RAOs at TIA. EA1-1R has been operating since September 2021.
East plume of VOCs beneath and east of Hangar 1 is not fully contained and cleaned up by the Site 28 extraction wells.	Further evaluate hydraulic control of the Site 28 extraction well network and assess if the optimized RAs at the TIA adequately control and remediate VOCs beneath Hangar 1 and the eastern VOC plume.	Issue addressed – Since the TIA and Building 88 are directly upgradient of Hangar 1, execution of Navy remedy has improved VOC destruction via EAB/ISCR and hydraulic capture of COCs that currently flow towards Hangar 1.
cVOCs may be migrating beyond WATS to the north near 14D09A in the A aquifer zone (EPA, 2004).	Evaluate options to increase capture in the A1 Aquifer.	Historical capture zone mapping indicated complete capture of A1 Aquifer of regional plume at Site 28. Several A1 Aquifer extraction wells were rehabilitated in 2019 and 2020 to increase pump rates. Optimized flow rate in REG-6A to improve hydraulic control. Recently installed extraction wells in TIA should increase upgradient plume capture and reduce COC migration.

Issue	Recommendations and Follow-up Actions	Status of Previous FYR Recommendations
Uncertainty of plume capture near REG-6A and increased degradation cVOCs in some wells (EPA, 2004).	Evaluate methods for enhancing monitoring to improve capture zone definition and evaluate options for additional capture.	14D30A was added to NASA's sampling network for additional data, capture zone definition, and channel identification. NASA will identify non-routine monitoring wells and/or additional analytes that may provide additional data for capture zone definition and channel identification.
Elevated TCE (>1,000 µg/L) in A2/B1 Aquifer near Hangar 1 (EPA, 2004).	Install new A2/B1 extraction well. Evaluate capture of area.	EA2-3 pumping in January 2004 improved per Navy annual reports. Navy EAB/ISCR studies in 2015 and 2016 with additional 2021 injection. Navy installed two extraction wells in 2020 with intermittent operation since April 2023 (APTIM, 2024).
TCE in the B2 Aquifer, indicates downward, vertical gradient of COCs (EPA, 2004).	Monitor selected wells in the B2 Aquifer on an annual basis.	Per the Navy Final Work Plan for the TIA (APTIM, 2020), no B2 Aquifer extraction is planned (APTIM, 2020). The Navy identified four existing B2 Aquifer wells for annual sampling (APTIM, 2024).
Potential COC sources in the former Building 88 area, associated sewer lines, and TIA (Navy, 2010).	Continue implementation of treatability study and next course of action based on the results.	EAB/ISCR (APTIM, 2020) was performed in 2015, 2016, and 2021. The installation of three groundwater extraction wells in the TIA and completion groundwater pretreatment in 2022. Full-scale system operation anticipated for 2023 (APTIM, 2024).

Issue	Recommendations and Follow-up Actions	Status of Previous FYR Recommendations
Groundwater contamination plume is not fully captured by existing extraction wells (EPA, 2009a and 2009b).	Install new extraction wells and optimize rates to achieve plume capture and enhance mass removal.	Historical capture zone mapping by MEW and Navy shows complete capture in the A1 Aquifer of regional plume in Site 28. Extensive rehabilitation of all Site 28 extraction wells resulted in increased flow rates. Continued extraction well repair anticipated to yield additional optimization. Recently installed Navy extraction wells in the TIA should increase plume capture once fully operational.

4.4.2 NASA GWTS

This is the first NASA FYR for the NASA GWTS; however, the EPA has completed multiple FYRs for the MEW Superfund Site, which includes the NASA RGRP. This section and **Table 4-5** present the issues, recommendations, and follow-up actions from the fourth EPA FYR for the NASA Groundwater AOR signed in 2019.

Table 4-5

Status of NASA GWTS Previous FYR Review Issues and Recommendations

Issue	Recommendations and Follow-up Actions	Status of Previous FYR Recommendations
Unknown COCs in the A2/B1 Aquifer in near 14D25A2 and WU4-19 (EPA, 2004).	Evaluate options to increase capture in this area.	NASA identified plume boundaries in northernmost A2/B1 Aquifer (ERT, 2016). The COC source is located upgradient of NASA's AOR and will continue to monitor plume edge. Since 2017 extensive O&M, increased the upgradient extraction at EA2-2 was increased and maintained from 9.5 gpm (2016) to 13.5 gpm (2020). Downgradient impacts from recent Navy EAB/ISCR work in the TIA will be evaluated over time.
Due to declining efficiency of groundwater remedy will not achieve groundwater cleanup levels for many decades (EPA, 2014 & 2019).	Implement optimization pilot tests at the facility specific areas and based on results, develop and propose a new groundwater remedy plan.	NASA will look to maximize mass removal by optimizing flow of existing wells in high COC areas and assessing locations suitable for in-situ treatment or potential relocation / replacement of extraction wells. Additionally, NASA believes MNA may be a viable remedy for the leading edge of the A1 Aquifer plume, near NASA-3A. NASA intends to evaluate MNA by further evaluating existing hydrogeologic and geologic data to better characterize the plume boundaries and hydrogeologic conditions.
No ICs selected for groundwater remedy to minimize the potential for human exposure to contamination and protect the integrity of the remedy (EPA, 2009c, 2014, and 2019).	Include groundwater ICs.	LUCs were the for groundwater in the 1989 MEW ROD. However, NASA has implemented LUCs for groundwater at the Site 28 WATS area, the former NAS Moffett Field Area of MEW Regional Plume, and NASA's AOR to the MEW Regional Plume. NASA's 2017 IMP and 2023 NASA Ames LUC IMP Update has restrictions on well construction, non-interference with remedy, and access provisions to operate the remedy.

4.5 Progress for NASA VI AOR

This is the first FYR for the NASA VI AOR since the implementation of the remedy component.

4.6 Progress for NASA LUCs

This is the first FYR for the NASA LUCs since the implementation of the remedy component.

5 FIVE-YEAR REVIEW PROCESS

The FYR process at each of the sites addressed in this report consisted of community notifications and involvement, site inspections (**Appendix A**), data reviews, and site interviews (**Appendix B**).

Community Notification and Involvement

The local community was notified of the development of this FYR during the May 2, 2024 Community Advisory Board meeting and would be subsequently notified when the Draft FYR is submitted for regulatory review and posted in the Regional Board 2/San Francisco Bay *GeoTracker* website. A public notice will be placed in the *Mountain View Voice* stating the purpose of the FYR under CERCLA, which describes the remedies selected to address contaminated soils and groundwater and conveyed the status of remedy implementation for each site. The public notice will also inform the community that the Draft FYR will be available for review on the *GeoTracker* website and the Mountain View Public Library. When the Final FYR is complete it will also be available on the GeoTracker website and the Mountain View Public Library. A copy of the public notice is in **Appendix C**.

Upon completion of the FYR Report, a second public notice is planned to inform the community of the findings. This FYR Report will be made available as a PDF on the Regional Board 2/San Francisco Bay *GeoTracker* website and at the Mountain View Public Library, Government Publications Department, 585 Franklin Street, Mountain View, California, 94041. The Mountain View Public Library is the Information Repository for the FYR.

Site Interviews

During the FYR process, interviews were conducted to document any perceived problems or successes with the remedies that have been implemented to date. The results of these interviews are summarized below by each site.

Site Inspections

BB&E conducted inspections for this review between February 7, 2024, and March 27, 2024. The purpose of the site inspections was to review and document current site conditions and to assess the protectiveness of the remedy at each site. EPA's Comprehensive Five-Year Review Guidance (EPA, 2001) provides a site inspection checklist that was modified and used during the site inspections. The modified checklists completed during the inspections along with the site photographs are included as **Appendix A**.

Data Review

Data generated during the FYR period was reviewed to assess the protectiveness of the remedy, remedy performance, and progress towards meeting RAOs.

5.1 Site 1

This section summarizes the site interviews, site inspection, and data review for Site 1.

5.1.1 Site Interviews

Interviews with the following points of contact were conducted for the Site 1:

- Hunter Dang – Solid Waste Program, Santa Clara County DEH
- Yvonne Fong – EPA Project Manager, EPA Region 9 Superfund and Emergency Management Division
- Nicole Jorgensen – Senior Registered Environmental Health Specialist (REHS), Solid Waste Program, Santa Clara County DEH
- Dana McCarthy – Engineering Geologist, Water Board
- Luke Metz – Environmental Restoration Specialist, BB&E/ERT
- AJ Sekhon – Solid Waste Program, Santa Clara County DEH
- Elizabeth Wells – Senior Water Resource Engineer, Water Board

Interview records are presented in **Appendix B**.

The interviewees were aware that NASA has been conducting methane measurement data, water level gauging data, groundwater sampling analytical data, and post-closure care (site inspections and as needed repairs) at Site 1. The interviewees felt well informed on the progress at Site 1 during this FYR period.

5.1.2 Site Inspection

A site inspection for Site 1 was conducted by Mr. Brian Reddig, P.G., on behalf of NASA on February 7, 2024. Mr. Reddig was also accompanied by Ms. Nicole Jorgensen, Mr. Luke Metz, and Mr. Hunter Dang with the County. Access to Site 1 is initially controlled by the main security checkpoint for Moffett Field and secondly by a security checkpoint located south of the runways that restricts access by unauthorized personnel to the east side of Moffett Field. In addition, Site 1 Former Landfill is enclosed within a chain-link fence, except for the northwest side which is bordered by a Storm Water Retention Pond (SWRP). There are currently two locked gates for authorized entry into the Site. Unauthorized entrance to Site 1 can be accomplished by way of the SWRP when it is dry or from the Moffett Field Bay Trail at the northeast end of the site where the fence ends. Remedies for Site 1 include landfill cover/containment, access controls, and ICs.

General observations noted during the Site 1 inspection included the following:

- O&M documents, Health and Safety Plans, training records, gas generation and monitoring records, and cost records were readily available and up to date.
- Fencing and security signs were in good condition.
- ICs were implemented and enforced appropriately.
- Roads and access paths were in good condition.
- The landfill surface was free of settlement, cracks, and erosion. Only one squirrel burrow was observed.

- No ponding was present and drainage systems appeared to be working effectively.
- The inspected gas vents and monitoring wells were properly secured/locked.

Indicators of potential O&M challenges and opportunities for optimization include the following:

- Burrowing mammal management will continue to be a critical O&M issue at Site 1. An evaluation of the burrowing mammal mitigation measures should be completed.
- The continued operation of the B191 Pump Station will be required to prevent flooding in the vicinity of Site 1.
- The presence of pickleweed in a portion of Site 1 presents challenges to employing more aggressive burrowing mammal management techniques.
- The presence of the Western Snowy Plover in the SWRP during breeding season has impacted the wet season event of the semiannual sampling schedule.

5.1.3 Data Review

A data review for Site 1 was based on the following and presented in **Appendix F**:

- Draft 2023 Annual Report, Site 1 and Site 22 Landfills, Moffett Federal Airfield (BB&E 2024)
    - Figure 3 - Site 1 Landfill Groundwater Level Measurement and Monitoring Locations
    - Figure 6 - Site 1 Landfill Potentiometric Surface, October 2023
    - Figure 9 - Site 1 Landfill Methane Monitoring Locations
    - Appendix D - Analytical Data Graphs
- Final 2022 Annual Report, Site 1 and 22 Landfills, Moffett Federal Airfield (BB&E 2024)
    - Appendix J – Barium Statistical Analysis Report

Based on the data reviewed for the FYR period, the following conclusions regarding Site 1 are made:

- Groundwater elevations and potentiometric surface analyses indicate that the predominant groundwater flow direction (southeast) was generally consistent over the FYR period and is also generally consistent with historical groundwater flow direction, but with a slightly more eastward vector towards Building 191.
- Dissolved Barium concentrations over the FYR period were identified to be slightly above the CCL in both upgradient and downgradient monitoring wells. Concentrations of dissolved metals throughout the FYR period were consistent with historical results.

- The methane monitoring results throughout the FYR period do not indicate landfill gas migration off-site above the action limit.
- Burrowing at Site 1 requires ongoing monitoring and abatement measures. The burrowing mammal management program has been successful. Fumigation was reintroduced to Site 1 in the fourth quarter of 2018. Carbon monoxide application continues at Site 1 to have greater control of the burrowing activity and reduce potential impact to Site 1 biotic barrier integrity. Fumigation applications at Site 1 during this FYR occurred on December 3, 2020, and continues into 2024. The landfill cover is intact and functional. Overall, the remedy remains effective in protecting human health and the environment.
- The LUCs for Site 1 are in place and remain effective. Landfill subsidence is not of concern at Site 1.

The barium concentrations in downgradient POC monitoring wells were identified above the revised CCLs during the FYR period. A revised CCL barium screening level for the three downgradient POC monitoring wells was applied that utilizes the 95% upper confidence limit of historical barium concentrations in these three wells (Trevet, 2016).

As outlined in Trevet, 2016, when the CCL is exceeded in any of the three POC wells in two out of three consecutive sampling events, these exceedances will be statistically evaluated by comparing them to the combined trend in barium concentrations in the three upgradient background monitoring wells (W1-5, W1-8, and W1-12R) identified in *Final Technical Memorandum, Site 1 Groundwater Evaluation Process* (TtFW, 2004b).

Although elevated barium concentrations were identified (most recent, 240 µg/L in well W1-15), when considering the historical range of concentrations in the three upgradient background wells, it is below the barium concentration of upgradient wells such as WI-5 having 653 µg/L in 2003.

Following the 2022 statistical evaluation of the barium data that was performed by EHS Support, a similar evaluation of the 2023 data was conducted that followed the criteria established in *Final Technical Memorandum, Site 1 Groundwater Evaluation Process* (TtFW, 2004b). The results of the statistical evaluation concluded that: 1) the barium data was representative based on Scenario 1 from *Final Technical Memorandum, Site 1 Groundwater Evaluation Process* (TtFW, 2004b); 2) there is no release from within the landfill; and 3) NFA is required.

Based on the data reviewed for the FYR period, the remedy at Site 1 appears to be functioning as intended. The detected COC concentrations are below cleanup levels and/or are decreasing, COCs and methane plumes are contained on-site, exposure to landfill contamination is prevented, and LUCs are in place and are enforced.

As part of this FYR, an evaluation of the potential impacts of sea level rise on the remedy for Site 1 remedy was conducted for possible mitigation planning and includes the following information: Based on a review of sea level rise projection models and the proximity of Site 1 to the San Francisco Bay, this site is very likely to be impacted by climate change (e.g., through increased aquifer recharge, elevated zones of saturation, localized groundwater mounding, greater influx of pollutants carried by stormwater, increased leaching and mobilization of contaminants in the vadose zone, shallow contaminants becoming submerged and mobilized, and increase in groundwater requiring treatment). However, review of the historical Site 1 monitoring well water levels indicate a general, near-flat long-term water level trend.

Change in sea level rise resulting in a potential increase in groundwater salinity, higher groundwater table, changes in groundwater flow direction, increased soil erosion, methane monitor probe replacement, change in groundwater classification, monitor well replacement, change in pumping rates, increased migration of contaminants, and impairment of in-situ processes. The potential impact from the sea level rise to the site groundwater during this FYR period is not evident. Continued groundwater monitoring data will be reviewed to determine if additional future planning activities proposed above in Section 1.4 are warranted for implementation.

5.2 Site 22

This section summarizes the site interviews, site inspection, and data review for Site 22.

5.2.1 Site Interviews

Interviews with the following points of contact were conducted for Site 22:

- Ryan Clauzel – Planetary Ventures, Interim Course General Manager at The Golf Club at Moffett Field
- Hunter Dang – Solid Waste Program, Santa Clara County DEH
- Yvonne Fong – EPA Project Manager, EPA Region 9 Superfund and Emergency Management Division
- Nicole Jorgensen – Senior Registered Environmental Health Specialist (REHS), Solid Waste Program, Santa Clara County DEH
- Anthony LaMarca – Planetary Ventures, Senior Director of Programs
- Dana McCarthy – Engineering Geologist, Water Board
- Luke Metz – Environmental Restoration Specialist, BB&E/ERT
- AJ Sekhon – Solid Waste Program, Santa Clara County DEH
- Elizabeth Wells – Senior Water Resource Engineer, Water Board

Interview records are presented in **Appendix B**.

The interviewees were aware that NASA has been conducting methane measurement data, water level gauging data, groundwater sampling analytical data, and post-closure care (site inspections and as needed repairs) at Site 22. The interviewees felt well informed on the progress at Site 22 and collaborated well with Planetary Ventures (The Golf Club at Moffett Field [golf course tenant]) during this FYR period.

5.2.2 Site Inspection

A site inspection for Site 22 was conducted by Mr. Brian Reddig, P.G., on behalf of NASA on February 7, 2024. Mr. Reddig was also accompanied by Ms. Nicole

Jorgensen and Hunter Dang with the County and Mr. Luke Metz, BB&E/ERT. Access to Site 22 is controlled by the main security checkpoint for Moffett Field. However, Site 22 is part of The Golf Club at Moffett Field; it is not fenced and is accessible. Remedies for Site 22 include landfill cover/containment and ICs.

General observations noted during the Site 22 inspection included the following:

- O&M documents, Health and Safety Plans, training records, gas generation and monitoring records, and cost records were readily available and up to date.
- ICs were implemented and enforced appropriately.
- Roads and access paths were in good condition.
- The landfill surface was free of settlement, cracks, and erosion. Several squirrel burrows were noted along the northern drainage ditch.
- Ponding was observed near cart paths and drainage ditches but was minimal.
- Gas vents and gas monitoring probes were routinely sampled and properly secured/locked.

5.2.3 Data Review

A data review for Site 22 was based on the following and presented in **Appendix F**:

- Draft 2023 Annual Report, Site 1 and Site 22 Landfills, Moffett Federal Airfield (BB&E 2024)
    - Figure 4 - Site 22 Landfill Groundwater Level Measurement and Monitoring Locations
    - Figure 7 - Site 22 Landfill Potentiometric Surface, October 2023
    - Figure 10 - Site 1 Landfill Methane Monitoring Locations
    - Appendix D - Analytical Data Graphs

Based on the data reviewed for the FYR period, the following conclusions regarding Site 22 are made:

- Groundwater elevations and potentiometric surface analyses observed over the FYR period indicate that a groundwater divide is present within Site 22. The predominant groundwater flow directions (west to northwest in the western portion of the site and east to northeast in the eastern portion of the site) varied only slightly throughout the FYR period and were generally consistent with historical groundwater flow directions.
- No VOC or pesticide MPs were detected above their respective CCLs in any wells over the FYR period.
- The methane monitoring results throughout the FYR period do not indicate landfill gas migration off-site.
- The landfill cover is intact and functional. The remedy remains effective in protecting human health and the environment.

- The LUCs for Site 22 are in place and remain effective.
- Landfill subsidence is not of concern at Site 22.
- Successfully employed burrowing mammal management measures.

Based on the data reviewed for the FYR period, the remedy at Site 22 appears to be functioning as intended. The detected COC concentrations are below cleanup levels and/or are decreasing, COCs and methane plumes are contained on-site, exposure to landfill contamination is prevented, and LUCs are in place and are enforced.

As part of this FYR, an evaluation of potential climate change impacts to the groundwater at Site 22 was conducted. Examples of applicable climate change impacts to the Site 22 groundwater may include the following:

- Based on a review of sea level rise projection models and the proximity of Site 22 to the San Francisco Bay, this site is very likely to be affected by climate change (e.g., through increased aquifer recharge, elevated zones of saturation, localized groundwater mounding, greater influx of pollutants carried by stormwater, increased leaching and mobilization of contaminants in the vadose zone, shallow contaminants becoming submerged and mobilized, and increase in groundwater requiring treatment. However, review of the historical Site 22 monitoring well water levels indicate a general, near-flat long-term water level trend.
- Change in sea level rise resulting in a potential increase in groundwater salinity, higher groundwater table, changes in groundwater flow direction, increased soil erosion, methane monitoring probes, change in groundwater classification, monitor well replacement, change in pumping rates, increased migration of contaminants, and impairment of in-situ processes. The potential impact from the sea level rise to the site groundwater during this FYR period is not evident. Continued groundwater monitoring data will be reviewed to determine if additional future planning activities proposed above in Section 1.4 are warranted for implementation.

5.3 Site 26

This section summarizes the site interviews, site inspection, and data review for Site 26.

5.3.1 Site Interviews

Interviews with the following points of contact were conducted for the Site 26:

- Yvonne Fong – EPA Project Manager, EPA Region 9 Superfund and Emergency Management Division
- Nicole Jorgensen – Senior Registered Environmental Health Specialist (REHS), Solid Waste Program, Santa Clara County DEH
- Dana McCarthy – Engineering Geologist, Water Board
- Deborah Varty – Environmental Management Division, NASA Ames Research Center

- Ingrid Warburg – Environmental Management Division, NASA Ames Research Center
- Elizabeth Wells – Senior Water Resource Engineer, Water Board

Interview records are presented in **Appendix B**.

The interviewees were aware that NASA has been conducting water level gauging, groundwater sampling, and maintaining ICs at Site 26 during this FYR period. The interviewees felt well informed on the progress at Site 26.

5.3.2 Site Inspection

A site inspection for Site 26 was conducted by Mr. Brian Reddig, P.G., on behalf of NASA on March 27, 2024. Access to Site 26 is initially controlled by the main security checkpoint for Moffett Field and secondly by a security checkpoint located east of the runways that restricts access by unauthorized personnel to the flightline and Hangar 2 and 3 area. The remedy for Site 26 includes ICs and Enhanced Anerobic Biodegradation/In situ Chemical Reduction.

General observations noted during the Site 26 inspection included the following:

- O&M documents, Health and Safety Plans, training records, monitoring records, and cost records were readily available and up to date.
- ICs were implemented and enforced appropriately.
- Fencing and gates were appropriately secured. Portions of Site 26 are located behind secured airfield gates (Hangars 2 & 3).
- Roads and access paths were in good condition.
- Demolition activities of Hangar 3 began in 2024. Construction zone restrictions may limit access to some Site 26 wells for 2024 sampling, gauging, and assessment activities.

5.3.3 Data Review

A data review for Site 26 was based on the following and presented in **Appendix F**:

- Draft Final 2020 Long-Term Monitoring Report, Installation Restoration Site 26, Former Naval Air Station Moffett Field (Leisnoi & KEMRON 2021)
    - Figure 3-10 - Trichloroethene (TCE) Distribution, IR Site 26, 2020 LTM
    - Figure 3-11 - cis-1,2-Dichloroethene (cis-1,2-DCE) Distribution, IR Site 26, 2020 LTM
    - Figure 3-12 - Tetrachloroethene (PCE) Distribution, IR Site 26, 2020 LTM
    - Figure 3-13 - Vinyl Chloride (VC) Distribution, IR Site 26, 2020 LTM
- Draft Final 2021 Installation Restoration Site 26 Long-Term Monitoring Report, Former Naval Air Station Moffett Field NASA Ames Research Center (BB&E 2022).
    - Figure 3-10 - Tetrachloroethene (PCE) Distribution, IR Site 26, 2021 LTM

  - Figure 3-11 - Trichloroethene (TCE) Distribution, IR Site 26, 2021 LTM
  - Figure 3-12 - cis-1,2-Dichloroethene (cis-1,2-DCE) Distribution, IR Site 26, 2021 LTM
  - Figure 3-13 - Vinyl Chloride (VC) Distribution, IR Site 26, 2021 LTM
- Draft Final 2022 Installation Restoration Site 26 Long Term Monitoring Report, Former Naval Air Station Moffett Field, NASA Ames Research Center (BB&E 2023)
  - Section 4.0 Conclusions (Draft Final 2022 Installation Restoration Site 26 Long Term Monitoring Report)
  - Table 3-3 – 2022 LTM Summary of Statistical Analyses
  - Appendix A – Mann-Kendall Test Results
- Draft 2023 Installation Restoration Site 26 Long Term Monitoring Report, Former Naval Air Station Moffett Field, NASA Ames Research Center (BB&E 2024)
  - Figure 3-2 - Tetrachloroethene (PCE) Distribution (2023)
  - Figure 3-3 - Trichloroethene (TCE) Distribution (2023)
  - Figure 3-4 - cis-1,2-Dichloroethene (cDCE) Distribution (2023)
  - Figure 3-5 - Vinyl Chloride (VC) Distribution (2023)

The water levels measured in September 2023 at Site 26 were very similar to those measured in September 2022 south of Zook Road/Macon Road. North of Zook Road/Macon Road, water levels measured in September 2023 were lower than those measured in September 2022. With outliers accounted for, the water levels in 2023 were on average 0.13 feet lower than the water levels in 2022. The predominant direction of groundwater flow based on the data collected during the 2023 groundwater gauging event is slightly northeast trending toward the San Francisco Bay with an overall gradient of 0.0029 ft/ft. The gradient and flow direction are consistent with historical observations.

Groundwater samples were collected as part of the 2023 annual groundwater monitoring event from 17 wells in the Site 26 area. In accordance with LTMP (KEMRON, 2018), the 2023 LTM sampling event included a reduced suite of wells, involving the plume core, source area, and fringe wells. Except for recently installed perimeter wells H3-MW-106 and H3-MW-112, the other perimeter wells were not sampled in 2023. The samples were analyzed for VOCs (EPA 8260).

Between 2019 and 2020, there was significant reduction in the areal extent of the COC plume as a direct result of the EVO/DHC injections. The injections resulted in a rapid decline in PCE distribution, especially in the vicinity of the injection zones. The areal extent of PCE between 2023 and 2022 was comparable; however, the concentrations of PCE were overall lower than the previous year.

Likewise, there was significant reduction in the areal extent of the TCE plumes after the 2019 EVO/DHC injections. The 2023 TCE plume boundary extent remained similar between 2022 and 2023; however, there was a slight contraction in the contour of the larger plume island. The total concentrations of TCE were overall lower than the previous year.

The areal extent of the mapped cis-1,2-DCE boundaries was modestly reduced because of the 2019 EVO/DHC injections. The 2023 areal distributions of the main remnant plumes were smaller to that of 2022 with one concentration-contour island removed in 2023. An overall average increase of seven percent in concentration was observed between 2023 and 2022, indicating cis-1,2-DCE is beginning to build up preferentially in some wells.

As a result of the 2019 EVO/DHC injections, the areal extent of VC has decreased dramatically. The 2020 VC plume mapping shows several isolated concentration-contour islands, as opposed to the extensive pre-injection plume mass. The areal extent of VC between 2022 and 2023 was smaller than the previous year.

Concentrations of COCs have significantly decreased due to remedy implementation between the time the ROD was signed (Navy, 1996) and the most recent groundwater monitoring in 2023, as shown in **Table 5-1**.

Table 5-1

Chemicals of Concern and Maximum Concentration Comparison for Site 26

COC	MCL (µg/L)	Maximum Concentration 1996 (µg/L)	Maximum Concentration 2023 (µg/L)	% Change
PCE	5	26	26	0%
TCE	5	14	18	+29%
1,2-DCE	6	90	14	-84%
1,1-DCE	6	16	0.44 J	-97%
1,2-DCA	0.5	14	0.44 J	-97%
VC	0.5	16	5.1	-68%

Based on the data reviewed for the FYR period, the remedy at Site 26 appears to be functioning as intended. The decreases in average concentrations over the FYR period, the review of groundwater parameters, and the prevalence of decreasing Mann-Kendall contamination trends are supportive that dechlorination is occurring. The aerial extents of COC plumes are stable and/or decreasing and LUCs are in place and are enforced.

An evaluation of the potential impacts of sea level rise on the remedy for Site 26 remedy was conducted. Examples of applicable climate change impacts to the Site 26 groundwater may include the following:

- Increased aquifer recharge, elevated zones of saturation, localized groundwater mounding, greater influx of pollutants carried by stormwater, increased leaching, and mobilization of contaminants in the vadose zone, shallow contaminants becoming submerged and mobilized, and increase in groundwater requiring treatment. Groundwater level measurements have been collected from most of the Site 26 area wells from 1995 through the present. A review of the hydrographs prepared in past events indicates that local seasonal changes in groundwater elevations are minimal, typically less than one foot, but with infrequent fluctuations up to 2 feet. A review of the potentiometric surface maps for 1995 through 2015, 2021, and 2022 (BB&E, 2023c) indicates that there is no seasonal variation in the direction of groundwater flow, with the predominant direction of groundwater flow in both spring and fall to be generally to the north (LDS/KEMRON, 2021).

- Change in sea level rise resulting in a potential increase in groundwater salinity, higher groundwater table, changes in groundwater flow direction, increased soil erosion, change in groundwater classification, monitor well replacement, change in pumping rates, increased migration of contaminants, and impairment of in-situ processes. The potential impact from the sea level rise to the site groundwater during this FYR period is not evident.
- Site 26 is beyond the expected impacted zones, based on a review of sea level rise projection models and is less likely to be significantly affected by sea level rise (e.g., localized groundwater mounding or saturation). Continued groundwater monitoring data will be reviewed to determine if additional future planning activities proposed above in Section 1.4 are warranted for implementation.

5.4 NASA RGRP

This section summarizes the site interviews, site inspection, and data review for the RGRP Site.

5.4.1 Site Interviews

Interviews with the following points of contact were conducted for the NASA RGRP:

- Alana Lee – EPA Project Manager, EPA Region 9 Superfund and Emergency Management Division
- Jeff Linder – Senior Environmental Restoration Specialist, BB&E/ERT
- Dana McCarthy – Engineering Geologist, Water Board
- Ingrid Warburg – Environmental Restoration Specialist, Environmental Management Division, NASA Ames Research Center
- Elizabeth Wells – Senior Water Resource Engineer, Water Board

Interview records are presented in **Appendix B**.

The interviewees were aware that NASA has been maintaining two groundwater treatment systems (GWTS and WATS) and ICs within NASA's RGRP during this FYR period. The interviewees felt well informed on the progress within the NASA RGRP.

5.4.2 Site Inspection

A site inspection for the NASA RGRP was conducted by Mr. Brian Reddig, P.G., on behalf of NASA on February 8, 2024. Mr. Reddig was also accompanied by Mr. Garrett

Turner and Ms. Alana Lee with EPA. Access to the NASA RGRP is initially controlled by the main security checkpoint for Moffett Field and secondly by a security checkpoint located south of the runways that restricts access by unauthorized personnel to the east side of Moffett Field. Current uses within the RGRP include administrative offices, and various buildings supporting daily operations at Moffett Field. Additionally, the site inspection consisted of a visual inspection of the components of the WATS treatment train. Remedies for the NASA RGRP include ICs and the two, groundwater pump and treatment systems, WATS and GWTS.

General observations noted during the NASA RGRP inspection included the following:

- O&M documents, Health and Safety Plans, training records, permits and service agreements, groundwater monitoring records and gauging data, discharge compliance records, access and security logs, and cost records were readily available and up to date.
- ICs were implemented and enforced appropriately.
- Fencing, gates, and signage were appropriately secured and displayed.
- Roads and access paths were in good condition.
- Extraction wells showed declined production rates implying their end of service time. In addition, increases in well pump pressure indicated that some portions of the WATS and GWTS conveyance piping needed high-pressure flushing.
- The treatment train was in good condition, filters and additives were added into the treatment train, equipment was accessible and in good operating condition, and all logs available and up to date.
- Electrical enclosures and panels, tanks, vaults, storage vessels, discharge structures, and treatment buildings were in good condition.

5.4.3 Data Review

A data review for the NASA RGRP was based on the following and presented in **Appendix F**:

- 2018 Annual Progress Report, NASA Ames Regional Groundwater Remediation Program, NASA Area of Responsibility and Site 28 WATS Area (ERT 2019)
    - Figure 2-23 - Capture Zone and Plume Boundary Overlay, A1 Aquifer, September 2018
    - Figure 2-24 - Capture Zone and Plume Boundary Overlay, A2/B1 Aquifer, September 2018
- 2022 Annual Progress Report, NASA Ames Regional Groundwater Remediation Program, NASA Area of Responsibility and Site 28 WATS Area (BB&E 2023)
    - Figure 2-13 - 2022 Estimated Iso-concentration Contours, Trichloroethene (TCE) in the A1 Aquifer

- Figure 2-14 - 2022 Estimated Iso-concentration Contours, Trichloroethene (TCE) in the A2/B1 Aquifer
- Figure 2-23 - Capture Zone and Plume Boundary Overlay, A1 Aquifer, September 2022
- Figure 2-24 - Capture Zone and Plume Boundary Overlay, A2/B1 Aquifer, September 2022
- Appendix L - Mann-Kendall Statistical Results Summary
- Table 2-11 - Mann-Kendall Summary Statistics

Based on the data reviewed during this FYR period, the groundwater remedy in NASA RGRP is functioning as intended.

Groundwater data indicates that the NASA GWTS and Site 28 WATS source control wells are achieving adequate capture and hydraulic control of targeted treatment zones. This is consistent throughout the FYR Period.

Within the NASA groundwater AOR, concentrations have dropped to below 60 µg/L of total VOCs (39 µg/L TCE) throughout the FYR period, making on-going pump and treat inefficient. NASA is currently finalizing a MNA Evaluation Work Plan to evaluate the applicability of MNA in the area, especially in the vicinity of NASA-3A, where total VOCs have dropped below 43 µg/L (41 µg/L TCE).

The influent VOC concentrations to NASA's two GWTSs have been declining over the last ten years. The most recent 2023 data indicated that the average annual influent VOC concentration has declined 58 percent at GWTS and declined 28 percent at WATS.

Reductive dechlorination has been observed in many of the TIA wells since the EAB/ISCR application in 2021. Although the data suggests that chemical rebound/matrix diffusion is occurring throughout the treatment zone, it is expected to have increases in daughter-product concentrations as reductive dechlorination progresses. Increasing PCE concentrations indicate source material remains in the subsurface. Additional groundwater monitoring is necessary to better evaluate the long-term effectiveness of the EAB/ISCR application. The summary table below presents this trend.

All Wells (130)	**PCE (% of Wells)**	**TCE (% of Wells)**	***c*DCE (% of Wells)**	**VC (% of Wells)**
Increasing	2%	8%	6%	18%
Decreasing	13%	35%	43%	19%
Stable	85%	56%	51%	62%
Non-detect	58%	19%	11%	28%

The groundwater remedy is performing as intended. Graphical flow net analysis, capture zone width calculations, spatial distribution analysis, and contour mapping provide converging lines of evidence that the NASA GWTS and Site 28 WATS area source control wells are achieving adequate hydraulic control of the targeted treatment zones. The source control wells are suitably located in high-concentration areas to maximize mass removal while maintaining hydraulic control of the majority of the plume's margins. However, if groundwater contaminants at concentrations exceeding the cleanup standards continue to flow from upgradient source(s), then the remedial objective of restoring groundwater quality to below the cleanup standards would not be achieved.

Three areas have been identified that contain chemical concentrations above cleanup levels and lie outside of the estimated zone of hydraulic containment. These areas are:

- The eastern margin of the plume in the A1 Aquifer in Site 28 beneath and northeast of Hangar 1.
- The leading edge of the plume in the A1 Aquifer in NASA's Area of Responsibility down-gradient of extraction well NASA-3A.
- The leading edge of the plume in the A2/B1 Aquifer in NASA's Area of Responsibility down-gradient of MEW extraction well REG-9B1.

Historical plume mapping and capture zone estimates have identified these conditions for many years. Although portions of the plume extend outside of mapped capture, no expansion in the plume boundaries have been observed. Contaminant trends calculated using the Mann-Kendall method indicate that a large majority of wells show stable or non-detectable concentrations. Decreasing concentration trends in TCE and cDCE are present in over one-third of all wells, signifying that active dechlorination is occurring within the plume.

As part of this FYR, an evaluation of sea level impacts to the groundwater at the NASA RGRP was conducted. Examples of applicable sea level change impacts to the NASA RGRP may include the following:

- Change in precipitation resulting in increased aquifer recharge, elevated zones of saturation, localized groundwater mounding, greater influx of pollutants carried by stormwater, increased leaching, and mobilization of contaminants in the vadose zone, shallow contaminants becoming submerged and mobilized, and increase in groundwater requiring treatment.
    - The overall gradient across the NASA RGRP was approximately the same in both the A1 and A2/B1 Aquifers throughout this FYR period. Some seasonal variation in gradient was observed, but within the historical range. In general, the horizontal gradients are steeper in the southern portions of the site and flatten to the north as the groundwater approaches San Francisco Bay.
    - There is not an adequate number or distribution of well pairs across the NASA RGRP to allow for a comprehensive study regarding vertical gradients among the aquifers. Vertical gradients between the A1 Aquifer

and A2/B1 Aquifer are variable across the site, but generally have a small upward gradient, particularly at the downgradient (northern) extent of the site. However, most well pairs have exhibited seasonal or annual reversals in vertical gradient (upward/downward/neutral) at various times. In the B2 and deeper aquifers, vertical gradients are predominantly upward.

- Change in sea level rise resulting in a potential increase in groundwater salinity, higher groundwater table, changes in groundwater flow direction, increased soil erosion, change in groundwater classification, change in pumping rates, increased migration of contaminants, and impairment of in-situ processes. To date, any potential impact from the sea level rise to the site groundwater during this FYR period is not evident. Continued groundwater monitoring data will be reviewed to determine if additional future planning activities proposed above in Section 1.4 are warranted for implementation.

5.5 NASA VI AOR

This section summarizes the site interviews, site inspection, and data review for the NASA VI AOR.

5.5.1 Site Interviews

Interviews with the following points of contact were conducted for the NASA VI AOR:

- Alana Lee – – EPA Project Manager, EPA Region 9 Superfund and Emergency Management Division
- Dana McCarthy – Engineering Geologist, Water Board
- Lili Pirbazari – Environmental Protection Specialist, Environmental Management Division, NASA Ames Research Center
- Deborah Varty – Environmental Restoration Specialist, Environmental Management Division, NASA Ames Research Center
- Ingrid Warburg – Environmental Restoration Specialist, Environmental Management Division, NASA Ames Research Center
- Elizabeth Wells – Senior Water Resource Engineer, Water Board

Interview records are presented in **Appendix B**.

The interviewees were aware that NASA has been performing VI LTM and maintaining ICs within NASA's VI AOR during this FYR period. The interviewees felt well informed on the progress within the NASA VI AOR.

5.5.2 Site Inspection

A site inspection for the NASA VI AOR was conducted by Mr. Brian Reddig, P.G., on behalf of NASA on January 14, 2024. Access to the NASA VI AOR is initially controlled by the main security checkpoint for Moffett Field and secondly by a security checkpoint located south of the runways that restricts access by unauthorized personnel to the east side of Moffett Field. Remedies for the NASA VI AOR include access controls and ICs.

General observations noted during the NASA VI AOR inspection included the following:

- Health and Safety Plans, training records, groundwater monitoring records and indoor air analysis data, and cost records were readily available and up to date.
- ICs were implemented and enforced appropriately.
- No construction or intrusive activities were observed that would impact vapor migration.

5.5.3 Data Review

Annual air sampling was performed each year of this FYR period. The sampling events were performed in accordance with the VI LTM Plan (ERT, 2017) for buildings within NASA VI AOR that were classified as Tier 3A. The annual sampling included collecting a series of indoor and outdoor air samples for all Tier 3A and Tier 3B buildings. A total of 35 air samples, including 32 indoor and three outdoor air samples, were collected during the most recent 2023 sampling event.

Based on the data reviewed as part of this FYR, none of the indoor air samples collected in breathing zones exceeded the commercial use air cleanup levels as outlined in the 2010 ROD Amendment. Six samples collected in Building N213 exceeded the ambient outdoor air concentration ranges but were below the commercial use air cleanup levels.

Based on analytical results reviewed over this FYR period, none of the buildings in NASA VI AOR have a Tier 1 or Tier 2 designation because indoor air concentrations for all seven COCs meet indoor air cleanup levels in work areas without an EC in place or operating. Therefore, interim mitigation measures and final remedial approaches are not required for any buildings in NASA VI AOR. However, buildings that have exhibited the presence of VI above background levels, or above clean up levels in *pathway* samples, have been designated Tier 3A as per the 2010 ROD Amendment for VI requiring LTM.

Additional lines of evidence, such as soil vapor samples from the perimeter of buildings, sub-slab samples, and shallow groundwater samples could be collected in the future to supplement existing data for buildings in Tier 3B to evaluate the feasibility of reclassification to Tier 4 (NFA) by demonstrating there is no potential for VI to cause indoor air to exceed indoor air cleanup levels and background levels.

Based on a review of the sampling data throughout this FYR period, the VI remedy is operating as intended and the cleanup levels are being achieved. The implementation of LUCs and the annual sampling event have been effective in ensuring the remedy is functioning as designed and remains protective of building occupants. Monitoring costs could potentially be reduced by collecting additional supporting data to evaluate the tier ranking of some of the buildings within the NASA VI AOR.

5.6 NASA LUCs

This section summarizes the site interviews, site inspection, and data review for the NASA LUCs.

5.6.1 Site Interviews

Interviews with the following points of contact were conducted for the NASA LUCs:

- Yvonne Fong – EPA Project Manager, EPA Region 9 Superfund and Emergency Management Division
- Alana Lee – – EPA Project Manager, EPA Region 9 Superfund and Emergency Management Division
- Dana McCarthy – Engineering Geologist, Water Board
- Lili Pirbazari – Environmental Protection Specialist, Environmental Management Division, NASA Ames Research Center
- Deborah Varty – Environmental Restoration Specialist, Environmental Management Division, NASA Ames Research Center
- Ingrid Warburg – Environmental Restoration Specialist, Environmental Management Division, NASA Ames Research Center
- Elizabeth Wells – Senior Water Resource Engineer, Water Board

Interview records are presented in **Appendix B**.

The interviewees were aware that NASA has been maintaining ICs (site inspections, LTM of media, use restrictions, and O&M of WATS and GWTS), as applicable, within NASA LUCs during this FYR period. The interviewees felt well informed on the progress within the NASA LUCs.

5.6.2 Site Inspection

The site inspection for the NASA LUCs was conducted throughout this FYR review period and this section focuses solely on the LUC inspection process and reporting requirements. Remedies for these NASA LUCs include access controls and ICs. Specific remedies associated with each NASA site or AOR are discussed above in the previous site inspection sections.

General observations noted during the site inspections performed during this FYR for the NASA LUCs included the following:

- O&M documents, Health and Safety Plans, training records, and cost records were readily available and up to date.
- Sites 1, 29, and portions of 26 have specific fencing, gates, and signage that were appropriately secured and displayed.
- ICs were implemented and enforced appropriately for each site.
- Roads and access paths were in good condition for each site.
- Redevelopment across the sites provides the greatest risk to the protectiveness of the remedy. NASA currently utilizes a construction permit review process to identify environmental impacts to NASA construction projects.

5.6.3 Data Review

The sites and associated LUCs for which NASA Ames has LUC responsibilities subject to the FFA are shown on **Figure 1**.

LUCs are being implemented per the NASA Ames LUCs IMP Update (BB&E, 2023b) for the following sites:

- Navy Site 1 Landfill
    - Prohibit landfill cap disturbance.
    - Maintain fencing and signage.
    - Operate and maintain Building 191 pump station and drainage system.
    - Restrict domestic groundwater use.
    - LUC restrictions are conveyed to the responsible user through the applicable type of lease documentation (e.g., Lease Agreement, Space Act Agreement, etc.).
- Navy Site 14 South
    - No residential land use: The site cannot support residential use due to potentially unacceptable vapor intrusion from residual contamination in soil vapor and groundwater.
    - No grading, excavation, or subsurface activities without a risk management plan: Any work involving soil excavation, trenching, or groundwater contact must be conducted pursuant to a risk management plan that is acceptable to Regional Water Board staff.
    - No shallow groundwater use: Shallow groundwater beneath the site should not be used for drinking water or for landscaping or garden irrigation without further assessment due to the presence of diminishing residual contamination.
    - Real estate documents: Include Water Board's 15 September 2022-letter conferring NFA status in all real estate disclosure, lease and transfer documents pertaining to this site.
    - LUC restrictions are conveyed to the responsible user through the applicable type of lease documentation (e.g., Lease Agreement, Space Act Agreement, etc.).
- Navy Site 22 Landfill
    - Protect the structural aspects of the landfill cap (biotic barrier) by restricting activities that could potentially disturb the cap.
    - Maintain vegetation, topsoil layer, irrigation system, and drainage components, including surface contours, encompassed within and adjacent to the Site 22 remedy boundary.
    - Maintain and operate the Building 191 pump station.

  - Prohibit the extraction of groundwater from Site 22.
  - Prohibit residential land use of the site and obtain regulatory approval for consideration of alternative land use.
  - LUC restrictions are conveyed to the responsible user through the applicable type of lease documentation (e.g., Lease Agreement, Space Act Agreement, etc.).
- Navy Site 26,
  - Restrict domestic groundwater use.
  - Address vapor intrusion in new construction or modifications to existing structures.
  - LUC restrictions are conveyed to the responsible user through the applicable type of lease documentation (e.g., Lease Agreement, Space Act Agreement, etc.).
- Navy Site 28,
  - NASA Ames implementation of domestic groundwater use restrictions.
  - LUC restrictions are conveyed to the responsible user through the applicable type of lease documentation (e.g., Lease Agreement, Space Act Agreement, etc.).
- Navy Site 29 Hangar 1,
  - Protect the remedy through restrictions on site access, activities and use, including site development or modifications to the Hangar 1 structure.
  - Incorporate LUCs into all current and prospective lease agreements.
  - Ensure building inhabitants are notified of potential exposure hazards.
  - Address worker exposure hazards and require post-construction repairs over the coating for building modifications.
  - LUC restrictions are conveyed to the responsible user through the applicable type of lease documentation (e.g., Lease Agreement, Space Act Agreement, etc.).
- Former NAS Moffett Field Area of MEW Regional Plume (Groundwater)
  - NASA Ames implementation of domestic groundwater use restrictions.
  - LUC restrictions are conveyed to the responsible user through the applicable type of lease documentation (e.g., Lease Agreement, Space Act Agreement, etc.).
- Former NAS Moffett Field Area of MEW Regional Plume VI Study Area
  - Incorporate requirements for vapor intrusion engineering controls in future construction (or modifications to existing buildings) in permitting and building design processes.

  - Establish Recorded Agreements to ensure installation and operation of vapor intrusion engineering controls.
  - Provide information on vapor intrusion to future owners, lessees, and tenants.
  - Provide information regarding building and occupancy changes to EPA.
  - LUC restrictions are conveyed to the responsible user through the applicable type of lease documentation (e.g., Lease Agreement, Space Act Agreement, etc.).

NASA Ames facilitates implementation of LUCs, communicates LUCs requirements to NASA Ames organizations, contractors, and tenants, maintains the GIS-based LUCs map, and monitors the maintenance of LUCs.

During this FYR period, no LUC deficiencies were observed, or corrective actions performed for 2019, 2020, and 2021. Several minor issues (burrowing activity and faded signs) were noted in the 2022 annual LUC report. NASA implemented and resolved corrective actions for these items. Based on a review of the LUCs data generated during this FYR period, the LUCs are functioning as intended.

All construction and/or redevelopment activities receive a complete NEPA review. NASA-managed activities get reviewed through NASA's Construction Permit Review Board, including a final review by NASA's NEPA Manager. When construction and/or redevelopment activities are conducted by other parties (tenants, resident agencies, etc.), a complete NEPA review is conducted by NASA's NEPA Manager. Project proponents are provided notification of the applicable LUC requirements through a Record of Environmental Consideration (REC) issued by NASA's NEPA Manager. This process provides for the remedy to remain protective. Additionally, if new protections/restrictions are established, then the LUC Plan is updated to maintain protectiveness.

In addition to the LUC review, Subject Matter Experts review all construction permits to identify any NASA Environmental Permit Requirements (EPRs) that are unique to each project. The EPRs are prescribed programmatic requirements that cover Air Quality, Groundwater, Hazardous Materials, Hazardous Waste, Industrial Waste Water, Natural Resources, Noise, Soils, SPCC, and Storm Water.

The exposure assumptions and toxicity data for NASA LUCs remain valid. There have been no significant site-specific conditions or physical changes that have occurred or have been observed that would result in an increased risk to human health and the environment, increased receptor exposure, or affect the protectiveness of the remedy selected. The ARARs, standards, and/or “to be considered” (TBCs) have been met and remain valid.

Land use of the sites has not changed, and no land use changes are currently being considered. There have been no changes to the physical conditions at the NASA LUCs that would affect the protectiveness of the remedy. Evaluation of implementation and performance of the selected remedy indicates that the remedy is functioning as intended and the remedy remains protective of human health and the environment.

6 TECHNICAL ASSESSMENT

In accordance with EPA guidance on FYRs (EPA, 2001), the technical assessment conducted to determine whether the remedies for Sites 1, 22, 26, NASA RGRP, NASA VI AOR, and NASA LUCs are protective of human health and the environment focused on responses to the following three questions:

Question A: Is the remedy functioning as intended by the decision documents?

- Areas of consideration include:
    - Remedial Action Performance – Is the remedy operating as designed?
    - System O&M – Will the system and current O&M activities maintain the effectiveness of the response actions?
    - Cost of O&M – Are there large variances between current annual costs and costs for previous years that might indicate potential remedy problems?
    - Implementation of ICs and Other Measures – Are these functioning as planned?
    - Monitoring Activities – Do the current monitoring activities provide adequate information to determine the protectiveness and effectiveness of the remedy implemented?
    - Optimization Opportunities – Are there any areas for improvement?
    - Early Indications of Potential Issues – Are there problems that could lead to the remedy being not protective or suggest protectiveness is at risk unless changes are made?

Question B: Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of the remedy still valid?

- Areas of consideration include changes in standards and *TBCs*, changes in exposure pathways, changes in toxicity and other contaminant characteristics, changes in risk assessment methods, and expected progress toward meeting RAOs.

Question C: Has any other information come to light that could call into question the protectiveness of the remedy?

- The final question in conducting a technical assessment of the selected remedy includes evaluation of any new information that could call into question its protectiveness. Examples of new information include newly exposed ecological risks, previously unconsidered unidentified risks from natural disasters (for example, flooding), or land use changes.

Each of these questions is addressed in the following subsections, building on the information and data summaries presented previously. The discussion presented here is a framework for the protectiveness determination that explains the conclusions of the review.

6.1 Site 1 Technical Assessment

This section provides a technical assessment for Site 1 by discussing and answering each of the three questions used to evaluate the protectiveness of the remedy.

6.1.1 Question A: Is the remedy functioning as intended by the decision documents? Yes.

Evaluation of implementation and performance of the selected remedy indicates that the landfill cover is functioning as intended and the remedy is currently protective of human health and the environment. Land use of the site has not changed, and no land use changes are currently being considered. Site 1 has a perimeter fence on three sides of the landfill with a locked gate, and the remaining perimeter is flanked by the SWRP on the northwest side. No plans currently exist for the Site 1 property to change ownership. The ICs are serving their intended purpose of limiting human and ecological exposure to landfill contaminants and groundwater. NASA will continue to perform quarterly inspections with annual reporting.

The Site 1 landfill cover, installation of the gas-venting trench and subsurface groundwater collection trench, groundwater and gas monitoring wells, use of ICs, and post-closure maintenance (e.g., O&M) are remedies that are ongoing and functioning as intended. There are no continuous active operating systems associated with Site 1. Burrowing activities at Site 1 require ongoing monitoring and abatement measures. The burrow collapsing and animal trapping program has been successful although fumigation was reintroduced to Site 1 in the fourth Quarters of 2018 and during this FYR occurred on December 3, 2020, and continues into 2024.

Groundwater and landfill gas monitoring are functioning as intended. Groundwater monitoring for SVOCs and pesticides was performed every five years and dissolved metals and VOCs analyses occur semi-annually. Based on review of the groundwater data, no releases to groundwater have occurred at Site 1. Landfill gas monitoring is conducted semiannually at Site 1. Historical landfill gas data has not indicated migration has or is occurring above the action limit.

Overall, the remedy remains effective in protecting human health and the environment.

6.1.2 Question B: Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of remedy selection still valid? Yes.

The exposure assumptions and toxicity data for Site 1 remain valid. There have been no significant site-specific conditions or physical changes that have occurred or have been observed that would result in an increased risk to human health and the environment, increase receptor access to landfill waste, impact groundwater, or affect the protectiveness of the remedy selected. The ARARs, standards, and/or TBCs have been met and remain valid. None of the RGs (CCLs) – except for the barium CCL, which is calculated annually – have changed over the past five years.

Land use of Site 1 has not changed, and no land use changes are currently being considered. There have been no changes to the physical conditions at Site 1 that would affect the protectiveness of the remedy. Evaluation of implementation and performance of the selected remedy indicates that the risk assessment assumptions and RAOs are valid, and the remedy remains protective of human health and the environment.

Although PFAS are not identified as contaminants of concern in any of the RODs, PFAS have been evaluated at certain locations on Moffett Field during this review period. PFAS has been detected in the groundwater samples collected at Sites 1 (and 2) at varying concentrations during the 2023 PFAS SI. Some of the PFAS concentrations detected exceeded the 2022 EPA RSLs and/or MCLs and the California RWB groundwater ESLs.

As of 2024, NASA's ongoing ESI is to further identify potential source areas associated with PFAS contamination found during the 2023 SI. Additional investigations (e.g., Remedial Investigation) will be required to further characterize PFAS impacts in groundwater contamination at the Site.

6.1.3 Question C: Has any other information come to light that could call into question the protectiveness of the remedy? No.

There has been no other information identified that would call into question the protectiveness of the remedy.

There have been no impacts from natural disasters during this review period. However, because of the low elevation and proximity to San Francisco Bay, water level rise from climate change could have future impacts on the protectiveness of the remedy at Site 1.

6.2 Site 22 Technical Assessment

This section provides a technical assessment for Site 22 by discussing and answering each of the three questions used to determine protectiveness of the remedy.

6.2.1 Question A: Is the remedy functioning as intended by the decision documents? Yes.

The primary RAO of the Site 22 remedy is to protect human health by preventing contact with landfill refuse. The constructed cap is an effective barrier that minimizes potential human and ecological exposure. NASA is responsible for maintaining ICs per the 2002 ROD which includes monitoring and maintaining the landfill cap integrity and preventing human and ecological exposure to landfill waste.

Groundwater and landfill gas monitoring is performed semi-annually, while LUC inspections are performed quarterly. All monitoring activities are adequate to determine the protectiveness and effectiveness of the remedy. Historical landfill gas data has not indicated migration has or is not occurring. One recommendation is to reduce the frequency of landfill gas monitoring from semiannually to annually to reduce monitoring costs. The implementation of the burrowing prevention and mitigation program helps maintain the integrity of the cap. There are no continuous operating systems associated with Site 22. O&M activities are performed in accordance with the Operations, Maintenance, and Monitoring Plan (FWEC, 2003a), and its Addendum (TtEC, 2005), which require inspection of the cap for signs of erosion, vegetation control, and burrowing activity.

The review of documents, and the results of the site inspection indicated that the Site 22 cover is functioning as intended by the ROD. The remedy is cost-effective, uses permanent solutions, and is protective of human health and the environment.

6.2.2 Question B: Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of remedy selection still valid? Yes.

The exposure assumptions and toxicity data for Site 22 remain valid. There have been no significant site-specific conditions or physical changes that have occurred or have been observed that would result in an increased risk to human health and the environment, increase receptor access to landfill waste, impact groundwater, or affect the protectiveness of the remedy selected. The ARARs, standards, and/or TBCs have remained valid. None of the RGs (CCLs) have changed over the past five years.

Land use of Site 22 has not changed, and no land use changes are currently being considered. There have been no changes to the physical conditions at Site 22 that would affect the protectiveness of the remedy. Evaluation of implementation and performance of the selected remedy indicates that the risk assessment assumptions and RAOs are valid, and the remedy remains protective of human health and the environment.

Although PFAS are not identified as contaminants of concern in any of the RODs, PFAS have been evaluated at certain locations on Moffett Field during this review period. PFAS has been detected in the groundwater samples collected at Site 22 at varying concentrations during the 2023 PFAS SI. Some of the PFAS concentrations detected exceeded the 2022 EPA RSLs and/or MCLs and the California RWB groundwater ESLs.

As of 2024, NASA’s ongoing ESI is to further identify potential source areas associated with PFAS contamination found during the 2023 SI. Additional investigations (e.g., Remedial Investigation) will be required to further characterize PFAS impacts in groundwater contamination at the Site.

6.2.3 Question C: Has any other information come to light that could call into question the protectiveness of the remedy? No.

There has been no other information identified that would call into question the protectiveness of the remedy.

There have been no impacts from natural disasters during the review period. However, because of its low elevation and proximity to San Francisco Bay, sea level rise from global warming could have future impacts on the protectiveness of the remedy at Site 22.

6.3 Site 26 Technical Assessment.

This section provides a technical assessment for Site 26 by discussing and answering each of the three questions used to determine protectiveness of the remedy.

6.3.1 Question A: Is the remedy functioning as intended by the decision documents? Yes

The 2014 ROD modified the remedy from the use of EATS to in-situ biostimulation/bio-augmentation treatment, MNA, and ICs. Groundwater data indicates that since EATS was turned off in 1999, COC plumes have not migrated, and COC concentrations have remained stable or decreased. Between 2019 and 2022, significant reduction of the COC plume was observed because of the 2019 EVO/DHC injections. The remedy is functioning as intended.

Groundwater sampling began in March 1999 (PRC, 1997) on a quarterly basis and is currently conducted by NASA on an annual basis in accordance with Draft Final LTMP (KEMRON, 2018). Specifically, the monitoring includes assessing well conditions and gauging groundwater levels, measuring groundwater field parameters, and collecting and analyzing groundwater samples. Historically, since the 1990s, TCE and PCE concentrations have generally been decreasing.

ICs specified in the 2014 ROD prohibit access to groundwater except for treatment and dewatering and to notify and require property owners/developers that any new building construction over the Site 26 groundwater plume be designed and constructed such that it will mitigate potential VI risks prior to construction. These ICs will remain in effect until cleanup standards have been met in groundwater underlying Site 26 and are ongoing.

Based on the monitoring data reviewed and the implementation of the LUCs by NASA, the remedy at Site 26 is functioning as intended.

6.3.2 Question B: Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of remedy selection still valid? Yes, however with no remedy impact.

The exposure assumptions for Site 26 remain valid. Toxicity factors for selected COCs (1,2-DCE; PCE; and TCE) at Site 26 have changed since the remedy selection. However, these changes in toxicity do not affect the protectiveness of the remedy, because no building currently overlies the VOC plume at Site 26. Therefore, the Site 26 indoor air exposure pathway is currently not complete. The COC characteristics have not changed in a way that could affect the protectiveness of the remedy.

There have been no significant site-specific conditions or physical changes that have occurred or have been observed that would result in an increased risk to human health and the environment, increase receptor access to landfill waste, impact groundwater, or affect the protectiveness of the remedy selected. The ARARs, standards, and/or TBCs have been met and remain valid. None of the RGs (MCLs for COCs) have changed over the past five years.

Land use of Site 26 has not changed, and no land use changes are currently being considered. There have been no changes to the physical conditions at Site 26 that would affect the protectiveness of the remedy. Evaluation of implementation and performance of the selected remedy indicates that the remedy is functioning as intended and the remedy remains protective of human health and the environment.

The RAO for Site 26 is to reduce COCs in the southern plume to drinking water MCLs. The 2019 EVO/DHC injections showed a significant reduction of the COC plume. The 2022 LTM data show continued reduction in COC data and progress towards meeting the RAOs.

Although PFAS are not identified as contaminants of concern in any of the RODs, PFAS have been evaluated at certain locations on Moffett Field during this review period. PFAS has been detected in the groundwater samples collected at Site 26 at varying concentrations during the 2023 PFAS SI. Some of the PFAS concentrations detected exceeded the 2022 EPA RSLs and/or MCLs and the California RWB groundwater ESLs.

As of 2024, NASA's ongoing ESI is to further identify potential source areas associated with PFAS contamination found during the 2023 SI. Additional investigations (e.g., Remedial Investigation) will be required to further characterize PFAS impacts in groundwater contamination at the Site.

6.3.3 Question C: Has any other information come to light that could call into question the protectiveness of the remedy? No

No additional information suggests that the remedy for Site 26 may not be protective of human health and the environment.

6.4 NASA RGRP Technical Assessment

This section provides a technical assessment for NASA'S RGRP by discussing and answering each of the three questions used to determine protectiveness of the remedy.

6.4.1 Question A: Is the remedy functioning as intended by the decision documents? Yes.

The NASA RGRP remedy includes operating the GWTS and WATS groundwater extraction and treatment systems to perform mass removal and hydraulic containment of the VOC- groundwater plume. It is also noted that the MEW PRPs operate and maintain the MEW North of 101 Treatment System which also captures and treats groundwater from the MEW AOR.

During this FYR period, the NASA GWTS and WATS operated effectively and treated contaminated groundwater as designed with O&M being performed regularly on both systems.

Based on the data reviewed through 2023 (NASA RGRP Annual Progress Reports over the past five years), the groundwater remedies in the NASA RGRP (GWTS and the WATS) are functioning as intended.

The estimated capture zones in the Draft NASA RGRP 2023 Annual Progress Report are comparable to those estimated in previous Annual Progress Reports indicating hydraulic containment of the plume is effective. The treatment systems continued to remove VOC mass from groundwater. The amount of mass removal is gradually declining as the influent concentrations to the systems are lower. The combined NASA RGRP removed approximately 51.42 kilograms of VOCs from 30,192,222 gallons of extracted groundwater. Over the last ten years, the average annual GWTS influent concentration has declined 58 percent, and the average annual WATS influent concentration has declined 28 percent. Total VOC concentrations in the core of the plume have decreased significantly since 1999. In the A1 Aquifer, core concentrations have decreased by 78 percent. In A2/B1 Aquifer, core concentrations have also decreased by 78 percent. The decline in the amount of mass removed is expected as the concentrations across the plume have declined in response to remedy effectiveness and other MNA factors.

The current biennial sampling events and annual sitewide water level gauging events provide timely, comprehensive data to evaluate the remedy to assess if it is performing as designed and remains protective of human health and the environment. NASA currently conducts voluntary groundwater sampling in the “off years” in a subset of the NASA RGRP wells to evaluate potential shifts in plume boundaries or concentration trends. Reductive dechlorination has been observed in many of the TIA wells since the EAB/ISCR application in 2021. The data suggests that chemical rebound/matrix diffusion is occurring throughout the treatment zone. This trend is expected due to the observed transitory increases in daughter-product concentrations as reductive dechlorination of PCE still present in source material continues. Additional groundwater monitoring is necessary to better evaluate the long-term effectiveness of the EAB/ISCR application.

Extensive rehabilitation of all extraction wells in 2021 (extraction well redevelopment and pump replacement) has resulted in increased flow rates. Continued extraction well maintenance and repair will lead to additional optimization opportunities. The recently installed Navy extraction wells in the TIA are expected to increase plume capture once fully operational and complement NASA’s efforts. However, the amount of time for the remedy to achieve the groundwater cleanup standards is estimated to be longer because the upgradient VOC groundwater plumes continue to migrate into the NASA RGRP.

There were no LUCs selected for groundwater in the 1989 MEW Study Area ROD. However, NASA Ames implements LUCs in accordance with the 2017 Final NASA Ames LUC IMP, including monitoring and associated reporting for administration of LUCs on NASA Ames. LUCs have been consistently implemented for this FYR period, as documented in the NASA Ames Annual LUC Reports.

Overall, the NASA RGRP remedy is functioning as intended in reducing VOC mass in the plume and maintaining hydraulic control of the plume. The GWTS and WATS systems operated on a consistent basis during the FYR period except for a rehabilitation project on the transformer and power infrastructure and extraction well maintenance. Maintenance is performed on the systems, including the extraction wells, on an as needed basis.

6.4.2 Question B: Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of remedy selection still valid? Yes.

The exposure assumptions and toxicity data for the NASA RGRP remain valid. There have been no significant site-specific conditions or physical changes that have occurred or have been observed that would result in an increased risk to human health and the environment, increase receptor exposure, or affect the protectiveness of the remedy selected. The ARARs, standards, and/or TBCs have been met and remain valid. None of the RGs have changed over the past five years.

NASA RGRP land use has not changed, and no land use changes are currently being considered. There have been no changes to the physical or chemical conditions at the NASA RGRP that would affect the protectiveness of the remedy. Evaluation of implementation and performance of the selected remedy indicates that the remedy is functioning as intended and the remedy remains protective of human health and the environment.

Although PFAS are not identified as contaminants of concern in any of the RODs, PFAS have been evaluated at certain locations on Moffett Field during this review period. PFAS has been detected in the groundwater samples collected at Sites 28 and NASA RGRP at varying concentrations during the 2023 PFAS SI. Some of the PFAS concentrations detected exceeded the 2022 EPA RSLs and/or MCLs and the California RWB groundwater ESLs.

In addition, one influent and one effluent sample were collected at each of the three groundwater treatment systems: AOPC 13 – NASA Groundwater Extraction Treatment System, AOPC 14 – Middlefield-Ellis-Whisman Groundwater Extraction Treatment System, and AOPC 15 – West-Side Aquifers Treatment System (IR 28). The influent sample results from all three treatment systems exceeded the 2022 groundwater EPA RSLs and/or MCLs for PFOS, PFOA, and PFHxS as well as the State groundwater ESLs for PFOS and PFOA.

The effluent sample results for AOPC 13 – NASA Groundwater Extraction Treatment System indicated an estimated concentration (“j value”) of 2.5 ppt for PFOS and a field duplicate sample result of 4.1 ppt for PFOS and all other results were below the 2022 groundwater EPA RSLs and/or MCLs for PFAS as well as the State groundwater ESLs for PFAS. The effluent sample results for AOPC 14 – Middlefield-Ellis-Whisman Groundwater Extraction Treatment System indicated exceedances of the 2022 groundwater EPA RSLs and/or MCLs for PFOS, PFOA, and PFHxS as well as the State groundwater ESLs for PFOS and PFOA. The effluent sample results for AOPC 15 – West-Side Aquifers Treatment System (IR 28) indicated no exceedance of the 2022 groundwater EPA RSLs and/or MCLs for PFAS as well as the State groundwater ESLs for PFAS (Tetra Tech 2023).

One surface water sample was collected in addition to the influent and effluent samples. PFAS constituents were detected at varying concentrations in the surface water sample. No PFAS standards or criteria have been developed for surface water.

As of 2024, NASA’s ongoing ESI is to further identify potential source areas associated with PFAS contamination found during the 2023 SI. Additional investigations (e.g., Remedial Investigation) will be required to further characterize PFAS impacts in groundwater contamination at the Site.

6.4.3 Question C: Has any other information come to light that could call into question the protectiveness of the remedy? No.

No additional information suggests that the remedy for NASA RGRP may not be protective of human health and the environment. No changes in the physical conditions, information, or data of the NASA RGRP have occurred that would affect or question the protectiveness of the remedy.

6.5 NASA VI AOR Technical Assessment

This section provides a technical assessment for NASA VI AOR by discussing and answering each of the three questions used to determine protectiveness of the remedy.

6.5.1 Question A: Is the remedy functioning as intended by the decision documents? Yes

In August 2010, the EPA amended the MEW ROD to address health risks associated with long-term exposure to TCE and other MEW Site COPCs through the VI pathway in current and future buildings overlying the shallow subsurface contamination. The EPA selected a remedy for the VI pathway to prevent subsurface volatile contaminants in groundwater from migrating into indoor air or accumulating in enclosed building spaces at levels exceeding its indoor air cleanup criteria for long-term exposure for residential and commercial buildings. The 2010 ROD Amendment provided a tiering system to determine the appropriate response action for each building/property within the VI Study Area based on indoor air sampling with or without a HVAC system in place and other lines of evidence. Pursuant to an agreement among NASA Ames, Navy, and the MEW PRPs, each entity is responsible for implementing the VI Remedy in their designated AOR.

The NASA VI AOR remedy includes implementation of LUCs combined with VI monitoring. The LUCs for the VI remedy are designed to provide building owners and/or tenants information on the VI remedy and to ensure the appropriate ECs are incorporated in the remedy to prevent exceedances of the indoor air cleanup levels. The VI monitoring is designed to evaluate indoor air data and, if required, determine an appropriate response action.

A Building-Specific VI LTMP was developed by NASA Ames in 2017 that documents air sampling activities to be conducted for buildings within the NASA VI AOR (ERT, 2017). Specifically, the LTMP outlines the procedures for LTM in all Tier 3A and Tier 3B buildings to evaluate the potential for VI into the seven buildings in the NASA VI AOR. The LTMP was developed based on the results of previous indoor air analytical results where only seven buildings within the NASA VI AOR meet the criteria for long-term indoor air monitoring.

Annual air sampling was performed each year of this FYR period. The sampling events were performed in accordance with the VI LTMP. The annual sampling included collecting a series of indoor and outdoor air samples for all Tier 3A and Tier 3B buildings. A total of 35 air samples, including 32 indoor and three outdoor air samples, were collected during the most recent 2023 sampling event.

Based on a review of the annual sampling data, the VI remedy is operating as intended and the cleanup levels are being achieved. The implementation of LUCs and the annual sampling event have been effective in ensuring the remedy is functioning as designed and remains protective of building occupants. As recommended in the 2023 LTM report, monitoring costs could potentially be reduced by collecting additional supporting data to evaluate the tier ranking of some of the buildings within the NASA VI AOR.

6.5.2 Question B: Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of remedy selection still valid? Yes

The exposure assumptions and toxicity data for NASA VI AOR remain valid. There have been no significant site-specific conditions or physical changes that have occurred or have been observed that would result in an increased risk to human health and the environment, increase receptor exposure, or affect the protectiveness of the remedy selected. The ARARs, standards, and/or TBCs have been met and remain valid. None of the indoor air cleanup levels have changed over the past five years.

Land use of NASA VI AOR has not changed, and no land use changes are currently being considered. There have been no changes to the physical conditions at the NASA VI AOR that would affect the protectiveness of the remedy. Evaluation of implementation and performance of the selected remedy indicates that the remedy is functioning as intended and the remedy remains protective of human health and the environment.

6.5.3 Question C: Has any other information come to light that could call into question the protectiveness of the remedy? No.

No additional information suggests that the remedy for NASA VI AOR may not be protective of human health and the environment. No changes in the physical conditions, information, or data of the NASA VI AOR have occurred that would affect or question the overall protectiveness of the remedy.

6.6 NASA LUCs Technical Assessment

This section provides a technical assessment for NASA LUCs by discussing and answering each of the three questions used to determine protectiveness of the remedy.

6.6.1 Question A: Is the remedy functioning as intended by the decision documents? Yes

LUCs are being implemented per the *NASA Ames Land Use Controls Implementation and Monitoring Plan Update* (BB&E, 2023b) for the following sites.

- Navy Site 1 Landfill,
- Navy Site 14 South,
- Navy Site 22 Landfill,
- Navy Site 26,
- Navy Site 28,
- Navy Site 29 Hangar 1,

- Former NAS Moffett Field Area of MEW Regional Plume (Groundwater), and
- Former NAS Moffett Field Area of MEW Regional Plume VI Study Area.

LUCs are implemented as part of the remedies at these sites or areas to prevent exposure to waste (landfill caps) prevent domestic use of groundwater or exposure to groundwater, or exposure to VOCs in indoor air. NASA Ames has established LUC implementing mechanisms, including policy, regulations, processes, procedures and permits to administer LUCs. NASA Ames facilitates implementation of LUCs, communicates LUCs requirements to NASA Ames organizations, contractors, and tenants, maintains the GIS-based LUCs map, and monitors the maintenance of LUCs.

LUC inspections are conducted quarterly or more frequently, as needed, to observe the continued maintenance of NASA LUCs at these locations. NASA prepares an annual LUC report to address the continued implementation and adequacy of LUCs for each site, including the results of inspections, document reviews and updates, review and confirmation of land use, and any noted deficiencies and corrective actions undertaken. The LUC reports are submitted to EPA and the Water Board. LUCs are appropriately reviewed and maintained for each site in accordance with the NASA Ames LUC IMP Update (BB&E, 2023b). During the FYR period, no LUC deficiencies were observed, or corrective actions performed for 2019, 2020, and 2021. Several minor issues (burrowing activity and faded signs) were noted in the 2022 Annual LUC Report (BB&E, 2023b). NASA implemented and resolved corrective actions for these items. Based on a review of the LUCs data generated during this FYR period, the LUCs are functioning as intended.

6.6.2 Question B: Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of remedy selection still valid? Yes

The exposure assumptions and toxicity data for NASA LUCs remain valid. There have been no significant site-specific conditions or physical changes that have occurred or have been observed that would result in an increased risk to human health and the environment, increase receptor exposure, or affect the protectiveness of the remedy selected. The ARARs, standards, and/or TBCs have been met and remain valid.

Land use of NASA LUCs has not changed, and no land use changes are currently being considered. There have been no changes to the physical conditions at the NASA LUCs that would affect the protectiveness of the remedy. Evaluation of implementation and performance of the selected remedy indicates that the remedy is functioning as intended and the remedy remains protective of human health and the environment.

NASA's implementation of LUCs within its AOR has aided the remedies for the various sites to meet site RAOs. NASA continues to review construction permits and tenant leases falling within a LUC boundary for compliance with LUCs and no issues were identified during this FYR period.

Although PFAS are not identified as contaminants of concern in any of the RODs, PFAS have been evaluated at certain locations on Moffett Field during this review period. PFAS has been detected in the groundwater samples collected at Sites 1 (and 2), 22, 26, 28, and NASA RGRP at varying concentrations during the 2023 PFAS SI. Some of the PFAS concentrations detected exceeded the 2022 EPA RSLs and/or MCLs and the California RWB groundwater ESLs.

As of 2024, NASA’s ongoing ESI is to further identify potential source areas associated with PFAS contamination found during the 2023 SI. Additional investigations (e.g., Remedial Investigation) will be required to further characterize PFAS impacts in groundwater contamination at the Site.

6.6.3 Question C: Has any other information come to light that could call into question the protectiveness of the remedy? No

No additional information suggests that the remedy for NASA LUCs may not be protective of human health and the environment. No changes in the physical conditions, information, or data of the NASA LUCs site have occurred that would affect or question the protectiveness of the remedy.

7 ISSUES, RECOMMENDATIONS, AND FOLLOW-UP ACTIONS

This section presents issues, recommendations, and follow-up actions for Sites 1, 22, 26, NASA RGRP and NASA VI AOR.

With PFAS detected in the groundwater samples collected at Sites 1, 22, 26, 28, and NASA RGRP at varying concentrations during the 2023 PFAS SI, NASA intends to perform an RI for PFAS to further delineate the extent of contamination.

7.1 Site 1

Table 7-1 summarizes the Site 1 issues, recommendations, responsible parties, completion dates, and protectiveness determinations.

Table 7-1

Site 1 Summary of Issues, Recommendations, and Follow-Up Actions

Issue	Recommendations and Follow-up Actions	Party Responsible	Oversight Agency	Milestone Date	Affects Protectiveness (Yes/No)	
					Current	**Future**
1. PFAS detected in the groundwater samples collected at Sites 1 and 2 (within LOI 4) at varying concentrations during the 2023 PFAS SI.	A PFAS RI in LOI 4 is needed to determine the nature and extent of PFAS contamination.	NASA	EPA and Water Board	November 28, 2028	No	Yes

Other Findings Discussion

1. Burrowing mammal management is and will continue to be a critical O&M issue at Site 1. Burrowing animals do not appear to affect the current protectiveness because burrowing is regularly monitored/maintained and generally has not exposed landfill waste. The landfill is inspected quarterly by the Water Board and NASA and weekly by a NASA wildlife biologist due to the frequency of mammal burrowing activity. Observed burrows are immediately backfilled; however, the weekly frequency is not indefinitely sustainable. Recommend evaluation of other potential management approaches and/or technologies that would maintain current and future protectiveness from burrowing mammals that require lower frequency of inspection and cost of mitigation.
2. Use of dissolved metals as MPs/COCs, that occur naturally at elevated levels (such as copper, barium, and selenium) at Site 1 has and continues to require additional sampling and reporting efforts. These dissolved metals are very likely associated with saltwater intrusion due to Site 1 being immediately adjacent to storm water retention pond (brackish water) that has connectivity to Ravenswood

Slough of San Francisco Bay. Brackish/saltwater intrusion around Site 1 may also be a result of Building 191 stormwater management pumping. These naturally occurring dissolved metals should be selected and delisted, as appropriate, as an MPs/COCs as they are not indicators of potential releases from Site 1 wastes to groundwater and would optimize Site 1 LTM efforts.

3. Optimization of groundwater sampling at Site 1 should be consistent with other NASA Ames sites for cost savings. MEW Parties and NASA have recently adopted the HydraSleeve™ sampling method for the NASA RGRP, Site 26, and MEW PRP wells. Site 1 should be evaluated for adopting the HydraSleeve™ sampling method as soon as practicable.

7.2 Site 22

Table 7-2 summarizes the Site 22 issues, recommendations, responsible parties, completion dates, and protectiveness determinations.

Table 7-2

Site 22 Summary of Issues, Recommendations, and Follow-Up Actions

Issue	Recommendations and Follow-up Actions	Party Responsible	Oversight Agency	Milestone Date	Affects Protectiveness (Yes/No)	
					Current	**Future**
1. PFAS detected in the groundwater samples collected at Site 22 (within LOI 4) at varying concentrations during the 2023 PFAS SI.	A PFAS RI in LOI 4 is needed to determine the nature and extent of PFAS contamination.	NASA	EPA and Water Board	November 28, 2028	No	Yes

Other Findings Discussion

1. Optimization of groundwater sampling at Site 22 should be consistent with other NASA Ames sites for cost savings. MEW Parties and NASA have recently adopted the HydraSleeve™ sampling method for the NASA RGRP, Site 26, and MEW PRP wells. Site 22 should be evaluated for adopting the HydraSleeve™ sampling method as soon as practicable.

7.3 Site 26

Table 7-3 summarizes the Site 26 issues, recommendations, responsible parties, completion dates, and protectiveness determinations.

Table 7-3
Site 26 Summary of Issues, Recommendations, and Actions

Issue	Recommendations and Follow-up Actions	Party Responsible	Oversight Agency	Milestone Date	Affects Protectiveness (Yes/No)	
					Current	**Future**
1. PFAS detected in the groundwater samples collected at Site 26 at varying concentrations during the 2023 PFAS SI.	A PFAS RI in LOI 4 is needed to determine the nature and extent of PFAS contamination.	NASA	EPA and Water Board	November 28, 2028	No	Yes

Other Findings Discussion

1. Annual LTM performed by NASA (2021-2023) following the Navy's 2019 EAB/ISCR implementation indicates that minimal matrix diffusion is occurring with sufficient source zone reduction. This allows MNA to be an appropriate long-term remedy such that biennial sampling would be sufficient. MNA data should be reviewed to transition from LTM of comprehensive well network to using select, optimized wells for annual LTM or, if substantiated, biennial LTM.

7.4 NASA RGRP and VI AOR

Table 7-4 summarizes the issues, recommendations, responsible parties, completion dates, and protectiveness determinations.

Table 7-4
NASA RGRP and VI AOR Summary of Issues, Recommendations, and Actions

Issue	Recommendations and Follow-up Actions	Party Responsible	Oversight Agency	Milestone Date	Affects Protectiveness (Yes/No)	
					Current	**Future**
1.PFAS detected in the groundwater samples collected within the RGRP and VI AOR at varying concentrations during the 2023 PFAS SI.	NASA intends to perform a PFAS RI to determine the nature and extent of PFAS contamination.	NASA	EPA and Water Board	November 28, 2028	No	Yes

Issue	Recommendations and Follow-up Actions	Party Responsible	Oversight Agency	Milestone Date	Affects Protectiveness (Yes/No)	
					Current	**Future**
2. NASA GWTS and WATS effluent should be monitored and the data evaluated to determine if any discharges of PFAS-impacted effluent are occurring and redistributing PFAS.	PFAS effluent sampling schedule for NASA GWTS and WATS will follow the pending NPDES PFAS requirements that are anticipated to be finalized in 2025.	NASA	EPA and Water Board	November 27, 2027	No	Yes

Other Findings Discussion

1. Because of the relatively low VOC concentrations and resulting poor mass removal efficiency, observed plume stability, and the limited potential of plume migration due to the low hydraulic gradient, NASA believes that MNA should be evaluated as a viable remedy component at the leading edge of the Regional A1 Aquifer plume in the vicinity of extraction well NASA-3A. NASA intends to perform a pilot study to evaluate the suitability of applying MNA as a remedy component by further evaluating existing hydrogeologic and geologic data to better characterize the plume boundaries and natural hydrogeologic conditions. Based upon the outcome of the initial suitability evaluation, NASA will provide additional recommendations in subsequent annual reports and with the possible aid of an RGRP site conceptional model, see below (discussion #3).
2. As noted above in discussion #1, COC mass removal has been successful since startup, however COC mass removal quantities have declined in the last 20+ years following startup. Each system's extraction well network should be evaluated annually using historical data to optimize the existing extraction wells for focused and maximal extraction in high COC areas for improved mass removal.
3. The site conceptual model for the NASA RGRP is incomplete. To improve remedy implementations, and aid with discussion #1 and #2 noted above, NASA should develop a site conceptual model for the RGRP to aid in evaluating, optimizing, and decision making of the RGRP remedy protectiveness. This should be accomplished with existing geologic and hydrogeologic data from Site 28 and NASA.
4. More frequent well redevelopment and conveyance line flushing will be required in future years to sustain design efficiency.

5. The lack of cleanouts in both system's conveyance piping limits the reach and effectiveness of maintenance activities (conveyance line flushing, etc.).
6. Tier 3A buildings are currently sampled for VI COCs annually as a NASA standard of practice for demonstrative remedy implementation and protectiveness. The EPA requires NASA to sample for VI COCs biennial. NASA should evaluate historical data, building/structure occupancy, and VI sample locations to identify which buildings/structures should be VI sampled annually versus biennially.

8 PROTECTIVENESS STATEMENTS

8.1 Site 1

Table 8-1
Site 1 Protectiveness Statement

Site 1 Protectiveness Statement
Protectiveness Determination: Short-term Protective
Short-term Protectiveness Statement: The remedy for Site 1 is currently protective of human health and the environment. All potential exposure pathways are incomplete, groundwater contaminant concentrations do not indicate any leaching or releases from the landfill, pumping from Building 191 continues to maintain the preferred groundwater flow direction, landfill gas is not migrating from the landfill, and the landfill cover is functioning as intended. To ensure long-term protectiveness, additional sampling for PFAS (per- and polyfluoroalkyl substances) should be performed to further assess potential risk is needed.

8.2 Site 22

Table 8-2
Site 22 Protectiveness Statement

Site 22 Protectiveness Statement
Protectiveness Determination: Short-term Protective
Short-term Protectiveness Statement: The remedy for Site 22 is currently protective of human health and the environment. All potential exposure pathways are incomplete, groundwater contaminant concentrations do not indicate any leaching or releases from the landfill, landfill gas is not migrating from the landfill, and the biotic barrier is functioning as intended. To ensure long-term protectiveness, additional sampling for PFAS (per- and polyfluoroalkyl substances) should be performed to further assess potential risk is needed.

8.3 Site 26

Table 8-3
Site 26 Protectiveness Statement

Site 26 Protectiveness Statement
Protectiveness Determination: Short-term Protective
Short-term Protectiveness Statement: The remedy for Site 26 is currently protective of human health and the environment. Groundwater contaminant plumes are stable or decreasing and land use controls are in place to prevent access to contaminated groundwater and minimize future potential vapor intrusion risk. Reductive dechlorination is still active and MNA is still viable. To ensure long-term protectiveness, additional sampling for PFAS (per- and polyfluoroalkyl substances) should be performed to further assess potential risk is needed.

8.4 NASA RGRP and VI AOR

Table 8-4
NASA RGRP and VI AOR Protectiveness Statement

NASA RGRP and VI AOR Protectiveness Statement
Protectiveness Determination: Short-term Protective
Short-term Protectiveness Statement: The groundwater remedy for the NASA RGRP and the vapor intrusion remedy for the NASA VI AOR are currently protective of human health and the environment because there is no direct exposure to contamination. Governmental controls are in place to prevent access to contaminated groundwater. The vapor intrusion control systems, monitoring program, and institutional controls are in place to minimize exposure risk from vapor intrusion. To ensure long-term protectiveness, additional sampling for PFAS (per- and polyfluoroalkyl substances) should be performed to further assess potential risk is needed. Additionally, for the remedy to be protective in the long-term, alternative

groundwater cleanup technologies should be selected to accelerate the reduction of the source of vapor intrusion.

8.5 Regional Water Board Position

The Regional Water Board's position on the protectiveness determination of the remedy at Site 1, Site 22, Site 26, NASA RGRP, and NASA VI AOR is "Deferred Protectiveness" with respect to PFAS in soil and groundwater. However, NASA's position is that a Short-term Protective determination is applicable because there is no known risk from PFAS contamination in soil. Additionally, ICs are in place to prevent access to contaminated groundwater. Based on the findings documented in the PFAS SI Report, further investigation of PFAS is needed to further assess potential risk and to ensure long-term protectiveness.

9 NEXT REVIEW

The next FYR for Sites 1, 22, 26, NASA RGRP, NASA VI AOR, and NASA LUCs at NASA Ames will be due February 12, 2030.

10 REFERENCES

ACC Environmental Consultants (ACC). 2017. Pilot Study Abatement Study of Hangar 1, Hangar One, Moffett Federal Airfield, Mountain View, California.

AMEC Environment & Infrastructure, Inc. (AMEC). 2013. Final Long Term Management Plan for Non-Time-Critical Removal Action for PCB Contamination at Installation Restoration Site 29 (Hangar 1) at Former Naval Air Station Moffett Field, California.

AMEC. 2014. Coating Spot Repair Report, Hangar 1, Former Naval Air Station Moffett Field, California.

Aptim Federal Services, LLC (APTIM). 2020. Final Work Plan, Remedial Action at the Traffic Island Area, Installation Restoration Site 28.

APTIM. 2024. Draft Interim Remedial Action Completion Report, Remedial Action at the Traffic Island Area.

Battelle. 2019. Addendum to the Final 2016/2017 Annual Groundwater Monitoring Report, 2018 Site Closure Report and Recommendation for No Further Action, Site 14 South, Former Naval Air Station, Moffett Field, California.

BB&E, Inc. (BB&E). 2020. Revised Final Five-Year Review Report Former Naval Air Station Moffett Field Installation Restoration Landfill Sites 1 and 22, Ames Research Center, Moffett Field, California, June.

BB&E. 2022. 2021 Annual Progress Report NASA Ames Regional Groundwater Remediation Program NASA Area of Responsibility and Site 28 WATS Area. Ames Research Center, Moffett Field, California. April.

BB&E. 2023a. Draft 2023 Building-Specific Vapor Intrusion Long-Term Monitoring Report. Ames Research Center, Moffett Field, California. April.

BB&E. 2023b. Draft NASA Ames Land Use Controls Implementation and Monitoring Plan Update. Ames Research Center, Moffett Field, California, June.

BB&E. 2023c. Draft Final 2022 Installation Restoration Site 26 Long Term Monitoring Report. Ames Research Center, Moffett Field, California. October.

BB&E. 2024. Draft CY2023 Annual Progress Report, NASA Ames Regional Groundwater Remediation Program, NASA Area of Responsibility and Site 28 WATS Area.

California Regional Water Quality Control Board, San Francisco Bay Region (Water Board). 2013. San Francisco (Region 2) Water Quality Control Plan (Basin Plan). Last amended July.

California Regional Water Quality Control Board, San Francisco Bay Region (Water Board). 2022. . No Further Action for Underground Storage Tanks (USTs) 19 and 20, Site 14 South, Former Naval Air Station Moffett Field, Moffett Field, Santa Clara County Letter dated September 15, 2022

California State Water Resources Control Board (SWRCB). 1998. Resolution No. 88-63, Adoption of Policy entitled "*Sources of Drinking Water*." May.

California SWRCB. 2006. Resolution No. 88-63, Adoption of Policy entitled "Sources of Drinking Water." Amended February 1.

Capital Planning Committee (CPC). 2020. Guidance for Incorporating Sea Level Rise into Capital Planning, Assessing Vulnerability and Risk to Support Adaptation. City and County of San Francisco, Capital Planning Committee, adopted September 22, 2014, revised and adopted December 14, 2015, San Francisco, CA. (https://onesanfrancisco.org/sea-level-rise-guidance/; accessed on 24 July 2024).

CB&I Federal Services LLC (CB&I). 2014. Draft Technical Memorandum, Supplemental Investigation Former Building 88 and Traffic Island Areas Installation Restoration Site 28, Former Naval Air Station Moffett Field, Moffett Field, California. July.

City and County of San Francisco (CCSF). 2020. Sea Level Rise Vulnerability and Consequence Assessment. City and County of San Francisco, San Francisco Planning and the Office of Resilience and Capital Planning, San Francisco, CA. (https://sfplanning.org/sea-level-rise-action-plan; accessed on 24 July 2024).

Design, Community & Environment (DC&E). 2002. NASA Ames Development Plan, Final Programmatic Environmental Impact Statement, NASA Ames Research Center, July.

Earth Sciences Associates, Inc. (ESA) and James M. Montgomery, Consulting Engineers, Inc. (JMM). 1986. Confirmation Study (Verification Step). Moffett Naval Air Station, California. April.

EKI Environment & Water, Inc. (EKI). 2014. Hangar 2 and Hangar 3 Sub-Slab Vapor Investigation, Former Naval Air Station, Moffett Field, California. September.

EKI, 2017. Environmental Issues Management Plan, MFA Leasehold, Former NAS Moffett Field, California.

EKI. 2019. Final Hangar 1 Engineering Evaluation/Cost Analysis, Former Naval Air Station Moffett Field, California.

EKI. 2020. Final Hangar 1 Action Memorandum, Former Naval Air Station Moffett Field, California. November 4.

EKI. 2022. Final Hangar 1 Non-Time-Critical Removal Action Work Plan, Former Naval Air Station Moffett Field, California. March.

Environmental Protection Agency (EPA). 1989. Record of Decision for the Fairchild, Intel, and Raytheon Sites, Middlefield/Ellis/Whisman (MEW) Study Area, Mountain View, California. EPA Region 9. June.

EPA. 1990. Explanation of Significant Differences of the Middlefield-Ellis-Whisman Record of Decision. September.

EPA. 1996. Record of Decision for Site 26, Moffett Naval Air Station. Moffett Field, California. EPA/ROD/R09-96/147. June.

EPA. 2001. Comprehensive Five-Year Review Guidance, EPA/540/R-01/007. OSWER 9355.7-03B-P. June.

EPA. 2004. Final First Five-Year Review Report for Middlefield-Ellis-Whisman (MEW) Superfund Study Area, Mountain View, California. September.

EPA. 2009a. Final Supplemental Feasibility Study for the Vapor Intrusion Pathway, Middlefield-Ellis-Whisman (MEW) Superfund Study Area, Mountain View and Moffett Field, California. June.

EPA. 2009b. Proposed Plan for the Vapor Intrusion Pathway, MEW Superfund Study Area, Mountain View and Moffett Field, California. July.

EPA. 2009c. Final Second Five-Year Review Report for MEW Superfund Site, Mountain. View and Moffett Field, California. September 30.

EPA. 2010. Record of Decision Amendment of the Vapor Intrusion Pathway, Middlefield-Ellis-Whisman (MEW) Superfund Study Area, Mountain View and Moffett Field, California. August 16.

EPA. 2011. Recommended Evaluation of Institutional Controls: Supplement to the "Comprehensive Five-Year Review Guidance." OSWER 9355.7-18. September.

EPA. 2012. Clarifying the Use of Protectiveness Determinations for Comprehensive Environmental Response, Compensation, and Liability Act Five-Year Reviews. OSWER 9200.2-11. September.

EPA. 2014. Third Five-Year Review Report for MEW Superfund Study Area, Mountain View and Moffett Field, California. September 29.

EPA. 2015. Federal Facility Agreement Between the EPA, State of California, and the National Aeronautics and Space Administration.

EPA. 2016. Five-Year Review Recommended Template. OLEM-9200.0-89. January.

EPA. 2019. Fourth Five-Year Review Report for MEW Superfund Study Area, Mountain View and Moffett Field, California. September.

Earth Resources Technology, Inc. (ERT). 2016. Revised Technical Memorandum, Summary Findings for the Northernmost A2/B1 Aquifer Plume Definition Assessment.

ERT. 2017. Draft Building-Specific Vapor Intrusion Long-Term Monitoring Plan. November.

ERT. 2019. Draft 2018 Building Specific Vapor Intrusion Long-Term Monitoring Report*, March.

ERT. 2020. Draft Addendum to the 2018 Building-Specific Vapor Intrusion Long-Term Monitoring Report, 2020 Sampling Event, July.

Erler & Kalinowski, Inc. 1994. Center-Wide Sampling and Analysis Program, Volume VII: Work Plan for Area of Investigation 7, NASA Ames Research Center, Moffett Field, CA.

Erler & Kalinowski, Inc. 1995. Proposed Locations of NASA Ames Groundwater Extraction Wells in the VTOL Pad and South Navy Warehouse Areas, NASA Ames Research Center, Moffett Field, California.

Foster Wheeler Environmental Corporation, Inc. (FWEC). 2001. Final Sampling and Analysis Plan Addendum for Post-Closure Monitoring (Site 1) and Groundwater Monitoring (Site 2). Revision 0, Moffett Federal Airfield, Moffett Field, California. June 5.

FWEC. 2002. Final First Annual Groundwater Report for WATS and EATS, Moffett Federal Airfield, Moffett Field, California.

FWEC. 2003a. Final Post-Construction Operations, Maintenance, and Monitoring Plan, Revision 0, Installation Restoration (IR) Site 22 Landfill, Moffett Federal Airfield, Moffett Field, California. September 16.

FWEC. 2003b. Final 2001 Annual Groundwater Report for WATS and EATS, Moffett Federal Airfield, Moffett Field, California. January 31.

Ghanbari, M., M. Arabi, J. Obeysekera, and W. Sweet. 2019. A Coherent Statistical Model for Coastal Flood Frequency Analysis Under Nonstationary Sea Level Conditions. Earth’s Future 7:162–177. DOI:10.1029/2018EF001089.

Heberger, Matthew, Heather Cooley, Eli Moore, and Pablo Herrera (Pacific Institute). 2012. The Impacts of Sea Level Rise on the San Francisco Bay. California Energy Commission. Publication number: CEC-500-2012-014. July.

International Technology Corporation (ITC). 1991. Phase 1 Characterization Report, Naval Air Station, Moffett Field, California, Volumes 1 through 5. April.

ITC. 1993. Remedial Investigation Report, Operable Unit I, NAS Moffett Field. March.

ITC. 2000. Post-Closure Monitoring (IR Site 1) and Groundwater Monitoring (IR Site 2) Sampling and Analysis Plan.

Iwamura, T.I. 1980. Saltwater Intrusion Investigation in the Santa Clara County Baylands Area, California. Unpublished Report of Santa Clara Valley Water District.

KEMRON Environmental Services, Inc. (KEMRON). 2018. Draft Final Long-Term Monitoring Plan, Installation Restoration Site 26, Former Naval Air Station Moffett Field, Moffett Field, California. September.

Leisnoi Diversified Services, LLC (LDS)/KEMRON. 2021. Draft Final 2020 Long-Term Monitoring Report, Installation Restoration Site 26, Former Naval Air Station Moffett Field, Moffett Field, California. August.

Metropolitan Transportation Commission (MTC). 2021. Final Plan Bay Area 2050. Chapter 1: Introduction and Growth Geographies. October 1.

National Aeronautics and Space Administration (NASA). 1994. Moffett Field Comprehensive Use Plan, Moffett Field, California. September.

NASA. 1998. Allocation and Settlement Agreement for MEW Remedial Program Management between the National Aeronautics and Space Administration and Fairchild Semiconductor Corporation, Raytheon Company, and Intel Corporation.

NASA. 2002. Telecommunication with Mr. Don Chuck, Environmental Manager, Restoration and Subsurface Group, regarding NASA controls for future potential groundwater consumption within the Regional Plume. October 31.

NASA. 2015. Environmental Resources Document, NASA-Ames Research Center. March.

National Oceanic and Atmospheric Administration (NOAA). 2023. Relative Sea Level Trend 9414290 San Francisco, California. (https://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?id=9414290; accessed on 24 July 2024).

National Research Council (NRC). 1987. Responding to Changes in Sea Level: Engineering Implications. Washington, DC: The National Academies Press. https://doi.org/10.17226/1006.

Naval Energy and Environmental Support Activity (NEESA). 1984. Initial Assessment Study of Naval Air Station, Moffett Field, Sunnyvale, California. March.

Department of the Navy (Navy). 1996. Moffett Federal Airfield Final Operable Unit 5 Record of Decision, Moffett Federal Airfield, California. June 28.

Navy. 1997. Moffett Federal Airfield Final Operable Unit I Record of Decision, Moffett Federal Airfield, California. August 1.

Navy. 2002. Final Record of Decision, Revision 0, Site 22 Landfill, Moffett Federal Airfield, Moffett Field, California. June 25.

Navy. 2005a. Final East-Side Aquifer Treatment System (Operable Unit 5) Five-Year Review Report for the Period January 1999 to December 2002. February.

Navy. 2005b. Final West-Side Aquifers Treatment System, Five-Year Review Report for the Period November 1998 to October 2002. February.

Navy. 2010. Final Five-Year Review Report, Installation Restoration Sites 1, 22, 26 and 28, Former Naval Air Station Moffett Field, Moffett Field, California.

Navy. 2014. Record of Decision Amendment for Site 26. September 30.

Navy. 2020. Final Five-Year Review Report Installation Restoration Program Sites 26 and 28 NAS Moffett Field Superfund Site, Mountain View, California. August 4.

Navy. 2021. Memorandum to File for Non-Significant Modification to Final Record of Decision Amendment for Installation Restoration Site 26.

NOREAS, Inc. 2019. Final Installation Restoration Site 28 Air Sampling and Vapor Intrusion Tier Evaluation Report, Former Naval Air Station Moffett Field, Mountain View, California, April 10.

Oneida Total Integrated Enterprises (OTIE). 2014. Final Sampling and Analysis Plan (Field Sampling Plan and Quality Assurance Project Plan, Operations, Maintenance, and Groundwater and Landfill Gas Monitoring at Site 1 Landfill and Site 22 Landfill, Former Naval Air Station Moffett Field, Moffett Field, California. May.

PRC Environmental Management, Inc. (PRC). 1995. Operable Unit 1, Final Feasibility Study Report. Moffett Federal Airfield, California. May.

PRC. 1997. East-Side Aquifer Treatment System Final Long-Term Groundwater Monitoring Plan, Moffett Federal Airfield, California. July 3.

San Francisco Bay Conservation and Development Commission (BCDC) – Adapting to Rising Tides (ART) Program. 2017. Bay Area Sea Level Rise and Shoreline Analysis maps 'Bay Shoreline Flood Explorer'. (https://explorer.adaptingtorisingtides.org/home; accessed on 24 July 2024).

Santa Clara Valley Water District (SCVWD). 1989. Standards for the Construction and Destruction of Wells and other Deep Excavation in Santa Clara County. Appendix A. Geology and Ground Water Quality.

SCVWD. 2001. Santa Clara Valley Water District Groundwater Management Plan, Prepared by Vanessa Reymers and Tracy Hemmeter under the direction of Behzad Ahmadi, Unit Manager, Groundwater Management Unit. July.

SES-Tech Remediation Services (SES-Tech). 2009. Final 2008 Annual Groundwater Report for WATS and EATS, Moffett Federal Airfield, California. June 15.

Shaw Environmental, Inc. 2012. Final Focused Feasibility Study Installation Restoration Site 26 Former Naval Air Station Moffett Field, Moffett Field, California, July.

Sidder, A. 2019. As Sea Levels Rise, Expect More Floods. Eos 100:8–11. DOI: 10.1029/2019eo122097.

Sweet, W. V., B. D. Hamlington, R. E. Kopp, C. P. Weaver, P. L. Barnard, D. Bekaert, W. Brooks, M. Craghan, G. Dusek, T. Frederikse, G. Garner, A. S. Genz, J. P. Krasting, E. Larour, D. Marcy, J. J. Marra, J. Obeysekera, M. Osler, M. Pendleton, D. Roman, L. Schmied, W. Veatch, K. D. White, and C. Zuzak. 2022. Global and Regional Sea Level Rise Scenarios for the United States: Updated Mean Projections and Extreme Water Level Probabilities Along U.S. Coastlines. NOAA Technical Report NOS 01. National Oceanic and Atmospheric Administration, National Ocean Service., Silver Spring, Maryland. (https://oceanservice.noaa.gov/hazards/sealevelrise/sealevelrise-tech-report.html; accessed on 24 July 2024).

Tetra Tech, Inc. 2023. Final Per- and Polyfluoroalkyl Substances Site Inspection Report for Ames Research Center. April.

Tetra Tech EC, Inc. (TtEC). 2005. Draft Site 22 Post-Construction Operations, Maintenance, and Monitoring Plan Addendum, Revision 0, Former Naval Air Station Moffett Field, Moffett Field, California. August 12.

TtEC. 2007. Final Site 22 Post-Construction Operations, Maintenance, and Monitoring Plan Addendum, Revision 0, Former Naval Air Station Moffett Field, Moffett Field, California. November 30.

TtEC. 2008. Final Former Building 88 Investigation Report. March 7.

Tetra Tech EM, Inc. (TtEMI). 1998. Site 1 Landfill Final Closure Plan and Post-Closure Maintenance Plan, Moffett Federal Airfield, California. December 18.

TtEMI. 2001a. Draft Final Interim Remedial Action Report West-Side Aquifers Treatment System (WATS), Moffett Federal Airfield, California. April 27.

TtEMI. 2001b. Draft Final Interim Remedial Action Report, East-Side Aquifer Treatment System (EATS). May 18.

Tetra Tech FW, Inc. (TtFW). 2004a. Final Remedial Action Report for Installation Restoration Site 22 Landfill, Revision 0, Former Naval Air Station Moffett Field, Moffett Field, California. April 148.

TtFW. 2004b. Final Technical Memorandum, Site 1 Groundwater Evaluation Process, Rev 0. April 8.

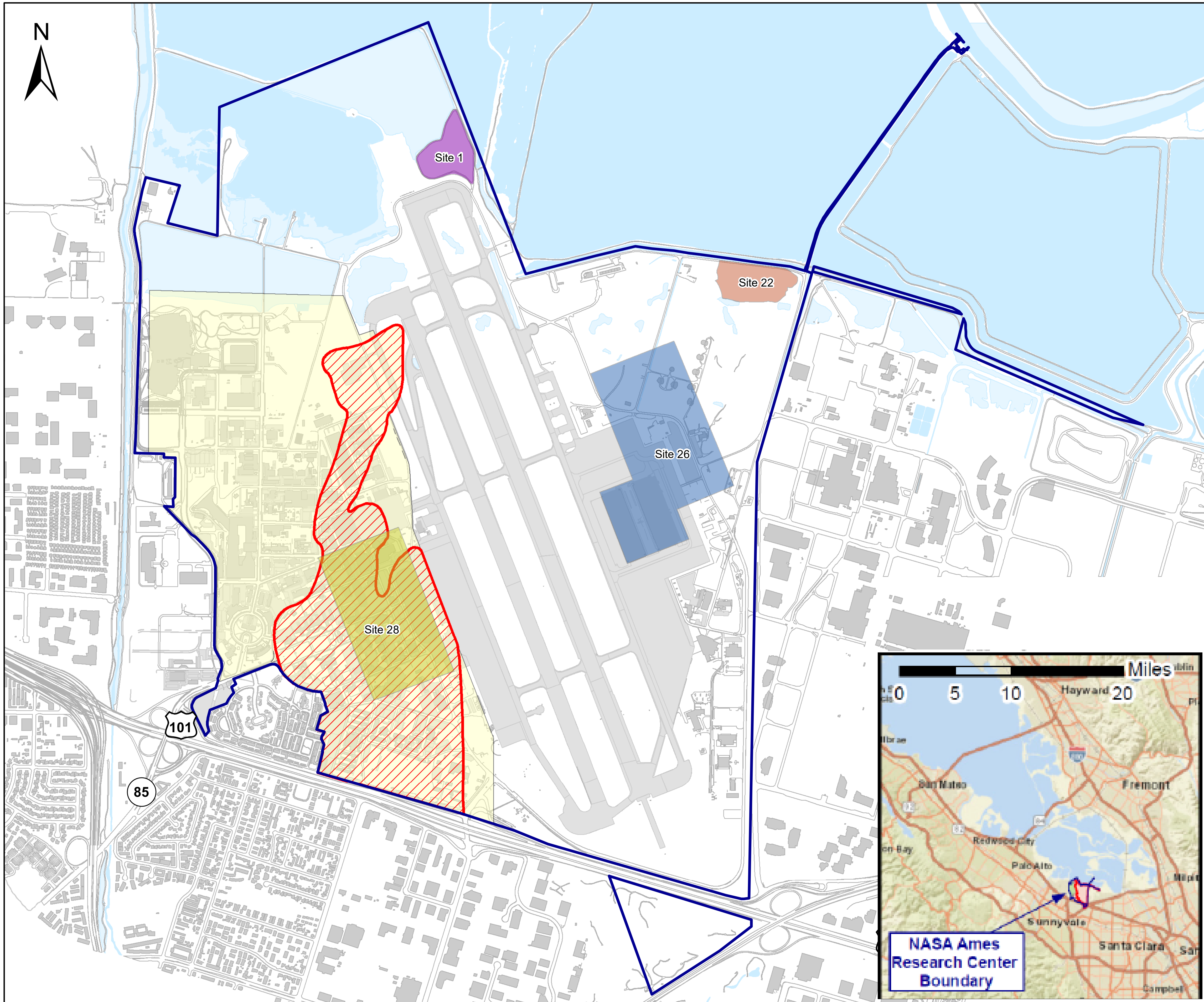
TtFW. 2005. Final Site 1 Landfill Post-Closure Long-Term Monitoring Plan, Rev 0. March 18.

Trevet. 2016. Final Modification to the Technical Memorandum, Site 1 Groundwater Evaluation Process and Post-Closure Long Term Monitoring Plan, Former Naval Air Station Moffett Field, California, December

United States Army Corps of Engineers (USACE) – Tulsa District. 2024. San Francisco Waterfront Coastal Flood Study (SFWCFS), CA. Draft Appendix B.1.1 – Coastal Extreme Water Levels and High Tide Flooding. January.

Vandever, J., M. Lightner, S. Kassem, J. Guyenet, M. Mak, and C. Bonham-Carter. 2017. Adapting to Rising Tides Bay Area Sea Level Rise Analysis and Mapping Project. Prepared by AECOM for the San Francisco Bay Conservation and Development Commission, the Metropolitan Transportation Commission, and the Bay Area Toll Authority, San Francisco, CA.

Figures



Legend:

- NASA Ames Research Center
- Site 1
- Site 22
- Site 26
- Site 28
- Former NAS Moffett Field Area of MEW Regional Plume Vapor Intrusion AOR & LUC Boundary
- NASA Groundwater LUC

Feet: 0, 1,000, 2,000, 4,000

Miles: 0, 0.25, 0.5

Notes:

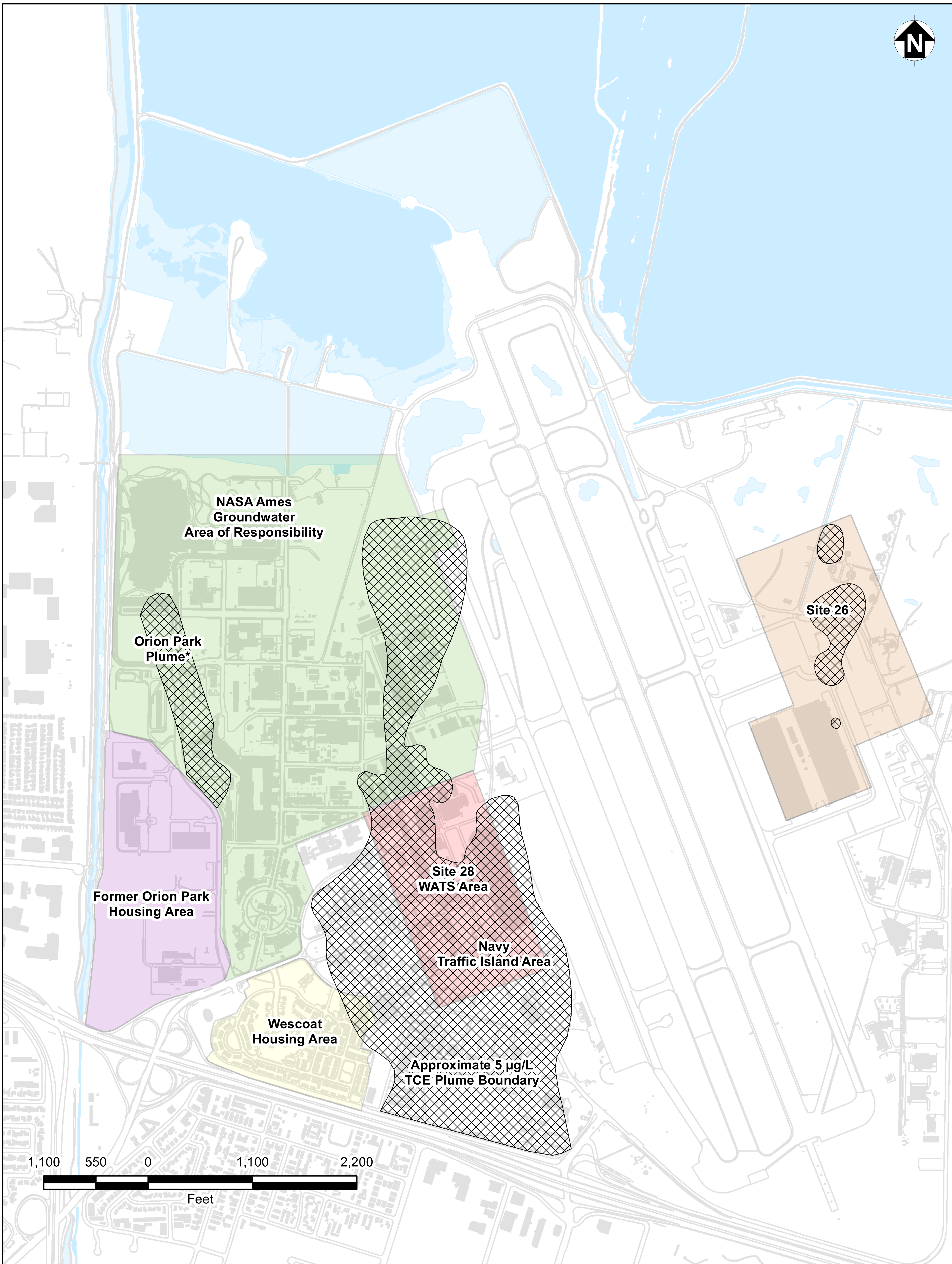
AOR	Area of Responsibility
LUC	Land Use Control
MEW	Middlefield-Ellis-Whisman
NAS	Naval Air Station
NASA	National Aeronautics and Space Administration

Ames Research Center
Moffett Field, California 94035

Source: NASA. 2023a. NASA Ames Land Use Controls Implementation and Monitoring Plan Update. Ames Research Center, Moffett Field, California. June.

NASA Ames Research Center
Moffett Field, California

Figure 1
Site Map



	Approximate 5 µg/L TCE plume boundary		Road
	Site 26		Wetland
	Site 28 WATS Area		Water
	NASA Area of Responsibility		Building
	Former Orion Park Housing Area		Runway
	Wescoat Housing Area		

Notes:
TCE - Trichloroethylene
µg/L - micrograms per liter
WATS - West-Side Aquifers Treatment System
*Extent of Orion Park Plume within NASA Ames Area of Responsibility

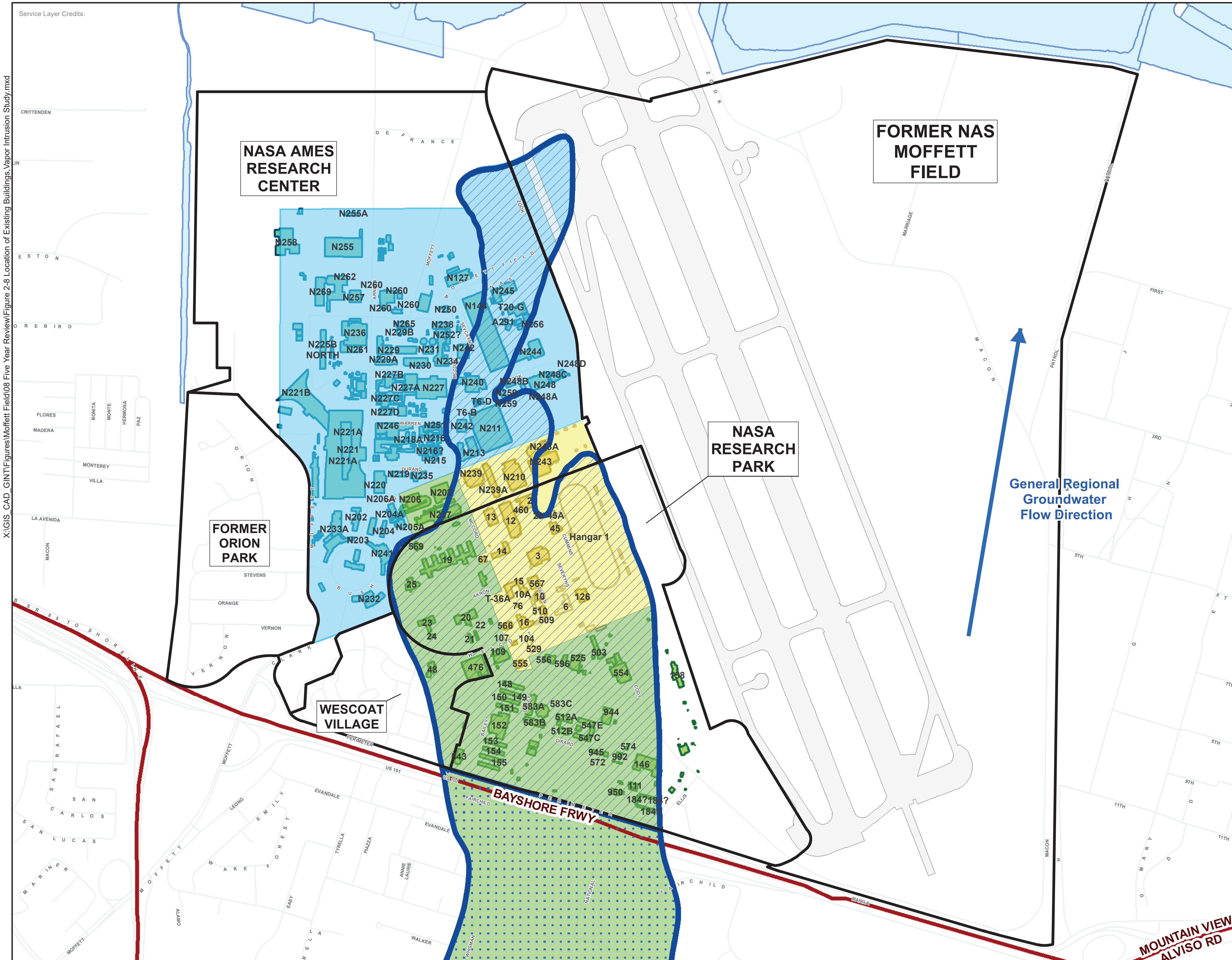
Ames Research Center
Moffett Field, CA 94035

Source: NASA. 2022. 2021 Annual Progress Report NASA Ames Regional Groundwater Remediation Program NASA Area of Responsibility and Site 28 WATS Area. April.

2023 Five Year Review Report for Sites 1, 22, 26, NASA RGRP, NASA VI AOR, and NASA LUCS

Figure 2
NASA Regional Groundwater Remediation Program Area of Responsibility

NASA AMES RESEARCH CENTER, MOFFETT FIELD, CALIFORNIA



LEGEND

Vapor Intrusion Area of Responsibility

- NAVY Area of Responsibility
- MEW Area of Responsibility
- NASA Area of Responsibility
- Zoning Boundaries
- Highway / Major Corridor
- Streets
- RUNWAY

*Original Vapor Intrusion Study Area**

- VI Study Area - MEW
- VI Study Area - Moffet

Ames Research Center
Moffett Field, CA 94035

* Defined as the approximate limit of TCE plume exceeding 5 µg/L in shallow groundwater as understood in 2009.

MEW - Middlefield-Ellis-Whisman
NASA - National Aeronautics and Space Administration
NAVY - Department of the Navy
TCE - Trichloroethene
VI - Vapor Intrusion
µg/L - micrograms per liter

N

0 500 1,000 2,000 Feet

Figure 3
NASA Vapor Intrusion AOR

FORMER NAS MOFFETT FIELD
MOFFETT FIELD, CALIFORNIA

2023 Five Year Review Report for Sites 1, 22, 26, NASA RGRP, NASA VI AOR, and NASA LUCS

FIGURE 2-8

reference: Figure extracted from 2014 Air Sampling and Vapor Intrusion Tier Response Evaluation Report, Former Naval Air Station Moffett Field (Accord MACTEC 8A JV, 2015)

Appendix A

Site Inspection Checklists

Site 1

Site 22

Site 26

NASA RGRP

NASA VI AOR

Five-Year Review Form
Site 1

I. SITE INFORMATION	
Site name: Site 1 Landfill	**Date of inspection: 2/7/24**
Location and Region: NASA Ames Research Center	**EPA ID: CA2170090078**
Agency, office, or company leading the five-year review: BB&E	**Weather/temperature: Rain to Mostly Cloudy, Wind to 25 mph, 48°F.**
Remedy Includes: (Check all that apply) ■Landfill cover/containment ☐ Monitored natural attenuation ■Access controls ☐ Groundwater containment ■Institutional controls ☐ Vertical barrier walls ☐ Groundwater pump and treatment ☐ Surface water collection and treatment ■Other Vegetation and burrowing mammal management.	
Attachments: ☐ Inspection team roster attached ■ Site map attached	
II. INTERVIEWS (Check all that apply)	
1. **O&M site manager** Luke Metz (Name) Restoration Specialist (Title) 2/7/24 (Date) Interviewed ■ at site ☐ at office ☐ by phone Phone no. (650) 906-3743 Problems, suggestions; ■Report attached See attached interview.*	
2. **O&M staff** Luke Metz (Name) Restoration Specialist (Title) 2/7/24 (Date) Interviewed ■ at site ☐ at office ☐ by phone Phone no. (650) 906-3743 Problems, suggestions; ☐ Report attached	

* Interviews provided in Appendix B of Five Year Review Report

3. **Local regulatory authorities and response agencies** (i.e., State and Tribal offices, emergency response office, police department, office of public health or environmental health, zoning office, recorder of deeds, or other city and county offices, etc.) Fill in all that apply.

Agency US EPA
Contact Yvonne Fong | Program Manager | 1/10/24 | (415) 947-4117
Name | Title | Date | Phone no.
Problems; suggestions; ■ Report attached See attached interview.*

Agency CA Regional Water Board-SF
Contact Dana McCarthy | Program Manager | 2/13/24 | (510) 622-2371
Name | Title | Date | Phone no.
Problems; suggestions; ■ Report attached See attached interview.*

Agency County of Santa Clara
Contact Nicole Jorgensen/Hunter Dang | Program Manager | 2/7/24 | (408) 918-3492
Name | Title | Date | Phone no.
Problems; suggestions; ■ Report attached See attached interview. *

Agency ______
Contact ______ | ______ | ______ | ______
Name | Title | Date | Phone no.
Problems; suggestions; ☐ Report attached ______

4. **Other interviews** (optional) ■ Report attached. *

Luke Metz (BB&E/ERT) – See attached interview*

* Interviews provided in Appendix B of the FIve Year Review Report.

III. ON-SITE DOCUMENTS & RECORDS VERIFIED (Check all that apply)

1. O&M Documents

■ O&M manual	■ Readily available	■ Up to date	☐ N/A
■ As-built drawings	■ Readily available	■ Up to date	☐ N/A
■ Maintenance logs	■ Readily available	■ Up to date	☐ N/A

Remarks Documents verified on JQ Server.

2. **Site-Specific Health and Safety Plan** ■ Readily available ☐ Up to date ☐ N/A
■ Contingency plan/emergency response plan ■ Readily available ☐ Up to date ☐ N/A
Remarks Documents verified on JQ Server. 2014 OTIE Sites 1 & 22 Site Safety Documents and 2023 BB&E Project Safety Plan

3. **O&M and OSHA Training Records** ■ Readily available ■ Up to date ☐ N/A
Remarks Documents verified on JQ Server.

4. Permits and Service Agreements

☐ Air discharge permit	☐ Readily available	☐ Up to date	■ N/A
☐ Effluent discharge	☐ Readily available	☐ Up to date	■ N/A
☐ Waste disposal, POTW	☐ Readily available	☐ Up to date	■ N/A
■ Other permits Closed Landfill	☐ Readily available	☐ Up to date	☐ N/A

Remarks

5. **Gas Generation Records** ■ Readily available ■ Up to date ☐ N/A
Remarks Methane monitoring and landfill gas analyses contained in annual reports.

6. **Settlement Monument Records** ■ Readily available ■ Up to date ☐ N/A
Remarks Settlement Monuments surveyed every 5 years. Last surveyed in 2020.

7. **Groundwater Monitoring Records** ■ Readily available ■ Up to date ☐ N/A
Remarks Groundwater analytical and water level gauging data contained in annual reports.

8. **Leachate Extraction Records** ☐ Readily available ☐ Up to date ■ N/A
Remarks

9. Discharge Compliance Records

☐ Air	☐ Readily available	☐ Up to date	■ N/A
☐ Water (effluent)	☐ Readily available	☐ Up to date	■ N/A

Remarks

10. **Daily Access/Security Logs** ☐ Readily available ☐ Up to date ■ N/A
Remarks Assess to Site 1 is behind security gate. EMD does not control access.

IV. O&M COSTS

1. O&M Organization

☐ State in-house ☐ Contractor for State
☐ PRP in-house ☐ Contractor for PRP
☐ Federal Facility in-house ■ Contractor for Federal Facility
☐ Other

2. O&M Cost Records

■ Readily available ■ Up to date
☐ Funding mechanism/agreement in place
Original O&M cost estimate ☐ Breakdown attached

Total annual cost by year for review period if available

From (Date)	To (Date)	Total cost	
1/1/19	12/31/19	$29,548 (Site 1 & 22 ODCs only)	☐ Breakdown attached
1/1/20	12/31/20	$29,645 (Site 1 & 22 ODCs only)	☐ Breakdown attached
1/1/21	12/31/21	$35,582 (Site 1 & 22 ODCs only)	☐ Breakdown attached
1/1/22	12/31/22	$47,413 (Site 1 & 22 ODCs only)	☐ Breakdown attached
1/1/23	12/31/23	$26,618 (Site 1 & 22 ODCs only)	☐ Breakdown attached

3. **Unanticipated or Unusually High O&M Costs During Review Period**

Describe costs and reasons: Burrowing mammal management is a costly component of the O&M requirements. During the review period, the burrowing mammal management program involves site inspection by a wildlife biologist twice per week, which includes burrow identification and exclusion. Fumigation of excluded burrows typically occurs twice per month, followed by burrow collapse or excavations. Landfill cap repair is required for burrows breaching the geotextile membrane.

*Note – Costs are combined for Sites 1 & 22 “other direct costs” (excludes labor).

V. ACCESS AND INSTITUTIONAL CONTROLS ■ Applicable ☐ N/A

A. Fencing

1. **Fencing damaged** ☐ Location shown on site map ■ Gates secured ☐ N/A
Remarks

B. Other Access Restrictions

1. **Signs and other security measures** ☐ Location shown on site map ☐ N/A
Remarks Signage on all access gates is recommended.

C. Institutional Controls (ICs)

1. **Implementation and enforcement**

Site conditions imply ICs not properly implemented ☐ Yes ■ No ☐ N/A
Site conditions imply ICs not being fully enforced ☐ Yes ■ No ☐ N/A

Type of monitoring (*e.g.*, self-reporting, drive by) County Inspections (quarterly), LUC Inspections (quarterly), Wildlife Inspections (weekly).
Frequency Weekly & Quarterly
Responsible party/agency Santa Clara County, NASA/BB&E and ERT

Contact	Name	Title	Date	Phone no.
	Luke Metz	Restoration Specialist		(650) 903-3743

Reporting is up-to-date ■ Yes ☐ No ☐ N/A
Reports are verified by the lead agency ■ Yes ☐ No ☐ N/A

Specific requirements in deed or decision documents have been met ■ Yes ☐ No ☐ N/A
Violations have been reported ■ Yes ☐ No ☐ N/A
Other problems or suggestions: ☐ Report attached
LUC checklists for 2023 attached for reference.

2. **Adequacy** ■ ICs are adequate ☐ ICs are inadequate ☐ N/A
Remarks

D. General

1. **Vandalism/trespassing** ☐ Location shown on site map ☐ No vandalism evident
Remarks Evidence of trespassing observed in June 2022. Additional signage was installed in response.

2. **Land use changes on site** ■ N/A
Remarks None that impact Site 1.

3. **Land use changes off site** ■ N/A
Remarks None that impact Site 1.

VI. GENERAL SITE CONDITIONS

A. Roads ■ Applicable ☐ N/A

1. **Roads damaged** ☐ Location shown on site map ■ Roads adequate ☐ N/A
Remarks Clear and in good condition.

B. Other Site Conditions

Remarks ____________________

VII. LANDFILL COVERS ■ Applicable ☐ N/A

A. Landfill Surface

1. **Settlement** (Low spots) ☐ Location shown on site map ■ Settlement not evident
Areal extent________ Depth________
Remarks________

2. **Cracks** ☐ Location shown on site map ■ Cracking not evident
Lengths________ Widths________ Depths________
Remarks________

3. **Erosion** ☐ Location shown on site map ■ Erosion not evident
Areal extent________ Depth________
Remarks Despite heavy rains over last two years, vegetation prevents slope erosion. Drainage control shows no signs of erosion.

4. **Holes** ☐ Location shown on site map ☐ Holes not evident
Areal extent________ Depth________
Remarks Holes created by burrowing animals have been quickly collapsed or filled by wildlife biologist. During inspection, only one squirrel burrow noted.

5. **Vegetative Cover** ■ Grass ■ Cover properly established ■ No signs of stress
☐ Trees/Shrubs (indicate size and locations on a diagram)
Remarks Vegetation noted to be of adequate distribution and height. Historically, mowing and spraying are conducted at routine intervals.

6. **Alternative Cover (armored rock, concrete, etc.)** ☐ N/A
Remarks Riprap with slurry cover along boundary with Stormwater Retention Pond is intact.

7. **Bulges** ☐ Location shown on site map ■ Bulges not evident
Areal extent________ Height________
Remarks________

8. **Wet Areas/Water Damage** ☐ Wet areas/water damage not evident

■ Wet areas ☐ Location shown on site map Areal extent wide spread

☐ Ponding ☐ Location shown on site map Areal extent______________

☐ Seeps ☐ Location shown on site map Areal extent______________

☐ Soft subgrade ☐ Location shown on site map Areal extent______________

Remarks Despite heavy rains, no ponding was evident. Drainage system was working effectively. Some vegetation noted in drainage ditches, which were promptly removed.

9. **Slope Instability** ☐ Slides ☐ Location shown on site map ■ No evidence of slope instability

Areal extent______________

Remarks______________

B. Benches ☐ Applicable ■ N/A

(Horizontally constructed mounds of earth placed across a steep landfill side slope to interrupt the slope in order to slow down the velocity of surface runoff and intercept and convey the runoff to a lined channel.)

1. **Flows Bypass Bench** ☐ Location shown on site map ☐ N/A or okay

Remarks______________

2. **Bench Breached** ☐ Location shown on site map ☐ N/A or okay

Remarks______________

3. **Bench Overtopped** ☐ Location shown on site map ☐ N/A or okay

Remarks______________

C. Letdown Channels ☐ Applicable ■ N/A

(Channel lined with erosion control mats, riprap, grout bags, or gabions that descend down the steep side slope of the cover and will allow the runoff water collected by the benches to move off of the landfill cover without creating erosion gullies.)

1. **Settlement** ☐ Location shown on site map ☐ No evidence of settlement

Areal extent______________ Depth____________

Remarks______________

2. **Material Degradation** ☐ Location shown on site map ☐ No evidence of degradation

Material type______________ Areal extent____________

Remarks______________

3. **Erosion** ☐ Location shown on site map ☐ No evidence of erosion

Areal extent______________ Depth____________

Remarks______________

4. **Undercutting** ☐ Location shown on site map ☐ No evidence of undercutting
Areal extent______________ Depth____________
Remarks____

5. **Obstructions** Type____________________ ☐ No obstructions
☐ Location shown on site map Areal extent______________
Size____________
Remarks____

6. **Excessive Vegetative Growth** Type____________________
☐ No evidence of excessive growth
☐ Vegetation in channels does not obstruct flow
☐ Location shown on site map Areal extent______________
Remarks____

D. Cover Penetrations ■ Applicable ☐ N/A

1. **Gas Vents** ☐ Active ■ Passive
■ Properly secured/locked ■ Functioning ■ Routinely sampled ■ Good condition
☐ Evidence of leakage at penetration ☐ Needs Maintenance
☐ N/A
Remarks Vents are sampled biannually and inspected quarterly.

2. **Gas Monitoring Probes**
■ Properly secured/locked ■ Functioning ■ Routinely sampled ■ Good condition
☐ Evidence of leakage at penetration ☐ Needs Maintenance ☐ N/A
Remarks Vapor wells are sampled biannually and inspected quarterly.

3. **Monitoring Wells** (within surface area of landfill)
☐ Properly secured/locked ☐ Functioning ☐ Routinely sampled ☐ Good condition
☐ Evidence of leakage at penetration ☐ Needs Maintenance ■ N/A
Remarks All groundwater monitoring wells are installed outside of landfill footprint.

4. **Leachate Extraction Wells**
■ Properly secured/locked ☐ Functioning ■ Routinely sampled ■ Good condition
☐ Evidence of leakage at penetration ☐ Needs Maintenance ☐ N/A
Remarks Two wells are installed in the collection trench for monitoring purposes.

5. **Settlement Monuments** ☐ Located ■ Routinely surveyed ☐ N/A
Remarks Settlement monuments were not located during inspection. Settlement surveys are performed every five years. The last settlement survey was conducted in 2020.

E. Gas Collection and Treatment ☐ Applicable ■ N/A	
1.	**Gas Treatment Facilities** ☐ Flaring ☐ Thermal destruction ☐ Collection for reuse ☐ Good condition ☐ Needs Maintenance Remarks________________________________
2.	**Gas Collection Wells, Manifolds and Piping** ☐ Good condition ☐ Needs Maintenance Remarks________________________________
3.	**Gas Monitoring Facilities** (*e.g.*, gas monitoring of adjacent homes or buildings) ☐ Good condition☐ Needs Maintenance ☐ N/A Remarks________________________________
F. Cover Drainage Layer ☐ Applicable ■ N/A	
1.	**Outlet Pipes Inspected** ☐ Functioning ☐ N/A Remarks________________________________
2.	**Outlet Rock Inspected** ☐ Functioning ☐ N/A Remarks________________________________
G. Detention/Sedimentation Ponds ☐ Applicable ■ N/A	
1.	**Siltation** Areal extent______________ Depth____________ ☐ N/A ☐ Siltation not evident Remarks________________________________
2.	**Erosion** Areal extent______________Depth______________ ☐ Erosion not evident Remarks________________________________
3.	**Outlet Works** ☐ Functioning ☐ N/A Remarks________________________________
4.	**Dam** ☐ Functioning ☐ N/A Remarks________________________________

H. Retaining Walls ☐ Applicable ■ N/A	
1.	**Deformations** ☐ Location shown on site map ☐ Deformation not evident Horizontal displacement______ Vertical displacement______ Rotational displacement______ Remarks______
2.	**Degradation** ☐ Location shown on site map ☐ Degradation not evident Remarks______
I. Perimeter Ditches/Off-Site Discharge ■ Applicable ☐ N/A	
1.	**Siltation** ☐ Location shown on site map ■ Siltation not evident Areal extent______ Depth______ Remarks Despite heavy rain and inundation of the Stormwater Retention Pond, runoff from Site 1 continues to flow into receiving waters.
2.	**Vegetative Growth** ☐ Location shown on site map ☐ N/A ■ Vegetation does not impede flow Areal extent______ Type______ Remarks Displaced vegetation was locally noted in permitter ditches, which did not impede flow of runoff. Vegetation was removed during site inspection.
3.	**Erosion** ☐ Location shown on site map ■ Erosion not evident Areal extent______ Depth______ Remarks______
4.	**Discharge Structure** ■ Functioning ☐ N/A Remarks______
VIII. VERTICAL BARRIER WALLS ☐ Applicable ■ N/A	
1.	**Settlement** ☐ Location shown on site map ☐ Settlement not evident Areal extent______ Depth______ Remarks______
2.	**Performance Monitoring** Type of monitoring______ ☐ Performance not monitored Frequency______ ☐ Evidence of breaching Head differential______ Remarks______

IX. GROUNDWATER/SURFACE WATER REMEDIES ■ Applicable ☐ N/A

A. Groundwater Extraction Wells, Pumps, and Pipelines ☐ Applicable ■ N/A

1. **Pumps, Wellhead Plumbing, and Electrical**
☐ Good condition ☐ All required wells properly operating ☐ Needs Maintenance ☐ N/A
Remarks

2. **Extraction System Pipelines, Valves, Valve Boxes, and Other Appurtenances**
☐ Good condition ☐ Needs Maintenance
Remarks

3. **Spare Parts and Equipment**
☐ Readily available ☐ Good condition ☐ Requires upgrade ☐ Needs to be provided
Remarks

B. Surface Water Collection Structures, Pumps, and Pipelines ■ Applicable ☐ N/A

1. **Collection Structures, Pumps, and Electrical**
■ Good condition ☐ Needs Maintenance
Remarks B191 Pump Station provides flood protection for the northern portion of Moffett Field. Drawdown created by pumping at B191 causes a southward groundwater gradient at Site 1.

2. **Surface Water Collection System Pipelines, Valves, Valve Boxes, and Other Appurtenances**
■ Good condition ☐ Needs Maintenance
Remarks Unknown. O&M managed by NASA's Facilities Engineering & Real Property Management Division.

3. **Spare Parts and Equipment**
☐ Readily available ☐ Good condition ☐ Requires upgrade ☐ Needs to be provided
Remarks Unknown.

C. Treatment System ☐ Applicable ■ N/A	
1.	**Treatment Train** (Check components that apply) ☐ Metals removal ☐ Oil/water separation ☐ Bioremediation ☐ Air stripping ☐ Carbon adsorbers ☐ Filters____ ☐ Additive (*e.g.*, chelation agent, flocculent)____ ☐ Others____ ☐ Good condition ☐ Needs Maintenance ☐ Sampling ports properly marked and functional ☐ Sampling/maintenance log displayed and up to date ☐ Equipment properly identified ☐ Quantity of groundwater treated annually____ ☐ Quantity of surface water treated annually____ Remarks____
2.	**Electrical Enclosures and Panels** (properly rated and functional) ■ N/A ☐ Good condition ☐ Needs Maintenance Remarks____
3.	**Tanks, Vaults, Storage Vessels** ■ N/A ☐ Good condition ☐ Proper secondary containment ☐ Needs Maintenance Remarks____
4.	**Discharge Structure and Appurtenances** ■ N/A ☐ Good condition ☐ Needs Maintenance Remarks____
5.	**Treatment Building(s)** ■N/A ☐ Good condition (esp. roof and doorways) ☐ Needs repair ☐ Chemicals and equipment properly stored Remarks____
6.	**Monitoring Wells** (pump and treatment remedy) ☐ Properly secured/locked ☐ Functioning ☐ Routinely sampled ☐ Good condition ☐ All required wells located ☐ Needs Maintenance ☐ N/A Remarks____
E. Monitoring Data	
1.	Monitoring Data ■ Is routinely submitted on time ■ Is of acceptable quality
2.	Monitoring data suggests: ■ Groundwater plume is effectively contained ☐ Contaminant concentrations are declining

E. Compliance Monitoring

1. **Monitoring Wells**

■ Properly secured/locked ■ Functioning ■ Routinely sampled ■ Good condition
■ All required wells located ☐ Needs Maintenance ☐ N/A

Remarks One standpipe well in the Stormwater Retention Pond is mostly underwater. All Site 1 wells are sampled on a biannual basis.

X. OTHER REMEDIES

If there are remedies applied at the site which are not covered above, attach an inspection sheet describing the physical nature and condition of any facility associated with the remedy. An example would be soil vapor extraction.

XI. OVERALL OBSERVATIONS

A. Implementation of the Remedy

Describe issues and observations relating to whether the remedy is effective and functioning as designed. Begin with a brief statement of what the remedy is to accomplish (i.e., to contain contaminant plume, minimize infiltration and gas emission, etc.).

O&M activities performed by NASA continue to successfully protect the integrity of the landfill cap. Excess vegetation, burrowing mammal burrows, and hydrologic management efforts are all routinely implemented and any unexpected O&M issues are quickly addressed. Groundwater sampling, water level measurements, and landfill gas monitoring programs are comprehensive and provide verification that the integrity of the landfill has been maintained. Additional LUC inspections also confirm that no unauthorized uses or activities are conducted at Site 1 .

B. Adequacy of O&M

Describe issues and observations related to the implementation and scope of O&M procedures. In particular, discuss their relationship to the current and long-term protectiveness of the remedy.

The Santa Clara County DEH has indicated that the O&M requirements and their implementation at Site 1 are model examples of closed landfill management. Continued successful implementation of the O&M requirements, along with groundwater and landfill gas monitoring, are expected to continue the long-term protectiveness of the remedy.

C.	Early Indicators of Potential Remedy Problems
	Describe issues and observations such as unexpected changes in the cost or scope of O&M or a high frequency of unscheduled repairs, that suggest that the protectiveness of the remedy may be compromised in the future.
	Burrowing mammal management will continue to be critical O&M issue at Site 1. The current level of management is probably not sustainable indefinitely. The continued operation of the B191 Pump Station will be required to prevent flooding in the vicinity of Site 1. The presence of pickleweed in a portion of Site 1 presents challenges to employing more aggressive burrowing mammal management techniques. The presence of the Snowy Plover in the Storm Water Retention Pond during breeding season has impacted the standard semiannual sampling schedule. The use of certain dissolved metals as MP/COC, which are naturally occurring at elevated levels, has resulted in the need for unproductive reporting and sampling activities.
D.	**Opportunities for Optimization**
	Describe possible opportunities for optimization in monitoring tasks or the operation of the remedy.
	1) Evaluate if switching groundwater sampling methodology from low-flow purging to HydraSleeves is viable (HydraSleeves are used for NASA RGRP and Site 26 sampling). 2) Evaluate additional burrowing mammal mitigation measures. 3) Evaluate applicability of continued use of certain naturally-occurring metals as MPs/COCs.

Site 1 Photo Log

Photo 1: Site 1 – Facing North – View of biotic barrier near South entrance area.

Photo 2: Site 1 – Facing East – South perimeter road separating South slope and pickleweed wetland area.


Photo 3: Site 1 – Facing North – West edge of cap along perimeter road.

Photo 4: Site 1 – Facing West - North slope of landfill along perimeter road.

Photo 5: Site 1 – Facing south – Eastern slope and drainage channel along fence-line.


Photo 6: Site 1 – Facing West – Top of cap near GV-8.

Photo 7: Site 1 – Facing North – Top of cap broadleaf vegetation near East slope and GV-8.

SITE 1

PHOTOGRAPH DIRECTION

N

0 50 100 200

Feet

Ames Research Center
Moffett Field, CA 94035

SITE 1 LANDFILL

PHOTOGRAPH MAP

Table 1: NASA Ames Research Center Land Use Controls
NASA Ames Research Center, Moffett Field, California

Site	Description	Basis for LUCs	NASA Ames LUCs
Navy Site 1 Landfill	Landfill cap vegetative cover, biotic barrier and low permeability layer, gas venting trench, landfill gas and groundwater monitoring system. (1997 Navy OU1 ROD)	Prevent exposure to waste and domestic use of groundwater	1. Prohibit landfill cap disturbance. 2. Maintain fencing and signage. 3. Operate and maintain Building 191 pump station and drainage system. 4. Restrict domestic groundwater use.

Five-Year Review Form
Site 22

I. SITE INFORMATION	
Site name: Site 22 Landfill	**Date of inspection: 2/7/24**
Location and Region: NASA Ames Research Center	**EPA ID: CA217009078**
Agency, office, or company leading the five-year review: BB&E	**Weather/temperature: Rain to Mostly Cloudy, Wind to 20 mph, 50°F.**

Remedy Includes: (Check all that apply)

- ■ Landfill cover/containment
- ☐ Access controls
- ■ Institutional controls
- ☐ Groundwater pump and treatment
- ☐ Surface water collection and treatment
- ■ Other Vegetation and burrowing mammal management.
- ☐ Monitored natural attenuation
- ☐ Groundwater containment
- ☐ Vertical barrier walls

Attachments: ☐ Inspection team roster attached ■ Site map attached

II. INTERVIEWS (Check all that apply)

1. **O&M site manager** Luke Metz — Restoration Specialist — 2/7/24
   (Name / Title / Date)
   Interviewed ■ at site ☐ at office ☐ by phone Phone no. (650) 906-3743
   Problems, suggestions; ■ Report attached See attached interview*

2. **O&M staff** Luke Metz — Restoration Specialist — 2/7/24
   (Name / Title / Date)
   Interviewed ■ at site ☐ at office ☐ by phone Phone no. (650) 906-3743
   Problems, suggestions; ☐ Report attached

* Interviews provided in Appendix B of the Five Year Review Report

3. **Local regulatory authorities and response agencies** (i.e., State and Tribal offices, emergency response office, police department, office of public health or environmental health, zoning office, recorder of deeds, or other city and county offices, etc.) Fill in all that apply.

Agency US EPA
Contact Yvonne Fong — Program Manager — 1/10/24 — (415) 947-4117
Name / Title / Date / Phone no.
Problems; suggestions; ■ Report attached See attached interview.*

Agency CA Regional Water Board-SF
Contact Dana McCarthy — Program Manager — 2/13/24 — (510) 622-2371
Name / Title / Date / Phone no.
Problems; suggestions; ■ Report attached See attached interview.*

Agency County of Santa Clara
Contact Nicole Jorgensen/Hunter Dang — Program Manager — 2/7/24 — (408) 918-3492
Name / Title / Date / Phone no.
Problems; suggestions; ■ Report attached See attached interview.*

Agency ______
Contact ______ ______ ______ ______
Name / Title / Date / Phone no.
Problems; suggestions; ☐ Report attached ______

4. **Other interviews** (optional) ■ Report attached.

Luke Metz (BB&E/ERT) – See attached interview

Ryan Clauzel & Anthony LaMarca – See attached *interview.

*

* Interviews provided in Appendix B of the FIve Year Review Report

III. ON-SITE DOCUMENTS & RECORDS VERIFIED (Check all that apply)

1. O&M Documents

■ O&M manual	■ Readily available	■ Up to date	☐ N/A
■ As-built drawings	■ Readily available	■ Up to date	☐ N/A
■ Maintenance logs	■ Readily available	■ Up to date	☐ N/A

Remarks Documents verified on JQ Server.

2. **Site-Specific Health and Safety Plan** ■ Readily available ☐ Up to date ☐ N/A
■ Contingency plan/emergency response plan ■ Readily available ☐ Up to date ☐ N/A
Remarks Documents verified on JQ Server. 2014 OTI Sites 1 & 22 Site Safety Documents and 2023 BB&E Project Safety Plan.

3. **O&M and OSHA Training Records** ■ Readily available ■ Up to date ☐ N/A
Remarks Documents verified on JQ Server.

4. Permits and Service Agreements

☐ Air discharge permit	☐ Readily available	☐ Up to date	■ N/A
☐ Effluent discharge	☐ Readily available	☐ Up to date	■ N/A
☐ Waste disposal, POTW	☐ Readily available	☐ Up to date	■ N/A
■ Other permits Closed Landfill	☐ Readily available	☐ Up to date	☐ N/A

Remarks

5. **Gas Generation Records** ■ Readily available ■ Up to date ☐ N/A
Remarks Methane monitoring and landfill gas analyses contained within annual reports.

6. **Settlement Monument Records** ☐ Readily available ☐ Up to date ■ N/A
Remarks

7. **Groundwater Monitoring Records** ■ Readily available ■ Up to date ☐ N/A
Remarks Groundwater analytical and water level gauging data included in annual reports.

8. **Leachate Extraction Records** ☐ Readily available ☐ Up to date ■ N/A
Remarks

9. Discharge Compliance Records

☐ Air	☐ Readily available	☐ Up to date	■ N/A
☐ Water (effluent)	☐ Readily available	☐ Up to date	■ N/A

Remarks

10. **Daily Access/Security Logs** ☐ Readily available ☐ Up to date ■ N/A
Remarks Site 22 is located on a public golf course. Area is open to the public.

IV. O&M COSTS

1. O&M Organization

☐ State in-house ☐ Contractor for State
☐ PRP in-house ☐ Contractor for PRP
☐ Federal Facility in-house ■ Contractor for Federal Facility
☐ Other

2. O&M Cost Records

■ Readily available ■ Up to date
☐ Funding mechanism/agreement in place
Original O&M cost estimate ☐ Breakdown attached

Total annual cost by year for review period if available

From	1/1/19	To	12/31/19	$29,548 (Site 1 & 22 ODCs only)	☐ Breakdown attached
	Date		Date	Total cost	
From	1/1/20	To	12/31/20	$29,645 (Site 1 & 22 ODCs only)	☐ Breakdown attached
	Date		Date	Total cost	
From	1/1/21	To	12/31/21	$35,582 (Site 1 & 22 ODCs only)	☐ Breakdown attached
	Date		Date	Total cost	
From	1/1/22	To	12/31/22	$47,413 (Site 1 & 22 ODCs only)	☐ Breakdown attached
	Date		Date	Total cost	
From	1/1/23	To	12/31/23	$26,618 (Site 1 & 22 ODCs only)	☐ Breakdown attached
	Date		Date	Total cost	

3. **Unanticipated or Unusually High O&M Costs During Review Period**

Describe costs and reasons:

*Note – Costs are combined for Sites 1 & 22 "other direct costs" (excludes labor).

V. ACCESS AND INSTITUTIONAL CONTROLS ■ Applicable ☐ N/A

A. Fencing

1. **Fencing damaged** ☐ Location shown on site map ☐ Gates secured ■ N/A
Remarks Site 22 is located on a public golf course. Area is open to the public

B. Other Access Restrictions

1. **Signs and other security measures** ☐ Location shown on site map ■ N/A
Remarks Site 22 is located on a public golf course. Area is open to the public.

C. Institutional Controls (ICs)

1. **Implementation and enforcement**

Site conditions imply ICs not properly implemented ☐ Yes ■ No ☐ N/A
Site conditions imply ICs not being fully enforced ☐ Yes ■ No ☐ N/A

Type of monitoring (*e.g.*, self-reporting, drive by) County Inspections (quarterly), LUC Inspections (quarterly), Wildlife Inspections (weekly), Golf Course Inspections (varies).
Frequency Weekly & Quarterly
Responsible party/agency BB&E

Contact			
Luke Metz	Restoration Specialist		(650) 903-3743
Name	Title	Date	Phone no.

Reporting is up-to-date ■ Yes ☐ No ☐ N/A
Reports are verified by the lead agency ■ Yes ☐ No ☐ N/A

Specific requirements in deed or decision documents have been met ■ Yes ☐ No ☐ N/A
Violations have been reported ■ Yes ☐ No ■ N/A
Other problems or suggestions: ■ Report attached
PV (OB Sports) and NASA share implementation responsibilities for ICs and LUCs. NASA ensures ICs and LUCs are enforced through inspections and reviews. LUC checklists for 2023 attached for reference.

2. **Adequacy** ■ ICs are adequate ☐ ICs are inadequate ☐ N/A
Remarks

D. General

1. **Vandalism/trespassing** ☐ Location shown on site map ■ No vandalism evident
Remarks

2. **Land use changes on site** ■ N/A
Remarks None that impact Site 22.

3. **Land use changes off site** ■ N/A
Remarks None that impact Site 22.

VI. GENERAL SITE CONDITIONS

A. Roads ■ Applicable ☐ N/A

1. **Roads damaged** ☐ Location shown on site map ■ Roads adequate ☐ N/A
Remarks Ponding on cart paths is a recurrent issue, but is promptly addressed by OB Sports personnel.

B. Other Site Conditions

Remarks

VII. LANDFILL COVERS ■ Applicable ☐ N/A

A. Landfill Surface

1. **Settlement** (Low spots) ☐ Location shown on site map ■ Settlement not evident
   Areal extent Depth
   Remarks

2. **Cracks** ☐ Location shown on site map ■ Cracking not evident
   Lengths Widths Depths
   Remarks

3. **Erosion** ☐ Location shown on site map ■ Erosion not evident
   Areal extent Depth
   Remarks

4. **Holes** ☐ Location shown on site map ☐ Holes not evident
   Areal extent Depth
   Remarks Holes created by burrowing animals have been quickly collapsed or filled by OB Sports. Several repaired burrows were evident. A number of burrows were noted along the northern drainage ditch.

5. **Vegetative Cover** ■ Grass ■ Cover properly established ■ No signs of stress
   ■ Trees/Shrubs (indicate size and locations on a diagram)
   Remarks Typical golf course landscaping. Trees have been planted in engineered planting boxes.

6. **Alternative Cover (armored rock, concrete, etc.)** ■ N/A
   Remarks

7. **Bulges** ☐ Location shown on site map ■ Bulges not evident
   Areal extent Height
   Remarks

8. **Wet Areas/Water Damage** ☐ Wet areas/water damage not evident
■Wet areas ☐ Location shown on site map Areal extent______________
■Ponding ☐ Location shown on site map Areal extent______________
☐ Seeps ☐ Location shown on site map Areal extent______________
☐ Soft subgrade ☐ Location shown on site map Areal extent______________
Remarks Due to the heavy rains, much of the golf course was soggy. Localized ponding was observed near cart paths and drainage ditches, but was minimal.

9. **Slope Instability** ☐ Slides ☐ Location shown on site map ■ No evidence of slope instability
Areal extent______________
Remarks Site 22 is relatively flat.

B. Benches ☐ Applicable ■ N/A
(Horizontally constructed mounds of earth placed across a steep landfill side slope to interrupt the slope in order to slow down the velocity of surface runoff and intercept and convey the runoff to a lined channel.)

1. **Flows Bypass Bench** ☐ Location shown on site map ☐ N/A or okay
Remarks______________

2. **Bench Breached** ☐ Location shown on site map ☐ N/A or okay
Remarks______________

3. **Bench Overtopped** ☐ Location shown on site map ☐ N/A or okay
Remarks______________

C. Letdown Channels ☐ Applicable ■ N/A
(Channel lined with erosion control mats, riprap, grout bags, or gabions that descend down the steep side slope of the cover and will allow the runoff water collected by the benches to move off of the landfill cover without creating erosion gullies.)

1. **Settlement** ☐ Location shown on site map ☐ No evidence of settlement
Areal extent______________ Depth____________
Remarks______________

2. **Material Degradation** ☐ Location shown on site map ☐ No evidence of degradation
Material type______________ Areal extent____________
Remarks______________

3. **Erosion** ☐ Location shown on site map ☐ No evidence of erosion
Areal extent______________ Depth____________
Remarks______________

4. **Undercutting** ☐ Location shown on site map ☐ No evidence of undercutting
Areal extent______________ Depth____________
Remarks____

5. **Obstructions** Type_____________________ ☐ No obstructions
☐ Location shown on site map Areal extent______________
Size____________
Remarks____

6. **Excessive Vegetative Growth** Type____________________
☐ No evidence of excessive growth
☐ Vegetation in channels does not obstruct flow
☐ Location shown on site map Areal extent______________
Remarks____

D. Cover Penetrations ■ Applicable ☐ N/A

1. **Gas Vents** ☐ Active ■ Passive
■ Properly secured/locked ■ Functioning ■ Routinely sampled ■ Good condition
☐ Evidence of leakage at penetration ☐ Needs Maintenance
☐ N/A
Remarks Vents are sampled biannually and inspected quarterly

2. **Gas Monitoring Probes**
■ Properly secured/locked ■ Functioning ■ Routinely sampled ■ Good condition
☐ Evidence of leakage at penetration ☐ Needs Maintenance ☐ N/A
Remarks Vapor wells are sampled biannually and inspected quarterly.

3. **Monitoring Wells** (within surface area of landfill)
☐ Properly secured/locked ☐ Functioning ☐ Routinely sampled ☐ Good condition
☐ Evidence of leakage at penetration ☐ Needs Maintenance ■ N/A
Remarks All groundwater monitoring wells are installed outside of landfill footprint.

4. **Leachate Extraction Wells**
☐ Properly secured/locked ☐ Functioning ☐ Routinely sampled ☐ Good condition
☐ Evidence of leakage at penetration ☐ Needs Maintenance ■ N/A
Remarks____

5. **Settlement Monuments** ☐ Located ☐ Routinely surveyed ■ N/A
Remarks____

E. Gas Collection and Treatment ☐ Applicable ■ N/A

1. **Gas Treatment Facilities**
☐ Flaring ☐ Thermal destruction ☐ Collection for reuse
☐ Good condition ☐ Needs Maintenance
Remarks____________________

2. **Gas Collection Wells, Manifolds and Piping**
☐ Good condition ☐ Needs Maintenance
Remarks____________________

3. **Gas Monitoring Facilities** (*e.g.*, gas monitoring of adjacent homes or buildings)
☐ Good condition ☐ Needs Maintenance ☐ N/A
Remarks____________________

F. Cover Drainage Layer ☐ Applicable ■ N/A

1. **Outlet Pipes Inspected** ☐ Functioning ☐ N/A
Remarks____________________

2. **Outlet Rock Inspected** ☐ Functioning ☐ N/A
Remarks____________________

G. Detention/Sedimentation Ponds ☐ Applicable ■ N/A

1. **Siltation** Areal extent__________ Depth__________ ☐ N/A
☐ Siltation not evident
Remarks____________________

2. **Erosion** Areal extent__________ Depth__________
☐ Erosion not evident
Remarks____________________

3. **Outlet Works** ☐ Functioning ☐ N/A
Remarks____________________

4. **Dam** ☐ Functioning ☐ N/A
Remarks____________________

H. Retaining Walls	☐ Applicable	■ N/A	
1.	**Deformations** ☐ Location shown on site map ☐ Deformation not evident Horizontal displacement_____________ Vertical displacement________________ Rotational displacement_____________ Remarks____		
2.	**Degradation** ☐ Location shown on site map ☐ Degradation not evident Remarks____		
I. Perimeter Ditches/Off-Site Discharge	■ Applicable	☐ N/A	
1.	**Siltation** ☐ Location shown on site map ■ Siltation not evident Areal extent_______________ Depth_____________ Remarks____		
2.	**Vegetative Growth** ☐ Location shown on site map ☐ N/A ☐ Vegetation does not impede flow Areal extent_______________ Type_____________ Remarks The northern drainage ditch and swale contained excessive vegetative growth (pampas grass, foxtails and broadleaves) and vegetation debris which partially obstructed flow, but did not result in flooding. Vegetation was cleared from the swale and drainage ditch within a week of inspection and notification.		
3.	**Erosion** ☐ Location shown on site map ■ Erosion not evident Areal extent_______________ Depth_____________ Remarks____		
4.	**Discharge Structure** ■ Functioning ☐ N/A Remarks____		
VIII. VERTICAL BARRIER WALLS	☐ Applicable	■ N/A	
1.	**Settlement** ☐ Location shown on site map ☐ Settlement not evident Areal extent_______________ Depth_____________ Remarks____		
2.	**Performance Monitoring** Type of monitoring____________________________ ☐ Performance not monitored Frequency_________________________________ ☐ Evidence of breaching Head differential____________________________ Remarks____		

IX. GROUNDWATER/SURFACE WATER REMEDIES ■ Applicable ☐ N/A

A. Groundwater Extraction Wells, Pumps, and Pipelines ☐ Applicable ■ N/A

1. **Pumps, Wellhead Plumbing, and Electrical**
☐ Good condition ☐ All required wells properly operating ☐ Needs Maintenance ☐ N/A
Remarks

2. **Extraction System Pipelines, Valves, Valve Boxes, and Other Appurtenances**
☐ Good condition ☐ Needs Maintenance
Remarks

3. **Spare Parts and Equipment**
☐ Readily available ☐ Good condition ☐ Requires upgrade ☐ Needs to be provided
Remarks

B. Surface Water Collection Structures, Pumps, and Pipelines ■ Applicable ☐ N/A

1. **Collection Structures, Pumps, and Electrical**
■ Good condition ☐ Needs Maintenance
Remarks B191 Pump Station provides flood protection for the northern portion of Moffett Field. Drawdown created by pumping at B191 causes a westward groundwater gradient at Site 22.

2. **Surface Water Collection System Pipelines, Valves, Valve Boxes, and Other Appurtenances**
■ Good condition ☐ Needs Maintenance
Remarks Unknown. O&M managed by NASA's Facilities Engineering & Real Property Management Division.

3. **Spare Parts and Equipment**
☐ Readily available ☐ Good condition ☐ Requires upgrade ☐ Needs to be provided
Remarks Unknown.

C. Treatment System ☐ Applicable ■ N/A

1. **Treatment Train** (Check components that apply)
☐ Metals removal ☐ Oil/water separation ☐ Bioremediation
☐ Air stripping ☐ Carbon adsorbers
☐ Filters____________________________________
☐ Additive (*e.g.*, chelation agent, flocculent)__________________________
☐ Others____________________________________
☐ Good condition ☐ Needs Maintenance
☐ Sampling ports properly marked and functional
☐ Sampling/maintenance log displayed and up to date
☐ Equipment properly identified
☐ Quantity of groundwater treated annually__________________
☐ Quantity of surface water treated annually__________________
Remarks____________________________________

2. **Electrical Enclosures and Panels** (properly rated and functional)
☐ N/A ☐ Good condition ☐ Needs Maintenance
Remarks____________________________________

3. **Tanks, Vaults, Storage Vessels**
☐ N/A ☐ Good condition ☐ Proper secondary containment ☐ Needs Maintenance Remarks_
____

4. **Discharge Structure and Appurtenances**
☐ N/A ☐ Good condition ☐ Needs Maintenance
Remarks____________________________________

5. **Treatment Building(s)**
☐ N/A ☐ Good condition (esp. roof and doorways) ☐ Needs repair
☐ Chemicals and equipment properly stored
Remarks____________________________________

6. **Monitoring Wells** (pump and treatment remedy)
☐ Properly secured/locked ☐ Functioning ☐ Routinely sampled ☐ Good condition
☐ All required wells located ☐ Needs Maintenance ☐ N/A
Remarks____________________________________

D. Monitoring Data

1. Monitoring Data
■ Is routinely submitted on time ■ Is of acceptable quality

2. Monitoring data suggests:
■ Groundwater plume is effectively contained ☐ Contaminant concentrations are declining

E. Compliance Monitoring

1. **Monitoring Wells**

■ Properly secured/locked ■ Functioning ■ Routinely sampled ■ Good condition
■ All required wells located ☐ Needs Maintenance ■ N/A

Remarks Flooding in the well box of well WGC2-1 needs to be addressed. All Site 22 wells are sampled on a biannual basis.

X. OTHER REMEDIES

If there are remedies applied at the site which are not covered above, attach an inspection sheet describing the physical nature and condition of any facility associated with the remedy. An example would be soil vapor extraction.

XI. OVERALL OBSERVATIONS

A. Implementation of the Remedy

Describe issues and observations relating to whether the remedy is effective and functioning as designed. Begin with a brief statement of what the remedy is to accomplish (i.e., to contain contaminant plume, minimize infiltration and gas emission, etc.).

O&M activities performed by NASA and OB Sports continue to successfully protect the integrity of the landfill cap. Excess vegetation, burrowing mammal burrows, and hydrologic management efforts are all routinely implemented and any unexpected O&M issues are quickly mitigated by the responsibility party. Groundwater sampling, water level measurements, and landfill gas monitoring programs are comprehensive and provide verification that the integrity of the landfill has been maintained. Additional LUC inspections also confirm that no unauthorized uses or activities are conducted at Site 22 .

B. Adequacy of O&M

Describe issues and observations related to the implementation and scope of O&M procedures. In particular, discuss their relationship to the current and long-term protectiveness of the remedy.

The Santa Clara County DEH has indicated that the O&M requirements and their implementation at Site 22 are model examples of closed landfill management. Continued successful implementation of the O&M requirements, along with groundwater and landfill gas monitoring, are expected to continue the long-term protectiveness of the remedy.

C.	**Early Indicators of Potential Remedy Problems**
	Describe issues and observations such as unexpected changes in the cost or scope of O&M or a high frequency of unscheduled repairs, that suggest that the protectiveness of the remedy may be compromised in the future. Burrowing mammal and hydrologic management will continue to be critical O&M issues at Site 22. The continued operation of the B191 Pump Station will be required to prevent flooding in the vicinity of Site 22. Close coordination between NASA and OB Sports will need to be continued to ensure all O&M requirements are promptly and effectively addressed.
D.	**Opportunities for Optimization**
	Describe possible opportunities for optimization in monitoring tasks or the operation of the remedy. 1)Develop standardized inspection and reporting templates to be utilized by OB Sports. 2) Evaluate if switching groundwater sampling methodology from low-flow purging to HydraSleeves is viable (HydraSleeves are used for NASA RGRP and Site 26 sampling).

Site 22 Photo Log

Photo 8: Site 22 – Facing West – Western portion of site footprint near LGMW-4.

Photo 9: Site 22 – Facing East – Western portion of cap footprint along cart path.

Photo 10: Site 22 – Facing North – Mid cap location and cart path condition.

Photo 11: Site 22 – Facing East – Eastern portion of cap showing tree wells and cart path.

Photo 12: Site 22 – Facing East – Drainage swale along perimeter road.


Photo 13: Site 22 – Facing East – Drainage swale and slope vegetation cleared on February 9, 2024.

Photo 14: Site 22 - Facing South – Pampas grass and open burrow on north slope. Burrow repaired on February 9, 2024.

Photo 15: Site 22 - Facing East – View of filled burrow and Pampas grass (Cut and sprayed on February 26, 2024).

SITE 22

Former NAS Moffett
Field Boundary

PHOTOGRAPH DIRECTION

N

0 75 150 300

Feet

Ames Research Center
Moffett Field, CA 94035

SITE 22 LANDFILL

PHOTOGRAPH MAP

Table 1: NASA Ames Research Center Land Use Controls
NASA Ames Research Center, Moffett Field, California

Site	Description	Basis for LUCs	NASA Ames LUCs
Navy Site 22 Landfill	Landfill cap with vegetative cover and biotic barrier, landfill gas and groundwater monitoring system. (2002 Navy Site 22 Landfill ROD)	Prevent exposure to waste and domestic use of groundwater	1. Protect the structural aspects of the landfill cap (biotic barrier) by restricting activities that could potentially disturb the cap. 2. Maintain vegetation, topsoil layer, irrigation system, and drainage components, including surface contours, encompassed within and adjacent to the Site 22 remedy boundary. 3. Maintain and operate the Building 191 pump station. 4. Prohibit extraction of groundwater from Site 22. 5. Prohibit residential land use of the site and obtain regulatory approval for consideration of alternative land use. 6. Include a restrictive covenant in the deed for conveyance of any portion of the Site 22 landfill to include LUCs.

Five-Year Review Form
Site 26

I. SITE INFORMATION	
Site name: Site 26	**Date of inspection: 3/27/24**
Location and Region: NASA Ames Research Center	**EPA ID: CA2170090078**
Agency, office, or company leading the five-year review: BB&E	**Weather/temperature: Mostly sunny, 65°F, wind to 5 mph**

Remedy Includes: (Check all that apply)

☐ Landfill cover/containment
■ Monitored natural attenuation
☐ Access controls
☐ Groundwater containment
■ Institutional controls
☐ Vertical barrier walls
☐ Groundwater pump and treatment
☐ Surface water collection and treatment
■ Other Enhanced Anerobic Biodegradation/Insitu Chemical Reduction

Attachments: ☐ Inspection team roster attached ■ Site map attached

II. INTERVIEWS (Check all that apply)

1. **O&M site manager** Ingrid Warburg — Name; Restoration Specialist — Title; 3/25/24 — Date

   Interviewed ☐ at site ■ at office ☐ by phone Phone no. (650) 604-1129

   Problems, suggestions; ■ Report attached *

2. **O&M staff** Ingrid Warburg — Name; Restoration Specialist — Title; ______ — Date

   Interviewed ☐ at site ☐ at office ☐ by phone Phone no.______

   Problems, suggestions; ☐ Report attached______

* Interviews provided in Appendix B of the Five Year Review Report.

3. **Local regulatory authorities and response agencies** (i.e., State and Tribal offices, emergency response office, police department, office of public health or environmental health, zoning office, recorder of deeds, or other city and county offices, etc.) Fill in all that apply.

Agency US EPA
Contact Yvonne Fong — Program Manager — 1/10/24 — (415) 947-4117
Name — Title — Date — Phone no.
Problems; suggestions; ■ Report attached See attached interview. *

Agency CA Regional Water Board-SF
Contact Dana McCarthy — Program Manager — 2/13/24 — (510) 622-2371
Name — Title — Date — Phone no.
Problems; suggestions; ■ Report attached See attached interview. *

Agency ____
Contact ____ ____ ____ ____
Name — Title — Date — Phone no.
Problems; suggestions; ☐ Report attached ____

Agency ____
Contact ____ ____ ____ ____
Name — Title — Date — Phone no.
Problems; suggestions; ☐ Report attached ____

4. **Other interviews** (optional) ☐ Report attached.

Ingrid Warburg (BB&E/ERT) – See attached interview *

* Interviews provided in Appendix B of the Five Year Review Report.

III. ON-SITE DOCUMENTS & RECORDS VERIFIED (Check all that apply)				
1.	**O&M Documents**			
	■ O&M manual	■ Readily available	☐ Up to date	☐ N/A
	■ As-built drawings	■ Readily available	☐ Up to date	☐ N/A
	■ Maintenance logs	■ Readily available	☐ Up to date	☐ N/A
	Remarks Documents verified on JQ Server.			
2.	**Site-Specific Health and Safety Plan**	■ Readily available	■ Up to date	☐ N/A
	☐ Contingency plan/emergency response plan	■ Readily available	■ Up to date	☐ N/A
	Remarks Documents verified on JQ Server. 2023 BB&E Standard Operating Procedures and 2023 BB&E Project Safety Plan.			
3.	**O&M and OSHA Training Records**	■ Readily available	■ Up to date	☐ N/A
	Remarks Documents verified on JQ Server.			
4.	**Permits and Service Agreements**			
	☐ Air discharge permit	☐ Readily available	☐ Up to date	■ N/A
	☐ Effluent discharge	☐ Readily available	☐ Up to date	■ N/A
	☐ Waste disposal, POTW	☐ Readily available	☐ Up to date	■ N/A
	☐ Other permits______	☐ Readily available	☐ Up to date	☐ N/A
	Remarks			
5.	**Gas Generation Records**	☐ Readily available	☐ Up to date	■ N/A
	Remarks			
6.	**Settlement Monument Records**	☐ Readily available	☐ Up to date	■ N/A
	Remarks			
7.	**Groundwater Monitoring Records**	■ Readily available	■ Up to date	☐ N/A
	Remarks Navy records from before October 1, 2021 only included information included in Annual Reports. Supporting documentation not provided.			
8.	**Leachate Extraction Records**	☐ Readily available	☐ Up to date	■ N/A
	Remarks			
9.	**Discharge Compliance Records**			
	☐ Air	☐ Readily available	☐ Up to date	■ N/A
	☐ Water (effluent)	☐ Readily available	☐ Up to date	■ N/A
	Remarks			
10.	**Daily Access/Security Logs**	☐ Readily available	☐ Up to date	■ N/A
	Remarks			

IV. O&M COSTS

1. O&M Organization

☐ State in-house ☐ Contractor for State
☐ PRP in-house ☐ Contractor for PRP
☐ Federal Facility in-house ■ Contractor for Federal Facility
☐ Other

2. O&M Cost Records

■ Readily available ■ Up to date
☐ Funding mechanism/agreement in place
Original O&M cost estimate ☐ Breakdown attached

Total annual cost by year for review period if available

From (Date)	To (Date)	Total cost	
10/1/21	12/31/21	$38,638	☐ Breakdown attached
1/1/22	12/31/22	$26,000 (ODCs only)	☐ Breakdown attached
1/1/23	12/31/23	$8,001 (ODCs only)	☐ Breakdown attached
			☐ Breakdown attached
			☐ Breakdown attached

3. **Unanticipated or Unusually High O&M Costs During Review Period**

Describe costs and reasons:

* Note – The 2021 costs include labor and ODCs. The 2022 and 2023 costs only include ODCs. Labor is captured in combined accounting with the RGRP project.

V. ACCESS AND INSTITUTIONAL CONTROLS ■ Applicable ☐ N/A

A. Fencing

1. **Fencing damaged** ☐ Location shown on site map ■ Gates secured ☐ N/A

Remarks Portion of Site 26 is located behind secured Airfield gates (Hangars 2 & 3 Area).

B. Other Access Restrictions

1. **Signs and other security measures** ☐ Location shown on site map ■ N/A

Remarks

C. Institutional Controls (ICs)

1. **Implementation and enforcement**

Site conditions imply ICs not properly implemented ☐ Yes ■ No ☐ N/A
Site conditions imply ICs not being fully enforced ☐ Yes ■ No ☐ N/A

Type of monitoring (*e.g.*, self-reporting, drive by) LUC Inspections, Well Condition Assessment
Frequency Quarterly (LUC Inspections), Annual (Well Condition)
Responsible party/agency NASA/BB&E/ERT
Contact Ingrid Warburg (Name) Restoration Specialist (Title) (650) 604-1129 (Phone no.)

Reporting is up-to-date ■ Yes ☐ No ☐ N/A
Reports are verified by the lead agency ■ Yes ☐ No ☐ N/A

Specific requirements in deed or decision documents have been met ■ Yes ☐ No ☐ N/A
Violations have been reported ☐ Yes ☐ No ■ N/A
Other problems or suggestions: ☐ Report attached

2. **Adequacy** ■ ICs are adequate ☐ ICs are inadequate ☐ N/A
Remarks

D. General

1. **Vandalism/trespassing** ☐ Location shown on site map ■ No vandalism evident
Remarks

2. **Land use changes on site** ☐ N/A
Remarks None that impact Site 26.

3. **Land use changes off site** ☐ N/A
Remarks None that impact Site 26.

VI. GENERAL SITE CONDITIONS

A. Roads ☐ Applicable ☐ N/A

1. **Roads damaged** ☐ Location shown on site map ■ Roads adequate ☐ N/A
Remarks

B. Other Site Conditions

Remarks Demolition activities of Hangar 3 begin in 2024. Construction zone restrictions may limit access to some Site 26 wells for 2024 sampling, gauging, and assessment activities.

VII. LANDFILL COVERS ☐ Applicable ■ N/A

A. Landfill Surface

1. **Settlement** (Low spots) ☐ Location shown on site map ☐ Settlement not evident
   Areal extent________ Depth________
   Remarks________

2. **Cracks** ☐ Location shown on site map ☐ Cracking not evident
   Lengths________ Widths________ Depths________
   Remarks________

3. **Erosion** ☐ Location shown on site map ☐ Erosion not evident
   Areal extent________ Depth________
   Remarks________

4. **Holes** ☐ Location shown on site map ☐ Holes not evident
   Areal extent________ Depth________
   Remarks________

5. **Vegetative Cover** ☐ Grass ☐ Cover properly established ☐ No signs of stress
   ☐ Trees/Shrubs (indicate size and locations on a diagram)
   Remarks________

6. **Alternative Cover (armored rock, concrete, etc.)** ☐ N/A
   Remarks________

7. **Bulges** ☐ Location shown on site map ☐ Bulges not evident
   Areal extent________ Height________
   Remarks________

8.	**Wet Areas/Water Damage** ☐ Wet areas ☐ Ponding ☐ Seeps ☐ Soft subgrade Remarks____________	☐ Wet areas/water damage not evident ☐ Location shown on site map ☐ Location shown on site map ☐ Location shown on site map ☐ Location shown on site map	 Areal extent____________ Areal extent____________ Areal extent____________ Areal extent____________
9.	**Slope Instability** ☐ Slides Areal extent____________ Remarks____________	☐ Location shown on site map	☐ No evidence of slope instability
B. Benches	☐ Applicable ■ N/A (Horizontally constructed mounds of earth placed across a steep landfill side slope to interrupt the slope in order to slow down the velocity of surface runoff and intercept and convey the runoff to a lined channel.)		
1.	**Flows Bypass Bench** Remarks____________	☐ Location shown on site map	☐ N/A or okay
2.	**Bench Breached** Remarks____________	☐ Location shown on site map	☐ N/A or okay
3.	**Bench Overtopped** Remarks____________	☐ Location shown on site map	☐ N/A or okay
C. Letdown Channels	☐ Applicable ■ N/A (Channel lined with erosion control mats, riprap, grout bags, or gabions that descend down the steep side slope of the cover and will allow the runoff water collected by the benches to move off of the landfill cover without creating erosion gullies.)		
1.	**Settlement** Areal extent____________ Remarks____________	☐ Location shown on site map Depth____________	☐ No evidence of settlement
2.	**Material Degradation** Material type____________ Remarks____________	☐ Location shown on site map Areal extent____________	☐ No evidence of degradation
3.	**Erosion** Areal extent____________ Remarks____________	☐ Location shown on site map Depth____________	☐ No evidence of erosion

4.	**Undercutting** ☐ Location shown on site map ☐ No evidence of undercutting Areal extent______________ Depth____________ Remarks____	
5.	**Obstructions** Type____________________ ☐ No obstructions ☐ Location shown on site map Areal extent______________ Size____________ Remarks____	
6.	**Excessive Vegetative Growth** Type____________________ ☐ No evidence of excessive growth ☐ Vegetation in channels does not obstruct flow ☐ Location shown on site map Areal extent______________ Remarks____	
D. Cover Penetrations ☐ Applicable ■ N/A		
1.	**Gas Vents** ☐ Active ☐ Passive ☐ Properly secured/locked ☐ Functioning ☐ Routinely sampled ☐ Good condition ☐ Evidence of leakage at penetration ☐ Needs Maintenance ☐ N/A Remarks____	
2.	**Gas Monitoring Probes** ☐ Properly secured/locked ☐ Functioning ☐ Routinely sampled ☐ Good condition ☐ Evidence of leakage at penetration ☐ Needs Maintenance ☐ N/A Remarks____	
3.	**Monitoring Wells** (within surface area of landfill) ☐ Properly secured/locked ☐ Functioning ☐ Routinely sampled ☐ Good condition ☐ Evidence of leakage at penetration ☐ Needs Maintenance ☐ N/A Remarks____	
4.	**Leachate Extraction Wells** ☐ Properly secured/locked ☐ Functioning ☐ Routinely sampled ☐ Good condition ☐ Evidence of leakage at penetration ☐ Needs Maintenance ☐ N/A Remarks____	
5.	**Settlement Monuments** ☐ Located ☐ Routinely surveyed ☐ N/A Remarks____	

E. Gas Collection and Treatment ☐ Applicable ■ N/A	
1.	**Gas Treatment Facilities** ☐ Flaring ☐ Thermal destruction ☐ Collection for reuse ☐ Good condition ☐ Needs Maintenance Remarks______________________________
2.	**Gas Collection Wells, Manifolds and Piping** ☐ Good condition ☐ Needs Maintenance Remarks______________________________
3.	**Gas Monitoring Facilities** (*e.g.*, gas monitoring of adjacent homes or buildings) ☐ Good condition ☐ Needs Maintenance ☐ N/A Remarks______________________________
F. Cover Drainage Layer ☐ Applicable ■ N/A	
1.	**Outlet Pipes Inspected** ☐ Functioning ☐ N/A Remarks______________________________
2.	**Outlet Rock Inspected** ☐ Functioning ☐ N/A Remarks______________________________
G. Detention/Sedimentation Ponds ☐ Applicable ■ N/A	
1.	**Siltation** Areal extent______________ Depth____________ ☐ N/A ☐ Siltation not evident Remarks______________________________
2.	**Erosion** Areal extent______________Depth______________ ☐ Erosion not evident Remarks______________________________
3.	**Outlet Works** ☐ Functioning ☐ N/A Remarks______________________________
4.	**Dam** ☐ Functioning ☐ N/A Remarks______________________________

H. Retaining Walls ☐ Applicable ■ N/A

1. **Deformations** ☐ Location shown on site map ☐ Deformation not evident
Horizontal displacement_____________ Vertical displacement________________
Rotational displacement_____________
Remarks____

2. **Degradation** ☐ Location shown on site map ☐ Degradation not evident
Remarks____

I. Perimeter Ditches/Off-Site Discharge ☐ Applicable ■ N/A

1. **Siltation** ☐ Location shown on site map ☐ Siltation not evident
Areal extent_______________ Depth_____________
Remarks____

2. **Vegetative Growth** ☐ Location shown on site map ☐ N/A
☐ Vegetation does not impede flow
Areal extent_______________ Type_____________
Remarks____

3. **Erosion** ☐ Location shown on site map ☐ Erosion not evident
Areal extent_______________ Depth_____________
Remarks____

4. **Discharge Structure** ☐ Functioning ☐ N/A
Remarks____

VIII. VERTICAL BARRIER WALLS ☐ Applicable ■ N/A

1. **Settlement** ☐ Location shown on site map ☐ Settlement not evident
Areal extent_______________ Depth_____________
Remarks____

2. **Performance Monitoring** Type of monitoring____________________________
☐ Performance not monitored
Frequency_________________________________ ☐ Evidence of breaching
Head differential____________________________
Remarks____

IX. GROUNDWATER/SURFACE WATER REMEDIES ■ Applicable ☐ N/A
A. Groundwater Extraction Wells, Pumps, and Pipelines ☐ Applicable ☐ N/A
1. **Pumps, Wellhead Plumbing, and Electrical** ☐ Good condition ☐ All required wells properly operating ☐ Needs Maintenance ■ N/A Remarks
2. **Extraction System Pipelines, Valves, Valve Boxes, and Other Appurtenances** ☐ Good condition ☐ Needs Maintenance Remarks
3. **Spare Parts and Equipment** ☐ Readily available ☐ Good condition ☐ Requires upgrade ☐ Needs to be provided Remarks
B. Surface Water Collection Structures, Pumps, and Pipelines ☐ Applicable ■ N/A
1. **Collection Structures, Pumps, and Electrical** ☐ Good condition ☐ Needs Maintenance Remarks
2. **Surface Water Collection System Pipelines, Valves, Valve Boxes, and Other Appurtenances** ☐ Good condition ☐ Needs Maintenance Remarks
3. **Spare Parts and Equipment** ☐ Readily available ☐ Good condition ☐ Requires upgrade ☐ Needs to be provided Remarks

C. Treatment System ☐ Applicable ☐ N/A	
1.	**Treatment Train** (Check components that apply) ☐ Metals removal ☐ Oil/water separation ■ Bioremediation ☐ Air stripping ☐ Carbon adsorbers ☐ Filters______ ■ Additive (*e.g.*, chelation agent, flocculent) EVO and microbial culture (EAB/ISCR). ☐ Others______ ☐ Good condition ☐ Needs Maintenance ☐ Sampling ports properly marked and functional ☐ Sampling/maintenance log displayed and up to date ☐ Equipment properly identified ☐ Quantity of groundwater treated annually______ ☐ Quantity of surface water treated annually______ Remarks In-situ injection work completed in 2019, followed by long-term monitoring for MNA.
2.	**Electrical Enclosures and Panels** (properly rated and functional) ■ N/A ☐ Good condition ☐ Needs Maintenance Remarks______
3.	**Tanks, Vaults, Storage Vessels** ■ N/A ☐ Good condition ☐ Proper secondary containment ☐ Needs Maintenance Remarks______
4.	**Discharge Structure and Appurtenances** ■ N/A ☐ Good condition ☐ Needs Maintenance Remarks______
5.	**Treatment Building(s)** ■ N/A ☐ Good condition (esp. roof and doorways) ☐ Needs repair ☐ Chemicals and equipment properly stored Remarks______
6.	**Monitoring Wells** (pump and treatment remedy) ☐ Properly secured/locked ☐ Functioning ☐ Routinely sampled ☐ Good condition ☐ All required wells located ☐ Needs Maintenance ■ N/A Remarks______
D. Monitoring Data	
1.	Monitoring Data ■ Is routinely submitted on time ■ Is of acceptable quality
2.	Monitoring data suggests: ■ Groundwater plume is effectively contained ■ Contaminant concentrations are declining

D. Monitored Natural Attenuation

1. **Monitoring Wells** (natural attenuation remedy)

■ Properly secured/locked ■ Functioning ■ Routinely sampled ■ Good condition
■ All required wells located ☐ Needs Maintenance ☐ N/A

Remarks 17 wells sampled annual, 29 wells sampled biennially.

X. OTHER REMEDIES

If there are remedies applied at the site which are not covered above, attach an inspection sheet describing the physical nature and condition of any facility associated with the remedy. An example would be soil vapor extraction.

XI. OVERALL OBSERVATIONS

A. Implementation of the Remedy

Describe issues and observations relating to whether the remedy is effective and functioning as designed. Begin with a brief statement of what the remedy is to accomplish (i.e., to contain contaminant plume, minimize infiltration and gas emission, etc.).

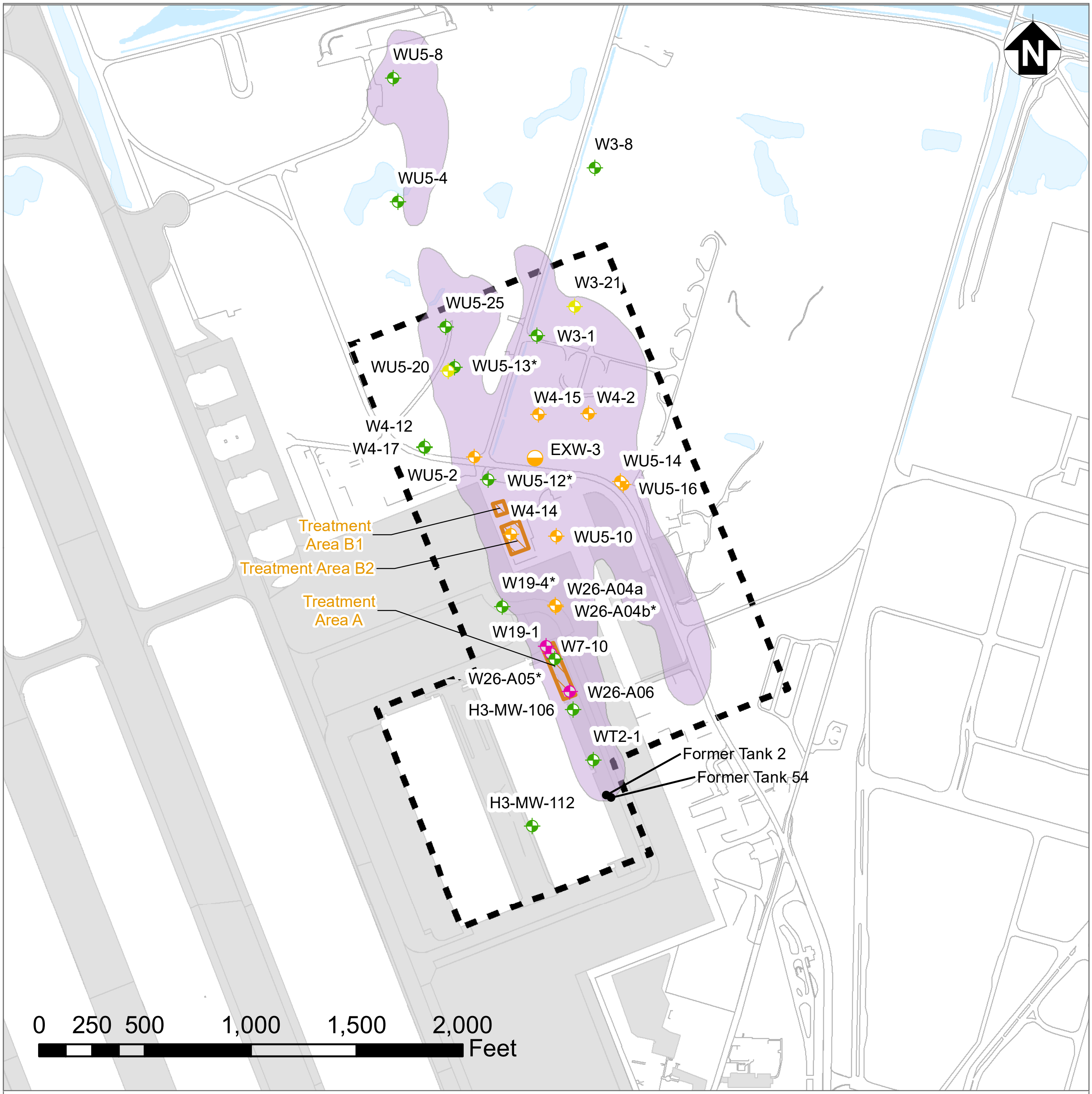
Long-term monitoring performed by NASA (2021-2023) after the Navy's EAB/ISCR remedy implementation (2019) indicates that minimal matrix diffusion is occurring and sufficient source zone reduction has occurred which will allow MNA to be an appropriate long-term remedy. Annual sampling is of sufficient frequency and scope to adequately monitor the continued applicability of MNA.

B. Adequacy of O&M

Describe issues and observations related to the implementation and scope of O&M procedures. In particular, discuss their relationship to the current and long-term protectiveness of the remedy.

Annual sampling is of sufficient frequency and scope to adequately monitor the continued applicability of MNA. Modifications in frequency and sampling network may be warranted in the future based on future findings.

C.	**Early Indicators of Potential Remedy Problems**
	Describe issues and observations such as unexpected changes in the cost or scope of O&M or a high frequency of unscheduled repairs, that suggest that the protectiveness of the remedy may be compromised in the future. There are currently no indications of potential remedy problems.
D.	**Opportunities for Optimization**
	Describe possible opportunities for optimization in monitoring tasks or the operation of the remedy. Based on the analytical results of the post-injection long-term monitoring, there may be an opportunity to optimize the monitoring network so that more relevant data is obtained on an annual basis, instead of only obtaining full monitoring results on a biennial basis.



Fringe Well, Monitoring

Perimeter Well, Monitoring

Plume Core Well, Former Extraction

Plume Core Well, Monitoring

Source Area Well, Monitoring

1993 Plume (Navy, 1996)

Treatment Area

IR Site 26 Boundary

Wetland

Water

Road

Paved Area

Notes:

IR - Installation Restoration

Ames Research Center
Moffett Field, CA 94035

NASA Ames Research Center
Moffett Field, California

FIGURE 3-1

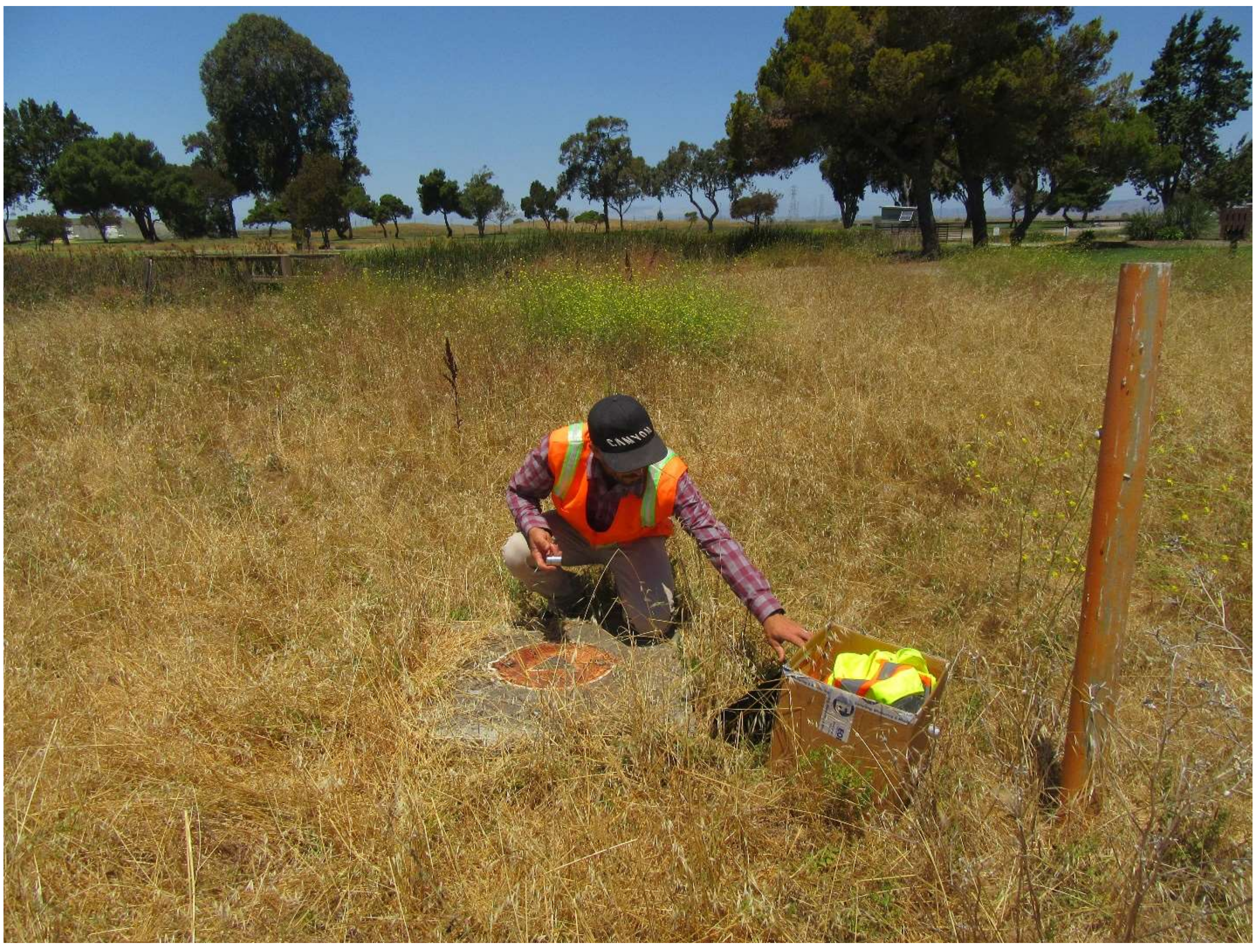
MONITORING AND FORMER EXTRACTION WELL LOCATIONS

IR SITE 26, 2023 LTM REPORT

EXW-3

H3-MW-106

H3-MW-112



W3-8

W3-21

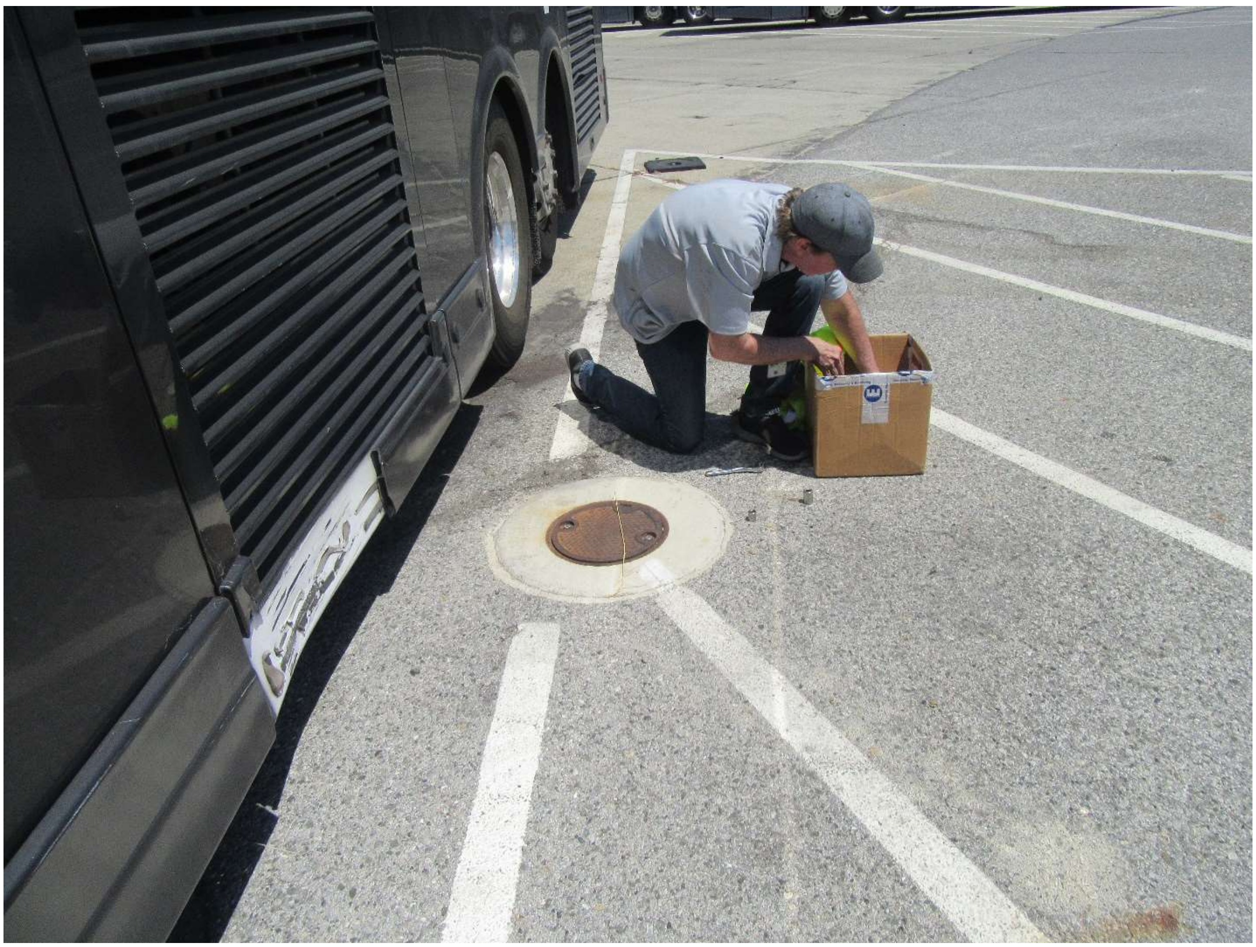
W4-2

W4-12

W4-15

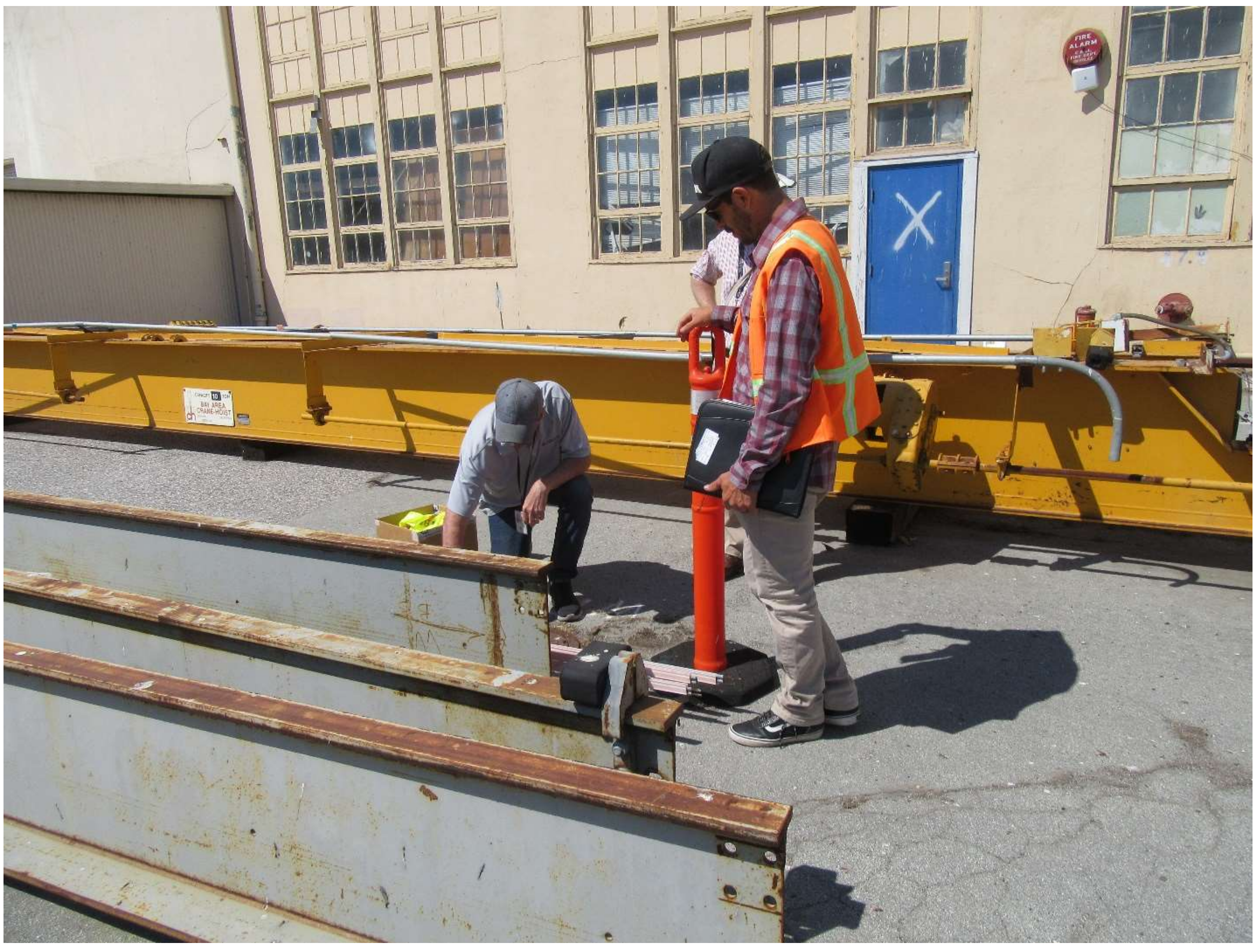
W19-1

W19-4



W26-04A

W26-A06



WT2-1

WU5-4

WU5-8

WU5-10

WU5-12

WU5-16

WU5-20

WU5-25

Table 1: NASA Ames Research Center Land Use Controls
NASA Ames Research Center, Moffett Field, California

Site	Description	Basis for LUCs	NASA Ames LUCs
Navy Site 26 (OU 5)	Groundwater treatment by biostimulation/ bioaugmentation and monitored natural attenuation. (1996 Navy OU5 ROD and 2014 Navy Site 26 ROD Amendment)	Prevent domestic use of groundwater	1. Restrict domestic groundwater use. 2. Address vapor intrusion in new construction or modifications to existing structures.

Five-Year Review Form
NASA RGRP

I. SITE INFORMATION	
Site name: NASA RGRP	**Date of inspection: 2/8/24**
Location and Region: NASA Ames Research Center	**EPA ID: CA1800005034, CA21700900078**
Agency, office, or company leading the five-year review: BB&E	**Weather/temperature: Partly cloudy, light wind to 10 mph, 64°F.**

Remedy Includes: (Check all that apply)

- ☐ Landfill cover/containment
- ☐ Access controls
- ■ Institutional controls
- ■ Groundwater pump and treatment
- ☐ Surface water collection and treatment
- ☐ Other______________________________
- ☐ Monitored natural attenuation
- ■ Groundwater containment
- ☐ Vertical barrier walls

Attachments: ☐ Inspection team roster attached ■ Site map attached

II. INTERVIEWS (Check all that apply)

1. **O&M site manager** Jeff Linder (Name) Senior Restoration Specialist (Title) 2/8/24 (Date)
   Interviewed ☐ at site ☐ at office ■ by phone Phone no. (805) 400-9588
   Problems, suggestions; ■ Report attached Interview provided in Appendix B of the FIve Year Review Report..

2. **O&M staff** Mike Ninokata (Name) Senior Technician (Title) 2/8/24 (Date)
   Interviewed ■ at site ☐ at office ☐ by phone Phone no. (650) 507-6227
   Problems, suggestions; ☐ Report attached____________________

3. **Local regulatory authorities and response agencies** (i.e., State and Tribal offices, emergency response office, police department, office of public health or environmental health, zoning office, recorder of deeds, or other city and county offices, etc.) Fill in all that apply.

Agency US EPA
Contact Alana Lee | Program Manager | 1/10/24 | (415) 972-3141
Name | Title | Date | Phone no.
Problems; suggestions; ☐Report attached

Agency CA Regional Water Board-SF
Contact Dana McCarthy | Program Manager | 2/13/24 | (510) 622-2371
Name | Title | Date | Phone no.
Problems; suggestions; ☐Report attached

Agency
Contact
Name | Title | Date | Phone no.
Problems; suggestions; ☐Report attached

Agency
Contact
Name | Title | Date | Phone no.
Problems; suggestions; ☐Report attached

4. **Other interviews** (optional) ■ Report attached.

Jeff Linder (ERT Subject Matter Expert) – See attached interview.*

Ingrid Warburg (ERT Subject Matter Expert) – See attached interview. *

* Interviews provided in Appendix B of the Five Year Review Report.

III. ON-SITE DOCUMENTS & RECORDS VERIFIED (Check all that apply)			
1. O&M Documents			
☐ O&M manual	■ Readily available	☐ Up to date	☐ N/A
☐ As-built drawings	■ Readily available	☐ Up to date	☐ N/A
☐ Maintenance logs	■ Readily available	■ Up to date	☐ N/A
Remarks Documents verified on JQ Server. O&M and as-built drawings will need to be finalized once disposition of Navy's pretreatment system and new extraction wells is settled.			
2. Site-Specific Health and Safety Plan	■ Readily available	■ Up to date	☐ N/A
■ Contingency plan/emergency response plan	■ Readily available	■ Up to date	☐ N/A
Remarks WATS HASP, GWTS HASP, Site 28 HASP, and BB&E Project Safety Plan verified on JQ Server.			
3. O&M and OSHA Training Records	■ Readily available	■ Up to date	☐ N/A
Remarks Documents verified on JQ Server.			
4. Permits and Service Agreements			
☐ Air discharge permit	☐ Readily available	☐ Up to date	■ N/A
■ Effluent discharge	■ Readily available	■ Up to date	☐ N/A
☐ Waste disposal, POTW	☐ Readily available	☐ Up to date	■ N/A
■ Other permits Valley Water	■ Readily available	■ Up to date	☐ N/A
Remarks NPDES Permit, Valley Water Water Usage verified on JQ Server.			
5. Gas Generation Records	☐ Readily available	☐ Up to date	■ N/A
Remarks			
6. Settlement Monument Records	☐ Readily available	☐ Up to date	■ N/A
Remarks			
7. Groundwater Monitoring Records	■ Readily available	■ Up to date	☐ N/A
Remarks Groundwater analytical, water level gauging data, and NPDES analytical verified on JQ Server.			
8. Leachate Extraction Records	☐ Readily available	☐ Up to date	■ N/A
Remarks			
9. Discharge Compliance Records			
☐ Air	☐ Readily available	☐ Up to date	■ N/A
■ Water (effluent)	■ Readily available	■ Up to date	☐ N/A
Remarks NPDES compliance sampling and Valley Water water usage record verified on JQ Server.			
10. Daily Access/Security Logs	■ Readily available	■ Up to date	☐ N/A
Remarks Safety training records for WATS access verified at WATS trailer.			

IV. O&M COSTS

1. O&M Organization

☐ State in-house ☐ Contractor for State
☐ PRP in-house ☐ Contractor for PRP
☐ Federal Facility in-house ■ Contractor for Federal Facility
☐ Other

2. O&M Cost Records

■ Readily available ☐ Up to date
■ Funding mechanism/agreement in place
Original O&M cost estimate ☐Breakdown attached

Total annual cost by year for review period if available

	Date		Date	Total cost	
From	1/1/19	To	12/31/19	N/A	☐ Breakdown attached
From	1/1/20	To	12/31/20	$266,064	☐ Breakdown attached
From	1/1/21	To	12/31/21	$279,028	☐ Breakdown attached
From	1/1/22	To	12/31/22	$327,452	☐ Breakdown attached
From	1/1/23	To	12/31/23	$322,186	☐ Breakdown attached

3. **Unanticipated or Unusually High O&M Costs During Review Period**

Describe costs and reasons:

*Note – All costs include labor and other direct costs. 2022 & 2023 costs include Site 26 labor.

V. ACCESS AND INSTITUTIONAL CONTROLS ■ Applicable ☐ N/A

A. Fencing

1. **Fencing damaged** ☐ Location shown on site map ■ Gates secured ☐ N/A
Remarks

B. Other Access Restrictions

1. **Signs and other security measures** ☐ Location shown on site map ☐ N/A
Remarks WATS and GWTS compounds secured by gated fences. Appropriate signage present.

C. Institutional Controls (ICs)

1. **Implementation and enforcement**

Site conditions imply ICs not properly implemented ☐ Yes ■ No ☐ N/A
Site conditions imply ICs not being fully enforced ☐ Yes ■ No ☐ N/A

Type of monitoring (*e.g.*, self-reporting, drive by) LUC inspections.
Frequency Quarterly
Responsible party/agency NASA/BB&E and ERT
Contact Jeff Linder and Ingrid Warburg (Name) Restoration Specialist (Title) (650) 604-4294 (Phone no.)

Reporting is up-to-date ■ Yes ☐ No ☐ N/A
Reports are verified by the lead agency ■ Yes ☐ No ☐ N/A

Specific requirements in deed or decision documents have been met ■ Yes ☐ No ☐ N/A
Violations have been reported ■Yes ☐ No ☐ N/A
Other problems or suggestions: ☐ Report attached

2. **Adequacy** ■ ICs are adequate ☐ ICs are inadequate ☐ N/A
Remarks

D. General

1. **Vandalism/trespassing** ☐ Location shown on site map ■ No vandalism evident
Remarks

2. **Land use changes on site** ☐N/A
Remarks None that impact NASA RGRP.

3. **Land use changes off site** ■ N/A
Remarks None that impact NASA RGRP.

VI. GENERAL SITE CONDITIONS

A. Roads ■ Applicable ☐ N/A

1. **Roads damaged** ☐ Location shown on site map ■ Roads adequate ☐ N/A
Remarks

B. Other Site Conditions

Remarks ____

____

____

____

____

____

VII. LANDFILL COVERS ☐ Applicable ■ N/A

A. Landfill Surface

1. **Settlement** (Low spots) ☐ Location shown on site map ☐ Settlement not evident
   Areal extent______________ Depth____________
   Remarks____
   ____

2. **Cracks** ☐ Location shown on site map ☐ Cracking not evident
   Lengths____________ Widths___________ Depths__________
   Remarks____
   ____

3. **Erosion** ☐ Location shown on site map ☐ Erosion not evident
   Areal extent______________ Depth____________
   Remarks____
   ____

4. **Holes** ☐ Location shown on site map ☐ Holes not evident
   Areal extent______________ Depth____________
   Remarks____
   ____

5. **Vegetative Cover** ☐ Grass ☐ Cover properly established ☐ No signs of stress
   ☐ Trees/Shrubs (indicate size and locations on a diagram)
   Remarks____
   ____

6. **Alternative Cover (armored rock, concrete, etc.)** ☐ N/A
   Remarks____
   ____

7. **Bulges** ☐ Location shown on site map ☐ Bulges not evident
   Areal extent______________ Height____________
   Remarks____
   ____

8. **Wet Areas/Water Damage** ☐ Wet areas/water damage not evident
☐ Wet areas ☐ Location shown on site map Areal extent_______________
☐ Ponding ☐ Location shown on site map Areal extent_______________
☐ Seeps ☐ Location shown on site map Areal extent_______________
☐ Soft subgrade ☐ Location shown on site map Areal extent_______________
Remarks____
____

9. **Slope Instability** ☐ Slides ☐ Location shown on site map ☐ No evidence of slope instability
Areal extent_______________
Remarks____
____

B. Benches ☐ Applicable ■ N/A
(Horizontally constructed mounds of earth placed across a steep landfill side slope to interrupt the slope in order to slow down the velocity of surface runoff and intercept and convey the runoff to a lined channel.)

1. **Flows Bypass Bench** ☐ Location shown on site map ☐ N/A or okay
Remarks____
____

2. **Bench Breached** ☐ Location shown on site map ☐ N/A or okay
Remarks____
____

3. **Bench Overtopped** ☐ Location shown on site map ☐ N/A or okay
Remarks____
____

C. Letdown Channels ☐ Applicable ■ N/A
(Channel lined with erosion control mats, riprap, grout bags, or gabions that descend down the steep side slope of the cover and will allow the runoff water collected by the benches to move off of the landfill cover without creating erosion gullies.)

1. **Settlement** ☐ Location shown on site map ☐ No evidence of settlement
Areal extent_______________ Depth_____________
Remarks____
____

2. **Material Degradation** ☐ Location shown on site map ☐ No evidence of degradation
Material type________________ Areal extent_____________
Remarks____
____

3. **Erosion** ☐ Location shown on site map ☐ No evidence of erosion
Areal extent_______________ Depth_____________
Remarks____
____

4. **Undercutting** ☐ Location shown on site map ☐ No evidence of undercutting
Areal extent______________ Depth____________
Remarks____
____

5. **Obstructions** Type_____________________ ☐ No obstructions
☐ Location shown on site map Areal extent______________
Size____________
Remarks____
____

6. **Excessive Vegetative Growth** Type____________________
☐ No evidence of excessive growth
☐ Vegetation in channels does not obstruct flow
☐ Location shown on site map Areal extent______________
Remarks____
____

D. Cover Penetrations ☐ Applicable ■ N/A

1. **Gas Vents** ☐ Active ☐ Passive
☐ Properly secured/locked ☐ Functioning ☐ Routinely sampled ☐ Good condition
☐ Evidence of leakage at penetration ☐ Needs Maintenance
☐ N/A
Remarks____
____

2. **Gas Monitoring Probes**
☐ Properly secured/locked ☐ Functioning ☐ Routinely sampled ☐ Good condition
☐ Evidence of leakage at penetration ☐ Needs Maintenance ☐ N/A
Remarks____
____

3. **Monitoring Wells** (within surface area of landfill)
☐ Properly secured/locked ☐ Functioning ☐ Routinely sampled ☐ Good condition
☐ Evidence of leakage at penetration ☐ Needs Maintenance ☐ N/A
Remarks____
____

4. **Leachate Extraction Wells**
☐ Properly secured/locked ☐ Functioning ☐ Routinely sampled ☐ Good condition
☐ Evidence of leakage at penetration ☐ Needs Maintenance ☐ N/A
Remarks____
____

5. **Settlement Monuments** ☐ Located ☐ Routinely surveyed ☐ N/A
Remarks____
____

E. Gas Collection and Treatment ☐ Applicable ■ N/A	
1.	**Gas Treatment Facilities** ☐ Flaring ☐ Thermal destruction ☐ Collection for reuse ☐ Good condition ☐ Needs Maintenance Remarks____________________
2.	**Gas Collection Wells, Manifolds and Piping** ☐ Good condition ☐ Needs Maintenance Remarks____________________
3.	**Gas Monitoring Facilities** (*e.g.*, gas monitoring of adjacent homes or buildings) ☐ Good condition☐ Needs Maintenance ☐ N/A Remarks____________________
F. Cover Drainage Layer ☐ Applicable ■ N/A	
1.	**Outlet Pipes Inspected** ☐ Functioning ☐ N/A Remarks____________________
2.	**Outlet Rock Inspected** ☐ Functioning ☐ N/A Remarks____________________
G. Detention/Sedimentation Ponds ☐ Applicable ■ N/A	
1.	**Siltation** Areal extent__________ Depth__________ ☐ N/A ☐ Siltation not evident Remarks____________________
2.	**Erosion** Areal extent__________Depth__________ ☐ Erosion not evident Remarks____________________
3.	**Outlet Works** ☐ Functioning ☐ N/A Remarks____________________
4.	**Dam** ☐ Functioning ☐ N/A Remarks____________________

H. Retaining Walls	☐ Applicable	■ N/A	
1.	**Deformations** ☐ Location shown on site map ☐ Deformation not evident Horizontal displacement_____________ Vertical displacement________________ Rotational displacement_____________ Remarks____		
2.	**Degradation** ☐ Location shown on site map ☐ Degradation not evident Remarks____		
I. Perimeter Ditches/Off-Site Discharge	☐ Applicable	■ N/A	
1.	**Siltation** ☐ Location shown on site map ☐ Siltation not evident Areal extent_______________ Depth_____________ Remarks____		
2.	**Vegetative Growth** ☐ Location shown on site map ☐ N/A ☐ Vegetation does not impede flow Areal extent_______________ Type_____________ Remarks____		
3.	**Erosion** ☐ Location shown on site map ☐ Erosion not evident Areal extent_______________ Depth_____________ Remarks____		
4.	**Discharge Structure** ☐ Functioning ☐ N/A Remarks____		
VIII. VERTICAL BARRIER WALLS	☐ Applicable	■ N/A	
1.	**Settlement** ☐ Location shown on site map ☐ Settlement not evident Areal extent_______________ Depth_____________ Remarks____		
2.	**Performance Monitoring** Type of monitoring____________________________ ☐ Performance not monitored Frequency_________________________________ ☐ Evidence of breaching Head differential____________________________ Remarks____		

IX. GROUNDWATER/SURFACE WATER REMEDIES ■ Applicable ☐ N/A

A. Groundwater Extraction Wells, Pumps, and Pipelines ■ Applicable ☐ N/A

1. **Pumps, Wellhead Plumbing, and Electrical**
■ Good condition ■ All required wells properly operating ■ Needs Maintenance ☐ N/A
Remarks Some extraction wells are showing declines in production, indicating end of service time.

2. **Extraction System Pipelines, Valves, Valve Boxes, and Other Appurtenances**
■ Good condition ■ Needs Maintenance
Remarks Increases in well pump pressure indicate that some portions of WATS and GWTS conveyance piping in need of high-pressure flushing.

3. **Spare Parts and Equipment**
■ Readily available ☐ Good condition ☐ Requires upgrade ☐ Needs to be provided
Remarks

B. Surface Water Collection Structures, Pumps, and Pipelines ☐ Applicable ■ N/A

1. **Collection Structures, Pumps, and Electrical**
☐ Good condition ☐ Needs Maintenance
Remarks

2. **Surface Water Collection System Pipelines, Valves, Valve Boxes, and Other Appurtenances**
☐ Good condition ☐ Needs Maintenance
Remarks

3. **Spare Parts and Equipment**
☐ Readily available ☐ Good condition ☐ Requires upgrade ☐ Needs to be provided
Remarks

C. Treatment System ■ Applicable ☐ N/A

1. **Treatment Train** (Check components that apply)
☐ Metals removal ☐ Oil/water separation ☐ Bioremediation
☐ Air stripping ■Carbon adsorbers (Both WATS & GWTS)
■Filters Filtration provided by bag filters prior to primary treatment.
■Additive (*e.g.*, chelation agent, flocculent) Ozone and Hydrogen Peroxide (WATS Only)
☐ Others
■Good condition ☐ Needs Maintenance
■Sampling ports properly marked and functional
■Sampling/maintenance log displayed and up to date
■Equipment properly identified
■Quantity of groundwater treated annually *
☐ Quantity of surface water treated annually
Remarks *Refer to the attached WATS and GWTS performance checklists from 2023 Annual Report for additional details.

2. **Electrical Enclosures and Panels** (properly rated and functional)
☐ N/A ■ Good condition ☐ Needs Maintenance
Remarks

3. **Tanks, Vaults, Storage Vessels**
☐ N/A ■ Good condition ☐ Proper secondary containment ■ Needs Maintenance
Remarks

4. **Discharge Structure and Appurtenances**
☐ N/A ■ Good condition ☐ Needs Maintenance
Remarks Discharge into storm drain system. Receiving waters at Settling Basin and Stormwater Retention Basin for WATS and Stevens Creek Outfall for GWTS.

5. **Treatment Building(s)**
☐ N/A ■ Good condition (esp. roof and doorways) ☐ Needs repair
■Chemicals and equipment properly stored
Remarks GWTS would benefit from having a roof installed. Would extend life of treatment train equipment and reduce frequency of treatment system pad flooding during rain events.

6. **Monitoring Wells** (pump and treatment remedy)
■Properly secured/locked ■ Functioning ■ Routinely sampled ■ Good condition
■All required wells located ☐ Needs Maintenance ☐ N/A
Remarks Large majority of 290+ programmatic wells have had new well boxes installed during FYR period as part of NASA's annual well assessment and repair program.

D. Monitoring Data

1. Monitoring Data
■ Is routinely submitted on time ■ Is of acceptable quality

2. Monitoring data suggests:
■ Groundwater plume is effectively contained ■ Contaminant concentrations are declining

D. Monitoring Data

1. **Monitoring Wells**

■ Properly secured/locked ■ Functioning ■ Routinely sampled ■ Good condition
■ All required wells located ■ Needs Maintenance ☐ N/A

Remarks Majority of RGRP well boxes and standpipes have been replaced or repaired over the last four years. Minimal repair efforts remaining.

X. OTHER REMEDIES

If there are remedies applied at the site which are not covered above, attach an inspection sheet describing the physical nature and condition of any facility associated with the remedy. An example would be soil vapor extraction.

XI. OVERALL OBSERVATIONS

A. Implementation of the Remedy

Describe issues and observations relating to whether the remedy is effective and functioning as designed. Begin with a brief statement of what the remedy is to accomplish (i.e., to contain contaminant plume, minimize infiltration and gas emission, etc.).

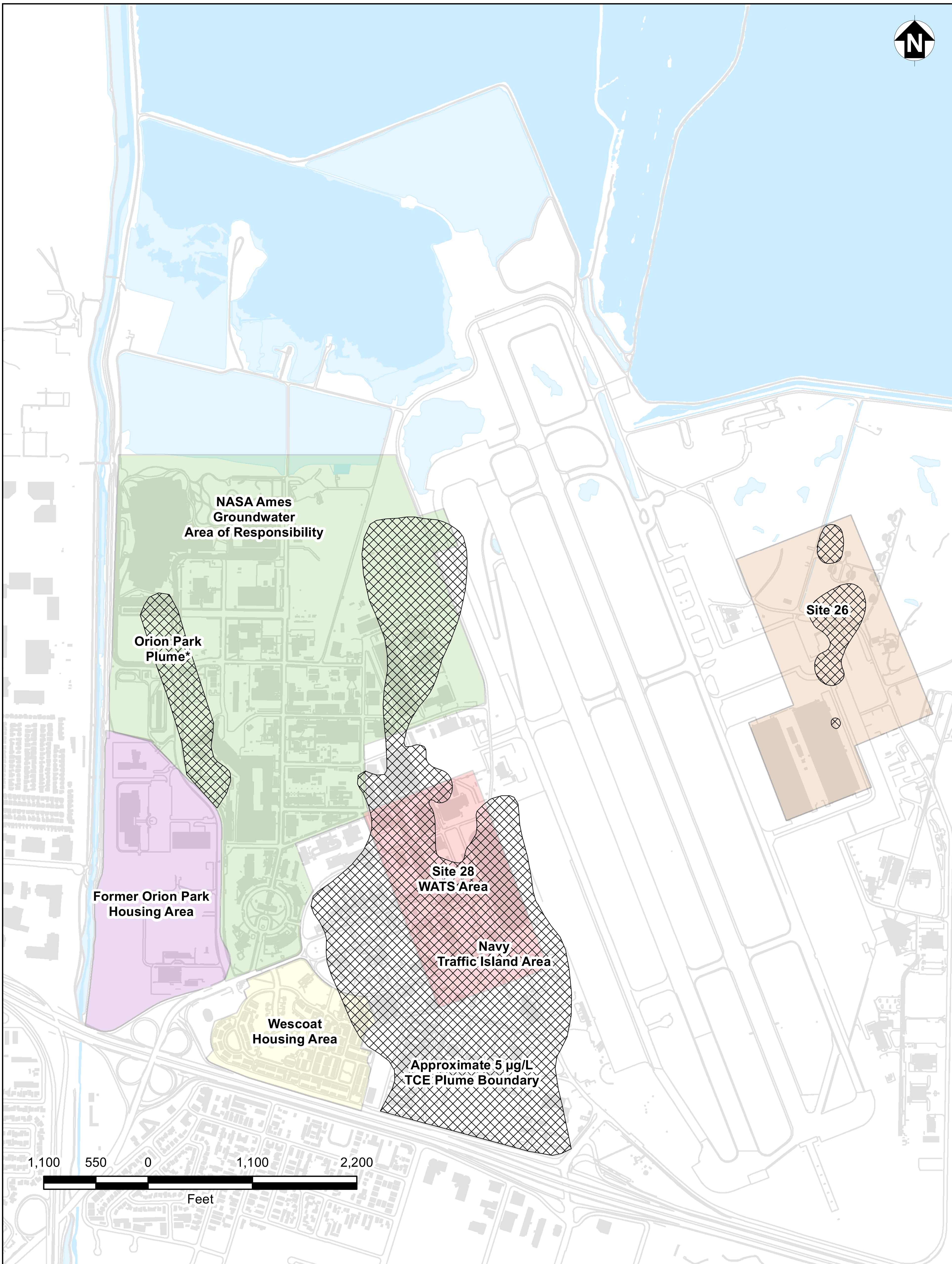
Groundwater elevations, graphical flow net analysis, capture zone width calculations and spatial distribution analysis provide converging lines of evidence that the NASA RGRP source control wells are achieving adequate capture and hydraulic control of targeted treatment zones. Although some localized plume bypass of the extraction networks may be occurring, capture zones are only one line of evidence for plume containment. Stability of the primary COC trends and concentration contour maps provide additional lines of evidence that containment is achieved, and that capture is adequate. The stability of concentration contours on the plume margins indicate that although the potential for groundwater bypass exists, expansion of the plume is not occurring. Furthermore, Mann-Kendall trend analysis indicates that primary COC concentrations over the last ten years are decreasing, stable, or non-detect in the majority of the sampled NASA RGRP wells. The ratio of increasing verses decreasing trends among the primary COCs (parent to daughter product) also indicates that reductive dechlorination is actively occurring throughout the Site.

B. Adequacy of O&M

Describe issues and observations related to the implementation and scope of O&M procedures. In particular, discuss their relationship to the current and long-term protectiveness of the remedy.

The current biennial sampling events and annual sitewide water level gauging events provide timely, comprehensive data to ensure the remedy is performing as designed and remains protective of human health and the environment. NASA currently conducts voluntary groundwater sampling in the "off years" in a subset of the NASA RGRP wells to evaluate potential shifts in plume boundaries or concentration trends.

C.	Early Indicators of Potential Remedy Problems
	Describe issues and observations such as unexpected changes in the cost or scope of O&M or a high frequency of unscheduled repairs, that suggest that the protectiveness of the remedy may be compromised in the future. Although the NASA RGRP (WATS & GWTS) remain effective, the treatment-system related infrastructure is aging (20+ years). More frequent well redevelopment and conveyance line flushing will be required in future years. In addition, the lack of clean outs in both system's conveyance piping limits the reach and effectiveness of maintenance activities. Furthermore, reductions in chemical concentrations since system installations has resulted in low mass removal rates at some locations, reducing cost effectiveness.
D.	**Opportunities for Optimization**
	Describe possible opportunities for optimization in monitoring tasks or the operation of the remedy. Other than the Navy's Traffic Island/Building 88 Areas, there are no significant source areas remaining within the NASA RGRP area. Continued mass removal optimization through maximizing groundwater extraction at high concentration locations should be pursued. It is also recommended that the conceptual site model for the Site 28 area be updated and expanded using existing geologic and hydrogeologic data. Within the NASA groundwater AOR, concentrations have dropped to below 60 µg/L of total VOCs (39 µg/L TCE), making on-going pump and treat inefficient. NASA is currently finalizing a MNA Evaluation Work Plan to evaluate the applicability of MNA in the area, especially in the vicinity of NASA-3A, where total VOCs have dropped below 43 µg/L (41 µg/L TCE).



Approximate 5 µg/L TCE plume boundary
Site 26
Site 28 WATS Area
NASA Area of Responsibility
Former Orion Park Housing Area
Wescoat Housing Area
Road
Wetland
Water
Building

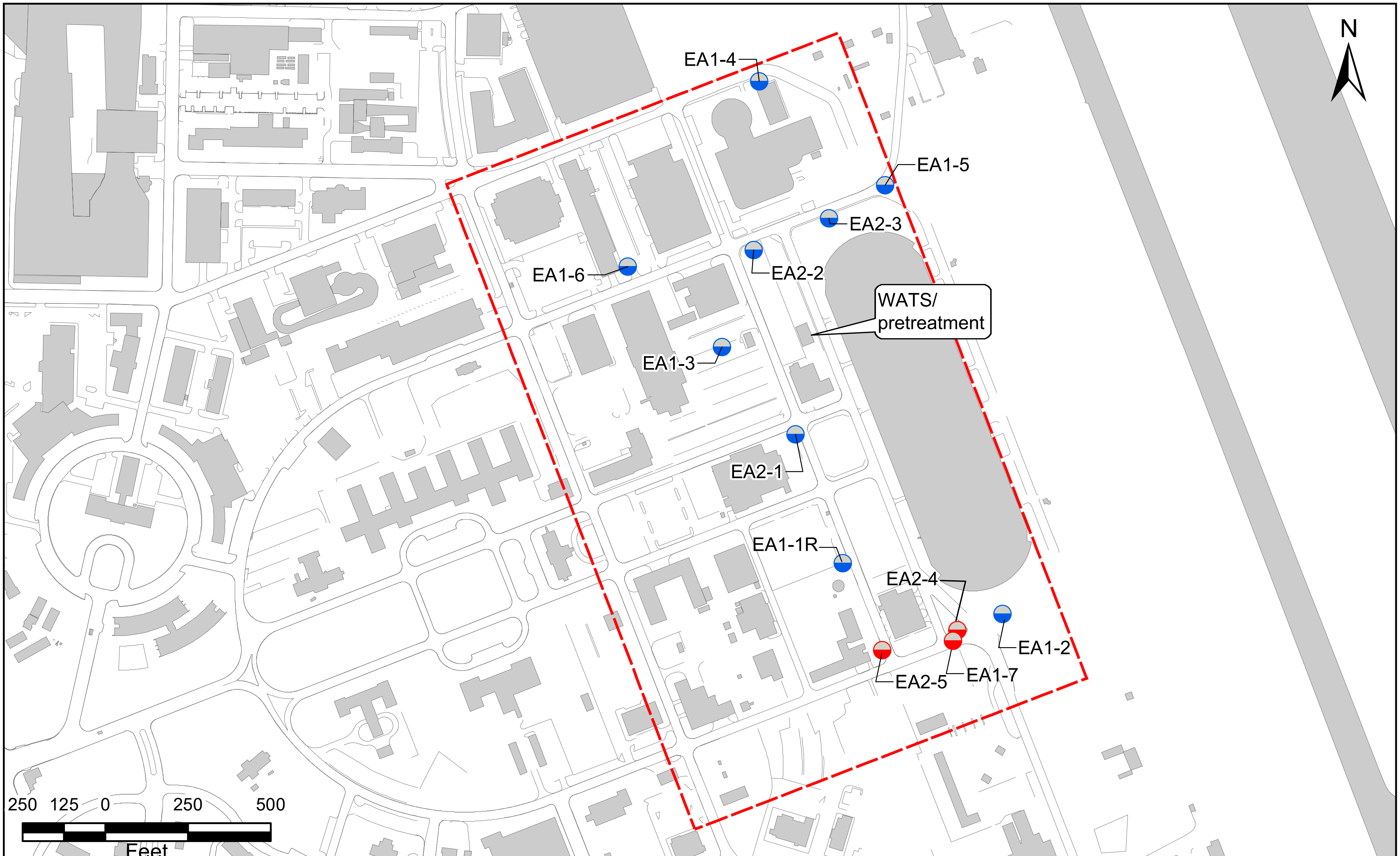
Notes: µg/L - micrograms per liter
WATS - West-Side Aquifers Treatment System
*Extent of Orion Park Plume within NASA Ames Area of Responsibility

NASA
Ames Research Center
Moffett Field, CA 94035

2023 ANNUAL PROGRESS REPORT
NASA RGRP

FIGURE 1-2
NASA RGRP SITE LOCATION MAP

NASA AMES RESEARCH CENTER, MOFFETT FIELD, CALIFORNIA



-WATS Extraction Wells

-Pretreatment Extraction Wells

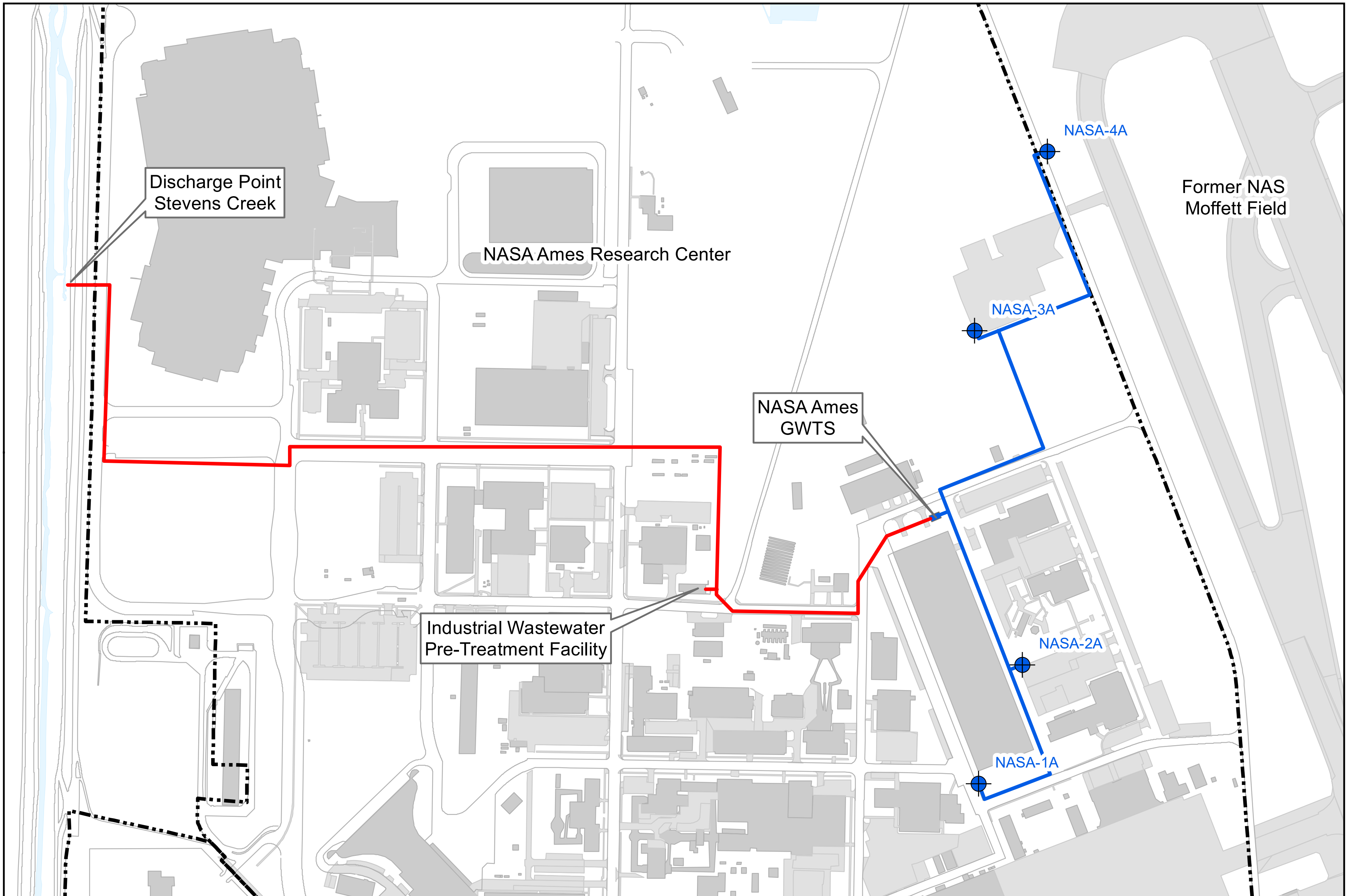
Site 28 Boundary

Notes:
WATS - West-side Aquifers Treatment System
NASA - National Aeronautics and Space Administration

Ames Research Center
Moffett Field, CA 94035

FIGURE 2-5
SITE 28 LOCATION AND FEATURES MAP
MOFFETT FIELD, CA

NASA AMES RESEARCH CENTER, MOFFETT FIELD, CALIFORNIA



Ames Research Center
Moffett Field, CA 94035

FIGURE 2-1
NASA GWTS LOCATION AND
SITE FEATURES MAP

NASA/MEW Discharge Pipeline
Treatment Piping

Feet
0 250 500

N

WATS/SITE 28 PHOTOGRAPHS

WATS Exterior View

WATS Interior View

WATS Equalization Tank

WATS Hydrogen Peroxide Tank

WATS Bag Filter Canisters

WATS HiPox Static Mixer

WATS HiPox Unit

WATS Primary Compressor

WATS Stand-By Generator

WATS Oxygen Concentrator

WATS Ozone Generator

WATS Secondary Equalization Tank

WATS GAC Vessels

Navy Traffic Island Pre-treatment System HiPox Unit

Typical Site 28 Extraction Well (EA1-3)

GWTS PHOTOGRAPHS

GWTS Exterior View

GWTS Interior View

GWTS Equalization Tank

GWTS Bag Filter Canisters

GWTS GAC Vessels

CY2023 Annual Remedy Performance Checklists

NASA GWTS Remedy Performance Checklist

2023 ANNUAL REPORT REMEDY PERFORMANCE CHECKLIST
NASA Groundwater Treatment System

I. GENERAL SITE INFORMATION

Facility Name: NASA Groundwater Treatment System (GWTS)

Facility Address, City, State: NASA Ames Research Center
Moffett Field, CA 94035
Environmental Protection Agency (EPA) Region 9

Checklist completion date: March 1, 2024	EPA Site ID: CA1800005034

Site Lead: ☐ Fund ☐ PRP ☐ State ☐ State Enforcement ☑ Federal Facility ☐ Other, specify:

Site Remedy Components (include other reference documents for more information, as appropriate):

GWTS is a groundwater pump and treat system. GWTS consists of four extraction wells (two currently operating), and a liquid phase granular activated carbon (GAC) adsorber. See *Final Operation and Maintenance Plan, NASA Ames Groundwater Treatment system, Moffett Field, CA (Locus, 2001)* for record drawings.

II. CONTACTS

<u>List important personnel associated with the Site</u>: Name, title, phone number, e-mail address:

	Name/Title	Phone	E-mail
PRP / Facility Representative	Garrett Michael Turner, PE Restoration Program Manager NASA Ames Research Center	650-604-1406	Turner, Garrett Michael (ARC-JQ) <garrett.michael.turner@nasa.gov>
PRP Contractor/ Consultant	Brian Reddig, PG, BB&E, Inc.	650-604-1315	Brian Reddig <brian.d.reddig@nasa.gov>
O&M Contractor/Consultant	Ingrid Warburg, PM, ERT, Inc. Michael Ninokata, Field Technician, ERT, Inc.	650-604-1129 650-604-3573	Warburg, Ingrid J (ARC-JQ)[BB&E, Inc.] <ingrid.j.warburg@nasa.gov> Ninokata, Michael D. (ARC-JQ)[BB&E, Inc.] <michael.d.ninokata@nasa.gov>
Other			

III. O&M COSTS (OPTIONAL)

What is your annual O&M cost total for the reporting year? **NA**
Breakout your annual O&M cost total into the following categories (use either dollars or %) (estimated):

- Analytical (e.g., lab costs): NA
- Subcontractor (e.g., O&M Labor): NA
- Materials and supplies: NA

Describe unanticipated/unusually high or low O&M costs (go to section [fill in] to recommend optimization methods):

IV. ON-SITE DOCUMENTS AND RECORDS (Check all that apply)

☑ O&M Manual ☑O&M Maintenance Logs ☑O&M As-built drawings ☑O&M reports
☐ Daily access/Security logs
☑ Site-Specific Health & Safety Plan ☐Contingency/Emergency Response Plan
☑O&M/OSHA Training Records ☐ Settlement Monument Records
☐ Gas Generation Records ☑Groundwater monitoring records ☐ Leachate extraction records
☑ Discharge Compliance Records
☐ Air discharge permit ☑Effluent discharge permit ☐ Waste disposal, POTW permit

Are these documents currently readily available? ☑Yes ☐ No If no, where are records kept?

V. INSTITUTIONAL CONTROLS (as applicable)

Applicable institutional controls:

- Properties within the Moffett Field Area are incorporated into the appropriate NASA Ames planning documents.
- Requirements listed in 2023 NASA Ames Land Use Controls Implementation and Monitoring Plan (IMP) Update.

Status of their implementation:

Where are the ICs documented and/or reported?

- These ICs are currently documented in the 2023 NASA Ames Land Use Controls IMP Update

ICs are being properly implemented and enforced? ☑ Yes ☐ No, elaborate below.

ICs are adequate for site protection? ☑ Yes ☐ No, elaborate below

VI. SIGNIFICANT SITE EVENTS
Check all Significant Site Events since the Last Checklist that Affects or May Affect Remedy Performance

☐ Community Issues
☐ Vandalism
☐ Maintenance Issues
☐ Other:

Please elaborate on Significant Site Events: **N/A**

2023 ANNUAL REPORT REMEDY PERFORMANCE CHECKLIST
NASA Groundwater Treatment System

VII. REDEVELOPMENT

Is redevelopment on property planned? ☑Yes ☐ No

If yes, what is planned? Please describe below.

2002 NASA Ames Development Plan Programmatic Environmental Impact Statement

Is redevelopment plan complete ☐ Yes, date:________________________; ☑ No ? ☐ Not Applicable

Redevelopment proposal in progress? ☐ Yes, elaborate below
☑No; If no, is a proposal anticipated? ☐ Yes ☑ No

☐ Is the redevelopment proposal compatible with remedy performance? ☑ Yes ☐ No
Elaborate on redevelopment proposal and how it affects remedy performance:

Redevelopment plan incorporates protection measures to ensure continued operations of the existing remedy. These protection measures include construction project reviews which include providing locations of groundwater treatment system components and associated monitoring wells, and the protection requirements for such.

VIII. GROUNDWATER REMEDY (reference isoconcentration, capture zone maps, trend analysis, and other documentation to support analysis)

Groundwater Quality Data

List the types of data that are available:	What is the source report?
2023 Data Tables, Historical Data Tables, Plume Maps, Estimated Capture Zone Maps, Chemical Contour Maps	*2023 NASA RGRP Annual Progress Report* (BB&E, 2024)

☑ Contaminant trend(s) tracked during O&M (i.e., temporal analysis of groundwater contaminant trends).
☑ Groundwater data tracked with software for temporal analyses.
☐ Reviewed monitored natural attenuation (MNA) parameters to ensure health of substrate (e.g., dissolved oxygen [DO], pH, temperature), if appropriate?

Groundwater Pump & Treat Extraction Well and Treatment System Data

List the types of data that are available:	What is the source report?
Volume & Mass Process Data; Downtime Summary; and Influent and Effluent Data Tables Compliance Evaluation Summary	*2023 Annual Self-Monitoring Report for NASA GWTS* (BB&E, 2024)

☑ The system is functioning adequately.
☐ The system has been shut down for significant periods of time in the past year. Please elaborate below.

Discharge Data

List the types of data that are available:	What is the source report?
Effluent Data Tables Compliance Evaluation Summary	*2023 Annual Self-Monitoring Report for NASA GWTS* (BB&E, 2024)

☑ The system is in compliance with discharge permits.

Slurry Wall Data

List the types of data that are available: What is the source report?

Not applicable to GWTS.

Is slurry wall operating as designed? ☐ Yes ☐ No

If not, what is being done to correct the situation?

Elaborate on technical data and/or other comments: N/A

IX. AIR MONITORING/VAPOR INTRUSION PATHWAY EVALUATION
(Include in Annual Progress Report and reference document)

NASA is conducting VI sampling per the Draft Tiering Report and Long-Term Monitoring Plan in its VI Area of Responsibility.

X. REMEDY PERFORMANCE ASSESSMENT

A. Groundwater Remedies

What are the remedial goals for groundwater? ☑ Plume containment (prevent plume migration); ☑ Plume restoration (attain Record of Decision [ROD]-specific cleanup levels in aquifer); ☐ Other goals, please explain:____

Have you done a trend analysis? ☑ Yes ☐ No;

Is it inconclusive due to inadequate data? Are the concentrations increasing or decreasing? Explain and provide source document reference.

Majority of wells showing stable trend or are "non-detect." More wells showing decreasing chemical trends than increasing trends. Reductive dechlorination process strongly supported by high percentage of decreasing trends of TCE with sequentially lower percentage of decreases trends in *c*DCE and VC. Overall, plume boundaries are stable and concentrations in core of plume fluctuating but generally in decline.

If plume containment is a remedial goal, check all that apply:
☑ Plume migration is under control (explain basis below)
☐ Plume migration is not under control (explain basis below)
☐ Insufficient data to determine plume stability (explain below)
(Include attachments that substantiate your answers, e.g., reference plume, trend analysis, and capture zone maps in source document)

Elaborate on basis for determining that plume containment goal is being met or not being met:

Capture zone estimation based on potentiometric surface map interpretation shows adequate capture of the target capture zones with NASA's Area of Responsibility. Stability of plume boundaries based on chemical concentration mapping and trend analysis provides converging lines of evidence. Portion of the MEW Regional Plume lies outside of NASA-3A source zone capture. Further expansion of the plume is limited by low hydraulic gradient.

If plume restoration is a cleanup objective, check all that apply:

☑ Progress is being made toward reaching cleanup levels (explain basis below)
☐ Progress is not being made toward reaching cleanup levels (explain basis below)
☐ Insufficient data to determine progress toward restoration goal (explain below)

Elaborate on basis for determining progress or lack of progress toward restoration goal:

Historical VOC concentration trends indicate decreasing or stable long-term trends from analysis of groundwater samples collected from monitoring wells considered representative of chemical conditions in the NASA Area of Responsibility to the MEW Regional Plume.

Although the GWTS is functioning as intended, dissolved VOCs in the MEW Regional Plume continue to migrate from up-gradient source(s) into NASA's Area of Responsibility. The up-gradient source(s) are contributing contaminants to NASA's Area of Responsibility at concentrations greater than cleanup standards. As long as there is contaminant flow into NASA's Area of Responsibility to the MEW Regional Plume above cleanup standards, the remedial objective to restore groundwater quality to cleanup standards cannot be reached.

B. Vertical Migration

Have you done an assessment of vertical gradients? ☐ Yes ☑ No; If Yes, what does it show?

Inconclusive due to insufficient data.

Are the concentrations increasing or decreasing? Explain and provide source document reference. N/A

C. Source Control Remedies

What are the remedial goals for source control? NASA-1A was installed as a source control well for an inferred up-gradient source. NASA-3A was installed as a source control well for residual contamination emanating from the previously excavated Navy Site 8 North source area. Both source control wells are performing as intended.

Elaborate on basis for determining progress or lack of progress toward these goals: Annual groundwater potentiometric maps and estimated capture zones indicate that the GWTS is functioning as designed. Although the GWTS is functioning as intended, dissolved VOCs in the MEW Regional Plume continue to migrate from up-gradient source(s) into NASA's Area of Responsibility to the MEW Regional Plume. NASA's source control wells were not designed to achieve capture of the Regional portion of the VOC plume.

XI. PROJECTIONS

Dates of next monitoring and sampling events for next annual reporting period: Monthly NPDES sampling and semi-annual NPDES reporting in 2024; site-wide water elevation gauging in March and September 2024; biennial water quality sampling in September/October 2024; 2024 Annual Progress Report for NASA RGRP due April 2025.

A. Groundwater Remedies - Projections for the upcoming year and long-term (Check all that apply)

<u>Remedy Projections for **the upcoming year (2024)**</u>
☑ No significant changes projected.
☐ Groundwater remedy will be converted to monitored natural attenuation. Target date:
☐ Groundwater Pump & Treat will be shut down. Target date:
☐ Groundwater cleanup standards to be modified. Target date:
☐ PRP will request remedy modification. Target date of request:
☐ Change in the number of water-level gauging wells. ☐ Increasing or ☐ decreasing?

Target date:
☐ Change in the number and/or types of analytes being analyzed. ☐ Increasing or ☐ decreasing? Target date:
☐ Change in groundwater extraction system. Expansion or minimization (i.e., number of extraction wells and/or pumping rate)? Target date:
☐ Modification on groundwater treatment? Elaborate below. Target date:
☐ Change in discharge location. Target date:
☐ Other modification(s) anticipated ? Elaborate below. Target date:

Elaborate on Remedy Projections: N/A..

Remedy Projections for **the Long-Term** (Check all that apply)
☑ No significant changes projected.
☐ Groundwater remedy will be converted to monitored natural attenuation. Target date:
☐ Groundwater Pump & Treat will be shut down. Target date:
☐ Groundwater cleanup standards to be modified. Target date:
☐ PRP will request remedy modification. Target date of request:
☐ Change in the number of monitoring wells. ☐ Increasing or ☐ decreasing? Target date:
☐ Change in the number and/or types of analytes being analyzed. ☐ Increasing or ☐ decreasing? Target date:
☐ Change in groundwater extraction system. Expansion or minimization (i.e., number of extraction wells and/or pumping rate)? Target date:
☐ Modification on groundwater treatment? Elaborate below.
☐ Change in discharge location. Target date:
☐ Other modification(s) anticipated:____________________ Elaborate below. Target date:

Elaborate on Remedy Projections:

B. Projections – Slurry Walls (Check all that apply) – **Not Applicable**

Remedy Projections for **the upcoming year (2023)**
☐ No significant changes projected.
☐ PRP will request remedy modification. Target date of request:
☐ Change in the number of monitoring wells. ☐ Increasing or ☐ decreasing? Target date:
☐ Other modification(s) anticipated:____________________ Elaborate below. Target date:

Elaborate on Remedy Projections:

Remedy Projections for **the long-term**
☐ No significant changes projected.
☐ PRP will request remedy modification. Target date of request:
☐ Change in the number of monitoring wells. ☐ Increasing or ☐ decreasing? Target date:
☐ Other modification(s) anticipated:____________________ Elaborate below. Target date:

Elaborate on Remedy Projections: **Not Applicable**

C. Projections – Other Remedial Options Being Reviewed to Enhance Cleanup

Progress implementing recommendations from last report or Five-Year Review
Has optimization study been implemented or scheduled? ☑ Yes; ☐ No; If Yes, please elaborate.

NASA's existing well network optimization recommendations from the 2016 and 2017 Annual Progress Reports have been implemented. Leading edge of the A2/B1 Aquifer plume (Northernmost) appears stable. The system will continue to be monitored for opportunities to optimize.

XII. ADMINISTRATIVE ISSUES (Check all that apply)

☐ Explanation of Significant Differences in progress ☐ ROD Amendment in progress
☑ Site is operational and functional
☐ Notice of Intent to Delete in progress ☐ Partial site deletion in progress ☐ TI Waivers
☐ Other administrative issues:

Date of Next EPA Five-Year Review: For review period 2019-2024 - scheduled to be completed by September 2024.

2023 ANNUAL REPORT REMEDY PERFORMANCE CHECKLIST
NASA Groundwater Treatment System

XIII. RECOMMENDATIONS
Continue to operate, maintain, and monitor GWTS and NASA Area of Responsibility monitoring wells as scheduled. Evaluate long-term alternatives to pump and treat technology for NASA Area of Responsibility contamination. Continue to maximum extraction rates as possible. Evaluate MNA as remedy component in the NASA-3A area.

Site 28 WATS Remedy Performance Checklist

2023 ANNUAL REPORT REMEDY PERFORMANCE CHECKLIST
Site 28 West-Side Aquifer Treatment System (WATS)

I. GENERAL SITE INFORMATION	
Facility Name: West-Side Aquifers Treatment System (WATS)	
Facility Address, City, State: Former Naval Air Station Moffett Field (Moffett) Moffett Field, CA 94035 Environmental Protection Agency (EPA) Region 9	
Checklist completion date: February 26, 2024	EPA Site ID: CA21700900078
Site Lead: ☐ Fund ☐ PRP ☐ State ☐ State Enforcement ☑ Federal Facility ☐ Other, specify:	
Site Remedy Components (include other reference documents for more information, as appropriate): WATS is a groundwater pump and treat system. WATS consists of nine extraction wells and a contribution from the Navy Pretreatment System Effluent. Treatment utilizes an advanced oxidation process (AOP), and a liquid phase granular activated carbon (GAC) adsorber. The AOP unit destroys the majority of the influent volatile organic compounds (VOCs). The liquid phase GAC units polish the effluent of any remaining VOCs. See *Draft Revised West-side Aquifers Treatment System Operation and Maintenance Manual, Attachment A* (ERT, 2017) for record drawings.	
II. CONTACTS	

List important personnel associated with the Site: Name, title, phone number, e-mail address:

	Name/Title	Phone	E-mail
PRP / Facility Representative	Garrett Turner, Restoration Program Manager, NASA Ames Research Center	650-604-1406	Garrett.Michael.Turner@nasa.gov
PRP Contractor/ Consultant	Jeff Linder, PM, BB&E, Inc. Michael Ninokata, Field Technician, BB&E, Inc.	650-604-4294 650-604-3573	Jeffery.l.linder@nasa.gov Michael.d.ninokata@nasa.gov
O&M Subcontractor	Charles Crocker, Field Operations Manager, Weiss Associates	510-599-8933	ctc@weiss.com
Other			

III. O&M COSTS (OPTIONAL)

What is your annual O&M cost total for the reporting year? **NA**
Breakout your annual O&M cost total into the following categories (use either dollars or %) (estimated):

- Analytical (e.g., lab costs): NA
- Subcontractor (e.g., O&M labor): NA
- Materials and supplies: NA

Describe unanticipated/unusually high or low O&M:
Rehabilitation efforts on the hydrogen peroxide pump and an unanticipated site power outage and fuse replacement at the WATS power transformer collectively resulted in an unanticipated downtime of 59.5 hours in the early part of CY2023.

IV. ON-SITE DOCUMENTS AND RECORDS (Check all that apply)

☑ O&M Manual ☑ O&M Maintenance Logs ☑ O&M As-built drawings ☑ O&M reports
☐ Daily access/Security logs
☑ Site-Specific Health & Safety Plan ☑ Contingency/Emergency Response Plan
☑ O&M/OSHA Training Records ☐ Settlement Monument Records
☐ Gas Generation Records ☑ Groundwater monitoring records ☐ Leachate extraction records
☑ Discharge Compliance Records
☐ Air discharge permit ☑ Effluent discharge permit ☐ Waste disposal, POTW permit

Are these documents currently readily available? ☑ Yes ☐ No If no, where are records kept?

Either in hard copy at the site trailer, or on the server, accessible by the computer in the site trailer.

V. INSTITUTIONAL CONTROLS (as applicable)

Applicable institutional controls:

- Properties within the Moffett Field Area are incorporated into the appropriate NASA Ames planning documents.
- Requirements as listed in the 2017 NASA Ames Land Use Controls Implementation and Monitoring Plan.

Status of their implementation:

Where are the ICs documented and/or reported?

- These ICs are currently documented in the 2017 NASA Ames Land Use Controls Report.

ICs are being properly implemented and enforced? ☑ Yes ☐ No, elaborate below

ICs are adequate for site protection? ☑ Yes ☐ No, elaborate below

VI. SIGNIFICANT SITE EVENTS
Check all Significant Site Events since the Last Checklist that Affects or May Affect Remedy Performance

☐ Community Issues
☐ Vandalism
☒ Maintenance Issues
☐ Other:

2023 ANNUAL REPORT REMEDY PERFORMANCE CHECKLIST
Site 28 West-Side Aquifer Treatment System (WATS)

Please elaborate on Significant Site Events: Rehabilitation efforts on the hydrogen peroxide pump and an unanticipated site power outage and fuse replacement at the WATS power transformer collectively resulted in an unanticipated downtime of 59.5 hours in the early part of CY2023.

VII. REDEVELOPMENT

Is redevelopment on property planned? ☑Yes ☐ No

If yes, what is planned? Please describe below.

2002 NASA Ames Development Plan Programmatic Environmental Impact Statement

Is redevelopment plan complete ☐ Yes, date:________________________; ☑ No ? ☐ Not Applicable

Redevelopment proposal in progress? ☑ Yes, elaborate below
☐No; If no, is a proposal anticipated? ☐ Yes ☑ No

☐ Is the redevelopment proposal compatible with remedy performance? ☑ Yes ☐ No

Elaborate on redevelopment proposal and how it affects remedy performance:
Redevelopment plan incorporates protection measures to ensure continued operations of the existing remedy. The protection measures include construction project reviews which provide locations of groundwater treatment system components and associated monitoring wells, and the protection requirements for such.

VIII. GROUNDWATER REMEDY (reference isoconcentration, capture zone maps, trend analysis, and other documentation to support analysis)

Groundwater Quality Data

List the types of data that are available:	What is the source report?
2023 Data Tables, Historical Data Tables, Estimated Capture Zone Maps, etc…	*2023 NASA RGRP Annual Progress Report* (BB&E, 2024).

☑ Contaminant trend(s) tracked during O&M (i.e., temporal analysis of groundwater contaminant trends).
☑ Groundwater data tracked with software for temporal analyses.
☐ Reviewed monitored natural attenuation (MNA) parameters to ensure health of substrate (e.g., dissolved oxygen [DO], pH, temperature), if appropriate?

Groundwater Pump & Treat Extraction Well and Treatment System Data

List the types of data that are available:	What is the source report?
Volume and mass process data, downtime summary, influent and effluent data tables, compliance evaluation summary, etc…	*Annual 2023 WATS Self-Monitoring Report* (BB&E, 2024)

☑ The system is functioning adequately.

☐ The system has been shut down for significant periods of time in the past year. Please elaborate below.

Discharge Data

List the types of data that are available:	What is the source report?
Effluent Data Tables Compliance evaluation summary	*Annual 2023 WATS Self-Monitoring Report* (BB&E, 2024)

☑ The system is in compliance with discharge permits.

Slurry Wall Data

2023 ANNUAL REPORT REMEDY PERFORMANCE CHECKLIST
Site 28 West-Side Aquifer Treatment System (WATS)

List the types of data that are available: What is the source report?

Not applicable to WATS.

Is slurry wall operating as designed? ☐ Yes ☐ No

If not, what is being done to correct the situation?

Elaborate on technical data and/or other comments:

IX. AIR MONITORING/VAPOR INTRUSION PATHWAY EVALUATION
(Include in Annual Progress Report and reference document)

The Navy is responsible for air monitoring in the Site 28 area; therefore, vapor intrusion pathway monitoring and reporting is completed by the Navy in a separate report.

X. REMEDY PERFORMANCE ASSESSMENT

A. Groundwater Remedies

What are the remedial goals for groundwater? ☑ Plume containment (prevent plume migration); ☑ Plume restoration (attain Record of Decision [ROD]-specific cleanup levels in aquifer); ☐ Other goals, please explain:_____

Have you done a trend analysis? ☑ Yes ☐ No; If Yes, what does it show? Chemical concentration trends of the four primary COCs (PCE, TCE, *c*DCE and VC) are not calculated during off-years (odd years). The 2022 analysis indicated that the majority of wells are either stable, no trend/non-detect, or decreasing. The limited amount of increasing trends are majority VC, indicating reductive dechlorination at the site.

Is it inconclusive due to inadequate data? Are the concentrations increasing or decreasing? Explain and provide source document reference. Conclusive data provided by Mann-Kendall trend analysis detailed in the 2022 NASA RGRP Annual Progress Report (BB&E, 2023).

If plume containment is a remedial goal, check all that apply:
☑Plume migration is under control (explain basis below)
☐ Plume migration is not under control (explain basis below)
☐ Insufficient data to determine plume stability (explain below)
(Include attachments that substantiate your answers, e.g., reference plume, trend analysis, and capture zone maps in source document)

Elaborate on basis for determining that plume containment goal is being met or not being met:

The stability of plume boundaries based on limited off-year chemical concentration and capture zone mapping provides converging lines of evidence that plume migration is under control. A full analysis including Mann-Kendall trends will be performed in CY2024.

If plume restoration is a cleanup objective, check all that apply:

☑Progress is being made toward reaching cleanup levels (explain basis below)
☐ Progress is not being made toward reaching cleanup levels (explain basis below)
☐ Insufficient data to determine progress toward restoration goal (explain below)

Elaborate on basis for determining progress or lack of progress toward restoration goal:

Comparison of concentration contours to previous years is a strong indication that progress is being made toward reaching cleanup levels in CY2023. A complete analysis will be performed during the next full-scale sampling event in CY2024.

Although progress is being made toward reaching the restoration goal, dissolved VOCs in the MEW Regional Plume continue to migrate from up-gradient, offsite source(s) and commingled Navy site sources into the WATS Site 28 area. The upgradient sources are contributing contaminants in the WATS Site 28 area at concentrations greater than cleanup standards. As long as there is groundwater contaminant underflow from upgradient sources above cleanup standards, the remedial objective to restore WATS Site 28 area groundwater quality to cleanup standards cannot be achieved.

B. Vertical Migration

Have you done an assessment of vertical gradients? ☐ Yes ☑ No; If Yes, what does it show? (Is it inconclusive due to inadequate data?

Are the concentrations increasing or decreasing? Explain and provide source document reference.

C. Source Control Remedies

What are the remedial goals for source control?

The remedial goal for groundwater is currently being met by operation of WATS. Vapor intrusion pathway monitoring, and source control in the Building 88/Traffic Island Area is being completed by the Navy (see information below).

The Navy conducted a treatability study in CY2015/CY2016 involving combined enhanced anaerobic bioremediation/in situ chemical reduction for chlorinated ethenes (CE) from 30 to 120 feet bgs in the Traffic Island area of Site 28 (APTIM, 2018). According to the report, the study temporarily reduced concentrations of dissolved CEs to less than 10 percent of the September 2015 baseline concentrations within the study area. However, unsatisfactory results after performance monitoring were evident at some locations. The inability to completely distribute the substrate (daylighting, lithologic control, utilities), along with desorption of CEs from soil and dissolution from the dense non-aqueous phase liquid (DNAPL) indicated that the combined enhanced anaerobic bioremediation/in situ chemical reduction would not be effective as the final remedial action. The Navy has completed the *Final Work Plan, Remedial Action at the Traffic Island Area, Installation Restoration Site 28* (APTIM, 2020) that addresses additional source reduction and hydraulic control of contaminated groundwater Additional extraction and monitoring wells were installed by the Navy in CY2020.

During CY2021, accommodations were made to facilitate the planning and permitting phase of the Navy's proposed groundwater pretreatment system for the TIA (Navy Pretreatment System). The proposed system will treat water from the newly installed extraction wells to an agreed upon standard prior to discharge into the WATS primary influent equalization tank. In November 2021, NASA's Construction Permit Review Board (CPRB) conditionally approved plans for the installation of the pretreatment system. During CY2022, construction of the Navy Pretreatment System and conveyance piping was completed. The One-Day Startup Test was completed by the Navy in December 2022. The Navy Pretreatment System began continuous operation on April 10th, 2023 after completion of the Five-Day Test and verification of successful integration between the two systems.

Elaborate on the basis for determining progress or lack of progress toward these goals:
Groundwater potentiometric maps, estimated capture zones, and chemical concentration contours based on the limited CY2023 voluntary sampling event indicate that WATS is functioning as designed. A complete chemical analysis will be performed during the next full-scale sampling event in CY2024. Vapor intrusion pathway and sources in the Building 88/Traffic Island Area is being evaluated by the Navy.

2023 ANNUAL REPORT REMEDY PERFORMANCE CHECKLIST
Site 28 West-Side Aquifer Treatment System (WATS)

XI. PROJECTIONS

Dates of next monitoring and sampling events for next annual reporting period: Monthly NPDES sampling and semi-annual NPDES reporting in 2024 (semi-annual and annual reports due August 15th and February 15th, respectively). September site-wide groundwater sampling and elevation gauging to occur in 2024.

A. Groundwater Remedies - Projections for the upcoming year and long-term (Check all that apply)

Remedy Projections for **the upcoming year (2024)**
☐ No significant changes projected.
☐ Groundwater remedy will be converted to monitored natural attenuation. Target date:
☐ Groundwater Pump & Treat will be shut down. Target date:
☐ Groundwater cleanup standards to be modified. Target date:
☐ PRP will request remedy modification. Target date of request:
☐ Change in the number of monitoring wells for gauging. ☐ Increasing or ☐ decreasing? Target date:
☐ Change in the number and/or types of analytes being analyzed. ☐ Increasing or ☐ decreasing? Target date:
☐ Change in groundwater extraction system. Expansion or minimization (i.e., number of extraction wells and/or pumping rate)? Target date:
☒ Modification on groundwater treatment? Potential modification of the WATS treatment system components following Navy's planned bypass of the pretreatment system.
☐ Change in discharge location. Target date:
☐ Other modification(s) anticipated ? Elaborate below. Target date:

Elaborate on Remedy Projections:

Changes to the selected remedy may be influenced by the impacts of the Navy's proposed remedial efforts in the Traffic Island/Building 88 areas.

Remedy Projections for **the long-term** (Check all that apply)
☑ No significant changes projected.
☐ Groundwater remedy will be converted to monitored natural attenuation. Target date:
☐ Groundwater Pump & Treat will be shut down. Target date:
☐ Groundwater cleanup standards to be modified. Target date:
☐ PRP will request remedy modification. Target date of request:
☐ Change in the number of monitoring wells. ☐ Increasing or ☐ decreasing? Target date:
☐ Change in the number and/or types of analytes being analyzed. ☐ Increasing or ☐ decreasing? Target date:
☐ Change in groundwater extraction system. Expansion or minimization (i.e., number of extraction wells and/or pumping rate)? Target date:
☒ Modification on groundwater treatment? Potential modification of the WATS treatment system components following Navy's planned bypass of the pretreatment system.
☐ Change in discharge location. Target date:
☐ Other modification(s) anticipated:____________________ Elaborate below. Target date:

Elaborate on Remedy Projections:
Changes to the selected remedy may be influenced by the impacts of the Navy's proposed remedial efforts in the Traffic Island/Building 88 areas.

B. Projections – Slurry Walls (Check all that apply) – **Not Applicable**
Remedy Projections for **the upcoming year (2024)** ☐ No significant changes projected. ☐ PRP will request remedy modification. Target date of request: ☐ Change in the number of monitoring wells. ☐ Increasing or ☐ decreasing? Target date: ☐ Other modification(s) anticipated:______________________ Elaborate below. Target date:
Elaborate on Remedy Projections:
Remedy Projections for **the long-term** ☐ No significant changes projected. ☐ PRP will request remedy modification. Target date of request: ☐ Change in the number of monitoring wells. ☐ Increasing or ☐ decreasing? Target date: ☐ Other modification(s) anticipated:______________________ Elaborate below. Target date:
Elaborate on Remedy Projections:
C. Projections – Other Remedial Options Being Reviewed to Enhance Cleanup Progress implementing recommendations from last report or Five-Year Review Has optimization study been implemented or scheduled? ☑ Yes; ☐ No; If Yes, please elaborate. The *WATS Optimization Work Plan* (FWENC 2003c) has been implemented. The system will continue to be monitored for opportunities to optimize. The optimization of WATS was documented in the *WATS Optimization Completion Report* (May 2005d). Ongoing Navy work in the Building 88/Traffic Island Area is summarized as follows: During CY2021, accommodations were made to facilitate the planning and permitting phase of the Navy's proposed groundwater pretreatment system for the TIA (Navy Pretreatment System). The proposed system will treat water from the newly installed extraction wells to an agreed upon standard prior to discharge into the WATS primary influent equalization tank. In November 2021, NASA's Construction Permit Review Board (CPRB) conditionally approved plans for the installation of the pretreatment system. During CY2022, construction of the Navy Pretreatment System and conveyance piping was completed. The One-Day Startup Test was completed by the Navy in December 2022. The Navy Pretreatment System began continuous operation on April 10th, 2023 after completion of the Five-Day Test and verification of successful integration between the two systems.
XII. ADMINISTRATIVE ISSUES (Check all that apply)
☐ Explanation of Significant Differences in progress ☐ ROD Amendment in progress ☐ Site in operational and functional; ☐ Notice of Intent to Delete in progress ☐ Partial site deletion in progress ☐ TI Waivers ☐ Other administrative issues: See major unanticipated system upgrades and maintenance issues described above.
XIII. RECOMMENDATIONS

2023 ANNUAL REPORT REMEDY PERFORMANCE CHECKLIST
Site 28 West-Side Aquifer Treatment System (WATS)

Continue to operate, maintain, and monitor the WATS groundwater treatment system. Evaluate opportunities to increase mass removal and capture through existing extraction well network in conjunction with ongoing work by the Navy and other MEW parties, as appropriate.

Table 1: NASA Ames Research Center Land Use Controls
NASA Ames Research Center, Moffett Field, California

Site	Description	Basis for LUCs	NASA Ames LUCs
Navy Site 28 WATS Area	Groundwater extraction, treatment and monitoring system.	Prevent domestic use of groundwater	NASA Ames implementation of domestic groundwater use restrictions.
Former NAS Moffett Field Area of MEW Regional Plume	Former NAS Moffett Field Area of MEW Regional Plume and MEW Companies, Navy and NASA geographical groundwater areas of responsibility	Prevent domestic use of groundwater	NASA Ames implementation of domestic groundwater use restrictions.

Five-Year Review Form

NASA Vapor Intrusion (VI) Area of Responsibility (AOR)

I. SITE INFORMATION	
Site name: NASA Vapor Intrusion AOR	**Date of inspection: 1/14/2024**
Location and Region: NASA Ames Research Center	**EPA ID: CA1800005034**
Agency, office, or company leading the five-year review: BB&E	**Weather/temperature: Partly cloudy, 56°F, wind to 10 mph.**

Remedy Includes: (Check all that apply)

- ☐ Landfill cover/containment
- ■ Access controls
- ■ Institutional controls
- ☐ Groundwater pump and treatment
- ☐ Surface water collection and treatment
- ☐ Monitored natural attenuation
- ☐ Groundwater containment
- ☐ Vertical barrier walls
- ■ Other Interim mitigation measures and final remedial approaches are not required for any buildings in NASA Ames VI AOR.

Attachments: ☐ Inspection team roster attached ■ Site map attached

II. INTERVIEWS (Check all that apply)

1. **O&M site manager** Brian Reddig — Restoration Group Manager — 1/14/24
   Name — Title — Date
   Interviewed ☐ at site ■ at office ☐ by phone Phone no. (650) 604-1315
   Problems, suggestions; ☐ Report attached

2. **O&M staff** Mike Ninokata — Senior Technician — 1/14/24
   Name — Title — Date
   Interviewed ■ at site ☐ at office ☐ by phone Phone no. (650) 507-6227
   Problems, suggestions; ☐ Report attached

3. **Local regulatory authorities and response agencies** (i.e., State and Tribal offices, emergency response office, police department, office of public health or environmental health, zoning office, recorder of deeds, or other city and county offices, etc.) Fill in all that apply.

Agency US EPA
Contact Alana Lee | Program Manager | 1/10/24 | (415) 972-3141
Name | Title | Date | Phone no.
Problems; suggestions; ■ Report attached *

Agency CA Regional Water Board-SF
Contact Dana McCarthy | Program Manager | 2/13/24 | (510) 622-2371
Name | Title | Date | Phone no.
Problems; suggestions; ■ Report attached *

Agency ______
Contact ______
Name | Title | Date | Phone no.
Problems; suggestions; ☐ Report attached

Agency ______
Contact ______
Name | Title | Date | Phone no.
Problems; suggestions; ☐ Report attached

4. **Other interviews** (optional) ■ Report attached.

Lili Pirbazari (NASA Technical Manager) – See attached interview.*

* Interviews provided in Appendix B of the Five Year Review Report.

III. ON-SITE DOCUMENTS & RECORDS VERIFIED (Check all that apply)				
1.	**O&M Documents**			
	☐ O&M manual	☐ Readily available	☐ Up to date	■ N/A
	☐ As-built drawings	☐ Readily available	☐ Up to date	■ N/A
	☐ Maintenance logs	☐ Readily available	☐ Up to date	■ N/A
	Remarks HMBPs and building floor plans are available and are utilized during pre-sampling building inspections.			
2.	**Site-Specific Health and Safety Plan**	■ Readily available	■ Up to date	☐ N/A
	☐ Contingency plan/emergency response plan	☐ Readily available	☐ Up to date	☐ N/A
	Remarks BB&E Project Safety Plan verified on JQ Server.			
3.	**O&M and OSHA Training Records**	■ Readily available	■ Up to date	☐ N/A
	Remarks			
4.	**Permits and Service Agreements**			
	☐ Air discharge permit	☐ Readily available	☐ Up to date	■ N/A
	☐ Effluent discharge	☐ Readily available	☐ Up to date	■ N/A
	☐ Waste disposal, POTW	☐ Readily available	☐ Up to date	■ N/A
	☐ Other permits______	☐ Readily available	☐ Up to date	■ N/A
	Remarks			
5.	**Gas Generation Records**	☐ Readily available	☐ Up to date	■ N/A
	Remarks			
6.	**Settlement Monument Records**	☐ Readily available	☐ Up to date	■ N/A
	Remarks			
7.	**Groundwater Monitoring Records**	■ Readily available	■ Up to date	☐ N/A
	Remarks Groundwater analytical results useful in evaluating indoor air analyticals.			
8.	**Leachate Extraction Records**	☐ Readily available	☐ Up to date	■ N/A
	Remarks			
9.	**Discharge Compliance Records**			
	☐ Air	☐ Readily available	☐ Up to date	■ N/A
	☐ Water (effluent)	☐ Readily available	☐ Up to date	■ N/A
	Remarks			
10.	**Daily Access/Security Logs**	☐ Readily available	☐ Up to date	■ N/A
	Remarks			

IV. O&M COSTS

1. O&M Organization

☐ State in-house ☐ Contractor for State
☐ PRP in-house ☐ Contractor for PRP
☐ Federal Facility in-house ■ Contractor for Federal Facility
☐ Other______________________________

2. O&M Cost Records

■ Readily available ■ Up to date
☐ Funding mechanism/agreement in place
Original O&M cost estimate____________________ ☐ Breakdown attached

Total annual cost by year for review period if available

From	Date	To	Date	Total cost	
From	1/1/19	To	12/31/19	$18,898	☐ Breakdown attached
From	1/1/20	To	12/31/20	$50,094	☐ Breakdown attached
From	1/1/21	To	12/31/21	$63,631	☐ Breakdown attached
From	1/1/22	To	12/31/22	$63,588	☐ Breakdown attached
From	1/1/23	To	12/31/23	$65,179	☐ Breakdown attached

3. **Unanticipated or Unusually High O&M Costs During Review Period**

Describe costs and reasons:______________________________

V. ACCESS AND INSTITUTIONAL CONTROLS ■ Applicable ☐ N/A

A. Fencing

1. **Fencing damaged** ☐ Location shown on site map ☐ Gates secured ■ N/A

Remarks______________________________

B. Other Access Restrictions

1. **Signs and other security measures** ☐ Location shown on site map ■ N/A

Remarks______________________________

C. Institutional Controls (ICs)

1. **Implementation and enforcement**

Site conditions imply ICs not properly implemented ☐ Yes ■ No ☐ N/A
Site conditions imply ICs not being fully enforced ☐ Yes ■ No ☐ N/A

Type of monitoring (*e.g.*, self-reporting, drive by) LUC inspections, Pre-sampling building inspections.
Frequency Quarterly (LUCs), Annual (pre-sampling)
Responsible party/agency NASA/BB&E and ERT
Contact Brian Reddig (Name) Restoration Group Manager (Title) (650) 604-1315 (Phone no.)

Reporting is up-to-date ■ Yes ☐ No ☐ N/A
Reports are verified by the lead agency ■ Yes ☐ No ☐ N/A

Specific requirements in deed or decision documents have been met ■ Yes ☐ No ☐ N/A
Violations have been reported ☐Yes ☐ No ■ N/A
Other problems or suggestions: ☐ Report attached
2017-2023 Annual Reports not formally reviewed or approved by EPA.

2. **Adequacy** ■ ICs are adequate ☐ ICs are inadequate ☐ N/A
Remarks Interim mitigation measures and final remedial approaches are not required for any buildings in NASA Ames VI AOR. However, buildings that have exhibited the presence of vapor intrusion above background levels, or above clean up levels in *pathway* samples, have been designated Tier 3A as per the ROD Amendment for Vapor Intrusion requiring long term monitoring.

D. General

1. **Vandalism/trespassing** ☐ Location shown on site map ■ No vandalism evident
Remarks

2. **Land use changes on site** ■ N/A
Remarks None that impact NASA Vapor Intrusion. Any changes in building use or construction activities are addressed through Construction Permit Review.

3. **Land use changes off site** ■ N/A
Remarks None that impact NASA Vapor Intrusion.

VI. GENERAL SITE CONDITIONS

A. Roads ☐ Applicable ■ N/A

1. **Roads damaged** ☐ Location shown on site map ☐ Roads adequate ☐ N/A
Remarks

B. Other Site Conditions

Remarks ____

____

____

____

____

____

VII. LANDFILL COVERS ☐ Applicable ■ N/A

A. Landfill Surface

1. **Settlement** (Low spots) ☐ Location shown on site map ☐ Settlement not evident
   Areal extent______________ Depth____________
   Remarks____
   ____

2. **Cracks** ☐ Location shown on site map ☐ Cracking not evident
   Lengths____________ Widths___________ Depths__________
   Remarks____
   ____

3. **Erosion** ☐ Location shown on site map ☐ Erosion not evident
   Areal extent______________ Depth____________
   Remarks____
   ____

4. **Holes** ☐ Location shown on site map ☐ Holes not evident
   Areal extent______________ Depth____________
   Remarks____
   ____

5. **Vegetative Cover** ☐ Grass ☐ Cover properly established ☐ No signs of stress
   ☐ Trees/Shrubs (indicate size and locations on a diagram)
   Remarks____
   ____

6. **Alternative Cover (armored rock, concrete, etc.)** ☐ N/A
   Remarks____
   ____

7. **Bulges** ☐ Location shown on site map ☐ Bulges not evident
   Areal extent______________ Height____________
   Remarks____
   ____

8. **Wet Areas/Water Damage** ☐ Wet areas/water damage not evident
☐ Wet areas ☐ Location shown on site map Areal extent______________
☐ Ponding ☐ Location shown on site map Areal extent______________
☐ Seeps ☐ Location shown on site map Areal extent______________
☐ Soft subgrade ☐ Location shown on site map Areal extent______________
Remarks____
____

9. **Slope Instability** ☐ Slides ☐ Location shown on site map ☐ No evidence of slope instability
Areal extent______________
Remarks____
____

B. Benches ☐ Applicable ■ N/A
(Horizontally constructed mounds of earth placed across a steep landfill side slope to interrupt the slope in order to slow down the velocity of surface runoff and intercept and convey the runoff to a lined channel.)

1. **Flows Bypass Bench** ☐ Location shown on site map ☐ N/A or okay
Remarks____
____

2. **Bench Breached** ☐ Location shown on site map ☐ N/A or okay
Remarks____
____

3. **Bench Overtopped** ☐ Location shown on site map ☐ N/A or okay
Remarks____
____

C. Letdown Channels ☐ Applicable ■ N/A
(Channel lined with erosion control mats, riprap, grout bags, or gabions that descend down the steep side slope of the cover and will allow the runoff water collected by the benches to move off of the landfill cover without creating erosion gullies.)

1. **Settlement** ☐ Location shown on site map ☐ No evidence of settlement
Areal extent______________ Depth____________
Remarks____
____

2. **Material Degradation** ☐ Location shown on site map ☐ No evidence of degradation
Material type_______________ Areal extent_____________
Remarks____
____

3. **Erosion** ☐ Location shown on site map ☐ No evidence of erosion
Areal extent______________ Depth____________
Remarks____
____

4. **Undercutting** ☐ Location shown on site map ☐ No evidence of undercutting
Areal extent______________ Depth____________
Remarks____
____

5. **Obstructions** Type_____________________ ☐ No obstructions
☐ Location shown on site map Areal extent______________
Size____________
Remarks____
____

6. **Excessive Vegetative Growth** Type____________________
☐ No evidence of excessive growth
☐ Vegetation in channels does not obstruct flow
☐ Location shown on site map Areal extent______________
Remarks____
____

D. Cover Penetrations ☐ Applicable ■ N/A

1. **Gas Vents** ☐ Active ☐ Passive
☐ Properly secured/locked ☐ Functioning ☐ Routinely sampled ☐ Good condition
☐ Evidence of leakage at penetration ☐ Needs Maintenance
☐ N/A
Remarks____
____

2. **Gas Monitoring Probes**
☐ Properly secured/locked ☐ Functioning ☐ Routinely sampled ☐ Good condition
☐ Evidence of leakage at penetration ☐ Needs Maintenance ☐ N/A
Remarks____
____

3. **Monitoring Wells** (within surface area of landfill)
☐ Properly secured/locked ☐ Functioning ☐ Routinely sampled ☐ Good condition
☐ Evidence of leakage at penetration ☐ Needs Maintenance ☐ N/A
Remarks____
____

4. **Leachate Extraction Wells**
☐ Properly secured/locked ☐ Functioning ☐ Routinely sampled ☐ Good condition
☐ Evidence of leakage at penetration ☐ Needs Maintenance ☐ N/A
Remarks____
____

5. **Settlement Monuments** ☐ Located ☐ Routinely surveyed ☐ N/A
Remarks____
____

E. Gas Collection and Treatment	☐ Applicable ■ N/A
1.	**Gas Treatment Facilities** ☐ Flaring ☐ Thermal destruction ☐ Collection for reuse ☐ Good condition ☐ Needs Maintenance Remarks______________________________
2.	**Gas Collection Wells, Manifolds and Piping** ☐ Good condition ☐ Needs Maintenance Remarks______________________________
3.	**Gas Monitoring Facilities** (*e.g.*, gas monitoring of adjacent homes or buildings) ☐ Good condition☐ Needs Maintenance ☐ N/A Remarks______________________________
F. Cover Drainage Layer	☐ Applicable ■ N/A
1.	**Outlet Pipes Inspected** ☐ Functioning ☐ N/A Remarks______________________________
2.	**Outlet Rock Inspected** ☐ Functioning ☐ N/A Remarks______________________________
G. Detention/Sedimentation Ponds	☐ Applicable ■ N/A
1.	**Siltation** Areal extent______________ Depth____________ ☐ N/A ☐ Siltation not evident Remarks______________________________
2.	**Erosion** Areal extent______________Depth______________ ☐ Erosion not evident Remarks______________________________
3.	**Outlet Works** ☐ Functioning ☐ N/A Remarks______________________________
4.	**Dam** ☐ Functioning ☐ N/A Remarks______________________________

H. Retaining Walls	☐ Applicable ■ N/A	
1.	**Deformations** ☐ Location shown on site map ☐ Deformation not evident Horizontal displacement_____________ Vertical displacement________________ Rotational displacement_____________ Remarks____ ____	
2.	**Degradation** ☐ Location shown on site map ☐ Degradation not evident Remarks____ ____	
I. Perimeter Ditches/Off-Site Discharge	☐ Applicable ■ N/A	
1.	**Siltation** ☐ Location shown on site map ☐ Siltation not evident Areal extent_______________ Depth_____________ Remarks____ ____	
2.	**Vegetative Growth** ☐ Location shown on site map ☐ N/A ☐ Vegetation does not impede flow Areal extent_______________ Type_____________ Remarks____ ____	
3.	**Erosion** ☐ Location shown on site map ☐ Erosion not evident Areal extent_______________ Depth_____________ Remarks____ ____	
4.	**Discharge Structure** ☐ Functioning ☐ N/A Remarks____ ____	
VIII. VERTICAL BARRIER WALLS	☐ Applicable ■ N/A	
1.	**Settlement** ☐ Location shown on site map ☐ Settlement not evident Areal extent_______________ Depth_____________ Remarks____ ____	
2.	**Performance Monitoring** Type of monitoring____________________________ ☐ Performance not monitored Frequency__________________________________ ☐ Evidence of breaching Head differential____________________________ Remarks____ ____	

IX. GROUNDWATER/SURFACE WATER REMEDIES ■ Applicable ☐ N/A

A. Groundwater Extraction Wells, Pumps, and Pipelines ■ Applicable ☐ N/A

1. **Pumps, Wellhead Plumbing, and Electrical**
☐ Good condition ☐ All required wells properly operating ☐ Needs Maintenance ☐ N/A
Remarks Please refer to the NASA RGRP (WATS & GWTS) Inspection Report. The WATS and GWTS address the groundwater portion of the MEW ROD, while the Vapor Intrusion program addresses the VI ROD Amendment requirements.

2. **Extraction System Pipelines, Valves, Valve Boxes, and Other Appurtenances**
☐ Good condition ☐ Needs Maintenance
Remarks

3. **Spare Parts and Equipment**
☐ Readily available ☐ Good condition ☐ Requires upgrade ☐ Needs to be provided
Remarks

B. Surface Water Collection Structures, Pumps, and Pipelines ☐ Applicable ■ N/A

1. **Collection Structures, Pumps, and Electrical**
☐ Good condition ☐ Needs Maintenance
Remarks

2. **Surface Water Collection System Pipelines, Valves, Valve Boxes, and Other Appurtenances**
☐ Good condition ☐ Needs Maintenance
Remarks

3. **Spare Parts and Equipment**
☐ Readily available ☐ Good condition ☐ Requires upgrade ☐ Needs to be provided
Remarks

C. Treatment System ■ Applicable ☐ N/A

1. **Treatment Train** (Check components that apply)
☐ Metals removal ☐ Oil/water separation ☐ Bioremediation
☐ Air stripping ☐ Carbon adsorbers
☐ Filters____________________
☐ Additive (*e.g.*, chelation agent, flocculent)____________________
☐ Others____________________
☐ Good condition ☐ Needs Maintenance
☐ Sampling ports properly marked and functional
☐ Sampling/maintenance log displayed and up to date
☐ Equipment properly identified
☐ Quantity of groundwater treated annually____________
☐ Quantity of surface water treated annually____________
Remarks Please refer to the NASA RGRP (WATS & GWTS) Inspection Report. The WATS and GWTS address the groundwater portion of the MEW ROD, while the Vapor Intrusion program addresses the VI ROD Amendment requirements

2. **Electrical Enclosures and Panels** (properly rated and functional)
☐ N/A ☐ Good condition ☐ Needs Maintenance
Remarks____________________

3. **Tanks, Vaults, Storage Vessels**
☐ N/A ☐ Good condition ☐ Proper secondary containment ☐ Needs Maintenance Remarks____________________

4. **Discharge Structure and Appurtenances**
☐ N/A ☐ Good condition ☐ Needs Maintenance
Remarks____________________

5. **Treatment Building(s)**
☐ N/A ☐ Good condition (esp. roof and doorways) ☐ Needs repair
☐ Chemicals and equipment properly stored
Remarks____________________

6. **Monitoring Wells** (pump and treatment remedy)
☐ Properly secured/locked ☐ Functioning ☐ Routinely sampled ☐ Good condition
☐ All required wells located ☐ Needs Maintenance ☐ N/A
Remarks____________________

D. Vapor Monitoring Data

1. Monitoring Data
■ Is routinely submitted on time ■ Is of acceptable quality

2. Monitoring data suggests:
☐ Groundwater plume is effectively contained ☐ Contaminant concentrations are declining

D. Monitored Natural Attenuation

1. **Monitoring Wells** (natural attenuation remedy)
☐ Properly secured/locked ☐ Functioning ☐ Routinely sampled ☐ Good condition
☐ All required wells located ☐ Needs Maintenance ■ N/A
Remarks____

X. OTHER REMEDIES

If there are remedies applied at the site which are not covered above, attach an inspection sheet describing the physical nature and condition of any facility associated with the remedy. An example would be soil vapor extraction.

XI. OVERALL OBSERVATIONS

A. Implementation of the Remedy

Describe issues and observations relating to whether the remedy is effective and functioning as designed. Begin with a brief statement of what the remedy is to accomplish (i.e., to contain contaminant plume, minimize infiltration and gas emission, etc.).

The indoor air sampling and reporting associated with the VI remedy are functioning as designed. NASA obtains timely analytical information to closely monitor changes in VI conditions. Additional programmatic areas (NASA RGRP and LUC Inspections) complement the VI program to ensure remedy effectiveness.

B. Adequacy of O&M

Describe issues and observations related to the implementation and scope of O&M procedures. In particular, discuss their relationship to the current and long-term protectiveness of the remedy.

None of the buildings in NASA Ames VI AOR have a Tier 1 or Tier 2 designation because indoor air concentrations for all seven COCs meet indoor air cleanup levels in work areas without an EC in place or operating. Therefore, interim mitigation measures and final remedial approaches are not required for any buildings in NASA Ames VI AOR. However, buildings that have exhibited the presence of vapor intrusion above background levels, or above clean up levels in *pathway* samples, have been designated Tier 3A as per the ROD Amendment for Vapor Intrusion requiring long term monitoring.

C.	Early Indicators of Potential Remedy Problems
	Describe issues and observations such as unexpected changes in the cost or scope of O&M or a high frequency of unscheduled repairs, that suggest that the protectiveness of the remedy may be compromised in the future. No issues or observations noted.

D.	Opportunities for Optimization
	Describe possible opportunities for optimization in monitoring tasks or the operation of the remedy The Tier 3A buildings are currently sampled annually, although they are only required to be sampled biennially. It may be beneficial to reevaluate the need to sample the Tier 3A buildings annually, especially in light of the delay in official EPA review of historical reports. Targeted annual sampling at locations warranting closer monitoring may be warranted. Investing the cost savings into other VI-related tasks (development of more robust construction permit review informational materials, statistical studies of existing data, etc.) may be a more prudent use of funds.

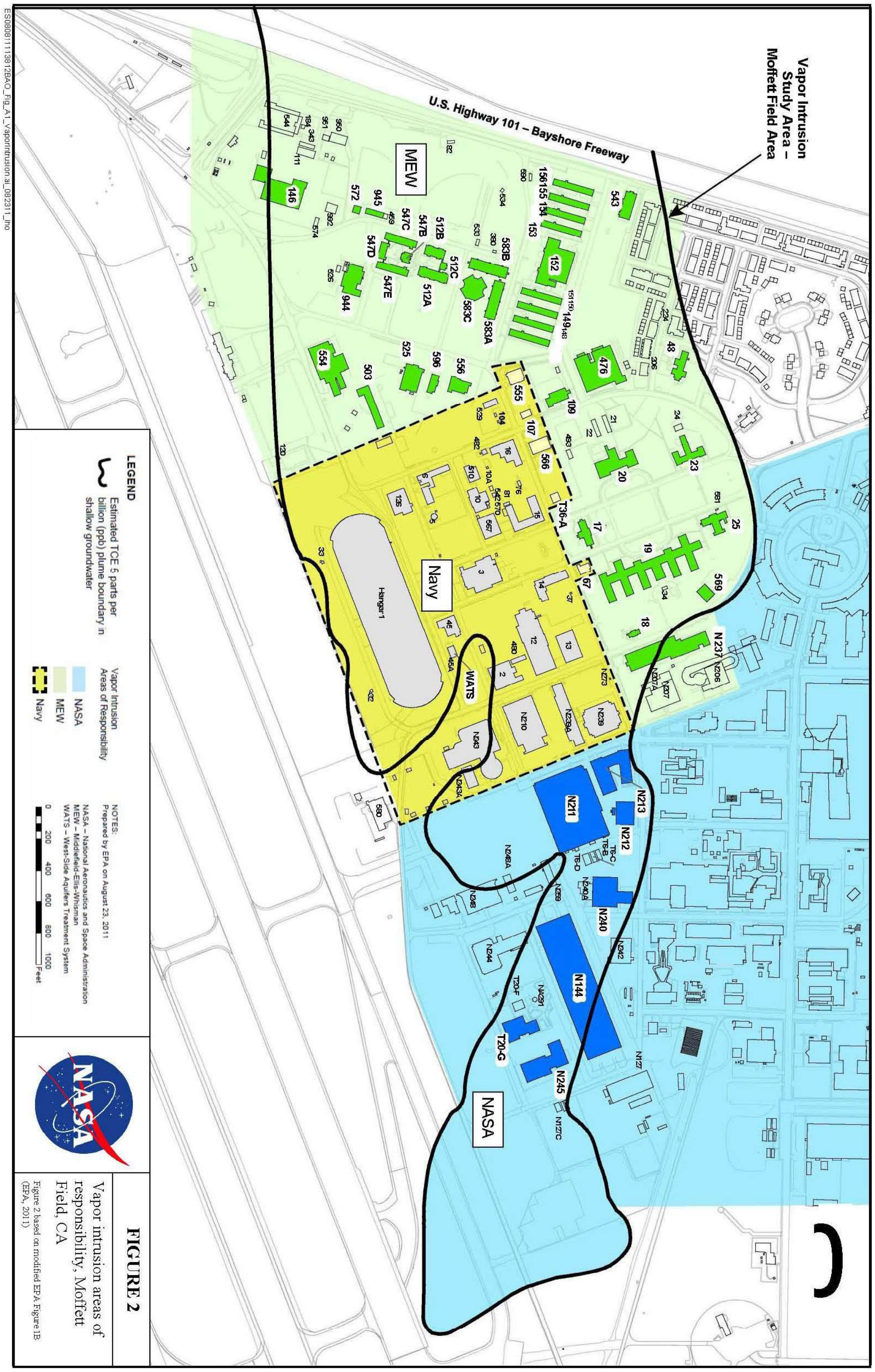
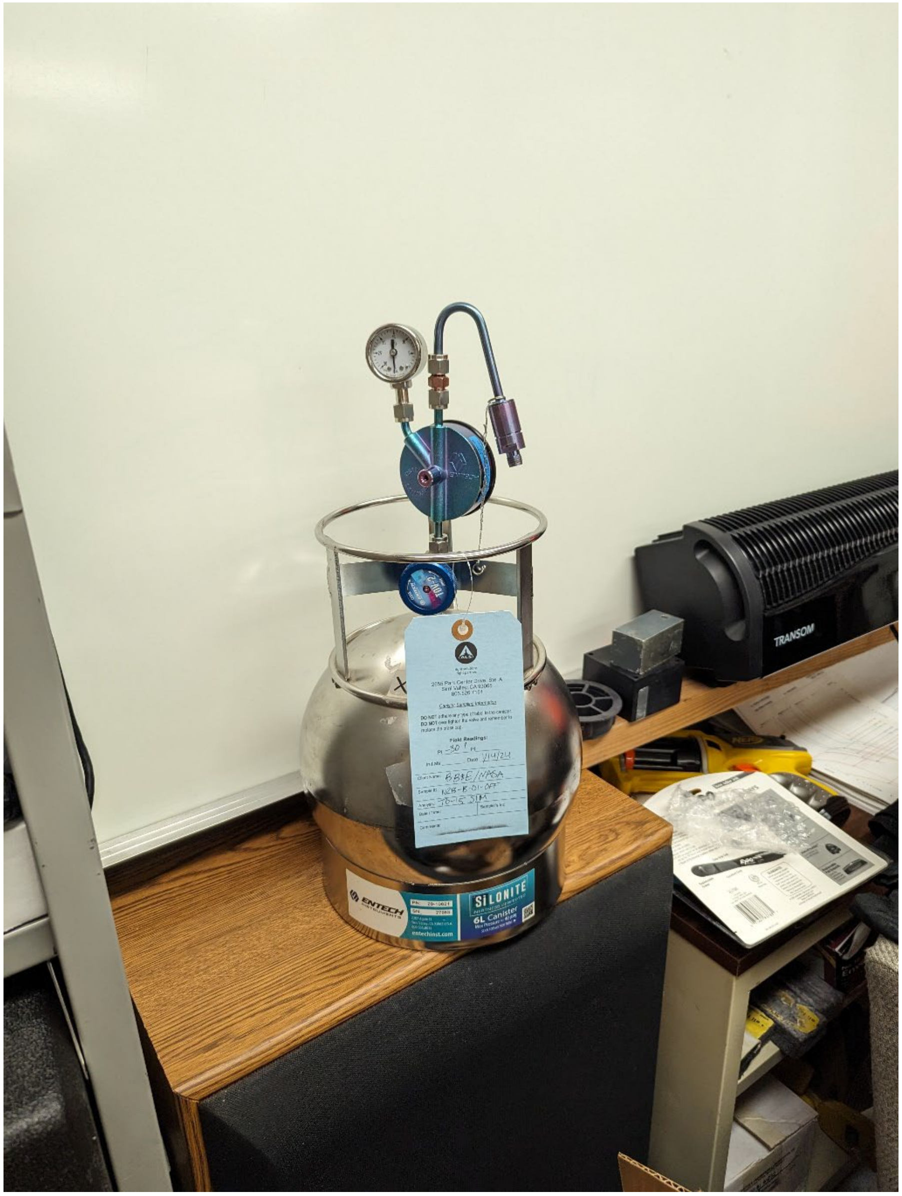
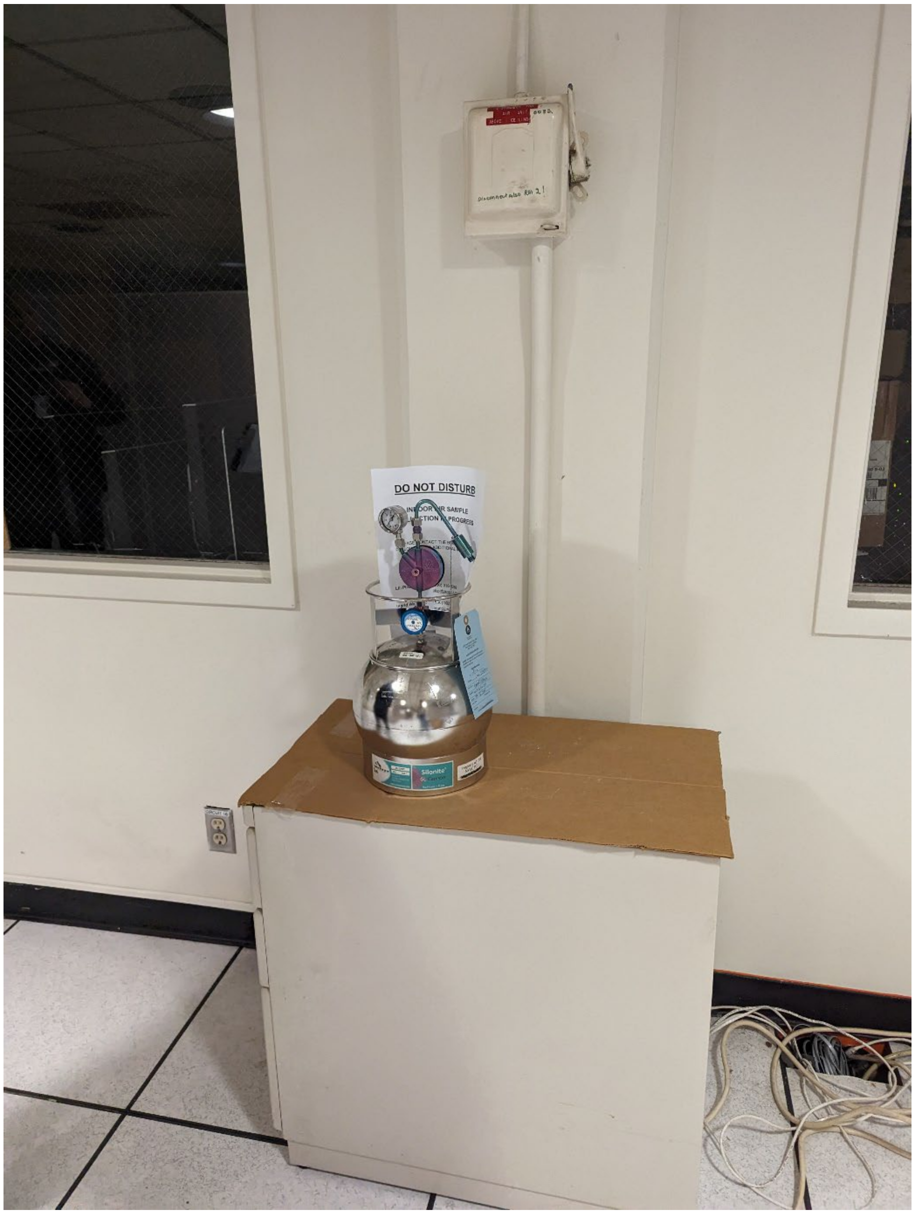


Figure 3: Vapor Intrusion Areas of Responsibility & Building Location Map

Photographs of Sampling Locations



N213-B-01-OFF
Building N213, Room 025
January 14, 2024



N213-B-02-OFF
Building N213, Room 004
January 14, 2024

N213-B-04-OFF
Building N213, Room N042
January 14, 2024

N213-B-05-OFF
Building N213, Room N002
January 14, 2024

N213-B-08-OFF & N213-B-08-OFFD
Building N213, V001 Elevator Vault
January 14, 2024

N213-1-02-OFF
Building N213, Room 104
January 14, 2024

N213-1-03-OFF
Building N213, Room 103
January 14, 2024

N213-1-04-OFF & N213-1-04-OFFD
Building N213, C103 Hallway
January 14, 2024

N213-01-06-OFF
Courtyard N213
January 14, 2024

N240-1-01-OFF
Building N240, C101 Hallway
January 14, 2024

N240-1-02-OFF
Building N240, Room 113
January 14, 2024

N240-1-03-OFF
Building N240, Room 144
January 14, 2024

N240-04-OFF
Building N240, E102 Elevator Vault
January 14, 2024

N258-1-01-OFF
Background located south of N258
January 14, 2024

Table 1: NASA Ames Research Center Land Use Controls
NASA Ames Research Center, Moffett Field, California

Site	Description	Basis for LUCs	NASA Ames LUCs
Former NAS Moffett Field Area of MEW Regional Plume Vapor Intrusion Study Area	Former NAS Moffett Field Area of MEW Regional Plume Vapor Intrusion Study Area. (2010 MEW Vapor Intrusion ROD Amendment)	Prevent exposure to volatile organic compounds in indoor air	1. Incorporate requirements for vapor intrusion engineering controls in future construction (or modifications to existing buildings) in permitting and building design processes. 2. Establish Recorded Agreements to ensure installation and operation of vapor intrusion engineering controls. 3. Provide information on vapor intrusion to future owners. 4. Provide information regarding building and occupancy changes to EPA.

Five-Year Review Form
NASA Land Use Controls

I. SITE INFORMATION	
Site name: Land Use Controls	**Date of inspection: Quarter 1, 2024**
Location and Region: NASA Ames Research Center	**EPA ID: CA1800005034, CA21700900078**
Agency, office, or company leading the five-year review: BB&E	**Weather/temperature: N/A**

Remedy Includes: (Check all that apply)

☐ Landfill cover/containment
■ Access controls
■ Institutional controls
☐ Groundwater pump and treatment
☐ Surface water collection and treatment
☐ Monitored natural attenuation
☐ Groundwater containment
☐ Vertical barrier walls
■ Other Specific remedies associated with each site are discussed in the individual site Inspection Forms. This inspection focused solely on the LUC inspection process and reporting requirements.

Attachments: ☐ Inspection team roster attached ■ Site map attached

II. INTERVIEWS (Check all that apply)

1. **O&M site manager** Brian Reddig | Restoration Group Manager | 4/12/24
Name | Title | Date
Interviewed ■ at site ☐ at office ☐ by phone Phone no. (650) 604-1315
Problems, suggestions; ☐ Report attached ______

2. **O&M staff** ______ ______ ______
Name | Title | Date
Interviewed ☐ at site ☐ at office ☐ by phone Phone no. ______
Problems, suggestions; ☐ Report attached ______

3. **Local regulatory authorities and response agencies** (i.e., State and Tribal offices, emergency response office, police department, office of public health or environmental health, zoning office, recorder of deeds, or other city and county offices, etc.) Fill in all that apply.

Agency US EPA
Contact Alana Lee | Program Manager | 1/10/24 | (415) 972-3141
Name | Title | Date | Phone no.
Problems; suggestions; ■ Report attached *

Agency US EPA
Contact Yvonne Fong | Program Manager | 1/10/24 | (415) 947-4117
Name | Title | Date | Phone no.
Problems; suggestions; ■ Report attached *

Agency US EPA
Contact Lucrina Jones | Program Manager | NA | (415) 972-3006
Name | Title | Date | Phone no.
Problems; suggestions; ☐ Report attached *

Agency CA Regional Water Board-SF
Contact Dana McCarthy | Program Manager | 2/13/24 | (510) 622-2371
Name | Title | Date | Phone no.
Problems; suggestions; ■ Report attached *

4. **Other interviews** (optional).

*Interviews provided in Appendix B of the Five Year Review Report.

III. ON-SITE DOCUMENTS & RECORDS VERIFIED (Check all that apply)

1. O&M Documents

■ O&M manual	☐ Readily available	☐ Up to date	☐ N/A
☐ As-built drawings	☐ Readily available	☐ Up to date	■ N/A
☐ Maintenance logs	☐ Readily available	☐ Up to date	■ N/A

Remarks Document verified on JQ Server. LUC Implementation and Monitoring Plan was updated in June 2023.

2. Site-Specific Health and Safety Plan ■ Readily available ■ Up to date ☐ N/A

☐ Contingency plan/emergency response plan ☐ Readily available ☐ Up to date ■ N/A

Remarks Document verified on JQ Server. 2023 BB&E Project Safety Plan.

3. O&M and OSHA Training Records ■ Readily available ■ Up to date ☐ N/A

Remarks Documents verified on JQ Server.

4. Permits and Service Agreements

☐ Air discharge permit	☐ Readily available	☐ Up to date	■ N/A
☐ Effluent discharge	☐ Readily available	☐ Up to date	■ N/A
☐ Waste disposal, POTW	☐ Readily available	☐ Up to date	■ N/A
☐ Other permits______	☐ Readily available	☐ Up to date	■ N/A

Remarks

5. Gas Generation Records ☐ Readily available ☐ Up to date ■ N/A

Remarks

6. Settlement Monument Records ☐ Readily available ☐ Up to date ■ N/A

Remarks

7. Groundwater Monitoring Records ☐ Readily available ☐ Up to date ■ N/A

Remarks

8. Leachate Extraction Records ☐ Readily available ☐ Up to date ■ N/A

Remarks

9. Discharge Compliance Records

☐ Air	☐ Readily available	☐ Up to date	■ N/A
☐ Water (effluent)	☐ Readily available	☐ Up to date	■ N/A

Remarks

10. Daily Access/Security Logs ☐ Readily available ☐ Up to date ■ N/A

Remarks

Five-Year Review Form
NASA Land Use Controls

IV. O&M COSTS

1. O&M Organization

☐ State in-house ☐ Contractor for State
☐ PRP in-house ☐ Contractor for PRP
☐ Federal Facility in-house ■ Contractor for Federal Facility
☐ Other ____________________

2. O&M Cost Records

■ Readily available ■ Up to date
☐ Funding mechanism/agreement in place
Original O&M cost estimate ____________ ☐ Breakdown attached

Total annual cost by year for review period if available

	Date		Date	Total cost	
From	1/1/19	To	12/31/19	$20,021	☐ Breakdown attached
From	1/1/20	To	12/31/20	$31,539	☐ Breakdown attached
From	1/1/21	To	12/31/21	$35,870	☐ Breakdown attached
From	1/1/22	To	12/31/22	$43,398	☐ Breakdown attached
From	1/1/23	To	12/31/23	$41,171	☐ Breakdown attached

3. Unanticipated or Unusually High O&M Costs During Review Period

Describe costs and reasons: ____________________

V. ACCESS AND INSTITUTIONAL CONTROLS ☐ Applicable ☐ N/A

A. Fencing

1. **Fencing damaged** ☐ Location shown on site map ■ Gates secured ■ N/A
Remarks Site 1, Site 29 (Hangar 1), and portions of Site 26 have specific fencing and access restrictions.

B. Other Access Restrictions

1. **Signs and other security measures** ☐ Location shown on site map ■ N/A
Remarks Site 1, Site 29, and portions of Site 26 have specific access restrictions other than routine entry requirements to NASA property.

C. Institutional Controls (ICs)

1. **Implementation and enforcement**

Site conditions imply ICs not properly implemented ☐ Yes ■ No ☐ N/A
Site conditions imply ICs not being fully enforced ☐ Yes ■ No ☐ N/A

Type of monitoring (*e.g.*, self-reporting, drive by) Site walks, drive bys
Frequency Quarterly
Responsible party/agency NASA/BB&E and ERT
Contact Brian Reddig — Restoration Group Manager — (650) 604-1315
Name — Title — Phone no.

Reporting is up-to-date ■ Yes ☐ No ☐ N/A
Reports are verified by the lead agency ■ Yes ☐ No ☐ N/A

Specific requirements in deed or decision documents have been met ■ Yes ☐ No ☐ N/A
Violations have been reported ☐ Yes ☐ No ■ N/A
Other problems or suggestions: ☐ Report attached

2. **Adequacy** ■ ICs are adequate ☐ ICs are inadequate ☐ N/A
Remarks The ICs that are addressed under the LUC Program supplement additional O&M requirements associated with each site.

D. General

1. **Vandalism/trespassing** ☐ Location shown on site map ■ No vandalism evident
Remarks

2. **Land use changes on site** ☐ N/A
Remarks None that impact the LUCs.

3. **Land use changes off site** ☐ N/A
Remarks None that impact the LUCs.

VI. GENERAL SITE CONDITIONS

A. Roads ☐ Applicable ☐ N/A

1. **Roads damaged** ☐ Location shown on site map ■ Roads adequate ☐ N/A
Remarks

B. Other Site Conditions	
	Remarks ____
VII. LANDFILL COVERS ☐ Applicable ■ N/A (refer to Sites 1 & 22 Reports)	
A. Landfill Surface	
1.	**Settlement** (Low spots) ☐ Location shown on site map ☐ Settlement not evident Areal extent______________ Depth____________ Remarks____
2.	**Cracks** ☐ Location shown on site map ☐ Cracking not evident Lengths____________ Widths___________ Depths__________ Remarks____
3.	**Erosion** ☐ Location shown on site map ☐ Erosion not evident Areal extent______________ Depth____________ Remarks____
4.	**Holes** ☐ Location shown on site map ☐ Holes not evident Areal extent______________ Depth____________ Remarks____
5.	**Vegetative Cover** ☐ Grass ☐ Cover properly established ☐ No signs of stress ☐ Trees/Shrubs (indicate size and locations on a diagram) Remarks____
6.	**Alternative Cover (armored rock, concrete, etc.)** ☐ N/A Remarks____
7.	**Bulges** ☐ Location shown on site map ☐ Bulges not evident Areal extent______________ Height____________ Remarks____

8. **Wet Areas/Water Damage** ☐ Wet areas/water damage not evident
☐ Wet areas ☐ Location shown on site map Areal extent______________
☐ Ponding ☐ Location shown on site map Areal extent______________
☐ Seeps ☐ Location shown on site map Areal extent______________
☐ Soft subgrade ☐ Location shown on site map Areal extent______________
Remarks____
____

9. **Slope Instability** ☐ Slides ☐ Location shown on site map ☐ No evidence of slope instability
Areal extent______________
Remarks____
____

B. Benches ☐ Applicable ■ N/A
(Horizontally constructed mounds of earth placed across a steep landfill side slope to interrupt the slope in order to slow down the velocity of surface runoff and intercept and convey the runoff to a lined channel.)

1. **Flows Bypass Bench** ☐ Location shown on site map ☐ N/A or okay
Remarks____
____

2. **Bench Breached** ☐ Location shown on site map ☐ N/A or okay
Remarks____
____

3. **Bench Overtopped** ☐ Location shown on site map ☐ N/A or okay
Remarks____
____

C. Letdown Channels ☐ Applicable ■ N/A
(Channel lined with erosion control mats, riprap, grout bags, or gabions that descend down the steep side slope of the cover and will allow the runoff water collected by the benches to move off of the landfill cover without creating erosion gullies.)

1. **Settlement** ☐ Location shown on site map ☐ No evidence of settlement
Areal extent______________ Depth____________
Remarks____
____

2. **Material Degradation** ☐ Location shown on site map ☐ No evidence of degradation
Material type_______________ Areal extent_____________
Remarks____
____

3. **Erosion** ☐ Location shown on site map ☐ No evidence of erosion
Areal extent______________ Depth____________
Remarks____
____

4.	**Undercutting** ☐ Location shown on site map ☐ No evidence of undercutting Areal extent______________ Depth____________ Remarks____	
5.	**Obstructions** Type____________________ ☐ No obstructions ☐ Location shown on site map Areal extent______________ Size____________ Remarks____	
6.	**Excessive Vegetative Growth** Type____________________ ☐ No evidence of excessive growth ☐ Vegetation in channels does not obstruct flow ☐ Location shown on site map Areal extent______________ Remarks____	
D. Cover Penetrations	☐ Applicable ■ N/A	
1.	**Gas Vents** ☐ Active ☐ Passive ☐ Properly secured/locked ☐ Functioning ☐ Routinely sampled ☐ Good condition ☐ Evidence of leakage at penetration ☐ Needs Maintenance ☐ N/A Remarks____	
2.	**Gas Monitoring Probes** ☐ Properly secured/locked ☐ Functioning ☐ Routinely sampled ☐ Good condition ☐ Evidence of leakage at penetration ☐ Needs Maintenance ☐ N/A Remarks____	
3.	**Monitoring Wells** (within surface area of landfill) ☐ Properly secured/locked ☐ Functioning ☐ Routinely sampled ☐ Good condition ☐ Evidence of leakage at penetration ☐ Needs Maintenance ☐ N/A Remarks____	
4.	**Leachate Extraction Wells** ☐ Properly secured/locked ☐ Functioning ☐ Routinely sampled ☐ Good condition ☐ Evidence of leakage at penetration ☐ Needs Maintenance ☐ N/A Remarks____	
5.	**Settlement Monuments** ☐ Located ☐ Routinely surveyed ☐ N/A Remarks____	

E. Gas Collection and Treatment ☐ Applicable ■ N/A

1. Gas Treatment Facilities
☐ Flaring ☐ Thermal destruction ☐ Collection for reuse
☐ Good condition ☐ Needs Maintenance
Remarks____
____

2. **Gas Collection Wells, Manifolds and Piping**
☐ Good condition ☐ Needs Maintenance
Remarks____
____

3. **Gas Monitoring Facilities** (*e.g.*, gas monitoring of adjacent homes or buildings)
☐ Good condition☐ Needs Maintenance ☐ N/A
Remarks____
____

F. Cover Drainage Layer ☐ Applicable ■ N/A

1. **Outlet Pipes Inspected** ☐ Functioning ☐ N/A
Remarks____
____

2. **Outlet Rock Inspected** ☐ Functioning ☐ N/A
Remarks____
____

G. Detention/Sedimentation Ponds ☐ Applicable ■ N/A

1. **Siltation** Areal extent______________ Depth____________ ☐ N/A
☐ Siltation not evident
Remarks____
____

2. **Erosion** Areal extent______________Depth______________
☐ Erosion not evident
Remarks____
____

3. **Outlet Works** ☐ Functioning ☐ N/A
Remarks____
____

4. **Dam** ☐ Functioning ☐ N/A
Remarks____
____

H. Retaining Walls ☐ Applicable ■ N/A

1. **Deformations** ☐ Location shown on site map ☐ Deformation not evident
Horizontal displacement______________ Vertical displacement________________
Rotational displacement______________
Remarks____
____

2. **Degradation** ☐ Location shown on site map ☐ Degradation not evident
Remarks____
____

I. Perimeter Ditches/Off-Site Discharge ☐ Applicable ■ N/A

1. **Siltation** ☐ Location shown on site map ☐ Siltation not evident
Areal extent_______________ Depth_____________
Remarks____
____

2. **Vegetative Growth** ☐ Location shown on site map ☐ N/A
☐ Vegetation does not impede flow
Areal extent_______________ Type_____________
Remarks____
____

3. **Erosion** ☐ Location shown on site map ☐ Erosion not evident
Areal extent_______________ Depth_____________
Remarks____
____

4. **Discharge Structure** ☐ Functioning ☐ N/A
Remarks____
____

VIII. VERTICAL BARRIER WALLS ☐ Applicable ■ N/A

1. **Settlement** ☐ Location shown on site map ☐ Settlement not evident
Areal extent_______________ Depth_____________
Remarks____
____

2. **Performance Monitoring** Type of monitoring____________________________
☐ Performance not monitored
Frequency_________________________________ ☐ Evidence of breaching
Head differential____________________________
Remarks____
____

IX. GROUNDWATER/SURFACE WATER REMEDIES ☐ Applicable ■ N/A (refer to individual inspection reports)

A. Groundwater Extraction Wells, Pumps, and Pipelines ☐ Applicable ■ N/A

1. **Pumps, Wellhead Plumbing, and Electrical**
☐ Good condition ☐ All required wells properly operating ☐ Needs Maintenance ☐ N/A
Remarks____

2. **Extraction System Pipelines, Valves, Valve Boxes, and Other Appurtenances**
☐ Good condition ☐ Needs Maintenance
Remarks____

3. **Spare Parts and Equipment**
☐ Readily available ☐ Good condition ☐ Requires upgrade ☐ Needs to be provided
Remarks____

B. Surface Water Collection Structures, Pumps, and Pipelines ☐ Applicable ■ N/A

1. **Collection Structures, Pumps, and Electrical**
☐ Good condition ☐ Needs Maintenance
Remarks____

2. **Surface Water Collection System Pipelines, Valves, Valve Boxes, and Other Appurtenances**
☐ Good condition ☐ Needs Maintenance
Remarks____

3. **Spare Parts and Equipment**
☐ Readily available ☐ Good condition ☐ Requires upgrade ☐ Needs to be provided
Remarks____

C. Treatment System	☐ Applicable ■ N/A (refer to NASA RGRP inspection report)	
1.	**Treatment Train** (Check components that apply) ☐ Metals removal ☐ Oil/water separation ☐ Bioremediation ☐ Air stripping ☐ Carbon adsorbers ☐ Filters__________ ☐ Additive (*e.g.*, chelation agent, flocculent)__________ ☐ Others__________ ☐ Good condition ☐ Needs Maintenance ☐ Sampling ports properly marked and functional ☐ Sampling/maintenance log displayed and up to date ☐ Equipment properly identified ☐ Quantity of groundwater treated annually__________ ☐ Quantity of surface water treated annually__________ Remarks__________	
2.	**Electrical Enclosures and Panels** (properly rated and functional) ☐ N/A ☐ Good condition ☐ Needs Maintenance Remarks__________	
3.	**Tanks, Vaults, Storage Vessels** ☐ N/A ☐ Good condition ☐ Proper secondary containment ☐ Needs Maintenance Remarks__________	
4.	**Discharge Structure and Appurtenances** ☐ N/A ☐ Good condition ☐ Needs Maintenance Remarks__________	
5.	**Treatment Building(s)** ☐ N/A ☐ Good condition (esp. roof and doorways) ☐ Needs repair ☐ Chemicals and equipment properly stored Remarks__________	
6.	**Monitoring Wells** (pump and treatment remedy) ☐ Properly secured/locked ☐ Functioning ☐ Routinely sampled ☐ Good condition ☐ All required wells located ☐ Needs Maintenance ☐ N/A Remarks__________	
D. Monitoring Data		
1.	Monitoring Data ☐ Is routinely submitted on time ☐ Is of acceptable quality	
2.	Monitoring data suggests: ☐ Groundwater plume is effectively contained ☐ Contaminant concentrations are declining	

D. Monitored Natural Attenuation

1. **Monitoring Wells** (natural attenuation remedy)
☐ Properly secured/locked ☐ Functioning ☐ Routinely sampled ☐ Good condition
☐ All required wells located ☐ Needs Maintenance ☐ N/A
Remarks____

X. OTHER REMEDIES

If there are remedies applied at the site which are not covered above, attach an inspection sheet describing the physical nature and condition of any facility associated with the remedy. An example would be soil vapor extraction.

XI. OVERALL OBSERVATIONS

A. Implementation of the Remedy

Describe issues and observations relating to whether the remedy is effective and functioning as designed. Begin with a brief statement of what the remedy is to accomplish (i.e., to contain contaminant plume, minimize infiltration and gas emission, etc.).

The LUCs for each covered site is provided in the attached LUC Table 1. Most of the sites include LUCs that prohibit development and domestic groundwater use. Where development is conditionally allowed, pre-construction review of project details is required before the issuance of NASA Construction Permits. Some LUCs require the long-term management of Institutional Controls and establishing LUC requirements in current and prospective lease agreements.

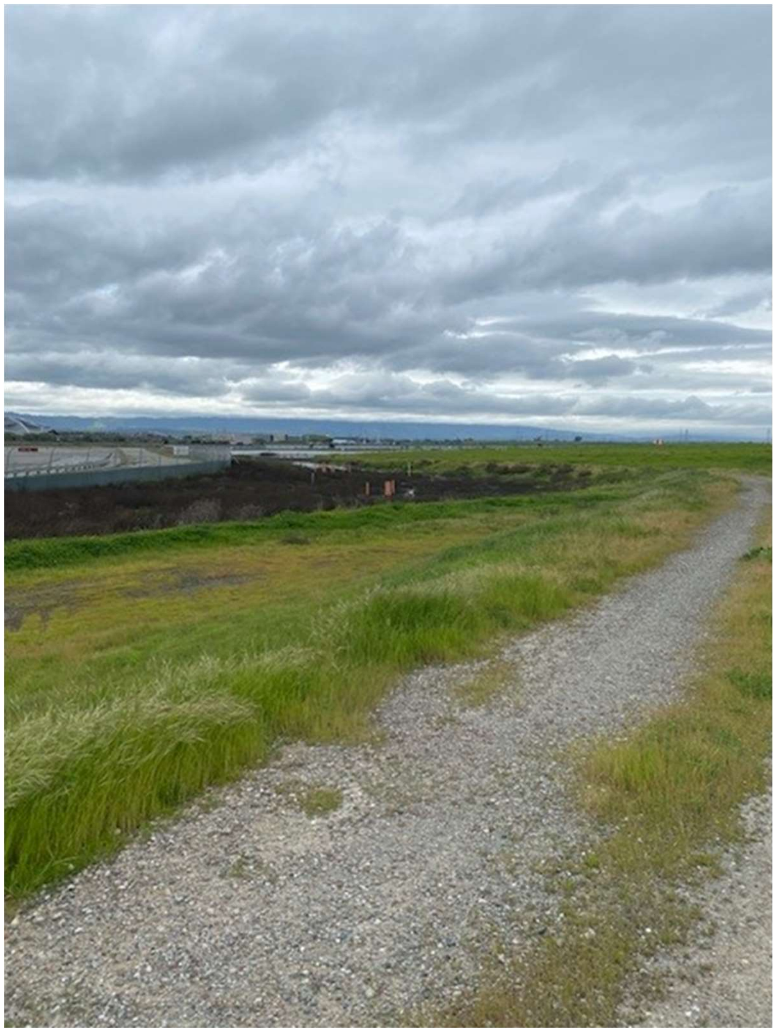
B. Adequacy of O&M

Describe issues and observations related to the implementation and scope of O&M procedures. In particular, discuss their relationship to the current and long-term protectiveness of the remedy.

In conjunction with the applicable ROD, FFA, and O&M requirements applicable to the individual sites, the LUCs provide adequate short-term and long-term protection of the remedy.

C.	**Early Indicators of Potential Remedy Problems**
	Describe issues and observations such as unexpected changes in the cost or scope of O&M or a high frequency of unscheduled repairs, that suggest that the protectiveness of the remedy may be compromised in the future. Redevelopment across the site provides the greatest risk to the protectiveness of the remedy. NASA currently utilizes a construction permit review process to identify environmental impacts to NASA construction projects. However, it appears that some construction/redevelopment activities conducted by other parties (tenants, resident agencies, etc.) receive somewhat abridged review. NASA will need to ensure that it continues to maintain visibility of those types of construction activities.
D.	**Opportunities for Optimization**
	Describe possible opportunities for optimization in monitoring tasks or the operation of the remedy. There are currently no "Environmental Permit Requirements" to address vapor intrusion issues under NASA's Construction Permit Review process. These VI requirements should be developed for use during construction permit reviews. In addition, LUC informational materials should be developed and distributed to NASA construction manager and project proponents to ensure LUC restrictions are considered from the earliest stages of construction/redevelopment planning.

LAND USE CONTROL AREA PHOTOGRAPHS



Site 1

Site 1

Site 1

Site 1

Site1

Site 1

Site 1

Site 1

Site 22

Site 22

Site 22

Site 22

Site 22

Sites 1 & 22
Building 191 Pump Station

Sites 1 & 22
Building 191 Pump Staton

Site 26
PV Bus Yard and Hangar 3 (looking west)

Site 26
Hangar 3 (nearest) and PV Bus Yard (looking west)

Site 26
Hangar 3 and PV Bus Yard (looking north)

Site 26
Moffett Golf Course Driving Range (looking north)

Site 26
Moffett Golf Course (looking north)

Hangar 1
South End

Hangar 1
Mid-West Section

Hangar 1
North End

Hangar 1
Navy Traffic Island Area in Foreground

Hangar 1
WATS to the West (right side of photo)

Site 14 South

Site 14 South

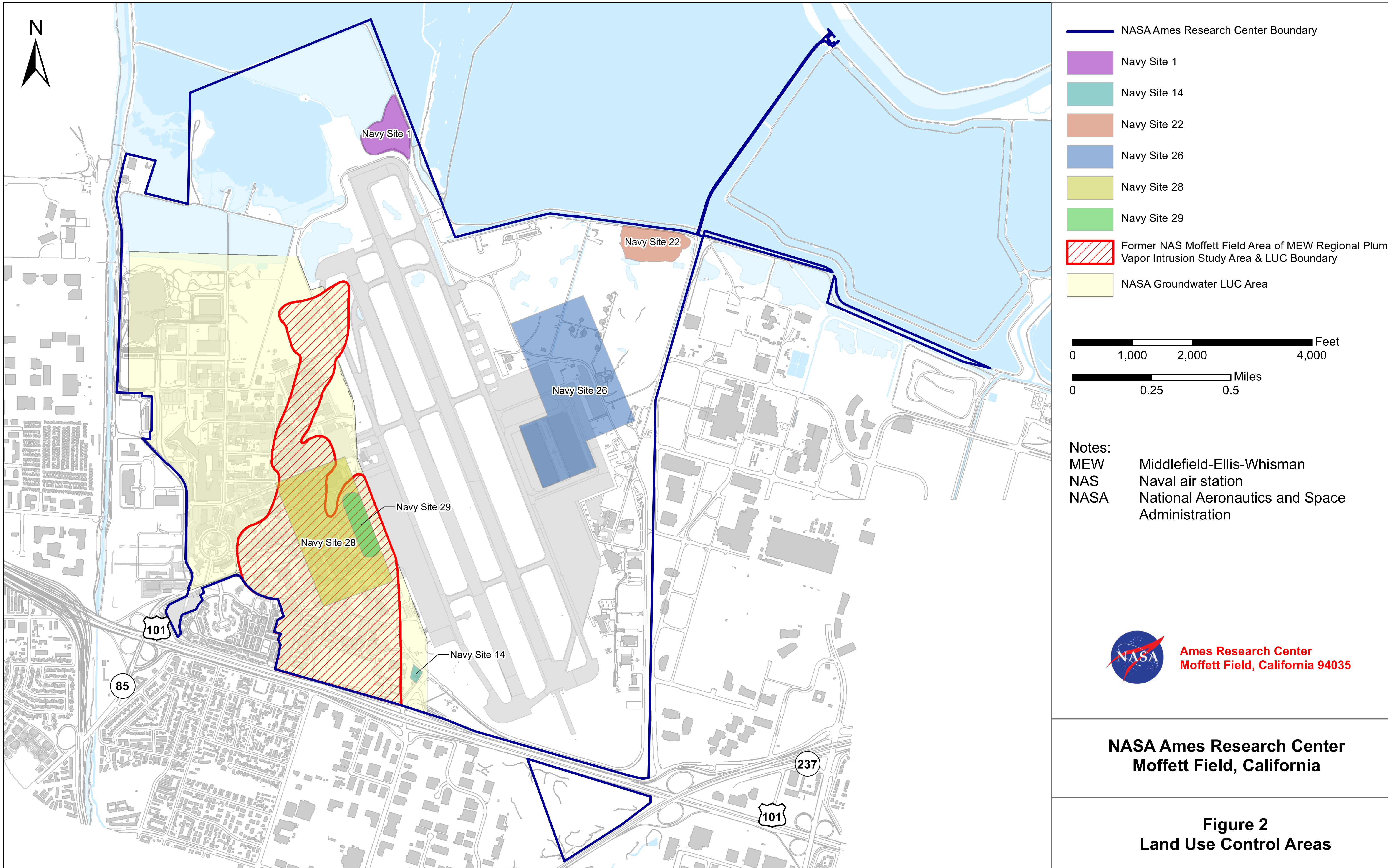
Site 14 South

Site 14 South

NASA VI LUC Area (Navy VI AOR)
Navy VI Remedy – Building 45

NASA VI LUC Area (Navy VI AOR)
Navy VI Remedy – Building 126

NASA VI LUC Area (Navy VI AOR)
Navy VI Remedy – Building 10



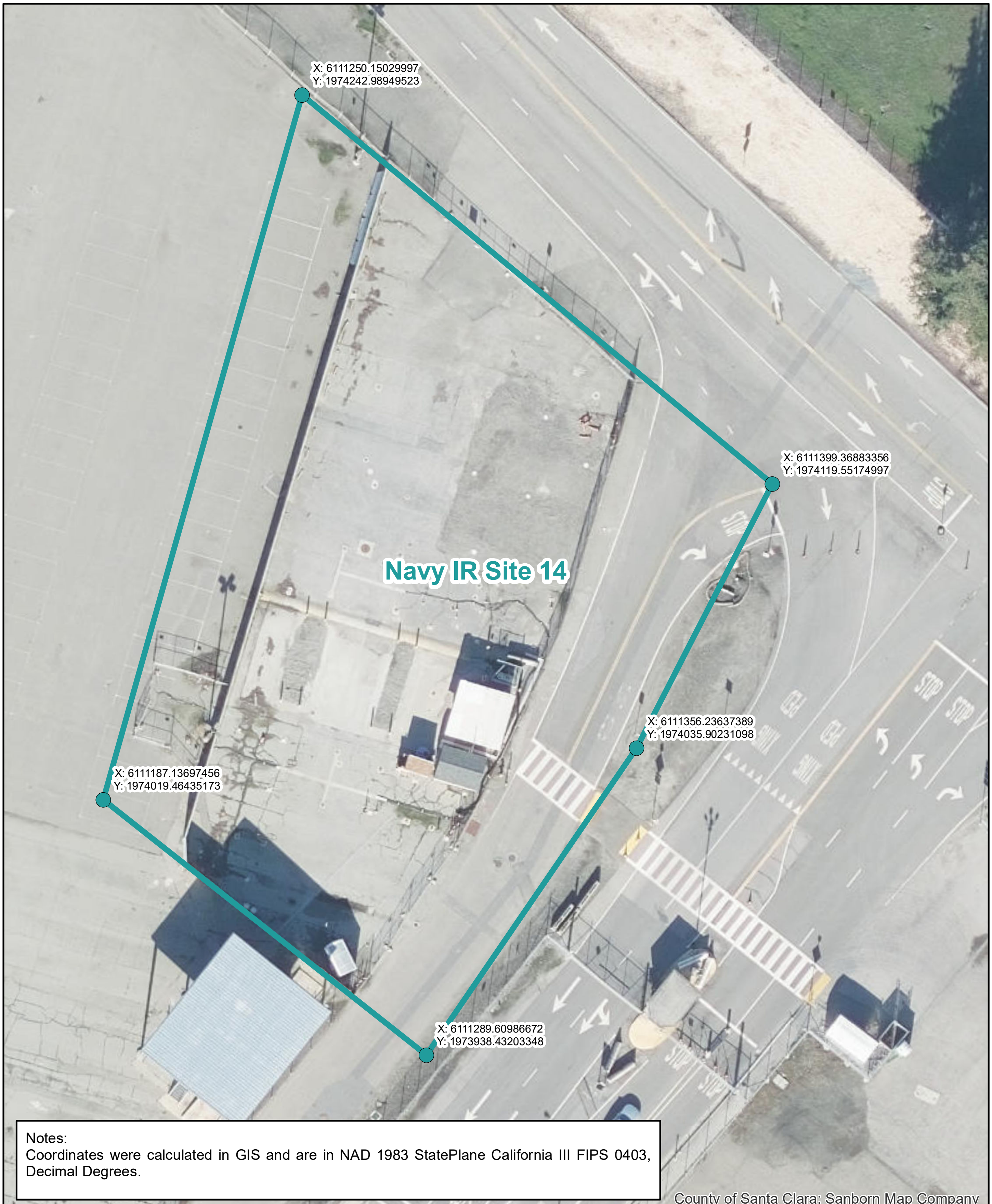
NASA Ames Research Center
Moffett Field, California

Figure 2
Land Use Control Areas

Notes:
Coordinates were calculated in GIS and are in NAD 1983 StatePlane California III FIPS 0403, Decimal Degrees.

Ames Research Center
Moffett Field, CA 94035

Figure 3
Land Use Control Boundary
Navy Site 1 Landfill



Notes:
Coordinates were calculated in GIS and are in NAD 1983 StatePlane California III FIPS 0403, Decimal Degrees.

Ames Research Center
Moffett Field, CA 94035

Figure 4
Land Use Control Boundary
Navy IR Site 14

Navy Site 14

0 12.5 25 50 Feet

N

Notes:
Coordinates were calculated in GIS and are in NAD 1983 StatePlane California III FIPS 0403, Decimal Degrees.

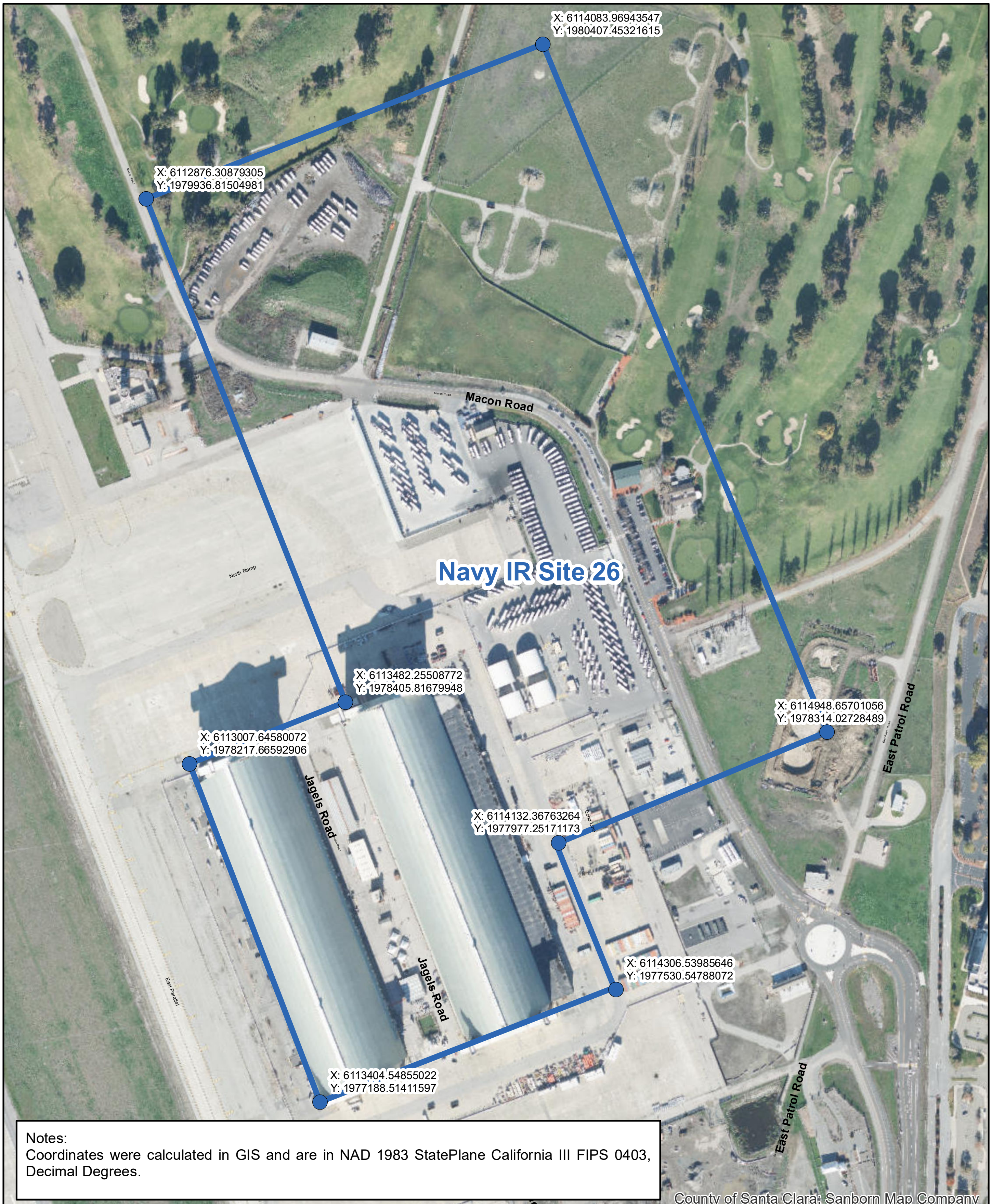
Ames Research Center
Moffett Field, CA 94035

Figure 5
Land Use Control Boundary
Navy IR Site 22 Landfill

Navy Site 22

0 60 120 240 Feet

N



Notes:
Coordinates were calculated in GIS and are in NAD 1983 StatePlane California III FIPS 0403, Decimal Degrees.

Ames Research Center
Moffett Field, CA 94035

Figure 6
Land Use Control Boundary
Navy IR Site 26

Navy Site 26

0 125 250 500 Feet

N

Notes:
Coordinates were calculated in GIS and are in NAD 1983 StatePlane California III FIPS 0403, Decimal Degrees.

Ames Research Center
Moffett Field, CA 94035

Figure 7
Land Use Control Boundary
Navy IR Site 28

Navy Site 28

0 100 200 400 Feet

N

Notes:
Coordinates were calculated in GIS and are in NAD 1983 StatePlane California III FIPS 0403, Decimal Degrees.

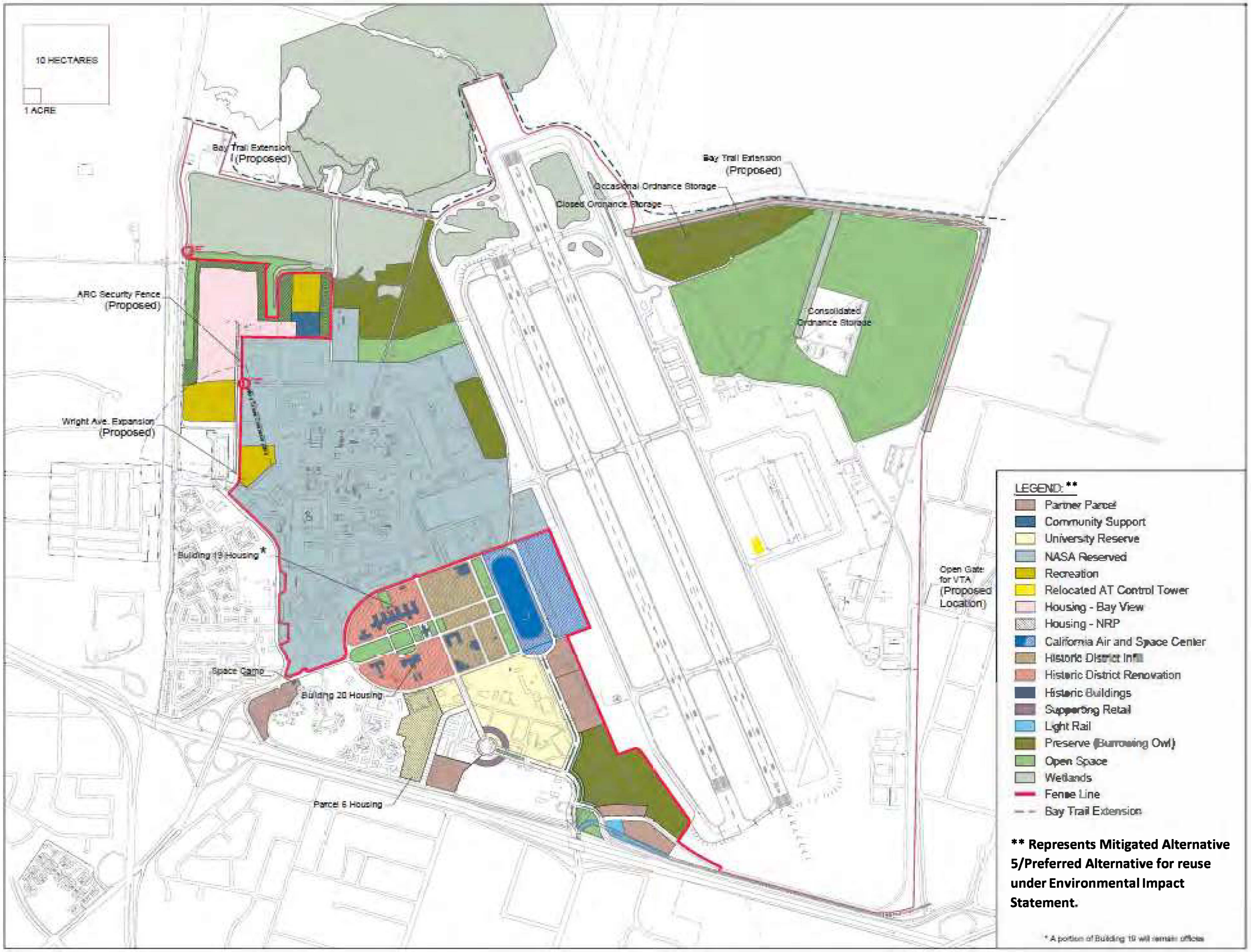
Ames Research Center
Moffett Field, CA 94035

Figure 8
Land Use Control Boundary
Navy IR Site 29

Navy Site 29

0 50 100 200 Feet

N



Ames Research Center
Moffett Field, CA 94035

Figure 9

NASA Ames Research Center Land Use

Source: Design, Community & Environment, 2002

Table 1: NASA Ames Research Center Land Use Controls
NASA Ames Research Center, Moffett Field, California

Site	Description	Basis for LUCs	NASA Ames LUCs
Navy Site 1 Landfill	Landfill cap vegetative cover, biotic barrier and low permeability layer, gas venting trench, landfill gas and groundwater monitoring system. (1997 Navy OU1 ROD)	Prevent exposure to waste and domestic use of groundwater	1. Prohibit landfill cap disturbance. 2. Maintain fencing and signage. 3. Operate and maintain Building 191 pump station and drainage system. 4. Restrict domestic groundwater use.
Navy Site 14 South	Former Navy fuel station. USTs and associated piping removed, and soil and groundwater remediation completed. NFA issued for the site in 2022.	Prevent exposure to contaminated soil and groundwater and prevent vapor intrusion.	1. No residential land use: The site cannot support residential use due to potentially unacceptable vapor intrusion from residual contamination in soil vapor and groundwater. 2. No grading, excavation, or subsurface activities without a risk management plan: Any work involving soil excavation, trenching, or groundwater contact must be conducted pursuant to a risk management plan that is acceptable to Regional Water Board staff. 3. No shallow groundwater use: Shallow groundwater beneath the site should not be used for drinking water or for landscaping or garden irrigation without further assessment due to the presence of diminishing residual contamination. 4. Real estate documents: Include Water Board's 15SEPT2022-letter conferring NFA status in all real estate disclosure, lease and transfer documents pertaining to this site.

Site	Description	Basis for LUCs	NASA Ames LUCs
Navy Site 22 Landfill	Landfill cap with vegetative cover and biotic barrier, landfill gas and groundwater monitoring system. (2002 Navy Site 22 Landfill ROD)	Prevent exposure to waste and domestic use of groundwater	1. Protect the structural aspects of the landfill cap (biotic barrier) by restricting activities that could potentially disturb the cap. 2. Maintain vegetation, topsoil layer, irrigation system, and drainage components, including surface contours, encompassed within and adjacent to the Site 22 remedy boundary. 3. Maintain and operate the Building 191 pump station. 4. Prohibit extraction of groundwater from Site 22. 5. Prohibit residential land use of the site and obtain regulatory approval for consideration of alternative land use. 6. Include a restrictive covenant in the deed for conveyance of any portion of the Site 22 landfill to include LUCs.
Navy Site 26 (OU 5)	Groundwater treatment by biostimulation/ bioaugmentation and monitored natural attenuation. (1996 Navy OU5 ROD and 2014 Navy Site 26 ROD Amendment)	Prevent domestic use of groundwater	1. Restrict domestic groundwater use. 2. Address vapor intrusion in new construction or modifications to existing structures.
Navy Site 28 WATS Area	Groundwater extraction, treatment and monitoring system.	Prevent domestic use of groundwater	NASA Ames implementation of domestic groundwater use restrictions.

Site	Description	Basis for LUCs	NASA Ames LUCs
Navy Site 29 Hangar 1	Navy removal action conducted in 2013 consisting of siding removal, soil excavation, storm drain sediment removal, and frame coating application. (2013 Navy Long-Term Management Plan; 2013 Navy Proposed Plan)	Prevent exposure to underlying paint on the Hangar 1 structure	1. Protect the remedy through restrictions on site access, activities and use, including site development or modifications to the Hangar 1 structure. 2. Incorporate LUCs into all current and prospective lease agreements; 3. Ensure building inhabitants are notified of potential exposure hazards. 4. Address worker exposure hazards and require post-construction repairs over the coating for building modifications. 5. Provide a restrictive covenant in the deed for conveyance of any portion of the Hangar 1 site to include LUCs.
Former NAS Moffett Field Area of MEW Regional Plume	Former NAS Moffett Field Area of MEW Regional Plume and MEW Companies, Navy and NASA geographical groundwater areas of responsibility	Prevent domestic use of groundwater	NASA Ames implementation of domestic groundwater use restrictions.
Former NAS Moffett Field Area of MEW Regional Plume Vapor Intrusion Study Area	Former NAS Moffett Field Area of MEW Regional Plume Vapor Intrusion Study Area. (2010 MEW Vapor Intrusion ROD Amendment)	Prevent exposure to volatile organic compounds in indoor air	1. Incorporate requirements for vapor intrusion engineering controls in future construction (or modifications to existing buildings) in permitting and building design processes. 2. Establish Recorded Agreements to ensure installation and operation of vapor intrusion engineering controls. 3. Provide information on vapor intrusion to future owners. 4. Provide information regarding building and occupancy changes to EPA.

Appendix B

Interview Records

Ryan Clauzel with Anthony LaMarca (OB Sports/Planetary Ventures) - Site 22

Yvonne Fong (EPA) - Sites 1, 22, 26, and NASA LUCs

Nicole Jorgensen with Hunter Dang and AJ Shekton (County of Santa Clara Department of Environmental Health) - Sites 1 and 22

Alana Lee (EPA) - RGRP, NASA LUCs

Jeff Linder (BB&E/ERT) - NASA RGRP

Dana McCarthy (CA Regional Water Board SF) - Sites 1, 22, 26, NASA RGRP, NASA VI AOR, and NASA LUCs

Luke Metz (BB&E/ERT) - Site 1 and 22

Lili Pirbazari (NASA ARC-JQ) - NASA VI AOR and NASA LUCs

Debra Varty (NASA ARC-JQ) - NASA VI AOR and NASA LUCs

Ingrid Warburg (NASAARC-JQ) - NASA RGRP, NASA VI AOR, and NASA LUCs

Five-Year Review Form

IR Site 22

NASA ARC Restoration

Name: Ryan Clauzel & Anthony LaMarca (Planetary Ventures, Sr. Dir. of PM; Ryan's boss)			
Title: Interim General Manager			
Organization: The Golf Club at Moffett Field			
Telephone Number: (650) 386-0720			
E-mail Address: rclauzel@moffettgolf.com>			
Address (Street, City, State, Zip Code): 934 Macon Road Moffett Field, CA 94035			
Date: Monday, January 29, 2024		**Time:** 1100 – 1131 PST	
Type of interview: Teleconference			
~~Telephone~~	~~Visit~~	**Other:** MS Teams	~~Describe Other:~~
Location of Visit: Virtual			
Relationship to Site: RPM (Remedial Project Manager)			
~~Political Official~~	~~Government Representative~~	~~Community Member~~	~~Community Group~~
~~Site Neighbor~~	~~Land Owner~~	**Tenant**	~~Stakeholder~~
Other **Describe Other:** IR Site 22			

1. What is your affiliation with Former NAS Moffett Field and oversight role of IR Site 22?

- *OB Sports is a service provider to NASA's tenant, Planetary Ventures LLC.*
- *Ryan is the interim General Manager with OB Sports. He and his staff monitor the site for animal burrows, burrows exhibiting waste or liner damage, standing water (regrade with gravel), repair any observed erosion, mitigation program with "Gopher X" (carbon monoxide sprayer) and fill and compact with clean sand.*

2. Have you or any of your colleagues conducted any site visits and/or inspections at IR Site 22? Yes ~~No~~ If "*Yes*", please give details:

At a minimum, weekly inspections by Ryan and daily by golf course staff with quarterly summary reporting via email.

Environmental responsibility for IR Site 22 remains with NASA even though OB Sports performs these inspections and maintenance.

3. Do you and/or your colleagues strive to follow NASA's land use restrictions regarding landscaping, course modifications, etc) at IR Site 22? Yes ~~No~~

If "*Yes*", please give details:

- *Not overwatering or performing intrusive work.*
- *May do repair(s) within tree box.*
- *Most irrigation system lines are $\leq$ 6 inches below ground surface (bgs) and stay within that depth.*
- *Use reclaimed water for all course irrigation needs.*

4. An important aspect of managing the golf course consistent with institutional controls (ICs) is "burrowing animal control". How is this IC performed regarding the inspection schedule, reporting requirements, and mitigation measures for controlling burrowing animals?

- *See #2; full/site-wide inspections performed weekly.*
- *Filling in low areas to regain proper sheet flow.*

5. Do you have any comments, suggestions, or recommendations regarding the site's management or operation?

- *Anthony noted:*
  - *"NASA does a great job of coordination with Lockheed Martin; such as pumping in advance of storm events, especially in North end of channel. That is a key factor that keeps the water levels under control to minimize localized flooding risks."*
  - *"NASA is open and receptive to constructive feedback when it comes to managing their storm drain pumping operations and making repairs to the pumps."*
- *Luke – "NASA will continue with open lines of communication in Ryan's new role."*
- *Garrett – "Golf Club" has been helpful with inspections and O&M."*

Interview Team: **Date:** Monday, Jan. 29, 2024 @ 1100 – 1131 PST

Name	Title	Affiliation
Garrett Turner	Restoration Program Manager	Environmental Management Division NASA Ames Research Center M/S 204-15
Brian Reddig Luke Metz	Restoration Group Lead ERT Restoration Team Member	BB&E – NASA Ames Research Center
Brent Jacobs Jonathan Grimes	Senior Technical Consultant Senior Geologist	BB&E – Atlanta, GA

Five-Year Review Form

IR Sites 1, 22, 26, and NASA Land Use Controls

NASA ARC Restoration

<table>
<tr><td colspan="4">Name: Yvonne Fong</td></tr>
<tr><td colspan="4">Title: EPA PM for Site 1, 22, 26, and NASA LUCs</td></tr>
<tr><td colspan="4">Organization: EPA Region 9 Superfund Division</td></tr>
<tr><td colspan="4">Telephone Number: 415-947-4117</td></tr>
<tr><td colspan="4">E-mail Address: Fong.YvonneW@epa.gov</td></tr>
<tr><td colspan="4">Address (Street, City, State, Zip Code):
75 Hawthorne St. (SFD-7-3), San Francisco, CA 94105</td></tr>
<tr><td colspan="2">Date: 2024-01-10</td><td colspan="2">Time: 1700-1749 EST</td></tr>
<tr><td colspan="4">Type of interview: Teleconference</td></tr>
<tr><td><s>Telephone</s></td><td><s>Visit</s></td><td>Other: MS Teams</td><td><s>Describe Other:</s></td></tr>
<tr><td colspan="4">Location of Visit: Virtual</td></tr>
<tr><td colspan="4">Relationship to Site: RPM (Remedial Project Manager)</td></tr>
<tr><td><s>Political Official</s></td><td>Government Representative</td><td><s>Community Member</s></td><td><s>Community Group</s></td></tr>
<tr><td><s>Site Neighbor</s></td><td><s>Land Owner</s></td><td><s>Tennant</s></td><td><s>Stakeholder</s></td></tr>
<tr><td colspan="4">Other Describe Other: IR Sites 1, 22, 26, and NASA Land Use Controls</td></tr>
<tr><td colspan="4">1. What is your affiliation with Former NAS Moffett Field and oversight role of IR Sites 1, 22, 26, and NASA LUCs?</td></tr>
<tr><td>Favorable</td><td><s>Neutral</s></td><td><s>Unfavorable</s></td><td><s>Unfamiliar</s></td></tr>
<tr><td colspan="4">Yvonne was the EPA Moffett PM, before Garrett was NASA RPM and worked mostly Site 26/EATS then later Sites 1 and 22. EPA oversight relationship with NASA is good and flexible as NASA is great about seeing that the work gets completed.</td></tr>
<tr><td colspan="4">2. Is NASA's Site 26 Long-Term Monitoring Program functioning as outlined in the Record of Decision (ROD [Navy, 1996]) Amendment (Navy, 2014)?"</td></tr>
<tr><td>Favorable</td><td><s>Neutral</s></td><td><s>Unfavorable</s></td><td><s>Unfamiliar</s></td></tr>
<tr><td colspan="4">Yes.
Is the Site meeting the requirements to move towards MNA as the final remedy as proposed by the Navy?
• Adjustments to be more effective have been good. NASA has met the requirements of the LTMP and recognized that, as the site matures there are opportunities to optimize the Program to adjust analytes included in testing while meeting the needs of the Program.
• LTM and ROD are functioning as intended at Hangars 2 and 3.
• Navy is doing FYR that is the trigger for transferring sites with an implemented remedy to NASA.
• NASA is only doing LTM documentation (future responsibilities dependent on outcome of Navy FYR)
• Hangar 3 is scheduled for demolition and passed SHPO requirements.
Are there additional actions that NASA should consider?
• No; agencies just interested in new data from the two, newly installed wells.</td></tr>
</table>

- *After Hangar 3 is demolished, the Navy and/or NASA should consider sub-slab sampling that was previously requested by the Agencies but unable to be conducted due to concerns that Hangar 3 is seismically unsound and unsafe to enter. This will provide better evidence about any possible sources under Hangar 3.*

3. Have you or any of your colleagues conducted any site visits and/or inspections at IR Sites 1, 22, and 26? ~~Yes~~ No

If "*Yes*", please give details:

- *Site-wide inspection was conducted by Yvonne Fong, Don Chuck, Alana Lee, and Elizabeth Wells in 2019 for MWs and Hangar 3 well location/siting for the Feb. 2020 installation.*

4. Have you or any of your colleagues conducted any LUC inspections at IR Sites 1, 22, and 26? ~~Yes~~ No

If "Yes", please give details:

- *EPA has relied on Santa Clara County inspection reports and NASA's construction permitting process.*

5. Please describe current efforts NASA is taking to implement permanent restrictions on land use and domestic groundwater use in NASA's land use planning and environmental resource documents, in accordance with the MOA for OU5 (Sites 1 and 26), signed in 1999, and the MOA for Site 22, signed in 2008.

- *NASA appears to be implementing deed restrictions.*
- *EPA does not have concerns, as these processes appear to be operating smoothly.*

Is NASA still planning to revise and incorporate institutional controls (ICs) into the Master Plan as previously indicated? Yes ~~No~~

6. In the 1999 MOA for Sites 1 and 22 (OU5), NASA agreed to, "*…maintain the Building 191 pump station and drain/subdrain system as long as NASA either owns the property or maintains operations control over the site.*" This restriction was to be recorded in NASA's revised Master Plan.

Is this still NASA's intent? Yes ~~No~~

If "No", then why not?

- *Notes that sea-level rise should be considered as noted in previous FYR.*

Please describe what efforts NASA is currently taking to implement this restriction.

- *NASA is looking at where PFAS is located onsite.*

7. Describe the effectiveness of the two pumps located in Building 191 pump station. In the past five years have these pumps been able to effectively regulate excessive storm surges?

- *Yes; satisfied with the effectiveness.*

Has extensive flooding occurred over the past five years such that the pumping capacity at Building 191 has proven inadequate?

- *No*

To what extent can the capacity be increased to offset rising sea levels in the event of an extreme storm?

- *Levees protect ARC.*
- *Garrett Turner notes that NASA is working with USACE as the lead and other Midpeninsula Regional Open Space District agencies on this issue.*
- *NASA is using low/med/high scenarios to estimate capacity increases.*

8. Is there a backup plan should the Building 191 pump station fail?

- *Yvonne Fong notes that she is not aware of a backup plan if the Building 191 pump station fails.*
- *Garrett Turner notes:*
  - *Three to four emergency pumps are in place that address the airfield (i.e., East Patrol Road, Marriage Road, and Gate 14 and 14A.*
  - *Standby pumps are located at Northern Channel.*
  - *These pumps are not environmental restoration requirements, only a component of facility maintenance.*

9. The pump station was constructed in the 1950s. In the past five years, how has NASA maintained and updated the pump station components.

- *EPA is not aware of any O&M needs or downtime.*
- *EPA notes that NASA is good at maintaining the pump station.*

When did the system update last occur?

- *None; just O&M.*

Describe the type of updates?

- *Design of low-flow system but not implemented.*

10. Do you have any comments, suggestions, or recommendations regarding the site's management or operation?

- *EPA has a solid track record with Garrett Turner managing the NASA environmental restoration program; he keeps agencies informed and forecasts emerging issues.*
- *There are good lines of communication between EPA and NASA.*
- *EPA recommends interviewees other than regulators; Garrett Turner notes that Alana Lee has already been interviewed as part of a broader FYR stakeholder outreach by NASA as noted in the previous FYR.*

Interview Team:			**Date:** 2024-01-10; 1700-1749 EST
Name	**Title**	**Affiliation/Organization**	
Garrett Turner	Restoration Program Manager	Environmental Management Division NASA Ames Research Center M/S 204-15	
Brian Reddig	Restoration Group Lead	BB&E – NASA Ames Research Center	
Jonathan Grimes	Senior Geologist	BB&E – Atlanta, GA	

Five-Year Review Form

IR Sites 1 and 22

NASA ARC Restoration

Name: Nicole Jorgensen (with Hunter Dang)			
Title: Senior REHS			
Organization: Solid Waste Program, Dept. of Env. Health (DEH), Santa Clara County			
Telephone Number: (408) 918-3492			
E-mail Address: nicole.jorgensen@deh.sccgov.org			
Address (Street, City, State, Zip Code): 1555 Berger Drive, Suite 300, San Jose, CA 95112			
Date: Wednesday, January 17, 2024		**Time:** 0930 - 0953 PST	
Type of interview: Teleconference			
~~Telephone~~	~~Visit~~	**Other:** MS Teams	~~Describe Other:~~
Location of Visit: Virtual			
Relationship to Site: RPM (Remedial Project Manager)			
~~Political Official~~	**Government Representative**	~~Community Member~~	~~Community Group~~
~~Site Neighbor~~	~~Landowner~~	~~Tennant~~	~~Stakeholder~~
Other **Describe Other:** IR Sites 1 and 22			
1. What is your affiliation/oversight role with Former NAS Moffett Field for IR Sites 1 and 22? *Santa Clara County Solid Waste Program Local Enforcement Agency conducts quarterly inspections of Sites 1 & 22 in accordance with county regulations and site post-closure care plan (PCCP).*			
2. Are NASA's Site 1 & Site 22 Operations, Maintenance, Monitoring, and Reporting Programs functioning as outlined in the Records of Decision (ROD [Navy, 1997 and Navy, 2002, respectively])? *NASA is meeting requirements and makes minor repairs immediately.* Is the Site meeting the requirements to move towards Monitored Natural Attenuation (MNA) as the final remedy as proposed by the Navy? Yes Is NASA's RGRP groundwater remedy performing as intended under the MEW ROD and ESD requirements? *Yes* Are there additional actions that NASA should consider? *Santa Clara County uses Sites 1 and 22 as an example/reference for PCCP of landfills.*			
3. Have you or any of your colleagues conducted any site visits and/or inspections at IR Sites 1 and 22? Yes ~~No~~ If "Yes", please give details: *The last inspection was November 8, 2023.*			
4. Have you or any of your colleagues conducted any LUC inspections at IR Sites 1 and 22? Yes ~~No~~ If "Yes", please give details: *The San Francisco Regional Water Board reviews NASA LUC inspection reports, however, they are not performed on the same day as County Inspections.*			

5. Do you have any comments, suggestions, or recommendations regarding the site's management or operation?

Sites 1 & 22 are the only closed CERCLA landfills in Santa Clara County.

NASA does an excellent job of O&M, integrity, managing wildlife control, and landfill gas (LFG) venting for Sites 1 & 22.

No recommendations for improvement, continue the good work.

Interview Team: | | **Date:** Wednesday, Jan. 17, 2024; 0930 - 0953 PST

Name	**Title**	**Affiliation**
Garrett Turner	Restoration Program Manager	Environmental Management Division NASA Ames Research Center M/S 204-15
Brian Reddig Luke Metz	Restoration Group Lead ERT Restoration Team Member	BB&E – NASA Ames Research Center
Jonathan Grimes	Senior Geologist	BB&E – Atlanta, GA
AJ Sekhon Hunter Dang		Santa Clara County DEH Santa Clara County DEH

Five-Year Review Form

NASA RGRP (Site 28 and NASA Groundwater AOR), NASA Vapor Intrusion AOR, and NASA LUCs

NASA ARC Restoration

Name: Alana Lee			
Title: Remedial Project Manager			
Organization: EPA Superfund Manager – Superfund and Emergency Management Division			
Telephone Number: 415-972-3141			
E-mail Address: Lee.Alana@epa.gov			
Address (Street, City, State, Zip Code): 75 Hawthorne St., San Francisco, CA 94105			
Date: 2024-01-10		**Time:** 1500 – 1541 EST	
Type of interview: Teleconference			
~~Telephone~~	~~Visit~~	**Other:** MS Teams	~~Describe Other:~~
Location of Visit: Virtual			
Relationship to Site: RPM (Remedial Project Manager)			
~~Political Official~~	**Government Representative**	~~Community Member~~	~~Community Group~~
~~Site Neighbor~~	~~Landowner~~	~~Tennant~~	~~Stakeholder~~
Other **Describe Other:** NASA's RGRP, VI AOR, and LUCs			
1. What is your affiliation with Former NAS Moffett Field and oversight role of NASA RGRP, NASA VI AOR, and NASA LUCs?			
Favorable	~~Neutral~~	~~Unfavorable~~	~~Unfamiliar~~
• *RPM for RGRP, VI, and LUCs; LUCs are shared but LUC with VI coincide.*			
2. Have you or any of your colleagues conducted any site visits and/or inspections at NASA RGRP or NASA VI AOR? Yes ~~No~~ If "Yes", please give details: • *No; this is performed by colleagues or contractors.* • *Only perform "annual" site visits but not inspections. NASA and the Navy mostly inspect and check on Sites.* • *During this FYR (2019-2023); Alana performed MEW and Navy inspections.*			
3. Have you or any of your colleagues conducted any LUC inspections at NASA RGRP or NASA VI AOR? ~~Yes~~ No If "Yes", please give details: • *Alana/EPA does not perform inspections but follows-up with the NASA and the Navy (1/month) on the status of LUCs; to check on things.*			

4. Please describe current efforts NASA is taking to implement permanent restrictions on land use and domestic groundwater use in NASA's land use planning and environmental resource documents, in accordance with the MOA for OU5 (Sites 1 and 26), signed in 1999, and the MOA for Site 22, signed in 2008.

- *Land Use domestic restriction is acceptable.*
- *Ongoing for potential VI associated with constructed requirements.*
- *NASA performs VI "monitoring" by review construction permits.*

Is NASA still planning to revise and incorporate institutional controls (ICs) into the Master Plan as previously indicated? Yes ~~No~~

- *EPA is considering an Environmental Inspection Management Plan (EIMP) for research park and other areas not covered by the 2006 EIMP. Garrett expects to get feedback from EPA concerning this.*

5. What is NASA currently doing to address VI risk at existing buildings within NASA's VI AOR?

- *NASA has implemented monitoring to evaluate LTM VI risk (LTM).*
- *NASA's ICs are in place and are triggered by sampling or intrusive construction.*

6. Has NASA conducted indoor air sampling at buildings within NASA's VI AOR where such sampling had not previously been conducted? Yes ~~No~~

If "*Yes*", do sampling results support a VI risk at these buildings?

- *NASA is sampling and the data shows no risk and therefore no mitigation required.*

7. Do you have any comments, suggestions, or recommendations regarding the site's management or operation?

- *NASA's community involvement has been through the Navy's RAB and Community Advisory Board (CAB).*
- *NASA should have its own website to report performance.*
  - *NASA relies on GeoTracker but thought it had a website to do so.*
  - *Garrett notes that NASA has Administrative Record (AR) and it is available to the public and updated via Mt. View Library.*
  - *AR just applicable site documents but not all documents.*
- *Alana notes that NASA should consider access to all documents and recommends hotlink within NASA website to the GeoTracker.*
- *Garrett notes that NASA should inform the CAB about GeoTracker at the May 2, 2024 presentation.*

Interview Team: **Name**	**Title**	**Affiliation/Organization**	**Date:** 2024-01-10; 1500-1541 EST
Garrett Turner	Restoration Program Manager	Environmental Management Division NASA Ames Research Center, M/S 204-15	
Brian Reddig	Restoration Group Lead	BB&E – NASA Ames Research Center	
Brent Jacobs Jonathan Grimes	Sr. Technical Consultant Senior Geologist	BB&E – Atlanta, GA	

Five-Year Review Form

NASA RGRP

NASA ARC Restoration

Name: Jeff Linder			
Title: Environmental Restoration Specialist			
Organization: BB&E/ERT (support contractor to NASA EMD)			
Telephone Number: (805) 400-9588			
E-mail Address: jeffery.l.linder@nasa.gov			
Address (Street, City, State, Zip Code): NASA Ames Research Center			
Date: 3/28/2024		**Time: 0900**	
Type of interview: Self-directed form completion			
Telephone	Visit	Other	Describe Other:
Location of Visit: N/A			
Relationship to Site: Project Subject Matter Expert			
Political Official	Government Representative	Community Member	Community Group
Site Neighbor	Land Owner	Tennant	Stakeholder
Other Describe Other: Project Subject Matter Expert			
1. What is your oversight role of NASA's RGRP?			
My oversight role of NASA's RGRP includes performing Operation, Maintenance and Monitoring (OM&M) duties and preparing the associated annual progress report. The purpose of the annual progress report is to is to present water level and chemical data, summarize groundwater remediation activities, and provide a technical assessment to document the effectiveness of the NASA groundwater treatment system (GWTS) and Site 28 West-Side Aquifers Treatment System (WATS) in meeting NASA's remedy objectives.			
2. Question A: Is the remedy functioning as intended?			
Graphical flow net analysis, capture zone width calculations, spatial distribution analysis, chemical concentration trends and contour mapping provide converging lines of evidence that the NASA RGRP remedy is functioning as intended. The source control wells are suitably located in high concentration areas to maximize mass removal, while maintaining hydraulic control of the majority of the plume margins.			

3. Question B: Are the exposure assumptions, toxicity data, cleanup levels, and Remedial Action Objectives still valid?
Based on data collected from 2019-2023, exposure assumptions, toxicity data, cleanup levels, and Remedial Action Objectives are still valid. However, as long as groundwater containing contaminants at concentrations exceeding the cleanup standards continues to flow from up-gradient source(s), the remedial objective of restoring groundwater quality to the cleanup standards cannot be achieved.
4. Question C: Has any other information come to light that could call into question the protectiveness of the remedy?
No additional information has come to light that could call into question the protectiveness of the remedy.
5. Do you have any comments, suggestions, or recommendations regarding the site's management or operation?
Implementation of the Navy's Traffic Island Area investigation and corresponding remedial action must be compatible with NASA's remedy in the Site 28 area. The data suggests that the Navy's enhanced anaerobic bioaugmentation/in-situ chemical reduction (EAB/ISCR) application did not effectively influence the entire source area and that chemical rebound/matrix diffusion is occurring throughout the treatment zone. Although it is expected to observe transitory increases in daughter-product concentrations as reductive dechlorination progresses, increasing tetrachloroethylene (PCE) concentrations indicate source material remains in the subsurface. Additional groundwater monitoring is necessary to better evaluate the long-term effectiveness of the EAB/ISCR application, as well as the degree of hydraulic control and capture provided by the Traffic Island Area extraction well network.

Interview Team:

Name	Title	Affiliation

Five-Year Review Form

IR Sites 1, 22, 26, NASA RGRP (Site 28 and NASA Groundwater AOR), NASA VI AOR, and NASA LUCs

NASA ARC Restoration

<table>
<tr><td colspan="4">Name: Dana McCarthy (Elizabeth Wells of the SFB Regional Water Quality Control Board attended to support this interview.)</td></tr>
<tr><td colspan="4">Title: Engineering Geologist</td></tr>
<tr><td colspan="4">Organization: San Francisco Bay Regional Water Quality Control Board</td></tr>
<tr><td colspan="4">Telephone Number: 510-622-2371</td></tr>
<tr><td colspan="4">E-mail Address: Dana.McCarthy@Waterboards.ca.gov</td></tr>
<tr><td colspan="4">Address (Street, City, State, Zip Code): 1515 Clay St. Suite 1400, Oakland, CA 94612</td></tr>
<tr><td colspan="2">Date: 2024-02-13</td><td colspan="2">Time: 1600 – 1644 EST</td></tr>
<tr><td colspan="4">Type of interview: Teleconference</td></tr>
<tr><td>Telephone</td><td><s>Visit</s></td><td><s>Other</s></td><td><s>Describe Other:</s></td></tr>
<tr><td colspan="4">Location of Visit: Virtual</td></tr>
<tr><td colspan="4">Relationship to Site: RPM (Remedial Project Manager)</td></tr>
<tr><td><s>Political Official</s></td><td>Government Representative</td><td><s>Community Member</s></td><td><s>Community Group</s></td></tr>
<tr><td><s>Site Neighbor</s></td><td><s>Landowner</s></td><td><s>Tennant</s></td><td><s>Stakeholder</s></td></tr>
<tr><td colspan="4">Other Describe Other: IR Sites 1, 22, 26, NASA RGRP, NASA VI AOR, and NASA LUCs</td></tr>
<tr><td colspan="4">1. What is your affiliation with Former NAS Moffett Field and oversight role of IR Sites 1, 22, 26, NASA RGRP, NASA VI AOR, and NASA LUCs?</td></tr>
<tr><td><s>Favorable</s></td><td>Neutral</td><td><s>Unfavorable</s></td><td><s>Unfamiliar</s></td></tr>
<tr><td colspan="4">

Remedial PM for Moffett Field.
Oversee NASA, Navy, and Planetary Ventures are compliant with state regulations.
Collaborates with EPA on investigation and cleanup oversight.

</td></tr>
<tr><td colspan="4">2. Is NASA’s Site 26 Long-Term Monitoring Program functioning as outlined in the Record of Decision (ROD [Navy, 1996]) Amendment (Navy, 2014)?”</td></tr>
<tr><td><s>Favorable</s></td><td>Neutral</td><td><s>Unfavorable</s></td><td><s>Unfamiliar</s></td></tr>
<tr><td colspan="4">

Groundwater concentrations are decreasing.
Concerns about Hangar 3 demo and potential source areas beneath the Hangar
Garrett notes NASA may urge the Navy to re-engage (reopen) under Hangar 3 to assess soils following its demolition/deconstruction.
E. Wells notes that SF RWQCB doesn’t assign responsibility if there are multiple parties but is engaged on new and/or additional potential sources of impact to groundwater.

Is the Site meeting the requirements to move towards MNA as the final remedy as proposed by the Navy?

Remedy operations at Site 26:
Are performing as intended; not much expansion of the plume spread.
Injections appear to be making an impact on the remaining concentrations.

</td></tr>
</table>

3. Have you or any of your colleagues conducted any site visits and/or inspections at IR Sites 1, 22, 26, NASA RGRP, NASA VI AOR? ~~Yes~~ No If "*Yes*", please give details:

- *No*

4. Have you or any of your colleagues conducted any LUC inspections at IR Sites 1, 22, 26, NASA RGRP, NASA VI AOR? ~~Yes~~ No If "Yes", please give details:

- *No*
- *NASA does quarterly inspections with annual reporting and LUC inspections that Water Board relies on.*

5. In the 1999 MOA for OU5, NASA agreed to, "*…maintain the Building 191 pump station and drain/subdrain system as long as NASA either owns the property or maintains operations control over the site.*" This restriction was to be recorded in NASA's revised Master Plan. Is this still NASA's intent? Yes ~~No~~ If "No", then why not?

- *Garrett Turner of NASA Ames responded to the question and stated this is recorded in the MP, Env. Resource documents, and GIS database.*
- *Lease required Building 191 to be retained and the pump system to be maintained.*

6. Describe the effectiveness of the two pumps located in Building 191 pump station. In the past five years have these pumps been able to effectively regulate excessive storm surges?

- *The Water Board does monitor of pumps at Building 191 with respect to storm surge regulation.*
- *Garrett Turner, NASA Ames, states, it is operating as intended; the Building 191 pump system has been effective for Sites 1 and 22 LF.*
- *Water Board states it has no responsibility but provide comments on the groundwater gradient.*

7. Do you have any comments, suggestions, or recommendations regarding the site's management or operation?

- *Recommend a source investigation under Hangar 3 following its demolition, including but not limited to groundwater and soil vapor. (Sampling soil for VOCs can be done, but finding non-detect or low concentrations in soil does not mean groundwater and soil vapor can be ignored).*

Interview Team: | **Date:** 2024-02-13, 1600 – 1644 EST

Name	**Title**	**Affiliation/Organization**
Garrett Turner	Restoration Program Manager	Environmental Management Division NASA Ames Research Center M/S 204-15
Brian Reddig	Restoration Group Lead	BB&E – NASA Ames Research Center
Jonathan Grimes	Senior Geologist	BB&E – Atlanta, GA

Five-Year Review Form
Site 1

Name: Luke Metz			
Title: Environmental Restoration Specialist			
Organization: BB&E/ERT (support contractor to NASA EMD)			
Telephone Number: 650-906-3743			
E-mail Address: luke.t.metz@nasa.gov			
Address (Street, City, State, Zip Code): NASA Ames Research Center			
Date: 3/27/24		**Time: 1030**	
Type of interview: Self-directed form completion			
Telephone	Visit	Other	Describe Other:
Location of Visit: N/A			
Relationship to Site: Project Subject Matter Expert			
Political Official	Government Representative	Community Member	Community Group
Site Neighbor	Land Owner	Tennant	Stakeholder
Other Describe Other: Project Subject Matter Expert			

1. What is your oversight role of IR Site 1?

I am responsible to ensure the Site 1 remedy installed by the Navy is maintained and functioning as designed and to ensure adherence to land use controls (LUCs). As part of the Site 1 monitoring and reporting requirements, I oversee biannual groundwater depth-to-water measurements, groundwater sample collection and landfill gas measurements. I orchestrate and oversee site maintenance including vegetation control, drainage management and burrowing animal control.

2. Question A: Is the remedy functioning as intended?

Yes

3. Question B: Are the exposure assumptions, toxicity data, cleanup levels, and Remedial Action Objectives still valid?
The calculated concentration limits (CCLs) for point of compliance wells are recalculated each year.
4. Question C: Has any other information come to light that could call into question the protectiveness of the remedy?
Site 1 burrow maintenance requires a significant level of effort from NASAs wildlife biologist. On average, site presence is required two times per week to keep up with the presence of burrowing animals. This is typically followed up with burrow exclusion and fumigation twice each month. The presence of pickleweed (Salt Marsh Harvest Mouse habit) limits the burrowing mammal mitigation measures that can be utilized at portions of Site 1. The presence of Snowy Plovers in the Stormwater Retention Pond has resulted in delays in inspection, vegetation and burrowing mammal control, and sampling activities as a result of needing to work outside of a “buffer zone” during certain periods of the Plover’s breeding season. A permanent shift in the biannual sampling schedule has resulted in monitoring data that represents somewhat different environmental conditions. The use of certain dissolved metals as monitoring parameters (MPs) and chemicals of concern (COCs) has resulted in unnecessary follow-up sampling, data analysis, and expenditure of additional resources to address the findings. High levels of naturally-occurring metals exist in the vicinity of Site 1 and are a poor indicator of potential releases from the landfill.

5. Do you have any comments, suggestions, or recommendations regarding the site's management or operation?
The issue of burrowing mammal management should be further assessed to determine if alternative or supplemental mitigation methods are viable for application at Site 1. The Long-Term Monitoring Plan and Quality Assurance Project Plan should be revisited to re-evaluate the COCs and MPs used to signify potential releases from the landfill. Specifically, the 2014 and 2016 Treve reports should be revisited to identify which metals are most appropriate for use and what concentrations should be applied as action levels.

Interview Team:

Name	**Title**	**Affiliation**

Five-Year Review Form
Site 22
NASA ARC Restoration

Name: Luke Metz			
Title: Environmental Restoration Specialist			
Organization: BB&E/ERT (support contractor to NASA EMD)			
Telephone Number: 650-906-3743			
E-mail Address: l u k e . t . m e t z @ n a s a . g o v			
Address (Street, City, State, Zip Code): NASA Ames Research Center			
Date: 3/26/24		**Time: 10:00**	
Type of interview: Self-directed form completion			
Telephone	Visit	Other	Describe Other:
Location of Visit: N/A			
Relationship to Site: Project Subject Matter Expert			
Political Official	Government Representative	Community Member	Community Group
Site Neighbor	Land Owner	Tennant	Stakeholder
Other Describe Other: Project Subject Matter Expert			
1. What is your oversight role of IR Site 22?			

I am responsible to ensure the Site 22 remedy installed by the Navy is maintained and functioning as designed and to ensure adherence to land use controls (LUCs). As part of the Site 22 monitoring and reporting requirements, I oversee biannual groundwater depth-to-water measurements, groundwater sample collection and landfill gas measurements. I coordinate and lead quarterly county inspections and ensure site compliance while maintaining a professional relationship with county inspectors. I coordinate with Moffett Golf Course staff to ensure that operation and maintenance (O&M) activities are conducted and documented as needed.

2. Question A: Is the remedy functioning as intended?

Yes.

3. Question B: Are the exposure assumptions, toxicity data, cleanup levels, and Remedial Action Objectives still valid?
Yes
4. Question C: Has any other information come to light that could call into question the protectiveness of the remedy?
Although mitigation measures to date have successfully managed burrowing mammal activity, there is a considerable amount of burrowing activity by ground squirrels and gophers. Exploring potential additional mitigation measures for future implementation is recommended.

5. Do you have any comments, suggestions, or recommendations regarding the site's management or operation?
The Moffett Golf Course quarterly reports that are summited to NASA don't always include all of the requested information. Suggest composing a form/ checklist that includes relevant information to replace the (free-written) email update.

Interview Team: **Name**	**Title**	**Affiliation**

Five-Year Review Form

NASA Vapor Intrusion Area of Responsibility and NASA VI Land Use Controls

NASA ARC Restoration

Name: Lili Pirbazari			
Title: Environmental Protection Specialist			
Organization: NASA ARC-JQ			
Telephone Number: 650-604-1767			
E-mail Address: lili.pirbazari-1@nasa.gov			
Address (Street, City, State, Zip Code): NASA Ames Research Center Moffett Field, CA 94035-1000			
Date: 2024-02-14		**Time:** 1300 – 1328 EST	
Type of interview: Teleconference			
~~Telephone~~	~~Visit~~	**Other:** MS Teams	~~Describe Other:~~
Location of Visit: Virtual			
Relationship to Site: RPM (Remedial Project Manager)			
~~Political Official~~	**Government Representative**	~~Community Member~~	~~Community Group~~
~~Site Neighbor~~	~~Landowner~~	~~Tennant~~	~~Stakeholder~~
Other **Describe Other:** NASA VI AOR and NASA VI LUCs			

1. What is your affiliation with Former NAS Moffett Field and oversight role of NASA VI AOR and NASA LUCs?

Restoration PM oversee VI for NASA Ames Research Center, MEW, and the Navy.

2. Have you or any of your colleagues conducted any site visits and/or inspections associated with the NASA VI AOR? Yes No If "Yes", please give details:

Not directly by NASA however this is performed by NASA's contractor during this FYR period.

3. Have you or any of your colleagues conducted any site visits and/or inspections associated with the Navy and MEW VI AORs at NASA? Yes or ~~No~~
If "Yes", please give details:

Yes, see response in 2. (above).

4. How well does NASA keep appraised of activities and developments associated with the Navy and MEW VI AORs?

- *NASA manages and coordinates sampling activities for VI including access and tenant coordination regarding the need for the installation of remedial system to address VI during construction permit reviews.*
- *NASA is actively engaged with all parties conduct VI work.*

5. In the past 5 years, has NASA successfully addressed the requirements of the 2010 VI Amendment to the MEW ROD? Yes ~~No~~ If "Yes", please give details:

- *Absolutely, NASA conducts annual indoor air sampling for its Tier 3A buildings and every 5 years for Tier 3B buildings.*
- *Sampling Tiers are re-evaluated each year based on report of findings.*
- *First FYR for LUCs and VI for NASA.*

6. What is NASA currently doing to address VI risk at existing buildings within NASA's VI AOR?

- *See 5. (preceding above).*
- *NASA implements the requirements of the 2010 ROD for VI including building walkthrough, indoor air sampling, report of findings, and tier evaluation to determine future steps.*
- *NASA works closely with regulatory agencies.*

7. Has NASA conducted indoor air sampling at buildings within NASA's VI AOR where such sampling had not previously been conducted? ~~Yes~~ No

If "Yes", do sampling results support a VI risk at these buildings?

- *No; all buildings sampled have been part of NASA's area of responsibility and designated for VI sampling from the beginning.*
- *Occasionally a building may be dropped from the sampling requirement based on findings and regulatory agency review.*

8. How does NASA manage the Land Use Control requirements for the "*Former NAS Moffett Field Area of MEW Regional Plume Vapor Intrusion Study Area.*"

- *NASA has a long-term monitoring plan (LTM) that outlines the incorporation of the VI area into land use control (LUC) requirements.*
- *There is a section under the NEPA checklist where applicants are required to indicate whether their project is in the "Former NAS Moffett Field Area of MEW Regional Plume Vapor Intrusion Study Area."*
- *There currently are no Environmental Permit Requirements for VI, which we are working to incorporate. However, the LUCs require us to "incorporate requirements for VI engineering controls in future construction (or modification to existing buildings) in permitting and building design processes. "*

9. What standards are required to be followed by entities performing construction activities / tenant improvements within the "*Former NAS Moffett Field Area of MEW Regional Plume VI Study Area*" to protect against VI issues?

- *NEPA environmental checklist and Record of Environmental Consideration (REC).*
- *EC & VI are included in the construction permitting process.*
- *LUC covers the entire MEW Regional Plume area, including NASA, Navy, and MEW AORs.*

10. Do you have any comments, suggestions, or recommendations regarding the VI Program's management or operation?

No comments other than NASA is doing a great job.

Interview Team: — **Date:** 2024-02-14; 1300 – 1328 EST

Name	**Title**	**Affiliation/Organization**
Garrett Turner	Restoration Program Mgr.	Environmental Management Division NASA Ames Research Center, M/S 204-15
Brian Reddig	Restoration Group Lead	BB&E – NASA Ames Research Center
Jonathan Grimes	Senior Geologist	BB&E – Atlanta, GA
Ingrid Warburg		ARC – JQ
Deborah Varty		ARC -- JQ

Five-Year Review Form

Site 26

NASA ARC Restoration

Name: Ingrid Warburg			
Title: Environmental Restoration Specialist			
Organization: BB&E/ERT (support contractor to NASA EMD)			
Telephone Number: (530) 902-6386			
E-mail Address: ingrid.j.warburg@nasa.gov			
Address (Street, City, State, Zip Code): NASA Ames Research Center			
Date: 3/25/2024		**Time: 11:00**	
Type of interview: Self-directed form completion			
Telephone	Visit	Other	Describe Other:
Location of Visit: N/A			
Relationship to Site: Project Subject Matter Expert			
Political Official	Government Representative	Community Member	Community Group
Site Neighbor	Land Owner	Tennant	Stakeholder
Other Describe Other: Project Subject Matter Expert			
1. What is your oversight role of IR Site 26?			
My oversight role of IR Site 26 includes performing Long-Term Monitoring (LTM) duties and preparing the associated LTM Report, which is included as an appendix in NASA's Annual Regional Groundwater Remediation Program (RGRP) Report. The purpose of the LTM is to document the monitoring of the IR Site 26 groundwater and demonstrate that monitored natural attenuation (MNA) is continuing. MNA was selected with Institutional Controls (ICs) as the long-term remedy for groundwater contamination at Operable Unit (OU) 5, IR Site 26 as outlined in the Record of Decision Amendment.			
2. Question A: Is the remedy functioning as intended?			
Based on the sampling conducted by NASA between 2021 and 2023 at IR Site 26, the long-term remedy for groundwater contamination implemented by the Navy Record of Decision (ROD) Amendment appears to continue to function as intended. Between 2019 and 2020, there was significant reduction in the areal extent of the chemical of concern (COC) plume as a direct result of the EVO/DHC injections. Additionally, the 2021 to 2023 monitoring results may be indicative of reductive chlorination of tetrachloroethene (PCE) and trichloroethene (TCE) at IR Site 26; change in concentrations of key COCs (decrease of PCE and vinyl chloride (VC), stability of TCE, and increase of cis-1,2-dichloroehtene (cis-1,2-DCE) as well as a prevalence of decreasing Mann-Kendall concentration were observed. However, further data is needed to evaluate whether the observed results are consistent with predicted cleanup time frames.			

3. Question B: Are the exposure assumptions, toxicity data, cleanup levels, and Remedial Action Objectives still valid?
Based on our observed results from 2021 to 2023, the exposure assumptions, toxicity data, cleanup levels, and Remedial Action Objectives are still valid at IR Site 26.
4. Question C: Has any other information come to light that could call into question the protectiveness of the remedy?
No additional information has come to light that could call into question the protectiveness of the remedy at IR Site 26.
5. Do you have any comments, suggestions, or recommendations regarding the site's management or operation?
I have no comments, suggestions, or recommendations regarding the site's management or operation.

Interview Team:

Name	**Title**	**Affiliation**

Appendix C

Public Notice for NASA 2023 ARC FYR (2019-2023)

EPA is REVIEWING the FIVE-YEAR REVIEW (2019-2023) for CERCLA SITES at AMES RESEARCH CENTER in MOUNTAIN VIEW, CA

The National Aeronautics and Space Administration (NASA) is currently conducting the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Five Year Review (FYR) at Ames Research Center (Ames), Moffett Field, California. Ames is located 35 miles south of San Francisco and 10 miles north of San Jose. NASA is conducting the FYR in accordance with the requirements of CERCLA Section 121(c). The purpose of the FYR is to determine whether the remedies selected for implementation in the Record of Decision (ROD) documents at Site 1, Site 22, and Site 26; and the NASA Regional Groundwater Remediation Program, the NASA Vapor Intrusion Area of Responsibility, and NASA Land Use Controls Monitoring and Implementation Program are to be compliant with their respective ROD within those areas. All sites and areas, noted above, are to remain protective of human health and the environment through their respective remedy implementation.

Federal law requires United States Environmental Protection Agency (USEPA) to review its cleanup plans every five years if:

– a cleanup takes more than five years to complete, or
– hazardous waste is still on-site.

What is included in the review?

- An inspection of the site and technologies used for the cleanup.
- A review of site data and maintenance records.
- A review of any new laws or requirements that could affect the cleanup.

How can I learn more?

If you would like to learn more about the site, please contact:

- Garret Turner, Restoration Program Manager, Environmental Management Division, NASA Ames Research Center, (650) 604-1406, garrett.michael.turner@nasa.gov

NASA has issued a Draft Five Year Review Report of findings to United States Environmental Protection Agency and California Regional Water Quality Control Board, San Francisco Bay Region for review; the final Report will be issued by September 30, 2024. When complete, NASA will post a copy on the GeoTracker (https://geotracker.waterboards.ca.gov/) webpage and send a digital copy to the Mountain View Public Library.

Appendix D

NASA ARC FYR (2019-2023) RTC Table

DRAFT REVIEW FORM

Project Name: 02084001 NASA ARC ESS Five Year Review Report
Contract Number GS00Q14OADS144, Task Order 80ARC020F0036
Comment Codes: **1 = Accepted - Change will be reflected in the next version of the report.**
2 = Not Incorporated - Rationale provided in response
3 = Unresolved - Further discussion needed during comment review teleconference

Review Document Name: Appendix D - NASA ARC FYR (2019-203) RTC Table
Date: 6/27/2025

Project Manager Garrett Turner

Comment No.	Comment By	Page no., Figure no., Table no.	Review Comment	Responder	Reponse to Comment	Comment Code
October 2024 Comments and November 2024 Responses						
1	Alana Lee and Yvonne Fong	General Comment	Per- and Polyfluoroalkyl Substances: PFAS should be addressed in NASA's revised Draft Final Five-Year Review Report, as PFAS are emerging contaminants with greatly increased regulatory concern, and they are documented to contaminate portions of Moffett Field at concentrations far exceeding EPA Regional Screening Levels (RSLs) and recently promulgated Maximum Contaminant Levels (MCLs), by orders of magnitude in some cases. For the Protectiveness Determination, short-term protective may be appropriate where there is at least a preliminary understanding of PFAS contamination and confidence that there are no current drinking water exposures. Alternatively, if characterization is incomplete, the protectiveness determination may be deferred.	Jonathan Grimes, Brian Reddig, and Garrett Turner	PFAS will be addressed in the revised Draft Final Five-Year Review Report. The results of the PFAS SI (Tetra Tech 2023) will be summarized in Appendix E (new appendix). The PFAS Expanded Site Investigation Inspection (ESI) will not be completed in time to incorporate any preliminary findings on the nature and extent of PFAS in the FYR. Therefore, the "Protectiveness Determination" will be deferred.	1
2a	Alana Lee and Yvonne Fong	General Comment	The Five-Year Review report should be revised to include the following additions regarding PFAS: a. Progress Since Last Review. Data Review, Tables, Figures, and Appendix. A summary of the status of NASA's PFAS Site Inspection (SI) and Expanded SI should be summarized in the Five-Year Review report and the results of the PFAS Site Inspection Report for Ames Research Center (Tetra Tech 2022) should be summarized. This information could include Table 5-2, Table 5-4, and Figure 1-2, and information from the Executive Summary or Conclusions and placed in an appendix.	Jonathan Grimes, Brian Reddig, and Garrett Turner	The results of the PFAS SI (Tetra Tech 2023) will be summarized in the Five-Year Review Report. A summary of the PFAS SI will be inserted in the "Progress Since Last Review" in Section 4 and pertinent information from the 2023 PFAS SI, including data tables and figures, are presented in Appendix E (new appendix). The following summary will be added in Section 4; following the first paragraph of Section 4 and preceding Section 4.1. "Groundwater samples were collected at 26 Areas of Potential Concern (AOPCs) across Moffett Field, including Site 1, Site 2, Site 22, Site 26, NASA RGRP, and Site 28 during the 2023 PFAS SI. PFAS was detected in groundwater samples at varying concentrations at the AOPCs. Some of the PFAS concentrations detected in groundwater exceeded the 2022 USEPA RSLs and/or the California RWB groundwater ESLs. Pertinent information from the 2023 SI, including the Executive Summary and Conclusions Sections, along with supporting data Tables 5-2 and 5-7 and figures are included in Appendix E. The 2023 SI recommended that additional investigations be performed to evaluate the horizontal and vertical extents of PFAS in groundwater, routine monitoring of the treated effluent from the groundwater systems, and further evaluation of surface water impacts. As of 2024, NASA's Expanded PFAS Site Investigation Inspection (ESI) is ongoing and will not be completed during this FYR review period. Therefore, no data or information regarding any preliminary findings on the nature and extent of PFAS can be incorporated in this FYR. As summarized in Appendix E, Table 5-2, PFAS were detected at a high frequency in certain PFAS analytes. Notably, of the PFAS with established screening levels, PFOA and PFHxS were detected in 25 of the 28 collected soil samples and PFOS was detected in 23 of the 28 samples. PFOS was present in 15 of the samples at concentrations exceeding the residential RSL and PFOA was present in three of the samples at concentrations exceeding the residential RSL. Similarly, certain PFAS analytes in groundwater samples (summarized in Appendix E, Table 5-242) were detected at high frequencies. Notably, of the PFAS with established screening levels, PFHxS was detected in 75 of the 79 collected groundwater samples, while PFBS, PFOA and PFOS were detected in 71 of the 79 samples. The groundwater RSL was also exceeded at high frequencies in certain PFAS analytes, mostly notably PFOS (59 samples), PFOA (53 samples) and PFHxS (42 samples)."	1
2b	Alana Lee and Yvonne Fong	General Comment	b. Question B: Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives (RAOs) used at the time of remedy selection still valid? PFAS should be addressed in the response to Question B. Superfund guidance (EPA 2001; EPA 540-R-01-007) indicates that Question B should be used to address when "new contaminants or contaminant sources have been identified." The response to Question B should include reference to PFAS SI results (Tetra Tech, 2022) and comparisons to EPA RSLs and MCLs for PFAS.	Jonathan Grimes, Brian Reddig, and Garrett Turner	The Five-Year Review Report will be revised to include a discussion of PFAS as a new contaminant and references the 2023 PFAS Site Inspection (SI) results. A comparison of SI analytical results with current EPA RSLs and MCLs is presented in Appendix E (new appendix). The following text will be added to each Question B for each Site, RGRP, VI, and LUCs in Section 6: "Although PFAS are not identified as contaminants of concern in any of the RODs, PFAS have been evaluated at certain locations on Moffett Field during this review period. PFAS has been detected in the groundwater samples collected at Sites 1 (and 2), 22, 26, 28, and NASA RGRP at varying concentrations during the 2023 PFAS SI. Some of the PFAS concentrations detected exceeded the 2022 USEPA RSLs and/or MCLs and the California RWB groundwater ESLs. In addition, one influent and one effluent sample were collected at each of the three groundwater treatment systems: AOPC 13 – NASA Groundwater Extraction Treatment System, AOPC 14 – Middlefield-Ellis-Whisman Groundwater Extraction Treatment System, and AOPC 15 – West-Side Aquifers Treatment System (IR 28). The influent sample results from all three treatment systems exceeded the 2022 groundwater USEPA RSLs and/or MCLs for PFOS, PFOA, and PFHxS as well as the State groundwater ESLs for PFOS and PFOA. The effluent sample results for AOPC 13 – NASA Groundwater Extraction Treatment System indicated an estimated concentration ("j value") of 2.5 ppt for PFOS and a field duplicate sample result of 4.1 ppt for PFOS and all other results were below the 2022 groundwater USEPA RSLs and/or MCLs for PFAS as well as the State groundwater ESLs for PFAS. The effluent sample results for AOPC 14 – Middlefield-Ellis-Whisman Groundwater Extraction Treatment System indicated exceedances of the 2022 groundwater USEPA RSLs and/or MCLs for PFOS, PFOA, and PFHxS as well as the State groundwater ESLs for PFOS and PFOA. The effluent sample results for AOPC 15 – West-Side Aquifers Treatment System (IR 28) indicated no exceedance of the 2022 groundwater USEPA RSLs and/or MCLs for PFAS as well as the State groundwater ESLs for PFAS (Tetra Tech 2023). One surface water sample was collected in addition to the influent and effluent samples. PFAS constituents were detected at varying concentrations in the surface water sample. No PFAS standards or criteria have been developed for surface water. As of 2024, NASA's ongoing Expanded Site Inspection (ESI) is to further identify potential source areas associated with PFAS contamination found during the 2023 SI. Additional investigations (e.g., Remedial Investigation) will be required to further characterize PFAS impacts in groundwater contamination at the Site."	1
2c	Alana Lee and Yvonne Fong	General Comment	c. Issues, Recommendations, and Follow-up Actions. A PFAS Remedial Investigation should be recommended to follow up on the 2022 PFAS SI and 2024 ESI to comprehensively characterize PFAS sources, delineate the extent of PFAS contamination across the Site and potential migration offsite, e.g., via surface water, and assess the potential human health and environmental risk that the PFAS contamination poses.	Jonathan Grimes, Brian Reddig, and Garrett Turner	A PFAS Remedial Investigation (RI) will be recommended in the FYR in the Issues, Recommendations, and Follow-up Actions. The following text will be added in Section 7; following the first paragraph of Section 7 and preceding Section 7.1, "With PFAS detected in the groundwater samples collected at Sites 1 (and 2), 22, 26, 28, and NASA RGRP at varying concentrations during the 2023 PFAS SI, NASA anticipates performing an RI within the next FYR period. This would likely occur during FY 27 at least at one of the AOPCs. Since AOPCs are matched with media, multiple RIs for the AOPCs may be required."	1
2d	Alana Lee and Yvonne Fong	General Comment	d. Issues, Recommendations, and Follow-up Actions. Influent and effluent PFAS concentrations of the groundwater extraction and treatment systems should be documented (e.g., PFAS SI results) as an issue and evaluated in determining the source of PFAS hot spot areas, and the potential for re-distribution of PFAS in treated groundwater via effluent discharge should be monitored and addressed.	Jonathan Grimes, Brian Reddig, and Garrett Turner	The Five-Year Review Report will be revised to include a discussion (provided below) of the influent and effluent PFAS concentrations of groundwater extraction and treatment systems. A recommendation for future monitoring of effluent of the groundwater systems will be added to Section 7, Table 7-4 as Issue 6. and in the Discussion as "6." as follow: 6. Site 28/WATS groundwater extraction system's effluent should be monitored and the data evaluated to determine if any discharges of PFAS-impacted effluent are occurring and redistributing PFAS. PFAS effluent sampling schedule for WATS will follow the pending NPDES PFAS requirements that are anticipated to be finalized in 2025. Additionally, NASA intends to perform an RI addressing this area within the next FYR period. NASA. USEPA and Water Board. November 27, 2026. "6. With PFAS detected in the groundwater samples collected at Sites 1 (and 2), 22, 26, 28, and NASA RGRP at varying concentrations during the 2023 PFAS SI, NASA anticipates performing an RI within the next FYR period. This would likely occur during FY 27 at least at one of the AOPCs. Since AOPCs are matched with media, multiple RIs for the AOPCs may be required."	1

DRAFT REVIEW FORM

Project Name: 02084001 NASA ARC ESS Five Year Review Report
Contract Number GS00Q14OADS144, Task Order 80ARC020F0036
Comment Codes: **1 = Accepted - Change will be reflected in the next version of the report.**
2 = Not Incorporated - Rationale provided in response
3 = Unresolved - Further discussion needed during comment review teleconference

Review Document Name: Appendix D - NASA ARC FYR (2019-203) RTC Table
Date: 6/27/2025

Project Manager Garrett Turner

Comment No.	Comment By	Page no., Figure no., Table no.	Review Comment	Responder	Reponse to Comment	Comment Code
3	Alana Lee and Yvonne Fong	General Comment	Items that should not be included in Issues/Recommendations table: There are several items listed for each site as "issues" that should not be included on the Summary Form or in the Issues/Recommendations table because they do not affect current or future protectiveness and the recommendations are to improve operations & maintenance (O&M) or optimization efforts. Items included in the "Issues/Recommendations" tables are tracked by EPA until actions are taken to resolve the stated issues/recommendations. The "non-issue" Items may be included in a separate "Other Findings" section below the Issues/Recommendations table if discussion of additional information is warranted in the Five-Year Review report. The "Other Findings" identified during the Five-Year Review may improve performance of the remedy, reduce costs, improve management of O&M, accelerate site close out, conserve energy, promote sustainability, etc., but generally would not affect current or future protectiveness. Specifically, the discussion of maintenance, monitoring, and optimization for Sites 1, 22, 26, NASA RGRP, and NASA Vapor Intrusion Area of Responsibility should reside in the "Other Findings" category.	Jonathan Grimes, Brian Reddig, and Garrett Turner	3. Within the Executive Summary, the Issues and Recommendations on the Summary Form and Summary of Issues, Recommendations, table will be revised as suggested removing items that do not affect current or future protectiveness. The Summary Form and "Issues:" and "…recommendations and follow-up actions…" tables will be modified as follows: Issues: Site 1 No issues were identified. Site 22 No issues were identified. Site 26 No issues were identified. NASA RGRP No issues were identified. NASA VI AOR No issues were identified. NASA LUCs No issues were identified. To ensure long-term protectiveness of each remedy, the following recommendations and follow-up actions listed below must be taken: Site 1 No recommendations or follow-up actions were identified. Site 22 No recommendations or follow-up actions were identified. Site 26 No recommendations or follow-up actions were identified. NASA RGRP No recommendations or follow-up actions were identified. Evaluate the potential for applying monitored natural attenuation (MNA) to low-concentration areas in the NASA Groundwater AOR: NASA VI AOR No recommendations or follow-up actions were identified. NASA LUCs Some construction and/or redevelopment activities conducted by other parties (tenants, resident agencies, etc.), are not managed by NASA's Construction Permit Review Board and receive an alternate review with regards to environmental impacts related to those activities. These projects do receive a complete NEPA review process, including the establishment of a Record of Environmental Consideration (REC) for each project. The "Non-issue" items noted by EPA in the Summary Form's "Issues:" and "Recommendations table will be presented in a separate "Other Findings" section (new) that follows the Protectiveness Statement within the Summary Form in the Executive Summary. It will be presented as follows: Other Findings: Site 1 Burrowing mammal management is and will continue to be a critical O&M issue at Site 1 and the current level of management is not indefinitely sustainable or cost-effective. The use of certain dissolved metals as monitoring parameters (MPs)/chemicals of concern (COCs), that occur naturally at elevated levels, has required additional and extraneous sampling and reporting activities. Optimization of groundwater sampling, consistent with other NASA sites as viable alternatives for cost savings. Site 22 Optimization of groundwater sampling, consistent with other NASA sites as viable alternatives for cost savings. Site 26 Based on the analytical results since the 2019 injection, there may be an opportunity to optimize the LTM well network so that more relevant data is obtained on an annual basis, rather than comprehensive biennial monitoring results. NASA RGRP NASA's WATS and GWTS are effective; however, both systems are 20+ years of age. More frequent well redevelopment and conveyance line flushing will be required in future years to sustain design efficiency. The lack of cleanouts in both system's conveyance piping limits the reach and effectiveness of maintenance activities (conveyance line flushing, etc.). Since GWTS system startup, the reduction of dissolved COCs has yielded lower mass removal rates at some locations and reduced cost effectiveness. Continued mass removal optimization through maximizing groundwater extraction for each extraction system at high-concentration locations should be pursued. The site conceptual model for the RGRP is incomplete. NASA VI AOR Tier 3A buildings are currently sampled annually as a NASA standard of practice, which exceeds USEPA biennial sampling requirements. NASA LUCs No other findings were identified. Redevelopment within the Former NAS Moffett Field Area of MEW Regional Plume VI Study Area & LUC Boundary provides the greatest risk to remedy protectiveness. NASA uses the construction permit review process to identify environmental impacts to NASA construction projects. NASA has also implemented a parallel system under the Development Support Office that ensures that all construction projects are reviewed. Lessees are required to submit an Environmental Issues Management Plan (EIMP) and the EIMP includes a requirement to notify EPA in advance of any activities that will impact the groundwater plume.	1
4	Alana Lee and Yvonne Fong	General Comment	Protectiveness Statements. The protectiveness statements should be revised to include both the engineered remedy and the land use controls for each site/OU. The protectiveness statements for the NASA RGRP and the NASA Vapor Intrusion Area of Responsibility should be revised to align with EPA's protectiveness statement determination in EPA's Fifth Five-Year Review Report for the MEW Superfund Study Area, Mountain View and Moffett Field (EPA, 2024).	Jonathan Grimes, Brian Reddig, and Garrett Turner	4. The protectiveness statements will be revised to include both the engineered remedy and the land use controls for each site/OU. The protectiveness statements for the NASA RGRP and the NASA Vapor Intrusion Area of Responsibility will be revised to align with EPA's protectiveness statement determination in EPA's Fifth Five-Year Review Report for the MEW Superfund Study Area, Mountain View and Moffett Field (EPA, 2024). The following text will be revised to the protectiveness statement for the NASA RGRP Protectiveness Statement in Table 8-4 and NASA Vapor Intrusion Area of Responsibility in Table 8-5. "The remedy for the NASA RGRP is protective of human health and the environment because there is no direct exposure to contamination. On-site contaminant plumes are stable or decreasing, as groundwater extraction provides adequate hydraulic containment, contaminated groundwater in the upper and lower A aquifers are being treated, and potential exposure pathways that could result in unacceptable risks are being controlled. Governmental controls are in place to prevent access to contaminated groundwater. The vapor intrusion control systems, monitoring program, and institutional controls are in place to minimize exposure risk from vapor intrusion. However, in order for the remedy to be protective in the long-term, alternative groundwater cleanup technologies should be evaluated to accelerate the reduction of the source of vapor intrusion in the Shallow Zone. Additionally, to ensure long-term protectiveness, sampling for PFAS (per- and polyfluoroalkyl substances) in groundwater to further assess potential risk is needed." "The remedy for the NASA VI AOR is protective of human health and the environment because there is no direct exposure to contamination.	1
5	Alana Lee and Yvonne Fong	General Comment	Consideration and Planning for Climate Change. In Section 1.4, the Five-Year Review Report describes planning considerations to mitigate the possible impacts of climate change. Revise the text and Table 1-2 to describe the process for how the identified potential mitigation measures might be implemented on a site-specific basis.	Jonathan Grimes, Brian Reddig, and Garrett Turner	Table 1-3 will be added after Table 1-2 to describe the potential mitigation measures that may be considered. Table 1-3 is attached at the end of this review document.	1

DRAFT REVIEW FORM

Project Name: 02084001 NASA ARC ESS Five Year Review Report
Contract Number GS00Q14OADS144, Task Order 80ARC020F0036
Comment Codes: **1 = Accepted - Change will be reflected in the next version of the report.**
2 = Not Incorporated - Rationale provided in response
3 = Unresolved - Further discussion needed during comment review teleconference

Review Document Name: Appendix D - NASA ARC FYR (2019-203) RTC Table
Date: 6/27/2025

Project Manager Garrett Turner

Comment No.	Comment By	Page no., Figure no., Table no.	Review Comment	Responder	Reponse to Comment	Comment Code
6a	Alana Lee and Yvonne Fong	General Comment	Supplemental Figures, Tables, Graphs for Data Review. a. Data review sections for Site 1, Site 22, Site 26, and NASA RGRP, include discussions of trend analysis, the evaluation of contaminant migration, and assessments of plume extents yet the results of these analyses are not presented or included in figures, tables, and graphs. Consider including figures depicting the location of wells used in the Mann-Kendall analysis, tables of the input data used for Mann-Kendall analysis, and graphs of Mann-Kendall trend analysis results, as appropriate.	Jonathan Grimes, Brian Reddig, and Garrett Turner	Supporting information and appropriate figures will be included in Appendix F (new appendix). The following text will be added to each of the following sections: Section 5.1.3, 1st paragraph: A data review for Site 1 was based on the following and presented in Appendix F: Draft 2023 Annual Report, Site 1 and Site 22 Landfills, Moffett Federal Airfield (BB&E 2024) Figure 3 - Site 1 Landfill Groundwater Level Measurement and Monitoring Locations Figure 6 - Site 1 Landfill Potentiometric Surface, October 2023 Figure 9 - Site 1 Landfill Methane Monitoring Locations Appendix D - Analytical Data Graphs Section 5.2.3, 1st paragraph: A data review for Site 22 was based on the following and presented in Appendix F: Draft 2023 Annual Report, Site 1 and Site 22 Landfills, Moffett Federal Airfield (BB&E 2024) Figure 4 - Site 22 Landfill Groundwater Level Measurement and Monitoring Locations Figure 7 - Site 22 Landfill Potentiometric Surface, October 2023 Figure 10 - Site 1 Landfill Methane Monitoring Locations Appendix D - Analytical Data Graphs Section 5.3.3, 1st paragraph: A data review for Site 26 was based on the following and presented in Appendix F: A data review for Site 26 was based on the following and presented in Appendix F: Draft Final 2020 Long-Term Monitoring Report, Installation Restoration Site 26, Former Naval Air Station Moffett Field (Leisnoi & KEMRON 2021) Figure 3-10 - Trichloroethene (TCE) Distribution, IR Site 26, 2020 LTM Figure 3-11 - cis-1,2-Dichloroethene (cis-1,2-DCE) Distribution, IR Site 26, 2020 LTM Figure 3-12 - Tetrachloroethene (PCE) Distribution, IR Site 26, 2020 LTM Figure 3-13 - Vinyl Chloride (VC) Distribution, IR Site 26, 2020 LTM Draft Final 2021 Installation Restoration Site 26 Long Term Monitoring Report, Former Naval Air Station Moffett Field, NASA Ames Research Center (BB&E 2022) Figure 3-10 - Tetrachloroethene (PCE) Distribution, IR Site 26, 2021 LTM Figure 3-11 - Trichloroethene (TCE) Distribution, IR Site 26, 2021 LTM Figure 3-12 - cis-1,2-Dichloroethene (cDCE) Distribution, IR Site 26, 2021 LTM Figure 3-13 - Vinyl Chloride (VC) Distribution, IR Site 26, 2021 LTM Draft 2023 Installation Restoration Site 26 Long Term Monitoring Report, Former Naval Air Station Moffett Field, NASA Ames Research Center (BB&E, 2024) Figure 3-2 - Tetrachloroethene (PCE) Distribution (2023) Figure 3-3 - Trichloroethene (TCE) Distribution (2023) Figure 3-4 - cis-1,2-Dichloroethene (cDCE) Distribution (2023) Figure 3-5 - Vinyl Chloride (VC) Distribution (2023) Draft Final 2022 Installation Restoration Site 26 Long Term Monitoring Report, Former Naval Air Station Moffett Field, NASA Ames Research Center (BB&E 2023) Appendix A – Mann-Kendall Test Results Section 5.4.3, 1st paragraph: A data review for the NASA RGRP was based on the following and presented in Appendix F: 2018 Annual Progress Report, NASA Ames Regional Groundwater Remediation Program, NASA Area of Responsibility and Site 28 WATS Area (ERT 2019) Figure 2-23 - Capture Zone and Plume Boundary Overlay, A1 Aquifer, September 2018 Figure 2-24 - Capture Zone and Plume Boundary Overlay, A2/B1 Aquifer, September 2018 2022 Annual Progress Report, NASA Ames Regional Groundwater Remediation Program, NASA Area of Responsibility and Site 28 WATS Area (BB&E 2023) Figure 2-13 - 2022 Estimated Iso-concentration Contours, Trichloroethene (TCE) in the A1 Aquifer Figure 2-14 - 2022 Estimated Iso-concentration Contours, Trichloroethene (TCE) in the A2/B1 Aquifer Figure 2-23 - Capture Zone and Plume Boundary Overlay, A1 Aquifer, September 2022 Figure 2-24 - Capture Zone and Plume Boundary Overlay, A2/B1 Aquifer, September 2022 Appendix L - Mann-Kendall Statistical Results Summary Table 2-11 - Mann-Kendall Summary Statistics	1
6b	Alana Lee and Yvonne Fong	General Comment	b. Include a discussion of the capture zone analysis in the Data Review section and include select figures from the NASA RGRP Annual Progress Report demonstrating capture in an Appendix.	Jonathan Grimes, Brian Reddig, and Garrett Turner	The text below will be added in Section 5.4.3 Data Review following the sixth paragraph to the discussion of capture zone analysis, and appropriate supporting figures will be included in Appendix F (new appendix; see above Response to Comment 6a.). "The summary table below presents this trend. All Wells (130) PCE (% of Wells) TCE (% of Wells) cDCE (% of Wells) VC (% of Wells) Increasing 2% 8% 6% 18% Decreasing 13% 35% 43% 19% Stable 85% 56% 51% 62% Non-detect 58% 19% 11% 28% The groundwater remedy is performing as intended. Graphical flow net analysis, capture zone width calculations, spatial distribution analysis, and contour mapping provide converging lines of evidence that the NASA GWTS and Site 28 WATS area source control wells are achieving adequate hydraulic control of the targeted treatment zones. The source control wells are suitably located in high-concentration areas to maximize mass removal while maintaining hydraulic control of the majority of the plume's margins. However, if groundwater contaminants at concentrations exceeding the cleanup standards continue to flow from upgradient source(s), then the remedial objective of restoring groundwater quality to below the cleanup standards would not be achieved. Three areas have been identified that contain chemical concentrations above cleanup levels and lie outside of the estimated zone of hydraulic containment. These areas are: The eastern margin of the plume in the A1 Aquifer in Site 28 beneath and northeast of Hangar 1. The leading edge of the plume in the A1 Aquifer in NASA's Area of Responsibility down-gradient of extraction well NASA-3A. The leading edge of the plume in the A2/B1 Aquifer in NASA's Area of Responsibility down-gradient of MEW extraction well REG-9B1. Historical plume mapping and capture zone estimates have identified these conditions for many years. Although portions of the plume extend outside of mapped capture, no expansion in the plume boundaries have been observed. Contaminant trends calculated using the Mann-Kendall method indicate that a large majority of wells show stable or non-detectable concentrations. Decreasing concentration trends in TCE and cDCE are present in over one-third of all wells, signifying that active dechlorination is occurring within the plume."	1
7a	Alana Lee and Yvonne Fong	ES-iv	Executive Summary, page iv. a. Revise the text to explain and state whether the Five-Year Review is a statutory, policy or discretionary review.	Jonathan Grimes, Brian Reddig, and Garrett Turner	The following sentence, in the second paragraph after the second sentence of the Executive Summary, will be revised to, "This FYR is an EPA policy requirement as hazardous substances, pollutants, or contaminants remain at the sites above levels that allow for unlimited use and unrestricted exposure and achieving the remedial action objectives (RAOs) and remediation goals (RGs) will take longer than five years."	1
7b	Alana Lee and Yvonne Fong	ES-iv	**b.** Include a brief statement about how Site 2 relates to Site 1 (see also Table 1-1 of the previous Five-Year Review).	Jonathan Grimes, Brian Reddig, and Garrett Turner	The following statement explaining the relationship between Site 2 to Site 1 will be added in Table ES-1 and Table 1-1. "Note: The IR Site 2 landfill was excavated in 1997, and approximately 23,000 cubic yards of refuse were transferred to the IR Site 1 landfill and consolidated with the IR Site 1 landfill contents. Three years of post-excavation monitoring showed that groundwater had not been adversely affected by these activities at IR Site 2, and groundwater monitoring was discontinued with concurrence from USEPA and the State of California Regional Water Quality Control Board, San Francisco Bay Region (Water Board). No further action is required at the IR Site 2 former landfill. "	1

DRAFT REVIEW FORM

Project Name: 02084001 NASA ARC ESS Five Year Review Report
Contract Number GS00Q14OADS144, Task Order 80ARC020F0036
Comment Codes: **1 = Accepted - Change will be reflected in the next version of the report.**
2 = Not Incorporated - Rationale provided in response
3 = Unresolved - Further discussion needed during comment review teleconference

Review Document Name: Appendix D - NASA ARC FYR (2019-203) RTC Table
Date: 6/27/2025

Project Manager Garrett Turner

Comment No.	Comment By	Page no., Figure no., Table no.	Review Comment	Responder	Reponse to Comment	Comment Code
8a	Alana Lee and Yvonne Fong	Site Status, page vii	Summary Form. a. Site Status, page vii. Clarify that while construction for specific sites/OUs has been completed, the overall Site-wide (fence line-to-fence line) construction has not yet been completed.	Jonathan Grimes, Brian Reddig, and Garrett Turner	The following text will be added in the SUMMARY FORM, SITE STATUS, Construction completion date: will be revised to include the following statement, "Note: While construction for specific sites/OUs has been completed, the overall Site-wide (fence-to-fence) construction was not completed during this review period."	1
8b	Alana Lee and Yvonne Fong	Review Period, page ii	b. Review Period, page vii. The "Review period" should correspond to the start and end dates associated with the preparation of the Five-Year Review report, not the actual timeframe which the report covers.	Jonathan Grimes, Brian Reddig, and Garrett Turner	In the SUMMARY FORM, Review period: the text will be revised to reflect the start and end dates associated with the preparation of the report; that is "August 8, 2024, to February 12, 2025".	1
8c	Alana Lee and Yvonne Fong	Issues-NASA LUCS, page ix, last line	c. Issues -NASA LUCS, page ix, last line. Delete the statement "before EPA will give them release from becoming a PRP at the site". This is not accurate. The Environmental Issues Management Plan (EIMP) provides acknowledgment that the lessee understands reasonable steps to be taken to not interfere with the existing remedies. This is part of establishing status as a Bona Fide Prospective Lessee, but it does not provide a release per se from potential liability.	Jonathan Grimes, Brian Reddig, and Garrett Turner	The statement "...before EPA will give them release from becoming a PRP at the site" will be deleted. See RTC 3. above.	1
8d	Alana Lee and Yvonne Fong	Long-Term Protectiveness Follow Up Actions - LUCS, page xi	d. Long-Term Protectiveness Follow Up Actions -LUCs, page xi: Explain the reference to "Environmental Permit Requirements." EPA supports development of specific requirements that align with the LUC and IC needs and agrees that incorporation of those environmental requirements into the permit process is necessary to maintain long term protectiveness. Clarify whether the Environmental Permit Requirements referenced are a determined set of requirements or are still to be developed.	Jonathan Grimes, Brian Reddig, and Garrett Turner	The text in Long-Term Protectiveness Follow-Up Actions, for the NASA LUCs, page xi and Section 5.6.3 of the 3rd paragraph from the end of the section will be revised to, " Some construction and/or redevelopment activities conducted by other parties (tenants, resident agencies, etc.), are not managed by NASA's Construction Permit Review Board and receive an alternate review with regards to environmental impacts related to those activities. These projects do receive a complete NEPA review process, including the establishment of a Record of Environmental Consideration (REC) for each project."	1
8e	Alana Lee and Yvonne Fong	Protectiveness Statement for NASA LUCS, page xii	e. Protectiveness Statement for NASA LUCs, page xii. The protectiveness statement for NASA LUCs seems to conflate engineered remedies and institutional controls. The status of the plumes, the fact that there is treatment of groundwater contamination, and the existence of biotic barriers are not LUCs. Protectiveness of LUCs should discuss the administrative and legal mechanisms in place to protect the remedy and control exposure and should be included along with the protectiveness statement for each site/OU.	Jonathan Grimes, Brian Reddig, and Garrett Turner	The text in Protectiveness Statement for the NASA LUCs, page xii and Section 8.6 in Table 8-6 will be revised to, "The remedy for NASA's LUCs is currently protective of human health and the environment through NASA's LUCs implementation and monitoring plan. This plan (updated in 2023) implements the use of NASA's environmental resources document, master plan, environmental management procedural requirements, design review program, construction permit reviews, environmental issues management plan, requirement of provisions for environmental requirements in leases, and a LUCs map."	1
9a	Alana Lee and Yvonne Fong	Section 5.6.3, Data Review of LUCs, page 68	Section 5.6.3, Data Review of LUCs, page 68. a. This section is very cursory. This section should explain whether Institutional Controls were implemented and enforced appropriately for each site. It would be helpful to explain whether there is a system to evaluate the implementation of the LUCs.	Jonathan Grimes, Brian Reddig, and Garrett Turner	Section 5.6.3 following the 2nd sentence will be revised as follows: Navy Site 1 Landfill Prohibit landfill cap disturbance. Maintain fencing and signage. Operate and maintain Building 191 pump station and drainage system. Restrict domestic groundwater use. Navy Site 14 South No residential land use: The site cannot support residential use due to potentially unacceptable vapor intrusion from residual contamination in soil vapor and groundwater. No grading, excavation, or subsurface activities without a risk management plan: Any work involving soil excavation, trenching, or groundwater contact must be conducted pursuant to a risk management plan that is acceptable to Regional Water Board staff. No shallow groundwater use: Shallow groundwater beneath the site should not be used for drinking water or for landscaping or garden irrigation without further assessment due to the presence of diminishing residual contamination. Real estate documents: Include Water Board's 15SEPT2022-letter conferring NFA status in all real estate disclosure, lease and transfer documents pertaining to this site. Navy Site 22 Landfill Protect the structural aspects of the landfill cap (biotic barrier) by restricting activities that could potentially disturb the cap. Maintain vegetation, topsoil layer, irrigation system, and drainage components, including surface contours, encompassed within and adjacent to the Site 22 remedy boundary. Maintain and operate the Building 191 pump station. Prohibit the extraction of groundwater from Site 22. Prohibit residential land use of the site and obtain regulatory approval for consideration of alternative land use. Include a restrictive covenant in the deed for conveyance of any portion of the Site 22 landfill to include LUCs. Navy Site 26, Restrict domestic groundwater use. Address vapor intrusion in new construction or modifications to existing structures. Navy Site 28, NASA Ames implementation of domestic groundwater use restrictions. Navy Site 29 Hangar 1, Protect the remedy through restrictions on site access, activities and use, including site development or modifications to the Hangar 1 structure. Incorporate LUCs into all current and prospective lease agreements. Ensure building inhabitants are notified of potential exposure hazards. Address worker exposure hazards and require post-construction repairs over the coating for building modifications. Provide a restrictive covenant in the deed for conveyance of any portion of the Hangar 1 site to include LUCs. Former NAS Moffett Field Area of MEW Regional Plume (Groundwater) NASA Ames implementation of domestic groundwater use restrictions. Former NAS Moffett Field Area of MEW Regional Plume VI Study Area Incorporate requirements for vapor intrusion engineering controls in future construction (or modifications to existing buildings) in permitting and building design processes. Establish Recorded Agreements to ensure installation and operation of vapor intrusion engineering controls. Provide information on vapor intrusion to future owners, lessees, and tenants. Provide information regarding building and occupancy changes to EPA.	1
9b	Alana Lee and Yvonne Fong	Section 5.6.3, Data Review of LUCs, page 68	b. The Five-Year Review Report cites to "abridged reviews" of construction and redevelopment activities that may not capture the environmental concerns at the locations of those activities. "NASA utilizes a construction permit review process to identify environmental impacts of construction projects within the NASA LUCs. However, it appears that some construction and/or redevelopment activities conducted by other parties (tenants, resident agencies, etc.) may receive an abridged review with regards to environmental impacts related to those activities. NASA will need to continue to maintain its engagement and visibility with other parties planning during the permit phase of construction activities to maintain the protectiveness of the remedy in relation to these projects." Explain how NASA is putting a system in place to evaluate whether this concern is being addressed with a notification process or other mechanism.	Jonathan Grimes, Brian Reddig, and Garrett Turner	The text in Section 5.6.3 of the 3rd paragraph from the end of the section will be revised to, "Some construction and/or redevelopment activities conducted by other parties (tenants, resident agencies, etc.)are not managed by NASA's Construction Permit Review Board and receive an alternate review with regards to environmental impacts related to those activities. These projects do receive a complete NEPA review process, including the establishment of a Record of Environmental Consideration (REC) for each project."	1

DRAFT REVIEW FORM

Project Name: 02084001 NASA ARC ESS Five Year Review Report
Contract Number GS00Q14OADS144, Task Order 80ARC020F0036
Comment Codes: **1 = Accepted - Change will be reflected in the next version of the report.**
2 = Not Incorporated - Rationale provided in response
3 = Unresolved - Further discussion needed during comment review teleconference

Review Document Name: Appendix D - NASA ARC FYR (2019-203) RTC Table
Date: 6/27/2025

Project Manager Garrett Turner

Comment No.	Comment By	Page no., Figure no., Table no.	Review Comment	Responder	Reponse to Comment	Comment Code
10	Alana Lee and Yvonne Fong	Table 7-3, Site 26 Summary of Issues, Recommendations, and Actions, page 83	Table 7-3, Site 26 Summary of Issues, Recommendations, and Actions, page 83: The regulatory agencies have requested that NASA and the Navy pursue sub-slab sampling beneath Hangar 3 which was previously proposed by the Navy, but not completed, due to the risk of the seismic instability of the structure. With the current, ongoing demolition of Hangar 3, there is an opportunity to resolve the data gap of unidentified sources under the Hangar. Without data from beneath the footprint of Hangar 3, the institutional controls established by the ROD Amendment will continue to require that property owners and developers: - Design and construct any new building over the groundwater plume at IR Site 26 in a manner that will mitigate potential unacceptable health risks from vapor intrusion, or - Evaluate and demonstrate that there are no potential unacceptable vapor intrusion risks prior to construction with all vapor intrusion risk evaluations requiring written approval by the regulatory agencies.	Jonathan Grimes, Brian Reddig, and Garrett Turner	NASA will continue to engage with the Navy to complete the sub-slab sampling beneath Hangar 3. NASA understands without this data, the institutional controls established by the ROD Amendment will continue to impose mitigation requirements on property owners and developers.	3
11	Alana Lee and Yvonne Fong	Review Period, page ii	REFERENCES EPA, 2012. Clarifying the Use of Protectiveness Determinations for Comprehensive Environmental Response, Compensation, and Liability Act Five-Year Reviews. OSWER 9200.2.111. September 13. EPA, 2019. Interim Recommendations to Address Groundwater Contaminated with Perfluorooctanoic Acid and Perfluorooctanesulfonate. OLEM Directive No 9283.1-47. December 19. EPA, 2024. Fifth Five-Year Review Report for Middlefield-Ellis-Whisman Superfund Study Area, Mountain View and Moffett Field, Santa Clara County, California. September 30. DOD, 2019. Investigating Per- and Polyfluoroalkyl Substances within the Department of Defense Cleanup Program. October 15. DOD, 2020. Per-and Polyfluoroalkyl Substances Sampling of Department of Defense Drinking Water Systems. March 2.	Jonathan Grimes, Brian Reddig, and Garrett Turner	The reference sections and text will be updated to include references to EPA 2019; EPA 2024; DOD 2019; and DOD 2020 documents. EPA 2012 was already referenced in the document and included in the reference section. The reference, "Tetra Tech, Inc. 2023. Final Per- and Polyfluoroalkyl Substances Site Inspection Report for Ames Research Center. April." will be added.	1
December 2024 Comments and January 2025 Responses						
12	Alana Lee and Yvonne Fong	Comment to Response 1	For clarification, EPA considers the remedies covered by this NASA Five Year Review Report to be at least protective in the short-term because there is no direct exposure to PFAS contamination and there are no current drinking water exposures. As stated in EPA Comment 2c and acknowledged by NASA, a remedial investigation will be recommended in the Issues, Recommendations, and Follow-up Actions, which affect future protectiveness.	Jonathan Grimes, Brian Reddig, and Garrett Turner	See response in EPA Comment 15.	1
13	Alana Lee and Yvonne Fong		" PFAS were detected at a high frequency in certain PFAS analytes." Clarify this statement. It seems that this text was intended to say "PFAS were detected at a high frequency in certain soil samples."	Jonathan Grimes, Brian Reddig, and Garrett Turner	Concur. The text in the FYR will be revised accordingly to: "As summarized in Appendix E, Table 5-2, PFAS were detected at a high frequency in certain soil samples.	1
14	Alana Lee and Yvonne Fong		"Similarly, certain PFAS analytes in groundwater samples (summarized in Appendix E, Table 5-2". Should be Table 5-4, not 5-2.	Jonathan Grimes, Brian Reddig, and Garrett Turner	This will be corrected .	1
15	Alana Lee and Yvonne Fong	Comment to Response 2c	It is unclear if NASA intends to include a PFAS RI as a "Recommendation and Follow-up Action" for each of the sites named in the response. If so, then the remedy should be considered protective in the short-term, and state to ensure long-term protectiveness, a PFAS RI is needed Also, clarify the relationship of the AOPCs to the sites included in the Five Year Review.	Jonathan Grimes, Brian Reddig, and Garrett Turner	The text will be revised to, "With PFAS detected in the groundwater samples collected at Sites 1, 22, 26, 28, and NASA RGRP at varying concentrations during the 2023 PFAS SI, NASA intends to perform an RI for PFAS to further delineate the extent of contamination." The following will be noted in the "Recommendation and Follow-up Action" for each site and the RGRP. "The remedy at Site X is currently protective. Site X is located within LOI 4. NASA intends to perform a PFAS RI in LOI 4"	1
16	Alana Lee and Yvonne Fong	Comment to Response 3	The Issues, Recommendations, and Follow-up Actions are linked. If there are no issues that affect protectiveness, then include as an Other Finding. There are issues and follow-up actions identified that affect future protectiveness and should be identified .	Jonathan Grimes, Brian Reddig, and Garrett Turner	Concur. Issues, Recommendations, and Follow-up Actions will be revised .	1
17	Alana Lee and Yvonne Fong	Comment to Response 3, NASA RGRP	Clarify how this impacts the protectiveness of the remedy such that it should be included as a recommendation or follow-up action for the RGRP.	Jonathan Grimes, Brian Reddig, and Garrett Turner	This has been moved to "Other Findings" and text will be revised to, "No recommendations of follow-up actions were identified."	1
18	Alana Lee and Yvonne Fong	Comment to Response 3, NASA LUCS	Clarify how this impacts the protectiveness of the remedy such that it should be included as a recommendation or follow-up action for the LUCs	Jonathan Grimes, Brian Reddig, and Garrett Turner	All construction and/or redevelopment activities receive a complete NEPA review. NASA-managed activities get reviewed through NASA's Construction Permit Review Board, including final review by NASA's NEPA Manager. When construction and/or redevelopment activities are conducted by other parties (tenants, resident agencies, etc.), a complete NEPA review is conducted by NASA's NEPA Manager. Project proponents are provided notification of the applicable LUC requirements through a Record of Environmental Consideration (REC) issued by NASA's NEPA Manager. This process provides for the remedy to remain protective. Additionally, if new protections/restrictions are established, then the LUC Plan is updated to maintain protectiveness." "In addition to the LUC review, Subject Matter Experts review all construction permits to identify any NASA Environmental Permit Requirements (EPRs) that are unique to each project. The EPRs are prescribed programmatic requirements that cover Air Quality, Groundwater, Hazardous Materials, Hazardous Waste, Industrial Waste Water, Natural Resources, Noise, Soils, SPCC, and Storm Water."	1
19	Alana Lee and Yvonne Fong	Comment to Response 3, Other Findings NASA LUCS	Delete statement: Redevelopment within the Former NAS Moffett Field Area of MEW Regional Plume VI Study Area & LUC Boundary provides the greatest risk to remedy protectiveness. NASA uses the construction permit review process to identify environmental impacts to NASA construction projects. NASA has also implemented a parallel system under the Development Support Office that ensures that all construction projects are reviewed. Lessees are required to submit an Environmental Issues Management Plan (EIMP) and the EIMP includes a requirement to notify EPA in advance of any activities that will impact the groundwater plume.	Jonathan Grimes, Brian Reddig, and Garrett Turner	This statement is no longer applicable. Revised text to "No other findings were identified."	1
20	Alana Lee and Yvonne Fong	Comment to Response 4	Suggest combining into one protectiveness statement, "The groundwater remedy for the NASA RGRP and the vapor intrusion remedy for the NASA VI AOR are protective of…	Jonathan Grimes, Brian Reddig, and Garrett Turner	Text will be revised to "The groundwater remedy for the NASA RGRP and the vapor intrusion remedy for the NASA VI AOR are protective of human health and the environment because there is no direct exposure to contamination. Governmental controls are in place to prevent access to contaminated groundwater. The vapor intrusion control systems, monitoring program, and institutional controls are in place to minimize exposure risk from vapor intrusion. However, in order for the remedy to be protective in the long-term, alternative groundwater cleanup technologies should be selected to accelerate the reduction of the source of vapor intrusion. Additionally, to ensure long-term protectiveness, sampling for PFAS (per- and polyfluoroalkyl substances) in groundwater to further assess potential risk is needed."	1
21	Alana Lee and Yvonne Fong	Comment to Response 6a	Clarify and revise the text for Section 5.3.3 and Appendix F to include review of the 2021 LTMR for Site 26 if it was included in the data review. Also, the same text is duplicated here in the response.	Jonathan Grimes, Brian Reddig, and Garrett Turner	The 2021 LTMR for Site 26 was reviewed and that reference will be listed , "Draft Final 2021 Installation Restoration Site 26 Long Term Monitoring Report, Former Naval Air Station Moffett Field NASA Ames Research Center (BB&E 2022)". Additionally the 2022 report compares and discusses the 2021 data with the 2022 data.	1
22	Alana Lee and Yvonne Fong	Comment to Response 7a	As with previous Five Year Reviews, the Five Year Reviews for Moffett Field are statutory reviews. Revise the text accordingly.	Jonathan Grimes, Brian Reddig, and Garrett Turner	The text will be revised to "statutory".	1

DRAFT REVIEW FORM

Project Name: 02084001 NASA ARC ESS Five Year Review Report
Contract Number GS00Q14OADS144, Task Order 80ARC020F0036
Comment Codes: **1 = Accepted - Change will be reflected in the next version of the report.**
2 = Not Incorporated - Rationale provided in response
3 = Unresolved - Further discussion needed during comment review teleconference

Review Document Name: Appendix D - NASA ARC FYR (2019-203) RTC Table
Date: 6/27/2025

Project Manager Garrett Turner

Comment No.	Comment By	Page no., Figure no., Table no.	Review Comment	Responder	Reponse to Comment	Comment Code
23	Alana Lee and Yvonne Fong	Comment to Response 8d	imilar to the comment below regarding construction permit review (where NASA indicates that it requires more visibility in the process to maintain protectiveness). EPA's comment was to clarify what is referred to by Environmental Permit Requirements. The revised language should explain how the NEPA review process and the RECs develop and convey environmental requirements on individual projects.	Jonathan Grimes, Brian Reddig, and Garrett Turner	All construction and/or redevelopment activities receive a complete NEPA review. NASA-managed activities get reviewed through NASA's Construction Permit Review Board, including a final review by NASA's NEPA Manager. When construction and/or redevelopment activities are conducted by other parties (tenants, resident agencies, etc.), a complete NEPA review is conducted by NASA's NEPA Manager. Project proponents are provided notification of the applicable LUC requirements through a Record of Environmental Consideration (REC) issued by NASA's NEPA Manager. This process provides for the remedy to remain protective. Additionally, if new protections/restrictions are established, then the LUC Plan is updated to maintain protectiveness." "In addition to the LUC review, Subject Matter Experts review all construction permits to identify any NASA Environmental Permit Requirements (EPRs) that are unique to each project. The EPRs are prescribed programmatic requirements that cover Air Quality, Groundwater, Hazardous Materials, Hazardous Waste, Industrial Waste Water, Natural Resources, Noise, Soils, SPCC, and Storm Water."	1
24	Alana Lee and Yvonne Fong	Comment to Response 9a	This should include how these limitations are conveyed to potential users.	Jonathan Grimes, Brian Reddig, and Garrett Turner	The following bullet will be added to each Site/Area, "LUC restrictions are conveyed to the responsible user through the applicable type of lease documentation (e.g., Lease Agreement, Space Act Agreement, etc)."	1
25	Alana Lee and Yvonne Fong	Comment to Response 9a - Navy Site 22 Landfill	This should reference what is included in the restrictive covenant, i.e. preceding limitations.	Jonathan Grimes, Brian Reddig, and Garrett Turner	This existing bullet will be replaced with the following bullet, "LUC restrictions are conveyed to the responsible user through the applicable type of lease documentation (e.g., Lease Agreement, Space Act Agreement, etc)."	1
26	Alana Lee and Yvonne Fong	Comment to Response 9a - Navy Site 26	LUCs should include notification of these requirements through in real estate disclosure, lease and transfer documents related to this site.	Jonathan Grimes, Brian Reddig, and Garrett Turner	The following bullet will be added, "LUC restrictions are conveyed to the responsible user through the applicable type of lease documentation (e.g., Lease Agreement, Space Act Agreement, etc)."	1
27	Alana Lee and Yvonne Fong	Comment to resposet 9a - Navy Site 28	LUCs should include notification of these requirements through in real estate disclosure, lease and transfer documents related to this site.	Jonathan Grimes, Brian Reddig, and Garrett Turner	The following bullet will be added to each Site/Area, "LUC restrictions are conveyed to the responsible user through the applicable type of lease documentation (e.g., Lease Agreement, Space Act Agreement, etc)."	1
28	Alana Lee and Yvonne Fong	Comment to Response 9a Former NASA Moffett Field Area of MEW Regional Plume VI Study Area	This section should clarify the mechanism for providing this information to land users.	Jonathan Grimes, Brian Reddig, and Garrett Turner	The following bullet will be added, "LUC restrictions are conveyed to the responsible user through the applicable type of lease documentation (e.g., Lease Agreement, Space Act Agreement, etc)."	1
29	Alana Lee and Yvonne Fong	Comment to Response 9b	This revision conveys a different meaning than the original and does not address the concern raised in the comment (e.g., alternate review v abridged review). Originally, the FYR indicated that NASA "will need to continue to maintain its engagement and visibility" … "during the permit phase of construction activities to maintain the protectiveness of the remedy in relation to these other projects." EPA's original comment was for NASA to explain what systems are in place to ensure that NASA is engaging in projects to ensure their protectiveness. Provide how the referenced process will accomplish that.	Jonathan Grimes, Brian Reddig, and Garrett Turner	Text will be revised to, "All construction and/or redevelopment activities receive a complete NEPA review. NASA-managed activities get reviewed through NASA's Construction Permit Review Board, including a final review by NASA's NEPA Manager. When construction and/or redevelopment activities are conducted by other parties (tenants, resident agencies, etc.), a complete NEPA review is conducted by NASA's NEPA Manager. Project proponents are provided notification of the applicable LUC requirements through a Record of Environmental Consideration (REC) issued by NASA's NEPA Manager. This process provides for the remedy to remain protective. Additionally, if new protections/restrictions are established, then the LUC Plan is updated to maintain protectiveness."	1
March 2025 Comments and May 2025 Responses						
30	Alana Lee	General Comment	Use "EPA" throughout the document.	Jonathan Grimes, Brian Reddig, and Garrett Turner	This change will be incorporated.	1
31	Alana Lee	Table ES-1 NASA RGRP	Correct spelling of "Facility"	Jonathan Grimes, Brian Reddig, and Garrett Turner	This change will be incorporated.	1
32	Alana Lee	Table ES-1 NASA RGRP	Delete "Site 28" and replace with MEW.	Jonathan Grimes, Brian Reddig, and Garrett Turner	This change will be incorporated.	1
33	Alana Lee	Table ES-1 LUCS	LUCs are part of the remedy for specific sites as mentioned here. However, in the document LUCs do not need its own protectiveness statement as they are part of the individual site remedy and are the protectiveness captured there	Jonathan Grimes, Brian Reddig, and Garrett Turner	This section of the table will be deleted.	1
34	Alana Lee	Table ES-1 LUCS	Include the decision documents that require LUCs as part of the Site remedy (i.e., Site 26 ROD Amendment, MEW VI ROD Amendment)	Jonathan Grimes, Brian Reddig, and Garrett Turner	This section will be updated to include the decision documents.	1
35	Alana Lee	Table ES-1 LUCS	PRP = potentially responsible party	Jonathan Grimes, Brian Reddig, and Garrett Turner	This change will be incorporated.	1
36	Alana Lee	ES - Summary Form	No dashes are needed in the U.S. EPA ID number. NASA LUCS does not need to be called out here. It should be clear what areas are covered. Due Date is 2025	Jonathan Grimes, Brian Reddig, and Garrett Turner	The dashes will be removed, and the LUCS reference will be deleted. The Due Date will be changed to 2025.	1
37	Alana Lee	ES - Issues Table	Move PFAS statement from Other Findings to Issues for individual sites. PFAS statement should be moved to issues as it affects future protectiveness and requires follow-up action. Combined and removed NASA LUCS (not as stand-alone site). Remove statements other than PFAS as these are not issues, they are findings.	Jonathan Grimes, Brian Reddig, and Garrett Turner	The PFAS statements will be moved after checking for consistency throughout the document. Other statements will be moved to Other Findings table.	1
38	Garrett Turner	ES - Recommendations and follow-up actions Table	Remove the follow-up items for each issue identified above. If the issue was removed, so should the follow-up.	Jonathan Grimes and Brian Reddig	These statements will be deleted from the table.	1
39	Alana Lee	ES - Recommendations and follow-up actions Table	NASA RGRP and NASA VI AOR together fall under the MEW ROD and MEW VI ROD Amendment such that there is one protectiveness statement and set of issues, recommendations and follow-up actions. OK to discuss components separately in the Five-Year Review but then bring it altogether and combine.	Jonathan Grimes, Brian Reddig, and Garrett Turner	Will combine these areas and make consistent throughout the document.	1
40	Alana Lee	ES - Recommendations and follow-up actions Table	As stated previously, NASA LUCs fall under each of the sites and while it can be discussed as a whole and recommendations, follow up actions and protectiveness should be part of the site remedy.	Jonathan Grimes, Brian Reddig, and Garrett Turner	Will delete all LUC language in this section.	1
41	Alana Lee	ES - Other Findings Table	Site 1 - Clarify what the finding is.	Jonathan Grimes, Brian Reddig, and Garrett Turner	Will revamp this to add more language to describe what we are prposing to change.	1
42	Alana Lee	ES - Other Findings Table	PFAS statements should be moved to Issues as it affects future protectiveness and requires follow-up action.	Jonathan Grimes, Brian Reddig, and Garrett Turner	This change will be incorporated.	1
43	Alana Lee	ES - Other Findings Table	Site 22 - Vague statement. Clarify what the finding is.	Jonathan Grimes, Brian Reddig, and Garrett Turner	Will revamp this to add more language to describe what we are prposing to change.	1
44	Alana Lee	ES - Other Findings Table	Site 26 - Is there a recommendation/follow-up action for this statement?	Jonathan Grimes, Brian Reddig, and Garrett Turner	Will revamp this to add more language to describe what we are prposing to change.	1

DRAFT REVIEW FORM

Project Name: 02084001 NASA ARC ESS Five Year Review Report
Contract Number GS00Q14OADS144, Task Order 80ARC020F0036
Comment Codes: **1 = Accepted - Change will be reflected in the next version of the report.**
2 = Not Incorporated - Rationale provided in response
3 = Unresolved - Further discussion needed during comment review teleconference

Review Document Name: Appendix D - NASA ARC FYR (2019-203) RTC Table
Date: 6/27/2025

Project Manager Garrett Turner

Comment No.	Comment By	Page no., Figure no., Table no.	Review Comment	Responder	Reponse to Comment	Comment Code
45	Alana Lee	ES - Other Findings Table	NASA RGRP - Last sentence - this is not a finding and should be moved and identified as a recommendation and follow-up action and linked to identified issues.	Jonathan Grimes, Brian Reddig, and Garrett Turner	Will revise the specific language.	1
46	Alana Lee	ES - Other Findings Table	Delete NASA LUCS section	Jonathan Grimes, Brian Reddig, and Garrett Turner	The section will be deleted.	1
45	Alana Lee	ES - List of Tables	Add "Follow-Up" to the Summary of Issues, Recommendations, and Actions Table	Jonathan Grimes, Brian Reddig, and Garrett Turner	This will be corrected .	1
46	Alana Lee	ES - List of Tables	Delete Table 7-5 and combine with Table 7-4.	Jonathan Grimes, Brian Reddig, and Garrett Turner	This will be incorporated.	1
47	Alana Lee	ES - List of Tables	Delete Table 7-6. No NASA LUCS	Jonathan Grimes, Brian Reddig, and Garrett Turner	This will be deleted.	1
48	Alana Lee	ES - List of Tables	Delete Table 8-5 and combine with Table 8-4	Jonathan Grimes, Brian Reddig, and Garrett Turner	This will be incorporated.	1
49	Alana Lee	ES - List of Tables	Delete Table 8-6. No separate NASA LUCS protectiveness statements	Jonathan Grimes, Brian Reddig, and Garrett Turner	This will be deleted.	1
50	Alana Lee	ES - Acronyms and Abbreviations	ESI - the "I" is for inspection	Jonathan Grimes, Brian Reddig, and Garrett Turner	This will be corrected .	1
51	Alana Lee	Section 2.4.1, p. 20	NASA Moffett FFA was signed in November 2014.	Garrett Turner	No change needed. 2015 is correct.	2
52	Alana Lee	Section 2.6, p 26	NASA Moffett FFA was signed in November 2014.	Garrett Turner	No change needed. 2015 is correct.	2
53	Alana Lee	Section 3.3.4, Institutional Controls, p 41	Update to indicate that the structure has been demolished and indicate the month/year. Update throughout document as needed.	Brian Reddig	This change will be incorporated.	1
54	Alana Lee	Section 3.4, p 41	NASA Moffett FFA was signed in November 2014.	Garrett Turner	No change needed. 2015 is correct.	2
55	Alana Lee	Section 3.4.3, p 43	Update to indicate date month/year this occurred.	Brian Reddig	This change will be incorporated.	1
56	Alana Lee	Section 3.6.1, p 47	In the case of the MEW Site ROD, it is EPA ROD. Private RPs do not prepare RODs.	Jonathan Grimes, Brian Reddig, and Garrett Turner	This will be corrected .	1
57	Alana Lee	Section 5.5.3, p 74	IC should be EC (engineering control).	Jonathan Grimes, Brian Reddig, and Garrett Turner	This will be corrected .	1
58	Alana Lee	Section 6.1.2 Question B	Recommend deleting paragraphs 4-6 as to only include information relevant to the individual site since presented separately.	Jonathan Grimes, Brian Reddig, and Garrett Turner	This will be deleted.	1
59	Alana Lee	Section 6.2.2 Question B	Recommend deleting paragraphs 4-6 as to only include information relevant to the individual site since presented separately.	Jonathan Grimes, Brian Reddig, and Garrett Turner	This will be deleted.	1
60	Alana Lee	Section 6.3.2 Question B	Recommend deleting paragraphs 6-8 as to only include information relevant to the individual site since presented separately.	Jonathan Grimes, Brian Reddig, and Garrett Turner	This will be deleted.	1
61	Alana Lee	Section 6.6.2 Question B	Recommend deleting paragraphs 5-7 as to only include information relevant to the individual site since presented separately.	Jonathan Grimes, Brian Reddig, and Garrett Turner	This will be deleted.	1
62	Alana Lee	Section 7.0	Delete NASA LUCS as there are no issues, recommendations, or follow-up actions.	Jonathan Grimes, Brian Reddig, and Garrett Turner	This will be deleted.	1
63	Garrett Turner	Section 7.1, Table 7-1	This table includes all of the needed information for Issues, Recommendations, and Follow-Up Actions. No discussion after the table is needed for anything in the table. Discussion after the table will be renamed "Other Findings Discussion" and include what is currently there.	Jonathan Grimes, Brian Reddig, and Garrett Turner	This table will be revised.	1
64	Alana Lee	Section 7.1, Table 7-1	PFAS is the only identified issue for the Site 1. The others should be removed from table and presented under Other Findings.	Jonathan Grimes, Brian Reddig, and Garrett Turner	This will be revised.	1
65	Alana Lee	Section 7.1, Table 7-1	Push out the realistic date within the Five-Year Review period so that it can be completed. EPA tracks these issues, recommendations, and follow-up actions quarterly.	Garrett Turner	Change the date to 2028.	1
66	Alana Lee	Section 7.1, Table 7-1	Move 1, 2, and 3 to separate section Other Findings. Delete 4 as it is retained in the Issues, Recommendations and Follow-Up Actions table and does not need to be repeated in text/discussion.	Garrett Turner	Change to Other Findings Discussion only.	1
67	Alana Lee	Section 7.2, Table 7-2	Push out the realistic date within the Five-Year Review period so that it can be completed. EPA tracks these issues, recommendations, and follow-up actions quarterly.	Garrett Turner	Change the date to 2028.	1
68	Alana Lee	Section 7.2, Table 7-2	Move 1 to separate section "Other Findings". Delete 2 as it is retained in the Issues, Recommendations and Follow-Up Actions table and does not need to be repeated in text/discussion.	Garrett Turner	Change to Other Findings Discussion only.	1
69	Alana Lee	Section 7.3, Table 7-3	Push out the realistic date within the Five-Year Review period so that it can be completed. EPA tracks these issues, recommendations, and follow-up actions quarterly.	Garrett Turner	Change the date to 2028.	1
70	Alana Lee	Section 7.3, Table 7-3	Move 1 to separate section "Other Findings". Delete 2 as it is retained in the Issues, Recommendations and Follow-Up Actions table and does not need to be repeated in text/discussion.	Garrett Turner	Change to Other Findings Discussion only.	1
71	Alana Lee	Section 7.4, Table 7.4	Add in the "generic" PFAS that is from all the previous.	Jonathan Grimes, Brian Reddig, and Garrett Turner	This will be revised.	1
72	Alana Lee	Section 7.4, Table 7.4	Identify and separate into two issues with separate recommendations and follow up actions.	Jonathan Grimes, Brian Reddig, and Garrett Turner	This will be revised.	1

DRAFT REVIEW FORM

Project Name: 02084001 NASA ARC ESS Five Year Review Report
Contract Number GS00Q14OADS144, Task Order 80ARC020F0036
Comment Codes: **1 = Accepted - Change will be reflected in the next version of the report.**
2 = Not Incorporated - Rationale provided in response
3 = Unresolved - Further discussion needed during comment review teleconference

Review Document Name: Appendix D - NASA ARC FYR (2019-203) RTC Table
Date: 6/27/2025

Project Manager Garrett Turner

Comment No.	Comment By	Page no., Figure no., Table no.	Review Comment	Responder	Reponse to Comment	Comment Code
73	Alana Lee	Section 7.4, Table 7.4	Deleted. Statement does not belong under Recommendation and Follow-Up Action	Jonathan Grimes, Brian Reddig, and Garrett Turner	This will be revised.	1
74	Alana Lee	Section 7.4, Table 7.4 Other Findings Discussion	There is no discussion needed below the summary table. The point is that it is a summary table and it was explained in response to questions a, b, or c and why/how protectiveness is affected. Some of these findings can be included and also covered under optimization. Need to be consistent in approach and make sure the tables in the beginning and end match	Jonathan Grimes, Brian Reddig, and Garrett Turner	This will be revised.	1
75	Alana Lee	Section 7.4, Table 7.4 Other Findings Discussion	This could have been identified as an issue with a recommendation and follow-up action, but since NASA does not plan to conduct further work at this time, just include as an Other finding with the suggested follow up	Jonathan Grimes, Brian Reddig, and Garrett Turner	This will be revised.	1
76	Alana Lee	Section 7.4, Table 7.4 Other Findings Discussion	This would be a pilot study.	Jonathan Grimes, Brian Reddig, and Garrett Turner	This will be revised.	1
77	Alana Lee	Section 7.5	Recommend deleting or combining with NASA RGRP since there are no issues, recommendations and follow-up actions for NASA VI AOR.	Jonathan Grimes, Brian Reddig, and Garrett Turner	This will be combined with NASA RGRP.	1
78	Alana Lee	Section 7.6	Recommend deleting table. If keep this section, then simply note that no issues, recommendations and follow-up actions were identified.	Jonathan Grimes, Brian Reddig, and Garrett Turner	This will be deleted.	1
79	Alana Lee	Section 8.1, Table 8-1	Changed protectiveness determination to short-term protective Deleted groundwater as other media may be conducted.. Could also indicate PFAS RI to assess nature and extent of PFAS contamination as this was included in the recommendation/follow-up action needed.	Jonathan Grimes, Brian Reddig, and Garrett Turner	This will be revised in all section 8 tables.	1
80	Alana Lee	Section 8.3, Table 8-3	This is not identified as an issue and follow up action and does not match earlier protectiveness statement. IC is already in place in the event of future development. There is currently no exposure (no building). Hangar 2 has a mitigation system.	Jonathan Grimes, Brian Reddig, and Garrett Turner	This will be deleted.	1
81	Alana Lee	Section 8.4, Table 8-4	Recommend that NASA RGRP and NASA VI AOR protectiveness statement be combined as is done for Site 28 and MEW protectiveness statement.	Jonathan Grimes, Brian Reddig, and Garrett Turner	This will be combined.	1
82	Alana Lee	Section 8.5, Table 8-5	Recommend deleting separate section and protectiveness statement for NASA VI AOR as it is included with NASA RGRP	Jonathan Grimes, Brian Reddig, and Garrett Turner	This will be deleted and combined with Table 8-4.	1
83	Alana Lee	Section 8.6, Table 8-6	Recommend deleting a separate protectiveness statement for NASA LUCs. The LUCs are incorporated in the protectiveness statements for each of the individual sites/remedies.	Jonathan Grimes, Brian Reddig, and Garrett Turner	This will be deleted.	1
84	Alana Lee	Section 9 References	Change the date to 2014 for the EPA Agreement between the EPA, the State of CA, and NASA	Garrett Turner	2015 is accurate.	2
85	Alana Lee	Section 9 References	Added 2024 FYR. Moved EPA references. Should also reference Navy FYR.	Garrett Turner	Not in the time period of this FYR.	2

DRAFT REVIEW FORM

Project Name: 02084001 NASA ARC ESS Five Year Review Report
Contract Number GS00Q14OADS144, Task Order 80ARC020F0036
Comment Codes: **1 = Accepted - Change will be reflected in the next version of the report.**
2 = Not Incorporated - Rationale provided in response
3 = Unresolved - Further discussion needed during comment review teleconference

Review Document Name: Appendix D - NASA ARC FYR (2019-203) RTC Table
Date: 6/27/2025

Project Manager Garrett Turner

Comment No.	Comment By	Page no., Figure no., Table no.	Review Comment	Responder	Reponse to Comment	Comment Code
October 2024 Comments and November 2024 Responses						
1a	Mary Snow	General Comment	Based on the findings of the Final Per- And Polyfluoroalkyl Substances [PFAS] Site Inspection Report for Ames Research Center (2023), PFAS have been detected in groundwater at concentrations that exceed United States Environmental Protection Agency's (USEPA's) recently established final National Primary Drinking Water Regulation (NPDWR) (April 2024), i.e., maximum contaminant levels (MCLs). Comment 1a: The protectiveness determinations should be reevaluated for each site and evidence should be provided that demonstrates how the remedy can remain protective when not specifically designed to address impacts from PFAS. A protectiveness determination of "Protectiveness Deferred" may be appropriate for a site if evidence cannot be presented to demonstrate that the remedy remains protective of human health and the environment when the remedy was not specifically designed to address PFAS contamination. PFAS are considered emerging contaminants and should be discussed in the Draft-Final Five-Year Review, consistent with USEPA guidance, Clarifying the Use of Protectiveness Determinations for Comprehensive Environmental Response, Compensation and Liability Act Five-Year Reviews (2012) and USEPA RPM [Remedial Project Manager] Bulletin 2024-01 Considerations When Reviewing PFAS in Five-Year Reviews (2024).	Jonathan Grimes, Brian Reddig, and Garrett Turner	PFAS will be addressed in the revised Draft Final Five-Year Review Report. The results of the PFAS SI (TetraTech 2023) will be summarized in Appendix E (new appendix). The PFAS Expanded Site Investigation (ESI) will not be completed in time to incorporate any preliminary findings on the nature and extent of PFAS in the FYR. Therefore, the "Protectiveness Determination" will be deferred. The results of the PFAS SI (TetraTech 2023) will be summarized in the Five-Year Review Report. A summary of the PFAS SI will be inserted in the "Progress Since Last Review" in Section 4 and pertinent information from the 2023 PFAS SI, including data tables and figures, are presented in Appendix E (new appendix). The following summary will be added in Section 4; following the first paragraph of Section 4 and preceding Section 4.1. "Groundwater samples were collected at 26 Areas of Potential Concern (AOPCs) across Moffett Field, including Site 1, Site 2, Site 22, Site 26, NASA RGRP, and Site 28 during the 2023 PFAS SI. PFAS was detected in groundwater samples at varying concentrations at the AOPCs. Some of the PFAS concentrations detected in groundwater exceeded the 2022 USEPA RSLs and/or the California RWB groundwater ESLs. Pertinent information from the 2023 SI, including the Executive Summary and Conclusions Sections, along with supporting data Tables 5-2 and 5-7 and figures are included in Appendix E. The 2023 SI recommended that additional investigations be performed to evaluate the horizontal and vertical extents of PFAS in groundwater, routine monitoring of the treated effluent from the groundwater systems, and further evaluation of surface water impacts. As of 2024, NASA's Expanded PFAS Site Investigation (ESI) is ongoing and will not be completed during this FYR review period. Therefore, no data or information regarding any preliminary findings on the nature and extent of PFAS can be incorporated in this FYR. As summarized in Appendix E, Table 5-2, PFAS were detected at a high frequency in certain PFAS analytes. Notably, of the PFAS with established screening levels, PFOA and PFHxS were detected in 25 of the 28 collected soil samples and PFOS was detected in 23 of the 28 samples. PFOS was present in 15 of the samples at concentrations exceeding the residential RSL and PFOA was present in three of the samples at concentrations exceeding the residential RSL. Similarly, certain PFAS analytes in groundwater samples (summarized in Appendix E, Table 5-2) were detected at high frequencies. Notably, of the PFAS with established screening levels, PFHxS was detected in 75 of the 79 collected groundwater samples, while PFBS, PFOA and PFOS were detected in 71 of the 79 samples. The groundwater RSL was also exceeded at high frequencies in certain PFAS analytes, mostly notably PFOS (59 samples), PFOA (53 samples) and PFHxS (42 samples)."	1
1b	Mary Snow	General Comment	To be consistent with the 2012 USEPA guidance, the responses to "Question B: Are the exposure assumptions, toxicity data, cleanup levels, and RAOs [Remedial Action Objectives] used at the time of remedy selection still valid?" should be reevaluated in the context of PFAS detections. Additionally, "Question C: Has any other information come to light that could call into question the protectiveness of the remedy?" as well as the protectiveness determinations should be changed to "Yes" due to the presence of PFAS and reevaluated for all sites where PFAS have been detected.	Jonathan Grimes, Brian Reddig, and Garrett Turner	The Five-Year Review Report will be revised to include a discussion of PFAS as a new contaminant and reference the 2023 PFAS Site Inspection (SI) results. A comparison of SI analytical results with current EPA RSLs and MCLs is presented in Appendix E (new appendix). The following text will be added to each Question B for each Site , RGRP, VI, and LUCs in Section 6: "Although PFAS are not identified as contaminants of concern in any of the RODs, PFAS have been evaluated at certain locations on Moffett Field during this review period. PFAS has been detected in the groundwater samples collected at Sites 1 (and 2), 22, 26, 28, and NASA RGRP at varying concentrations during the 2023 PFAS SI. Some of the PFAS concentrations detected exceeded the 2022 USEPA RSLs and/or MCLs and the California RWB groundwater ESLs. In addition, one influent and one effluent sample were collected at each of the three groundwater treatment systems: AOPC 13 – NASA Groundwater Extraction Treatment System, AOPC 14 – Middlefield-Ellis-Whisman Groundwater Extraction Treatment System, and AOPC 15 – West-Side Aquifers Treatment System (IR 28). The influent sample results from all three treatment systems exceeded the 2022 groundwater USEPA RSLs and/or MCLs for PFOS, PFOA, and PFHxS as well as the State groundwater ESLs for PFOS and PFOA. The effluent sample results for AOPC 13 – NASA Groundwater Extraction Treatment System indicated an estimated concentration ("j value") of 2.5 ppt for PFOS and a field duplicate sample result of 4.1 ppt for PFOS and all other results were below the 2022 groundwater USEPA RSLs and/or MCLs for PFAS as well as the State groundwater ESLs for PFAS. The effluent sample results for AOPC 14 – Middlefield-Ellis-Whisman Groundwater Extraction Treatment System indicated exceedances of the 2022 groundwater USEPA RSLs and/or MCLs for PFOS, PFOA, and PFHxS as well as the State groundwater ESLs for PFOS and PFOA. The effluent sample results for AOPC 15 – West-Side Aquifers Treatment System (IR 28) indicated no exceedance of the 2022 groundwater USEPA RSLs and/or MCLs for PFAS as well as the State groundwater ESLs for PFAS (Tetra Tech 2023). One surface water sample was collected in addition to the influent and effluent samples. PFAS constituents were detected at varying concentrations in the surface water sample. No PFAS standards or criteria have been developed for surface water. As of 2024, NASA's ongoing Expanded Site Inspection (ESI) is to further identify potential source areas associated with PFAS contamination found during the 2023 SI. Additional investigations (e.g., Remedial Investigation) will be required to further characterize PFAS impacts in groundwater contamination at the Site."	1
2a	Mary Snow	Section 1.4, Section 4.1 Table 4-1, Section 4.2 and Table 4.2	The most up to date and regional guidance's for climate change were not considered. In conjunction with reference and guidance materials used to prepare the sections specified above, these sections should be reevaluated to include the following guidance documents: Ocean Protection Council. 2024. State of California Sea-Level Rise Guidance. Ocean Protection Council. 2022. State Agency Sea-Level Rise Action Plan for California. Department of Toxic Substances Control. 2023. Sea Level Rise Guidance to DTSC Project Managers for Cleanup Activities. Pathways Climate Institute and San Francisco Estuary Institute. 2022. Shallow Groundwater Response to Sea Level Rise: Alameda, Marin, San Francisco, and San Mateo Counties. (Includes adjacent county/regional information which is likely applicable.)	Jonathan Grimes, Brian Reddig, and Garrett Turner	Thank you for these additional documents for review. A review of these recommendations complements the references used. The recommended guidance documents: Ocean Protection Council. 2024. State of California Sea-Level Rise Guidance, Ocean Protection Council. 2022. State Agency Sea-Level Rise Action Plan for California, Department of Toxic Substances Control. 2023. Sea Level Rise Guidance to DTSC Project Managers for Cleanup Activities, and Pathways Climate Institute and San Francisco Estuary Institute. 2022. Shallow Groundwater Response to Sea Level Rise: Alameda, Marin, San Francisco, and San Mateo Counties were reviewed in conjunction with the data, model, and literary review work documented in this FYR.	1
2b	Mary Snow	Section 1.4, Section 4.1 Table 4-1, Section 4.2 and Table 4.2	We recommend that comprehensive site-specific climate vulnerability assessments be developed for each site and associated remedy within the next five-year review period. Site-specific climate vulnerability assessments should be prioritized and developed by NASA, in coordination with the regulatory agencies so that long-term planning and mitigation can be properly scoped and funded.	Jonathan Grimes, Brian Reddig, and Garrett Turner	NASA will seek funding to evaluate site-specific climate vulnerability for each site within the next five-year review period.	2
3	Mary Snow	Section 5.3.3, pp 62 and 63	It appears that current relevant and local/regional guidance were not included in the data review; therefore, it is unclear if this statement is correct. The above quoted statement should be reevaluated in the context of the guidance documents referenced in Comment 2.	Jonathan Grimes, Brian Reddig, and Garrett Turner	Data used in this FYR was sourced from 2023 National Oceanic and Atmospheric Administration (NOAA) public documentation for San Francisco Bay spanning data records from 1897 to 2023 to estimate sea-level trend. The guidance documents noted in **Comment 2** are complimentary to this information. The quoted statement has been confirmed to be correct.	1

DRAFT REVIEW FORM

Project Name: 02084001 NASA ARC ESS Five Year Review Report
Contract Number GS00Q14OADS144, Task Order 80ARC020F0036
Comment Codes: **1 = Accepted - Change will be reflected in the next version of the report.**
2 = Not Incorporated - Rationale provided in response
3 = Unresolved - Further discussion needed during comment review teleconference

Review Document Name: Appendix D - NASA ARC FYR (2019-203) RTC Table
Date: 6/27/2025

Project Manager Garrett Turner

Comment No.	Comment By	Page no., Figure no., Table no.	Review Comment	Responder	Reponse to Comment	Comment Code
4a	Mary Snow	Sections 7.1 through 7.6 and Tables 7-1 through 7-6	Please add site-specific climate vulnerability assessments and a discussion of PFAS for each site/remedy in the sections and tables specified above. Because of the uncertainty and complex planning involved, site-specific climate vulnerability assessments should be developed within the next five-year review period.	Jonathan Grimes, Brian Reddig, and Garrett Turner	Table 1-3 will be added after Table 1-2 to describe the potential mitigation measures that may be considered. It is attached for review. It has been attached at the end of this review document. As noted in response to Comment 2b, NASA will seek funding to evaluate site-specific climate vulnerability for each site within the next five-year review period. As noted in response to Comment 1a, NASA's ESI is ongoing and will not be completed during this FYR review period.	1
4b	Mary Snow	Sections 7.1 through 7.6 and Tables 7-1 through 7-6	We recommend that the current and future steps with respect to the ongoing PFAS investigations be included and discussed in these sections and tables. Although it is understood that the PFAS investigations are ongoing, the presence of PFAS in groundwater greater than recently established NPDWR MCLs calls in to question the protectiveness of the existing remedies.	Jonathan Grimes, Brian Reddig, and Garrett Turner	Please refer to response to Comment 1b.	1
5	Mary Snow	Sections 7.1 through 7.4 and Tables 7-1 through 7-4	These sections and tables include optimization and cost efficiency items that are not specifically related to the protectiveness of the existing remedies. Please remove the optimizations and/or modifications not specifically related to remedy protectiveness from Tables 7-1 through 7-4 and provide separate technical memoranda or other primary document(s) for review and concurrence by the regulatory agencies.	Jonathan Grimes, Brian Reddig, and Garrett Turner	Acknowledged. Optimizations and/or modifications do provide for equal or improved protectiveness with budgetary constraints and will therefore be retained in Tables 7-1 through 7-4.	1
6	Mary Snow	Table 7-3 Site 26	The proposed modifications to the LTM program should be delayed until a soil vapor and groundwater investigation in the area between and beneath Hangars 2 and 3 are completed; and as discussed in Comment 5 above, when appropriate such recommendations should be presented in a technical memorandum or other appropriate primary document for regulatory review. LTM optimization at Site 26 is premature, as demonstrated by the Regional Water Board's interview (Appendix B, pdf pages 372 and 373), our response to Question #2 states that "…NASA may urge the Navy to re-engage (reopen) under Hangar 3 to assess soils following its demolition/deconstruction." Further, our response to Question #7 recommended a source investigation under Hangar 3 following its demolition, including but not limited to groundwater and soil vapor. Additionally, in the Navy's Final Five-Year Review Report for NAS Moffett Field Superfund Site dated August 2020, the protectiveness statement for Site 26 (page 7-1) stated "For the IR Site 26 remedy to be protective in the long-term, a soil vapor and groundwater investigation in the area between and beneath Hangars 2 and 3 must be completed. In addition, as a result of this investigation, follow-on in situ treatment, modifications to the ICs [institutional controls], and/or revisions to the long-term monitoring program may be needed."	Jonathan Grimes, Brian Reddig, and Garrett Turner	Acknowledged. "NASA's LUCs implementation and monitoring plan (updated in 2023) implements the use of NASA's environmental resources document, master plan, environmental management procedural requirements, design review program, construction permit reviews, environmental issues management plan, requirement of provisions for environmental requirements in leases, and a LUCs map." LTM modifications do provide for equal protectiveness with cost savings to address budgetary constraints and will therefore be retained in Table 7-3. LTM modifications are separate and complimentary to a soil vapor, soil, and groundwater investigation for understanding protectiveness in this area. The proposed LTM optimization would provide more timely and representative data than provided by the current LTM network. Review of data obtained since the Navy's establishment of the LTM network indicates that a more appropriate well network and frequency of sampling is warranted. NASA will continue to encourage the Navy to perform a source investigation of soil vapor, soils, and groundwater at Site 26 at previously inaccessible locations.	1
7	Mary Snow	Table 8-3 Site 26	Due to the data gap as described/discussed in Comment 6 above the protectiveness determination of "Protective" is not adequately supported. Additional detail should be presented to demonstrate that "Protective" is the appropriate protectiveness determination, otherwise, "Protectiveness Deferred" or "Short-term Protective" may be more appropriate for the Site 26 remedy.	Jonathan Grimes, Brian Reddig, and Garrett Turner	Acknowledged. NASA has LUC implementation and monitoring plan for these potential risks. -- Table 8-3 will be revised to read as: Short-term Protectiveness Statement: The remedy for Site 26 is protective of human health and the environment. Groundwater contaminant plumes are stable or decreasing and potential exposure pathways are incomplete. Reductive dechlorination is still active and MNA is still viable. Land Use Control implementation and monitoring are protective to human health. Long-term Protectiveness Statement For the IR Site 26 remedy to be protective in the long-term, a soil vapor and groundwater investigation in the area between and beneath Hangars 2 and 3 must be completed. In addition, as a result of this investigation, follow-on in situ treatment, modifications to the ICs [institutional controls], and/or revisions to the long-term monitoring program may be needed.	1
December 2024 Comments and January 2025 Responses						
8	Mary Snow	Comment to Response 1a	Please provide clarity with respect to where in the Draft Final Five-Year Review the protectiveness determination(s) will be updated to state that protectiveness is "deferred" due to the presence of Per- and Polyfluoroalkyl Substances (PFAS). A figure should be provided that depicts both the Record of Decision sites/remedies and the PFAS Areas of Potential Concern (AOPCs) to provide geographic context between the two.	Jonathan Grimes, Brian Reddig, and Garrett Turner	The text will be revised to, "With PFAS detected in the groundwater samples collected at Sites 1, 22, 26, 28, and NASA RGRP at varying concentrations during the 2023 PFAS SI, NASA intends to perform an RI for PFAS to further delineate the extent of contamination." The following will be noted in the "Recommendation and Follow-up Action" for each site and the RGRP. "The remedy at Site X is currently protective. Site X is located within LOI 4. NASA intends to perform a PFAS RI in LOI 4" A figure has been created and will be included in Appendix E.	1

Appendix E

Summary of Results: Tetra Tech 2023 PFAS SI

PFAS information from "*Final Per- and Polyfluoroalkyl Substances Site Inspection Report for Ames Research Center*" (Tetra Tech, Inc. 2023) to support Five-Year Review PFAS discussion and address EPA General Comment 2.

Figure 1-2 Overview of Areas of Potential Concern
Figure A Locations of Interest and Areas of Potential Concern
Figure B Locations of Interest and Installation Restoration Sites
Table 5-2 PFAS Soil Frequencies of Detection
Table 5-4 PFAS Groundwater Frequencies of Detection
Table 5-7 PFAS Analytical Results for Water Treatment Systems

<u>Section 6 Conclusions And Recommendations</u>

6.1 AOPC 1 – Former Firefighting Training Area (IR 10, 12, 20)
6.2 AOPC 2 – Crash Site (Sunnyvale Golf Course)
6.3 AOPC 3 – Hangars 2 And 3 (IR 7)
6.4 AOPC 4 – Former Engine Test Stand Area (IR 11)
6.5 AOPC 5 – Hangar N211 (Within AOI 3, Formerly AOI 12)
6.6 AOPC 6 – Hangar N248 (AOI 3 East)
6.7 AOPC 7 – Fire Department (Building 580)
6.8 AOPC 8 – Site 1 Runway Landfill (IR 1)
6.9 AOPC 9 – Site 2 Former Golf Course Landfill (IR 2)
6.10 AOPC 10 – Site 22 Landfill (IR 22)
6.11 AOPC 11 – Building 191 Pump Station
6.12 AOPC 12 – Stormwater Settling Basin/Eastern Diked Marsh (Within IR 25)
6.13 AOPC 13 – Nasa Groundwater Extraction Treatment System
6.14 AOPC 14 – Middlefield-Ellis-Whisman Groundwater Extraction Treatment System
6.15 AOPC 15 – West-Side Aquifers Treatment System (IR 28)
6.16 AOPC 16 – North Patrol Road Ditch (IR 21) And Northern Channel (IR 27)
6.17 AOPC 17 – Marriage Road Ditch (IR 3)
6.18 AOPC 18 – Lindbergh Avenue Storm Drain Ditch (AOI 6)
6.19 AOPC 19 – Stormwater Retention Ponds (Within IR 25)
6.20 AOPC 20 – Building N271 Industrial Wastewater Pretreatment Plant
6.21 AOPC 21 – Former Industrial Wastewater Surface Impoundment (IR 4)
6.22 AOPC 22 – Building N249 Outdoor Aerodynamic Research Facility
6.23 AOPC 23 – Hangar 4 (Cang) Building 662
6.24 AOPC 24 – Middlefield-Ellis-Whisman (Mew) Plume
6.25 AOPC 25 – Orion Park Plume
6.26 AOPC 26 – Eastern Boundary (IR 5)
6.27 Path Forward

National Aeronautics and Space Administration

PER- AND POLYFLUOROALKYL SUBSTANCES
SITE INSPECTION REPORT
FOR
AMES RESEARCH CENTER

Prepared for:
National Aeronautics and Space Administration
Headquarters
Washington, DC 20546

Prepared by:
Tetra Tech, Inc.
661 Andersen Drive
Pittsburgh, PA 15220
(412) 921-7090

April 2023

Final

**PER- AND POLYFLUOROALKYL SUBSTANCES
SITE INSPECTION REPORT
FOR
AMES RESEARCH CENTER**

Final

Prepared for:
National Aeronautics and Space Administration
Headquarters
Washington, DC 20546

Prepared by:
Tetra Tech, Inc.
661 Andersen Drive
Pittsburgh, PA 15220

Prepared by: Kevin Bricknell
Kevin Bricknell, P.E.
Project Manager
Tetra Tech, Inc.

Approved by: Mark P Speranza
Mark Speranza
Program Manager
Tetra Tech, Inc.

April 2023

EXECUTIVE SUMMARY

This Site Inspection (SI) is part of an ongoing effort to identify sources and presence of per- and polyfluoroalkyl substances (PFAS) at the National Aeronautics and Space Administration (NASA) Ames Research Center (ARC) in Mountain View, California. Tetra Tech, Inc. (Tetra Tech) prepared this document for NASA. PFAS SI activities at ARC were conducted in accordance with the PFAS SI Work Plan (SIWP), but with some modifications, which are discussed in Section 4.7 of this report. The SIWP was included as an appendix to the ARC PFAS Preliminary Assessment (PA) Report (PAR) (Tetra Tech 2021a) and is also in Appendix A to this report for reference.

In May 2016, the United States Environmental Protection Agency (USEPA) issued a lifetime drinking water health advisory (HA) level for two PFASs (perfluorooctanoic acid [PFOA] and perfluorooctanesulfonic acid [PFOS]). In June 2022, USEPA Office of Land and Emergency Management issued interim updated drinking water lifetime HAs for PFOA and PFOS, and issued new lifetime drinking water HAs for perfluorobutanesulfonic acid (PFBS) and hexafluoropropylene oxide dimer acid (HFPO-DA), also known as GenX. Federal regional screening levels (RSLs) also have been established for soil and groundwater for PFOA, PFOS, PFBS, perfluorononanoic acid (PFNA), perfluorohexanesulfonic acid (PFHxS), and HFPO-DA. The purpose of RSLs is to aid in decision-making concerning Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) investigations, and to help make the determination if chemical levels in site media warrant further investigation based on these risk-based levels or no further investigation is needed. As such, the RSLs are appropriate to use as screening criteria for this PFAS SI. The most recent RSL table, issued in May 2022, was used for screening in this SI report.

In California as well, health-based advisory values for drinking water and screening levels for soil and groundwater have been developed for PFOA and PFOS. In July 2018, the California State Water Resources Control Board (CSWRCB) Division of Drinking Water (DDW) established drinking water Notification Levels (NLs) for PFOS and PFOA. Information on California's advisory and screening levels is included in this report.

A PFAS PA at ARC between 2019 and 2020 occurred as part of an Agency-wide effort to identify areas of potential concern (AOPCs) at NASA Centers/Facilities. A PAR/SIWP was generated by use of information gathered from literature searches (facility documents), web-based searches (aqueous film-forming foam [AFFF] manufacturer specifications and PFAS use, regulations, and health effects), and site interviews/reconnaissance. Potential PFAS sources at NASA ARC included areas where AFFF had been used (e.g., fire-fighting training areas, equipment test areas, crash sites, fire suppression systems, and storage and transfer areas), electroplating facilities, areas that had received waste (e.g., landfills, waste disposal areas, and water treatment systems), and other potential sources (e.g., certain detergents, aviation hydraulic fluids, and manufacture of photographic supplies).

The PAR/SIWP identified 23 on-site (AOPCs 1 through 23), two off-site AOPCs (AOPCs 24 and 25), and one on- or off-site source (AOPC 26) where PFAS could be a concern. At 12 AOPCs within ARC (AOPCs 1, 2, 5 through 7, 11, 12, 16 through 19, and 23), the primary source of PFAS was AFFF. AFFF use or releases resulted from firefighting training activities, aircraft crashes, accidental AFFF discharges at four hangars, use by the fire department's mobile AFFF units, and releases into four stormwater ditches and systems and two National Pollutant Discharge Elimination System (NPDES) stormwater discharge points. Non-AFFF sources with potential PFAS use or releases were identified at 12 AOPCs (AOPCs 3, 4, 8 through 10, 13 through 15, 20 through 22, and 26). Non-AFFF sources with potential PFAS use or releases included three former unlined landfills, five hydraulic fluid disposal or related-use sites, one fuel storage area, vapor, and brine from an industrial wastewater pretreatment plant (IWPP), and three groundwater extraction systems that treat volatile organic compounds (VOCs) potentially commingled with PFAS.

Within a 1-mile radius of ARC, non-AFFF sources with a potential PFAS release were identified at three AOPCs (AOPCs 24 through 26) where semiconductor and metal finishing operations had occurred over the Middlefield-Ellis-Whisman (MEW) regional plume, a trichloroethene

(TCE) plume migrating from Orion Park, and where discharges of PFAS could have come from the adjacent Lockheed Martin facility.

The PAR/SIWP detailed project objectives, field inspection rationale and methodology, and reporting requirements for the SI. The SIWP recommended sampling all 26 AOPCs identified as potential PFAS source areas at ARC. These areas were selected based on known historical or suspected use of AFFF and/or protein-based foams, other sources of PFAS, and PFAS data previously collected at NASA ARC. The primary objectives of the SI were to inspect each identified potential source area for presence of PFAS as outlined in the SIWP, compare PFAS concentrations to screening levels (as applicable), and determine whether further investigation would be warranted. SI results will guide additional investigations and potential actions to mitigate exposure to PFAS-containing media. Areas recommended for SI included:

- AOPC 1 – Former Firefighting Training Area (Installation Restoration [IR] 10, 12, and 20)
- AOPC 2 – Crash Site (Sunnyvale Golf Course)
- AOPC 3 – Hangars 2 & 3 (IR 7)
- AOPC 4 – Former Engine Test Stand Area (IR 11)
- AOPC 5 – Hangar N211 (within Area of Interest [AOI] 3, formerly AOI 12)
- AOPC 6 – Hangar N248 (AOI 3 East)
- AOPC 7 – Fire Department (Building 580)
- AOPC 8 – Site 1 Runway Landfill (IR 1)
- AOPC 9 – Site 2 Former Golf Course Landfill (IR 2)
- AOPC 10 – Site 22 Landfill (IR 22)
- AOPC 11 – Building 191 Pump Station
- AOPC 12 – Stormwater Settling Basin/Eastern Diked Marsh (EDM) (within IR 25)
- AOPC 13 – NASA Groundwater Extraction Treatment System (GWETS)
- AOPC 14 – MEW GWETS
- AOPC 15 – West-Side Aquifers Treatment System (WATS) (IR 28)
- AOPC 16 – North Patrol Road Ditch (IR 21) and Northern Channel (IR 27)
- AOPC 17 – Marriage Road Ditch (IR 3)
- AOPC 18 – Lindbergh Avenue Storm Drain Ditch (AOI 6)
- AOPC 19 – Stormwater Retention Ponds (within IR 25)

- AOPC 20 – Building N271 IWPP
- AOPC 21 – Former Industrial Wastewater Surface Impoundment (IR 4)
- AOPC 22 – Building N249 Outdoor Aerodynamic Research Facility
- AOPC 23 – Hangar 4 (CANG) Building 662
- AOPC 24 – MEW Plume
- AOPC 25 – Orion Park Plume
- AOPC 26 – Eastern Boundary (IR 5)

Tetra Tech conducted field activities supporting the SI from July 7 to August 18, 2021. Sampled media included soil (surface and subsurface [from surface to 2 feet below ground surface {bgs}]), groundwater (existing and new permanent monitoring wells), and influent/effluent of water treatment systems. BB&E later performed surface water sampling on November 12, 2021, when sufficient precipitation allowed accumulation of enough surface water for adequate sample collection. Tetra Tech received surface water data for inclusion in this report. Pace Laboratory analyzed all PFAS samples via a method compliant with Table B-15 of the United States Department of Defense (DoD) Quality Systems Manual (QSM) version 5.3. The 28 PFAS compounds in the USEPA Method 537.1 list were analytes which included PFAS compounds from CSWRCB order for determination of PFAS at chrome plating facilities. Of the 28 PFAS compounds, analytical results detected the following 24 PFAS analytes:

1. 4:2 fluorotelomer sulfonate
2. 6:2 fluorotelomer sulfonate
3. 8:2 fluorotelomer sulfonate
4. PFOA
5. PFOS
6. PFBS
7. perfluorobutanoic acid (PFBA)
8. perfluorodecanoic acid (PFDA)
9. perfluorododecanoic acid (PFDoA)
10. perfluorodecanesulfonic acid (PFDS)
11. perfluoroheptanesulfonic acid (PFHpS)
12. perfluoroheptanoic acid (PFHpA)

13. perfluorohexanoic acid (PFHxA)
14. PFHxS
15. PFNA
16. Perfluorononanesulfonic acid (PFNS)
17. Perfluorooctane sulfonamide (FOSA)
18. Perfluoropentanoic acid (PFPEA)
19. Perfluoropentanesulfonic acid (PFPES)
20. perfluorotetradecanoic acid (PFTeA)
21. perfluorotridecanoic acid (PFTrDA or PFTfIA)
22. perfluoroundecanoic acid (PFUnA)
23. n-ethyl perfluorooctanesulfonamidoacetic acid (NEtFOSAA)
24. HFPO-DA, also known as GenX

PFAS concentrations in soil and groundwater samples were compared to applicable human health-based screening levels to determine where further investigation would be necessary. The groundwater screening levels used in this SI include the USEPA RSL of 4 nanograms per liter (ng/L) for PFOS, 6 ng/L for PFOA, 5.9 ng/L for PFNA, 39 ng/L for PFHxS, 600 ng/L for PFBS, and 6 ng/L for HFPO-DA. Data also were screened against the CSWRCB and San Francisco Bay Regional Water Quality Control Board (Regional Water Board) Interim Environmental Screening Levels (ESL) for PFOA (5.1 ng/L) and PFOS (6.5 ng/L).

Soil screening levels used in this SI include the USEPA RSL of 13 micrograms per kilogram (µg/kg) for PFOS, 19 µg/kg for PFOA and PFNA, 130 µg/kg for PFHxS, 1,900 µg/kg for PFBS, and 23 µg/kg for HFPO-DA. Soil screening levels also include the CSWRCB interim ESL of 3.8 µg/kg (human health) and 84 µg/kg (ecological) for PFOA, and 12 µg/kg (human health) and 13 µg/kg (ecological) for PFOS (CSWRCB 2020a, Regional Water Board 2020).

No USEPA PFAS screening levels have been established for surface water or influent/effluent. As a result, surface water data acquired during the SI appear in this report but are not compared to any screening levels. Influent/effluent results were compared to USEPA and State groundwater screening levels for evaluation purposes only. At ARC, discharges of surface water from Building 191 pump station (AOPC 11) flow east and are pumped over a dike and directly discharged to the Guadalupe Slough. Treated water from NASA GWETS (AOPC 13) and MEW GWETS (AOPC 14) either discharges to Stevens Creek or is treated via reverse osmosis at the Building N271 IWPP (AOPC 20) and then used for the ARC Jet Complex before discharge into the Palo Alto Sanitary Sewer. Treated water from the WATS (AOPC 15) is discharged into the storm drains where it flows through the EDM (AOPC 12) into the Stormwater Retention Pond (SWRP).

Conclusions and recommendations for each AOPC are below, with detected concentrations of PFAS compared to State of California ESLs and USEPA RSLs. Figures included in this report present PFAS data, which are compared to USEPA RSLs, as applicable. The tables included in this report include full PFAS datasets, which are compared to USEPA and State ESLs, as applicable.

AOPC 1 – Former Firefighting Training Area (IR 10, 12, 20)

- **Soil**: PFOS was detected at a maximum concentration of 920 µg/kg, and at concentrations exceeding the soil RSL of 13 µg/kg in five samples and above the human health and ecologic ESLs of 12 and 13 µg/kg, respectively, in five samples. PFOA was detected at maximum concentration of 120 µg/kg, and at concentrations exceeding the human health ESL of 3.8 µg/kg in five samples. PFOA concentrations exceeded the ecologic ESL of 84 µg/kg in one sample. PFOA exceeded the soil RSL of 19 µg/kg in three samples. There were no exceedances of the RSL by concentrations of PFNA, PFHxS, HFPO-DA, or PFBS.

- **Groundwater**: PFOA was detected at a maximum concentration of 5,540 ng/L, and concentrations exceeding the groundwater RSL of 6 ng/L and exceeding the groundwater ESL of 5.1 ng/L in six samples. PFOS was detected at a maximum concentration of 7,700 ng/L, and concentrations exceeding the groundwater RSL of 4 ng/L and exceeding the groundwater ESL of 6.5 ng/L in seven samples. PFHxS was also detected at a maximum concentration of 10,400 ng/L, and concentrations exceeding the groundwater RSL of 39 ng/L in six samples. PFNA was detected at a a maximum concentration of 111 ng/L, and concentration exceeding the groundwater RSL of 5.9 ng/L in two samples. PFBS was detected at a concentration of 931 ng/L exceeding the groundwater RSL of 600 ng/L in one sample, and HFPO-DA was non-detect in all samples.

Prior to this SI, some groundwater samples were collected at AOPC 1. During the September 2019 sampling event, groundwater samples were collected at two locations at AOPC 1. PFOA was detected at concentrations exceeding the groundwater RSL of 6 ng/L and exceeding the groundwater ESL of 5.1 ng/L in both samples. PFOS was detected at concentrations exceeding the groundwater RSL of 4 ng/L and exceeding the groundwater ESL of 6.5 ng/L in both samples. PFHxS also was detected at concentrations exceeding the groundwater RSL of 39 ng/L in both samples. PFNA was detected at a concentration exceeding the groundwater RSL of 5.9 ng/L in one sample. PFBS also was detected at a concentration exceeding the groundwater RSL of 600 ng/L in one sample.

- **Recommendation**: Further investigation of the horizontal and vertical extents of PFAS in groundwater and soil is recommended.

AOPC 2 – Crash Site (Sunnyvale Golf Course)

- **Soil**: PFOS was detected a maximum concentration of 41.0 µg/kg, and at concentrations exceeding the RSL, human health and ecologic ESLs in four samples. PFOA was detected a maximum concentration of 7.70 µg/kg, and at concentrations exceeding the human health ESL of 3.8 µg/kg in four samples. PFBS, PFHxS, and PFNA were not detected above screening criteria. HFPO-DA was non-detect in all samples.

- **Groundwater**: PFOS was detected at a maximum concentration of 35.0 ng/L, and concentrations exceeding the groundwater ESL of 6.5 ng/L and the groundwater RSL of 4 ng/L in three samples. PFOA, PFBS, PFNA, and PFHxS did not exceed any screening values. HFPO-DA was non-detect in all samples.

- **Recommendation**: Further investigation of the horizontal and vertical extents of PFAS in groundwater and soil is recommended.

AOPC 3 – Hangars 2 & 3 (IR 7)

- **Groundwater**: PFOA was detected at a maximum concentration of 62.0 ng/L, and concentration exceeding the groundwater RSL of 6 ng/L and the groundwater ESL of 5.1 ng/L in six samples. PFOS was detected at a maximum concentration of 160 ng/L, and concentrations exceeding the groundwater RSL of 4 ng/L and the groundwater ESL in seven samples. PFNA was detected at a maximum concentration of 11.0 ng/L exceeding the groundwater RSL of 5.9 ng/L in one sample. HFPO-DA was detected at a maximum concentration of 6.10 ng/L, and concentration exceeding the groundwater RSL of 6 ng/L in one sample. PFHxS was detected at maximum concentration of 180 ng/L, and concentration exceeding the groundwater RSL of 39 ng/L in five samples. PFBS was non-detect in all samples.

- **Recommendation**: Further investigation of horizontal and vertical extents of PFAS in groundwater is recommended.

AOPC 4 – Former Engine Test Stand Area (IR 11)

- **Groundwater**: PFOA was detected at a maximum concentration of 110 ng/L, and concentration exceeding the groundwater RSL of 6 ng/L and groundwater ESL of 5.1 ng/L in both samples. There were no screening level exceedances for PFBS, PFHxS, or PFOS. PFNA and HFPO-DA were non-detect in all samples.

- **Recommendation**: Further investigation of horizontal and vertical extents of PFAS in groundwater is recommended.

AOPC 5 – Hangar N211 (within AOI 3, formerly AOI 12)

- **Groundwater**: PFBS was detected in one sample at a maximum concentration of 1,500 ng/L exceeding the groundwater RSL of 600 ng/L. PFOA was detected at a maximum concentration of 380 ng/L, and concentrations exceeding the groundwater RSL of 6 ng/L and the groundwater ESL of 5.1 ng/L in seven samples. PFOS was detected at a maximum concentration of 40,000 ng/L, and concentrations exceeding the groundwater RSL of 4 ng/L and the groundwater ESL of 6.5 ng/L in seven samples. PFHxS was detected at a maximum concentration of 4,400 ng/L, and concentrations exceeding the groundwater RSL of 39 ng/L in five samples. PFNA was detected at a maximum concentration of 27.0 ng/L, and concentrations exceeding the groundwater RSL of 5.9 ng/L in five samples. HFPO-DA was non-detect in all samples.

- **Recommendation**: Further investigation of horizontal and vertical extents of PFAS in groundwater is recommended.

AOPC 6 – Hangar N248 (AOI 3 East)

- **Soil**: PFOS was detected a maximum concentration of 1,900 µg/kg, and at concentrations exceeding the RSL of 13 µg/kg and the human health and ecologic ESLs of 12 and 13 µg/kg respectively in two samples. PFOA was detected a maximum concentration of 5.10 µg/kg, and at a concentration exceeding the human health ESL of 3.8 µg/kg in one sample. There were no detections exceeding PFBS, PFNA, or PFHxS screening levels. HFPO-DA was non-detect in all samples.

- **Groundwater**: PFBS was detected at a maximum concentration of 620 ng/L, and concentrations exceeding the groundwater RSL of 600 ng/L in one sample. PFOA was detected at a maximum concentration of 610 ng/L, and concentrations exceeding the groundwater RSL of 6 ng/L and the groundwater ESL of 5.1 ng/L in all three samples. PFOS was also detected at a maximum concentration of 15,000 ng/L, and concentrations exceeding the groundwater RSL of 4 ng/L and the groundwater ESL of 6.5 ng/L in all three samples. PFHxS was detected at a maximum concentration of 5,200 ng/L, and exceeded the groundwater RSL of 39 ng/L in three samples, and PFNA was detected at a a maximum concentration of 14 ng/L and exceeded the groundwater RSL of 5.9 ng/L in one sample. HFPO-DA was non-detect in all samples.

- **Recommendation**: Further investigation of the horizontal and vertical extents of PFAS in groundwater and soil is recommended. There is a data gap for AOPCs with only one sample. Further samples may be collected at these AOPCs during the ESI to help support the development of a future RI work plan.

AOPC 7 – Fire Department (Building 580)

- **Soil**: PFOS was detected a maximum concentration of 1,500 µg/kg, and at concentrations exceeding the soil RSL of 13 µg/kg and the human health and ecologic ESLs of 12 and 13 µg/kg, respectively, in all four samples. PFOA was detected a maximum concentration of 4.20 µg/kg, and at a concentration exceeding the human health ESL of 3.8 µg/kg in one sample. There were no PFHxS, PFNA, or PFBS screening level exceedances. HFPO-DA was non-detect in all samples.

- **Groundwater**: PFOA was detected at a maximum concentration of 240 ng/L, and concentrations exceeding the groundwater RSL of 6 ng/L and the groundwater ESL of 5.1 ng/L in four samples. PFOS was detected at a maximum concentration of 5,000 ng/L, and concentrations exceeding the groundwater RSL of 4 ng/L and the groundwater ESL of 6.5 ng/L in five samples. PFHxS was detected at a maximum concentration of 2,200 ng/L, and exceeded the groundwater RSL of 39 ng/L in four samples, and PFNA was detected at a maximum concentration of 36 ng/L and exceeded the groundwater RSL of 5.9 ng/L in one sample. PFBS did not exceed any screening levels. HFPO-DA was non-detect in all samples.

- **Recommendations**: Further investigation of horizontal and vertical extents of PFAS in groundwater and soil is recommended. For the purposes of further investigation, AOPC 7 will be subsumed into AOPC 1 as the PFAS are the same or similar, and AOPC 7 is within AOPC 1.

AOPC 8 – Site 1 Runway Landfill (IR 1)

- **Groundwater**: PFOA was detected at a maximum concentration of 6.5 ng/L, exceeding the groundwater RSL of 6 ng/L and the groundwater ESL of 5.1 ng/L in two samples. PFOS, PFBS, and PFHxS did not exceed any screening levels. PFNA and HFPO-DA were non-detect in all samples.

- **Recommendation**: Further investigation of horizontal and vertical extents of PFAS in groundwater is recommended.

AOPC 9 – Site 2 Former Golf Course Landfill (IR 2)

- **Groundwater**: PFOA was detected at a maximum concentration of 230 ng/L, and concentrations exceeding the groundwater RSL of 6 ng/L and the groundwater ESL of 5.1 ng/L in three samples. PFOS was detected at a maximum concentration of 500 ng/L, and concentrations exceeding the groundwater RSL of 4 ng/L and the groundwater ESL of 6.5 ng/L in three samples. PFHxS was detected at a maximum concentration of 500 ng/L, and concentrations exceeding the groundwater RSL of 39 ng/L in three samples. PFBS and PFNA did not exceed any screening levels. HFPO-DA was non-detect in all samples.

- **Recommendation**: Further investigation of horizontal and vertical extents of PFAS in groundwater is recommended.

AOPC 10 – Site 22 Landfill (IR 22)

- **Groundwater**: PFOA was detected at a maximum concentration of 41.0 ng/L, and concentrations exceeding the groundwater RSL of 6 ng/L and the groundwater ESL of 5.1 ng/L in five samples. PFOS was detected at a maximum concentration of 53.0 ng/L, and concentration exceeding the groundwater RSL of 4 ng/L and the groundwater ESL of 6.5 ng/L in five samples. PFHxS was detected at a maximum concentration of 120 ng/L, and concentration exceeding the groundwater RSL of 39 ng/L in one sample. PFBS and PFNA did not exceed any screening levels. HFPO-DA was non-detect in all samples.

- **Recommendation**: Further investigation of the horizontal and vertical extents of PFAS in groundwater is recommended.

AOPC 11 – Building 191 Pump Station

- **Surface water**: PFNA was detected at concentration of 13 ng/L, PFHxS was detected at a concentration of 930 ng/L exceeding the surface water RSL of 565 ng/L, PFBS was detected at concentration of 130 ng/L, PFOA was detected at a concentration of 340 ng/L exceeding the surface water RSL of 87.7 ng/L, and ESL of 75 ng/L, and PFOS was detected at a concentration of 1,400 ng/L exceeding the surface water RSL of 58.5 ng/L. HFPO-DA was non-detect in all samples.

- **Recommendations**: Further investigation of the presence of PFAS in surface water is recommended, including the possibility of a pathway between AOPC 11 (Building 191 Pump Station), AOPC 16 (North Patrol Road Ditch and Northern Channel), and AOPC 17 (Marriage Road Ditch). There is a data gap for AOPCs with only one sample. Further samples may be collected at these AOPCs during the ESI to help support the development of a future RI work plan.

AOPC 12 – Stormwater Settling Basin/EDM (within IR 25)

- **Surface water**: PFBS, PFOA and PFOS were detected below surface water screening levels listed in Table 2-1. PFBS was detected at a concentration of 4 ng/L, PFOA was detected at an estimated concentration of 1.1 ng/L, PFHxS was detected at 6 ng/L, and PFOS was detected at a concentration of 5.5 ng/L. HFPO-DA and PFNA were non-detect in all samples.

- **Recommendations**: Further investigation of the sources and extent of PFAS in surface water in AOPC 12 is recommended. There is a data gap for AOPCs with only one sample. Further samples may be collected at these AOPCs during the ESI to help support the development of a future RI work plan.

AOPC 13 – NASA Groundwater Extraction Treatment System

- **Influent/Effluent**: Influent/effluent results were compared to USEPA and State groundwater screening levels for evaluation purposes only. Concentrations in the influent sample exceeded the groundwater RSLs for PFOS (at 6,800 ng/L), PFHxS (at 2,600 ng/L), and PFOA (at 330 ng/L), as well as the groundwater ESLs for PFOS and PFOA. Concentrations of PFOS in the effluent sample exceeded the groundwater RSL of 4 ng/L; however, concentrations in the duplicate sample were under the RSL.

- **Surface water**: All detections were below RSL and ESL surface water screening levels listed in Table 2-1. PFBS was detected at estimated concentration of 1.3 ng/L, PFOA was detected at estimated concentration of 1.1 ng/L, PFHxS was detected at 5.4 ng/L, and PFOS was detected at 7.4 ng/L. HFPO-DA and PFNA were not detected in the sample.

- **Recommendation**: Further investigation of the extents of PFAS in surface water at AOPC 13 is recommended with additional evaluation of the influent and effluent data with a focus on off-site migration of PFAS, along with routine quarterly monitoring of the influent and effluent and taking additional steps as needed based on results.

<u>AOPC 14 – MEW Groundwater Extraction Treatment System</u>

- **Influent/Effluent**: Influent/effluent results were compared to USEPA and State groundwater screening levels for evaluation purposes only. Concentrations in both samples exceeded the groundwater RSLs for PFOS (maximum concentrations in the influent at 120 ng/L), PFOA (maximum concentrations in the influent at14 ng/L) , and PFHxS (maximum concentrations in the influent at130 ng/L), as well as the groundwater ESLs for PFOS and PFOA. In all cases except for PFBA and PFPeA, the influent concentration was higher than the effluent concentration, and for these two compounds the difference was negligible.

- **Surface water**: PFBS was detected at an estimated concentration of 1.3 ng/L, PFOA was detected at an estimated concentration of 1.1 ng/L, PFHxS was detected at 5.4 ng/L, and PFOS was detected at 7.4 ng/L. HFPO-DA and PFNA were non-detect in all samples. All detections were below RSL and ESL surface water screening levels listed in Table 2-1. There is a data gap for AOPCs with only one sample. Further samples may be collected at these AOPCs during the ESI to help support the development of a future RI work plan.

- **Recommendation**: Further investigation of discharges from the MEW GWETS into Stevens Creek is recommended (no PFAS has been detected in effluent from NASA's GWETS). There is a data gap for AOPCs with only one sample. Further samples may be collected at these AOPCs during the ESI to help support the development of a future RI work plan. Routine quarterly monitoring of the influent and effluent is also recommended, and additional steps should be taken based on results. The MEW GWETS should be updated to reduce concentrations of PFAS to below appropriate discharge concentrations in Stevens Creek.

AOPC 15 – West-Side Aquifers Treatment System (IR 28)

- **Influent/Effluent**: Influent and effluent results were compared to USEPA and State groundwater screening levels for evaluation purposes only. Concentrations in the influent sample exceeded groundwater RSLs for PFOS (at 47 ng/L), PFOA (at 17 ng/L), and PFHxS (at 48 ng/L), as well as groundwater ESLs for PFOS and PFOA. Twelve of the 28 PFAS compounds were detected in the influent sample from AOPC 15. The only PFAS compound detected in the effluent sample was PFBA at an estimated concentration of 3.9 ng/L.

- **Recommendation**: Routine quarterly monitoring of the influent and effluent is recommended, and additional steps should be taken as needed based on results.

AOPC 16 – North Patrol Road Ditch (IR 21) and Northern Channel (IR 27)

- **Groundwater**: PFOA was detected at a maximum concentration of 230 ng/L, and concentrations exceeding the groundwater RSL of 6 ng/L and the groundwater ESL of 5.1 ng/L in four samples. PFOS was also detected at a maximum concentration of 500 ng/L, and concentrations exceeding the groundwater RSL of 4 ng/L and the groundwater ESL of 6.5 ng/L in three samples. PFHxS was detected at concentrations exceeding the groundwater RSL of 39 ng/L in two samples. PFBS and PFNA were not detected at concentrations exceeding any screening levels, and HFPO-DA was non-detect in all samples.

- **Recommendation**: Further investigation of the horizontal and vertical extents of PFAS in groundwater is recommended. The pathway of PFAS in surface water between AOPC 11 (Building 191 Pump Station), AOPC 16 (North Patrol Road Ditch and Northern Channel), and AOPC 17 (Marriage Road Ditch) should also be investigated.

AOPC 17 – Marriage Road Ditch (IR 3)

- **Groundwater**: PFOA was detected at a maximum concentration of 160 ng/L, and concentrations exceeding the groundwater RSL of 6 ng/L and the groundwater ESL of 5.1 ng/L in four samples. PFOS was detected at a maximum concentration of 150 ng/L, and concentrations exceeding the groundwater RSL of 4 ng/L and the groundwater ESL of 6.5 ng/L in four samples. PFHxS was detected at a maximum concentration of 190 ng/L, and concentrations exceeding the groundwater RSL in four samples. PFNA, PFBS, and HFPO-DA were not detected at concentrations exceeding any screening levels.

- **Recommendation**: Further investigation of the horizontal and vertical extents of PFAS in groundwater is recommended. The pathway of PFAS in surface water between AOPC 11 (Building 191 Pump Station), AOPC 16 (North Patrol Road Ditch and Northern Channel), and AOPC 17 (Marriage Road Ditch) should also be investigated.

AOPC 18 – Lindbergh Avenue Storm Drain Ditch (AOI 6)

- **Groundwater**: PFOA was detected at a maximum concentration of 34.0 ng/L, and concentrations exceeding the groundwater RSL of 6 ng/L and the groundwater ESL of 5.1 ng/L in two samples. PFOS was detected at a maximum concentration of 470 ng/L, and concentrations exceeding the groundwater RSL of 4 ng/L and the groundwater ESL of 6.5 ng/L in all three samples. PFHxS was detected at a maximum concentration of 220 ng/L, and concentrations exceeding the groundwater RSL in two samples. PFBS and PFNA did not exceed any screening levels. HFPO-DA was non-detect in all samples.

- **Recommendation**: Further investigation of the horizontal and vertical extents of PFAS in groundwater is recommended.

AOPC 19 – Stormwater Retention Ponds (within IR 25)

- **Surface water**: One surface water sample was collected at AOPC 19. However, this sample was flagged during data validation and not included in the data evaluation.

- **Recommendations**: There is a data gap for AOPCs with only one sample. Further samples may be collected at these AOPCs during the ESI to help support the development of a future RI work plan. Re-sampling of surface water is recommended for AOPC 19, along with sediment sampling including additional surface water samples from AOPC 19 to account for high salinity after the dry seasons, collection of the sample during the rainy season with duplicate samples, and additional analysis for total dissolved solids (TDS) and other appropriate parameters to better determine representative PFAS analytical results

AOPC 20 – Building N271 IWPP

- **Effluent**: Effluent results were compared to USEPA and State groundwater screening levels for evaluation purposes only. Concentrations in the sample (PFOS at 210 ng/L), PFOA at 36 ng/L and PFHxS at 230 ng/L) exceeded the groundwater RSLs for PFOS, PFOA, and PFHxS, and the groundwater ESLs for PFOS and PFOA. There were no PFBS screening level exceedances, and PFNA and HFPO-DA were non-detect in all samples.

- **Recommendation**: Routine quarterly monitoring of the effluent is recommended, and additional steps should be taken as needed based on results. There is a data gap for AOPCs with only one sample. Further samples may be collected at these AOPCs during the ESI to help support the development of a future RI work plan.

AOPC 21 – Former Industrial Wastewater Surface Impoundment (IR 4)

- **Groundwater**: PFOA was detected at a maximum concentration of 60.0 ng/L, and concentrations exceeding the groundwater RSL of 6 ng/L and the groundwater ESL of 5.1 ng/L in seven samples. PFOS was detected at a maximum concentration of 99.0 ng/L, and concentrations exceeding the groundwater RSL of 4 ng/Lin six samples, and the groundwater ESL of 6.5 ng/L in five samples.PFHxS was detected at a maximum concentration of 83 ng/L, and concentrations exceeding the groundwater RSL of 39 ng/L in five samples. PFNA, PFBS, and HFPO-DA were not detected at concentrations exceeding any screening level.

- **Recommendation**: Further investigation of the horizontal and vertical extents of PFAS in groundwater is recommended.

<u>AOPC 22 – Building N249 Outdoor Aerodynamic Research Facility</u>

- **Groundwater**: PFOS was detected at a maximum concentration of 15 ng/L, and concentrations exceeding the groundwater RSL of 4 ng/L and the groundwater ESL of 6.5 ng/L in three samples. PFHxS was detected at a maximum concentration of 56.0 ng/L exceeding the groundwater RSL of 39 ng/L in one sample. PFOA, PFNA, PFBS, and HFPO-DA were not detected at concentrations exceeding any screening levels.

- **Recommendation**: Further investigation of the horizontal and vertical extents of PFAS in groundwater is recommended.

<u>AOPC 23 – Hangar 4 (CANG) Building 662</u>

- **Groundwater/Soil/Sediment**: No samples were collected at AOPC 23 during the SI as previous sampling efforts already identified the presence of PFAS at this site. Previous sampling identified maximum concentration of PFOA (580 ng/L) in the groundwater sample, and PFOS in a grab groundwater sample (80.2 ng/L).

- **Groundwater**: However, during the SI, one groundwater sample was collected from a new well, PFAS-C, which is near a well previously sampled for AOPC 23. In sample from well PFAS-C, PFOS was detected at a concentration of 35 ng/L exceeding the groundwater RSL of 4 ng /L and the groundwater ESL of 6.5 ng/L

- Results from PFAS-C are discussed in Section 5.23 and results from previous sampling in 2018-2019 at AOPC 23 are discussed in Section 3.6.23

- **Recommendation**: A remedial investigation is recommended for AOPC 23.

<u>AOPC 24 – Middlefield-Ellis-Whisman (MEW) Plume</u>

- **Groundwater**: PFOA was detected at a maximum concentration of 11.0 ng/L, and concentrations exceeding the groundwater RSL of 6 ng/L and the groundwater ESL of

5.1 ng/L in one sample. PFOS was detected at a maximum concentration of 57.0 ng/L, and concentrations exceeding the groundwater RSL of 4 ng/L in three samples. PFOS also exceeded the groundwater ESL of 6.5 ng/L in two samples. PFHxS was detected at a maximum concentration of 130 ng/L, and concentration exceeding the groundwater RSL of 39 ng/L in one sample. PFBS was not detected at concentrations exceeding any screening levels. PFNA and HFPO-DA were non-detect in all samples.

- **Recommendation**: Further investigation of the horizontal and vertical extents of PFAS in groundwater is recommended. Appendix J includes relevant data from MEW parties found in the https://geotracker.waterboards.ca.gov, and an evaluation of this data will be included in an ESI.

AOPC 25 – Orion Park Plume

- **Groundwater**: PFOS was detected at a maximum concentration of 9.00 ng/L, and concentrations exceeding the groundwater ESL of 6.5 ng/L in one sample and exceeding the groundwater RSL of 4 ng/L in two samples. PFOA, PFNA, PFHxS, HFPO-DA, and PFBS were not detected at any concentrations exceeding any screening levels.

- **Recommendation**: Further investigation of the horizontal and vertical extents of PFAS in groundwater is recommended.

AOPC 26 – Eastern Boundary (IR-5)

- **Groundwater**: PFOA was detected at a maximum concentration of 350 ng/L, and concentrations exceeding the groundwater RSL of 6 ng/L and the groundwater ESL of 5.1 ng/L. PFOS was detected at a maximum concentration of 490 ng/L, and concentrations exceeding the groundwater RSL of 4 ng/L and the groundwater ESL of 6.5 ng/L. PFNA at 16.0 ng/L and PFHxS at 350 ng/L exceeded the groundwater RSLs of 5.9 ng/L and 39 ng/L, respectively. The detected concentration of PFBS did not exceed any screening level, and HFPO-DA was non-detect in all samples.

- **Recommendation**: Further investigation of the horizontal and vertical extents of PFAS in groundwater is recommended. Appendix J includes relevant data from Lockheed

Martin NIROP facility found in the https://geotracker.waterboards.ca.gov, and an evaluation of this data will be included in an ESI.

All 26 AOPCs included in this SI are recommended for further PFAS evaluation based on data exceeding screening levels or the need to collect additional data to evaluate potential PFAS impacts (e.g., AOPC 19 - Stormwater Retention Pond [within IR 25]). The highest detections for PFAS compounds with USEPA RSLs that have been identified in groundwater and soil, respectively, at ARC to date include: PFOS (40,000 ng/L, 1,900 µg/kg), PFOA (5,540 ng/L, 120 µg/kg), PFBS (1,500 ng/L, 1.8 µg/kg), HPFO-DA (estimated 6.10 ng/L, not detected in soil), PFHxS (10,400 ng/L, 92.0 µg/kg), and PFNA (111 ng/L, 2.60 µg/kg).

Currently the SI data indicate that PFAS are present in the surface water migrating off-site. Further investigation is necessary to determine if there are unacceptable impacts from the presence of PFAS in off-site surface water based on determination of potential receptors and development of risk-based criteria using site specific parameters.

The RI will provide a more accurate depiction of groundwater flow directions for unconfined aquifer at the entire site, and PFAS transport and migration pathways with the priority being the off-site migration of PFAS in surface water (see RTC 17 & RTC 19)

This report including conclusions and recommendations were reviewed with USEPA and Regional Water Board before publishing.

Table ES-1 PFAS Soil and Groundwater Frequencies of Detection

Analyte	Detection Frequency	Maximum Detected Result	Minimum Detected Result	Location with Maximum Result	Average (Detected Results)	Average (All)[1]	Standard Deviation[1]	Screening Levels: EPA Res RSL[2]	No. of Samples > Res RSL	HH ESL[3]	No. of Samples > HH ESL	Eco ESL[4]	No. of Samples > Eco ESL
PFAS Soil Frequencies of Detection (µg/kg)													
HEXAFLUOROPROPYLENE OXIDE DIMER ACID (HFPO-DA)	0/28	ND	ND	--	--	1.09	0.11	23	0	--	--	--	--
PERFLUOROBUTANESULFONIC ACID (PFBS)	10/28	1.80	0.190 J	AOPC1-SB03	0.59	0.39	0.33	1,900	0	--	--	--	--
PERFLUOROHEXANESULFONIC ACID (PFHXS)	25/28	92.0	0.460 J	AOPC6-SB01	13.10	11.73	18.66	130	0	--	--	--	--
PERFLUORONONANOIC ACID (PFNA)	15/28	2.60	0.250 J	AOPC7-SB02	0.76	0.53	0.55	19	0	--	--	--	--
PERFLUOROOCTANOIC ACID (PFOA)	25/28	120	0.260 J	AOPC1-SB04	10.59	9.48	23.68	19	3	3.8	11	84	1
PERFLUOROOCTANESULFONIC ACID (PFOS)	23/28	1,900	2.50	AOPC6-SB01	241.96	198.80	464.87	13	15	12	15	13	15

Notes:
1 Values calculated using non-detects at 1/2 the limit of detection
2 Screening values are USEPA RSLs (May 2022) (HQ = 0.1), which includes the 6 PFAS compounds referenced in the table.
3 HH ESL = Residential cancer risk ESLs for direct exposure, human health risk in soil (Regional Water Board 2020).
4 Eco ESL = No observed adverse effects levels (NOAEL) in significantly vegetated area ESLs for terrestrial habitat in soils (Regional Water Board 2020)

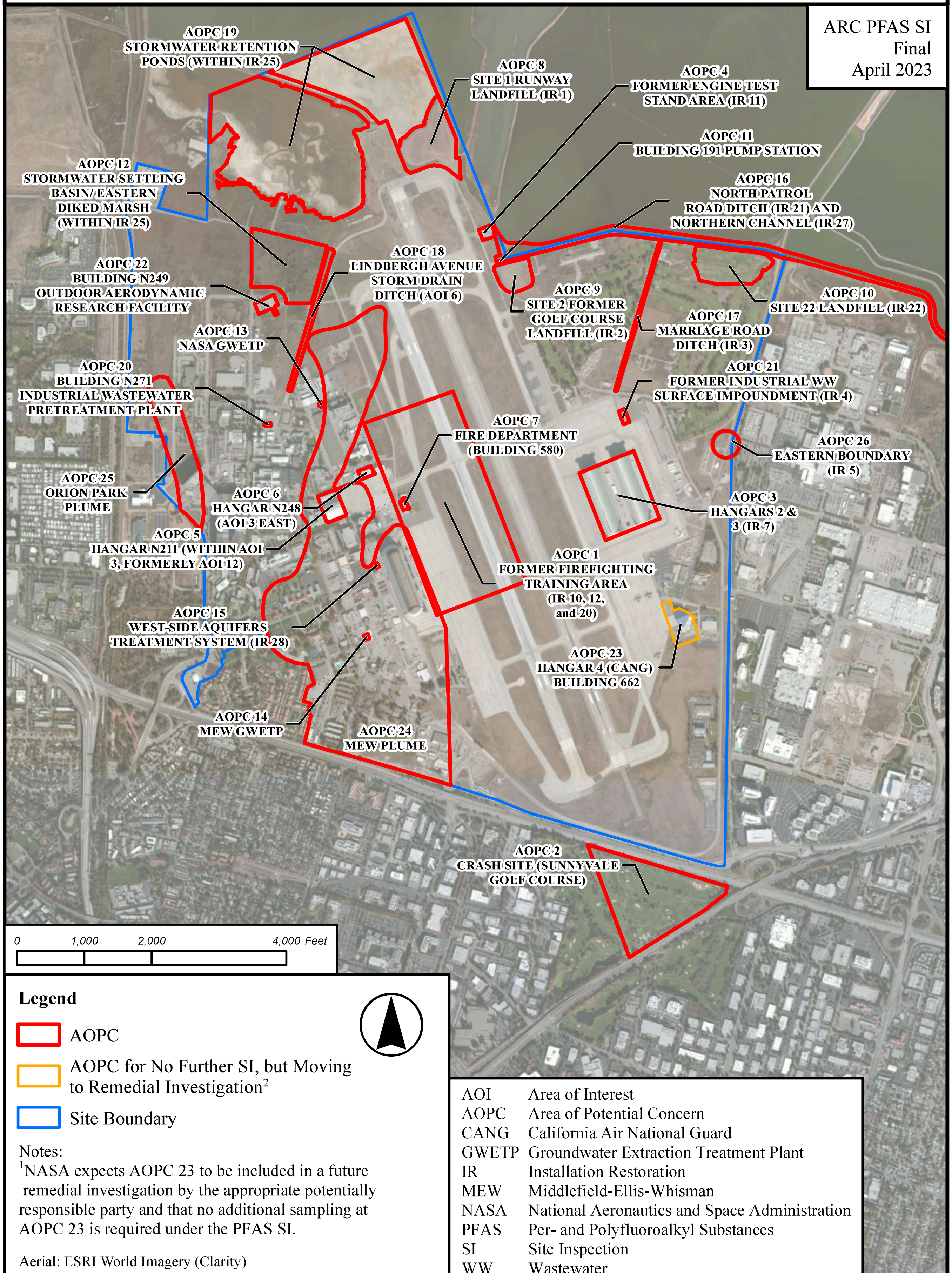
Analyte	Detection Frequency	Maximum Detected Result	Minimum Detected Result	Location with Maximum Result	Average (Detected Results)	Average (All)[1]	Standard Deviation[1]	Screening Levels: EPA GW RSL[2]	No. of Samples > GW RSL	GW ESL[3]	No. of Samples > GW ESL
PFAS with screening levels (ng/L)											
HEXAFLUOROPROPYLENE OXIDE DIMER ACID (HFPO-DA)	1/77	6.10 J	6.10 J	UST3-MW-02	6.10	7.16	25.48	6	1	--	--
PERFLUOROBUTANESULFONIC ACID (PFBS)	71/79	1,500	0.870 J	WU4-19	90.96	81.84	222.85	600	3	--	--
PERFLUOROHEXANESULFONIC ACID (PFHXS)	75/79	10,400	1.00 J	W12-20	600.62	570.26	1532.84	39	42	--	--
PERFLUORONONANOIC ACID (PFNA)	25/79	111	0.910 J	W12-20	11.15	6.59	17.74	5.9	9	--	--
PERFLUOROOCTANOIC ACID (PFOA)	71/79	5,540	1.00 J	W12-20	155.37	139.73	627.16	6	53	5.1	53
PERFLUOROOCTANESULFONIC ACID (PFOS)	71/79	40,000	1.40 J	14D39A	1716.56	1542.83	5513.97	4	59	6.5	55

Notes:
1 Values calculated using non-detects at 1/2 the limit of detection
2 Screening values are USEPA RSLs (May 2022) (HQ = 0.1), which includes the 6 PFAS compounds referenced in the table.
3 GW ESL = Maximum Contaminant Level (MCL), Priority Environmental Screening Levels (ESL) for direct exposure human health risk in water (Regional Water Board 2020).

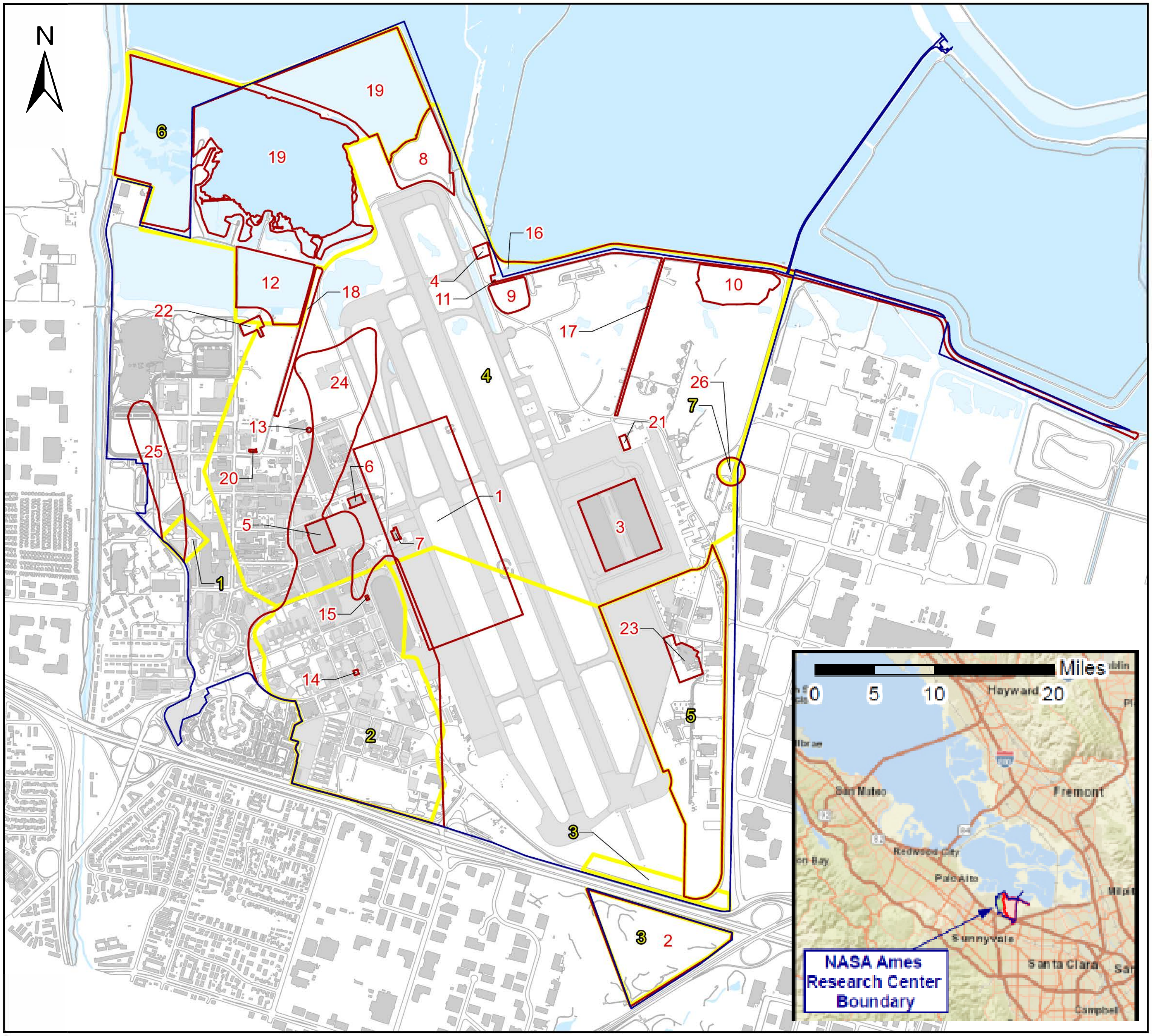
-- not available
AOPC Area of Potential Concern
Eco Ecological
EPA U.S. Environmental Protection Agency
ESL Environmental Screening Levels
GW Groundwater
HH Human Health
J Estimated value
ND Non-detect
ng/L Nanograms per liter
PFAS per- and polyfluoroalkyl substances
RSL Regional Screening Level
µg/kg Micrograms per kilogram

FIGURE 1-2 OVERVIEW OF AREAS OF POTENTIAL CONCERN

PFAS SITE INSPECTION FOR AMES RESEARCH CENTER



PGH:P:\NASA AMES_PFAS_103IG667601(P)\GIS FILES\FROMKEVINMOORE\AMES_NASA\MXD\FIG1-2_AOPC.MXD 8/17/2022



Legend

NASA Ames Research Center

Area of Potential Concern

Location of Interest

Notes:
1. NASA - National Aeronautics and Space Administration
2. GIS shapefiles have been sourced from the Draft Final Ames Research Center Per- and Polyfluoroalkyl Substances (PFAS) Expanded Site Inspection (ESI) Work Plan, June 2024 from Tetra Tech.

0 1,250 2,500
Feet

Ames Research Center
Moffett Field, California 94035

Figure A

LOCATIONS OF INTEREST AND AREAS OF POTENTIAL CONCERN

Document Path: H:\ITGIS\NASA AMES ARC\FYR\Figures\AOI Correlation Figure.aprx

Service Layer Credits: NASA. 2023a. NASA Ames Land Use Controls Implementation and Monitoring Plan Update. Ames Research Center, Moffett Field, California. June.
Cmoore 1/31/2025 12:28 PM

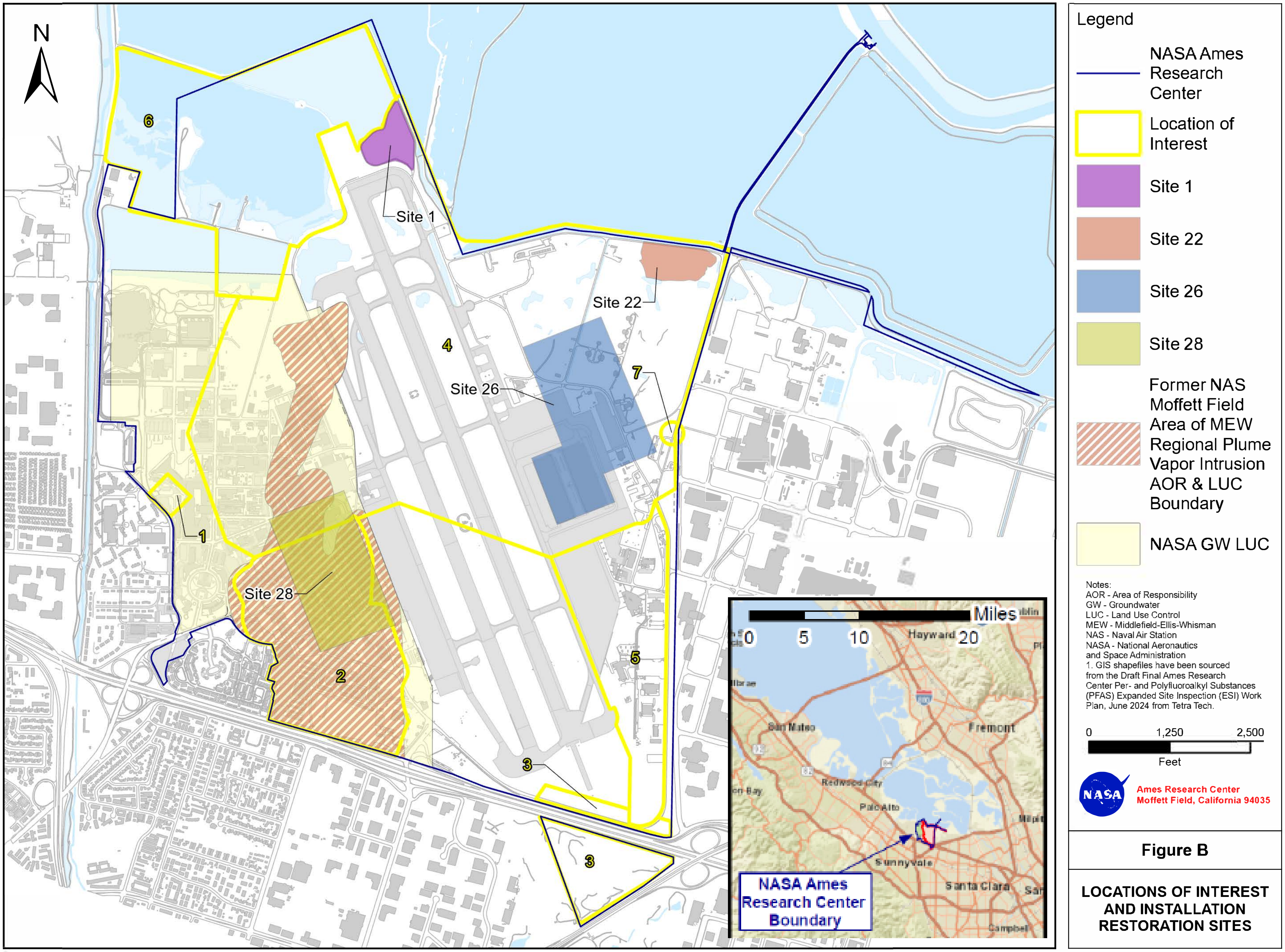


Figure B

LOCATIONS OF INTEREST AND INSTALLATION RESTORATION SITES

Document Path: H:\ITGIS\NASA AMES ARC\FYR\Figures\AOI Correlation Figure.aprx

Service Layer Credits: NASA. 2023a. NASA Ames Land Use Controls Implementation and Monitoring Plan Update. Ames Research Center, Moffett Field, California. June.
Cmoore 1/31/2025 3:34 PM

TABLE 5-2: PFAS Soil Frequencies of Detection

PFAS Site Inspection for the Ames Research Center

Analyte	Detection Frequency	Maximum Detected Result	Minimum Detected Result	Location with Maximum Result	Average (Detected Results)	Average (All) [1]	Standard Deviation [1]	Screening Levels: EPA Res RSL[2]	No. of Samples > Res RSL	HH ESL[3]	No. of Samples > HH ESL	Eco ESL[4]	No. of Samples > Eco ESL
PFAS with screening levels (µg/kg)													
HEXAFLUOROPROPYLENE OXIDE DIMER ACID (HFPO-DA)	0/28	ND	ND	--	--	1.09	0.11	23	0	--	--	--	--
PERFLUOROBUTANESULFONIC ACID (PFBS)	10/28	1.80	0.190 J	AOPC1-SB03	0.59	0.39	0.33	1,900	0	--	--	--	--
PERFLUOROHEXANESULFONIC ACID (PFHXS)	25/28	92.0	0.460 J	AOPC6-SB01	13.10	11.73	18.66	130	0	--	--	--	--
PERFLUORONONANOIC ACID (PFNA)	15/28	2.60	0.250 J	AOPC7-SB02	0.76	0.53	0.55	19	0	--	--	--	--
PERFLUOROOCTANOIC ACID (PFOA)	25/28	120	0.260 J	AOPC1-SB04	10.59	9.48	23.68	19	3	3.8	11	84	1
PERFLUOROOCTANESULFONIC ACID (PFOS)	23/28	1,900	2.50	AOPC6-SB01	241.96	198.80	464.87	13	15	12	15	13	15
PFAS without screening levels (µg/kg)													
11-CHLOROEICOSAFLUORO-3-OXAUNDECANE-1-SULFONIC ACID	0/28	ND	ND	--	--	0.55	0.06	--	--	--	--	--	--
4,8-DIOXA-3H-PERFLUORONONANOIC ACID (ADONA)	0/28	ND	ND	--	--	0.55	0.06	--	--	--	--	--	--
4:2 FLUOROTELOMER SULFONATE	0/28	ND	ND	--	--	0.55	0.06	--	--	--	--	--	--
6:2 FLUOROTELOMER SULFONATE	1/28	1.30 J	1.30 J	AOPC7-SB02	1.30	0.58	0.15	--	--	--	--	--	--
8:2 FLUOROTELOMER SULFONATE	3/28	0.810 J	0.730 J	AOPC6-SB01	0.77	0.58	0.09	--	--	--	--	--	--
9-CHLOROHEXADECAFLUORO-3-OXANONE-1-SULFONIC ACID	0/28	ND	ND	--	--	0.55	0.06	--	--	--	--	--	--
N-ETHYLPERFLUOROOCTANE SULFONAMIDOACETIC ACID	1/28	1.10 J	1.10 J	AOPC6-SB01	1.10	0.58	0.12	--	--	--	--	--	--
N-METHYLPERFLUOROOCTANE SULFONAMIDOACETIC ACID	0/28	ND	ND	--	--	0.55	0.06	--	--	--	--	--	--
PERFLUOROBUTANOIC ACID (PFBA)	25/28	4.40	0.340 J	AOPC2-SB04	1.12	1.03	0.99	--	--	--	--	--	--
PERFLUORODECANESULFONIC ACID (PFDS)	5/28	5.10	0.420 J	AOPC7-SB02	2.20	0.62	1.05	--	--	--	--	--	--
PERFLUORODECANOIC ACID (PFDA)	8/28	2.40	0.270 J	AOPC7-SB02	0.87	0.44	0.45	--	--	--	--	--	--
PERFLUORODODECANOIC ACID (PFDOA)	2/28	0.940	0.250 J	AOPC6-SB01	0.60	0.30	0.13	--	--	--	--	--	--
PERFLUOROHEPTANESULFONIC ACID (PFHPS)	15/28	25.0	0.210 J	AOPC6-SB01	2.58	1.51	4.68	--	--	--	--	--	--
PERFLUOROHEPTANOIC ACID (PFHPA)	22/28	11.0	0.180 J	AOPC7-SB02	1.15	0.96	2.03	--	--	--	--	--	--
PERFLUOROHEXANOIC ACID (PFHXA)	26/28	12.0	0.270 J	AOPC7-SB02	2.00	1.88	2.36	--	--	--	--	--	--
PERFLUORONONANESULFONIC ACID (PFNS)	7/28	4.40	0.320 J	AOPC7-SB02	1.94	0.69	1.15	--	--	--	--	--	--
PERFLUOROOCTANE SULFONAMIDE (FOSA)	11/28	24.0	0.270 J	AOPC7-SB02	3.43	1.51	4.55	--	--	--	--	--	--
PERFLUOROPENTANESULFONIC ACID (PFPES)	12/28	3.20	0.240 J	AOPC1-SB03	0.99	0.58	0.76	--	--	--	--	--	--
PERFLUOROPENTANOIC ACID (PFPEA)	25/28	31.0	0.200 J	AOPC7-SB02	2.29	2.07	5.84	--	--	--	--	--	--
PERFLUOROTETRADECANOIC ACID (PFTEA)	1/28	0.280 J	0.280 J	AOPC6-SB01	0.28	0.27	0.02	--	--	--	--	--	--
PERFLUOROTRIDECANOIC ACID (PFTRIA)	1/28	0.190 J	0.190 J	AOPC6-SB01	0.19	0.27	0.03	--	--	--	--	--	--
PERFLUOROUNDECANOIC ACID (PFUNA)	6/28	1.40	0.250 J	AOPC7-SB02	0.58	0.34	0.23	--	--	--	--	--	--

TABLE 5-2: PFAS Soil Frequencies of Detection (continued)

PFAS Site Inspection for the Ames Research Center

Notes:

1	Values calculated using non-detects at 1/2 the limit of detection
2	Screening values are USEPA RSLs (May 2022) (HQ = 0.1), which includes the 6 PFAS compounds referenced in the table.
3	HH ESL = Residential cancer risk ESLs for direct exposure, human health risk in soil (Regional Water Board 2020).
4	Eco ESL = No observed adverse effects levels (NOAEL) in significantly vegetated area ESLs for terrestrial habitat in soils (Regional Water Board 2020)

--	not available
AOPC	Area of Potential Concern Ecological
Eco	U.S. Environmental Protection Agency
EPA	Environmental Screening Levels
ESL	Human Health
HH	Estimated value
J	Non-detect
ND	per- and polyfluoroalkyl substances
PFAS	Residential
Res	Regional Screening Level Micrograms
RSL	per kilogram
µg/kg	

TABLE 5-4: PFAS Groundwater Frequencies of Detection

PFAS Site Inspection for the Ames Research Center

Analyte	Detection Frequency	Maximum Detected Result	Minimum Detected Result	Location with Maximum Result	Average (Detected Results)	Average (All) [1]	Standard Deviation [1]	Screening Levels: EPA GW RSL [2]	No. of Samples > GW RSL	GW ESL[3]	No. of Samples > GW ESL
PFAS with screening levels (ng/L)											
HEXAFLUOROPROPYLENE OXIDE DIMER ACID (HFPO-DA)	1/77	6.10 J	6.10 J	UST3-MW-02	6.10	7.16	25.48	6	1	--	--
PERFLUOROBUTANESULFONIC ACID (PFBS)	71/79	1,500	0.870 J	WU4-19	90.96	81.84	222.85	600	3	--	--
PERFLUOROHEXANESULFONIC ACID (PFHXS)	75/79	10,400	1.00 J	W12-20	600.62	570.26	1532.84	39	42	--	--
PERFLUORONONANOIC ACID (PFNA)	25/79	111	0.910 J	W12-20	11.15	6.59	17.74	5.9	9	--	--
PERFLUOROOCTANOIC ACID (PFOA)	71/79	5,540	1.00 J	W12-20	155.37	139.73	627.16	6	53	5.1	53
PERFLUOROOCTANESULFONIC ACID (PFOS)	71/79	40,000	1.40 J	14D39A	1716.56	1542.83	5513.97	4	59	6.5	55
PFAS without screening levels (ng/L)											
11-CHLOROEICOSAFLUORO-3-OXAUNDECANE-1-SULFONIC ACID	0/77	ND	ND	--	--	7.11	25.49	--	--	--	--
4,8-DIOXA-3H-PERFLUORONONANOIC ACID (ADONA)	0/77	ND	ND	--	--	7.11	25.49	--	--	--	--
4:2 FLUOROTELOMER SULFONATE	4/79	130	2.40 J	W5-3	37.19	8.75	28.70	--	--	--	--
6:2 FLUOROTELOMER SULFONATE	68/79	4,600	2.00 J	W5-3	263.00	226.64	767.53	--	--	--	--
8:2 FLUOROTELOMER SULFONATE	11/79	1,740	2.00 J	W12-20	172.70	30.55	196.46	--	--	--	--
9-CHLOROHEXADECAFLUORO-3-OXANONE-1-SULFONIC ACID	0/77	ND	ND	--	--	7.11	25.49	--	--	--	--
N-ETHYLPERFLUOROOCTANE SULFONAMIDOACETIC ACID	1/79	8.30	8.30	W7-11	8.30	7.03	25.17	--	--	--	--
N-METHYLPERFLUOROOCTANE SULFONAMIDOACETIC ACID	0/79	ND	ND	--	--	6.95	25.17	--	--	--	--
PERFLUOROBUTANOIC ACID (PFBA)	78/79	675	1.00 J	W12-20	58.44	57.71	116.75	--	--	--	--
PERFLUORODECANESULFONIC ACID (PFDS)	0/79	ND	ND	--	--	3.47	12.36	--	--	--	--
PERFLUORODECANOIC ACID (PFDA)	14/79	13.6	1.10 J	W12-20	3.86	3.98	12.39	--	--	--	--
PERFLUORODODECANOIC ACID (PFDOA)	3/79	1.40 J	1.10 J	UST3-MW-02	1.27	3.48	12.36	--	--	--	--
PERFLUOROHEPTANESULFONIC ACID (PFHPS)	38/79	720	0.890 J	14D39A	76.19	37.14	117.98	--	--	--	--
PERFLUOROHEPTANOIC ACID (PFHPA)	56/79	944	0.930 J	W12-20	65.26	46.53	132.14	--	--	--	--
PERFLUOROHEXANOIC ACID (PFHXA)	64/79	3,590	1.00 J	W12-20	262.87	213.13	556.20	--	--	--	--
PERFLUORONONANESULFONIC ACID (PFNS)	4/79	50.0	1.40 J	14D39A	15.80	4.22	13.41	--	--	--	--
PERFLUOROOCTANE SULFONAMIDE (FOSA)	12/79	128	0.930 J	W12-20	14.54	5.53	18.75	--	--	--	--
PERFLUOROPENTANESULFONIC ACID (PFPES)	63/79	1,200	1.60 J	WU4-19	91.46	73.12	194.86	--	--	--	--
PERFLUOROPENTANOIC ACID (PFPEA)	61/79	2,880	1.10 J	W12-20	169.00	130.70	398.59	--	--	--	--
PERFLUOROTETRADECANOIC ACID (PFTEA)	1/79	14.0	14.0	W7-11	14.00	3.63	12.41	--	--	--	--
PERFLUOROTRIDECANOIC ACID (PFTRIA)	1/79	2.10 J	2.10 J	W7-11	2.10	3.48	12.36	--	--	--	--
PERFLUOROUNDECANOIC ACID (PFUNA)	2/79	2.20 J	1.20 J	WNB-14	1.70	3.48	12.36	--	--	--	--

TABLE 5-4: PFAS Groundwater Frequencies of Detection (continued)

PFAS Site Inspection for the Ames Research Center

Notes:

1 Values calculated using non-detects at 1/2 the limit of detection
2 Screening values are USEPA RSLs (May 2022) (HQ = 0.1), which includes the 6 PFAS compounds referenced in the table.
3 GW ESL = Maximum Contaminant Level (MCL), Priority Environmental Screening Levels (ESL) for direct exposure human health risk in water (Regional Water Board 2020).

--	not available
AOPC	Area of Potential Concern
EPA	U.S. Environmental Protection Agency
ESL	Environmental Screening Levels
GW	Groundwater
J	Estimated value
ND	Non-detect
ng/L	Nanograms per liter
PFAS	per- and polyfluoroalkyl substances
RSL	Regional Screening Level

TABLE 5-7: PFAS Analytical Results for Water Treatment Systems

PFAS Site Inspection for the Ames Research Center

Sample Location ID	CAS No.	USEPA Ground water RSL	State ESL	AOPC13-SW01	AOPC13-SW01	AOPC13-SW01	AOPC14-SW01
Sample ID				**AOPC13-SW01-EF-072221**	**AOPC13-SW01-EF-072221-FD**	**AOPC13-SW01-IN-072221**	**AOPC14-SW01-EF-081821**
Sample Date				**07/22/2021**	**07/22/2021**	**07/22/2021**	**08/01/2021**
PFAS with screening levels (ng/L)							
HEXAFLUOROPROPYLENE OXIDE DIMER ACID (HFPO-DA)	13252-13-6	6	--	3.6 U	3.8 U	200 U	4.1 UJ
PERFLUOROBUTANESULFONIC ACID (PFBS)	375-73-5	600	--	1.8 U	1.9 U	310	24 J
PERFLUOROHEXANESULFONIC ACID (PFHXS)	355-46-4	39	--	1.8 U	1.9 U	**2600**	**100 J**
PERFLUORONONANOIC ACID (PFNA)	375-95-1	5.9	--	1.8 U	1.9 U	100 U	2.1 UJ
PERFLUOROOCTANOIC ACID (PFOA)	335-67-1	6	5.1	1.8 U	0.97 J	**330**	**13 J**
PERFLUOROOCTANESULFONIC ACID (PFOS)	1763-23-1	4	6.5	2.5 J	**4.1**	**6800**	**94 J**
PFAS without screening levels (ng/L)							
11-CHLOROEICOSAFLUORO-3-OXAUNDECANE-1-SULFONIC ACID	763051-92-9	--	--	3.6 U	3.8 U	200 U	4.1 UJ
4,8-DIOXA-3H-PERFLUORONONANOIC ACID (ADONA)	919005-14-4	--	--	3.6 U	3.8 U	200 U	4.1 UJ
4:2 FLUOROTELOMER SULFONATE	757124-72-4	--	--	3.6 U	3.8 U	200 U	4.1 UJ
6:2 FLUOROTELOMER SULFONATE	27619-97-2	--	--	3.6 UJ	3.8 UJ	4300	4.1 UJ
8:2 FLUOROTELOMER SULFONATE	39108-34-4	--	--	3.6 U	3.8 U	200 U	4.1 UJ
9-CHLOROHEXADECAFLUORO-3-OXANONE-1-SULFONIC ACID	756426-58-1	--	--	3.6 U	3.8 U	200 U	4.1 UJ
N-ETHYLPERFLUOROOCTANE SULFONAMIDOACETIC ACID	2991-50-6	--	--	3.6 U	3.8 U	200 U	4.1 UJ
N-METHYLPERFLUOROOCTANE SULFONAMIDOACETIC ACID	2355-31-9	--	--	3.6 U	3.8 U	200 U	4.1 UJ
PERFLUOROBUTANOIC ACID (PFBA)	375-22-4	--	--	1.8 U	1.9 U	260	10 J
PERFLUORODECANESULFONIC ACID (PFDS)	335-77-3	--	--	1.8 U	1.9 U	100 U	2.1 UJ
PERFLUORODECANOIC ACID (PFDA)	335-76-2	--	--	1.8 U	1.9 U	100 U	2.1 UJ
PERFLUORODODECANOIC ACID (PFDOA)	307-55-1	--	--	1.8 U	1.9 U	100 U	2.1 UJ
PERFLUOROHEPTANESULFONIC ACID (PFHPS)	375-92-8	--	--	1.8 U	1.9 U	180 J	4.9 J
PERFLUOROHEPTANOIC ACID (PFHPA)	375-85-9	--	--	1.8 U	1.9 U	160 J	4.5 J
PERFLUOROHEXANOIC ACID (PFHXA)	307-24-4	--	--	1.8 U	1.9 U	1600	22 J
PERFLUORONONANESULFONIC ACID (PFNS)	68259-12-1	--	--	1.8 U	1.9 U	100 U	2.1 UJ
PERFLUOROOCTANE SULFONAMIDE (FOSA)	754-91-6	--	--	1.8 U	1.9 U	100 U	2.1 UJ
PERFLUOROPENTANESULFONIC ACID (PFPES)	2706-91-4	--	--	1.8 U	1.9 U	330	20 J
PERFLUOROPENTANOIC ACID (PFPEA)	2706-90-3	--	--	1.8 U	1.9 U	620	9.6 J
PERFLUOROTETRADECANOIC ACID (PFTEA)	376-06-7	--	--	1.8 U	1.9 U	100 U	2.1 UJ
PERFLUOROTRIDECANOIC ACID (PFTRIA)	72629-94-8	--	--	1.8 U	1.9 U	100 U	2.1 UJ
PERFLUOROUNDECANOIC ACID (PFUNA)	2058-94-8	--	--	1.8 U	1.9 U	100 U	2.1 UJ

Water from Water Treatment Systems were compared to USEPA and State groundwater screening criteria for evaluation purposes only
Highlighted cell indicates concentration is greater than screening criteria.
"--" = No criteria available.
EPA = Environmental Protection Agency.
ESL = Environmental Screening Level
ng/L = nanogram per liter.
PFAS = per- and polyfluoroalkyl substances
RSL = Regional Screening Level.
U = Not detected at or above the Limit of Qualitation (LOQ)
J = Estimated result < LOQ and > Detection Limit (DL)

TABLE 5-7: PFAS Analytical Results for Water Treatment Systems (continued)

PFAS Site Inspection for the Ames Research Center

Sample Location ID	CAS No.	USEPA Ground water RSL	State ESL	AOPC14-SW01	AOPC15-SW01	AOPC15-SW01	AOPC20-SW01
Sample ID				AOPC14-SW01-IN-081821	AOPC15-SW01-EF-072321	AOPC15-SW01-IN-072321	AOPC20-SW01-EF-072221
Sample Date				08/01/2021	07/23/2021	07/23/2021	07/22/2021
PFAS with screening levels (ng/L)							
HEXAFLUOROPROPYLENE OXIDE DIMER ACID (HFPO-DA)	13252-13-6	6	--	4 UJ	4 U	3.7 U	3.5 U
PERFLUOROBUTANESULFONIC ACID (PFBS)	375-73-5	600	--	26 J	2 U	12	60
PERFLUOROHEXANESULFONIC ACID (PFHXS)	355-46-4	39	--	**130 J**	2 U	**48**	**230**
PERFLUORONONANOIC ACID (PFNA)	375-95-1	5.9	--	2 UJ	2 U	1.9 U	1.8 U
PERFLUOROOCTANOIC ACID (PFOA)	335-67-1	6	5.1	**14 J**	2 U	**17**	**36**
PERFLUOROOCTANESULFONIC ACID (PFOS)	1763-23-1	4	6.5	**120 J**	2 U	**47**	**210**
PFAS without screening levels (ng/L)							
11-CHLOROEICOSAFLUORO-3-OXAUNDECANE-1-SULFONIC ACID	763051-92-9	--	--	4 UJ	4 U	3.7 U	3.5 U
4,8-DIOXA-3H-PERFLUORONONANOIC ACID (ADONA)	919005-14-4	--	--	4 UJ	4 U	3.7 U	3.5 U
4:2 FLUOROTELOMER SULFONATE	757124-72-4	--	--	4 UJ	4 U	3.7 U	3.5 U
6:2 FLUOROTELOMER SULFONATE	27619-97-2	--	--	2.7 J	4 UJ	6.9 J	5.3 J
8:2 FLUOROTELOMER SULFONATE	39108-34-4	--	--	4 UJ	4 U	2 J	3.5 U
9-CHLOROHEXADECAFLUORO-3-OXANONE-1-SULFONIC ACID	756426-58-1	--	--	4 UJ	4 U	3.7 U	3.5 U
N-ETHYLPERFLUOROOCTANE SULFONAMIDOACETIC ACID	2991-50-6	--	--	4 UJ	4 U	3.7 U	3.5 U
N-METHYLPERFLUOROOCTANE SULFONAMIDOACETIC ACID	2355-31-9	--	--	4 UJ	4 U	3.7 U	3.5 U
PERFLUOROBUTANOIC ACID (PFBA)	375-22-4	--	--	8.2 J	3.9 J	9.7	25
PERFLUORODECANESULFONIC ACID (PFDS)	335-77-3	--	--	2 UJ	2 U	1.9 U	1.8 U
PERFLUORODECANOIC ACID (PFDA)	335-76-2	--	--	2 UJ	2 U	1.9 U	1.8 U
PERFLUORODODECANOIC ACID (PFDOA)	307-55-1	--	--	2 UJ	2 U	1.9 U	1.8 U
PERFLUOROHEPTANESULFONIC ACID (PFHPS)	375-92-8	--	--	6.5 J	2 U	1.4 J	12
PERFLUOROHEPTANOIC ACID (PFHPA)	375-85-9	--	--	5.7 J	2 U	6.4	11
PERFLUOROHEXANOIC ACID (PFHXA)	307-24-4	--	--	27 J	2 U	20	58
PERFLUORONONANESULFONIC ACID (PFNS)	68259-12-1	--	--	2 UJ	2 U	1.9 U	1.8 U
PERFLUOROOCTANE SULFONAMIDE (FOSA)	754-91-6	--	--	2 UJ	2 U	1.9 U	1.8 U
PERFLUOROPENTANESULFONIC ACID (PFPES)	2706-91-4	--	--	21 J	2 U	8.3	50
PERFLUOROPENTANOIC ACID (PFPEA)	2706-90-3	--	--	8.8 J	2 U	19	23
PERFLUOROTETRADECANOIC ACID (PFTEA)	376-06-7	--	--	2 UJ	2 U	1.9 U	1.8 U
PERFLUOROTRIDECANOIC ACID (PFTRIA)	72629-94-8	--	--	2 UJ	2 U	1.9 U	1.8 U
PERFLUOROUNDECANOIC ACID (PFUNA)	2058-94-8	--	--	2 UJ	2 U	1.9 U	1.8 U

Water from Water Treatment Systems were compared to USEPA and State groundwater screening criteria for evaluation purposes only
Highlighted cell indicates concentration is greater than screening criteria.
"--" = No criteria available.
EPA = Environmental Protection Agency.
ESL = Environmental Screening Level
ng/L = nanogram per liter.
PFAS = per- and polyfluoroalkyl substances
RSL = Regional Screening Level.
U = Not detected at or above the Limit of Qualitation (LOQ)
J = Estimated result < LOQ and > Detection Limit (DL)

SECTION 6
CONCLUSIONS AND RECOMMENDATIONS

During the SI, each identified potential source area was inspected for presence of PFAS as specified in the SIWP. PFAS concentrations in sampled media were compared to screening levels, as applicable, to determine whether further investigation would be warranted. PFAS concentrations exceeding screening levels were detected in samples at all AOPCs sampled for soil or groundwater or both. Conclusions and recommendations for each medium and AOPC are below and summarized in Table 6-1.

Conclusions that follow compare detected concentrations of PFAS to State of California ESLs and USEPA RSLs. Figure 5-1 through Figure 5-16 compare detected concentrations of PFAS to USEPA RSLs only, as applicable, for soil and groundwater (USEPA screening levels have not been established for surface water).

Recommendations that follow are based on the conclusions, and the following potential steps for each AOPC:

1. **Further Investigation:** Based on the technical conclusions in this SI, general technical recommendations for further investigation are offered in the following sections for each AOPC.

6.1 AOPC 1 – FORMER FIREFIGHTING TRAINING AREA (IR 10, 12, 20)

Conclusions

Soil samples were collected at four locations, with a surface (0 to 0.5 feet bgs) and subsurface (0.5 to 2 feet bgs) soil sample collected at each location, for a total of eight soil samples. Seventeen of the 28 PFAS were detected in soil samples from AOPC 1. PFOS was detected at at a maximum concentration of 920 μg/kg, and concentrations exceeding the soil RSL of 13 μg/kg in five samples and above the human health and ecologic ESLs of 12 and 13 μg/kg, respectively, in five samples. PFOA was detected at a maximum concentration of 120 μg/kg and at concentrations exceeding the human health ESL of 3.8 μg/kg in five samples. PFOA concentration exceeded the ecologic ESL of 84 μg/kg in one sample. PFOA concentrations exceeded the soil RSL of 19 µg/kg in three samples. PFNA, PFHxS, HFPO-DA, and PFBS concentrations did not exceed RSLs.

Groundwater samples were collected at seven existing monitoring well locations during the SI. Seventeen of the 28 PFAS were detected in groundwater samples from AOPC 1. PFOA was detected at maximum concentration of 5,540 ng/L, and at concentrations exceeding the groundwater RSL of 6 ng/L and the groundwater ESL of 5.1 ng/L in six samples. PFOS was detected at maximum concentration of 7,700 ng/L, and concentrations exceeding the groundwater RSL of 4 ng/L and the groundwater ESL of 6.5 ng/L in seven samples. PFHxS was detected at maximum concentration of 10,400 ng/L, and concentrations exceeding the groundwater RSL of 39 ng/L in six samples. PFNA was detected at maximum concentration of 111 ng/L, and concentration exceeding the groundwater RSL of 5.9 ng/L in two samples. PFBS was detected at a concentration of 931 ng/L exceeding the groundwater RSL of 600 ng/L in one sample. HFPO-DA was non-detect in all samples.

Recommendations

- Further Investigation: Further investigation of the horizontal and vertical extents of PFAS in groundwater and soil is recommended.

6.2 AOPC 2 – CRASH SITE (SUNNYVALE GOLF COURSE)

Conclusions

Soil samples were collected at seven locations, with a surface (0 to 0.5 feet bgs) and subsurface (0.5 to 2 feet bgs) soil sample collected at each location, for a total of 14 soil samples. Thirteen of the 28 PFAS were detected in soil samples from AOPC 2. PFOS was detected a maximum concentration of 41.0 µg/kg, and at concentrations exceeding the RSL, human health, and ecologic ESLs in four samples. PFOA was detected a maximum concentration of 7.70 µg/kg, and at concentrations exceeding the human health ESL of 3.8 µg/kg in four samples. PFBS, PFHxS, and PFNA were not detected above screening criteria. HFPO-DA was non-detect in all samples.

Groundwater samples were collected at five locations. Eleven of the 28 PFAS were detected in groundwater samples from AOPC 2. PFOS was detected at a maximum concentration of 35.0

ng/L, and concentrations exceeding the groundwater ESL of 6.5 ng/L and the groundwater RSL of 4 ng/L in three samples. Concentrations of PFOA, PFBS, PFNA, and PFHxS did not exceed screening values. HFPO-DA was non-detect in all samples.

Recommendations

- Further Investigation: Further investigation of the horizontal and vertical extents of PFAS in groundwater and soil is recommended.

6.3 AOPC 3 – HANGARS 2 AND 3 (IR 7)

Conclusions

Groundwater samples were collected at seven locations within AOPC 3. Nineteen of the 28 PFAS were detected in groundwater samples from AOPC 3. PFOA was detected at a maximum concentration of 62.0 ng/L, and concentrations exceeding the groundwater RSL of 6 ng/L and the groundwater ESL of 5.1 ng/L in six samples. PFOS was detected at a maximum concentration of 160 ng/L, and concentrations exceeding the groundwater RSL of 4 ng/L and the groundwater ESL in seven samples. PFNA was detected at maximum concentration of 11.0 ng/L exceeding the groundwater RSL of 5.9 ng/L in one sample. HFPO-DA was detected at a maximum concentration of 6.1 ng/L, and concentration exceeding the groundwater RSL of 6 ng/L in one sample. PFHxS was detected at a maximum concentration of 180 ng/L, and concentration exceeding the groundwater RSL of 39 ng/L in five samples. PFBS was not detected above the screening level in any sample.

Recommendations

- Further Investigation: Further investigation of horizontal and vertical extents of PFAS in groundwater is recommended.

6.4 AOPC 4 – FORMER ENGINE TEST STAND AREA (IR 11)

Conclusions

Groundwater samples were collected at AOPC 4 at two locations. Nine of the 28 PFAS were detected in groundwater samples from AOPC 4. PFOA was detected at a maximum concentration of 110 ng/L, and concentrations exceeding the groundwater RSL of 6 ng/L and groundwater ESL of 5.1 ng/L in both samples. There were no screening level exceedances for PFBS, PFHxS, or PFOS. PFNA and HFPO-DA were non-detect in all samples.

Recommendations

- Further Investigation: Further investigation of horizontal and vertical extents of PFAS in groundwater is recommended.

6.5 AOPC 5 – HANGAR N211 (WITHIN AOI 3, FORMERLY AOI 12)

Conclusions

Groundwater samples were collected at six locations within AOPC 5. Nineteen of the 28 PFAS were detected in groundwater samples from AOPC 5. PFBS was detected in one sample at a maximum concentration of 1,500 ng/L exceeding the groundwater RSL of 600 ng/L. PFOA was detected at a maximum concentration of 380 ng/L, and concentrations exceeding the groundwater RSL of 6 ng/L and the groundwater ESL of 5.1 ng/L in seven samples. PFOS was detected at a maximum concentration of 40,000 ng/L, and concentrations exceeding the groundwater RSL of 4 ng/L and the groundwater ESL of 6.5 ng/L in seven samples. PFHxS was detected at a maximum concentration of 4,400 ng/L, and concentrations exceeding the groundwater RSL of 39 ng/L in five samples. PFNA was detected at a maximum concentration of 27.0 ng/L, and concentrations exceeding the groundwater RSL of 5.9 ng/L in five samples. HFPO-DA was non-detect in all samples.

Recommendations

- Further Investigation: Further investigation of horizontal and vertical extents of PFAS in groundwater is recommended. There is a data gap for AOPCs with only one sample. Further samples may be collected at these AOPCs during the ESI to help support the development of a future RI work plan.

6.6 AOPC 6 – HANGAR N248 (AOI 3 EAST)

Conclusions

Soil samples were collected at one location, which included a surface (0 to 0.5 feet bgs) and subsurface (0.5 to 2 feet bgs) soil samples, for a total of two samples. Twenty-one of the 28 PFAS were detected in soil samples from AOPC 6. PFOS was detected a maximum concentration of 1900 µg/kg, and at concentrations exceeding the RSL of 13 µg/kg and the human health and ecologic ESLs of 12 and 13 µg/kg, respectively, in both samples. PFOA was detected a maximum concentration of 5.10 µg/kg, and at concentration exceeding the human health ESL of 3.8 µg/kg in one sample. PFBS, PFNA, and PFHxS concentrations did not exceed screening levels. HFPO-DA was non-detect in all samples.

Groundwater samples were collected at three locations within AOPC 6. Thirteen of the 28 PFAS were detected in groundwater samples from AOPC 6. PFBS was detected at concentration exceeding the groundwater RSL of 600 ng/L in one sample. PFOA was detected at a maximum concentration of 610ng/L, and concentrations exceeding the groundwater RSL of 6 ng/L and the groundwater ESL of 5.1 ng/L in all three samples. PFOS was detected at a maximum concentration of 15,000 ng/L, and concentrations exceeding the groundwater RSL of 4 ng/L and the groundwater ESL of 6.5 ng/L in all three samples. PFHxS was detected at a maximum concentration of 5,200 ng/L, and concentrations exceeded the groundwater RSL of 39 ng/L in three samples, and PFNA was detected at a concentration 14 ng/L exceeding the groundwater RSL of 5.9 ng/L in one sample. HFPO-DA was non-detect in all samples.

Recommendations

- Further Investigation: Further investigation of the horizontal and vertical extents of PFAS in groundwater and soil is recommended. There is a data gap for AOPCs with only one sample. Further samples may be collected at these AOPCs during the ESI to help support the development of a future RI work plan.

6.7 AOPC 7 – FIRE DEPARTMENT (BUILDING 580)

Conclusions

Soil samples were collected at AOPC 7 at two locations, each of which included a surface (0 to 0.5 feet bgs) and subsurface (0.5 to 2 feet bgs) soil sample, for a total of four soil samples. Eighteen of the 28 PFAS were detected in soil samples from AOPC 7. PFOS was detected a maximum concentration of 1,500 µg/kg, and at concentrations exceeding the soil RSL of 13 µg/kg and the human health and ecologic ESLs of 12 and 13 µg/kg, respectively, in all four samples. PFOA was detected a maximum concentration of 4.2 µg/kg, and at a concentration exceeding the human health ESL of 3.8 µg/kg in one sample. PFHxS, PFNA, and PFBS concentrations did not exceed screening levels. HFPO-DA was non-detect in all samples.

Groundwater samples were collected at five locations within AOPC 7. Seventeen of the 28 PFAS were detected in groundwater samples from AOPC 7. PFOA was detected at a maximum concentration of 240 ng/L, and concentrations exceeding the groundwater RSL of 6 ng/L and the groundwater ESL of 5.1 ng/L in four samples. PFOS was detected at a maximum concentration of 5,000 ng/L, and concentrations exceeding the groundwater RSL of 4 ng/L and the groundwater ESL of 6.5 ng/L in five samples. PFHxS was detected at a maximum concentration of 27.0 ng/L, and exceeded the groundwater RSL of 39 ng/L in four samples, and PFNA was detected at a concentration of 36 ng/L and exceeded the groundwater RSL of 5.9 ng/L in one sample. PFBS concentrations did not exceed any screening levels. HFPO-DA was non-detect in all samples.

Recommendations

- Further Investigation: Further investigation of the horizontal and vertical extents of PFAS in groundwater and soil is recommended. For the purposes of further investigation, AOPC 7 will be subsumed into AOPC 1 as the PFAS and potential source of PFAS are the same or similar, and AOPC 7 is within AOPC 1.

6.8 AOPC 8 – SITE 1 RUNWAY LANDFILL (IR 1)

Conclusions

Groundwater samples were collected at five locations within AOPC 8. Ten of the 28 PFAS were detected in groundwater samples from AOPC 8. PFOA was detected at a maximum concentration of 6.5 ng/L, and concentrations exceeding the groundwater RSL of 6 ng/L and the groundwater ESL of 5.1 ng/L in two samples. PFOS, PFBS, and PFHxS concentrations did not exceed any screening levels. PFNA and HFPO-DA were non-detect in all samples.

Recommendations

- Further Investigation: Further investigation of horizontal and vertical extents of PFAS in groundwater is recommended.

6.9 AOPC 9 – SITE 2 FORMER GOLF COURSE LANDFILL (IR 2)

Conclusions

Groundwater samples were collected at three locations within AOPC 9. Thirteen of the 28 PFAS were detected in groundwater samples from AOPC 9. PFOA was detected at a maximum concentration of 230 ng/L, and concentrations exceeding the groundwater RSL of 6 ng/L and the groundwater ESL of 5.1 ng/L in three samples. PFOS was detected at a maximum concentration of 500 ng/L, and concentrations exceeding the groundwater RSL of 4 ng/L and the groundwater ESL of 6.5 ng/L in three samples. PFHxS was detected at a maximum concentration of 500 ng/L, and concentrations exceeding the groundwater RSL of 39 ng/L in three samples. PFBS and PFNA concentrations did not exceed any screening levels. HFPO-DA was non-detect in all samples.

Recommendations

- Further Investigation: Further investigation of the horizontal and vertical extents of PFAS in groundwater is recommended.

6.10 AOPC 10 – SITE 22 LANDFILL (IR 22)

Conclusions

Groundwater samples were collected at nine locations within AOPC 10. Thirteen of the 28 PFAS were detected in groundwater samples from AOPC 10. PFOA was detected at a maximum concentration of 41 ng/L, and concentrations exceeding the groundwater RSL of 6 ng/L and the groundwater ESL of 5.1 ng/L in five samples. PFOS was detected at a a maximum concentration of 53.0 ng/L, and concentration exceeding the groundwater RSL of 4 ng/L and the groundwater ESL of 6.5 ng/L in five samples. PFHxS was detected at a maximum concentration of 120 ng/L, and concentration exceeding the groundwater RSL of 39 ng/L in one sample. PFBS and PFNA concentrations did not exceed any screening levels. HFPO-DA was non-detect in all samples.

Recommendations

- Further Investigation: Further investigation of the horizontal and vertical extents of PFAS in groundwater is recommended.

6.11 AOPC 11 – BUILDING 191 PUMP STATION

Conclusions

One surface water sample was collected at AOPC 11. PFNA was detected at concentration of 13 ng/L, PFHxS was detected at 930 ng/L exceeding the surface water RSL of 565 ng/L, PFBS was detected at 130 ng/L, PFOA was detected at 340 ng/L exceeding the surface water RSL of 87.7 ng/L and ESL of 75 ng/L, and PFOS was detected at 1,400 ng/L exceeding the surface water RSL of 58.5 ng/L. HFPO-DA was not detected in the sample.

Recommendations

- Further Investigation: Further investigation of the presence of PFAS in surface water is recommended, including the possibility of a pathway between AOPC 11 (Building 191 Pump Station), AOPC 16 (North Patrol Road Ditch and Northern Channel), and AOPC 17 (Marriage Road Ditch). There is a data gap for AOPCs with only one sample. Further samples may be collected at these AOPCs during the ESI to help support the development of a future RI work plan.

6.12 AOPC 12 ‑ STORMWATER SETTLING BASIN/EASTERN DIKED MARSH (WITHIN IR 25)

Conclusions

One surface water sample was collected at AOPC 12. PFBS, PFOA and PFOS were detected below surface water screening levels listed in Table 2-1. PFBS was detected at concentration of 4 ng/L, PFOA was detected at estimated concentration of 1.1 ng/L, PFHxS was detected at 6 ng/L, and PFOS was detected at 5.5 ng/L. HFPO-DA and PFNA were not detected in the sample.

Recommendations

- Further Investigation: Further investigation of the sources and extent of PFAS in surface water in AOPC 12 is recommended. There is a data gap for AOPCs with only one sample. Further samples may be collected at these AOPCs during the ESI to help support the development of a future RI work plan.

6.13 AOPC 13 ‑ NASA GROUNDWATER EXTRACTION TREATMENT SYSTEM

Conclusions

One influent and one effluent sample were collected at AOPC 13. Eleven of the 28 PFAS were detected in the samples from AOPC 13. These results were compared to USEPA and State groundwater screening levels for evaluation purposes only. Concentrations in the influent sample (AOPC 13-SW01) exceeded the groundwater RSLs for PFOS (at 6,800 ng/L), PFHxS (at 2,600 ng/L), and PFOA (at 330 ng/L), as well as the groundwater ESLs for PFOS and PFOA. Concentrations of PFOS in the effluent sample exceeded the groundwater RSL of 4 ng/L; however, the concentration in the duplicate sample was under the RSL. At ARC, treated water from NASA GWETS (AOPC 13) and MEW GWETS (AOPC 14) either discharges to Stevens Creek or is treated via RO at the Building N271 IWPP (AOPC 20), and then is used for the ARC Jet Complex before discharge into the Palo Alto Sanitary Sewer.

One surface water sample was collected at AOPC 13. This is the same sample collected to evaluate AOPC 14 (see next section). All detections were below RSL and ESL surface water screening levels listed in Table 2-1. PFBS was detected at estimated concentration of 1.3 ng/L, PFOA was detected at estimated concentration of 1.1 ng/L, PFHxS was detected at 5.4 ng/L, and PFOS was detected at 7.4 ng/L. HFPO-DA and PFNA were not detected in the sample.

Recommendations

- Further Investigation: Further investigation of the extents of PFAS in surface water at AOPC 13 is recommended with additional evaluation of the influent and effluent data with a focus on off-site migration of PFAS along with routine quarterly monitoring of the influent and effluent and taking additional steps as needed based on results.

6.14 AOPC 14 ‑ MIDDLEFIELD-ELLIS-WHISMAN GROUNDWATER EXTRACTION TREATMENT SYSTEM

Conclusions

One influent and one effluent sample were collected at AOPC 14. Influent and effluent results were compared to USEPA and State groundwater screening levels for evaluation purposes only. PFOS (at a maximum concentration of 120 ng/L in influent), PFOA (at a maximum concentration of 140 ng/L in influent), and PFHxS (at a maximum concentration of 120 ng/L in influent) concentrations in both samples exceeded the groundwater RSLs. Concentrations of PFOS and PFOA in both samples also exceeded the groundwater ESLs. Eleven of the 28 PFAS were detected in the samples from AOPC 14. In all cases except for PFBA and PFPeA, the influent concentration was higher than the effluent concentration, and those respective sets of concentrations of the two analytes differed negligibly (less than two ng/L).

At ARC, treated water from MEW GWETS (AOPC 14) either discharges to Stevens Creek or is treated via RO at the Building N271 IWPP (AOPC 20), and then is used for the ARC Jet Complex before discharge into the Palo Alto Sanitary Sewer.

One surface water sample was collected at AOPC 14 (same sample as AOPC 13). All detections were below RSL and ESL surface water screening levels listed in Table 2-1. PFBS was detected at estimated concentration of 1.3 ng/L, PFOA was detected at estimated concentration of 1.1 ng/L, PFHxS was detected at 5.4 ng/L, and PFOS was detected at 7.4 ng/L. HFPO-DA and PFNA were not detected in the sample..

Recommendations

- Further Investigation: Further investigation of discharges from the MEW GWETS into Stevens Creek is recommended. PFAS detected in surface water samples from Stevens Creek could also be attributable to impacted urban runoff from elsewhere in the watershed. There is a data gap for AOPCs with only one sample. Further samples may be collected at these AOPCs during the ESI to help support the development of a future RI work plan. Routine quarterly monitoring of the influent and effluent is also recommended, and additional steps should be taken based on results. The MEW GWETS should be updated to reduce concentrations of PFAS to below appropriate discharge concentrations in Stevens Creek.

6.15 AOPC 15 ‑ WEST-SIDE AQUIFERS TREATMENT SYSTEM (IR 28)

Conclusions

One influent and one effluent sample were collected at AOPC 15. Influent and effluent results were compared to USEPA and State groundwater screening levels for evaluation purposes only. PFOS (at 47 ng/L), PFOA (at 17 ng/L), and PFHxS (at 48 ng/L0 concentrations in the influent sample exceeded the groundwater RSLs. Concentrations of PFOS and PFOA in the influent sample also exceeded the groundwater ESLs. Twelve of the 28 PFAS were detected in the influent sample from AOPC 15. The only PFAS detected in the effluent sample was PFBA at an estimated concentration of 3.9 ng/L.

Recommendations

- Further Investigation: Routine quarterly monitoring of the influent and effluent is recommended, and additional steps should be taken as needed based on results.

6.16 AOPC 16 ‑ NORTH PATROL ROAD DITCH (IR 21) AND NORTHERN CHANNEL (IR 27)

Conclusions

Five groundwater samples were collected at AOPC 16. All of the 28 PFAS were detected in groundwater samples from AOPC 16. PFOA was detected at a maximum concentration of 230 ng/L, and concentrations exceeding the groundwater RSL of 6 ng/L and the groundwater ESL of 5.1 ng/L in four samples. PFOS was detected at a maximum concentration of 500 ng/L, and concentrations exceeding the groundwater RSL of 4 ng/L and the groundwater ESL of 6.5 ng/L in three samples. PFHxS was detected at concentrations exceeding the groundwater RSL of 39 ng/L in two samples. PFBS and PFNA were not detected at any concentrations exceeding any screening levels. HFPO-DA was non-detect in all samples.

Recommendations

- Further Investigation: Further investigation of the horizontal and vertical extents of PFAS in groundwater is recommended. The pathway of PFAS in surface water between AOPC 11 (Building 191 Pump Station), AOPC 16 (North Patrol Road Ditch and Northern Channel), and AOPC 17 (Marriage Road Ditch) should also be investigated.

6.17 AOPC 17 – MARRIAGE ROAD DITCH (IR 3)

Conclusions

Groundwater samples were collected at five locations within AOPC 17. Thirteen of the 28 PFAS were detected in groundwater samples from AOPC 17. PFOA was detected at a maximum concentration of 160 ng/L, and concentrations exceeding the groundwater RSL of 6 ng/L and the groundwater ESL of 5.1 ng/L in four samples. PFOS was detected at a maximum concentration of 150 ng/L, and concentrations exceeding the groundwater RSL of 4 ng/L and the groundwater ESL of 6.5 ng/L in four samples. PFHxS was detected at a maximum concentration of 190 ng/L, and concentrations exceeding the groundwater RSL in four samples. PFNA and PFBS were not detected at concentrations exceeding any screening levels. HFPO-DA was non-detect in all samples.

Recommendations

- Further Investigation: Further investigation of the horizontal and vertical extents of PFAS in groundwater is recommended. The pathway of PFAS in surface water between AOPC 11 (Building 191 Pump Station), AOPC 16 (North Patrol Road Ditch and Northern Channel), and AOPC 17 (Marriage Road Ditch) should also be investigated.

6.18 AOPC 18 ‑ LINDBERGH AVENUE STORM DRAIN DITCH (AOI 6)

Conclusions

Groundwater samples were collected at three locations within AOPC 18. Twelve of the 28 PFAS were detected in groundwater samples from AOPC 18. PFOA was detected at a maximum concentration of 34.0 ng/L, and concentrations exceeding the groundwater RSL of 6 ng/L and the groundwater ESL of 5.1 ng/L in two samples. PFOS was detected at a maximum concentration of 470 ng/L, and concentrations exceeding the groundwater RSL of 4 ng/L and the groundwater ESL of 6.5 ng/L in all three samples. PFHxS was detected at a maximum concentration of 220 ng/L, and concentrations exceeding the groundwater RSL in two samples. PFBS and PFNA did not exceed any screening levels. HFPO-DA was non-detect in all samples.

Recommendations

- Further Investigation: Further investigation of the horizontal and vertical extents of PFAS in groundwater is recommended.

6.19 AOPC 19 ‑ STORMWATER RETENTION PONDS (WITHIN IR 25)

Conclusions

One surface water sample was collected at AOPC 19; however, the data were flagged with the X and UX qualifiers (see Appendix H). The “X” qualifier in the DoD program indicates that the data point should be excluded, so results from this sample were excluded from data evaluation.

Recommendations

- Further Investigation: Re-sampling of surface water is recommended for AOPC 19, along with sediment sampling. There is a data gap for AOPCs with only one sample. Further samples may be collected at these AOPCs during the ESI to help support the development of a future RI work plan. Further samples may include additional surface water samples from AOPC 19 to account for high salinity after the dry seasons, collection of the sample during the rainy season with duplicate samples, and additional analysis for total dissolved solids (TDS) and other appropriate parameters to better determine representative PFAS analytical results

6.20 AOPC 20 ‑ BUILDING N271 INDUSTRIAL WASTEWATER PRETREATMENT PLANT

Conclusions

One effluent sample was collected at AOPC 20. Effluent results were compared to USEPA and State groundwater screening levels for evaluation purposes only. PFOS (210 ng/L), PFOA (36.0 ng/L), and PFHxS (230 ng/L0 concentrations in the sample exceeded the groundwater RSLs. Concentrations of PFOS and PFOA exceeded groundwater ESLs. There were no PFBS screening level exceedances, and PFNA and HFPO-DA were both non-detect. Eleven of the 28 PFAS were detected in the sample from AOPC 20. At ARC, water from NASA GWETS (AOPC 13) and MEW GWETS (AOPC 14) is treated via RO at the Building N271 IWPP (AOPC 20), and then is used for the ARC Jet Complex before discharge into the Palo Alto Sanitary Sewer.

Recommendations

- Further Investigation: There is a data gap for AOPCs with only one sample. Further samples may be collected at these AOPCs during the ESI to help support the development of a future RI work plan. Routine quarterly monitoring of the treated water effluent is recommended, and additional steps should be taken as needed based on results.

6.21 AOPC 21 ‑ FORMER INDUSTRIAL WASTEWATER SURFACE IMPOUNDMENT (IR 4)

Conclusions

Groundwater samples were collected at eight locations within AOPC 21. Fourteen of the 28 PFAS were detected in groundwater samples from AOPC 21. PFOA was detected at a maximum concentration of 60.0 ng/L, and concentrations exceeding the groundwater RSL of 6 ng/L and the groundwater ESL of 5.1 ng/L in seven samples. PFOS was detected at a maximum concentration of 99.0 ng/L, and concentrations exceeding the groundwater RSL of 4 ng/L and the groundwater ESL of 6.5 ng/L in five samples. In one additional sample, only the PFOS groundwater RSL of 4 ng/L was exceeded. PFHxS was detected at a maximum concentration of

83 ng/L, and concentrations exceeding the groundwater RSL of 39 ng/L in five samples. PFNA, PFBS, and HFPO-DA were not detected at concentrations exceeding any screening levels.

Recommendations

- Further Investigation: Further investigation of the horizontal and vertical extents of PFAS in groundwater is recommended.

6.22 AOPC 22 ‑ BUILDING N249 OUTDOOR AERODYNAMIC RESEARCH FACILITY

Conclusions

Groundwater samples were collected at two locations within AOPC 22. Seven of the 28 PFAS were detected in groundwater samples from AOPC 22. PFOS was detected at a maximum concentration of 15 ng/L, and concentrations exceeding the groundwater RSL of 4 ng/L and the groundwater ESL of 6.5 ng/L in three samples. PFHxS was detected at maximum concentration of 56.0 ng/L exceeding the groundwater RSL of 39 ng/L in one sample. PFOA, PFNA, PFBS, and HFPO-DA were not detected at concentrations exceeding any screening levels.

Recommendations

- Further Investigation: Further investigation of the horizontal and vertical extents of PFAS in groundwater is recommended.

6.23 AOPC 23 ‑ HANGAR 4 (CANG) BUILDING 662

Conclusions

Previous sampling efforts already identified the presence of PFAS at AOPC 23 prior to this SI. Previous sampling identified maximum concentration of PFOA (580 ng/L) in the groundwater sample, and PFOS in a grab groundwater sample (80.2 ng/L) However, during the SI, one groundwater sample was collected from a new well, PFAS-C, which is near a well previously sampled for AOPC 23. In sample PFAS-C, PFOS was detected at a maximum concentration of 35 ng/L, and concentration exceeding the groundwater RSL of 4 ng /L and the groundwater ESL of 6.5 ng/L. Results from PFAS-C are discussed in Section 5.23 and results from previous sampling in 2018-2019 at AOPC 23 are discussed in Section 3.6.23.

Recommendations

- Further Investigation: A remedial investigation is recommended for AOPC 23.

6.24 AOPC 24 ‑ MIDDLEFIELD-ELLIS-WHISMAN (MEW) PLUME

Conclusions

Groundwater samples were collected at four locations within AOPC 24. Eleven of the 28 PFAS were detected in groundwater samples from AOPC 24. PFOA was detected at a maximum concentration of 11.0 ng/L, and concentrations exceeding the groundwater RSL of 6 ng/L and the groundwater ESL of 5.1 ng/L in one sample. PFOS was detected at a maximum concentration of 57.0 ng/L, and concentrations exceeding the groundwater RSL of 4 ng/L in three samples. PFOS concentrations exceeded the groundwater ESL of 6.5 ng/L in two samples. PFHxS was detected at concentration of 130 ng/L exceeding the groundwater RSL of 39 ng/L in one sample. PFBS was not detected at concentrations exceeding any screening levels. PFNA and HFPO-DA were non-detect in all samples.

Recommendations

- Further Investigation: Further investigation of the horizontal and vertical extents of PFAS in groundwater is recommended. Appendix J includes relevant data from MEW parties found in the https://geotracker.waterboards.ca.gov, and an evaluation of this data will be included in an ESI.

6.25 AOPC 25 ‑ ORION PARK PLUME

Conclusions

Groundwater samples were collected at two locations within AOPC 25. Ten of the 28 PFAS were detected in groundwater samples from AOPC 25. PFOS was detected at a maximum concentration of 9.00 ng/L, and concentrations exceeding the groundwater ESL of 6.5 ng/L in one sample and exceeding the groundwater RSL of 4 ng/L in two samples. PFOA, PFNA, PFHxS, HFPO-DA, and PFBS were not detected at concentrations exceeding any screening levels.

Recommendations

- Further Investigation: Further investigation of the horizontal and vertical extents of PFAS in groundwater is recommended.

6.26 AOPC 26 - EASTERN BOUNDARY (IR 5)

Conclusions

A groundwater sample was collected along the ARC eastern property boundary at one location beside Lockheed Martin at well W5-3 and within former Site 5. Fifteen of the 28 PFAS were detected in the groundwater sample at this location. PFOA was detected at a maximum concentration of 350 ng/L, and concentration exceeding the groundwater RSL of 6 ng/L and the groundwater ESL of 5.1 ng/L. PFOS was detected at a maximum concentration of 490 ng/L, and concentration exceeding the groundwater RSL of 4 ng/L and the groundwater ESL of 6.5 ng/L. PFNA at 16.0 ng/L and PFHxS at 350 ng/L concentrations exceeded the groundwater RSLs of 5.9 and 39 ng/L, respectively. The detected concentration of PFBS did not exceed any screening levels, and HFPO-DA was not detected in the sample.

Recommendations

- Further Investigation: Further investigation of the horizontal and vertical extents of PFAS in groundwater is recommended. Appendix J includes relevant data from Lockheed Martin NIROP facility found in the https://geotracker.waterboards.ca.gov, and an evaluation of this data will be included in an ESI.

6.27 PATH FORWARD

All 26 AOPCs included in this SI are recommended for further PFAS evaluation based on data exceeding screening levels or the need to collect additional data to evaluate potential PFAS impacts (e.g., AOPC 19 - Stormwater Retention Pond [within IR 25]). The highest detections for PFAS compounds with USEPA RSLs that have been identified in groundwater and soil, respectively, at ARC to date include: PFOS (40,000 ng/L, 1,900 µg/kg), PFOA (5,540 ng/L, 120 µg/kg), PFBS (1,500 ng/L, 1.8 µg/kg), HPFO-DA (estimated 6.10 ng/L, not detected in soil), PFHxS (10,400 ng/L, 92.0 µg/kg), and PFNA (111 ng/L, 2.60 µg/kg). Recommendations for each medium and AOPC are summarized in Table 6-1.

Currently the SI data indicate that PFAS are present in the surface water migrating off site. Further investigation is necessary to determine if there are unacceptable impacts from the presence of PFAS in off-site surface water based on determination of potential receptors and development of risk-based criteria using site specific parameters.

The Remedial Investigation (RI) work plan will discuss off-site migration pathways and assess the potential for exposure of off-site human and ecological receptors to secondary areas of PFAS contamination. The RI work plan will include an ecological risk conceptual site model (CSM) that will be used to evaluate off-site exposure of birds and mammals to PFAS in surface water, and a human health CSM that will be used to evaluate off-site exposure to humans from PFAS in drinking water wells and PFAS-impacted surface water.

The RI will provide a more accurate depiction of groundwater flow directions for unconfined aquifer at the entire site, and PFAS transport and migration pathways with the priority being the off-site migration of PFAS in surface water (RTC 17)

This report including conclusions and recommendations were reviewed with USEPA and Regional Water Board before publishing. NASA responded to comments from USEPA and Regional Water Board. NASA, USEPA and Regional Water Board concurred on the responses. Appendix K includes copies of the comments and responses.

Table 6-1. Conclusions and Recommendations

AOPC	Screening Level Exceedances				Recommendations
	Soil	Groundwater	Surface Water	Influent/Effluent	
AOPC 1 - FORMER FIREFIGHTING TRAINING AREA (IR 10, 12, 20)	PFOS was detected at concentrations exceeding the soil RSL of 13 µg/kg in five samples and above the human health and ecologic ESLs of 12 µg/kg and 13 µg/kg, respectively, in five samples. PFOA was detected at concentrations exceeding the human health ESL of 3.8 µg/kg in five samples. PFOA concentrations exceeded the ecologic ESL of 84 µg/kg in one sample. PFOA exceeded the soil RSL of 19 µg/kg in three samples. There were no exceedances of the RSL for PFNA, PFHxS, HFPO-DA, or PFBS.	PFOA was detected at concentrations exceeding the groundwater RSL of 6 ng/L and exceeding the groundwater ESL of 5.1 ng/L in eight samples. PFOS was detected at concentrations exceeding the groundwater RSL of 4 ng/L and exceeding the groundwater ESL of 6.5 ng/L in nine samples. PFHxS was detected at concentrations exceeding the groundwater RSL of 39 ng/L in six samples. PFNA was detected at a concentration exceeding the groundwater RSL of 5.9 ng/L in one sample. There were no PFBS screening level exceedances. All HFPO-DA results were non-detect.	--	--	Further investigate the horizontal and vertical extents of PFAS in groundwater and soil.
AOPC 2 - CRASH SITE (SUNNYVALE GOLF COURSE)	PFOS was detected at concentrations exceeding the RSL, human health and ecologic ESLs in four samples. PFOA was detected at concentrations exceeding the human health ESL of 3.8 µg/kg in four samples. PFBS, PFHxS, and PFNA were not detected above screening criteria. HFPO-DA was not detected in any samples.	PFOS was detected at concentrations exceeding the groundwater ESL of 6.5 ng/L and the groundwater RSL of 4 ng/L in three samples. PFOA, PFBS, PFNA, and PFHxS did not exceed any screening values. HFPO-DA was not detected in any samples.	--	--	Further investigate the horizontal and vertical extents of PFAS in groundwater and soil.
AOPC 3 - HANGARS 2 AND 3 (IR 7)	--	PFOA was detected at a concentration exceeding the groundwater RSL of 6 ng/L and the groundwater ESL of 5.1 ng/L in six samples. PFOS was detected at concentrations exceeding the groundwater RSL of 4 ng/L and the groundwater ESL in seven samples. PFNA was detected at a concentration exceeding the groundwater RSL of 5.9 ng/L in one sample. HFPO-DA was detected at a concentration exceeding the groundwater RSL of 6 ng/L in one sample. PFBS was not detected above any screening levels.	--	--	Further investigatee horizontal and vertical extents of PFAS in groundwater.
AOPC 4 - FORMER ENGINE TEST STAND AREA (IR 11)	--	PFOA was detected at a concentration exceeding the groundwater RSL of 6 ng/L and groundwater ESL of 5.1 ng/L in both samples. There were no screening level exceedances for PFBS, PFHxS or PFOS, and neither PFNA nor HFPO-DA were detected in any samples.	--	--	Further investigate the horizontal and vertical extents of PFAS in groundwater.
AOPC 5 – HANGAR N211 (WITHIN AOI 3 AND FORMERLY AOI 12)	--	PFBS was detected in one sample at concentrations exceeding the groundwater RSL of 600 ng/L. PFOA was detected at concentrations exceeding the groundwater RSL of 6 ng/L and the groundwater ESL of 5.1 ng/L in seven samples. PFOS was detected at concentrations exceeding the groundwater RSL of 4 ng/L and the groundwater ESL of 6.5 ng/L in seven samples. PFHxS was detected at concentrations exceeding the groundwater RSL of 39 ng/L in five samples. PFNA was detected at concentrations exceeding the groundwater RSL of 5.9 ng/L in five samples. HFPO-DA was not detected in any samples.	--	--	Further investigate the horizontal and vertical extents of PFAS in groundwater. There is a data gap for AOPCs with only one sample. Further samples may be collected at these AOPCs during the ESI to help support the development of a future RI work plan
AOPC 6 – HANGAR N248 (AOI 3 EAST)	PFOS was detected at concentrations exceeding the RSL of 13 µg/kg and the human health and ecologic ESLs of 12 µg/kg and 13 µg/kg in both samples. PFOA was detected at concentrations exceeding the human health ESL of 3.8 µg/kg in one sample. There were no detections exceeding PFBS, PFNA, or PFHxS screening level exceedances. HFPO-DA was not detected in any samples.	PFBS was detected at concentrations exceeding the groundwater RSL of 600 ng/L in one sample. PFOA was detected at concentrations exceeding the groundwater RSL of 6 ng/L and the groundwater ESL of 5.1 ng/L in all three samples. PFOS was also detected at concentrations exceeding the groundwater RSL of 4 ng/L and the groundwater ESL of 6.5 ng/L in all three samples. PFHxS exceeded the groundwater RSL of 39 ng/L in three samples and PFNA exceeded the groundwater RSL of 5.9 ng/L in one sample. HFPO-DA was not detected in any samples.	--	--	Further investigate the horizontal and vertical extents of PFAS in groundwater and soil. There is a data gap for AOPCs with only one soil sample. Further samples may be collected at these AOPCs during the ESI to help support the development of a future RI work plan.

Table 6-1. Conclusions and Recommendations

AOPC	Screening Level Exceedances				Recommendations
	Soil	Groundwater	Surface Water	Influent/Effluent	
AOPC 7 – FIRE DEPARTMENT (BUILDING 580)	PFOS was detected at concentrations exceeding the soil RSL of 13 µg/kg and the human health and ecologic ESLs of 12 µg/kg and 13 µg/kg, respectively, in all four samples. PFOA was detected at a concentration exceeding the human health ESL of 3.8 µg/kg in one sample. There were no PFHxS, PFNA, or PFBS screening level exceedances. HFPO-DA was not detected in any samples.	PFOA was detected at concentrations exceeding the groundwater RSL of 6 ng/L and the groundwater ESL of 5.1 ng/L in four samples. PFOS was detected at concentrations exceeding the groundwater RSL of 4 ng/L and the groundwater ESL of 6.5 ng/L in five samples. PFHxS exceeded the groundwater RSL of 39 ng/L in four samples and PFNA exceeded the groundwater RSL of 5.9 ng/L in one sample. PFBS did not exceed any screening levels. HFPO-DA was not detected in any samples.	--	--	Further investigate the horizontal and vertical extent of PFAS in groundwater and soil. For the purposes of further investigation, AOPC 7 will be subsumed into AOPC 1 as the PFAS compounds are the same or similar, and AOPC 7 is within AOPC 1.
AOPC 8 – SITE 1 RUNWAY LANDFILL (IR 1)	--	PFOA was detected at concentrations exceeding the groundwater RSL of 6 ng/L and the groundwater ESL of 5.1 ng/L in two samples. PFOS, PFBS, and PFHxS did not exceed any screening levels. PFNA and HFPO-DA were not detected in any samples.		--	Further investigate the horizontal and vertical extents of PFAS in groundwater.
AOPC 9 – SITE 2 FORMER GOLF COURSE LANDFILL (IR 2)	--	PFOA was detected at concentrations exceeding the groundwater RSL of 6 ng/L in three samples. These three samples also exceeded the groundwater ESL of 5.1 ng/L. PFOS was detected at concentrations exceeding the groundwater RSL of 4 ng/L in three samples. These three samples also exceeded the groundwater ESL of 6.5 ng/L. PFHxS was detected at concentrations exceeding the groundwater RSL of 39 ng/L in three samples. PFBS and PFNA did not exceed any screening levels. HFPO-DA was not detected in any samples.	--	--	Further investigate the horizontal and vertical extents of PFAS in groundwater.
AOPC 10 – SITE 22 LANDFILL (IR 22)	--	PFOA was detected at concentrations exceeding the groundwater RSL of 6 ng/L and the groundwater ESL of 5.1 ng/L in five samples. PFOS was detected at a concentration exceeding the groundwater RSL of 4 ng/L and the groundwater ESL of 6.5 ng/L in five samples. PFHxS was detected at concentrations exceeding the groundwater RSL of 39 ng/L in one sample. PFBS and PFNA did not exceed any screening levels. HFPO-DA was not detected in any samples.	--	--	Further investigate the horizontal and vertical extents of PFAS in groundwater.
AOPC 11 - BUILDING 191 PUMP STATION	--	PFOA was detected at a concentration exceeding the groundwater RSL of 6 ng/L and groundwater ESL of 5.1 ng/L in the sample. There were no screening level exceedances for PFBS, PFHxS or PFOS, and neither PFNA nor HFPO-DA were detected.	PFNA was detected at a concentration of 13 ng/L, PFHxS was detected at a concentration of 930 ng/L, PFBS was detected at a concentration of 130 ng/L, PFOA was detected at a concentration of 340 ng/L, and PFOS was detected at a concentration of 1,400 ng/L. HFPO-DA was not detected in the sample. There are currently no screening levels for surface water.	--	Further investigation of the presence of PFAS in groundwater around the pump station and surface water is recommended, including the possibility of a pathway from AOPC 4 (Former Enginer Test Stand Area), AOPC 11 (Building 191 Pump Station), AOPC 16 (North Patrol Road Ditch and Northern Channel), and AOPC 17 (Marriage Road Ditch). There is a data gap for AOPCs with only one sample. Further samples may be collected at these AOPCs during the ESI to help support the development of a future RI work plan.
AOPC 12 - STORMWATER SETTLING BASIN/EASTERN DIKED MARSH (WITHIN IR 25)	--	--	PFBS was detected at a concentration of 4 ng/L, PFOA was detected at an estimated concentration of 1.1 ng/L, PFHxS was detected at 6 ng/L, and PFOS was detected at a concentration of 5.5 ng/L. HFPO-DA and PFNA were not detected in the sample. There are currently no screening levels for surface water.	--	Further investigate the sources and extent of PFAS in surface water. There is a data gap for AOPCs with only one sample. Further samples may be collected at these AOPCs during the ESI to help support the development of a future RI work plan.
AOPC 13 - NASA GROUNDWATER EXTRACTION TREATMENT SYSTEM	--	--	PFBS was detected at a concentration of 1.3 ng/L, PFOA was detected at an estimated concentration of 1.1 ng/L, PFHxS was detected at 5.4 ng/L, and PFOS was detected at a concentration of 7.4 ng/L. HFPO-DA and PFNA were not detected in the sample. There are currently no screening levels for surface water.	Influent/effluent results were compared to USEPA and State groundwater screening levels for evaluation purposes only. Concentrations in the influent sample exceeded the groundwater RSLs for PFOS, PFHxS, and PFOA, as well as the groundwater ESLs for PFOS and PFOA. Concentrations of PFOS in the effluent sample exceeded the groundwater RSL of 4 ng/L; however, the concentration in the duplicate sample was under the RSL.	Further investigation of the extent of PFAS in surface water at AOPC 13 is recommended, along with continued routine quarterly monitoring of the influent and effluent and taking additional steps as needed based on results.

Table 6-1. Conclusions and Recommendations

AOPC	Screening Level Exceedances				Recommendations
	Soil	Groundwater	Surface Water	Influent/Effluent	
AOPC 14 - MIDDLEFIELD-ELLIS-WHISMAN GROUNDWATER EXTRACTION TREATMENT SYSTEM	--	--	PFBS was detected at an estimated concentration of 1.3 ng/L, PFOA was detected at an estimated concentration of 1.1 ng/L, PFHxS was detected at 5.4 ng/L, and PFOS was detected at a concentration of 7.4 ng/L. HFPO-DA and PFNA were not detected in the sample. There are currently no screening levels for surface water.	Influent/effluent results were compared to USEPA and State groundwater screening levels for evaluation purposes only. Concentrations in both samples exceeded the groundwater RSLs for PFOS, PFOA, and PFHxS, as well as the groundwater ESLs for PFOS and PFOA. In all cases except for PFBA and PFPeA, the influent concentration was higher than the effluent concentration, and for these two compounds the difference was negligible.	Further investigation of discharges from the MEW GWETS into Stevens Creek is recommended. PFAS detected in surface water samples from Stevens Creek could also be attributable to impacted urban runoff from elsewhere in the watershed. There is a data gap for AOPCs with only one sample. Further samples may be collected at these AOPCs during the ESI to help support the development of a future RI work plan. Routine quarterly monitoring of the influent and effluent is also recommended, and additional steps should be taken based on results. The MEW GWETS should be updated to reduce concentrations of PFAS to below appropriate discharge concentrations in Stevens Creek.
AOPC 15 - WEST-SIDE AQUIFERS TREATMENT SYSTEM	--	--	--	Influent and effluent results were compared to USEPA and State groundwater screening levels for evaluation purposes only. Concentrations in the influent sample exceeded the groundwater RSLs for PFOS, PFOA, and PFHxS, as well as the groundwater ESLs for PFOS and PFOA. Twelve of the 28 PFAS compounds were detected in the influent sample from AOPC 15. The only PFAS compound detected in the effluent sample was PFBA, at an estimated concentration of 3.9 ng/L.	Continued routine quarterly monitoring of the influent and effluent is recommended, and take additional steps should be taken as needed based on the results.
AOPC 16 - NORTH PATROL ROAD DITCH (IR 21) AND NORTHERN CHANNEL (IR 27)	--	PFOA was detected at concentrations exceeding the groundwater RSL of 6 ng/L and the groundwater ESL of 5.1 ng/L in four samples. PFOS was also detected at concentrations exceeding the groundwater RSL of 4 ng/L and the groundwater ESL of 6.5 ng/L in three samples. PFHxS was detected at concentrations exceeding the groundwater RSL of 39 ng/L in two samples. PFBS and PFNA were not detected at any concentrations exceeding any screening levels, and HFPO-DA was not detected in any of the samples.	--	--	Further investigation of the horizontal and vertical extents of PFAS in groundwater is recommended. The pathway of PFAS in surface water between AOPC 11 (Building 191 Pump Station), AOPC 16 (North Patrol Road Ditch and Northern Channel), and AOPC 17 (Marriage Road Ditch) should also be investigated.
AOPC 17 - MARRIAGE ROAD DITCH (IR 3)	--	PFOA was detected at concentrations exceeding the groundwater RSL of 6 ng/L and the groundwater ESL of 5.1 ng/L in four samples. PFOS was detected at concentrations exceeding the groundwater RSL of 4 ng/L and the groundwater ESL of 6.5 ng/L in four samples. PFHxS was detected at concentrations exceeding the groundwater RSL in four samples. PFNA, PFBS, and HFPO-DA were not detected at concentrations exceeding any screening levels.	--	--	Further investigation of the horizontal and vertical extents of PFAS in groundwater is recommended. The pathway of PFAS in surface water between AOPC 11 (Building 191 Pump Station), AOPC 16 (North Patrol Road Ditch and Northern Channel), and AOPC 17 (Marriage Road Ditch) should also be investigated.
AOPC 18 - LINDBERGH AVENUE STORM DRAIN DITCH (AOI 6)	--	PFOA was detected at concentrations exceeding the groundwater RSL of 6 ng/L and the groundwater ESL of 5.1 ng/L in two samples. PFOS was detected at concentrations exceeding the groundwater RSL of 4 ng/L and the groundwater ESL of 6.5 ng/L in all three samples. PFHxS was detected at concentrations exceeding the groundwater RSL in two samples. PFBS and PFNA did not exceed any screening levels. HFPO-DA was not detected in any samples.	--	--	Further investigate the horizontal and vertical extents of PFAS in groundwater.
AOPC 19 - STORMWATER RETENTION PONDS (WITHIN IR 25)	--	--	One surface water sample was collected at AOPC 19. However, this sample was flagged with qualifiers during data validation that indicated the sample should be excluded from the dataset. This sample was therefore not included in the data evaluation.	--	Re-sampling of surface water is recommended for AOPC 19, along with sediment sampling. There is a data gap for AOPCs with only one sample. Further samples may be collected at these AOPCs during the ESI to help support the development of a future RI work plan. Further samples may include additional surface water samples from AOPC 19 to account for high salinity after the dry seasons, collection of the sample during the rainy season with duplicate samples, and additional analysis for total dissolved solids (TDS) and other appropriate parameters to better determine representative PFAS analytical results

Table 6-1. Conclusions and Recommendations

AOPC	Screening Level Exceedances				Recommendations
	Soil	**Groundwater**	**Surface Water**	**Influent/Effluent**	
AOPC 20 - BUILDING N271 INDUSTRIAL WASTEWATER PRETREATMENT PLANT	--	--	--	Effluent results were compared to USEPA and State groundwater screening levels for evaluation purposes only. Concentrations in the sample exceeded the groundwater RSLs for PFOS, PFOA, and PFHxS, and the groundwater ESLs for PFOS and PFOA. There were no PFBS screening level exceedances, and PFNA and HFPO-DA were non-detect.	There is a data gap for AOPCs with only one sample. Further samples may be collected at these AOPCs during the ESI to help support the development of a future RI work plan. Routine quarterly monitoring of the treated water effluent is recommended, and additional steps should be taken as needed based on results.
AOPC 21 - FORMER INDUSTRIAL WASTEWATER SURFACE IMPOUNDMENT (IR 4)	--	PFOA was detected at concentrations exceeding the groundwater RSL of 6 ng/L and the groundwater ESL of 5.1 ng/L in seven samples. PFOS was detected at concentrations exceeding the groundwater RSL of 4 ng/L and the groundwater ESL of 6.5 ng/L in five samples. One sample also exceeded the groundwater ESL for PFOS (6.4 ng/L). PFHxS was detected at concentrations exceeding the groundwater RSL of 39 ng/L in five samples. PFNA, PFBS, and HFPO-DA were not detected at concentrations exceeding any screening levels.	--	--	Further investigate the horizontal and vertical extents of PFAS in groundwater.
AOPC 22 - BUILDING N249 OUTDOOR AERODYNAMIC RESEARCH FACILITY	--	PFOS was detected at concentrations exceeding the groundwater RSL of 4 ng/L and the groundwater ESL of 6.5 ng/L in three samples. PFHxS was detected at concentrations exceeding the groundwater RSL of 39 ng/L in one sample. PFOA, PFNA, PFBS, and HFPO-DA were not detected at concentrations exceeding any screening levels.	--	--	Further investigate the horizontal and vertical extents of PFAS in groundwater.
AOPC 23 - HANGAR 4 (CANG) BUILDING 662	No samples were collected from this AOPC as a part of this SI, as the presence of PFAS already had been established during previous investigations. Results from these previous investigations are discussed in Section 3.6.23.	No samples were collected at AOPC 23 during the SI as previous sampling efforts already identified the presence of PFAS at this site. However, during the SI, one groundwater sample was collected from a new well, PFAS-C, which is near a well previously sampled for AOPC 23. Results from PFAS-C are discussed in Section 5.23 and results from previous sampling in 2018-2019 at AOPC 23 are discussed in Section 3.6.23.	--	--	A remedial investigation is recommended for AOPC 23.
AOPC 24 - MIDDLEFIELD-ELLIS-WHISMAN (MEW) PLUME	--	PFOA was detected at concentrations exceeding the groundwater RSL of 6 ng/L and the groundwater ESL of 5.1 ng/L in one sample. PFOS was detected at concentrations exceeding the groundwater RSL of 4 ng/L in three samples. PFOS also exceeded the groundwater ESL of 6.5 ng/L in two samples. PFHxS was detected at a concentration exceeding the groundwater RSL of 39 ng/L in one sample. PFBS was not detected at concentrations exceeding any screening levels. PFNA and HFPO-DA were not detected in any samples.	--	--	Further investigate the horizontal and vertical extents of PFAS in groundwater. Appendix J includes relevant data from MEW parties found in the https://geotracker.waterboards.ca.gov, and an evaluation of this data will be included in an ESI.
AOPC 25 - ORION PARK PLUME	--	PFOS was detected at concentrations exceeding the groundwater ESL of 6.5 ng/L in one sample and exceeding the groundwater RSL of 4 ng/L in two samples. PFOA, PFNA, PFHxS, HFPO-DA, and PFBS were not detected at any concentrations exceeding any screening levels.	--	--	Further investigate the horizontal and vertical extents of PFAS in groundwater.
AOPC 26 - EASTERN BOUNDARY (IR 5)	--	PFOA was detected at concentrations exceeding the groundwater RSL of 6 ng/L and the groundwater ESL of 5.1 ng/L. PFOS was detected at concentrations exceeding the groundwater RSL of 4 ng/L and the groundwater ESL of 6.5 ng/L. PFNA and PFHxS exceeded the groundwater RSLs of 5.9 ng/L and 39 ng/L, respectively. The detected concentration for PFBS did not exceed any screening levels, and HFPO-DA was not detected in the sample.	--	--	Further investigate the horizontal and vertical extents of PFAS in groundwater. Appendix J includes relevant data from Lockheed Martin NIROP facility found in the https://geotracker.waterboards.ca.gov, and an evaluation of this data will be included in an ESI.

Notes:
AOPC - Area of Potential Concern
RSL - Regional Screening Level (Federal/USEPA)
ESL - Environmental Screening Level (California Water Board)
-- Not applicable

Appendix F

Mann-Kendall Analysis, Figures, and Graphs

Site 1

The following data were drawn from the "*Draft 2023 Annual Report, Site 1 and Site 22 Landfills, Moffett Federal Airfield*" (BB&E 2024) to support Five-Year Review Site 1 discussion and address EPA General Comment 6.

Figure 3 - Site 1 Landfill Groundwater Level Measurement and Monitoring Locations
Figure 6 - Site 1 Landfill Potentiometric Surface, October 2023
Figure 9 - Site 1 Landfill Methane Monitoring Locations

Appendix D - Analytical Data Graphs

The following data were drawn from the "*Final 2022 Annual Report, Site 1 and Site 22 Landfills, Moffett Federal Airfield*"(BB&E 2024) to support Five-Year Review Site 1 discussion and address EPA General Comment 6.

Appendix J - Barium Statistical Analysis Report

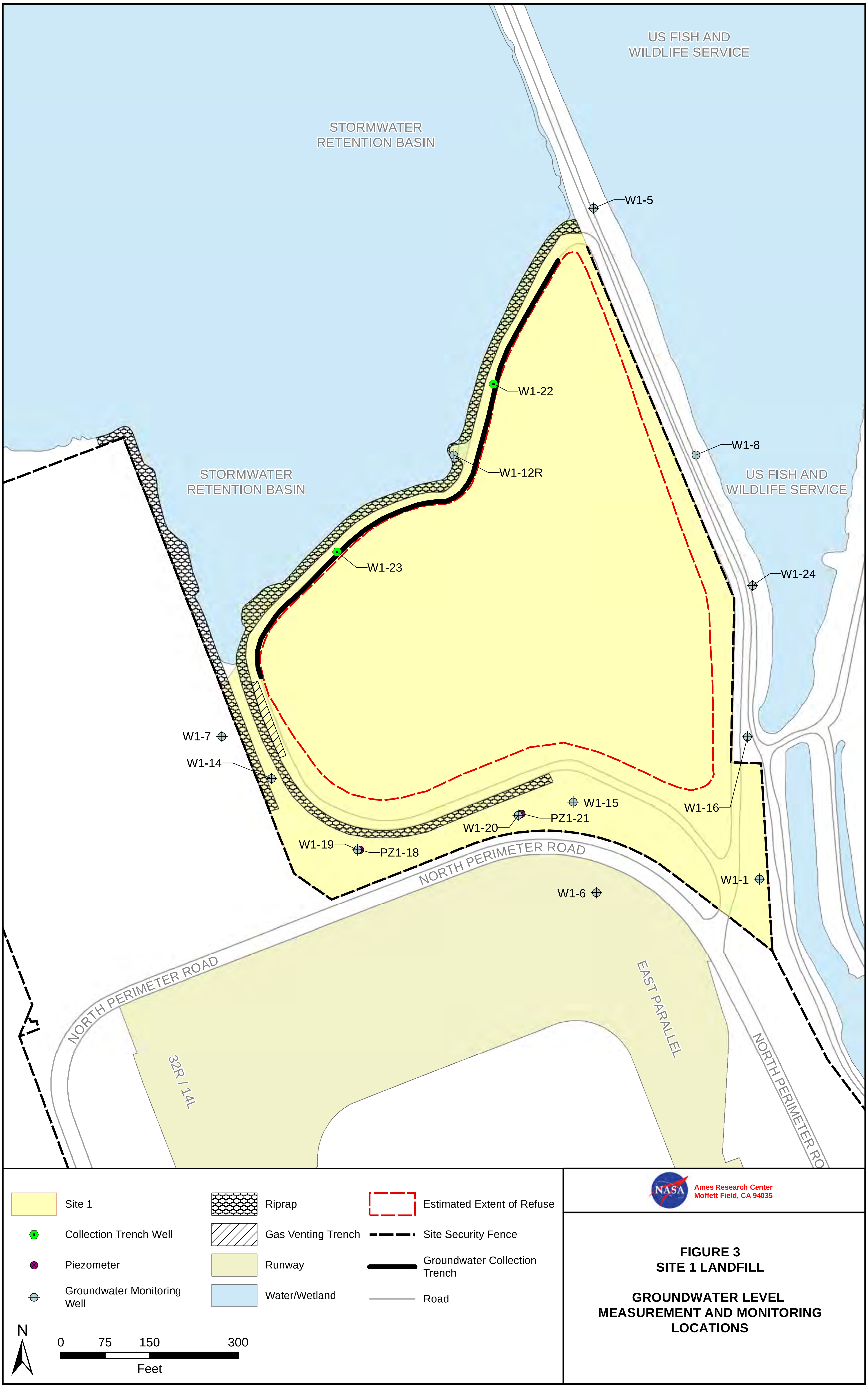


FIGURE 3
SITE 1 LANDFILL

GROUNDWATER LEVEL MEASUREMENT AND MONITORING LOCATIONS

SITE 1

Interpreted Groundwater Elevation (MSL) Contoured in Feet. Negative Values are Below MSL

Interpreted Groundwater Elevation (MSL) Contoured in Feet, Inferred. Negative Values are Below MSL

Approximate Groundwater Flow Direction

Collection Trench Well (Water Level Not Used To Create a Potentiometric Surface)

Deep Screened Wells (Water Level Not Used To Create a Potentiometric Surface)

Groundwater Monitoring Well (Groundwater Elevation in Feet [MSL])

Piezometer (Water Level Not Used To Create a Potentiometric Surface)

N

0 50 100 200

Feet

MSL Mean Sea Level

* Outlier value not used to create Potentiometric Surface

Ames Research Center
Moffett Field, CA 94035

FIGURE 6
SITE 1 LANDFILL

POTENTIOMETRIC SURFACE
OCTOBER 2023

Site 1

Approximate Perimeter Landfill Gas Monitoring Location

Landfill Gas Monitoring Well

Approximate Gas Vent Location

Riprap

Gas Venting Trench

Runway

Water/Wetland

Estimated Extent of Refuse

Site Security Fence

Groundwater Collection Trench

Road

N

0 75 150 300

Feet

Ames Research Center
Moffett Field, CA 94035

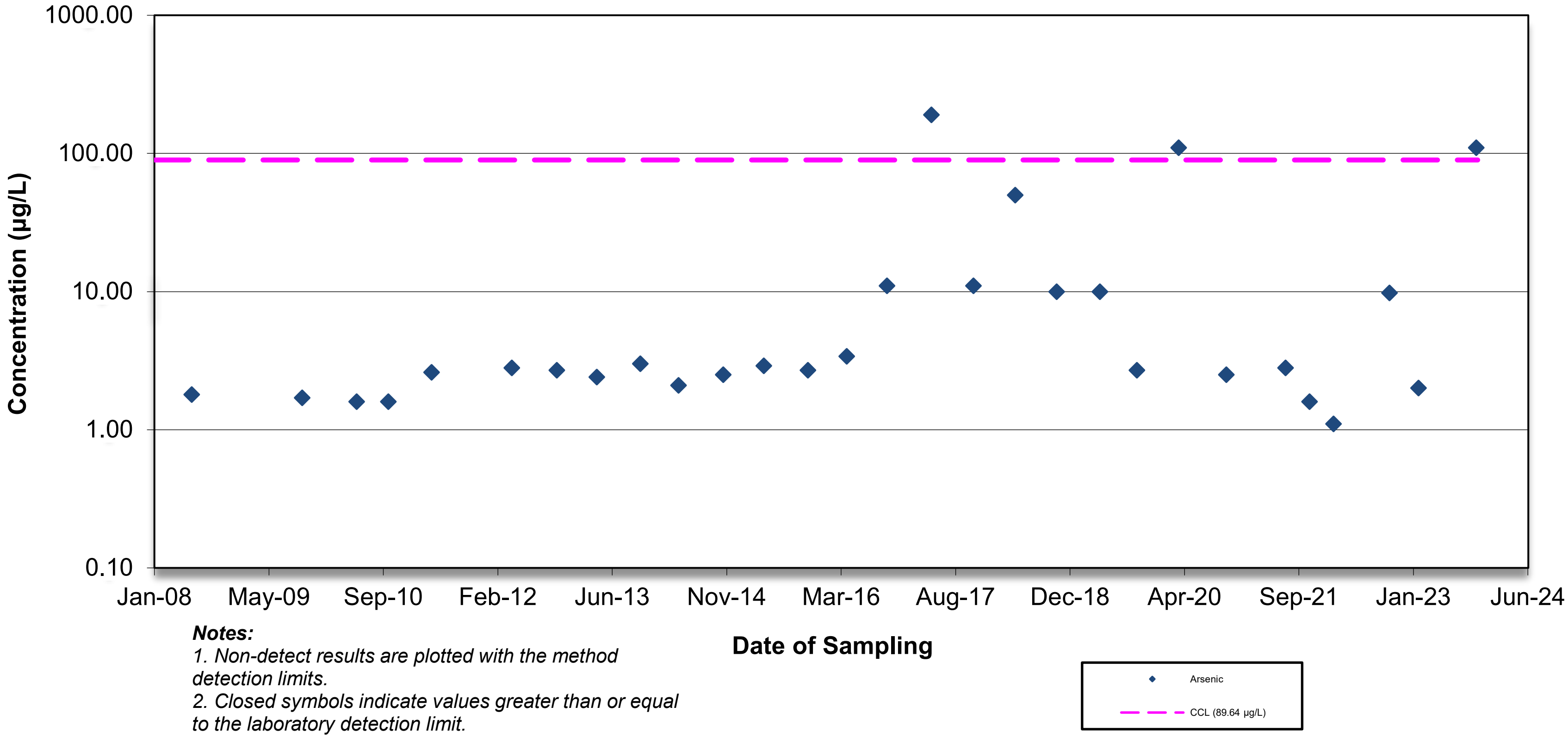
FIGURE 9
SITE 1 LANDFILL

METHANE MONITORING LOCATIONS

Appendix D
Analytical Data Graphs

Figure D-1

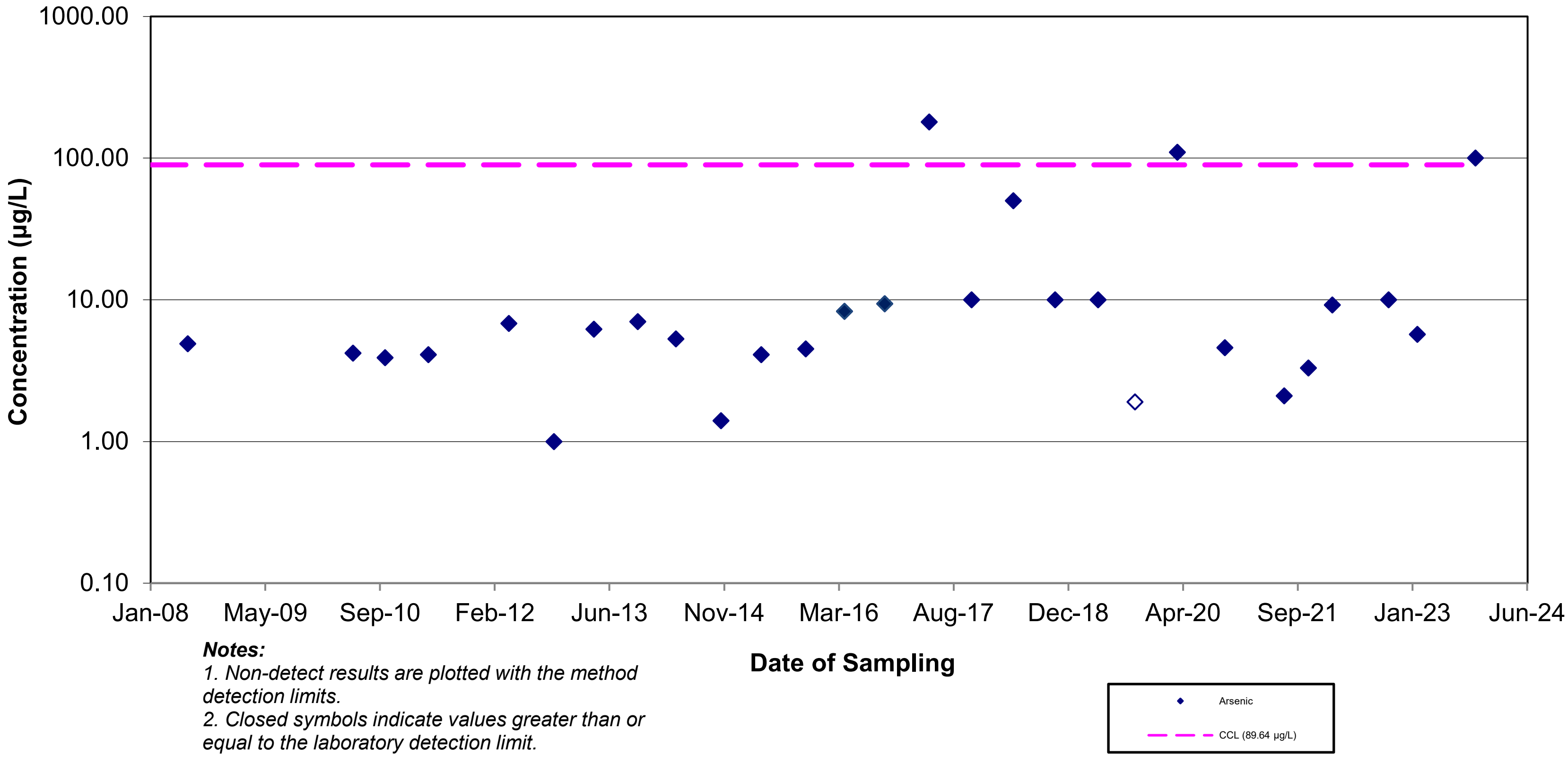
Site 1 Dissolved Arsenic Concentrations
Downgradient Monitoring Well W1-1R



Notes:
1. Non-detect results are plotted with the method detection limits.
2. Closed symbols indicate values greater than or equal to the laboratory detection limit.
3. Open symbols indicate estimated values.
4. N = total number of samples.
5. CCL = calculated concentration limit.

Figure D-2

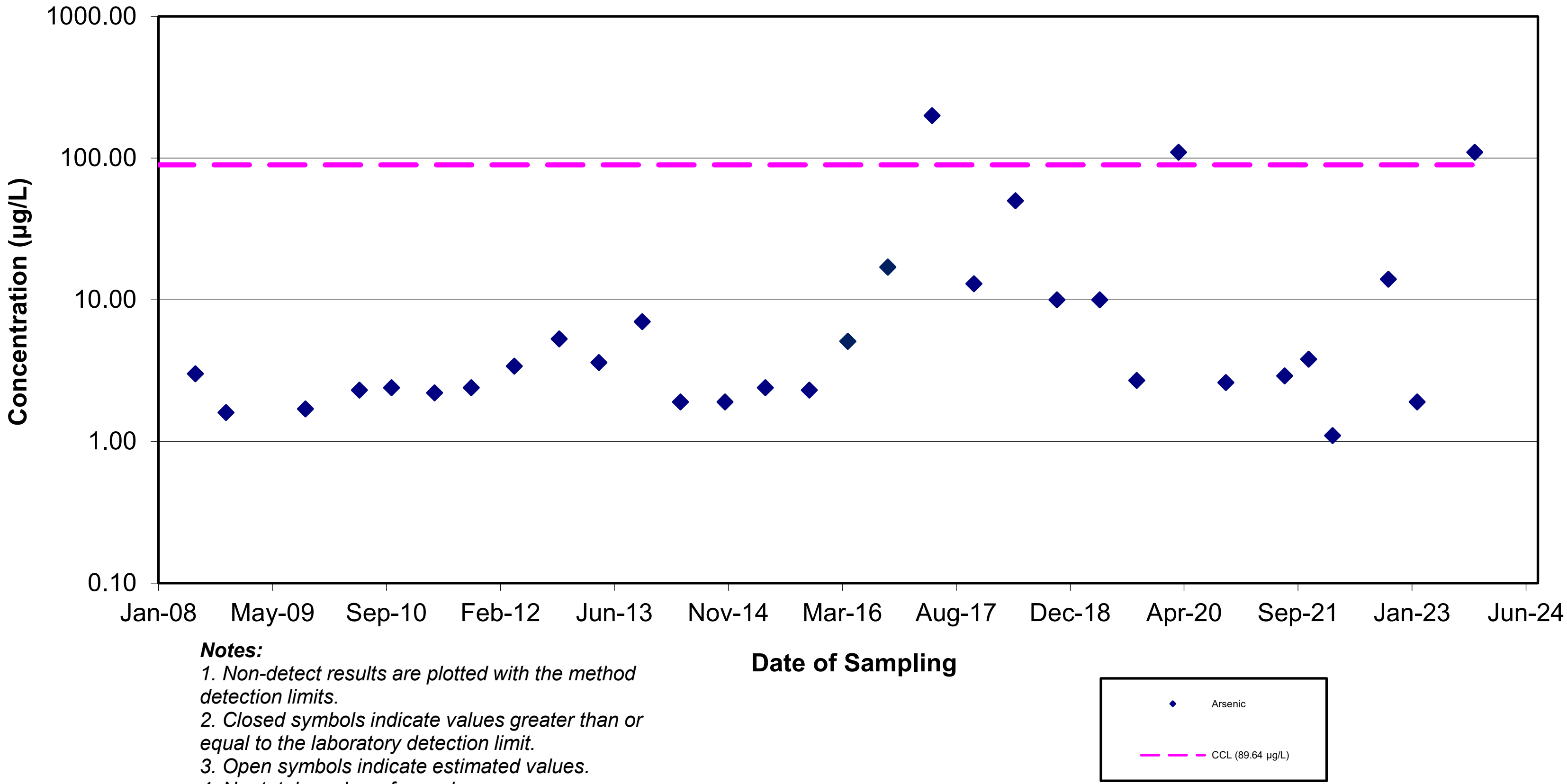
Site 1 Dissolved Arsenic Concentrations
Upgradient Monitoring Well W1-5



Notes:
1. Non-detect results are plotted with the method detection limits.
2. Closed symbols indicate values greater than or equal to the laboratory detection limit.
3. Open symbols indicate estimated values.
4. N = total number of samples.
5. CCL = calculated concentration limit.

Figure D-3

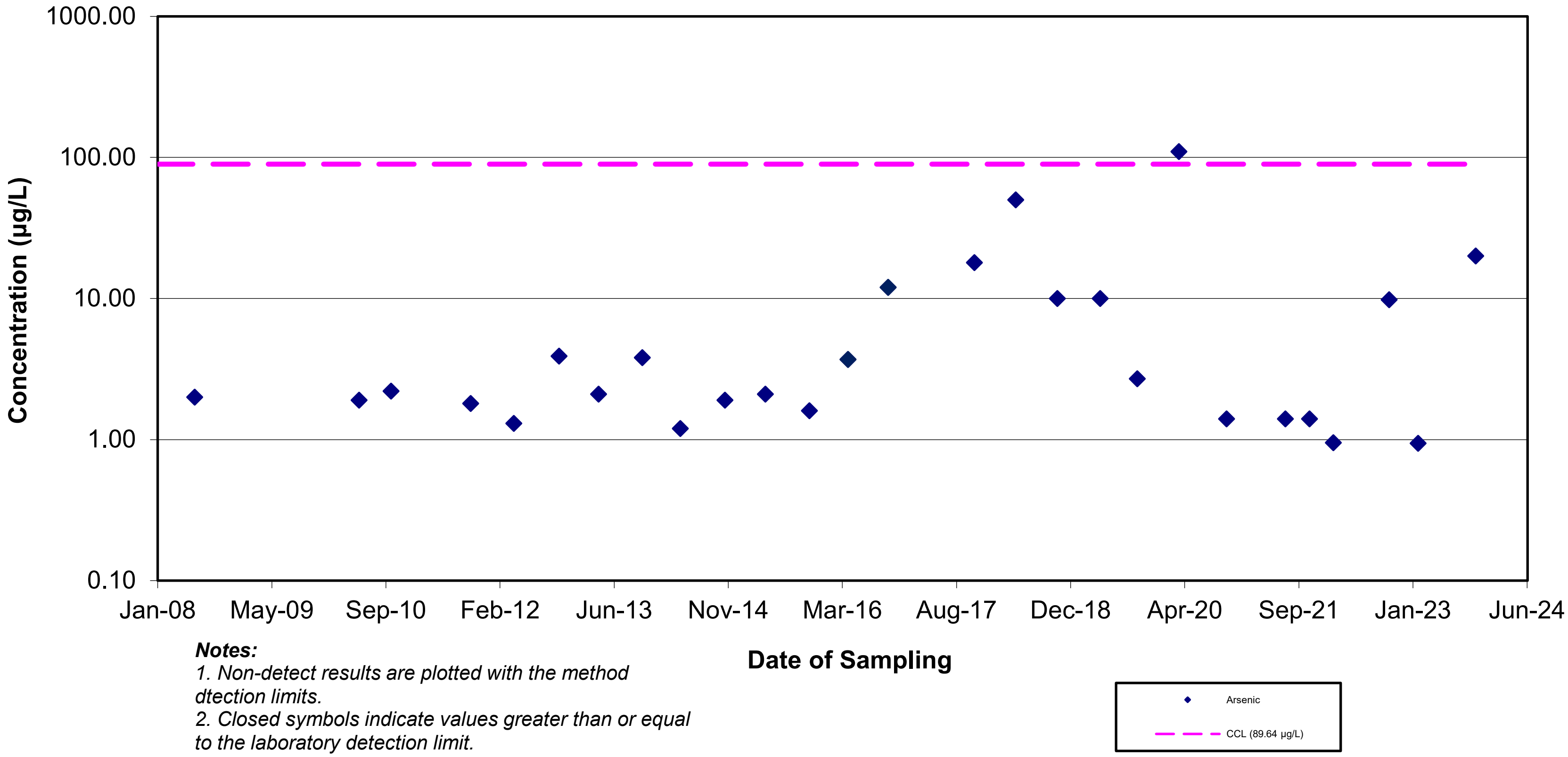
Site 1 Dissolved Arsenic Concentrations
Upgradient Monitoring Well W1-8



Notes:
1. Non-detect results are plotted with the method detection limits.
2. Closed symbols indicate values greater than or equal to the laboratory detection limit.
3. Open symbols indicate estimated values.
4. N = total number of samples.
5. CCL = calculated concentration limit.

Figure D-4

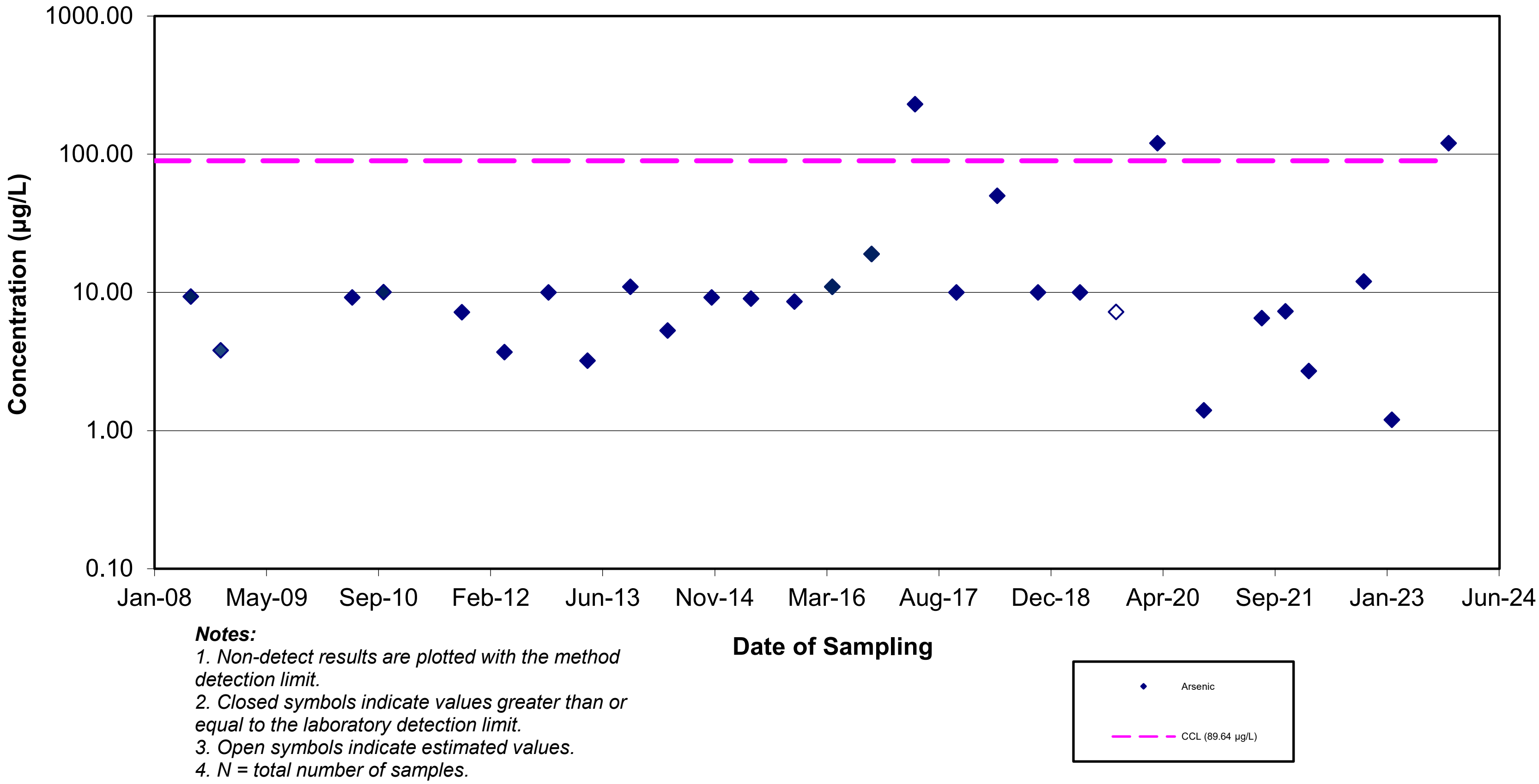
Site 1 Dissolved Arsenic Concentrations
Upgradient Monitoring Well W1-12R



Notes:
1. Non-detect results are plotted with the method dtection limits.
2. Closed symbols indicate values greater than or equal to the laboratory detection limit.
3. Open symbols indicate estimated values.
4. N = total number of samples.
5. CCL = calculated concentration limit.

Figure D-5

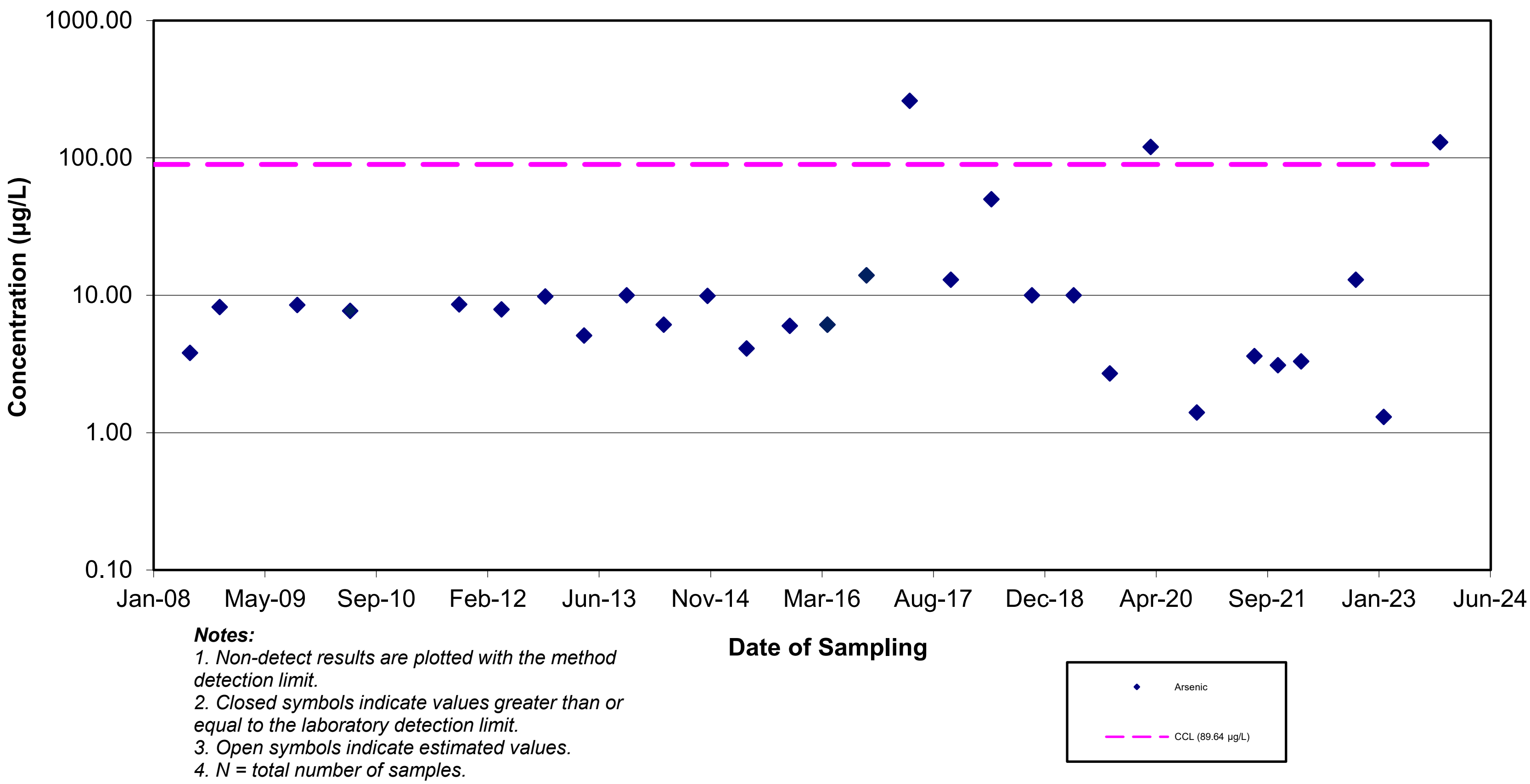
Site 1 Dissolved Arsenic Concentrations
Cross-gradient Monitoring Well W1-14



Notes:
1. Non-detect results are plotted with the method detection limit.
2. Closed symbols indicate values greater than or equal to the laboratory detection limit.
3. Open symbols indicate estimated values.
4. N = total number of samples.
5. CCL = calculated concentration limit.

Figure D-6

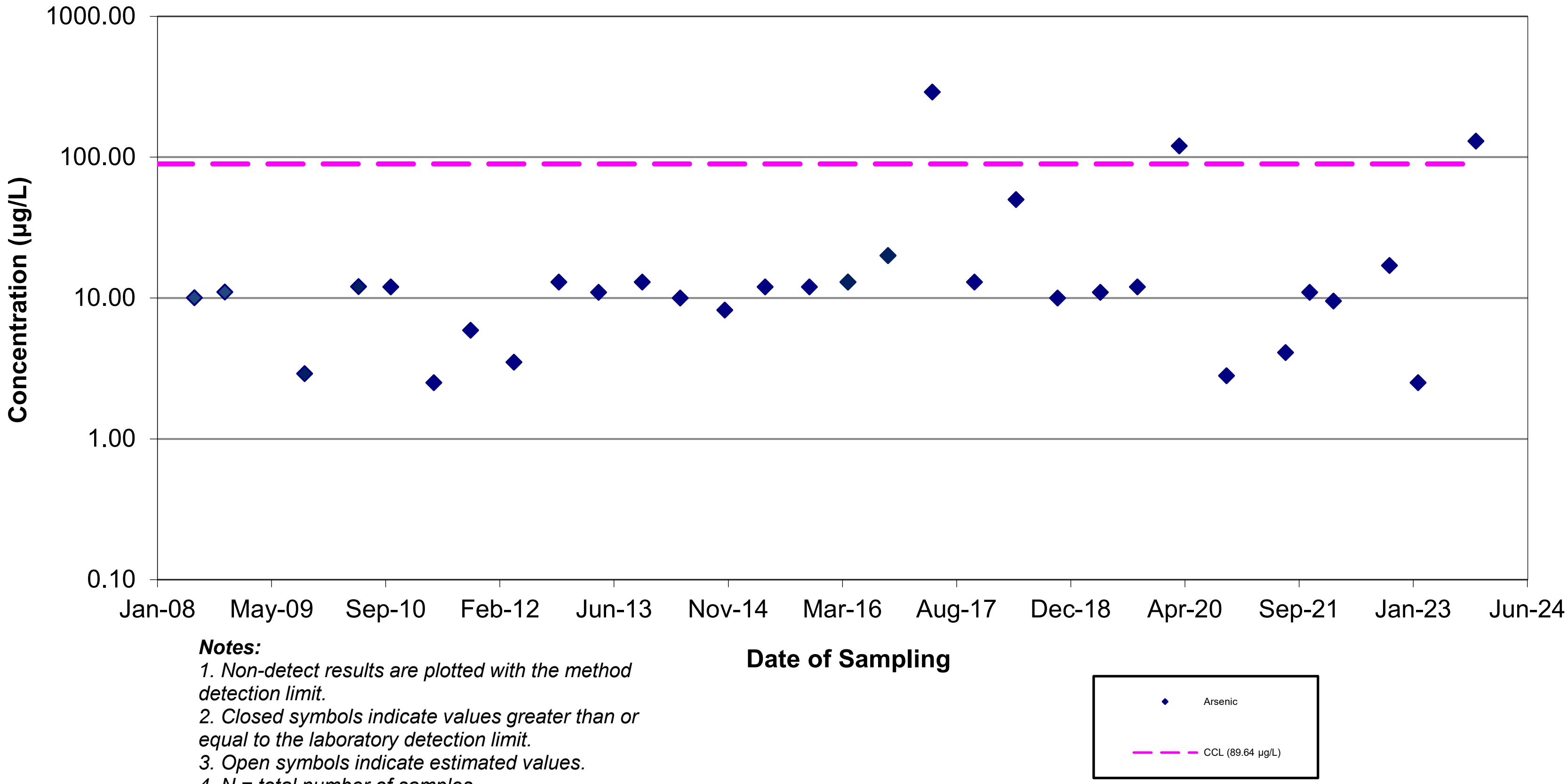
Site 1 Dissolved Arsenic Concentrations
Downgradient Monitoring Well W1-15



Notes:
1. Non-detect results are plotted with the method detection limit.
2. Closed symbols indicate values greater than or equal to the laboratory detection limit.
3. Open symbols indicate estimated values.
4. N = total number of samples.
5. CCL = calculated concentration limit.

Figure D-7

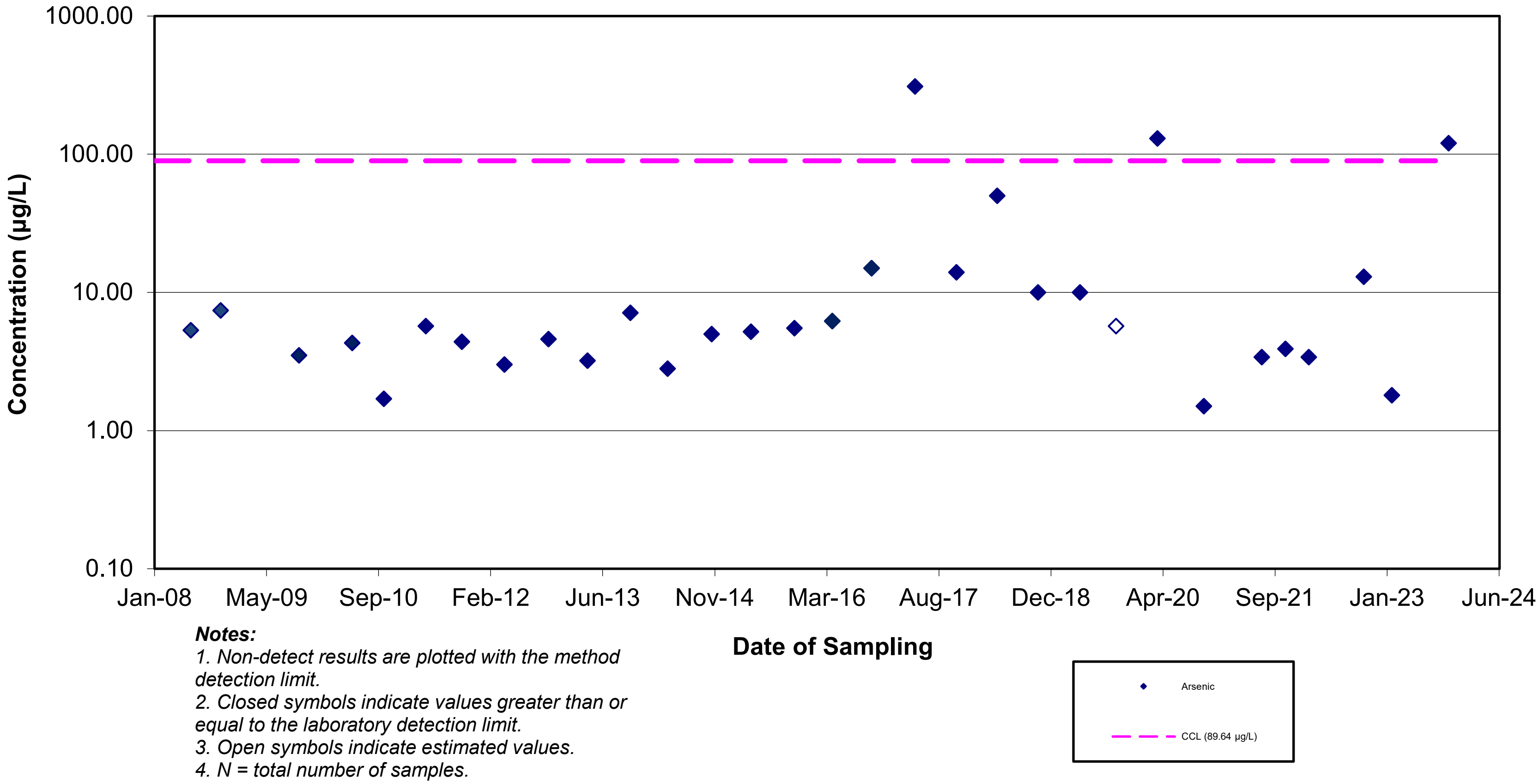
Site 1 Dissolved Arsenic Concentrations
Cross-gradient Monitoring Well W1-16



Notes:
1. Non-detect results are plotted with the method detection limit.
2. Closed symbols indicate values greater than or equal to the laboratory detection limit.
3. Open symbols indicate estimated values.
4. N = total number of samples.
5. CCL = calculated concentration limit.

Figure D-8

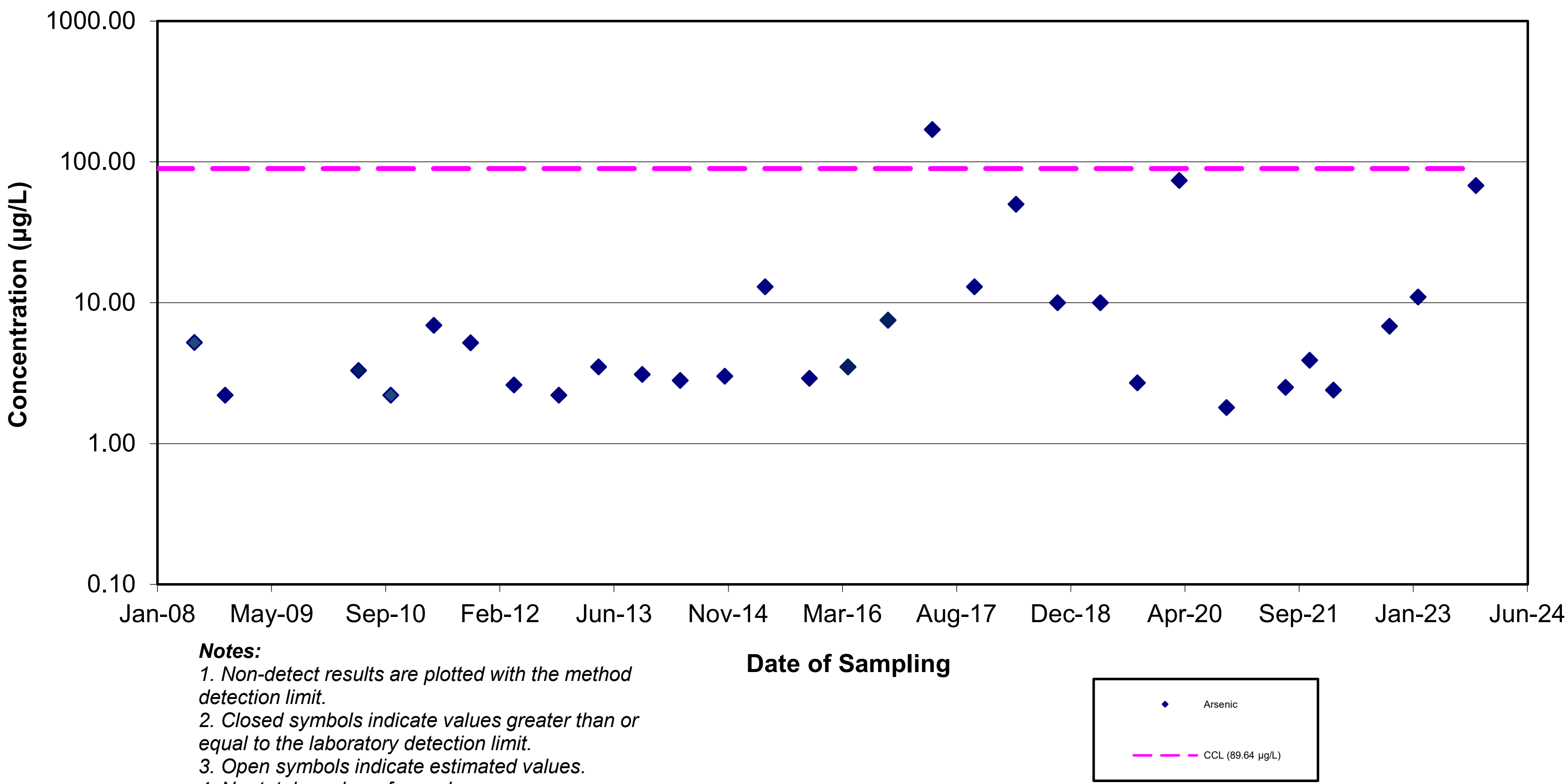
Site 1 Dissolved Arsenic Concentrations
Downgradient Monitoring Well W1-19



Notes:
1. Non-detect results are plotted with the method detection limit.
2. Closed symbols indicate values greater than or equal to the laboratory detection limit.
3. Open symbols indicate estimated values.
4. N = total number of samples.
5. CCL = calculated concentration limit.

Figure D-9

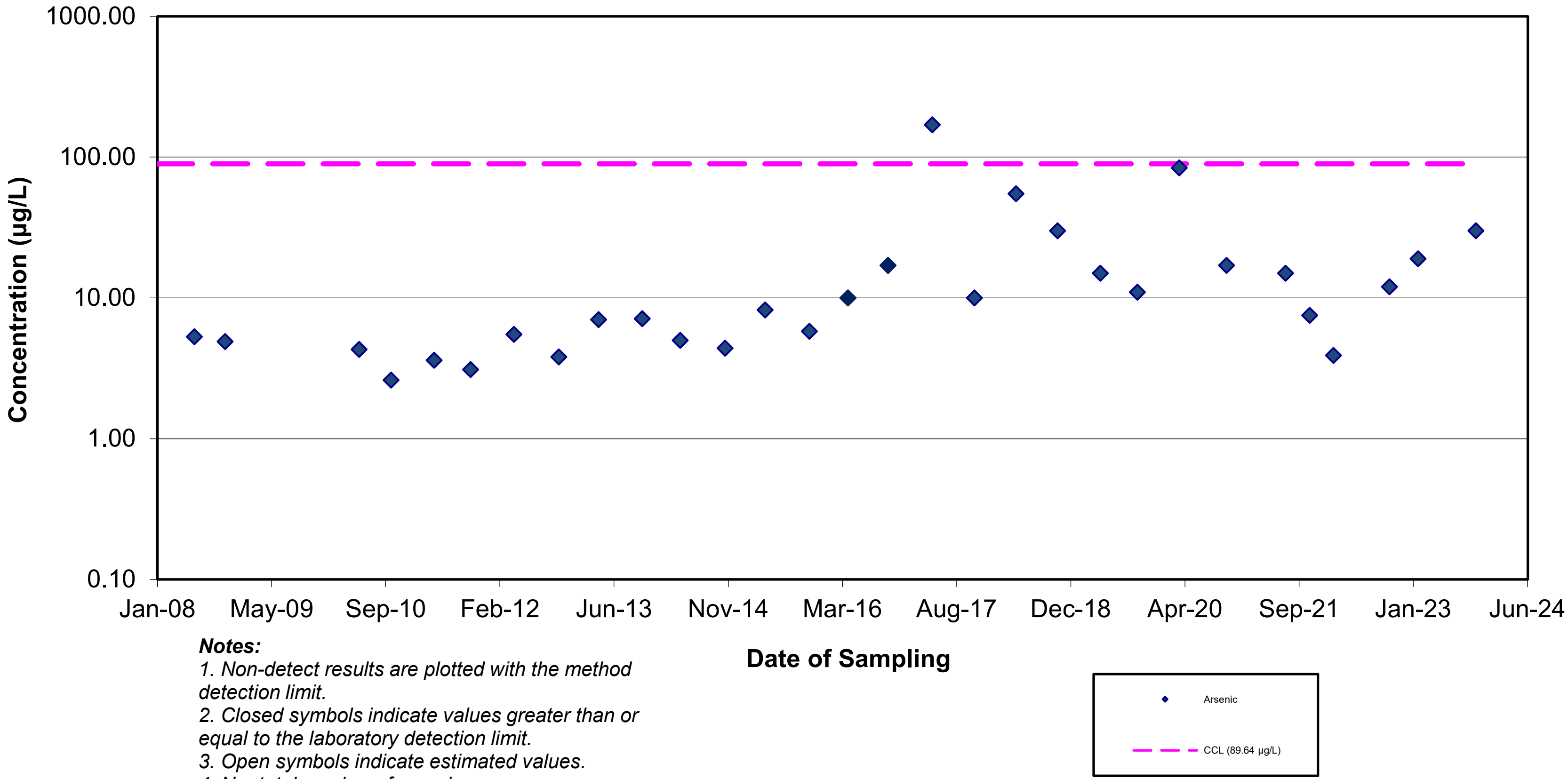
Site 1 Dissolved Arsenic Concentrations
Collection Trench Well W1-22



Notes:
1. Non-detect results are plotted with the method detection limit.
2. Closed symbols indicate values greater than or equal to the laboratory detection limit.
3. Open symbols indicate estimated values.
4. N = total number of samples.
5. CCL = calculated concentration limit.

Figure D-10

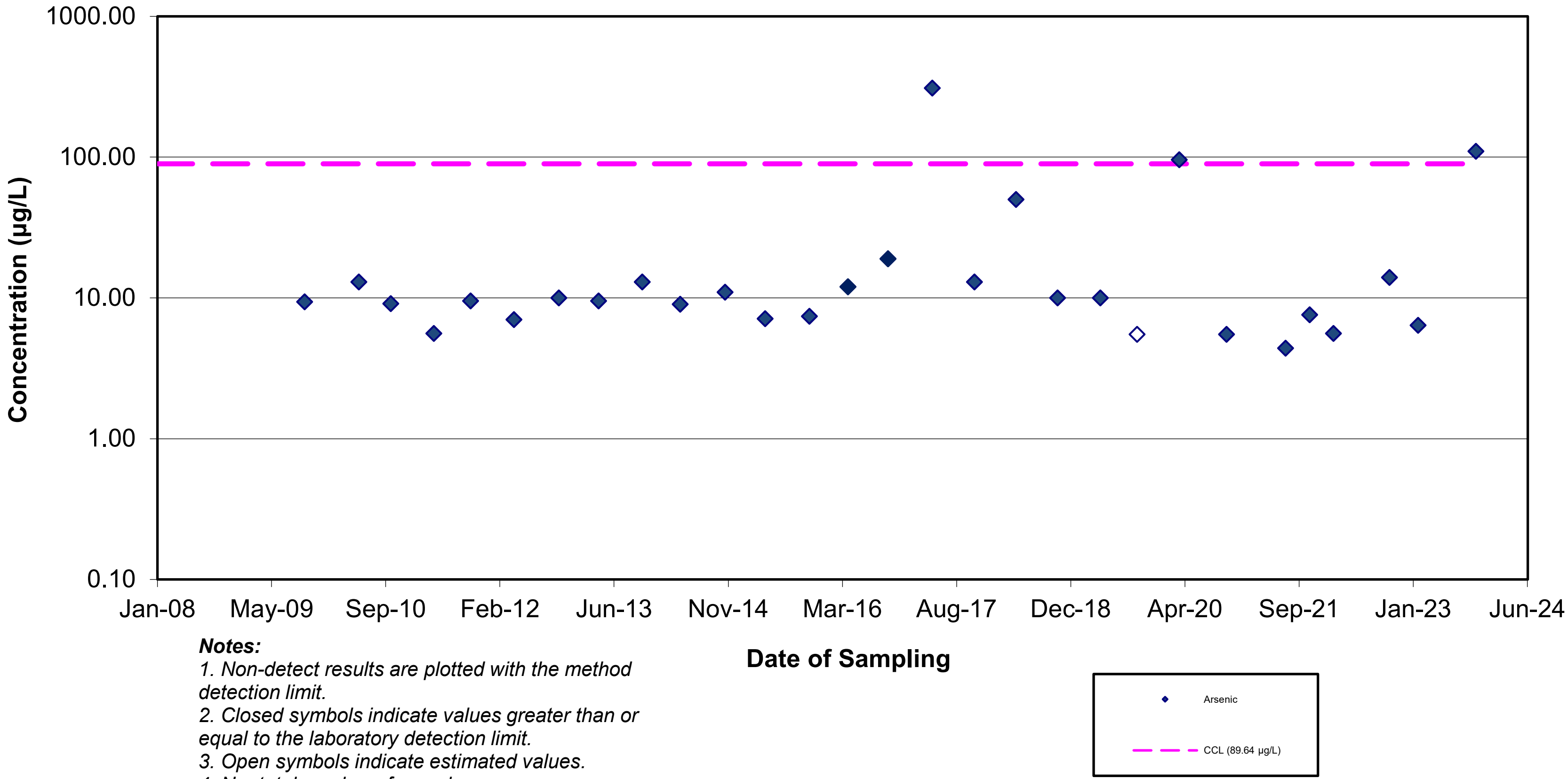
Site 1 Dissolved Arsenic Concentrations
Collection Trench Well W1-23



Notes:
1. Non-detect results are plotted with the method detection limit.
2. Closed symbols indicate values greater than or equal to the laboratory detection limit.
3. Open symbols indicate estimated values.
4. N = total number of samples.
5. CCL = calculated concentration limit.

Figure D-11

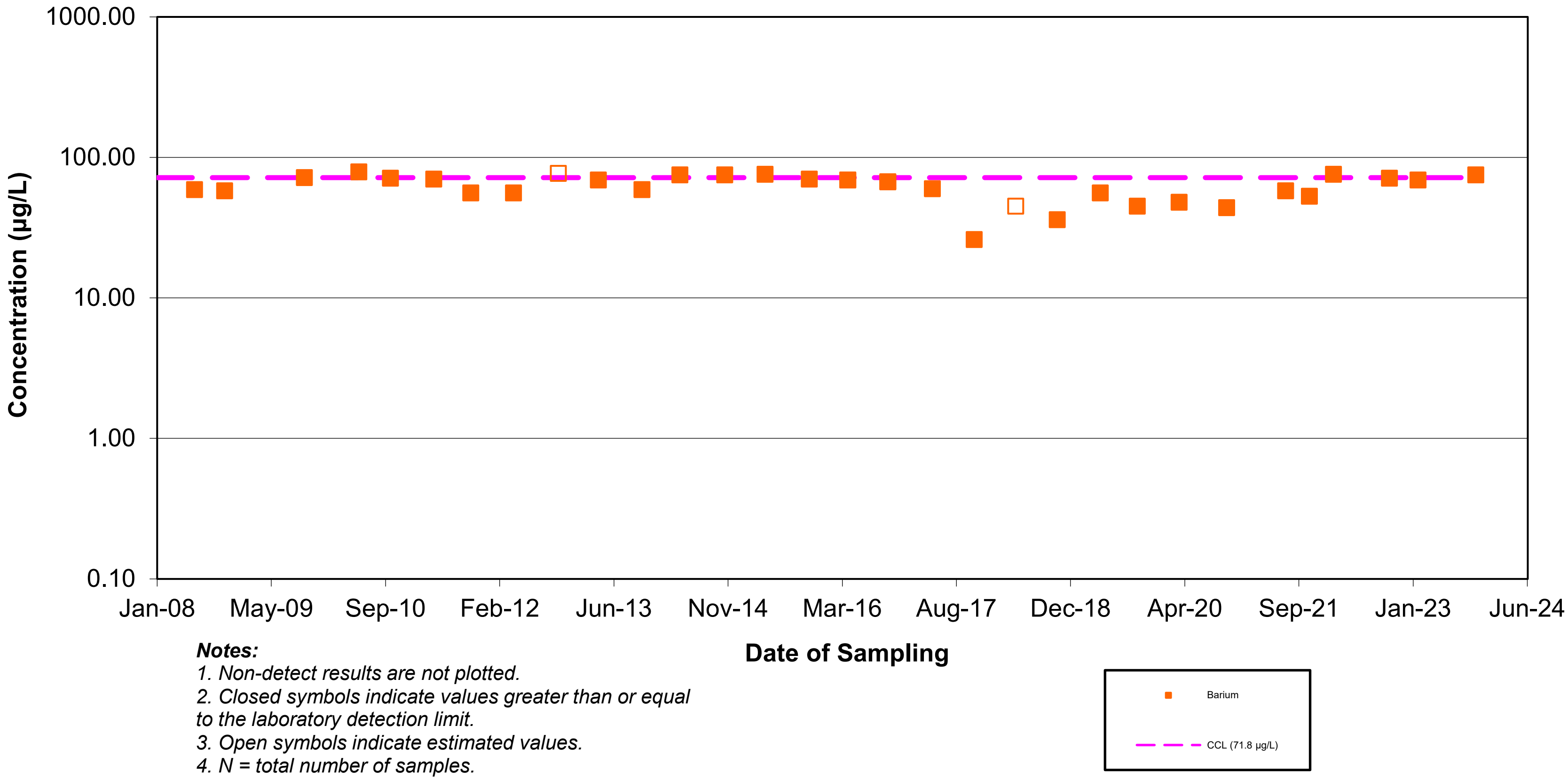
Site 1 Dissolved Arsenic Concentrations
Cross-gradient Monitoring Well W1-24



Notes:
1. Non-detect results are plotted with the method detection limit.
2. Closed symbols indicate values greater than or equal to the laboratory detection limit.
3. Open symbols indicate estimated values.
4. N = total number of samples.
5. CCL = calculated concentration limit.

Figure D-12

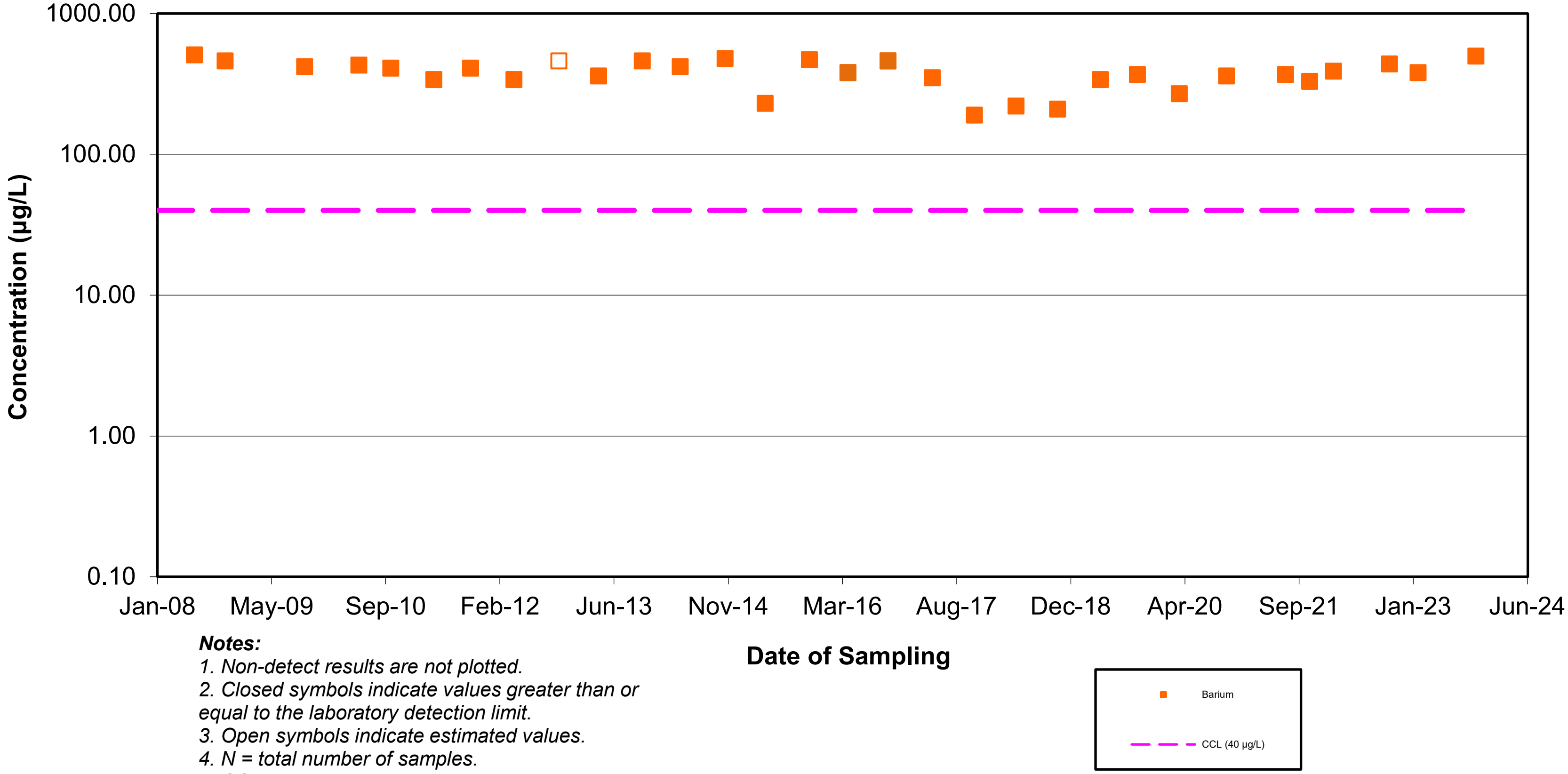
Site 1 Dissolved Barium Concentrations
Downgradient Monitoring Well W1-1R



Notes:
1. Non-detect results are not plotted.
2. Closed symbols indicate values greater than or equal to the laboratory detection limit.
3. Open symbols indicate estimated values.
4. N = total number of samples.
5. CCL = calculated concentration limit.

Figure D-13

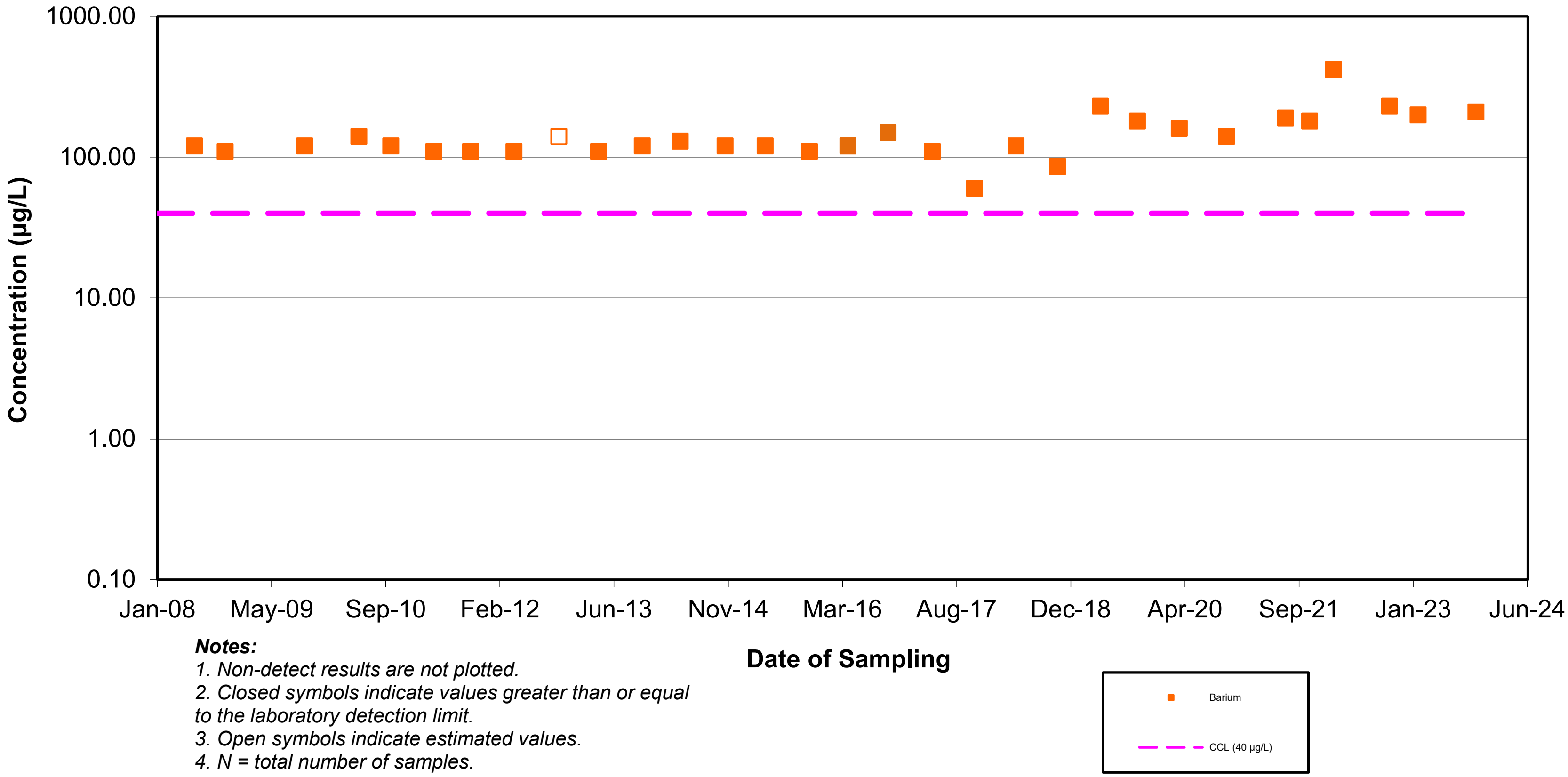
Site 1 Dissolved Barium Concentrations
Upgradient Monitoring Well W1-5



Notes:
1. Non-detect results are not plotted.
2. Closed symbols indicate values greater than or equal to the laboratory detection limit.
3. Open symbols indicate estimated values.
4. N = total number of samples.
5. CCL = calculated concentration limit.

Figure D-14

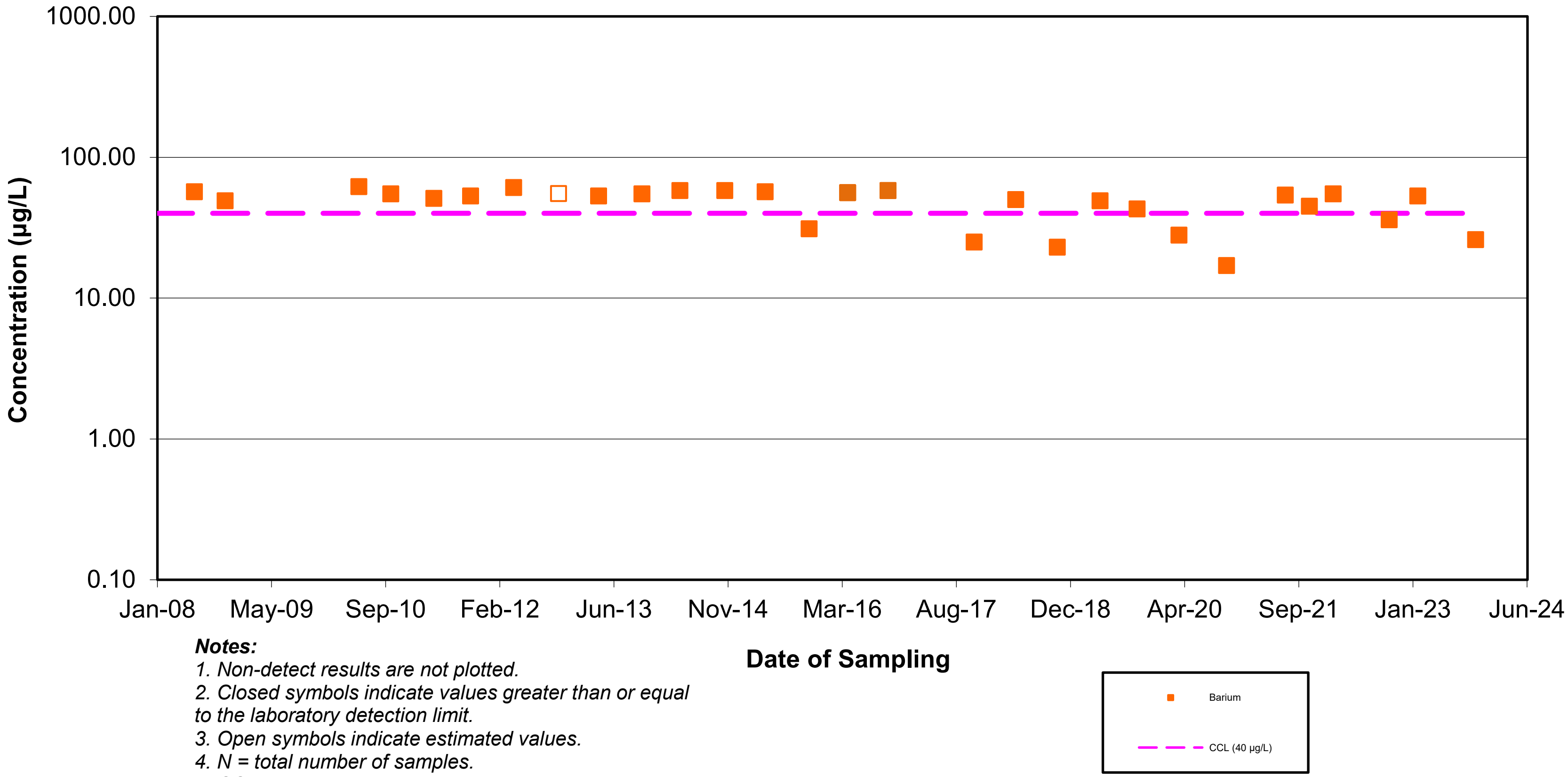
Site 1 Dissolved Barium Concentrations
Upgradient Monitoring Well W1-8



Notes:
1. Non-detect results are not plotted.
2. Closed symbols indicate values greater than or equal to the laboratory detection limit.
3. Open symbols indicate estimated values.
4. N = total number of samples.
5. CCL = calculated concentration limit.

Figure D-15

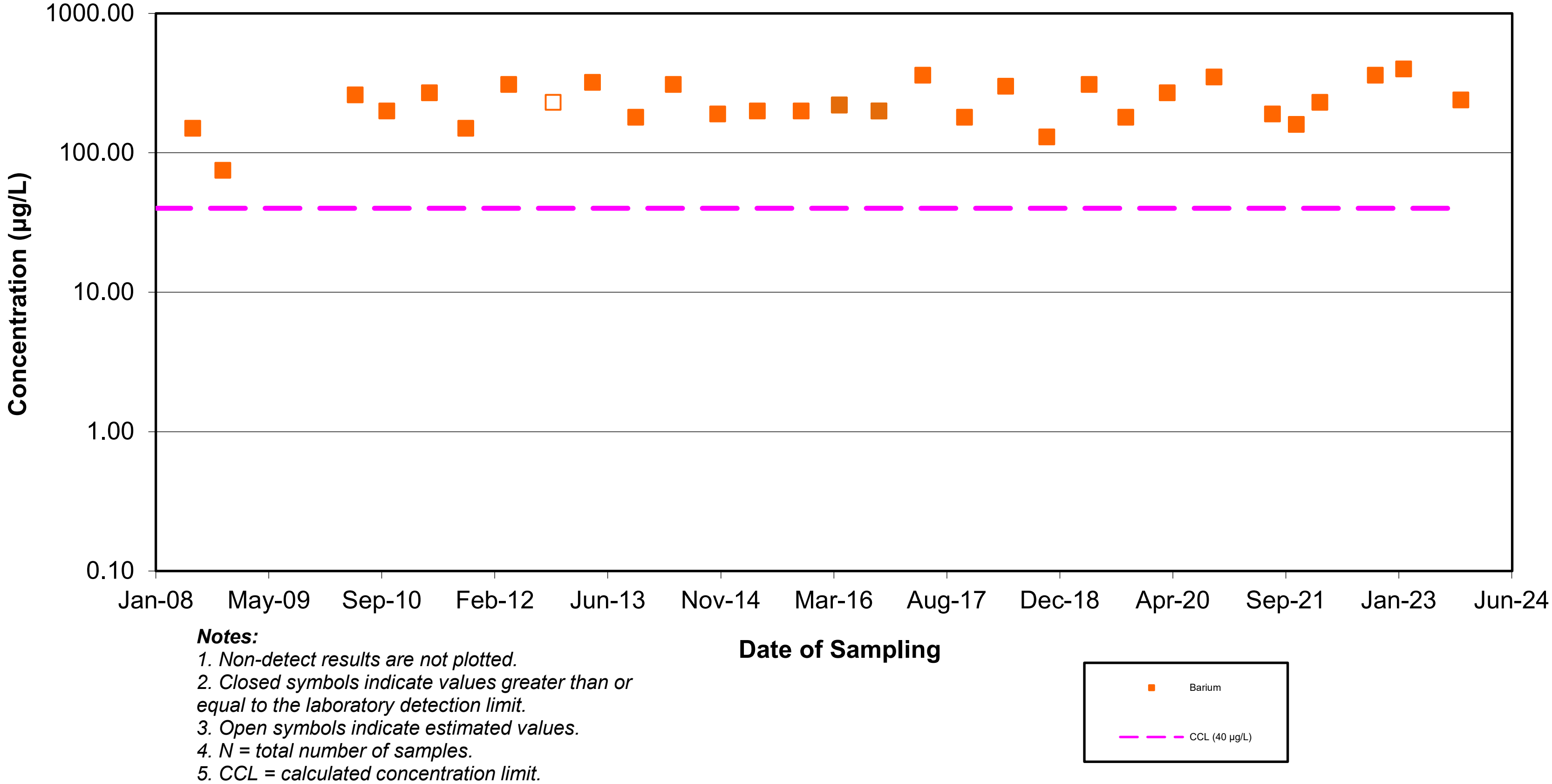
Site 1 Dissolved Barium Concentrations
Upgradient Monitoring Well W1-12R



Notes:
1. Non-detect results are not plotted.
2. Closed symbols indicate values greater than or equal to the laboratory detection limit.
3. Open symbols indicate estimated values.
4. N = total number of samples.
5. CCL = calculated concentration limit.

Figure D-16

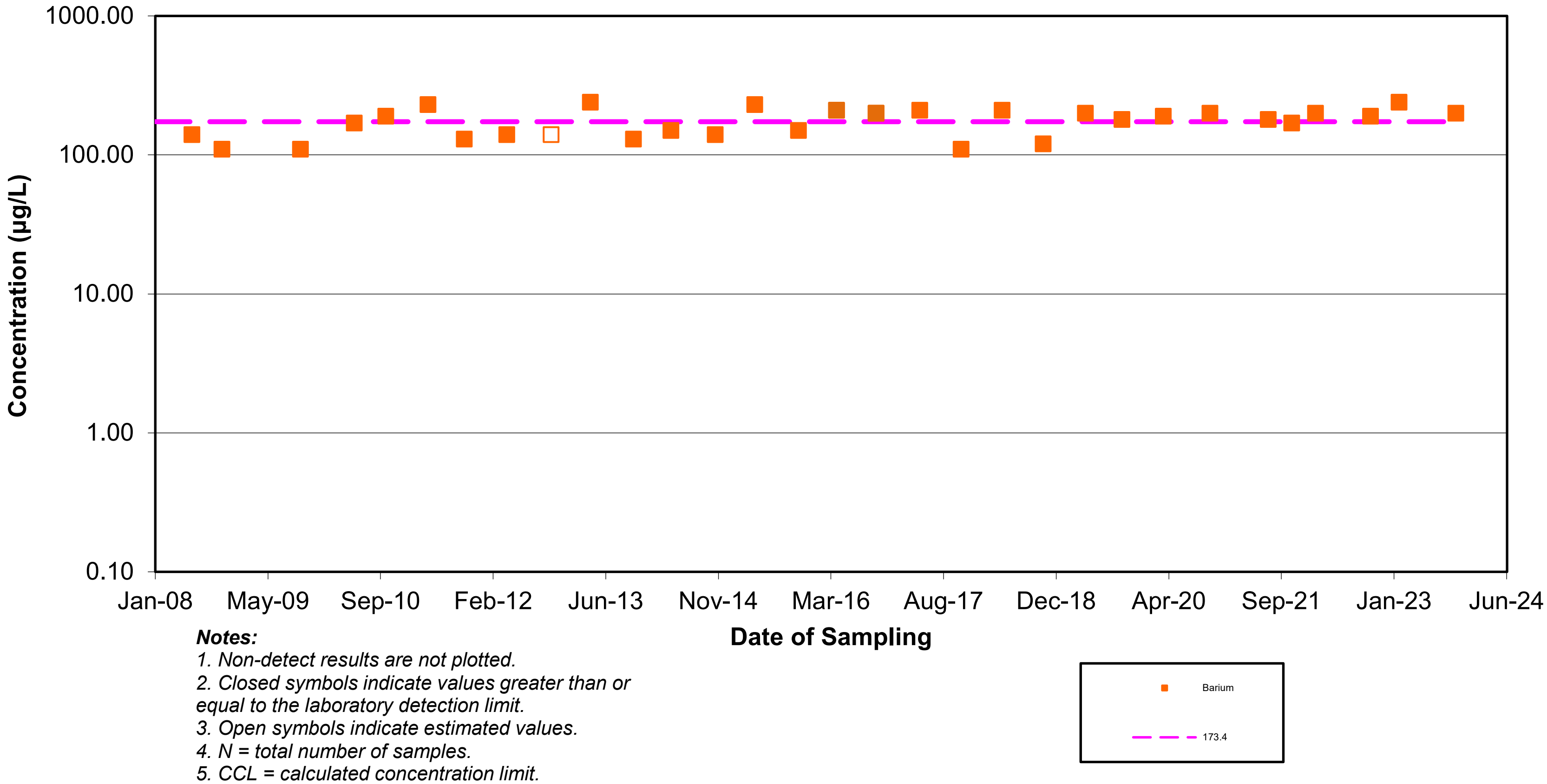
Site 1 Dissolved Barium Concentrations
Cross-gradient Monitoring Well W1-14



Notes:
1. Non-detect results are not plotted.
2. Closed symbols indicate values greater than or equal to the laboratory detection limit.
3. Open symbols indicate estimated values.
4. N = total number of samples.
5. CCL = calculated concentration limit.

Figure D-17

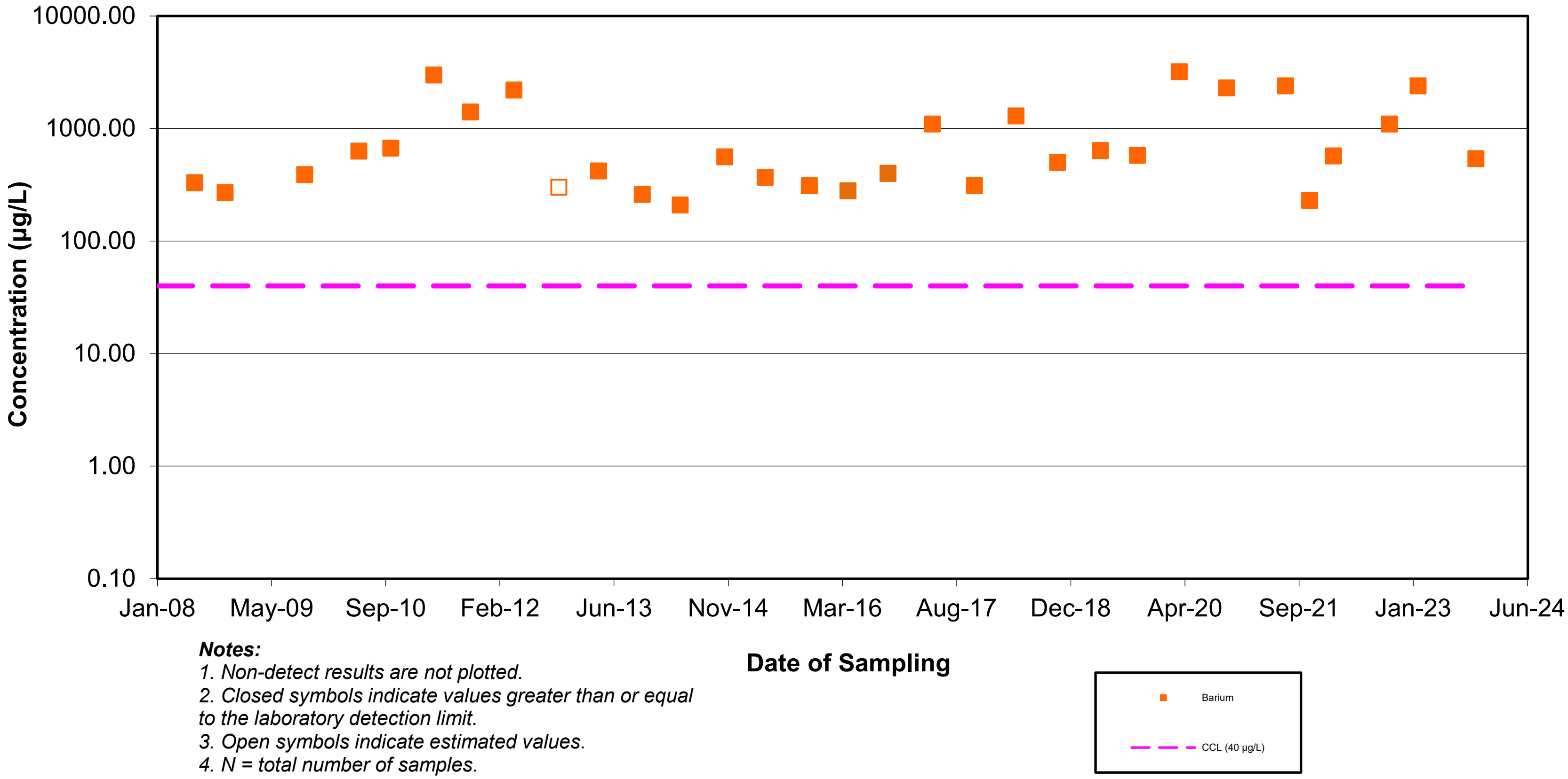
Site 1 Dissolved Barium Concentrations
Downgradient Monitoring Well W1-15



Notes:
1. Non-detect results are not plotted.
2. Closed symbols indicate values greater than or equal to the laboratory detection limit.
3. Open symbols indicate estimated values.
4. N = total number of samples.
5. CCL = calculated concentration limit.

Figure D-18

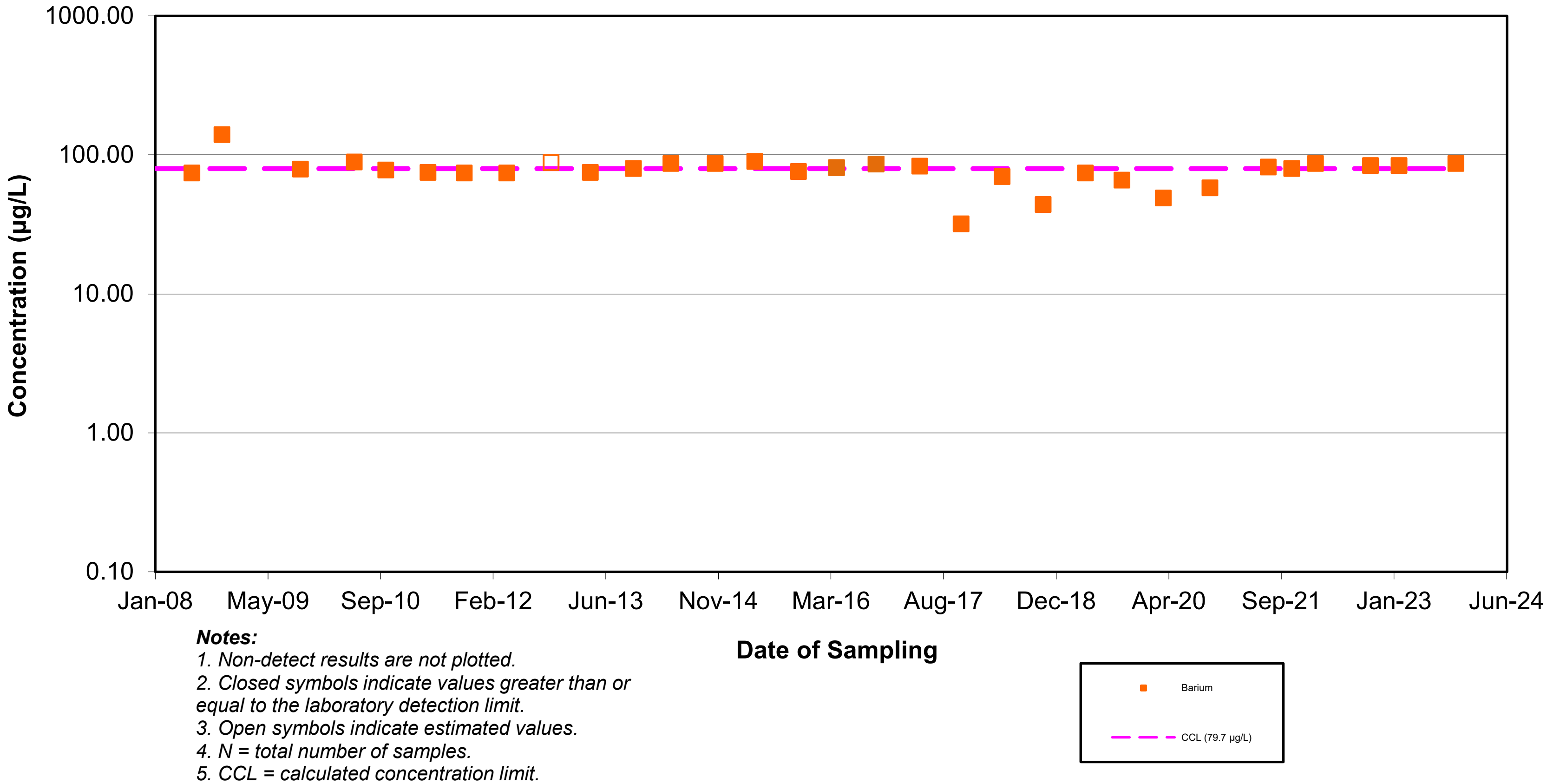
Site 1 Dissolved Barium Concentrations
Cross-gradient Monitoring Well W1-16



Notes:
1. Non-detect results are not plotted.
2. Closed symbols indicate values greater than or equal to the laboratory detection limit.
3. Open symbols indicate estimated values.
4. N = total number of samples.
5. CCL = calculated concentration limit.

Figure D-19

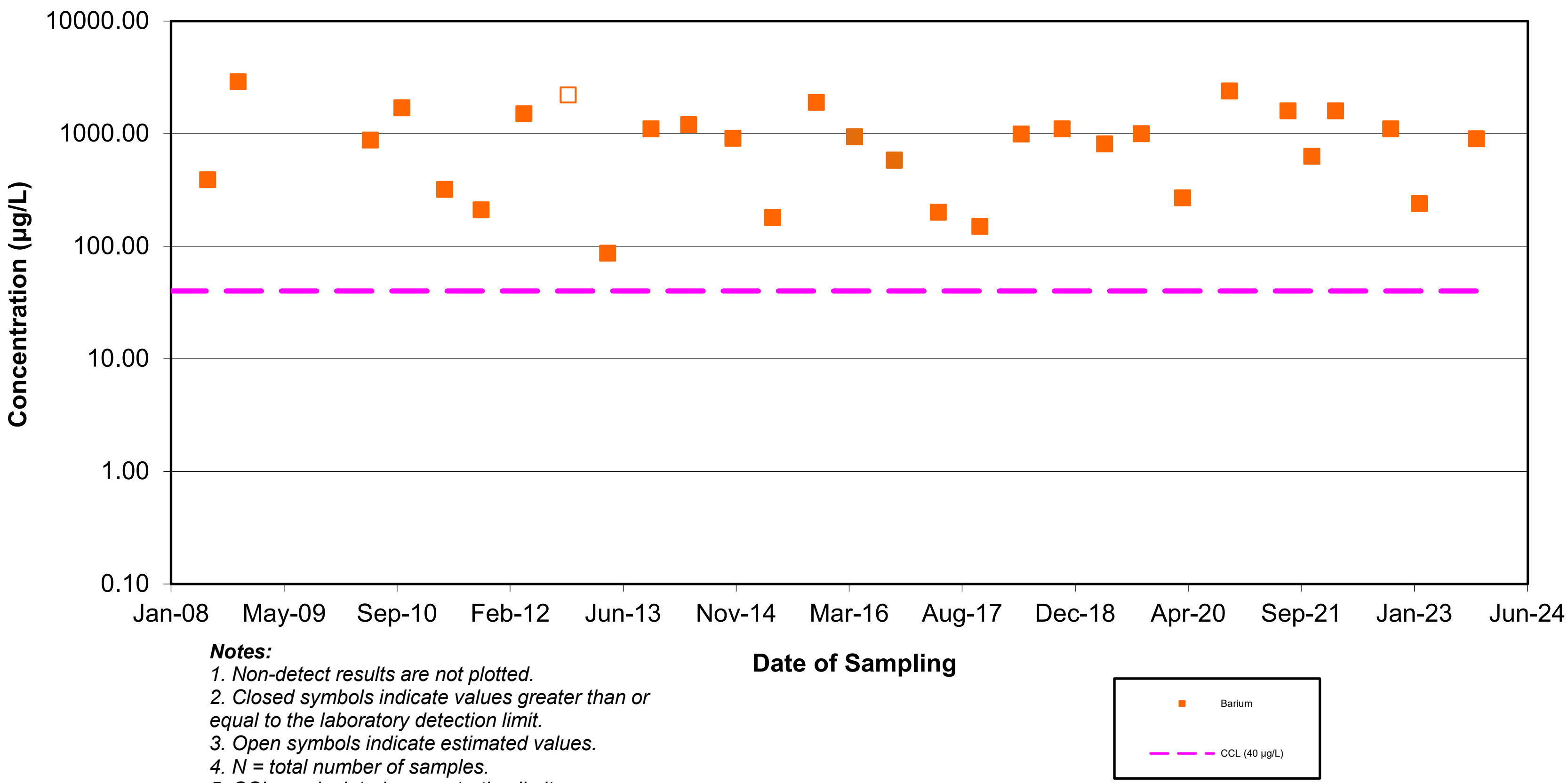
Site 1 Dissolved Barium Concentrations
Downgradient Monitoring Well W1-19



Notes:
1. Non-detect results are not plotted.
2. Closed symbols indicate values greater than or equal to the laboratory detection limit.
3. Open symbols indicate estimated values.
4. N = total number of samples.
5. CCL = calculated concentration limit.

Figure D-20

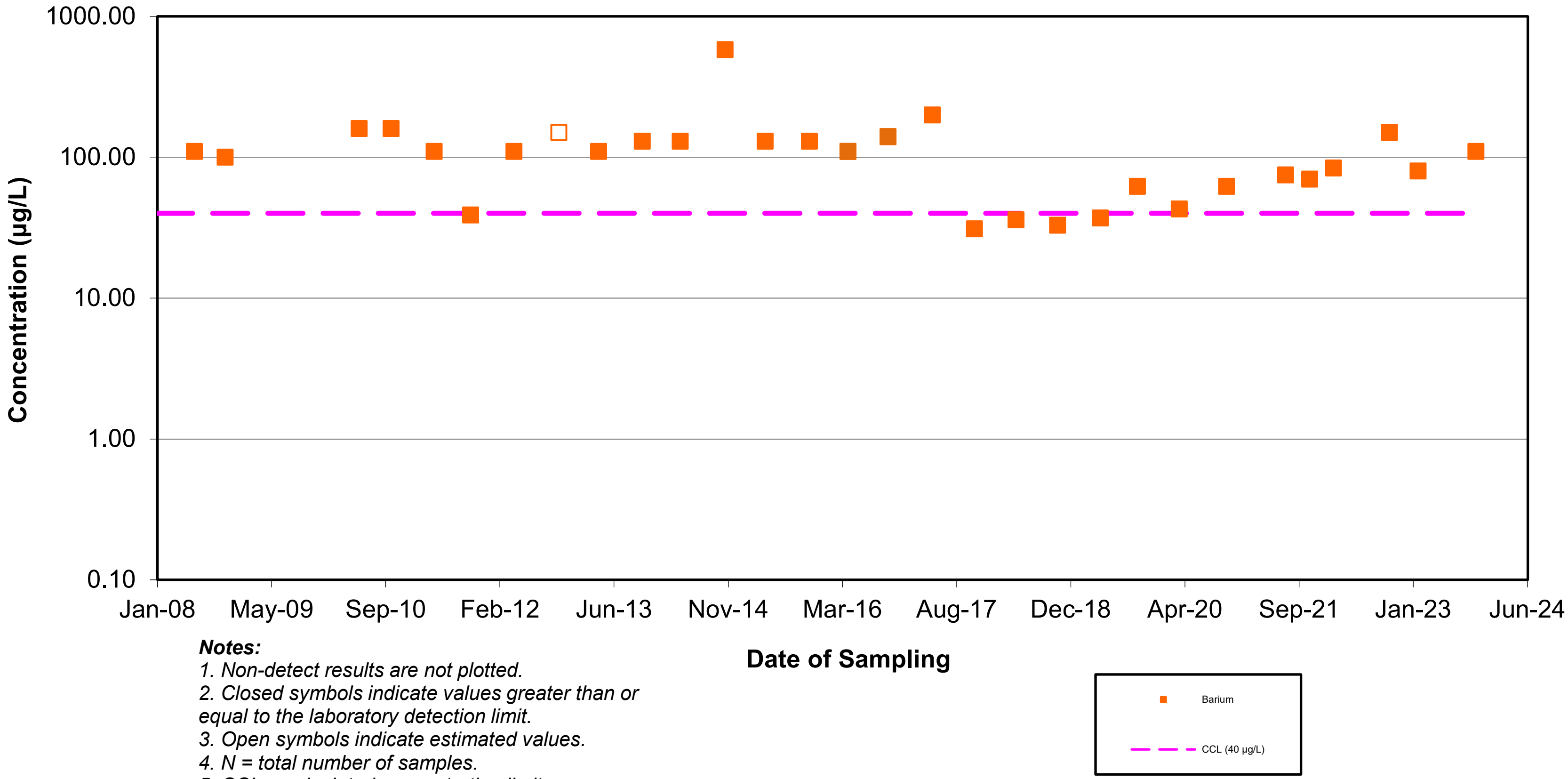
Site 1 Dissolved Barium Concentrations
Collection Trench Well W1-22



Notes:
1. Non-detect results are not plotted.
2. Closed symbols indicate values greater than or equal to the laboratory detection limit.
3. Open symbols indicate estimated values.
4. N = total number of samples.
5. CCL = calculated concentration limit.

Figure D-21

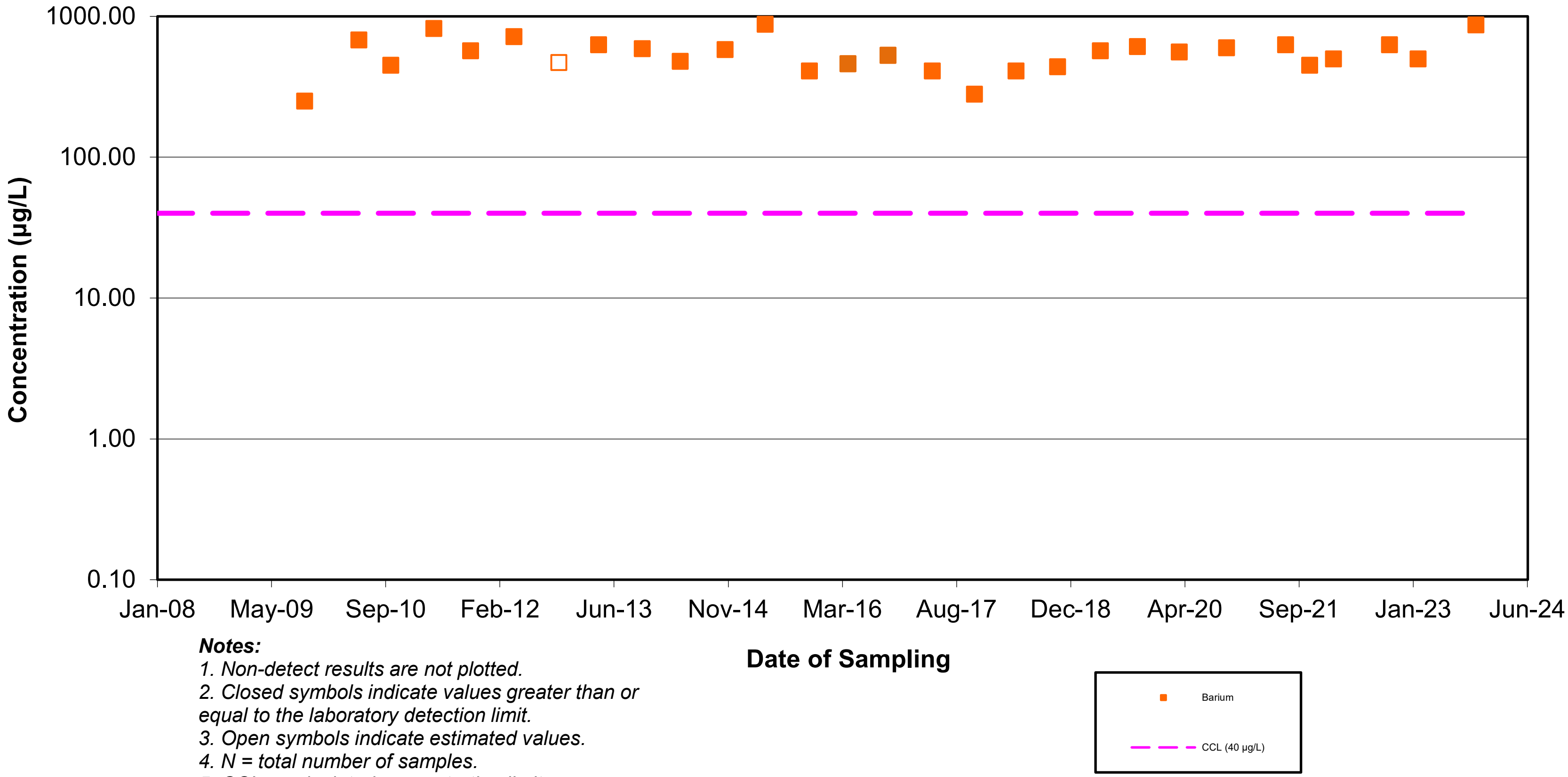
Site 1 Dissolved Barium Concentrations
Collection Trench Well W1-23



Notes:
1. Non-detect results are not plotted.
2. Closed symbols indicate values greater than or equal to the laboratory detection limit.
3. Open symbols indicate estimated values.
4. N = total number of samples.
5. CCL = calculated concentration limit.

Figure D-22

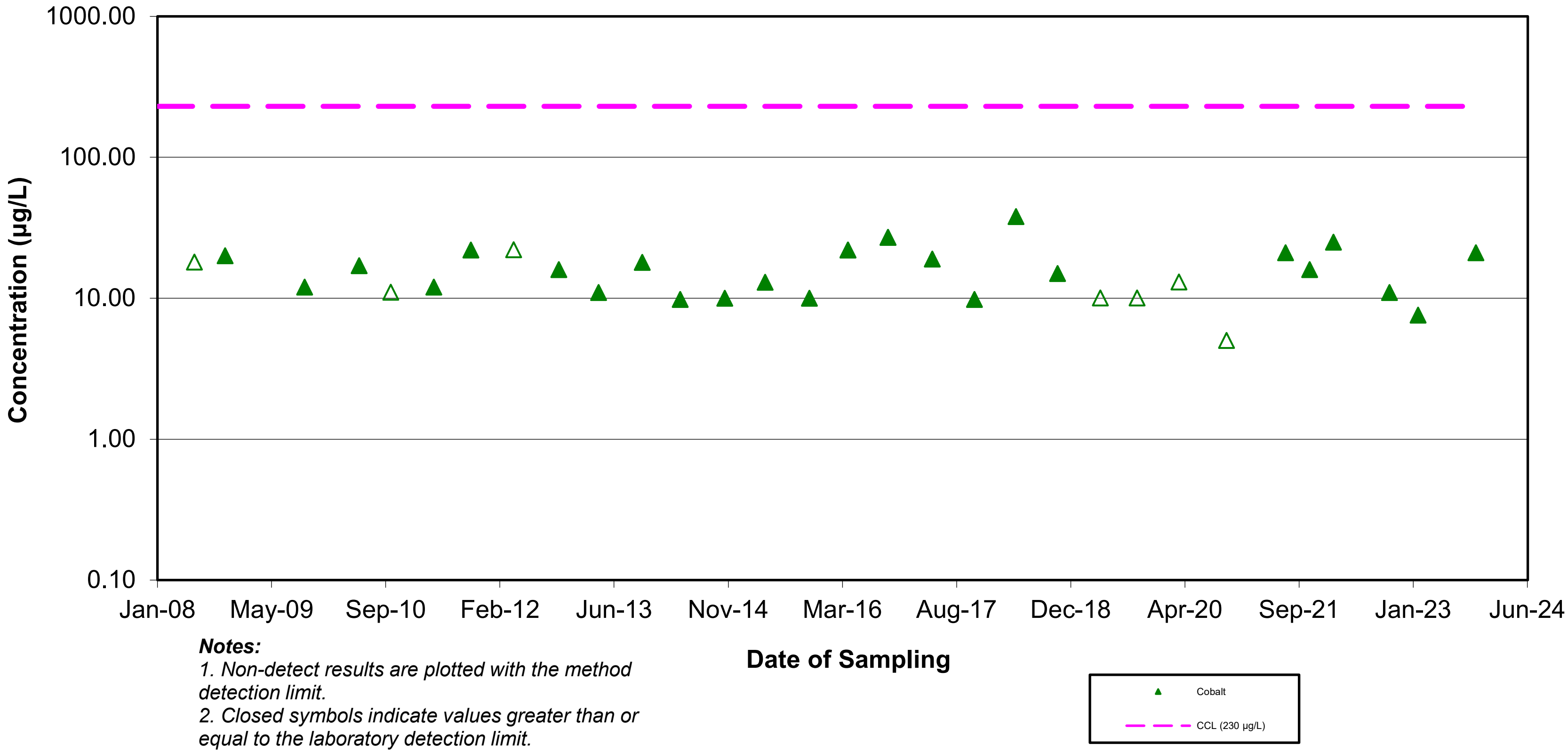
Site 1 Dissolved Barium Concentrations
Cross-gradient Monitoring Well W1-24



Notes:
1. Non-detect results are not plotted.
2. Closed symbols indicate values greater than or equal to the laboratory detection limit.
3. Open symbols indicate estimated values.
4. N = total number of samples.
5. CCL = calculated concentration limit.

Figure D-23

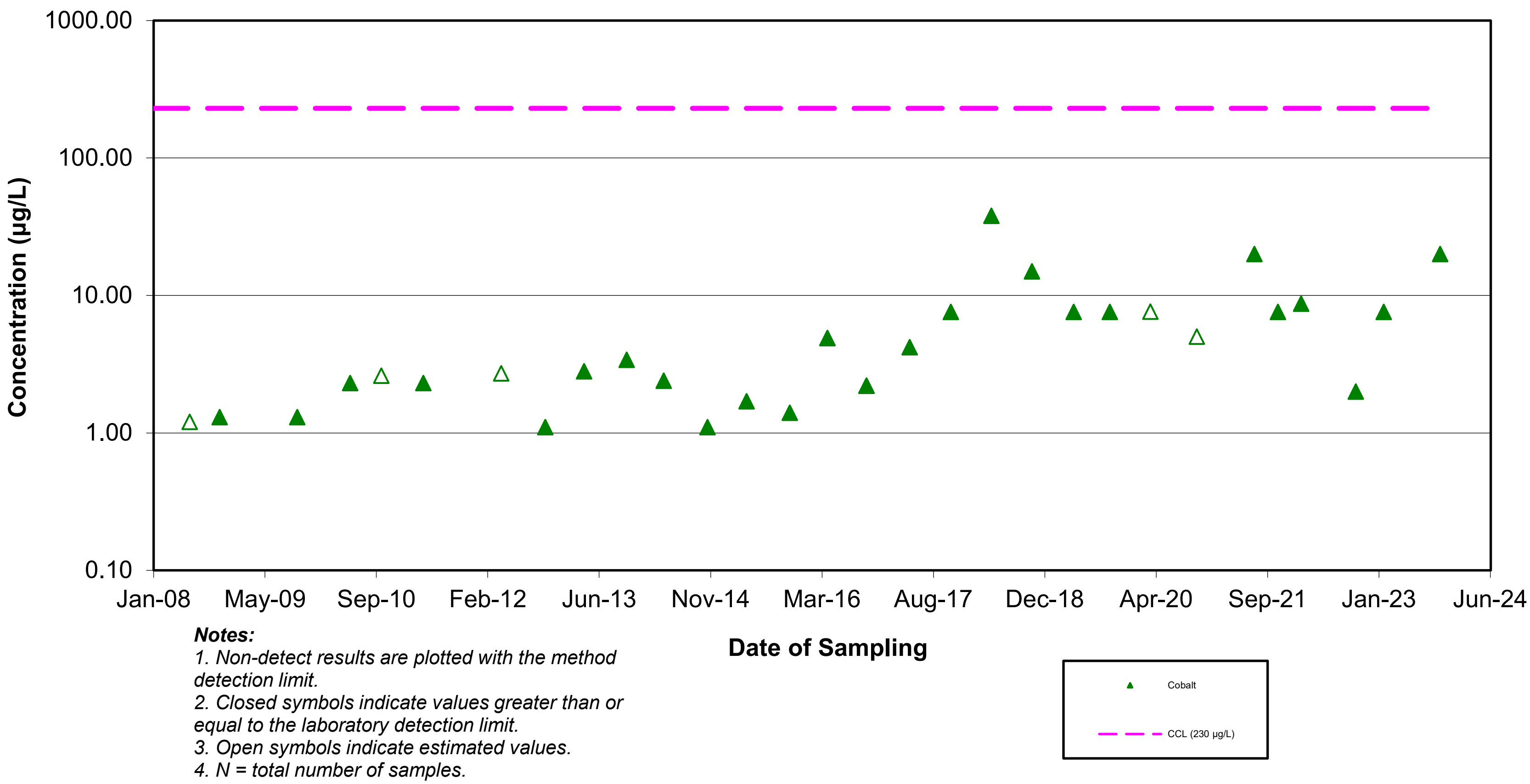
Site 1 Dissolved Cobalt Concentrations
Downgradient Monitoring Well W1-1R



Notes:
1. Non-detect results are plotted with the method detection limit.
2. Closed symbols indicate values greater than or equal to the laboratory detection limit.
3. Open symbols indicate estimated values.
4. N = total number of samples.
5. CCL = calculated concentration limit.

Figure D-24

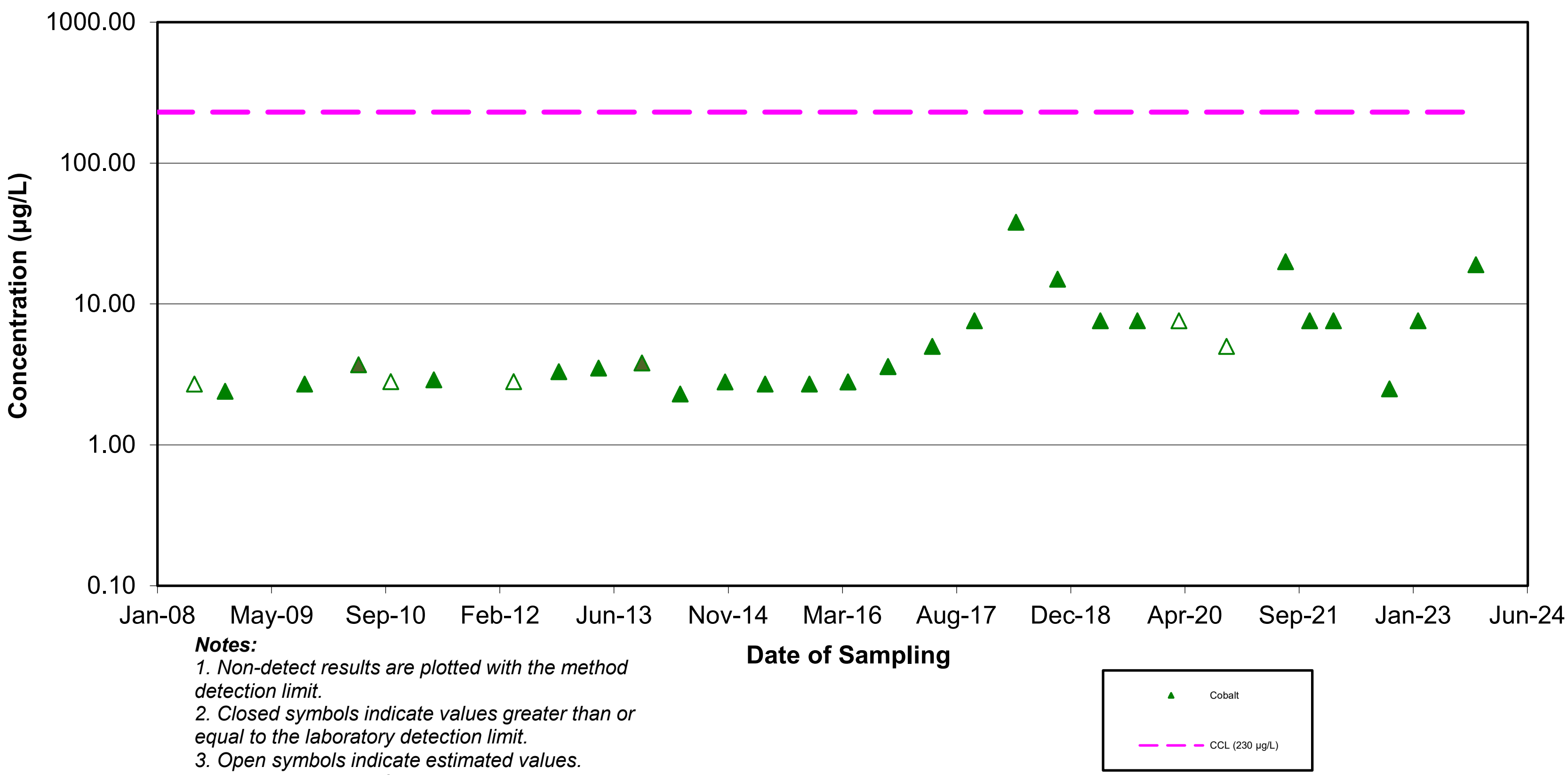
Site 1 Dissolved Cobalt Concentrations
Upgradient Monitoring Well W1-5



Notes:
1. Non-detect results are plotted with the method detection limit.
2. Closed symbols indicate values greater than or equal to the laboratory detection limit.
3. Open symbols indicate estimated values.
4. N = total number of samples.
5. CCL = calculated concentration limit.

Figure D-25

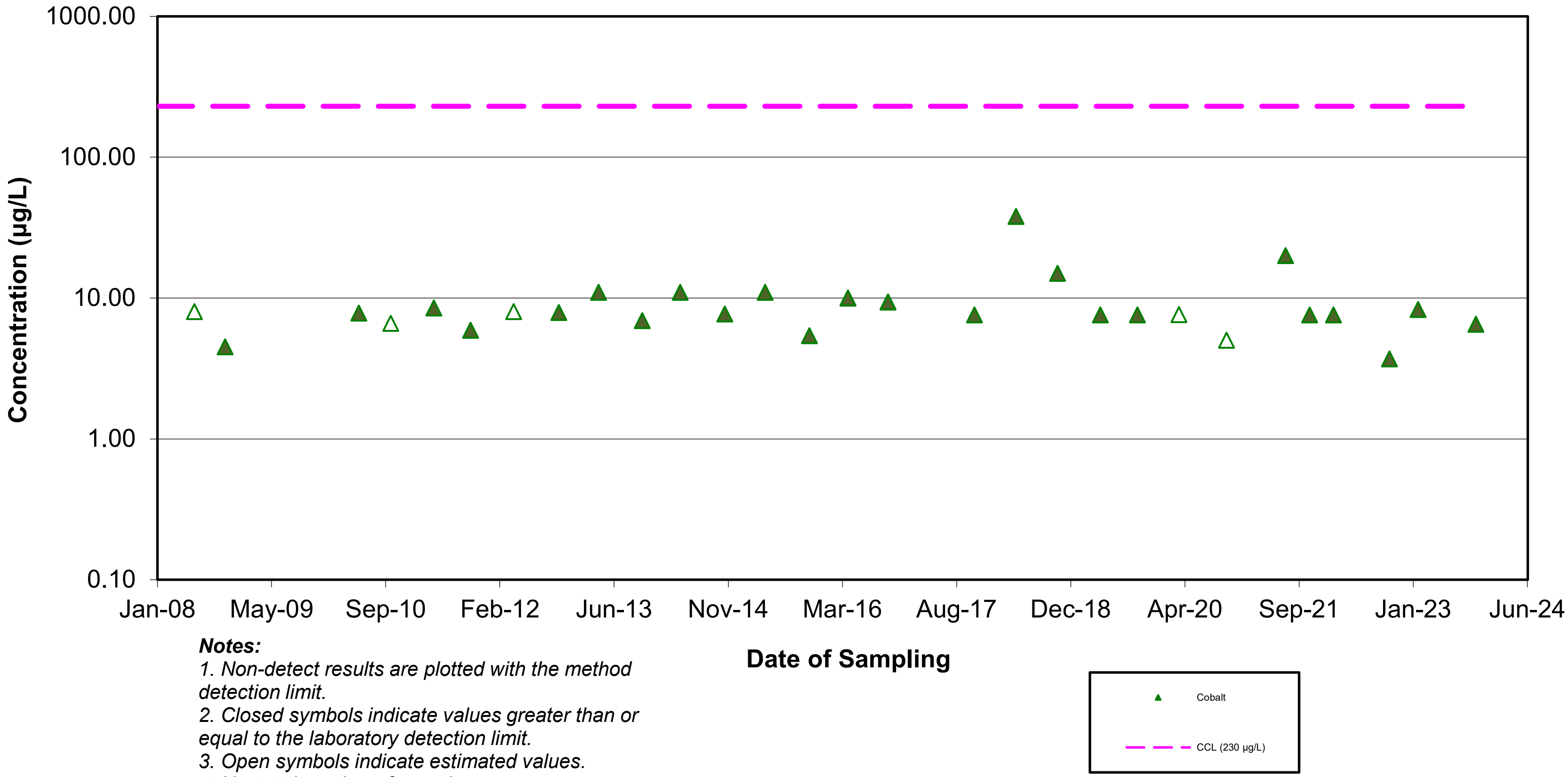
Site 1 Dissolved Cobalt Concentrations
Upgradient Monitoring Well W1-8



Notes:
1. Non-detect results are plotted with the method detection limit.
2. Closed symbols indicate values greater than or equal to the laboratory detection limit.
3. Open symbols indicate estimated values.
4. N = total number of samples.
5. CCL = calculated concentration limit.

Figure D-26

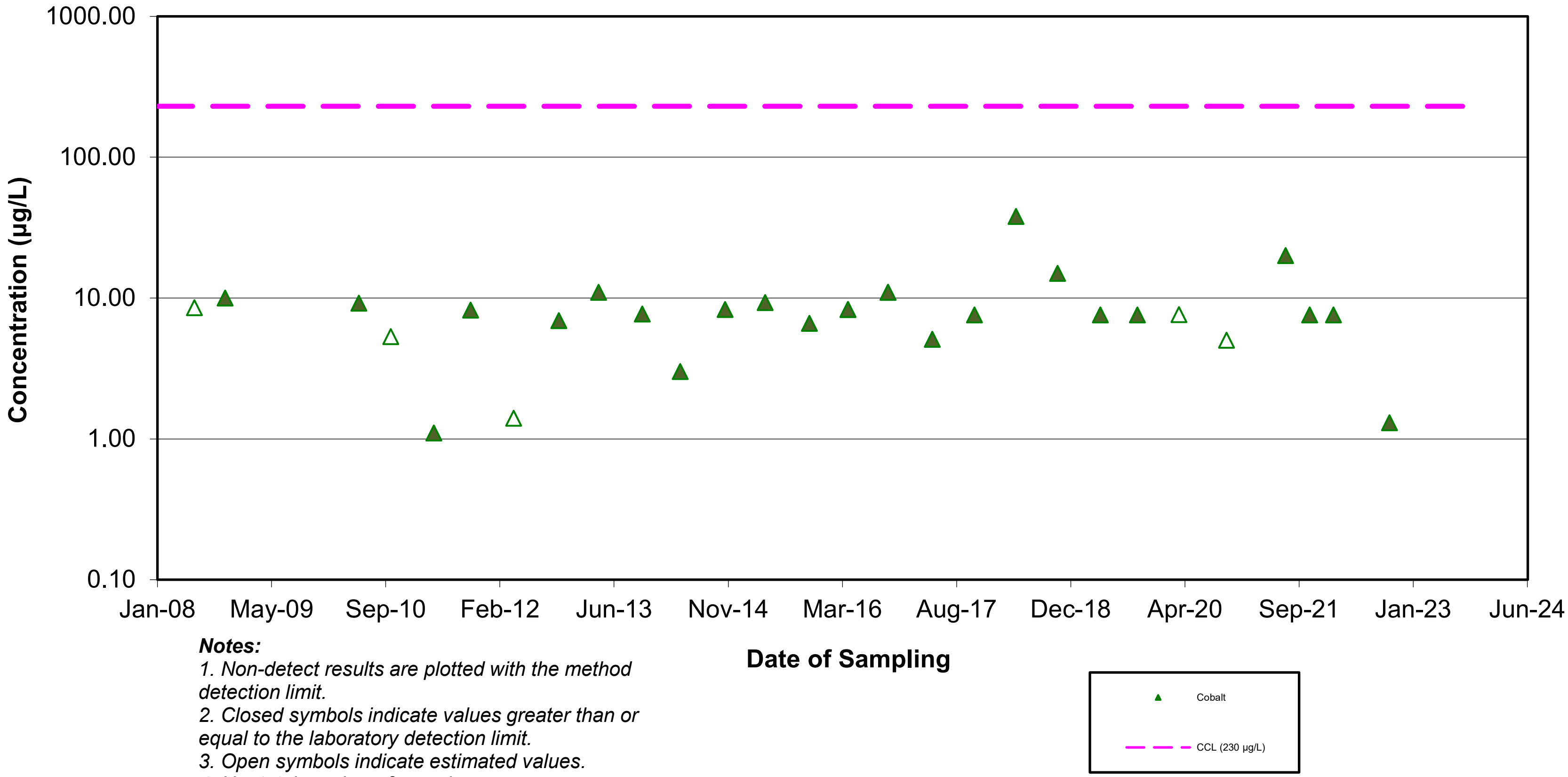
Site 1 Dissolved Cobalt Concentrations
Upgradient Monitoring Well W1-12R



Notes:
1. Non-detect results are plotted with the method detection limit.
2. Closed symbols indicate values greater than or equal to the laboratory detection limit.
3. Open symbols indicate estimated values.
4. N = total number of samples.
5. CCL = calculated concentration limit.

Figure D-27

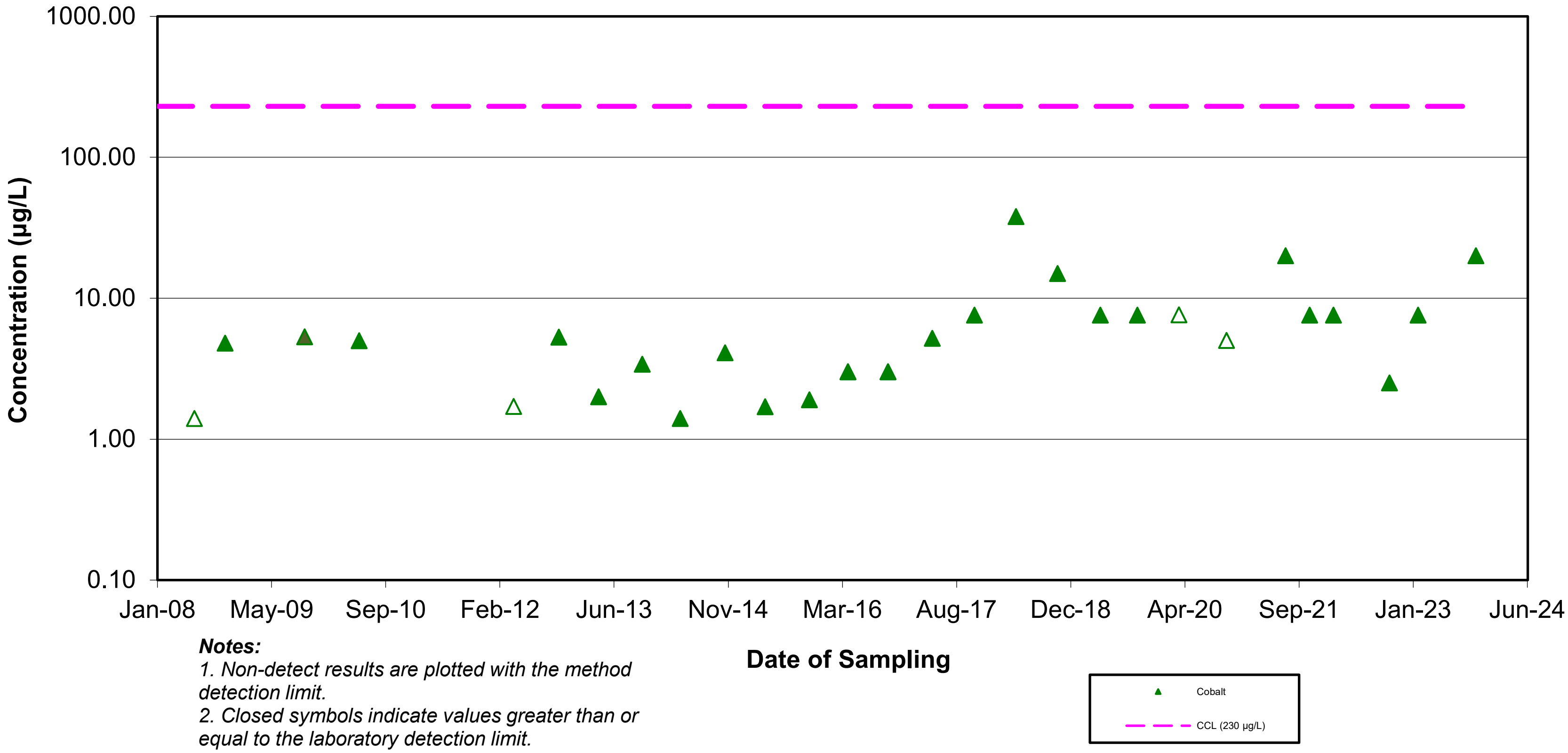
Site 1 Dissolved Cobalt Concentrations
Cross-gradient Monitoring Well W1-14



Notes:
1. Non-detect results are plotted with the method detection limit.
2. Closed symbols indicate values greater than or equal to the laboratory detection limit.
3. Open symbols indicate estimated values.
4. N = total number of samples.
5. CCL = calculated concentration limit.

Figure D-28

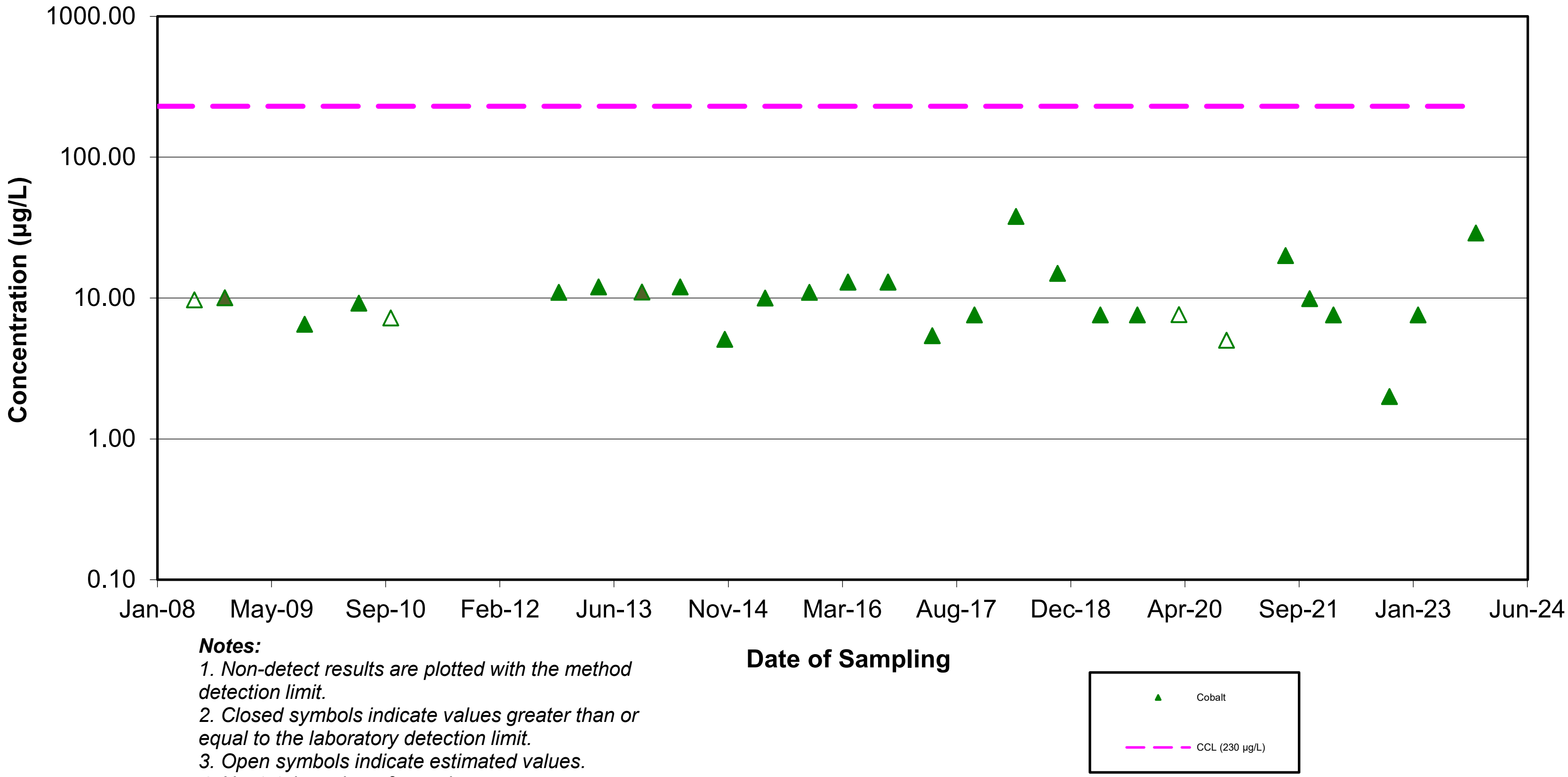
Site 1 Dissolved Cobalt Concentrations
Downgradient Monitoring Well W1-15



Notes:
1. Non-detect results are plotted with the method detection limit.
2. Closed symbols indicate values greater than or equal to the laboratory detection limit.
3. Open symbols indicate estimated values.
4. N = total number of samples.
5. CCL = calculated concentration limit.

Figure D-29

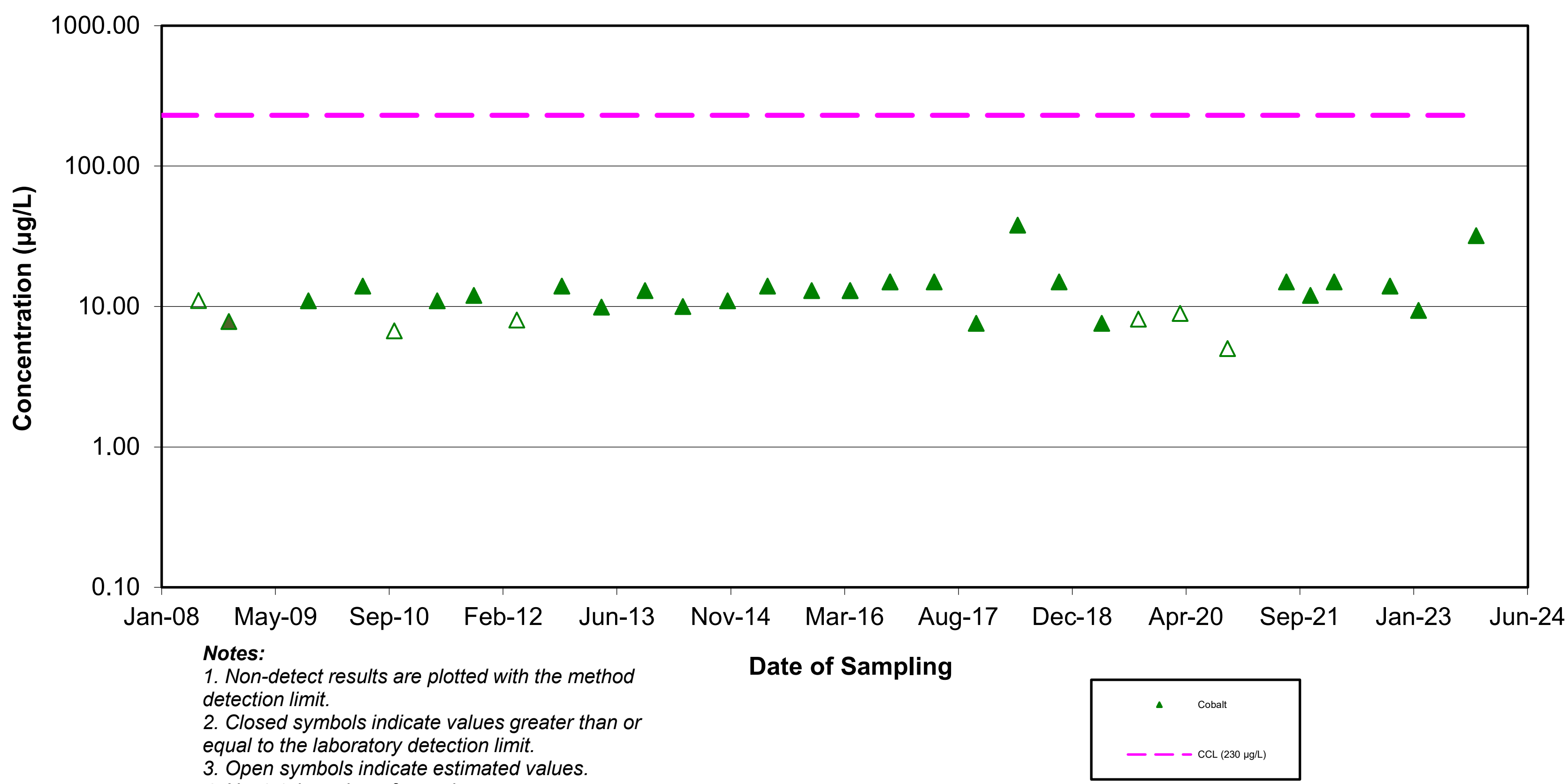
Site 1 Dissolved Cobalt Concentrations
Cross-gradient Monitoring Well W1-16



Notes:
1. Non-detect results are plotted with the method detection limit.
2. Closed symbols indicate values greater than or equal to the laboratory detection limit.
3. Open symbols indicate estimated values.
4. N = total number of samples.
5. CCL = calculated concentration limit.

Figure D-30

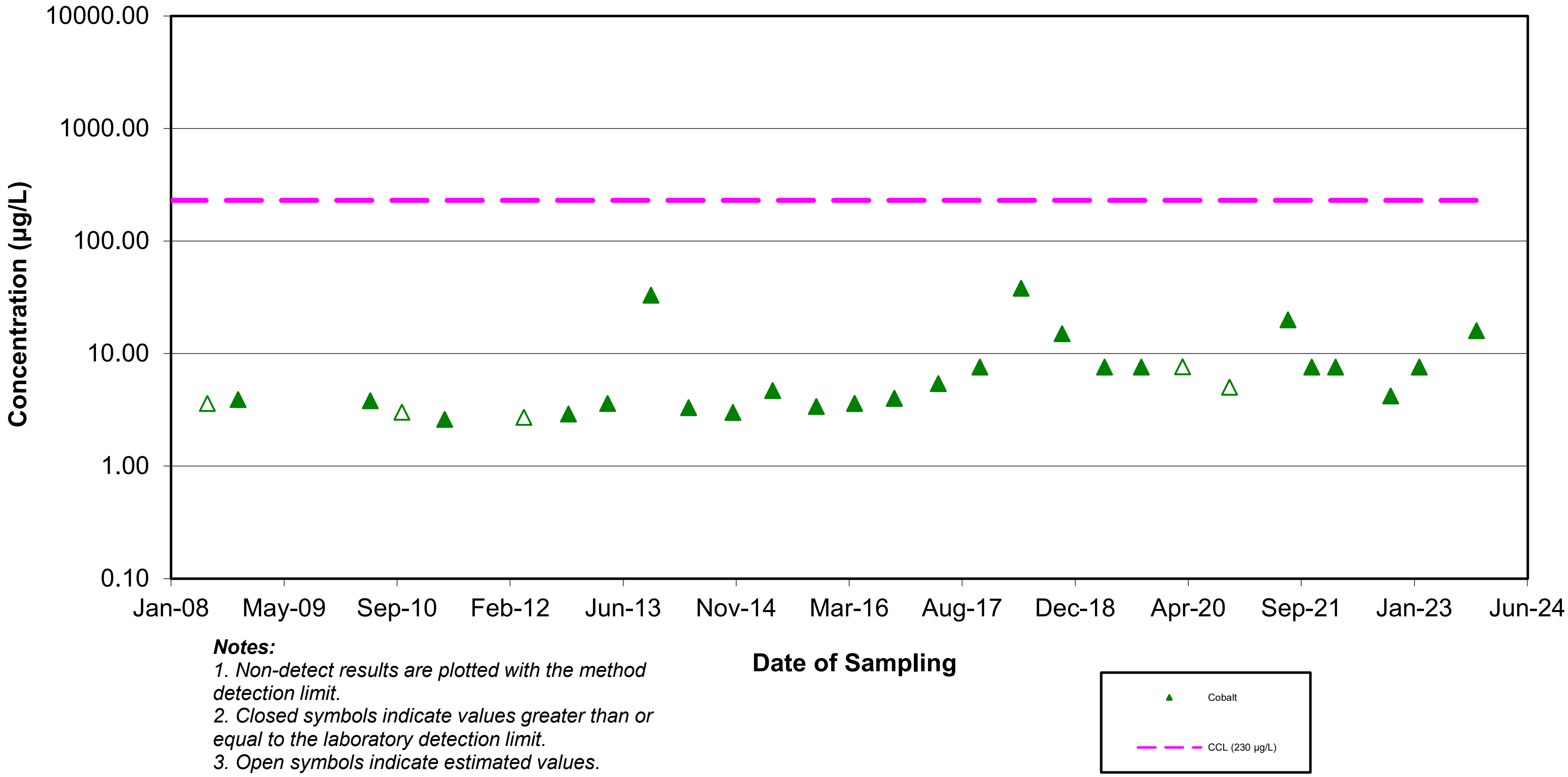
Site 1 Dissolved Cobalt Concentrations
Downgradient Monitoring Well W1-19



Notes:
1. Non-detect results are plotted with the method detection limit.
2. Closed symbols indicate values greater than or equal to the laboratory detection limit.
3. Open symbols indicate estimated values.
4. N = total number of samples.
5. CCL = calculated concentration limit.

Figure D-31

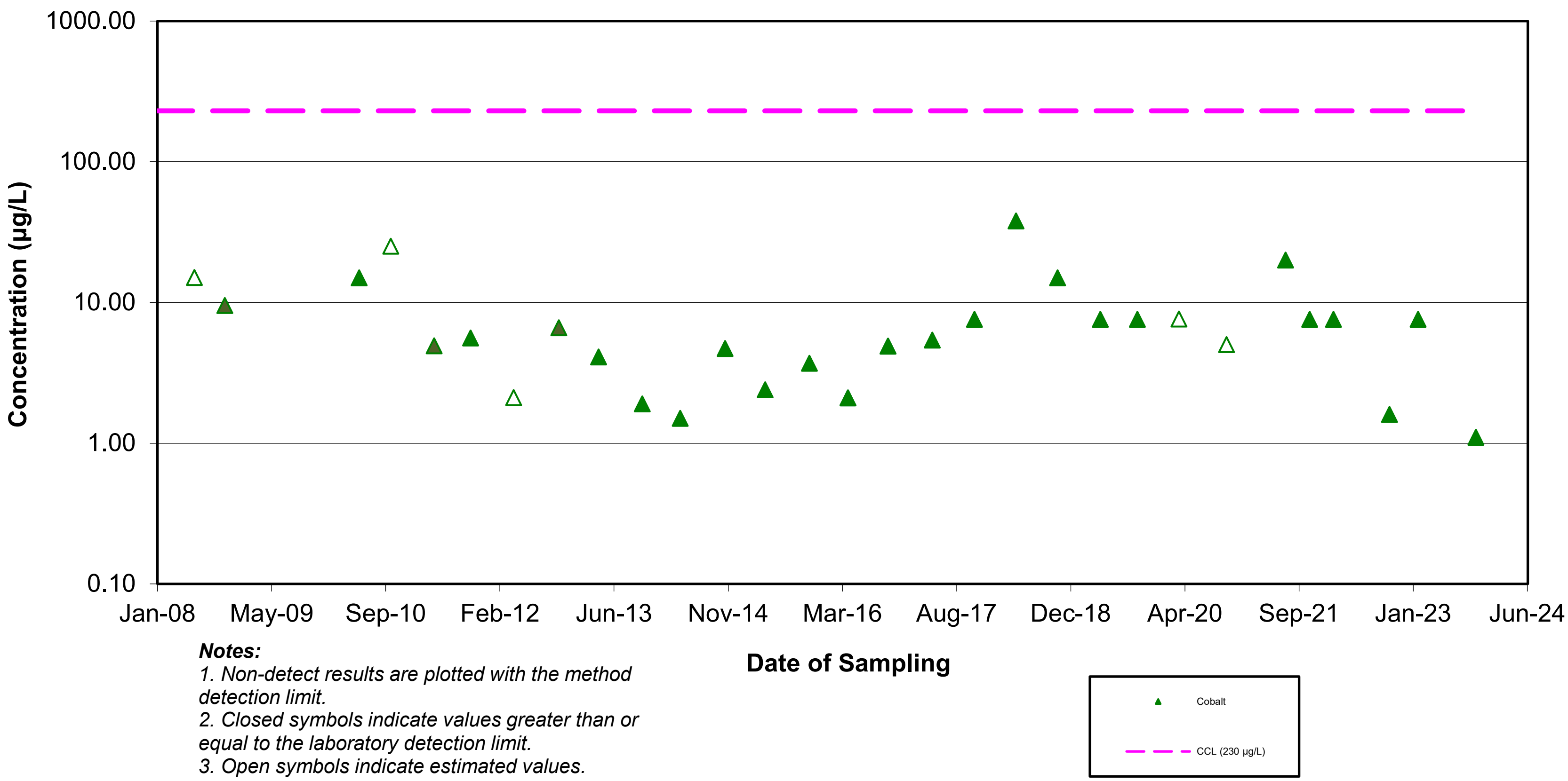
Site 1 Dissolved Cobalt Concentrations
Collection Trench Well W1-22



Notes:
1. Non-detect results are plotted with the method detection limit.
2. Closed symbols indicate values greater than or equal to the laboratory detection limit.
3. Open symbols indicate estimated values.
4. N = total number of samples.
5. CCL = calculated concentration limit.

Figure D-32

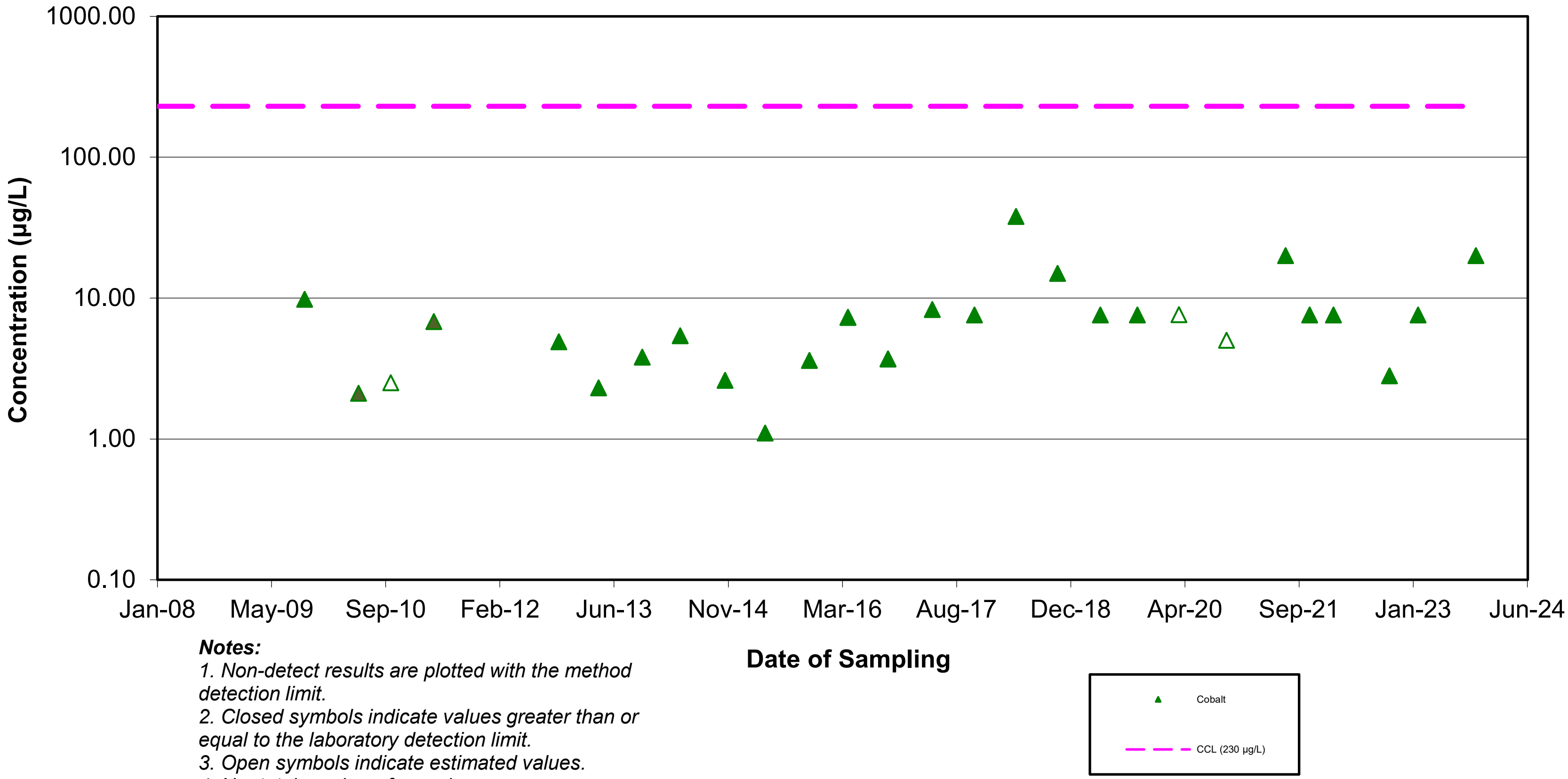
Site 1 Dissolved Cobalt Concentrations
Collection Trench Well W1-23



Notes:
1. Non-detect results are plotted with the method detection limit.
2. Closed symbols indicate values greater than or equal to the laboratory detection limit.
3. Open symbols indicate estimated values.
4. N = total number of samples.
5. CCL = calculated concentration limit.

Figure D-33

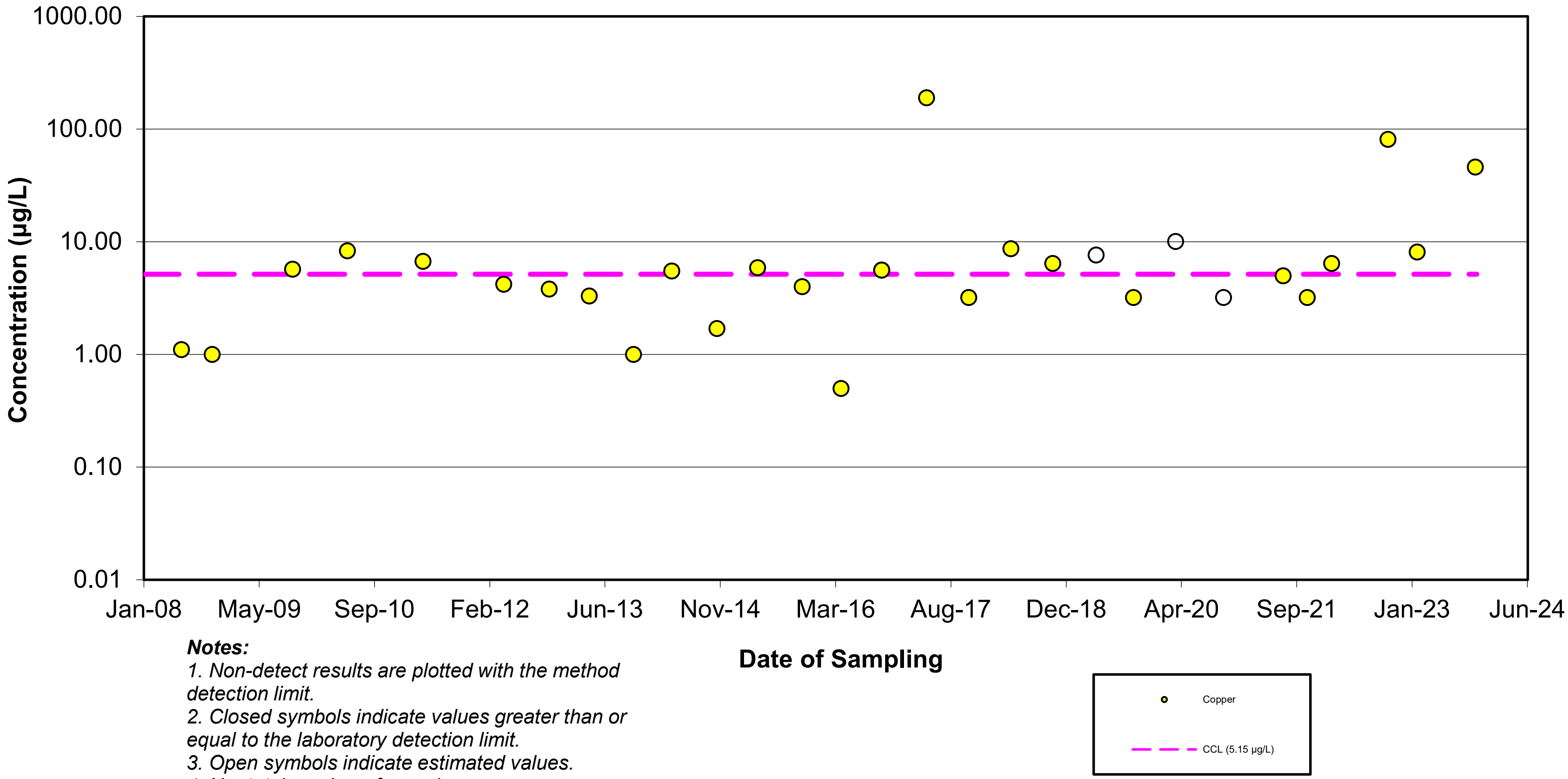
Site 1 Dissolved Cobalt Concentrations
Cross-gradient Monitoring Well W1-24



Notes:
1. Non-detect results are plotted with the method detection limit.
2. Closed symbols indicate values greater than or equal to the laboratory detection limit.
3. Open symbols indicate estimated values.
4. N = total number of samples.
5. CCL = calculated concentration limit.

Figure D-34

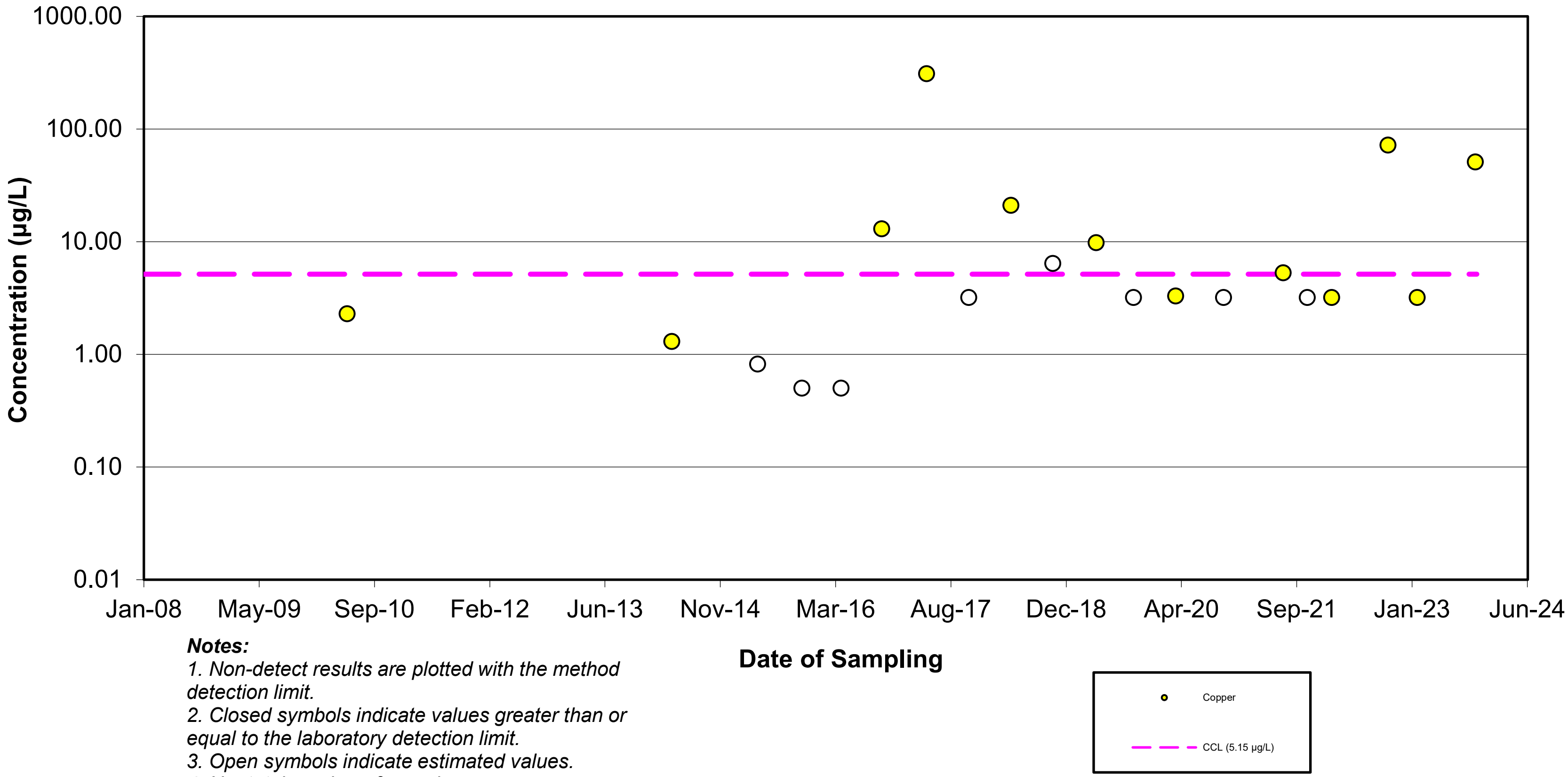
Site 1 Dissolved Copper Concentrations
Downgradient Monitoring Well W1-1R



Notes:
1. Non-detect results are plotted with the method detection limit.
2. Closed symbols indicate values greater than or equal to the laboratory detection limit.
3. Open symbols indicate estimated values.
4. N = total number of samples.
5. CCL = calculated concentration limit.

Figure D-35

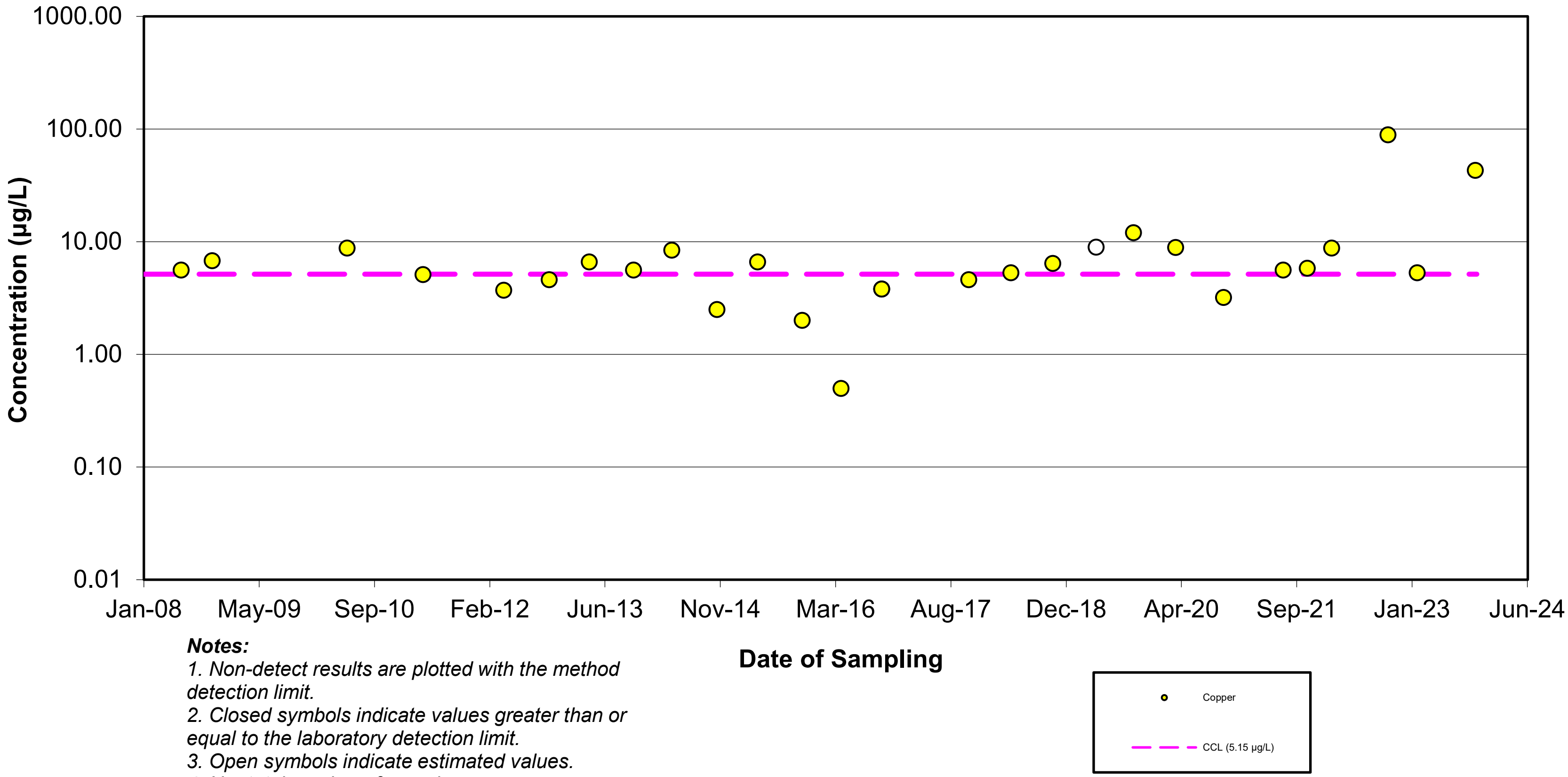
Site 1 Dissolved Copper Concentrations
Upgradient Monitoring Well W1-8



Notes:
1. Non-detect results are plotted with the method detection limit.
2. Closed symbols indicate values greater than or equal to the laboratory detection limit.
3. Open symbols indicate estimated values.
4. N = total number of samples.
5. CCL = calculated concentration limit.

Figure D-36

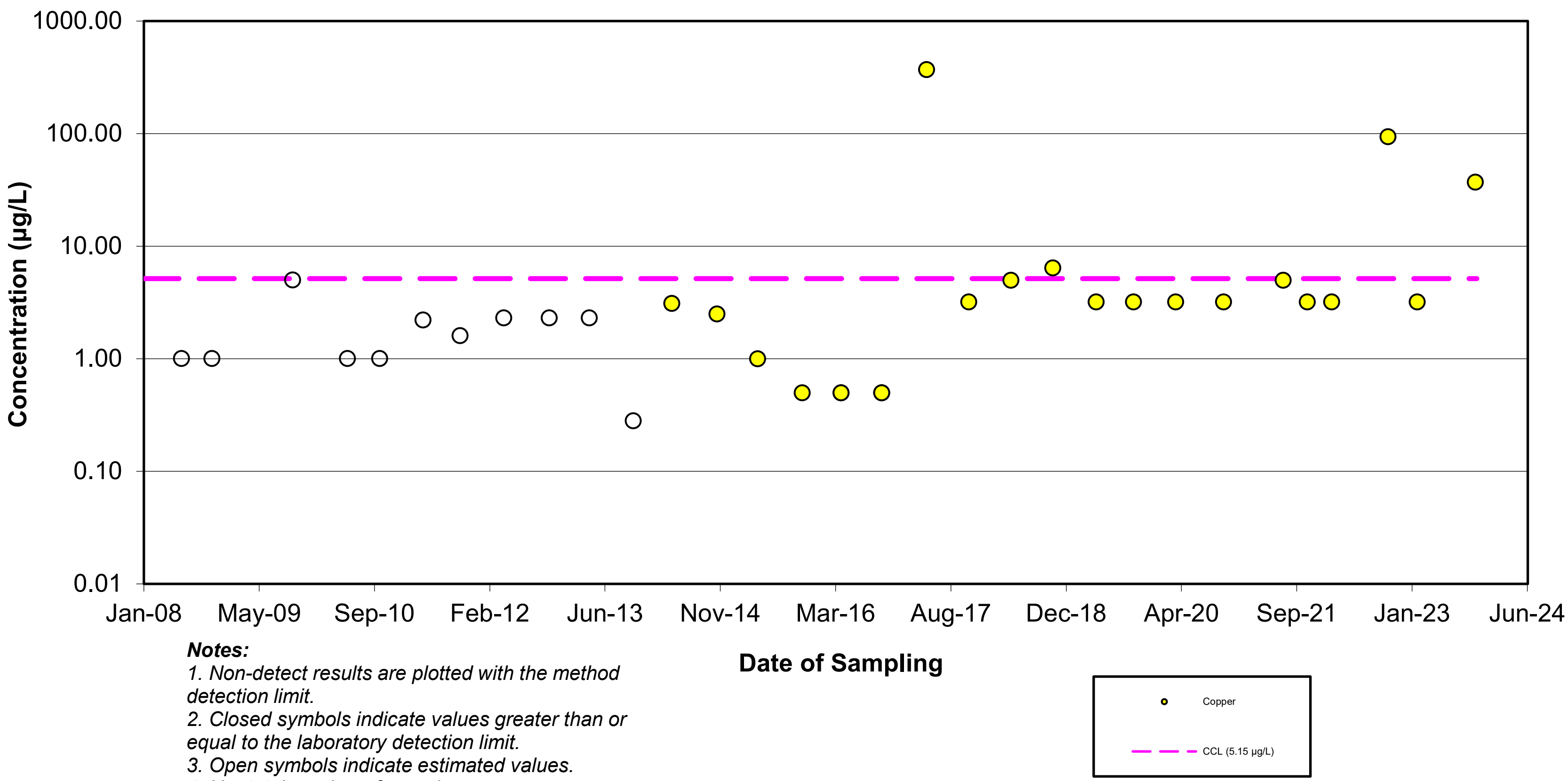
Site 1 Dissolved Copper Concentrations
Upgradient Monitoring Well W1-12R



Notes:
1. Non-detect results are plotted with the method detection limit.
2. Closed symbols indicate values greater than or equal to the laboratory detection limit.
3. Open symbols indicate estimated values.
4. N = total number of samples.
5. CCL = calculated concentration limit.

Figure D-37

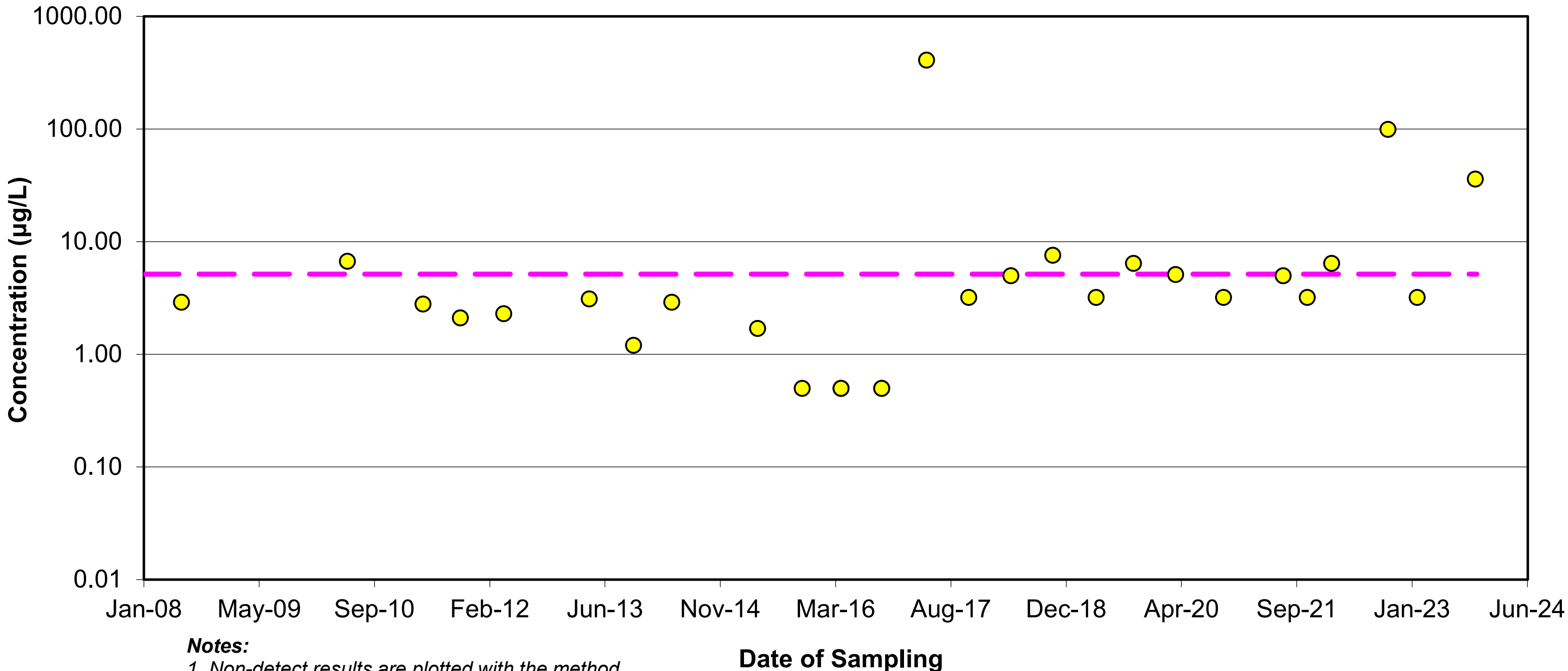
Site 1 Dissolved Copper Concentrations
Downgradient Monitoring Well W1-15



Notes:
1. Non-detect results are plotted with the method detection limit.
2. Closed symbols indicate values greater than or equal to the laboratory detection limit.
3. Open symbols indicate estimated values.
4. N = total number of samples.
5. CCL = calculated concentration limit.

Figure D-37

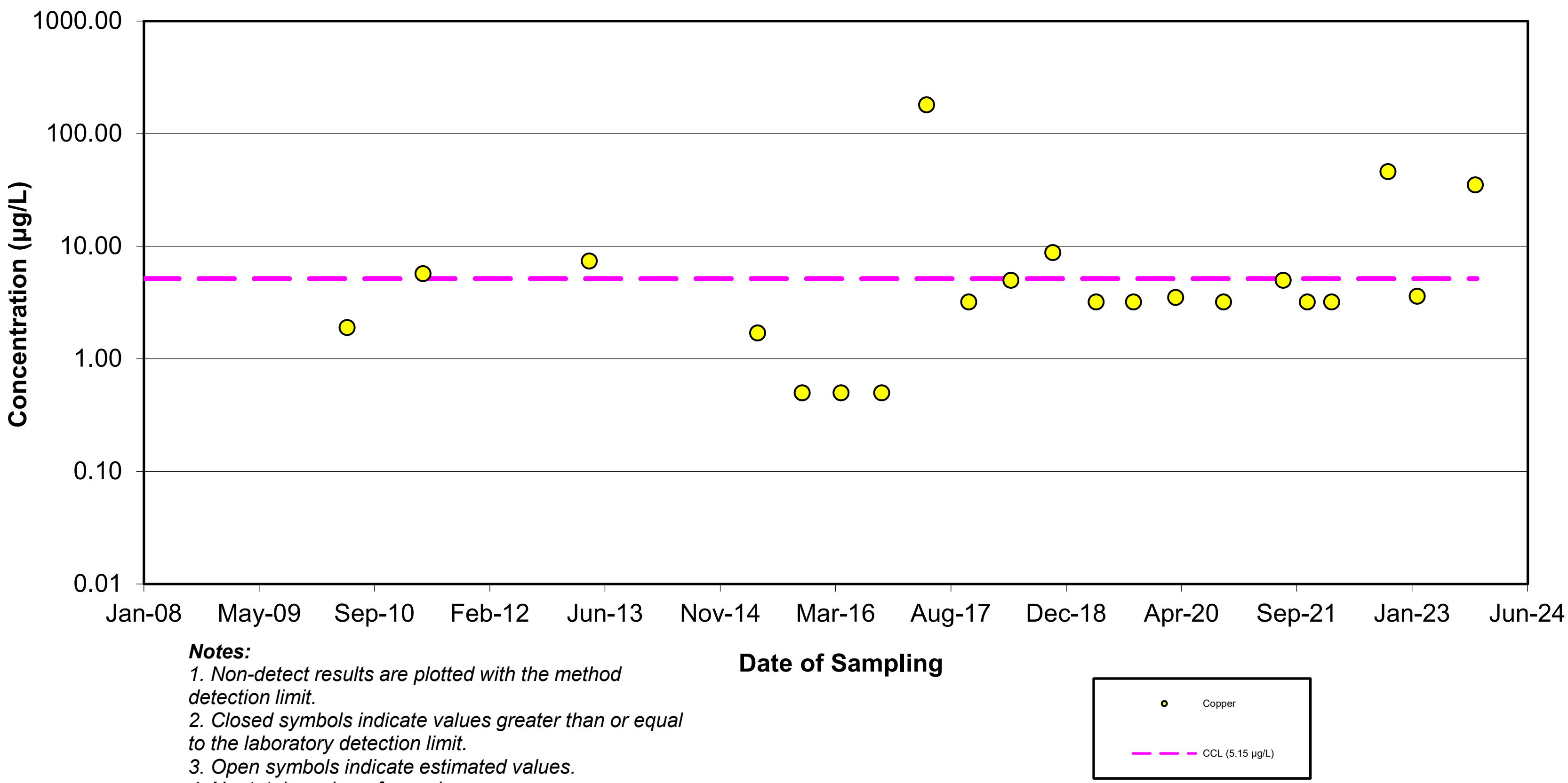
Site 1 Dissolved Copper Concentrations
Downgradient Monitoring Well W1-19



Notes:
1. Non-detect results are plotted with the method detection limit.
2. Closed symbols indicate values greater than or equal to the laboratory detection limit.
3. Open symbols indicate estimated values.
4. N = total number of samples.
5. CCL = calculated concentration limit.

Figure D-38

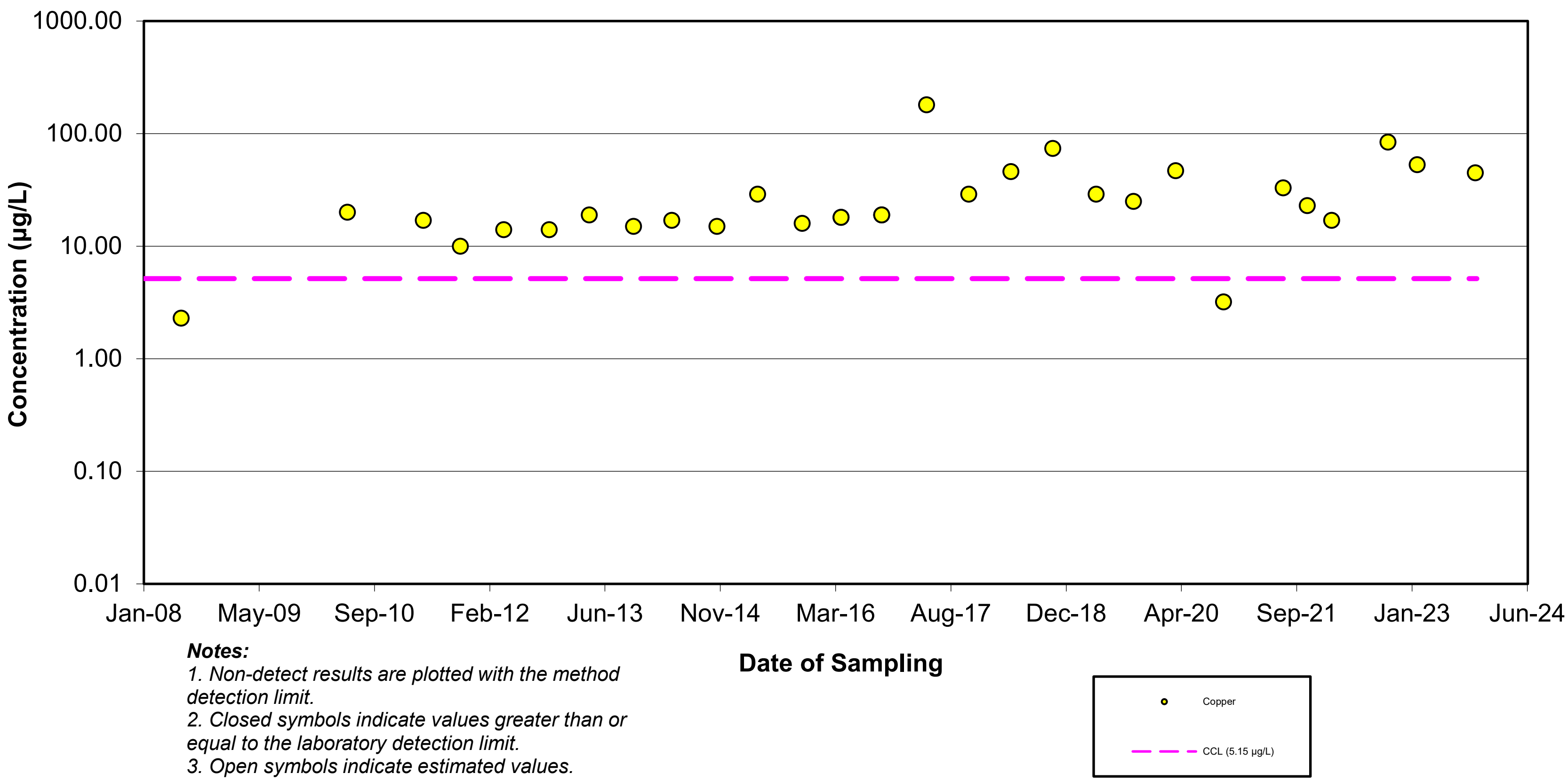
Site 1 Dissolved Copper Concentrations
Collection Trench Well W1-22



Notes:
1. Non-detect results are plotted with the method detection limit.
2. Closed symbols indicate values greater than or equal to the laboratory detection limit.
3. Open symbols indicate estimated values.
4. N = total number of samples.
5. CCL = calculated concentration limit.

Figure D-39

Site 1 Dissolved Copper Concentrations
Collection Trench Well W1-23



Notes:
1. Non-detect results are plotted with the method detection limit.
2. Closed symbols indicate values greater than or equal to the laboratory detection limit.
3. Open symbols indicate estimated values.
4. N = total number of samples.
5. CCL = calculated concentration limit.

Appendix J

Barium Statistical Analysis Report

MEMO

To: Robyn Kreimborg, Program Manager, BB&E

From: Dana McCue, Senior Risk Assessor

Date: March 17, 2023

Re: **Statistical Analysis for Site 1 Landfill, National Aeronautics and Space Administration (NASA) Ames Research Center (ARC)**

BB&E, Inc. (BB&E) supports the National Aeronautics and Space Administration (NASA) Ames Research Center (ARC) under an Environmental Services Support (ESS) contract. Under that performance work statement, the BB&E team provides comprehensive support for the restoration program. As part of the restoration program, the team conducts required sampling, analysis, and reporting associated with the Site 1 Landfill. EHS Support LLC (EHS Support) has prepared this technical memorandum to provide assistance to BB&E in evaluating the Site 1 Landfill groundwater data set consistent with methods outlined in *2004 Tech Memo Site 1 Groundwater Evaluation Process* and *2016 -Final Tech Memo Addendum*.

Scope of Work

The Site 1 Landfill is a closed 12-acre landfill located in the northernmost portion of the former Naval Air Station Moffett Field (NASMF). Post-closure groundwater monitoring continues at the landfill semiannually. Downgradient point of compliance (POC) wells are W1-1R, W1-15, and W1-19. Upgradient (background) wells are W1-5, W1-8 and W1-12R.

The groundwater data evaluation process involves comparing the sampled groundwater analytical data to the site calculated concentration limits (CCLs). If downgradient analytical data are lower than or equal to the associated CCLs, then no further action is necessary. If the downgradient analytical data are greater than the associated CCLs, then a statistical evaluation is required.

The following tasks were completed consistent with the Scope of Work dated February 27, 2023.

Task 1: 95 percent (%) Upper Confidence Limit (95 % UCL) Calculations

The 95% UCL on the arithmetic mean was calculated for barium in each of the three POC wells to determine the well-specific CCLs. The data set used in the calculation includes groundwater monitoring data collected between July 1999 and February 2023, depending on the location (see **Attachment A**).

The 95% UCL was calculated using parametric methods (for a normal or lognormal distribution) or nonparametric methods if the data were neither normally nor lognormally distributed (USEPA, 1992 and 2002). Statistical calculations were performed using USEPA's ProUCL software (version 5.2.0). For data sets that contained values reported as non-detect, USEPA's ProUCL software chose the methodology used in calculating the 95% UCL. Non-detects were included in the data set at the detection limit (no substitution methods were used such as replacing with ½ the detection limit).

Sample summary statistics and outlier testing was conducted on the data set prior to calculating the UCLs. ProUCL software provides statistical methods consistent with *2004 Tech Memo Site 1 Groundwater Evaluation Process*.

Task 2: Determine Statistical Significance Between Pooled Upgradient Population and Downgradient Population

As outlined in the *2004 Tech Memo Site 1 Groundwater Evaluation Process* and *2016 -Final Tech Memo Addendum*, if detected barium concentrations in any of the three POC wells exceed the associated 95% UCL barium concentration calculated for that individual well in two out of three consecutive sampling events, then those exceedances are to be statistically evaluated. The purpose of the statistical evaluation is to determine if there is a statistical difference between the pooled upgradient (background) population and the downgradient (POC) monitoring well locations.

This comparison was conducted using two-sample hypothesis testing in ProUCL. Based on the distribution of the data set and presence of non-detects, the Gehan test in ProUCL was selected to compare the two populations (background and POC). The Gehan test is a nonparametric test which handles data sets with non-detects and multiple detection limits. Results of the hypothesis testing were also supplemented with Box Plots to visually compare the data sets.

The null hypothesis tested was "Sample 1 <= Sample 2" at a confidence coefficient of 95% (or a significance level of $\alpha = 0.05$). Sample 1 in the testing was assigned to each downgradient POC well. Sample 2 was assigned to the pooled background data set.

Findings

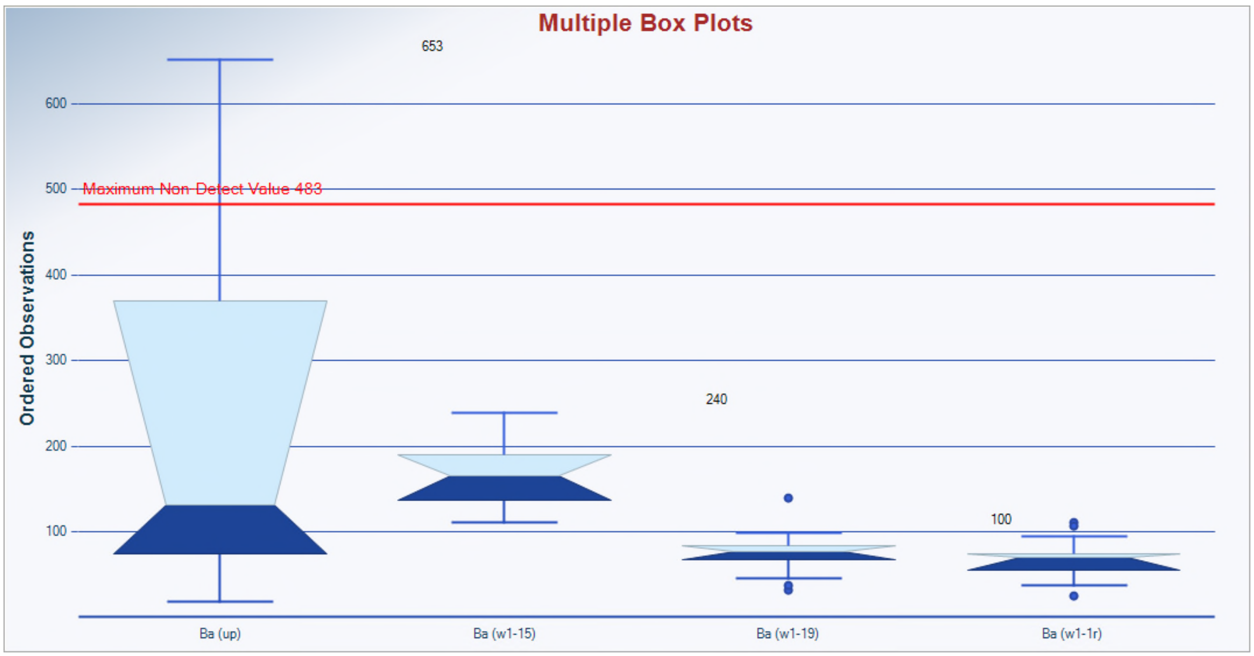
Table 1 provides summary statistics for the barium data set including minimum and maximum detections, mean detection, data distribution and calculated 95% UCLs. As indicated in the table, one outlier was identified for POC well W1-19 (October 2008 sampling event). Based on professional judgment, the outlier was not removed from the data set. No other outliers were identified. Outlier tests and supporting quantile-quantile plots are provided in **Attachment B**

95% UCL outputs are also presented in **Attachment B**. ProUCL recommendations regarding the calculated UCL to be used were followed. 95% Student's-t UCL was recommended for POC well W1-1R while Kaplan-Meier (KM) statistics were recommended for POC wells W1-15 and W1-19.

The barium data set was then plotted for each POC well and the 95%UCL was identified on the chart to identify CCL exceedances. As indicated in the plots (see **Attachment C**), exceedances were observed for W1-15 and W1-19.

Consistent with the groundwater data evaluation approach, further analysis of the data set was therefore conducted using hypothesis testing and graphical analysis. First, pooled upgradient data was compared to the pooled downgradient data set to determine if there was no difference between the data sets (Sample 1 mean/median = Sample 2 mean/median). Gehan's Test concluded that the alternate hypothesis was true (Sample 1 mean/median <> Sample 2 mean/median). Therefore, further analysis was conducted determine if the difference may be due to barium concentrations in the downgradient well results being either lower or higher than the barium concentrations (current and historical) in the background wells.

Gehan's Test concluded that each of the mean/medians tested for each POC well were less than the pooled background mean/median (confirming the null hypothesis). These conclusions were further confirmed with graphical analysis using box plots. Side-by-side box plot comparisons also suggest the barium concentrations in the POC wells were less than barium concentrations in the pooled upgradient data set.



Finally, current sampling event barium concentrations in the downgradient wells were compared to current/historical barium concentrations in the upgradient wells. As detailed in **Attachment A**, current barium concentrations in the downgradient wells were lower than current or historical barium concentrations in one or more of the upgradient background wells.

Conclusion

Based on the groundwater data set evaluation (Scenario 1 of the *2004 Tech Memo Site 1 Groundwater Evaluation Process*), there is no release from within the landfill and no further action is required.

Scenario 1: ***(Figure 4-3):***

1. Concentration of analyte A is above the CCL for analyte A.
2. Statistics are performed for analyte A (per Appendix E).
3. Pooled analytical results for analyte A in the downgradient well are statistically significant relative to the pooled upgradient (background) for analyte A.
4. The current sampling event concentration of analyte A in the downgradient well is lower than the current or historical concentrations for analyte A in one or more of the upgradient (background) wells.
5. There is no release from within the landfill.
6. No further action is required.

Based on the data distribution of some of the POC wells (i.e., non-normal), the *Current Calculation Method for 95UCL for Site 1* spreadsheet is not accurate. Therefore, it is recommended that ProUCL be used for the statistical analysis going forward. EHS Support will provide BB&E with ProUCL instruction under separate cover.

References

USEPA. 1992. Guidance for Data Useability in Risk Assessment (Part A). United States Environmental Protection Agency, PB92-963356, May 1992.

USEPA. 2002. Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. United States Environmental Protection Agency, OSWER 9285.6-10, December 2002.

Tables

Table 1
Barium Summary Statistics
Site 1 Landfill, Former Naval Air Station Moffett Field

Type	Location	Units	No. of Samples	No. of Detects	Minimum Detect	Maximum Detect	Minimum Detection Limit	Maximum Detection Limit	Mean Detect[1]	Std Dev[1]	Potential Outlier(s)	Data Distribution	95% UCL	Type
POC	W1-1R	µg/L	39	39	26	111	-	-	67.15	16.85	None	Data appear Normal at 1% Significance Level	71.7	95% Student's-t UCL
POC	W1-15	µg/L	53	52	110	240	160	160	163.8	35.62	None	Detected Data appear Normal at 1% Significance Level	172.1	95% KM (t) UCL
POC	W1-19	µg/L	53	52	32	140	65.8	65.8	75.29	16.58	1	Data do not follow a Discernible Distribution	79.15	95% KM (t) UCL
Upgradient	W1-5	µg/L	54	53	190	653	483	483	420.4	94.4	ND	Data do not follow a Discernible Distribution	NC	--
Upgradient	W1-8	µg/L	53	52	60	420	102	102	131.7	52.64	ND		NC	--
Upgradient	W12-R	µg/L	38	38	17	78.2	-	-	53.06	14.57	ND		NC	--

µg/L - micrograms per liter

KM (t) - UCL based upon Kaplan-Meier estimates using the Student’s t-distribution critical value

ND - not determined

NC - not calculated

UCL - upper confidence limit

Notes:

1 - Mean and standards deviation for locations with non-detects (ND) use the Kaplan Meier Method.

Attachment A

Attachment A
Groundwater Monitoring Data - Barium

Sample Date	POC Wells			Upgradient Wells		
	W1-1R	W1-15	W1-19	W1-5	W1-8	W1-12R
Jul-99	--	180	71.7 B	366	100	--
Oct-99	--	171 B	85.9 B	460B	113 B	--
Jan-00	--	166	59.7 B	350	89.8 B	--
May-00	--	137	60 B	359	89 B	--
Jul-00	--	120	57.3 B	342	90.8 B	--
Oct-00	--	130	58.8 J	360	80.4 J	--
Jan-01	--	126	59.8 J	358	84.6 J	--
May-01	--	166	63 J	448	96.6 J	--
Aug-01	--	166	67.4 J	485	100	--
Oct-01	--	<160	<65.8	<483	<102	--
Jan-02	--	176	77.5 J	519	112	--
Apr-02	--	150 J	74.1 J	408 J	97.3 J	--
Aug-02	--	171 J	74.2 J	612 J	131 J	--
Oct-02	--	203 J	79 J	465 J	111 J	--
Jul-03	--	--	--	653	--	--
May-04	71.5	181	86.6	524	130	78.2
Nov-04	111	126	81.3 J	481	149	60.5
Apr-05	73.3	145 J	83.8	507	130	74.3
Oct-05	107	176	99.9	576	150	72
Apr-06	96.6 J	111 J	37.5 J	559 J	133 J	69.2 J
Oct-06	86.6 J	137 J	83.9 J	557 J	140 J	70.5 J
Apr-07	72.3	136	83.7	504	134	66.7
Oct-07	71.5	137	91.5	527	146	78
Jun-08	59	140	74	510	120	57
Oct-08	58	110	140	460	110	49
Apr-09	72	130	75	400	120	56
Oct-09	72	110	79	420	120	43
Jun-10	79	170	89	470	140	62
Oct-10	71	190	78	410	120	55
Apr-11	70	230	75	340	110	51
Oct-11	56	130	74	410	110	53
Apr-12	56	140	74	340	110	61
Oct-12	77 J	140	88 J	460 J	140	55 J
Apr-13	69	240	75	360	110	53
Oct-13	59	130	80	460	120	55
Apr-14	75	150	87	420	130	58
Oct-14	75	140	87	510	120	58
Apr-15	76	230	90	400	120	57
Oct-15	70	150	76	470	110	31
Apr-16	70	210	81	380	120	56
Oct-16	67	200	86	460	150	58
Apr-17	67	210	83	350	110	na
Oct-17	26	110	32	190	60	25
Apr-18	45	210	70	220	120	50
Oct-18	36	120	44	210	86	23
Apr-19	56	200	74	340	230	50
Oct-19	47	180	66	370	180	43
Apr-20	48	190	49	270	160	28
Oct-20	44	200	58	360	140	17 J
Jun-21	60	180	82	370	190	54
Oct-21	53	170	80	330	180	45
Feb-22	76	200	87	390	420	55
Oct-22	71	190	84	440	230	36
Feb-23	69	240	84	380	200	53

Attachment B

				Outlier Tests for Selected Variables excluding nondetects			
			User Selected Options				
Date/Time of Computation			ProUCL 5.2 3/16/2023 8:51:47 AM				
			From File	Ba_ProUCLReady_a.xls			
			Full Precision	OFF			

Rosner's Outlier Test for 1 Outliers in 15

Total N	53
Number NDs	1
Number Detects	52
Mean of Detects	164.4
SD of Detects	35.98
Number of data	52
Number of suspected outliers	1
NDs not included in the following:	

#	Mean	sd	Potential outlier	Obs. Number	Test value	Critical value (5%)	Critical value (1%)
1	164.4	35.63	240	32	2.12	3.144	3.496

For 5% Significance Level, there is no Potential Outlier

For 1% Significance Level, there is no Potential Outlier

Rosner's Outlier Test for 1 Outliers in 19

Total N	53
Number NDs	1
Number Detects	52
Mean of Detects	75.72
SD of Detects	16.53
Number of data	52
Number of suspected outliers	1
NDs not included in the following:	

#	Mean	sd	Potential outlier	Obs. Number	Test value	Critical value (5%)	Critical value (1%)
1	75.72	16.37	140	23	3.926	3.144	3.496

For 5% Significance Level, there is 1 Potential Outlier

Therefore, Observation 140 is a Potential Statistical Outlier

For 1% Significance Level, there is 1 Potential Outlier

	Outlier Tests for Selected Variables excluding nondetects
User Selected Options	
Date/Time of Computation	ProUCL 5.2 3/16/2023 8:51:47 AM
From File	Ba_ProUCLReady_a.xls
Full Precision	OFF

Rosner's Outlier Test for 1 Outliers in 15

Total N	53
Number NDs	1
Number Detects	52
Mean of Detects	164.4
SD of Detects	35.98
Number of data	52
Number of suspected outliers	1
NDs not included in the following:	

#	Mean	sd	Potential outlier	Obs. Number	Test value	Critical value (5%)	Critical value (1%)
1	164.4	35.63	240	32	2.12	3.144	3.496

For 5% Significance Level, there is no Potential Outlier

For 1% Significance Level, there is no Potential Outlier

Rosner's Outlier Test for 1 Outliers in 19

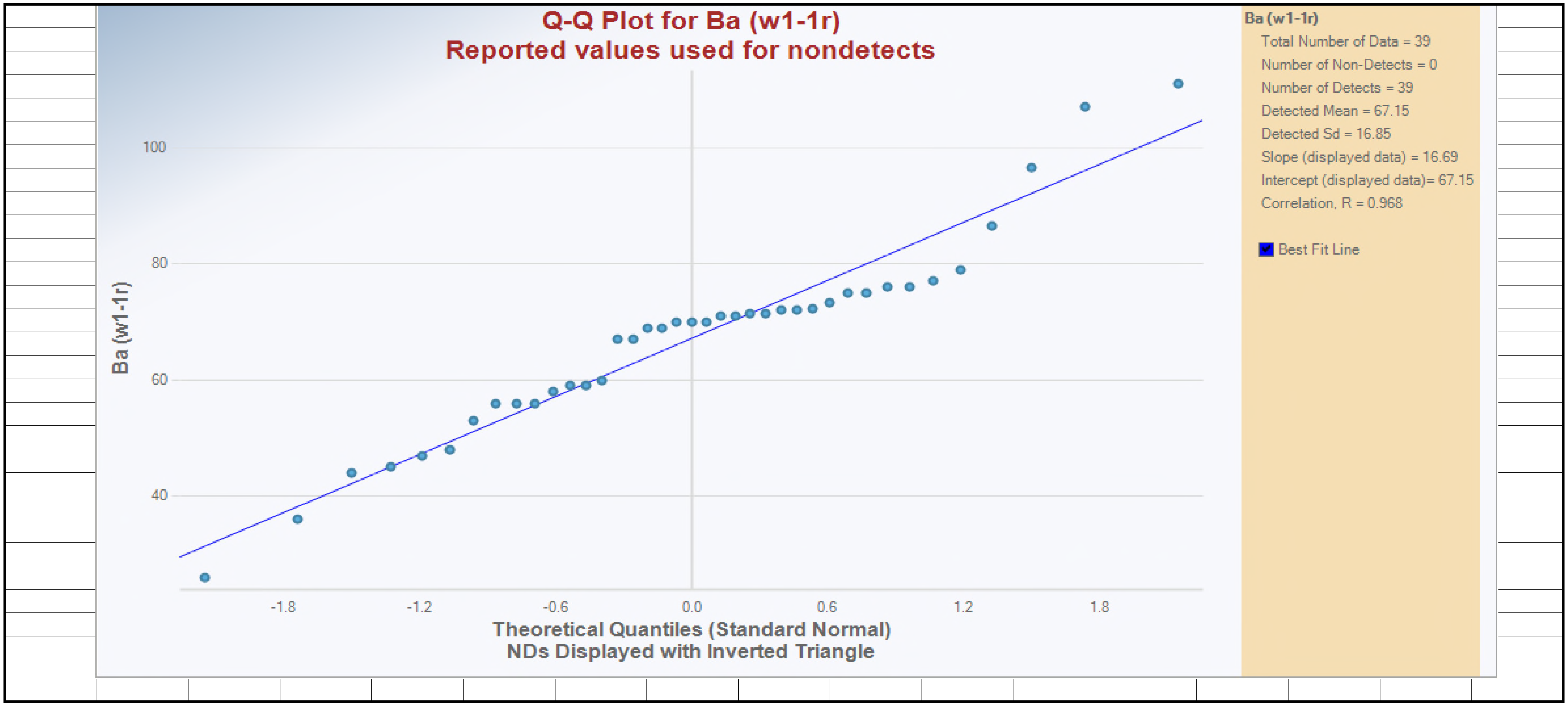
Total N	53
Number NDs	1
Number Detects	52
Mean of Detects	75.72
SD of Detects	16.53
Number of data	52
Number of suspected outliers	1
NDs not included in the following:	

#	Mean	sd	Potential outlier	Obs. Number	Test value	Critical value (5%)	Critical value (1%)
1	75.72	16.37	140	23	3.926	3.144	3.496

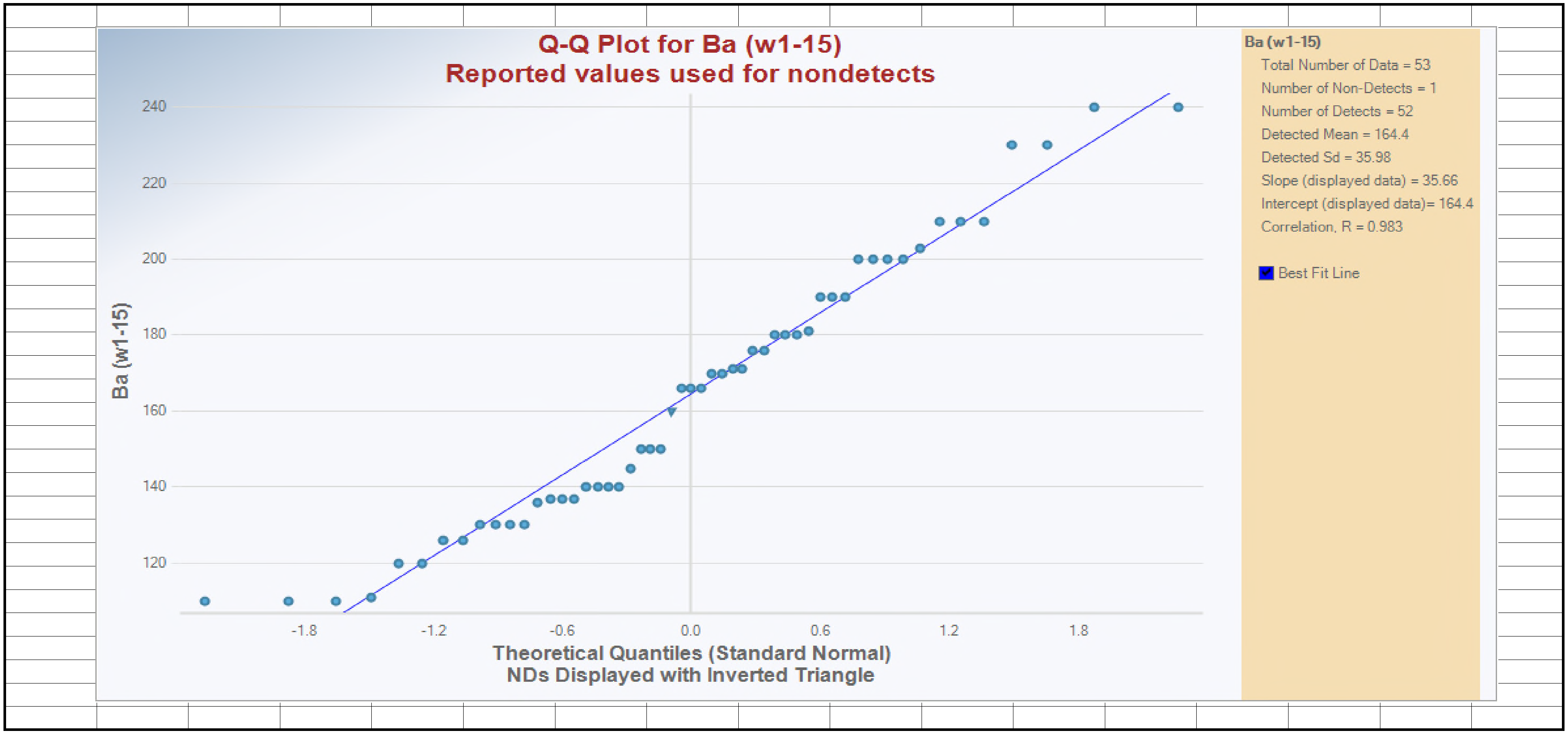
For 5% Significance Level, there is 1 Potential Outlier

Therefore, Observation 140 is a Potential Statistical Outlier

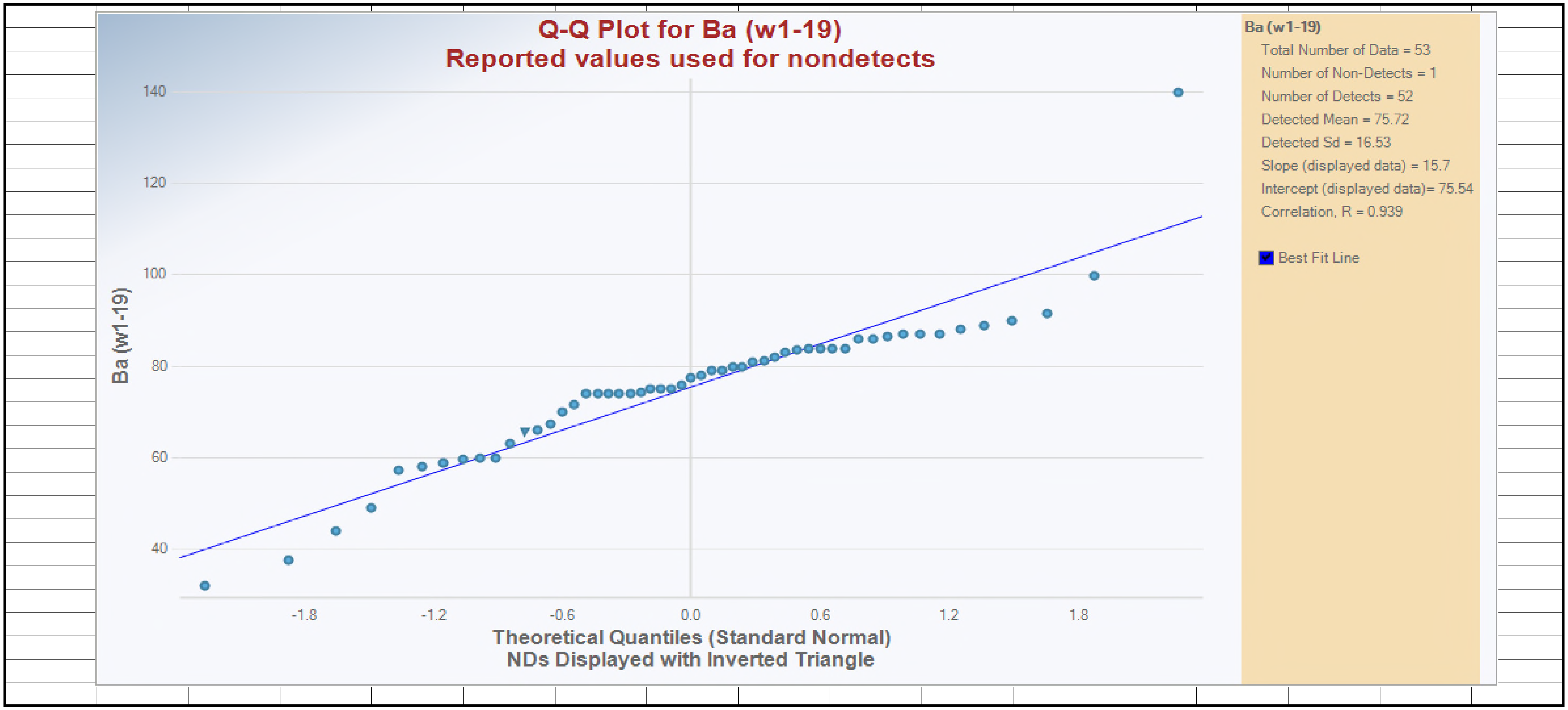
For 1% Significance Level, there is 1 Potential Outlier



Q-Q Plot for Ba (w1-1r)
Reported values used for nondetects
Ba (w1-1r)
100
80
60
40
-1.8
-1.2
-0.6
0.0
0.6
1.2
1.8
Theoretical Quantiles (Standard Normal)
NDs Displayed with Inverted Triangle
Ba (w1-1r)
Total Number of Data = 39
Number of Non-Detects = 0
Number of Detects = 39
Detected Mean = 67.15
Detected Sd = 16.85
Slope (displayed data) = 16.69
Intercept (displayed data)= 67.15
Correlation, R = 0.968
Best Fit Line



Q-Q Plot for Ba (w1-15)
Reported values used for nondetects
240
220
200
180
160
140
120
Ba (w1-15)
-1.8
-1.2
-0.6
0.0
0.6
1.2
1.8
Theoretical Quantiles (Standard Normal)
NDs Displayed with Inverted Triangle
Ba (w1-15)
Total Number of Data = 53
Number of Non-Detects = 1
Number of Detects = 52
Detected Mean = 164.4
Detected Sd = 35.98
Slope (displayed data) = 35.66
Intercept (displayed data)= 164.4
Correlation, R = 0.983
Best Fit Line


Q-Q Plot for Ba (w1-19)
Reported values used for nondetects
140
120
100
80
60
40
Ba (w1-19)
-1.8
-1.2
-0.6
0.0
0.6
1.2
1.8
Theoretical Quantiles (Standard Normal)
NDs Displayed with Inverted Triangle
Ba (w1-19)
Total Number of Data = 53
Number of Non-Detects = 1
Number of Detects = 52
Detected Mean = 75.72
Detected Sd = 16.53
Slope (displayed data) = 15.7
Intercept (displayed data)= 75.54
Correlation, R = 0.939
Best Fit Line

	Goodness-of-Fit Test Statistics for Uncensored Full Data Sets without Non-Detects
User Selected Options	
Date/Time of Computation	ProUCL 5.2 3/16/2023 9:20:26 AM
From File	Ba_ProUCLReady_a.xls
Full Precision	OFF
Confidence Coefficient	0.95

1R

Raw Statistics	
Number of Valid Observations	39
Number of Distinct Observations	27
Minimum	26
Maximum	111
Mean of Raw Data	67.15
Standard Deviation of Raw Data	16.85
Khat	14.95
Theta hat	4.492
Kstar	13.82
Theta star	4.86
Mean of Log Transformed Data	4.173
Standard Deviation of Log Transformed Data	0.274
Normal GOF Test Results	
Correlation Coefficient R	0.968
Shapiro Wilk Test Statistic	0.948
Shapiro Wilk Critical (0.05) Value	0.939
Approximate Shapiro Wilk P Value	0.0926
Lilliefors Test Statistic	0.151
Lilliefors Critical (0.05) Value	0.14
Data appear Approximate Normal at (0.05) Significance Level	
Gamma GOF Test Results	
Correlation Coefficient R	0.966
A-D Test Statistic	1.1
A-D Critical (0.05) Value	0.747
K-S Test Statistic	0.172
K-S Critical(0.05) Value	0.141
Data not Gamma Distributed at (0.05) Significance Level	
Lognormal GOF Test Results	
Correlation Coefficient R	0.949
Shapiro Wilk Test Statistic	0.918
Shapiro Wilk Critical (0.05) Value	0.939
Approximate Shapiro Wilk P Value	0.00796
Lilliefors Test Statistic	0.187
Lilliefors Critical (0.05) Value	0.14
Data not Lognormal at (0.05) Significance Level	

	Goodness-of-Fit Test Statistics for Data Sets with Non-Detects
User Selected Options	
Date/Time of Computation	ProUCL 5.2 3/16/2023 9:20:44 AM
From File	Ba_ProUCLReady_a.xls
Full Precision	OFF
Confidence Coefficient	0.95

15

	Num Obs	Num Miss	Num Valid	Detects	NDs	% NDs
Raw Statistics	53	0	53	52	1	1.89%

	Number	Minimum	Maximum	Mean	Median	SD
Statistics (Non-Detects Only)	1	160	160	160	160	N/A
Statistics (Detects Only)	52	110	240	164.4	166	35.98
Statistics (All: NDs treated as DL value)	53	110	240	164.4	166	35.64
Statistics (All: NDs treated as DL/2 value)	53	80	240	162.8	166	37.47
Statistics (Normal ROS Imputed Data)	53	110	240	163.9	166	35.83
Statistics (Gamma ROS Imputed Data)	53	110	240	163.9	166	35.85
Statistics (Lognormal ROS Imputed Data)	53	110	240	163.9	166	35.85

	K hat	K Star	Theta hat	Log Mean	Log Stdv	Log CV
Statistics (Detects Only)	21.46	20.23	7.664	5.079	0.219	0.0432
Statistics (NDs = DL)	21.86	20.64	7.519	5.079	0.217	0.0428
Statistics (NDs = DL/2)	18.75	17.7	8.684	5.066	0.237	0.0468
Statistics (Gamma ROS Estimates)	21.58	20.37	7.596	5.076	0.218	0.043
Statistics (Lognormal ROS Estimates)	--	--	--	5.076	0.218	0.043

Normal GOF Test Results

	No NDs	NDs = DL	NDs = DL/2	Normal ROS
Correlation Coefficient R	0.982	0.983	0.988	0.98

	Apr. Test	P Value	Conclusion with Alpha(0.05)
Shapiro-Wilk (Detects Only)	0.942	0.0205	Data Not Normal
Shapiro-Wilk (NDs = DL)	0.944	0.0257	Data Not Normal
Shapiro-Wilk (NDs = DL/2)	0.965	0.232	Data Appear Normal
Shapiro-Wilk (Normal ROS Estimates)	0.939	0.0145	Data Not Normal
	Test value	Crit. (0.05)	Conclusion with Alpha(0.05)
Lilliefors (Detects Only)	0.136	0.122	Data Not Normal
Lilliefors (NDs = DL)	0.13	0.121	Data Not Normal
Lilliefors (NDs = DL/2)	0.125	0.121	Data Not Normal
Lilliefors (Normal ROS Estimates)	0.144	0.121	Data Not Normal

Gamma GOF Test Results

	No NDs	NDs = DL	NDs = DL/2	Gamma ROS
Correlation Coefficient R	0.986	0.987	0.988	0.985

	Test value	Crit. (0.05)	Conclusion with Alpha(0.05)
Anderson-Darling (Detects Only)	0.627	0.748	
Kolmogorov-Smirnov (Detects Only)	0.128	0.123	Detected Data appear Approximate Gamma Distribution
Anderson-Darling (NDs = DL)	0.555	0.748	
Kolmogorov-Smirnov (NDs = DL)	0.122	0.122	Detected Data appear Approximate Gamma Distribution
Anderson-Darling (NDs = DL/2)	0.47	0.749	
Kolmogorov-Smirnov (NDs = DL/2)	0.109	0.122	Data Appear Gamma Distributed
Anderson-Darling (Gamma ROS Estimates)	0.678	0.748	
Kolmogorov-Smirnov (Gamma ROS Est.)	0.135	0.122	Detected Data appear Approximate Gamma Distribution

Lognormal GOF Test Results

	No NDs	NDs = DL	NDs = DL/2	Log ROS
Correlation Coefficient R	0.986	0.987	0.986	0.985

	Apr. Test	P Value	Conclusion with Alpha(0.05)
Shapiro-Wilk (Detects Only)	0.948	0.0428	Data Not Lognormal
Shapiro-Wilk (NDs = DL)	0.952	0.0569	Data Appear Lognormal
Shapiro-Wilk (NDs = DL/2)	0.967	0.27	Data Appear Lognormal
Shapiro-Wilk (Lognormal ROS Estimates)	0.948	0.0374	Data Not Lognormal
	Test value	Crit. (0.05)	Conclusion with Alpha(0.05)
Lilliefors (Detects Only)	0.119	0.122	Data Appear Lognormal
Lilliefors (NDs = DL)	0.114	0.121	Data Appear Lognormal
Lilliefors (NDs = DL/2)	0.105	0.121	Data Appear Lognormal
Lilliefors (Lognormal ROS Estimates)	0.127	0.121	Data Not Lognormal

Note: Substitution methods such as DL or DL/2 are not recommended.

19

	Num Obs	Num Miss	Num Valid	Detects	NDs	% NDs
Raw Statistics	53	0	53	52	1	1.89%

	Number	Minimum	Maximum	Mean	Median	SD
Statistics (Non-Detects Only)	1	65.8	65.8	65.8	65.8	N/A
Statistics (Detects Only)	52	32	140	75.72	77.75	16.53
Statistics (All: NDs treated as DL value)	53	32	140	75.54	77.5	16.43
Statistics (All: NDs treated as DL/2 value)	53	32	140	74.92	77.5	17.4
Statistics (Normal ROS Imputed Data)	53	32	140	75.34	77.5	16.6
Statistics (Gamma ROS Imputed Data)	53	32	140	75.36	77.5	16.58
Statistics (Lognormal ROS Imputed Data)	53	32	140	75.34	77.5	16.61

	K hat	K Star	Theta hat	Log Mean	Log Stdv	Log CV		
Statistics (Detects Only)	19.58	18.46	3.867	4.301	0.239	0.0555		
Statistics (NDs = DL)	19.82	18.71	3.811	4.299	0.237	0.0551		
Statistics (NDs = DL/2)	16.68	15.75	4.49	4.286	0.261	0.0609		
Statistics (Gamma ROS Estimates)	19.41	18.32	3.883	4.296	0.239	0.0557		
Statistics (Lognormal ROS Estimates)	--	--	--	4.296	0.24	0.0558		
Normal GOF Test Results								
	No NDs	NDs = DL	NDs = DL/2	Normal ROS				
Correlation Coefficient R	0.937	0.939	0.938	0.941				
	Apr. Test	P Value	Conclusion with Alpha(0.05)					
Shapiro-Wilk (Detects Only)	0.909	5.1603E-4	Data Not Normal					
Shapiro-Wilk (NDs = DL)	0.913	6.9415E-4	Data Not Normal					
Shapiro-Wilk (NDs = DL/2)	0.906	2.9453E-4	Data Not Normal					
Shapiro-Wilk (Normal ROS Estimates)	0.916	9.1805E-4	Data Not Normal					
	Test value	Crit. (0.05)	Conclusion with Alpha(0.05)					
Lilliefors (Detects Only)	0.17	0.122	Data Not Normal					
Lilliefors (NDs = DL)	0.161	0.121	Data Not Normal					
Lilliefors (NDs = DL/2)	0.177	0.121	Data Not Normal					
Lilliefors (Normal ROS Estimates)	0.166	0.121	Data Not Normal					
Gamma GOF Test Results								
	No NDs	NDs = DL	NDs = DL/2	Gamma ROS				
Correlation Coefficient R	0.931	0.934	0.929	0.935				
	Test value	Crit. (0.05)	Conclusion with Alpha(0.05)					
Anderson-Darling (Detects Only)	2.075	0.748						
Kolmogorov-Smirnov (Detects Only)	0.201	0.123	Data Not Gamma Distributed					
Anderson-Darling (NDs = DL)	1.957	0.748						
Kolmogorov-Smirnov (NDs = DL)	0.192	0.122	Data Not Gamma Distributed					
Anderson-Darling (NDs = DL/2)	2.445	0.749						
Kolmogorov-Smirnov (NDs = DL/2)	0.211	0.122	Data Not Gamma Distributed					
Anderson-Darling (Gamma ROS Estimates)	1.946	0.748						
Kolmogorov-Smirnov (Gamma ROS Est.)	0.196	0.122	Data Not Gamma Distributed					
Lognormal GOF Test Results								
	No NDs	NDs = DL	NDs = DL/2	Log ROS				
Correlation Coefficient R	0.923	0.925	0.915	0.929				
	Apr. Test	P Value	Conclusion with Alpha(0.05)					
Shapiro-Wilk (Detects Only)	0.878	1.5004E-5	Data Not Lognormal					
Shapiro-Wilk (NDs = DL)	0.883	2.2264E-5	Data Not Lognormal					
Shapiro-Wilk (NDs = DL/2)	0.856	1.0068E-6	Data Not Lognormal					
Shapiro-Wilk (Lognormal ROS Estimates)	0.888	4.0251E-5	Data Not Lognormal					

	Test value	Crit. (0.05)	Conclusion with Alpha(0.05)		
Lilliefors (Detects Only)	0.216	0.122	Data Not Lognormal		
Lilliefors (NDs = DL)	0.206	0.121	Data Not Lognormal		
Lilliefors (NDs = DL/2)	0.226	0.121	Data Not Lognormal		
Lilliefors (Lognormal ROS Estimates)	0.212	0.121	Data Not Lognormal		
Note: Substitution methods such as DL or DL/2 are not recommended.					

UCL Statistics for Uncensored Full Data Sets	
User Selected Options	
Date/Time of Computation	ProUCL 5.2 3/16/2023 8:53:26 AM
From File	Ba_ProUCLReady_a.xls
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

1R

General Statistics			
Total Number of Observations	39	Number of Distinct Observations	27
		Number of Missing Observations	0
Minimum	26	Mean	67.15
Maximum	111	Median	70
SD	16.85	Std. Error of Mean	2.698
Coefficient of Variation	0.251	Skewness	0.225

Normal GOF Test		
Shapiro Wilk Test Statistic	0.948	**Shapiro Wilk GOF Test**
1% Shapiro Wilk Critical Value	0.917	Data appear Normal at 1% Significance Level
Lilliefors Test Statistic	0.151	**Lilliefors GOF Test**
1% Lilliefors Critical Value	0.163	Data appear Normal at 1% Significance Level
Data appear Normal at 1% Significance Level		

Assuming Normal Distribution			
95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	71.7	95% Adjusted-CLT UCL (Chen-1995)	71.69
		95% Modified-t UCL (Johnson-1978)	71.71

Gamma GOF Test		
A-D Test Statistic	1.1	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.747	Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.172	**Kolmogorov-Smirnov Gamma GOF Test**
5% K-S Critical Value	0.141	Data Not Gamma Distributed at 5% Significance Level
Data Not Gamma Distributed at 5% Significance Level		

Gamma Statistics			
k hat (MLE)	14.95	k star (bias corrected MLE)	13.82
Theta hat (MLE)	4.492	Theta star (bias corrected MLE)	4.86
nu hat (MLE)	1166	nu star (bias corrected)	1078
MLE Mean (bias corrected)	67.15	MLE Sd (bias corrected)	18.07
		Approximate Chi Square Value (0.05)	1002
Adjusted Level of Significance	0.0437	Adjusted Chi Square Value	999.6

Assuming Gamma Distribution			
95% Approximate Gamma UCL	72.19	95% Adjusted Gamma UCL	72.39
Lognormal GOF Test			
Shapiro Wilk Test Statistic	0.918	**Shapiro Wilk Lognormal GOF Test**	
10% Shapiro Wilk Critical Value	0.948	Data Not Lognormal at 10% Significance Level	
Lilliefors Test Statistic	0.187	**Lilliefors Lognormal GOF Test**	
10% Lilliefors Critical Value	0.129	Data Not Lognormal at 10% Significance Level	
Data Not Lognormal at 10% Significance Level			
Lognormal Statistics			
Minimum of Logged Data	3.258	Mean of logged Data	4.173
Maximum of Logged Data	4.71	SD of logged Data	0.274
Assuming Lognormal Distribution			
95% H-UCL	72.94	90% Chebyshev (MVUE) UCL	76.33
95% Chebyshev (MVUE) UCL	80.41	97.5% Chebyshev (MVUE) UCL	86.07
99% Chebyshev (MVUE) UCL	97.18		
Nonparametric Distribution Free UCL Statistics			
Data appear to follow a Discernible Distribution			
Nonparametric Distribution Free UCLs			
95% CLT UCL	71.59	95% BCA Bootstrap UCL	72.06
95% Standard Bootstrap UCL	71.56	95% Bootstrap-t UCL	71.76
95% Hall's Bootstrap UCL	72.07	95% Percentile Bootstrap UCL	71.77
90% Chebyshev(Mean, Sd) UCL	75.24	95% Chebyshev(Mean, Sd) UCL	78.91
97.5% Chebyshev(Mean, Sd) UCL	84	99% Chebyshev(Mean, Sd) UCL	93.99
Suggested UCL to Use			
95% Student's-t UCL	71.7		
Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.			
Recommendations are based upon data size, data distribution, and skewness using results from simulation studies.			
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.			

UCL Statistics for Data Sets with Non-Detects			
User Selected Options			
Date/Time of Computation	ProUCL 5.2 3/16/2023 8:53:37 AM		
From File	Ba_ProUCLReady_a.xls		
Full Precision	OFF		
Confidence Coefficient	95%		
Number of Bootstrap Operations	2000		
15			
General Statistics			
Total Number of Observations	53	Number of Distinct Observations	23
Number of Detects	52	Number of Non-Detects	1
Number of Distinct Detects	22	Number of Distinct Non-Detects	1
Minimum Detect	110	Minimum Non-Detect	160
Maximum Detect	240	Maximum Non-Detect	160
Variance Detects	1295	Percent Non-Detects	1.887%
Mean Detects	164.4	SD Detects	35.98
Median Detects	166	CV Detects	0.219
Skewness Detects	0.336	Kurtosis Detects	-0.795
Mean of Logged Detects	5.079	SD of Logged Detects	0.219
Normal GOF Test on Detects Only			
Shapiro Wilk Test Statistic	0.942	**Normal GOF Test on Detected Observations Only**	
1% Shapiro Wilk P Value	0.0205	Detected Data appear Normal at 1% Significance Level	
Lilliefors Test Statistic	0.136	**Lilliefors GOF Test**	
1% Lilliefors Critical Value	0.141	Detected Data appear Normal at 1% Significance Level	
Detected Data appear Normal at 1% Significance Level			
Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs			
KM Mean	163.8	KM Standard Error of Mean	4.947
90KM SD	35.62	95% KM (BCA) UCL	172
95% KM (t) UCL	172.1	95% KM (Percentile Bootstrap) UCL	172
95% KM (z) UCL	172	95% KM Bootstrap t UCL	172.7
90% KM Chebyshev UCL	178.7	95% KM Chebyshev UCL	185.4
97.5% KM Chebyshev UCL	194.7	99% KM Chebyshev UCL	213
Gamma GOF Tests on Detected Observations Only			
A-D Test Statistic	0.627	**Anderson-Darling GOF Test**	
5% A-D Critical Value	0.748	Detected data appear Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.128	**Kolmogorov-Smirnov GOF**	
5% K-S Critical Value	0.123	Detected Data Not Gamma Distributed at 5% Significance Level	
Detected data follow Appr. Gamma Distribution at 5% Significance Level			

Gamma Statistics on Detected Data Only			
k hat (MLE)	21.46	k star (bias corrected MLE)	20.23
Theta hat (MLE)	7.664	Theta star (bias corrected MLE)	8.128
nu hat (MLE)	2232	nu star (bias corrected)	2104
Mean (detects)	164.4		
Gamma ROS Statistics using Imputed Non-Detects			
GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs			
GROS may not be used when kstar of detects is small such as <1.0, especially when the sample size is small (e.g., <15-20)			
For such situations, GROS method may yield incorrect values of UCLs and BTVs			
This is especially true when the sample size is small.			
For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates			
Minimum	110	Mean	163.9
Maximum	240	Median	166
SD	35.85	CV	0.219
k hat (MLE)	21.58	k star (bias corrected MLE)	20.37
Theta hat (MLE)	7.596	Theta star (bias corrected MLE)	8.047
nu hat (MLE)	2287	nu star (bias corrected)	2159
Adjusted Level of Significance (β)	0.0455		
Approximate Chi Square Value (N/A, α)	2052	Adjusted Chi Square Value (N/A, β)	2049
95% Gamma Approximate UCL	172.4	95% Gamma Adjusted UCL	172.7
Estimates of Gamma Parameters using KM Estimates			
Mean (KM)	163.8	SD (KM)	35.62
Variance (KM)	1269	SE of Mean (KM)	4.947
k hat (KM)	21.15	k star (KM)	19.97
nu hat (KM)	2242	nu star (KM)	2116
theta hat (KM)	7.746	theta star (KM)	8.205
80% gamma percentile (KM)	193.6	90% gamma percentile (KM)	212.2
95% gamma percentile (KM)	228.4	99% gamma percentile (KM)	260.9
Gamma Kaplan-Meier (KM) Statistics			
Approximate Chi Square Value (N/A, α)	2010	Adjusted Chi Square Value (N/A, β)	2008
95% KM Approximate Gamma UCL	172.4	95% KM Adjusted Gamma UCL	172.7
Lognormal GOF Test on Detected Observations Only			
Shapiro Wilk Approximate Test Statistic	0.948	**Shapiro Wilk GOF Test**	
10% Shapiro Wilk P Value	0.0428	Detected Data Not Lognormal at 10% Significance Level	
Lilliefors Test Statistic	0.119	**Lilliefors GOF Test**	
10% Lilliefors Critical Value	0.112	Detected Data Not Lognormal at 10% Significance Level	
Detected Data Not Lognormal at 10% Significance Level			
Lognormal ROS Statistics Using Imputed Non-Detects			
Mean in Original Scale	163.9	Mean in Log Scale	5.076
SD in Original Scale	35.85	SD in Log Scale	0.218
95% t UCL (assumes normality of ROS data)	172.1	95% Percentile Bootstrap UCL	171.9
95% BCA Bootstrap UCL	171.5	95% Bootstrap t UCL	172.7
95% H-UCL (Log ROS)	172.8		

Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution			
KM Mean (logged)	5.075	KM Geo Mean	160
KM SD (logged)	0.217	95% Critical H Value (KM-Log)	1.721
KM Standard Error of Mean (logged)	0.0302	95% H-UCL (KM -Log)	172.5
KM SD (logged)	0.217	95% Critical H Value (KM-Log)	1.721
KM Standard Error of Mean (logged)	0.0302		
DL/2 Statistics			
DL/2 Normal		DL/2 Log-Transformed	
Mean in Original Scale	162.8	Mean in Log Scale	5.066
SD in Original Scale	37.47	SD in Log Scale	0.237
95% t UCL (Assumes normality)	171.5	95% H-Stat UCL	172.6
DL/2 is not a recommended method, provided for comparisons and historical reasons			
Nonparametric Distribution Free UCL Statistics			
Detected Data appear Normal Distributed at 1% Significance Level			
Suggested UCL to Use			
95% KM (t) UCL	172.1		
Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.			
Recommendations are based upon data size, data distribution, and skewness using results from simulation studies.			
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.			

19			
General Statistics			
Total Number of Observations	53	Number of Distinct Observations	43
Number of Detects	52	Number of Non-Detects	1
Number of Distinct Detects	42	Number of Distinct Non-Detects	1
Minimum Detect	32	Minimum Non-Detect	65.8
Maximum Detect	140	Maximum Non-Detect	65.8
Variance Detects	273.3	Percent Non-Detects	1.887%
Mean Detects	75.72	SD Detects	16.53
Median Detects	77.75	CV Detects	0.218
Skewness Detects	0.358	Kurtosis Detects	4.351
Mean of Logged Detects	4.301	SD of Logged Detects	0.239
Normal GOF Test on Detects Only			
Shapiro Wilk Test Statistic	0.909	Normal GOF Test on Detected Observations Only	
1% Shapiro Wilk P Value	5.1603E-4	Detected Data Not Normal at 1% Significance Level	
Lilliefors Test Statistic	0.17	Lilliefors GOF Test	
1% Lilliefors Critical Value	0.141	Detected Data Not Normal at 1% Significance Level	
Detected Data Not Normal at 1% Significance Level			
Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs			
KM Mean	75.29	KM Standard Error of Mean	2.308
90KM SD	16.58	95% KM (BCA) UCL	78.97
95% KM (t) UCL	79.15	95% KM (Percentile Bootstrap) UCL	78.95
95% KM (z) UCL	79.08	95% KM Bootstrap t UCL	79.27
90% KM Chebyshev UCL	82.21	95% KM Chebyshev UCL	85.35
97.5% KM Chebyshev UCL	89.7	99% KM Chebyshev UCL	98.25
Gamma GOF Tests on Detected Observations Only			
A-D Test Statistic	2.075	Anderson-Darling GOF Test	
5% A-D Critical Value	0.748	Detected Data Not Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.201	Kolmogorov-Smirnov GOF	
5% K-S Critical Value	0.123	Detected Data Not Gamma Distributed at 5% Significance Level	
Detected Data Not Gamma Distributed at 5% Significance Level			
Gamma Statistics on Detected Data Only			
k hat (MLE)	19.58	k star (bias corrected MLE)	18.46
Theta hat (MLE)	3.867	Theta star (bias corrected MLE)	4.101
nu hat (MLE)	2036	nu star (bias corrected)	1920
Mean (detects)	75.72		
Gamma ROS Statistics using Imputed Non-Detects			
GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs			
GROS may not be used when kstar of detects is small such as <1.0, especially when the sample size is small (e.g., <15-20)			
For such situations, GROS method may yield incorrect values of UCLs and BTVs			
This is especially true when the sample size is small.			
For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates			
Minimum	32	Mean	75.36

Maximum	140	Median	77.5
SD	16.58	CV	0.22
k hat (MLE)	19.41	k star (bias corrected MLE)	18.32
Theta hat (MLE)	3.883	Theta star (bias corrected MLE)	4.113
nu hat (MLE)	2058	nu star (bias corrected)	1942
Adjusted Level of Significance (β)	0.0455		
Approximate Chi Square Value (N/A, α)	1841	Adjusted Chi Square Value (N/A, β)	1838
95% Gamma Approximate UCL	79.51	95% Gamma Adjusted UCL	79.63
Estimates of Gamma Parameters using KM Estimates			
Mean (KM)	75.29	SD (KM)	16.58
Variance (KM)	274.7	SE of Mean (KM)	2.308
k hat (KM)	20.63	k star (KM)	19.48
nu hat (KM)	2187	nu star (KM)	2065
theta hat (KM)	3.649	theta star (KM)	3.866
80% gamma percentile (KM)	89.14	90% gamma percentile (KM)	97.81
95% gamma percentile (KM)	105.4	99% gamma percentile (KM)	120.5
Gamma Kaplan-Meier (KM) Statistics			
Approximate Chi Square Value (N/A, α)	1960	Adjusted Chi Square Value (N/A, β)	1957
95% KM Approximate Gamma UCL	79.3	95% KM Adjusted Gamma UCL	79.42
Lognormal GOF Test on Detected Observations Only			
Shapiro Wilk Approximate Test Statistic	0.878	**Shapiro Wilk GOF Test**	
10% Shapiro Wilk P Value	1.5004E-5	Detected Data Not Lognormal at 10% Significance Level	
Lilliefors Test Statistic	0.216	**Lilliefors GOF Test**	
10% Lilliefors Critical Value	0.112	Detected Data Not Lognormal at 10% Significance Level	
Detected Data Not Lognormal at 10% Significance Level			
Lognormal ROS Statistics Using Imputed Non-Detects			
Mean in Original Scale	75.34	Mean in Log Scale	4.296
SD in Original Scale	16.61	SD in Log Scale	0.24
95% t UCL (assumes normality of ROS data)	79.16	95% Percentile Bootstrap UCL	79.17
95% BCA Bootstrap UCL	78.97	95% Bootstrap t UCL	79.19
95% H-UCL (Log ROS)	79.99		
Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution			
KM Mean (logged)	4.295	KM Geo Mean	73.3
KM SD (logged)	0.241	95% Critical H Value (KM-Log)	1.72
KM Standard Error of Mean (logged)	0.0337	95% H-UCL (KM -Log)	79.93
KM SD (logged)	0.241	95% Critical H Value (KM-Log)	1.72
KM Standard Error of Mean (logged)	0.0337		

DL/2 Statistics			
DL/2 Normal		DL/2 Log-Transformed	
Mean in Original Scale	74.92	Mean in Log Scale	4.286
SD in Original Scale	17.4	SD in Log Scale	0.261
95% t UCL (Assumes normality)	78.92	95% H-Stat UCL	80.03
DL/2 is not a recommended method, provided for comparisons and historical reasons			
Nonparametric Distribution Free UCL Statistics			
Data do not follow a Discernible Distribution			
Suggested UCL to Use			
95% KM (t) UCL	79.15		
Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.			
Recommendations are based upon data size, data distribution, and skewness using results from simulation studies.			
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.			

Gehan Sample 1 vs Sample 2 Comparison Hypothesis Test for Data Sets with Non-Detects

User Selected Options	
Date/Time of Computation	ProUCL 5.2 3/17/2023 1:50:32 PM
From File	Ba_ProUCLReady_a.xls
Full Precision	OFF
Confidence Coefficient	95%
Selected Null Hypothesis	Sample 1 Mean/Median = Sample 2 Mean/Median (Two Sided Alternative)
Alternative Hypothesis	Sample 1 Mean/Median <> Sample 2 Mean/Median

Sample 1 Data: Ba(poc)

Sample 2 Data: Ba(up)

Raw Statistics

	Sample 1	Sample 2
Number of Valid Data	145	145
Number of Non-Detects	2	2
Number of Detect Data	143	143
Minimum Non-Detect	65.8	102
Maximum Non-Detect	160	483
Percent Non-detects	1.38%	1.38%
Minimum Detect	26	17
Maximum Detect	240	653
Mean of Detects	105.6	218.4
Median of Detects	83.8	131
SD of Detects	51.38	172.5
KM Mean	105.1	217.1
KM SD	51.14	171.7

Sample 1 vs Sample 2 Gehan Test

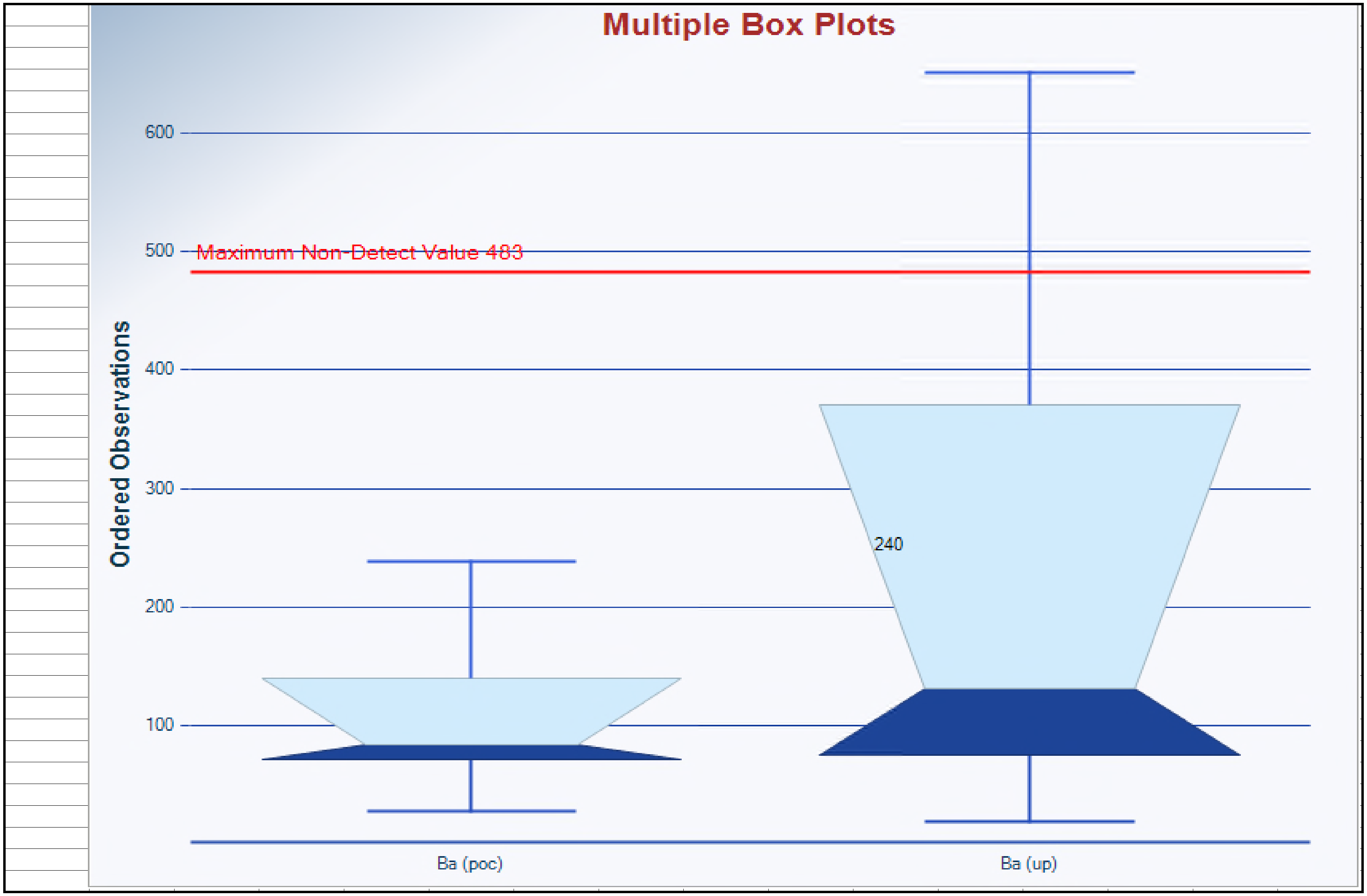
H0: Mean of Sample 1 = Mean of background

Gehan z Test Value	-4.564
Lower Critical z (0.025)	-1.96
Upper Critical z (0.975)	1.96
P-Value	5.0175E-6

Conclusion with Alpha = 0.05

Reject H0, Conclude Sample 1 <> Sample 2

P-Value < alpha (0.05)



Multiple Box Plots
Ordered Observations
600
500
400
300
200
100
Maximum Non-Detect Value 483
240
Ba (poc)
Ba (up)

Gehan Sample 1 vs Sample 2 Comparison Hypothesis Test for Data Sets with Non-Detects	
User Selected Options	
Date/Time of Computation	ProUCL 5.2 3/17/2023 1:37:31 PM
From File	Ba_ProUCLReady_a.xls
Full Precision	OFF
Confidence Coefficient	95%
Selected Null Hypothesis	Sample 1 Mean/Median <= Sample 2 Mean/Median (Form 1)
Alternative Hypothesis	Sample 1 Mean/Median > Sample 2 Mean/Median

Sample 1 Data: Ba(w1-1r)

Sample 2 Data: Ba(up)

Raw Statistics		
	Sample 1	Sample 2
Number of Valid Data	39	145
Number of Non-Detects	0	2
Number of Detect Data	39	143
Minimum Non-Detect	N/A	102
Maximum Non-Detect	N/A	483
Percent Non-detects	0.00%	1.38%
Minimum Detect	26	17
Maximum Detect	111	653
Mean of Detects	67.15	218.4
Median of Detects	70	131
SD of Detects	16.85	172.5
KM Mean	67.15	217.1
KM SD	16.85	171.7

Sample 1 vs Sample 2 Gehan Test

H0: Mean/Median of Sample 1 <= Mean/Median of background

Gehan z Test Value	-5.565
Critical z (0.05)	1.645
P-Value	1

Conclusion with Alpha = 0.05

Do Not Reject H0, Conclude Sample 1 <= Sample 2

P-Value >= alpha (0.05)

Gehan Sample 1 vs Sample 2 Comparison Hypothesis Test for Data Sets with Non-Detects	
User Selected Options	
Date/Time of Computation	ProUCL 5.2 3/17/2023 1:35:51 PM
From File	Ba_ProUCLReady_a.xls
Full Precision	OFF
Confidence Coefficient	95%
Selected Null Hypothesis	Sample 1 Mean/Median <= Sample 2 Mean/Median (Form 1)
Alternative Hypothesis	Sample 1 Mean/Median > Sample 2 Mean/Median

Sample 1 Data: Ba(w1-15)

Sample 2 Data: Ba(up)

Raw Statistics

	Sample 1	Sample 2
Number of Valid Data	53	145
Number of Non-Detects	1	2
Number of Detect Data	52	143
Minimum Non-Detect	160	102
Maximum Non-Detect	160	483
Percent Non-detects	1.89%	1.38%
Minimum Detect	110	17
Maximum Detect	240	653
Mean of Detects	164.4	218.4
Median of Detects	166	131
SD of Detects	35.98	172.5
KM Mean	163.8	217.1
KM SD	35.62	171.7

Sample 1 vs Sample 2 Gehan Test

H0: Mean/Median of Sample 1 <= Mean/Median of background

Gehan z Test Value	0.895
Critical z (0.05)	1.645
P-Value	0.185

Conclusion with Alpha = 0.05

Do Not Reject H0, Conclude Sample 1 <= Sample 2

P-Value >= alpha (0.05)

Gehan Sample 1 vs Sample 2 Comparison Hypothesis Test for Data Sets with Non-Detects

User Selected Options	
Date/Time of Computation	ProUCL 5.2 3/17/2023 1:36:39 PM
From File	Ba_ProUCLReady_a.xls
Full Precision	OFF
Confidence Coefficient	95%
Selected Null Hypothesis	Sample 1 Mean/Median <= Sample 2 Mean/Median (Form 1)
Alternative Hypothesis	Sample 1 Mean/Median > Sample 2 Mean/Median

Sample 1 Data: Ba(w1-19)

Sample 2 Data: Ba(up)

Raw Statistics

	Sample 1	Sample 2
Number of Valid Data	53	145
Number of Non-Detects	1	2
Number of Detect Data	52	143
Minimum Non-Detect	65.8	102
Maximum Non-Detect	65.8	483
Percent Non-detects	1.89%	1.38%
Minimum Detect	32	17
Maximum Detect	140	653
Mean of Detects	75.72	218.4
Median of Detects	77.75	131
SD of Detects	16.53	172.5
KM Mean	75.29	217.1
KM SD	16.58	171.7

Sample 1 vs Sample 2 Gehan Test

H0: Mean/Median of Sample 1 <= Mean/Median of background

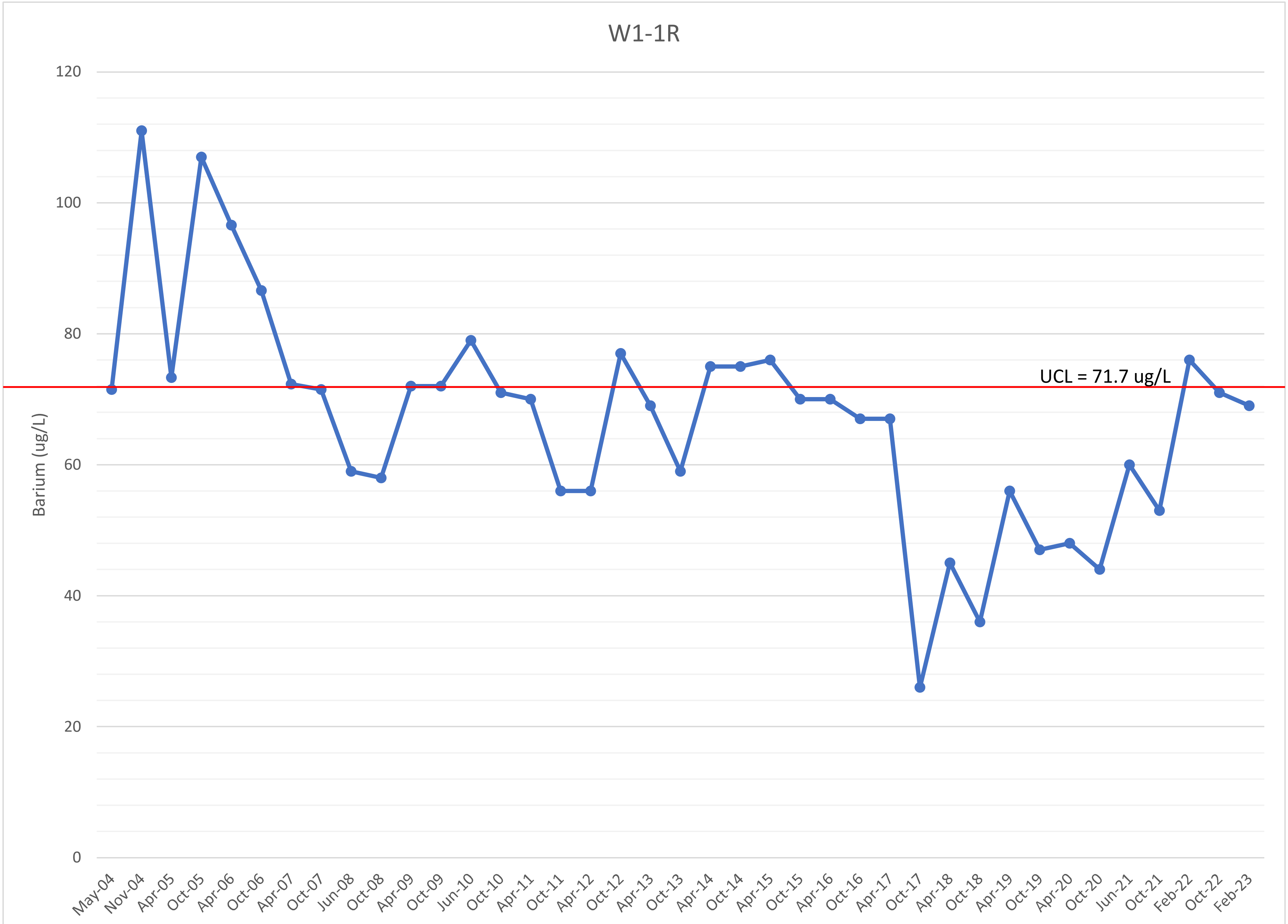
Gehan z Test Value	-5.424
Critical z (0.05)	1.645
P-Value	1

Conclusion with Alpha = 0.05

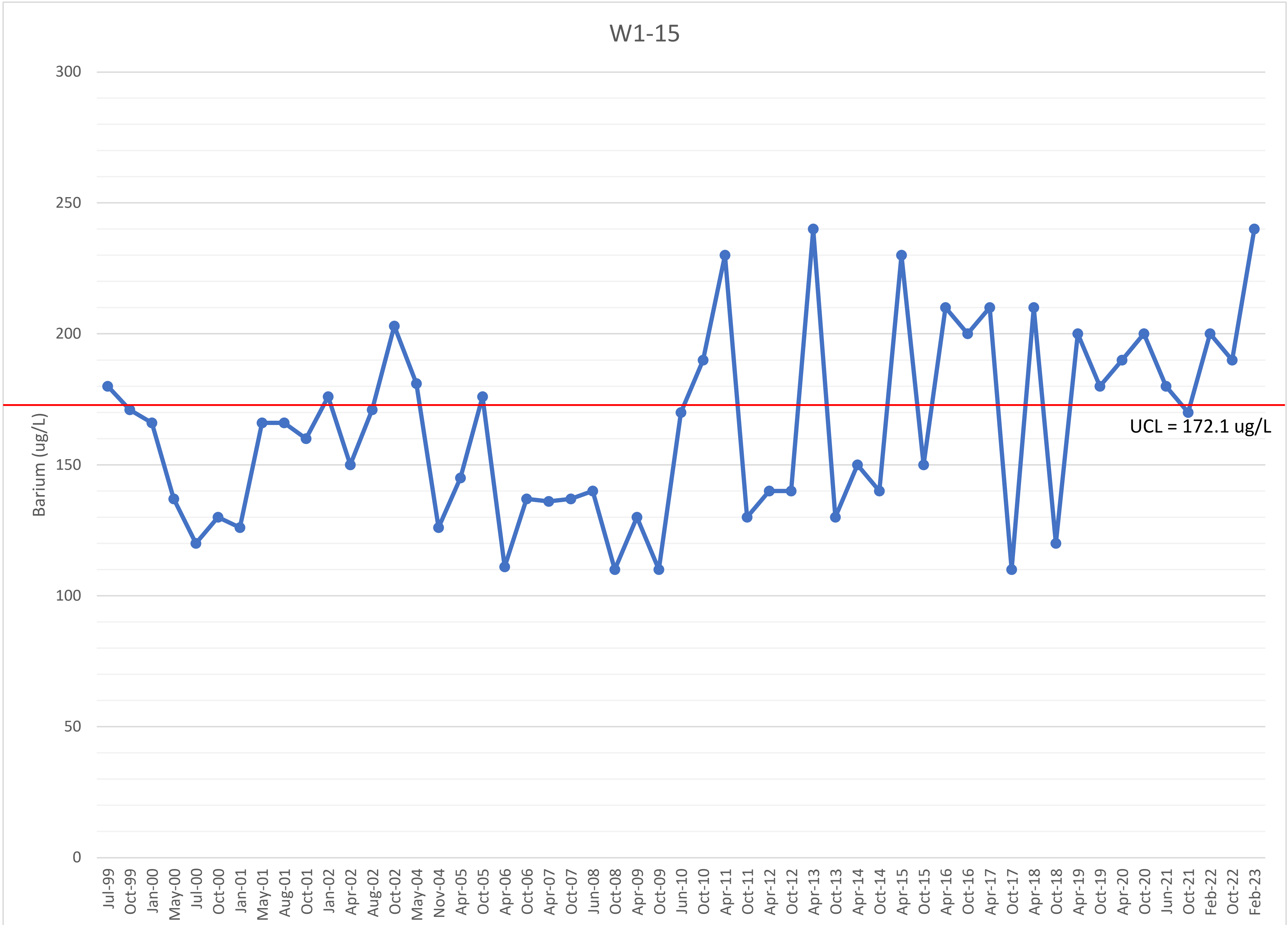
Do Not Reject H0, Conclude Sample 1 <= Sample 2

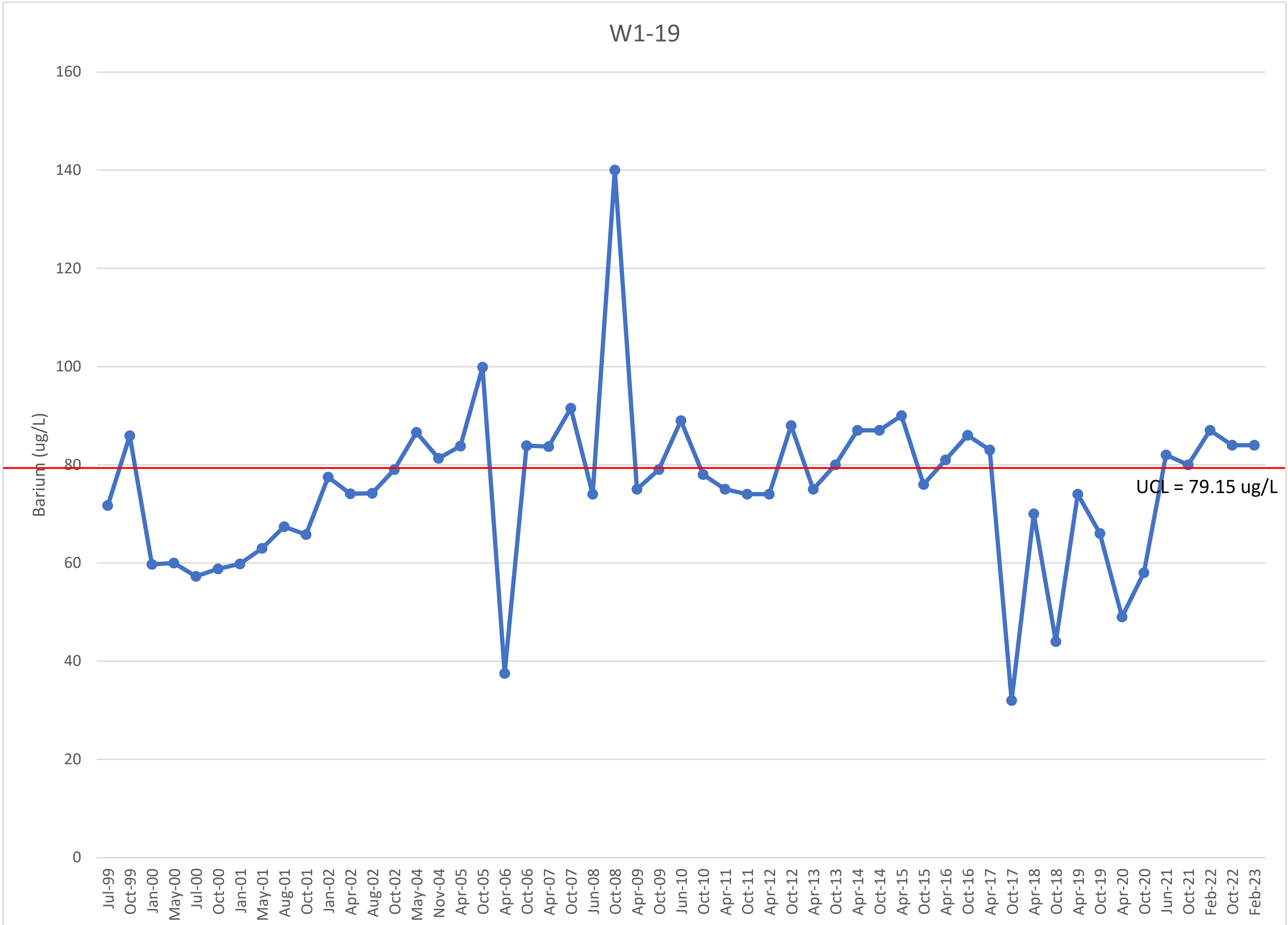
P-Value >= alpha (0.05)

Attachment C



W1-1R
Barium (ug/L)
120
100
80
60
40
20
0
UCL = 71.7 ug/L
May-04
Nov-04
Apr-05
Oct-05
Apr-06
Oct-06
Apr-07
Oct-07
Jun-08
Oct-08
Apr-09
Oct-09
Jun-10
Oct-10
Apr-11
Oct-11
Apr-12
Oct-12
Apr-13
Oct-13
Apr-14
Oct-14
Apr-15
Oct-15
Apr-16
Oct-16
Apr-17
Oct-17
Apr-18
Oct-18
Apr-19
Oct-19
Apr-20
Oct-20
Jun-21
Oct-21
Feb-22
Oct-22
Feb-23


W1-15
Barium (ug/L)
300
250
200
150
100
50
0
UCL = 172.1 ug/L
Jul-99
Oct-99
Jan-00
May-00
Jul-00
Oct-00
Jan-01
May-01
Aug-01
Oct-01
Jan-02
Apr-02
Aug-02
Oct-02
May-04
Nov-04
Apr-05
Oct-05
Apr-06
Oct-06
Apr-07
Oct-07
Jun-08
Oct-08
Apr-09
Oct-09
Jun-10
Oct-10
Apr-11
Oct-11
Apr-12
Oct-12
Apr-13
Oct-13
Apr-14
Oct-14
Apr-15
Oct-15
Apr-16
Oct-16
Apr-17
Oct-17
Apr-18
Oct-18
Apr-19
Oct-19
Apr-20
Oct-20
Jun-21
Oct-21
Feb-22
Oct-22
Feb-23

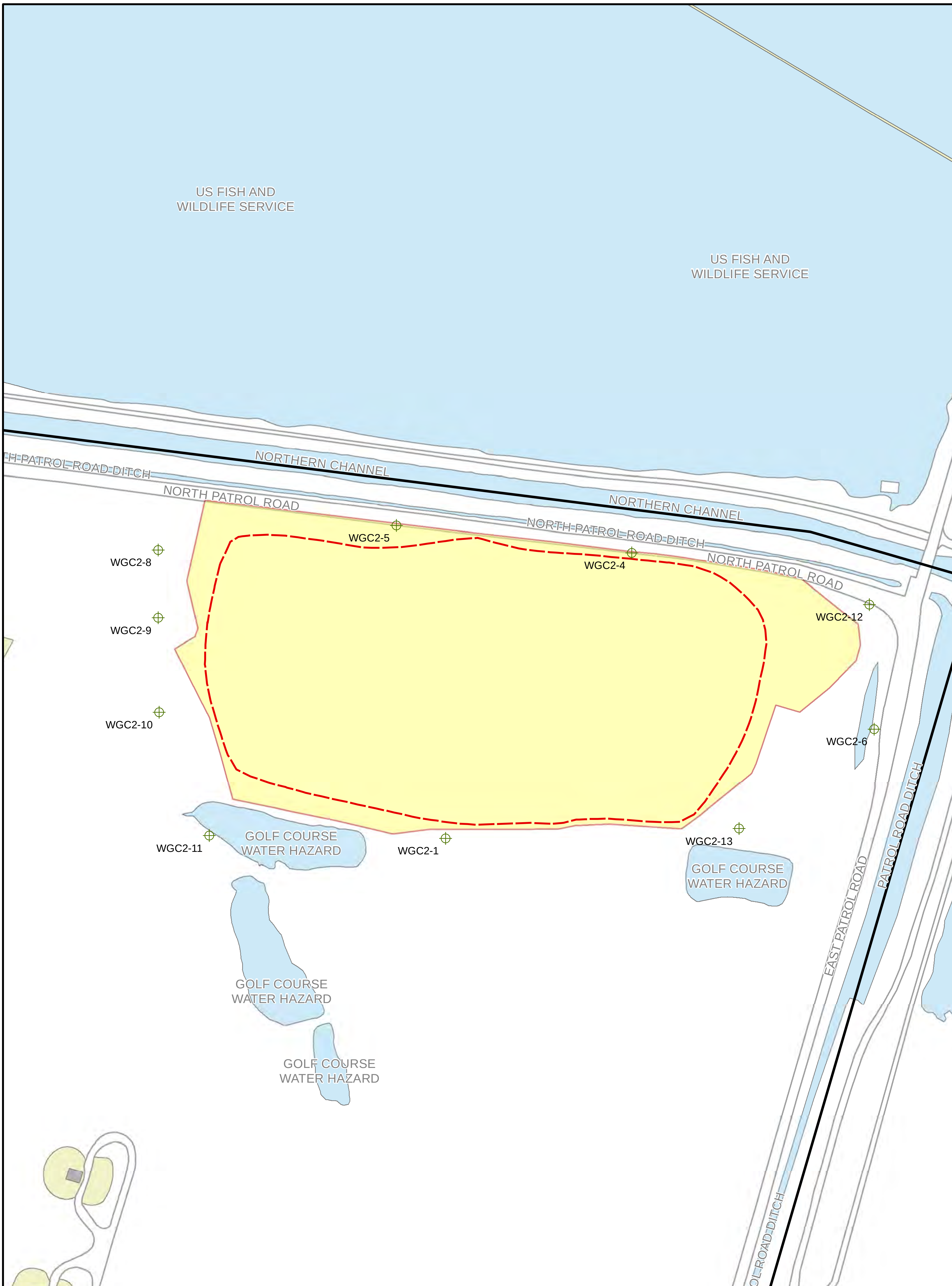

W1-19
Barium (ug/L)
UCL = 79.15 ug/L
160
140
120
100
80
60
40
20
0
Jul-99
Oct-99
Jan-00
May-00
Jul-00
Oct-00
Jan-01
May-01
Aug-01
Oct-01
Jan-02
Apr-02
Aug-02
Oct-02
May-04
Nov-04
Apr-05
Oct-05
Apr-06
Oct-06
Apr-07
Oct-07
Jun-08
Oct-08
Apr-09
Oct-09
Jun-10
Oct-10
Apr-11
Oct-11
Apr-12
Oct-12
Apr-13
Oct-13
Apr-14
Oct-14
Apr-15
Oct-15
Apr-16
Oct-16
Apr-17
Oct-17
Apr-18
Oct-18
Apr-19
Oct-19
Apr-20
Oct-20
Jun-21
Oct-21
Feb-22
Oct-22
Feb-23

Site 22

The following data were drawn from the “Draft 2023 Annual Report, Site 1 and Site 22 Landfills, Moffett Federal Airfield” (BB&E 2024) to support Five-Year Review Site 22 discussion and address EPA General Comment 6.

Figure 4 - Site 22 Landfill Groundwater Level Measurement and Monitoring Locations
Figure 7 - Site 22 Landfill Potentiometric Surface, February 2023
Figure 10 - Site 22 Landfill Methane Monitoring Locations

Appendix D - Analytical Data Graphs



Site 22

Groundwater Monitoring Well Location

Estimated Extent of Refuse

Former NAS Moffett Field Boundary

Road

Water/Wetland

Paved

Ames Research Center
Moffett Field, CA 94035

FIGURE 4
SITE 22 LANDFILL

GROUNDWATER LEVEL MEASUREMENT AND MONITORING LOCATIONS

Site 22

Former NAS Moffett Field Boundary

Groundwater Monitoring Well (Groundwater Elevation [MSL] in Feet)

Approximate Groundwater Flow Direction

Interpreted Groundwater Elevation (MSL) in Feet. Negative Values are Below MSL

Interpreted Groundwater Elevation (MSL) in Feet, Inferred. Negative Values are Below MSL

MSL Mean Sea Level

* Outlier value not used to create Potentiometric Surface

N

0 75 150 300

Feet

Ames Research Center
Moffett Field, CA 94035

FIGURE 7
SITE 22 LANDFILL

POTENTIOMETRIC SURFACE
FEBRUARY 2023

Site 22
Estimated Extent of Refuse
Former NAS Moffett Field Boundary
Road
Water/Wetland
Paved

Perimeter Methane Monitoring Point
Landfill Gas Monitoring Well
Tree Well
Tree Well Methane Monitoring Point

0 75 150 300
Feet

N

Ames Research Center
Moffett Field, CA 94035

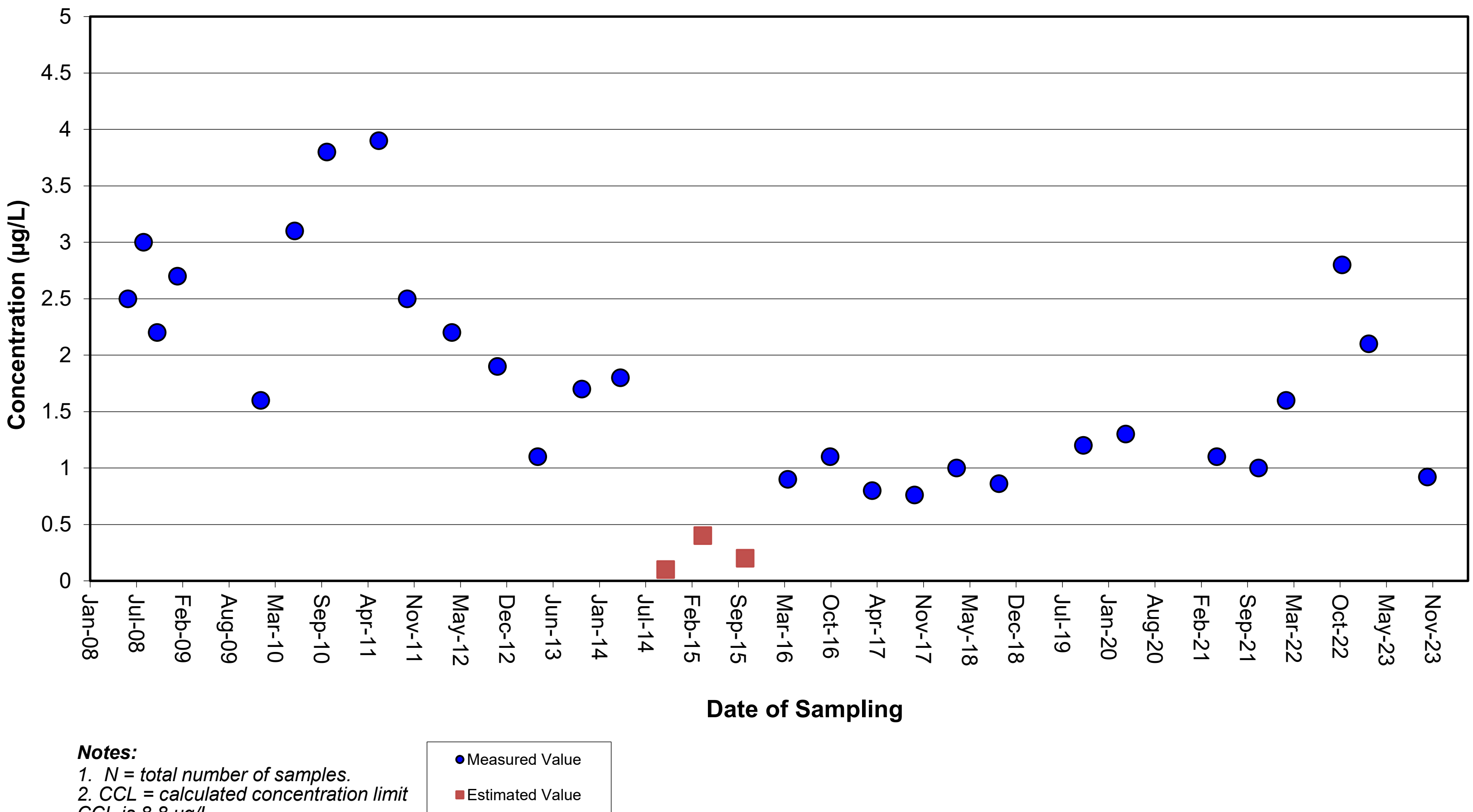
FIGURE 10
SITE 22 LANDFILL

METHANE MONITORING LOCATIONS

Appendix D
Analytical Data Graphs

Figure D-40

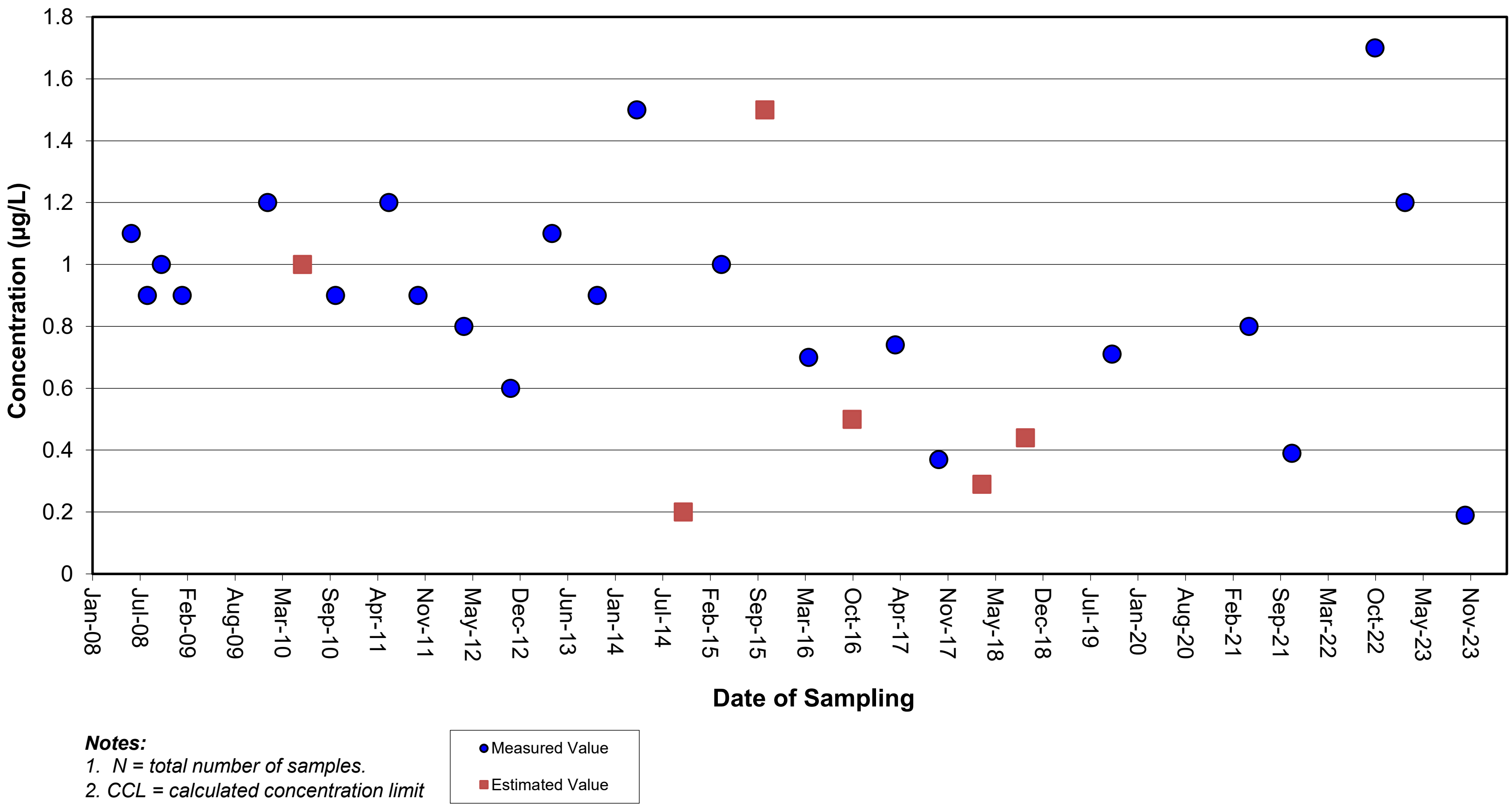
Site 22 Trichloroethene Concentrations
Monitoring Well WGC2-8



Notes:
1. N = total number of samples.
2. CCL = calculated concentration limit
CCL is 8.8 µg/L

Figure D-41

Site 22 Trichloroethene Concentrations
Monitoring Well WGC2-9



Notes:
1. N = total number of samples.
2. CCL = calculated concentration limit
CCL is 8.8 µg/L

Site 26

Site 26 data was drawn from multiple reports to illustrate changes in Site 26 chemical distributions over time.

The following data were drawn from the "*Draft Final 2020 Long-Term Monitoring Repot, Installation Restoration Site 26, Former Naval Air Station Moffett Field* (Leisnoi & KEMRON 2021) to support Five-Year Review Site 26 discussion and address EPA General Comment 6.

Figure 3-10 - Trichloroethene (TCE) Distribution, IR Site 26, 2020 LTM

Figure 3-11 - cis-1,2-Dichloroethene (cis-1,2-DCE) Distribution, IR Site 26, 2020 LTM

Figure 3-12 - Tetrachloroethene (PCE) Distribution, IR Site 26, 2020 LTM

Figure 3-13 - Vinyl Chloride (VC) Distribution, IR Site 26, 2020 LTM

The following data were drawn from the "Draft Final 2021 Installation Restoration Site 26 Long-Term Monitoring Report, Former Naval Air Station Moffett Field NASA Ames Research Center" (BB&E 2022) to support Five-Year Review Site 26 discussion and address EPA General Comment 6.

Figure 3-10 - Trichloroethene (TCE) Distribution, IR Site 26, 2021 LTM

Figure 3-11 - cis-1,2-Dichloroethene (cis-1,2-DCE) Distribution, IR Site 26, 2021 LTM

Figure 3-12 - Tetrachloroethene (PCE) Distribution, IR Site 26, 2021 LTM

Figure 3-13 - Vinyl Chloride (VC) Distribution, IR Site 26, 2021 LTM

The following data were drawn from the "Draft Final 2022 Installation Restoration Site 26 Long Term Monitoring Report, Former Naval Air Station Moffett Field, NASA Ames Research Center" (BB&E, 2023) to support Five-Year Review Site 26 discussion and address EPA General Comment 6.

Section 4.0 Conclusions (Draft Final 2022 Installation Restoration Site 26 Long Term Monitoring Report)
Table 3-3 - 2022 LTM Summary of Statistical Analyses
Appendix A – Mann-Kendall Test Results

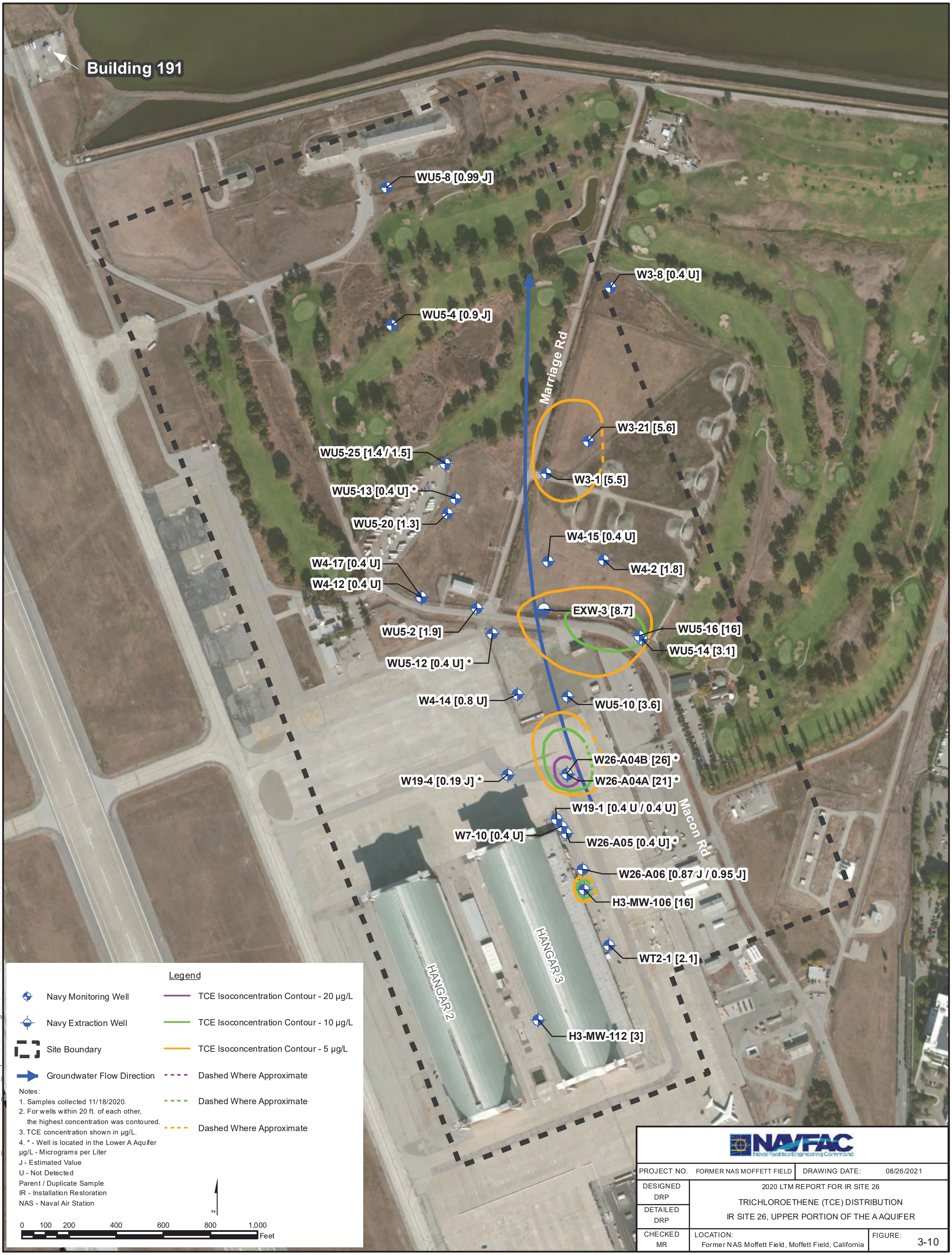
The following data were drawn from the "*Draft 2023 Installation Restoration Site 26 Long Term Monitoring Report, Former Naval Air Station Moffett Field, NASA Ames Research Center*" (BB&E, 2024) to support Five-Year Review Site 26 discussion and address EPA General Comment 6.

Figure 3-2 - Tetrachloroethene (PCE) Distribution (2023)

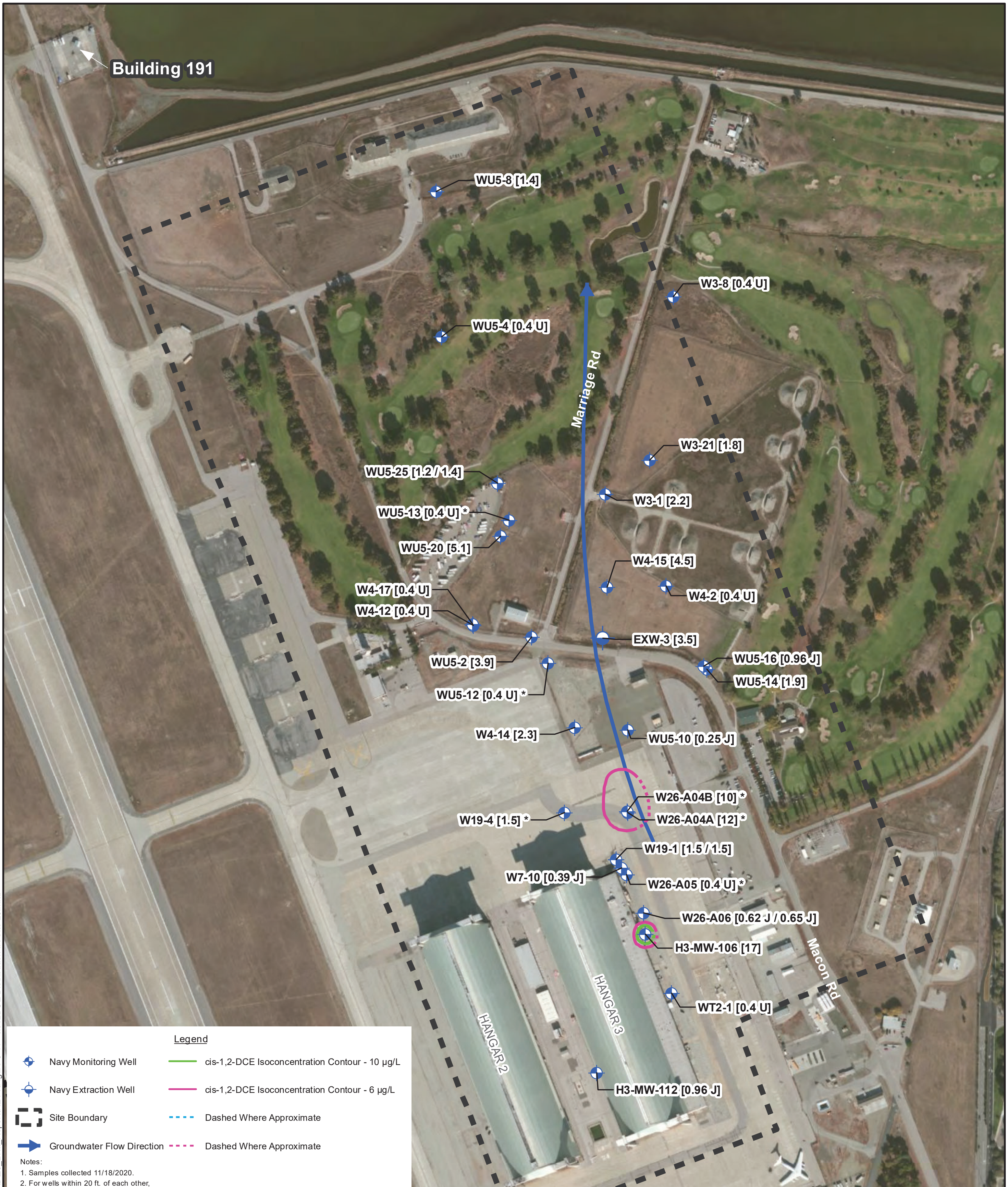
Figure 3-3 - Trichloroethene (TCE) Distribution (2023)

Figure 3-4 - cis-1,2-Dichloroethene (*c*DCE) Distribution (2023)

Figure 3-5 - Vinyl Chloride (VC) Distribution (2023)



Document Path: G:\Moffett_Field\MXD\26_LTM_Report\REV4\Figure 3-10 - TCE Distribution IR Site 26.mxd



NAVFAC Naval Facilities Engineering Command

PROJECT NO.	FORMER NAS MOFFETT FIELD	DRAWING DATE:	08/26/2021
DESIGNED DRP	2020 LTM REPORT FOR IR SITE 26		
DETAILED DRP	cis-1,2-DICHLOROETHENE (cis-1,2-DCE) DISTRIBUTION IR SITE 26, UPPER PORTION OF THE A AQUIFER		
CHECKED MR	LOCATION: Former NAS Moffett Field, Moffett Field, California	FIGURE:	3-11

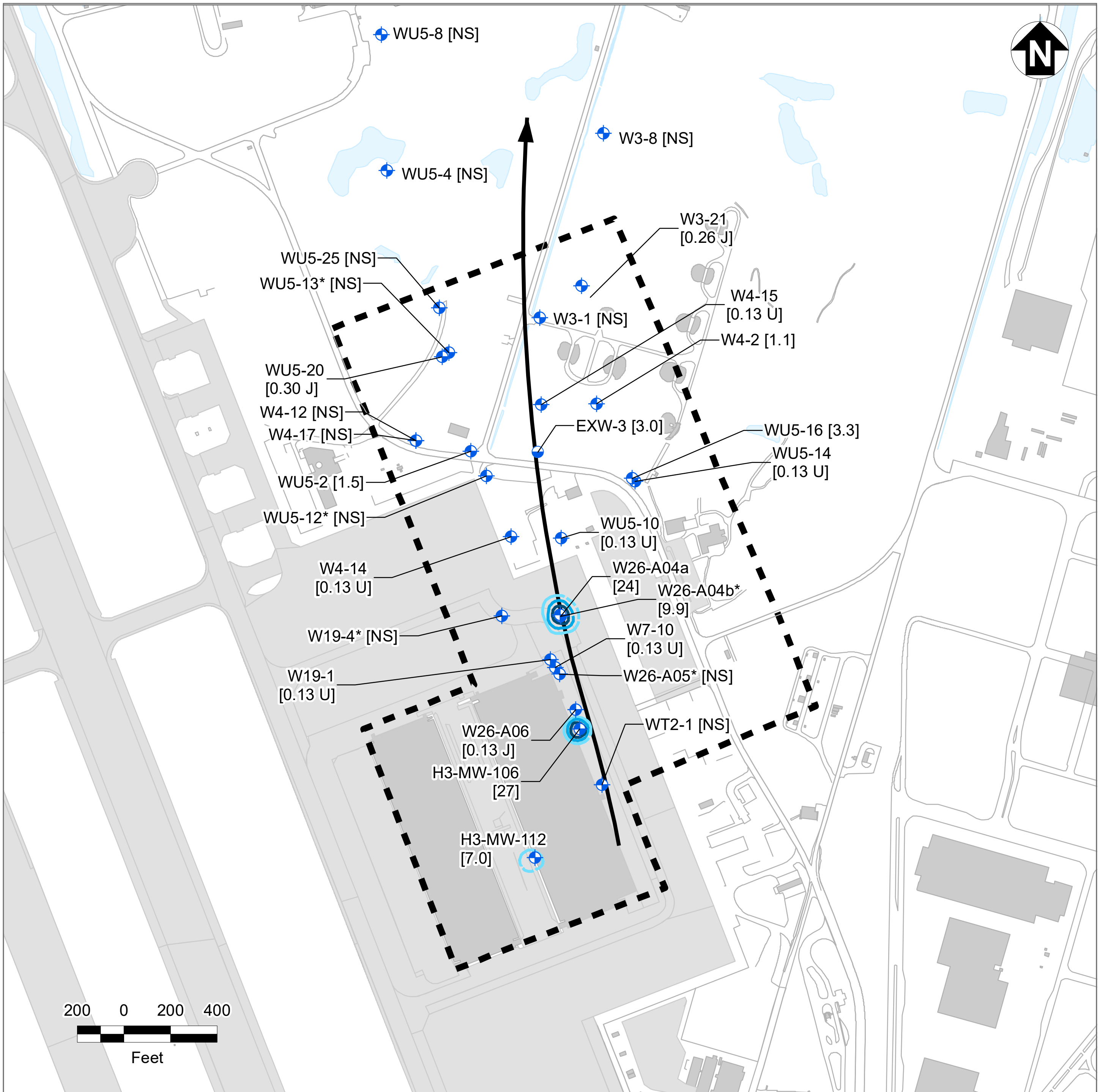
Document Path: G:\Moffett_Field\MXD\26_LTM_Report\REV4\Figure 3-11 - cis12DCE Distribution IR Site 26.mxd

Document Path: G:\Moffett_Field\MXD\26_LTM_Report\REV4\Figure 3-12 - PCE Distribution IR Site 26.mxd

NAVFAC Naval Facilities Engineering Command

PROJECT NO.	FORMER NAS MOFFETT FIELD	DRAWING DATE:	08/26/2021
DESIGNED DRP	2020 LTM REPORT FOR IR SITE 26		
DETAILED DRP	VINYL CHLORIDE (VC) DISTRIBUTION IR SITE 26, UPPER PORTION OF THE A AQUIFER		
CHECKED MR	LOCATION: Former NAS Moffett Field, Moffett Field, California	FIGURE:	3-13

Document Path: G:\Moffett_Field\MXD\26_LTM_Report\REV4\Figure 3-13 - VC Distribution IR Site 26.mxd



Navy Extraction Well

Navy Monitoring Well

IR Site 26 Boundary

Wetland

Water

Road

Building

Paved Area

PCE Isoconcentration Contour - 5 µg/L

Dashed Where Inferred

PCE Isoconcentration Contour - 10 µg/L

Dashed Where Inferred

PCE Isoconcentration Contour - 20 µg/L

Dashed Where Inferred

Notes:
1. Samples collected 10/06/2021.
2. For wells within 20 ft of each other, the highest concentration was contoured.
3. PCE concentration shown in µg/L
4. * - Well is located in the Lower A Aquifer

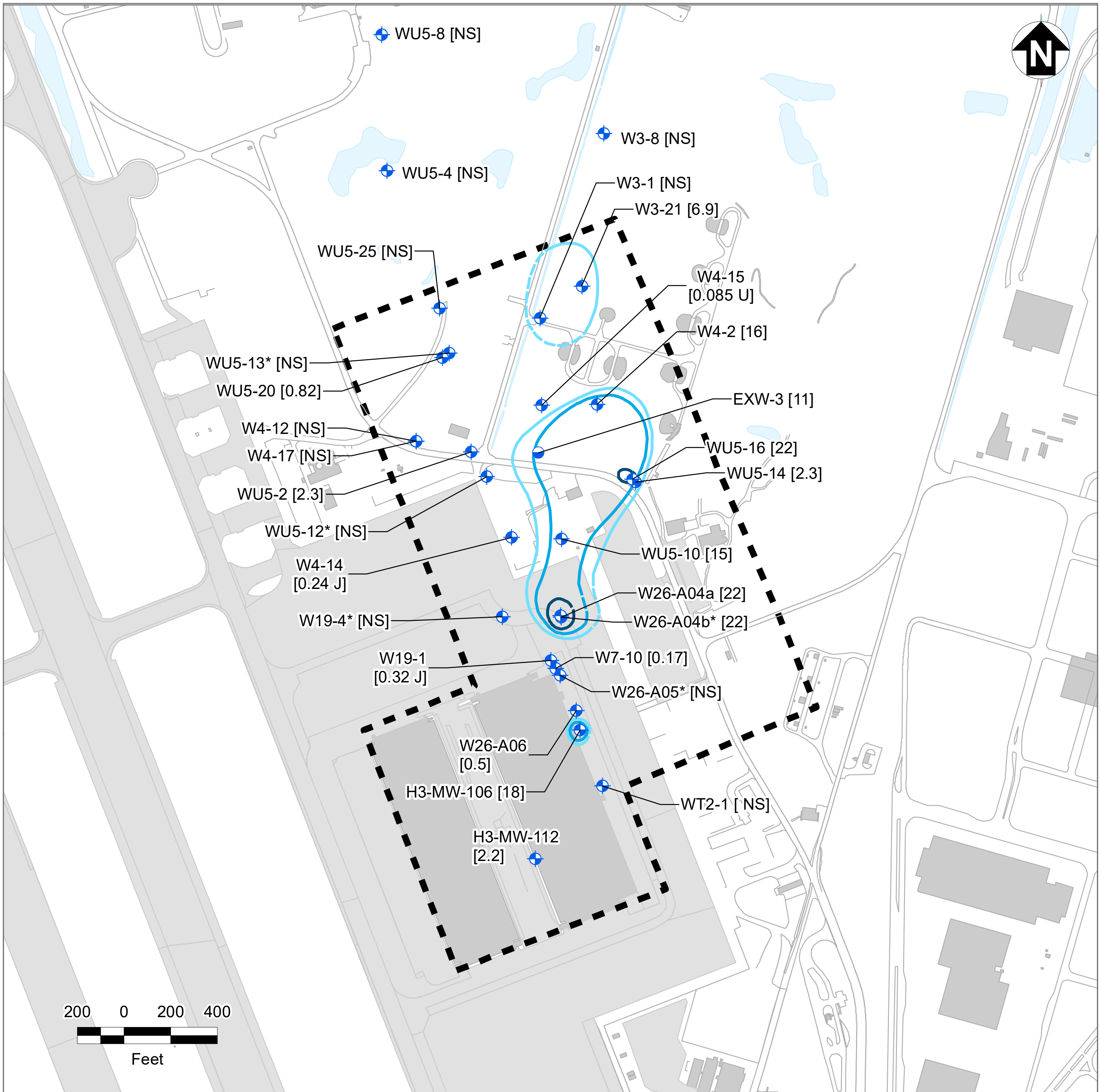
µg/L - Micrograms per Liter
J - Estimated Value
U - Not Detected
NS - Not Sampled
IR - Installation Restoration

Ames Research Center
Moffett Field, CA 94035

NASA Ames Research Center
Moffett Field, California

FIGURE 3-10

TETRACHLOROETHENE (PCE) DISTRIBUTION
IR SITE 26, 2021 LTM



Navy Extraction Well
Navy Monitoring Well
IR Site 26 Boundary
Wetland
Water
Road
Building
Paved Area

TCE Isoconcentration Contour - 5 µg/L
Dashed Where Inferred
TCE Isoconcentration Contour - 10 µg/L
Dashed Where Inferred
TCE Isoconcentration Contour - 20 µg/L
Dashed Where Inferred

Notes:
1. Samples collected 10/06/2021.
2. For wells within 20 ft of each other, the highest concentration was contoured.
3. TCE concentration shown in µg/L
4. * - Well is located in the Lower A Aquifer

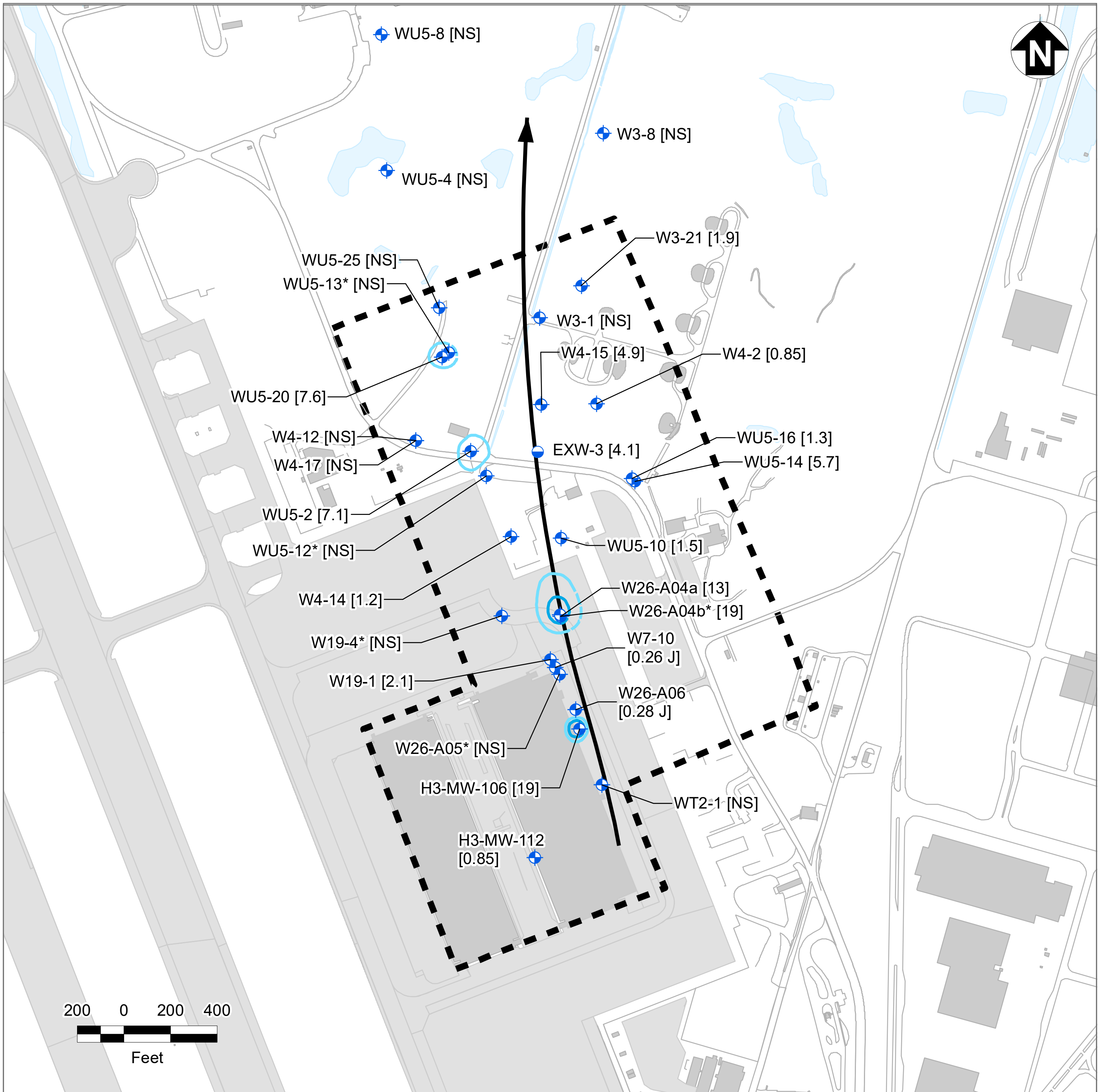
µg/L - Micrograms per Liter
J - Estimated Value
U - Not Detected
NS - Not Sampled
IR - Installation Restoration

Ames Research Center
Moffett Field, CA 94035

NASA Ames Research Center
Moffett Field, California

FIGURE 3-11

TRICHLOROETHENE (TCE) DISTRIBUTION
IR SITE 26, 2021 LTM



Navy Extraction Well

Navy Monitoring Well

IR Site 26 Boundary

Wetland

Water

Road

Building

Paved Area

cis-1,2-DCE Isoconcentration Contour - 6 µg/L

Dashed Where Inferred

cis-1,2-DCE Isoconcentration Contour - 10 µg/L

Dashed Where Inferred

Notes:
1. Samples collected 10/06/2021.
2. For wells within 20 ft of each other, the highest concentration was contoured.
3. cDCE concentration shown in µg/L
4. * - Well is located in the Lower A Aquifer

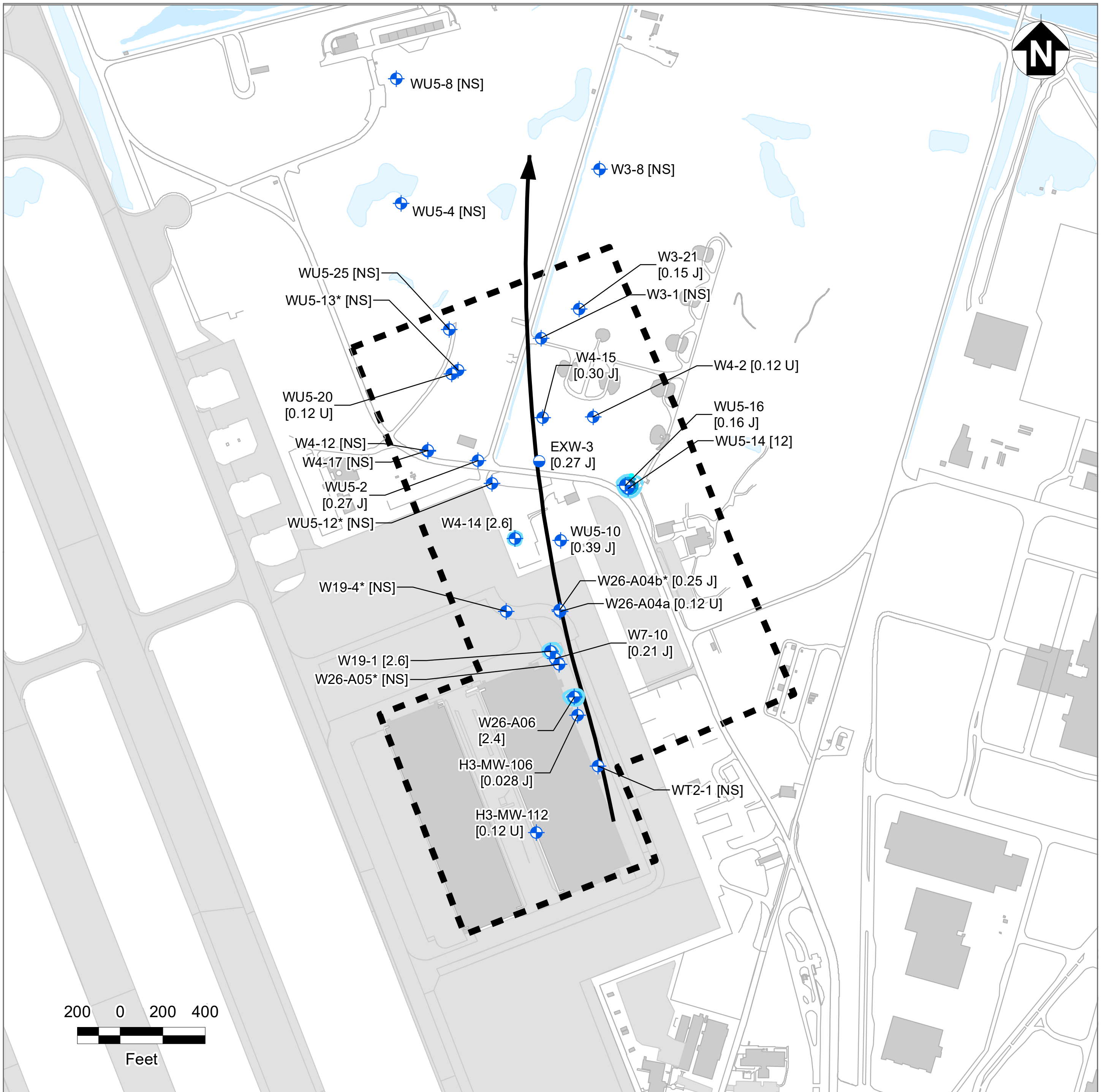
µg/L - Micrograms per Liter
J - Estimated Value
U - Not Detected
NS - Not Sampled
IR - Installation Restoration

Ames Research Center
Moffett Field, CA 94035

NASA Ames Research Center
Moffett Field, California

FIGURE 3-12

cis-1,2-DICHLOROETHENE (cDCE) DISTRIBUTION
IR SITE 26, 2021 LTM



Navy Extraction Well

Navy Monitoring Well

IR Site 26 Boundary

Wetland

Water

Road

Building

Paved

VC Isoconcentration Contour - 0.5 µg/L

Dashed Where Inferred

VC Isoconcentration Contour - 1.0 µg/L

Dashed Where Inferred

VC Isoconcentration Contour - 10 µg/L

Dashed Where Inferred

Notes:
1. Samples collected 10/06/2021.
2. For wells within 20 ft of each other, the highest concentration was contoured.
3. VC concentration shown in µg/L
4. * - Well is located in the Lower A Aquifer

µg/L - Micrograms per Liter
J - Estimated Value
U - Not Detected
NS - Not Sampled
IR - Installation Restoration

Ames Research Center
Moffett Field, CA 94035

NASA Ames Research Center
Moffett Field, California

FIGURE 3-13

VINYL CHLORIDE (VC) DISTRIBUTION
IR SITE 26, 2021 LTM

Draft Final 2022 Installation Restoration Site 26 Long Term Monitoring Report

Former Naval Air Station Moffett Field NASA Ames Research Center

National Aeronautics and Space Administration
Ames Research Center
Moffett Field, CA

October 2023

4 Conclusions and Recommendation

This Section presents conclusions and recommendations, developed based on the current 2022 LTM and previous analytical results for IR Site 26 and the current remedy per the 2014 ROD Amendment.

4.1 Conclusions

The water levels measured in September 2022 were very similar to those measured in September 2021. With outliers accounted for, the water levels in 2022 were on average 0.02 ft higher than the water levels in 2021. The predominant direction of groundwater flow based on the data collected during the 2022 groundwater gauging event is slightly northeast trending toward the San Francisco Bay with an overall gradient of 0.0028 ft/foot. The gradient and flow direction are consistent with historical observations.

Groundwater samples were collected as part of the 2022 annual groundwater monitoring event from 29 monitoring wells. In accordance with LTM Plan (KEMRON, 2018b), the 2022 LTM sampling event included the full suite of wells, involving the plume core, source area, fringe wells and perimeter wells. The samples were analyzed for VOCs (EPA 8260).

The analytical results of the 29 sampled wells can be summarized as follows:

- PCE was detected in 13 of the 29 wells at concentrations ranging from 0.19J µg/L to 20 µg/L. The cleanup level of 5.0 µg/L was exceeded in four wells. PCE was detected at higher concentrations in 2022 in three of the 17 wells when compared to the concentration measured in that well in 2021.

- TCE was detected in 24 of the 29 wells at concentrations ranging from 0.11J µg/L to 18 µg/L. The cleanup level of 5.0 µg/L was exceeded in nine wells. TCE was detected at higher concentrations in 2022 in one of the 17 wells when compared to the concentration measured in that well in 2021.

- *c*DCE was detected in 22 of the 29 wells at concentrations ranging from 0.10J µg/L to 15 µg/L. The cleanup level of 6.0 µg/L was exceeded in four wells. *c*DCE was detected at higher concentrations in 2022 in three of the 17 wells when compared to the concentration measured in that well in 2021.

- *t*DCE was detected in 14 of the 29 wells at concentrations ranging from 0.15J µg/L to 1.8 µg/L. The cleanup level of 10 µg/L was not exceeded in any of the 29 wells. *t*DCE was detected at higher concentrations in 2022 in two of the 17 wells when compared to the concentration measured in that well in 2021.

- 1,1-DCE was detected in six of the 29 wells at concentrations ranging from 0.18J µg/L to 1.4 µg/L. The cleanup level of 6.0 µg/L was not exceeded in any of the 29 wells. 1,1-DCE was detected at higher concentrations in 2022 in one of the 17 wells when compared to the concentration measured in that well in 2021.

- VC was detected in 12 of the 29 wells at concentrations ranging from 0.13J µg/L to 11 µg/L. The cleanup level of 0.5 µg/L was exceeded in six wells. VC was detected at higher concentrations in 2022 in one of the 17 wells when compared to the concentration measured in that well in 2021.

- 1,2-DCA was detected in three of the 29 wells at concentrations ranging from 0.17J µg/L to 0.40J µg/L. The cleanup level of 0.50 µg/L was not exceeded in any of the 29 wells. 1,2-DCA was detected at higher concentrations in 2022 in one of the 17 wells when compared to the concentration measured in that well in 2021.

The areal distributions of the contoured COCs can be summarized as follows:

- The remnant PCE plumes mapped in 2022 are nearly identical to those mapped in 2021. Slight concentration decreases were noted in seven wells, although the area of the of the plume boundaries remained consistent with those observed in 2021. The three source area wells (W7-10, W19-1 and W26-A06) continue to show non-detect for PCE concentrations.

- The TCE remnant plume boundaries have remained constant between 2021 and 2022. However, there has been an overall decrease in TCE concentrations across Site 26. This is consistent with as the enhanced dechlorination process continuing to dechlorinate the TCE.

- *c*DCE concentrations measured in 2022 were overall lower than the previous 2021 LTM sampling, resulting in only four isolated plume remnants mapped. This indicates that there is likely no buildup of *c*DCE without subsequent dechlorination ("*cis stall*")occurring as speculated in the 2021 LTM report. However, future data will be evaluated to verify continued dechlorination.

- Because the reporting limit for VC coincides with the cleanup level (0.50 µg/L), expansion of VC plume boundaries and the appearance of new plume masses is common in VC mapping. One additional concentration island (W19-4) and the expansion of another (WU4-14 expanded to WU5-10) have been mapped in 2022. W19-4, which was not sampled during 2021, was measured at a concentration of 0.74 µg/L creating a new concentration island. VC often accumulates because it preferentially degrades under aerobic conditions, not the anaerobic conditions established by the EVO injection.

Mann-Kendall concertation trends were developed for the predominant reductive dechlorination chemicals (primary COCs). A summary of these trends is provided below The analysis indicates that reductive dechlorination is very active in the source area and to a large degree in the plume core area as well (Table 3-3). Decreasing trends are observed across all four of the primary COCs. The large majority of the primary COCs that show stable trends (or no trends) are present at concentrations below their respective cleanup standard.

	Number of Wells	Increasing Trend	Decreasing Trend	Stable/No Trend	Non-Detect
PCE	22	2	3	8	9
TCE	22	2	8	9	3
*c*DCE	22	0	9	9	4
VC	22	1	6	4	11

4.2 Technical Assessment of Remedy

Evaluating the success of the EVO/DHC remedy is a complex assignment. Numerous physical, chemical, and biological variables interact both spatially and temporally over the duration of active remediation. Processes that are active in one area during a monitoring period may be absent in that area in the following monitoring period, but active in another area. Certain chemicals may be degrading in one area, but accumulating in another. In addition, short-term trends in response to the subsurface injection of materials can result from contaminant rebound, contaminant mass displacement, accelerated plume migration, etc.

None of these observations, viewed in isolation, can determine the success or failure of the remedy. Instead, they need to be viewed in total to assess the overall impact of the remedy across the site and over time. Ultimately, the goal of evaluating all these processes viewed over time is to demonstrate that MNA is still active at the site.

Based on the data and evaluations presented in Section 3.3, the following conclusions address the questions posed in Section 1.1:

1. *Is the areal extent of the COC plume stable or shrinking?*

   - Between 2019 and 2020, there was significant reduction in the areal extent of the COC plume as a direct result of the EVO/DHC injections. The injections resulted in a rapid decline in PCE distribution, especially in the vicinity of the injection zones. The areal extent of PCE between 2021 and 2022 was comparable, however the concentrations of PCE were overall lower than the previous year.
   - Likewise, there was significant reduction in the areal extent of the TCE plumes subsequent to the 2019 EVO/DHC injections. The 2021 TCE plume boundary extent remained consistent between 2021 and 2022, however the concentrations of TCE were overall lower than the previous year.
   - The areal extent of the mapped *c*DCE boundaries was modestly reduced as a result of the 2019 EVO/DHC injections. The 2022 areal distributions of the main remnant plumes were comparable to that of 2021, however the concentrations of *c*DCE were overall lower than the previous year. One concentration-contour island was removed between 2021 and 2022.
   - As a result of the 2019 EVO/DHC injections, the areal extent of VC has decreased dramatically. The 2020 VC plume mapping shows a number of isolated concentration-contour islands, as opposed to the extensive pre-injection plume mass. The areal extent of VC between 2021 and 2022 was larger than the previous year due to more wells being sampled. Although the concentrations of VC were overall lower than the previous year, VC is the only COC exhibiting expansion in 2022.

2. *Are COCs in key indicator wells within the plume indicating: (1) Concentrations of PCE and TCE are declining and thus reductive dechlorination is occurring? (2) Concentrations of daughter products (cDCE and VC) present are due to reductive dechlorination of PCE and TCE?; and (3) Concentrations of the daughter products are ultimately declining?*

   - In 2022, the majority of the 29 wells that were sampled contained TCE, *c*DCE, and VC at concentrations that were comparable those observed in 2020 (see Section 4.1). In the 17 wells that were sampled in both 2021 and 2022, PCE concentration decreased an average of 9%, TCE concentrations decreased an average of 26%, *c*DCE concentrations decreased and average of 10%, and VC concentration decreased an average of 15%. The decreases in average concentrations, along with the prevalence of decreasing Mann-Kendall consternation trends is supportive that dechlorination is occurring.
   - As previously discussed, different physical, chemical, and biological processes can be occurring in different areas of the site in the same time frame following in situ remediation. The 2022 monitoring results may be indicative of more steady-state processes. The up-coming 2023 LTM sampling event provide additional evidence for determining: (1) the reducing environment has persisted, providing an ecosystem where DHC can flourish and enhanced dechlorination can occur; (2) the relatively low

hydraulic gradient allows the continued expansion of reducing conditions; and (3) the dechlorination process can progress through the transformation of VC to ethane.

3. *Is the rate of COC dechlorination consistent with the predicted 30 to 35-year time frame?*

- Although the majority of the calculated 10-year Mann Kendall trend analyses indicate stable or declining concentration trends, the 2022 LTM sampling event indicate a number of short-term rises in concentrations. This observation is consistent with the 2021 LTM sampling. Therefore, it would not be prudent to calculate predicted cleanup time frames until the short-term concentration trends coincide with the long-term concentration trends.

4.3 Recommendations

Based on the data presented in this report and the ensuing discussion provided above, the following is recommended:

- Continue LTM of the IR Site 26 using LTM network described in the IR Site 26 RD LTM Plan (KEMRON, 2018a). The purpose of LTM is to demonstrate that natural attenuation is occurring at the entire IR Site 26. The samples will be analyzed for six VOCs that are the COCs for the site.

- Continue to perform Mann-Kendall trend analyses for PCE, TCE, *c*DCE, , 1,2-DCA, 1,1-DCE, and *t*DCE for all Site 26 LTM wells with sufficient data to continue to fully evaluate the progress of dechlorination across Site 26.

TABLE 3-3
2022 LTM Summary of Statistical Analyses

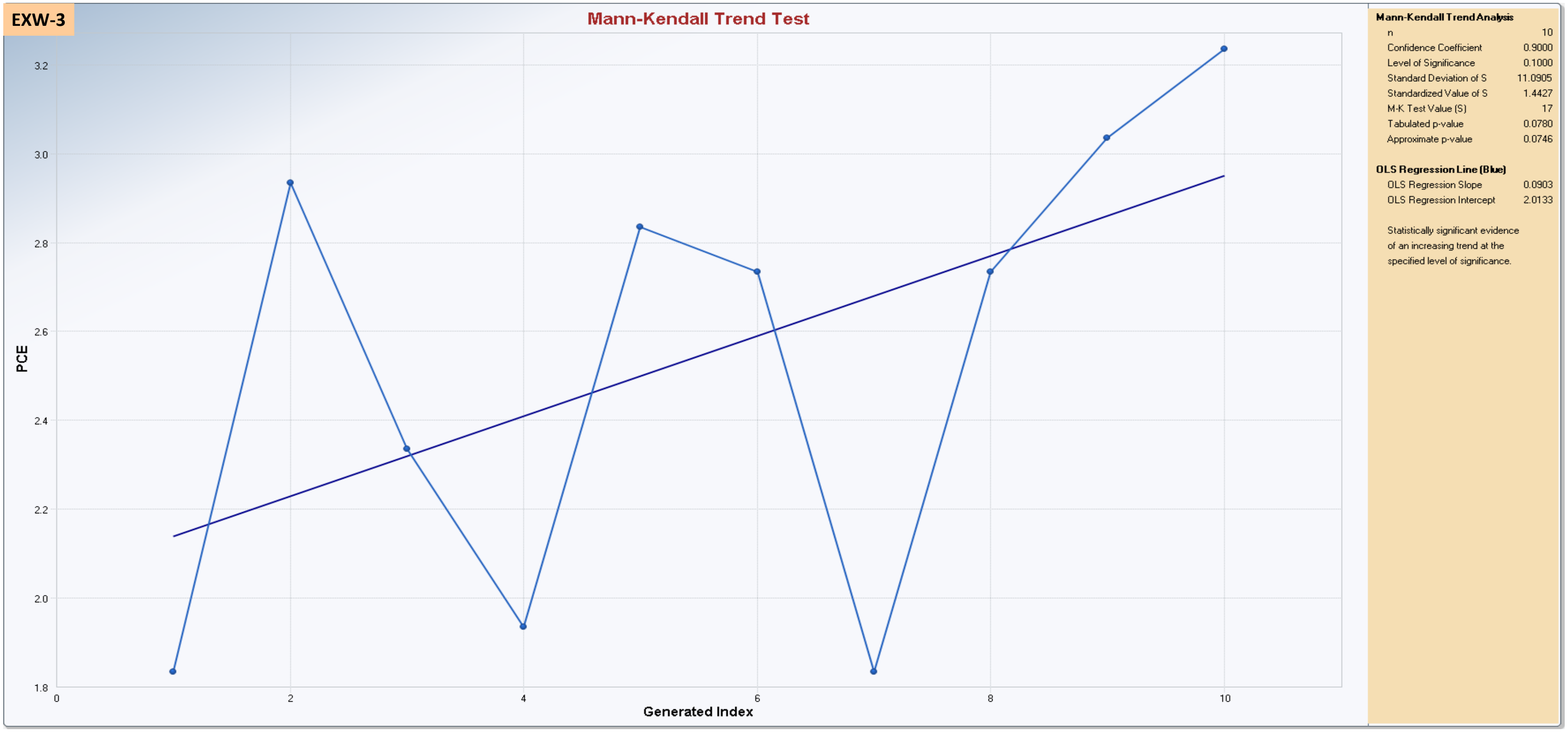
Well ID	Designation	Data Coverage	PCE	TCE	*c* DCE	VC	*t* DCE	1,1-DCE	1,2-DCA
EXW-3	Plume Core	2013-2022	PI	I	NT	D	ND	ND	ND
H3-MW-106	Perimeter	2020-2022	ID	ID	ID	ID	ID	ID	ID
H3-MW-112	Perimeter	2020-2022	ID	ID	ID	ID	ID	ID	ID
W3-1	Perimeter	2020-2022	ID	ID	ID	ID	ID	ID	ID
W3-8	Perimeter	2020-2022	ID	ID	ID	ID	ID	ID	ID
W3-21	Fringe	2013-2022	ND	I	S	ND	S	ND	ND
W4-2	Plume Core	2013-2022	S	S	D	ND	D	ND	ND
W4-12	Perimeter	2020-2022	ID	ID	ID	ID	ID	ID	ID
W4-14	Plume Core	2013-2022	ND	D	D	D	ND	ND	ND
W4-15	Plume Core	2013-2022	D	D	S	ND	S	ND	ND
W4-17	Perimeter	2020-2022	ID	ID	ID	ID	ID	ID	ID
W7-10	Source Area	2013-2022	D	D	D	NT	D	ND	ND
W19-1	Source Area	2013-2022	ND	D	D	D	S	ND	ND
W19-4	Perimeter	2020-2022	ID	ID	ID	ID	ID	ID	ID
W26-A04a	Plume Core	2016-2022	S	S	S	ND	ID	ND	ND
W26-A04b	Plume Core	2016-2022	S	S	S	D	ID	ND	ND
W26-A05	Perimeter	2016-2022	S	ND	ND	ND	ID	ND	ND
W26-A06	Source Area	2016-2022	D	D	D	I	S	ND	ND
WT2-1	Perimeter	2018-2022	S	S	S	ND	ND	ND	ND
WU5-2	Plume Core	2013-2022	S	D	D	D	D	ND	ND
WU5-4	Perimeter	2013-2022	ND	D	ND	ND	ND	ND	ND
WU5-8	Perimeter	2013-2022	ND	S	S	NT	NT	ND	ND
WU5-10	Plume Core	2013-2022	ND	S	S	S	ND	I	ND
WU5-12	Perimeter	2013-2022	ND	ND	ND	ND	ND	ND	ND
WU5-13	Perimeter	2013-2022	ND	ND	ND	ND	ND	ND	ND
WU5-14	Plume Core	2013-2022	ND	D	S	S	S	PI	ND
WU5-16	Plume Core	2013-2022	I	S	D	D	D	D	ND
WU5-20	Fringe	2013-2022	S	S	D	ND	ND	ND	S
WU5-25	Fringe	2013-2022	S	S	D	ND	ND	ND	ND

PCE = Tetrachloroethene
TCE = Trichloroethene
c DCE = *cis* -1,2-Dichloroethene
VC = Vinyl Chloride
t DCE = *trans* -1,2-Dichloroethene
1,1-DCE = 1,1 Dichloroethene
1,2-DCA = 1,2-Dichloroethane

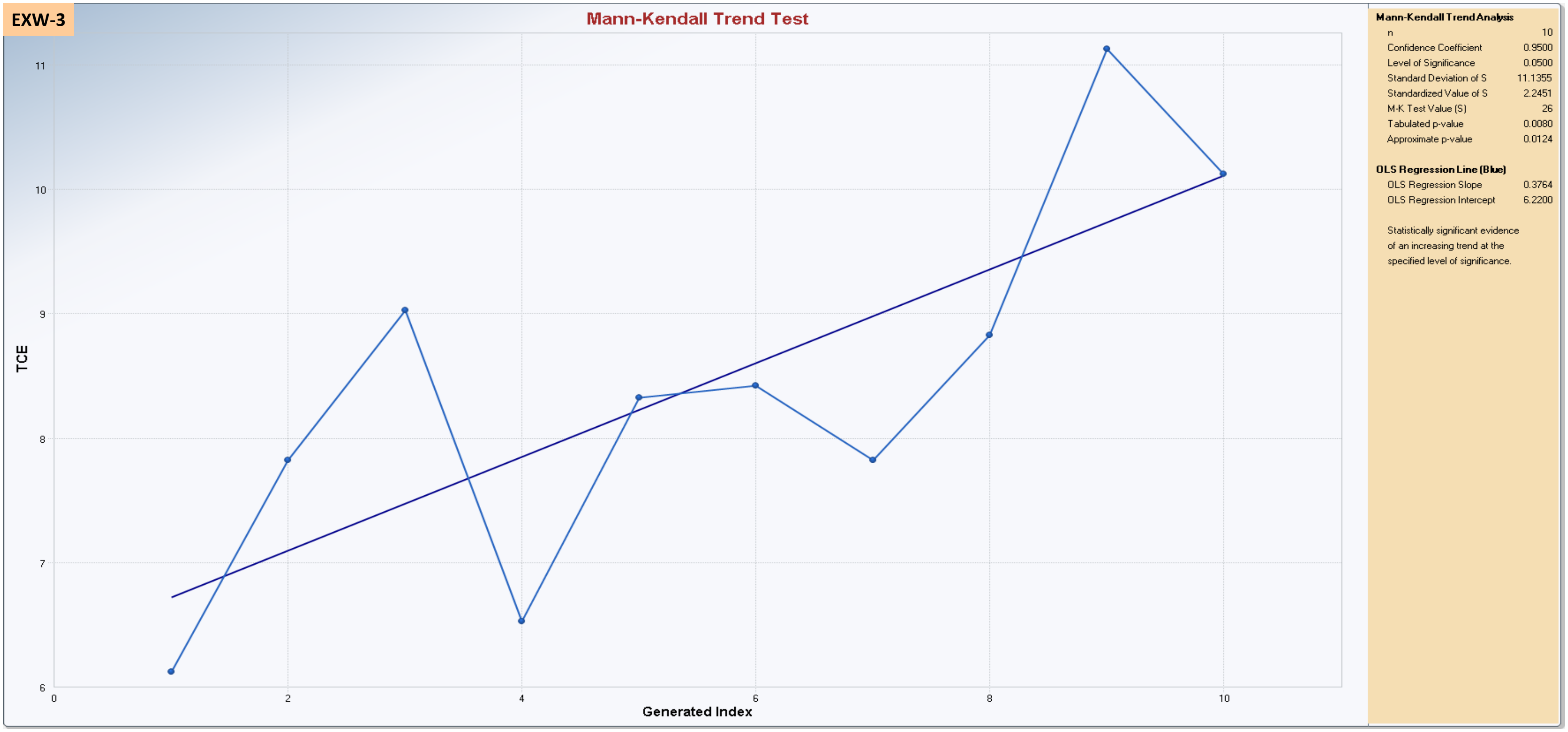
D = Declining
PD = Probably Declining
I = Increasing
PI = Probably Increasing
ND = Non-Detect
NT = No Trend
S = Stable
ID = Insufficient Data (at least four data sets required for statistical analysis)

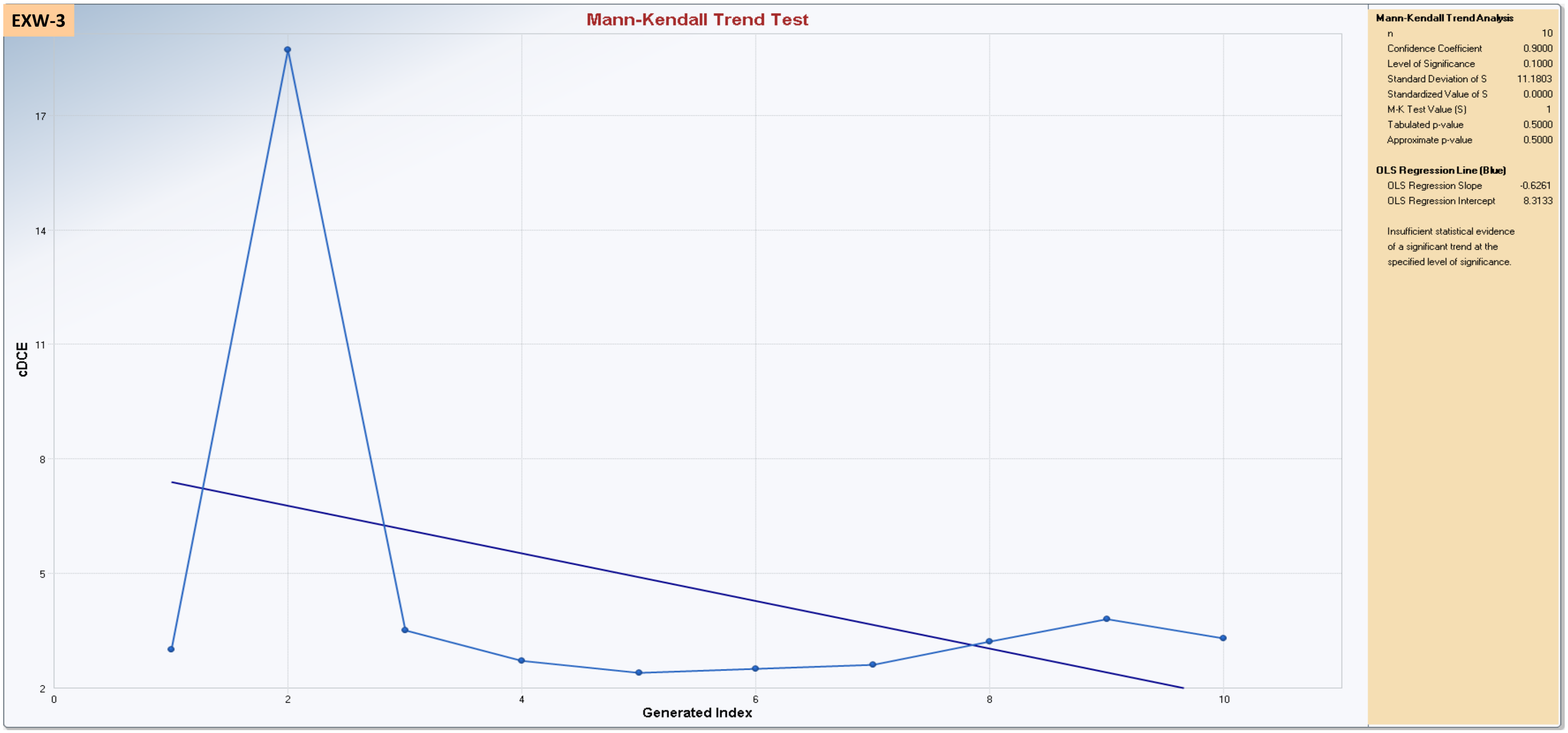
Appendix A

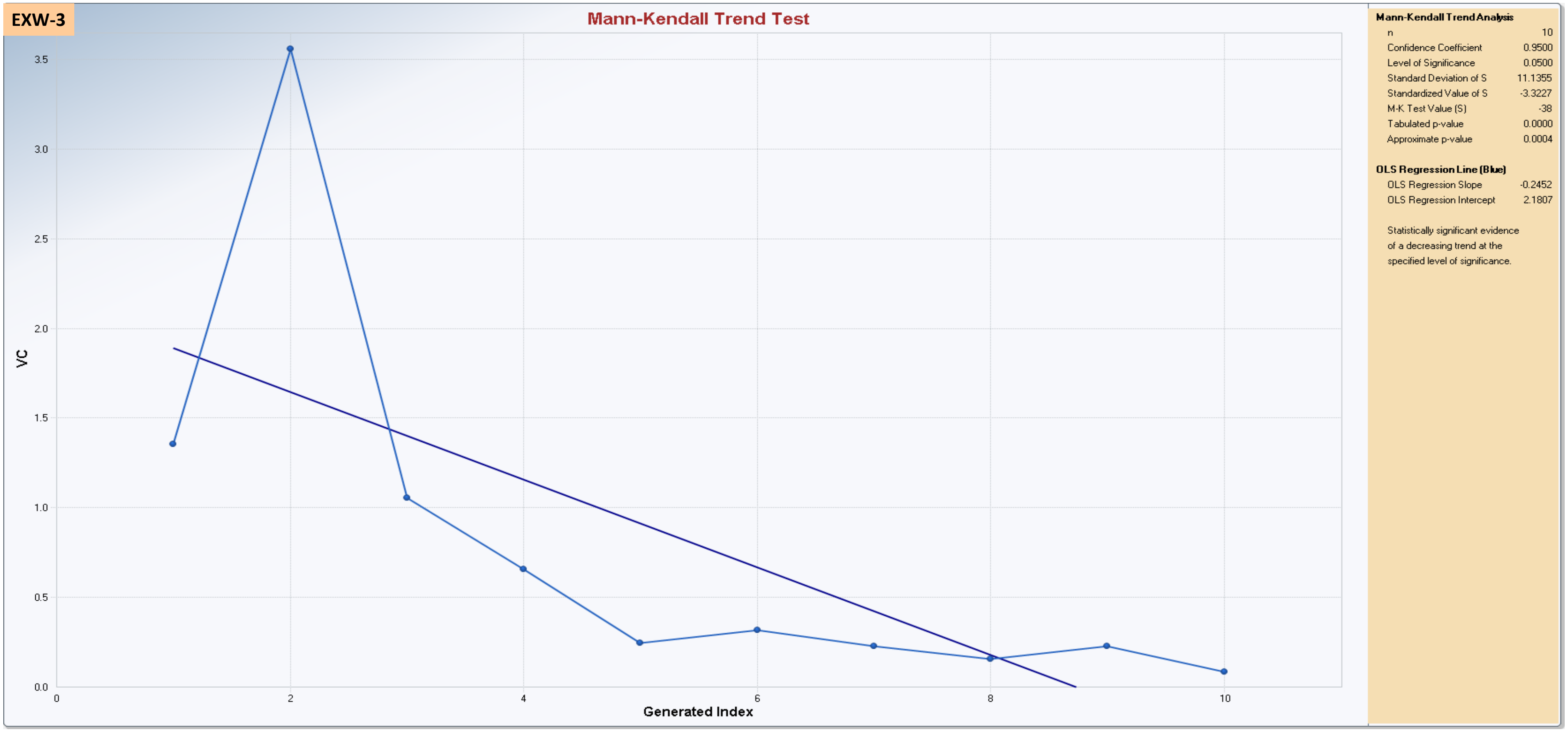
Mann-Kendall Test Results



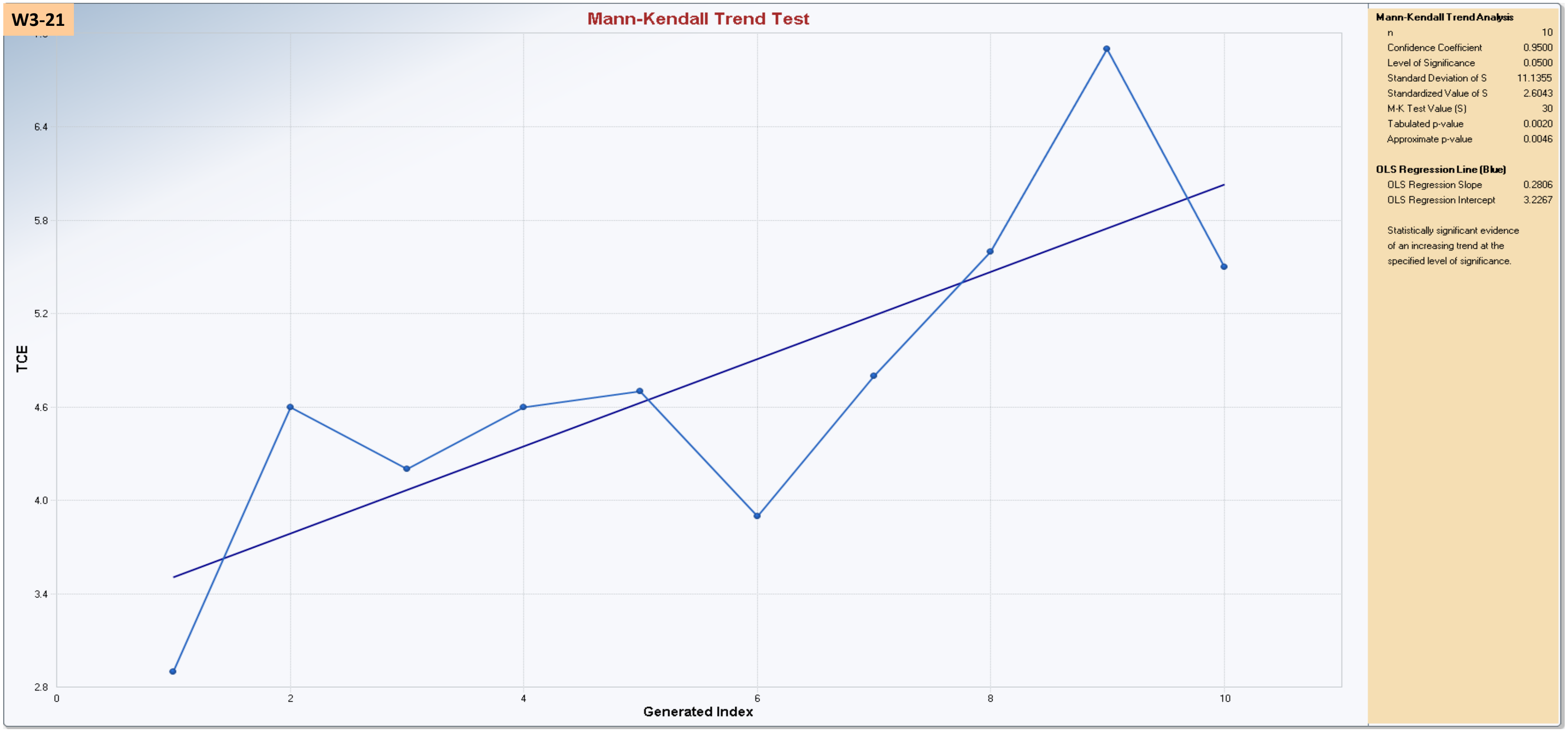
EXW-3
Mann-Kendall Trend Test
PCE
Generated Index
3.2
3.0
2.8
2.6
2.4
2.2
2.0
1.8
0
2
4
6
8
10
Mann-Kendall Trend Analysis
n 10
Confidence Coefficient 0.9000
Level of Significance 0.1000
Standard Deviation of S 11.0905
Standardized Value of S 1.4427
M-K Test Value (S) 17
Tabulated p-value 0.0780
Approximate p-value 0.0746
OLS Regression Line (Blue)
OLS Regression Slope 0.0903
OLS Regression Intercept 2.0133
Statistically significant evidence
of an increasing trend at the
specified level of significance.


EXW-3
Mann-Kendall Trend Test
TCE
Generated Index
0
2
4
6
8
10
6
7
8
9
10
11
Mann-Kendall Trend Analysis
n 10
Confidence Coefficient 0.9500
Level of Significance 0.0500
Standard Deviation of S 11.1355
Standardized Value of S 2.2451
M-K Test Value (S) 26
Tabulated p-value 0.0080
Approximate p-value 0.0124
OLS Regression Line (Blue)
OLS Regression Slope 0.3764
OLS Regression Intercept 6.2200
Statistically significant evidence
of an increasing trend at the
specified level of significance.

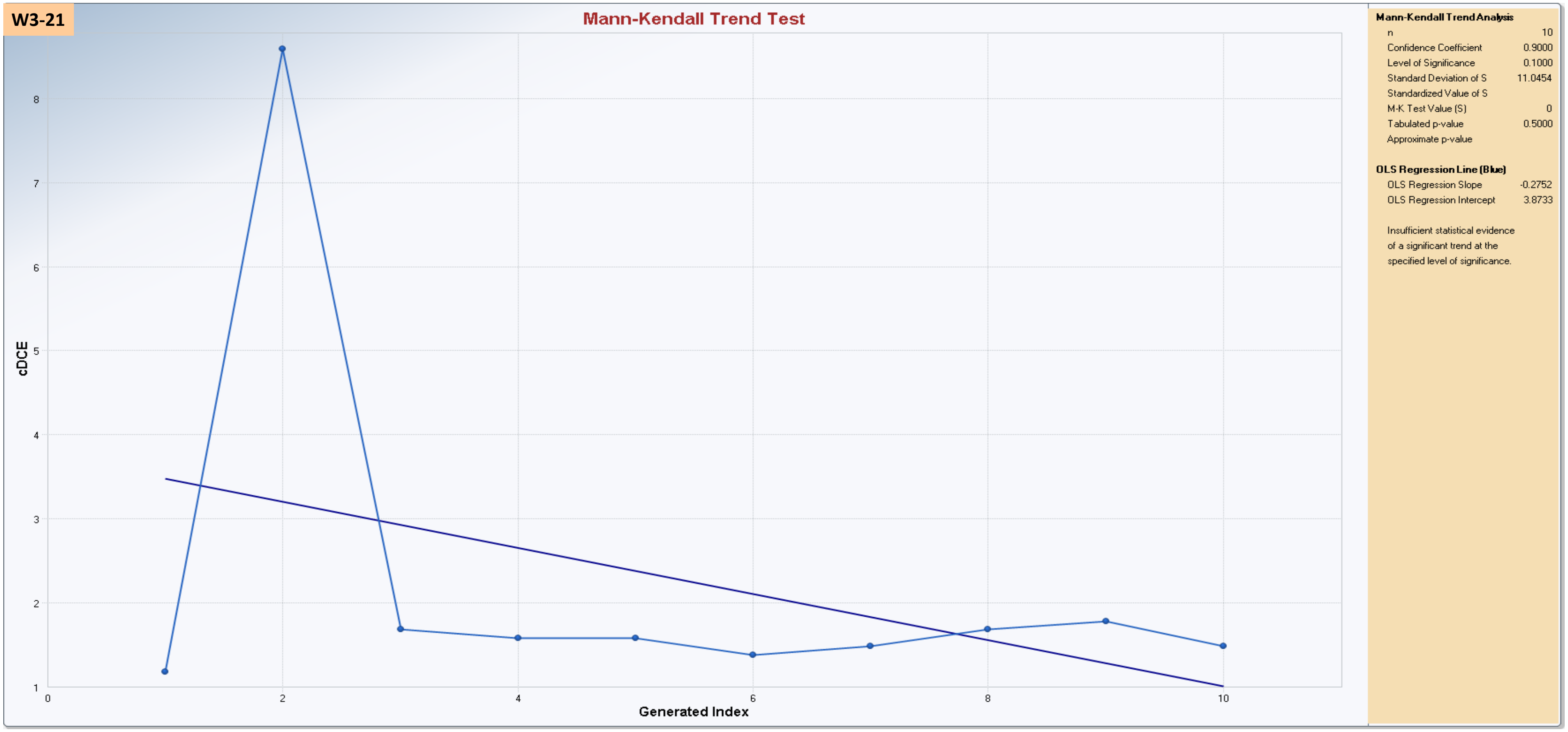

EXW-3
Mann-Kendall Trend Test
cDCE
Generated Index
Mann-Kendall Trend Analysis
n 10
Confidence Coefficient 0.9000
Level of Significance 0.1000
Standard Deviation of S 11.1803
Standardized Value of S 0.0000
M-K Test Value (S) 1
Tabulated p-value 0.5000
Approximate p-value 0.5000
OLS Regression Line (Blue)
OLS Regression Slope -0.6261
OLS Regression Intercept 8.3133
Insufficient statistical evidence
of a significant trend at the
specified level of significance.

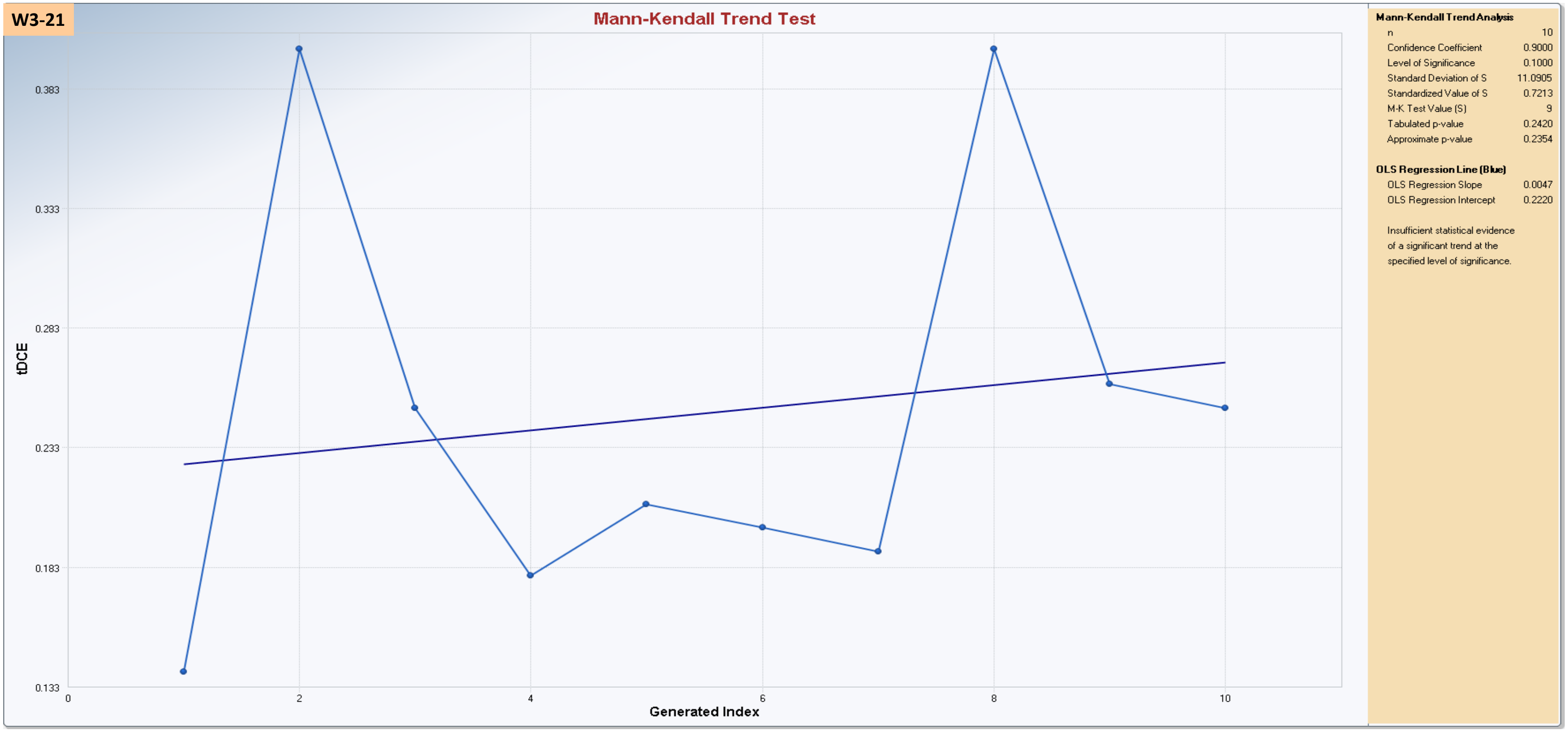


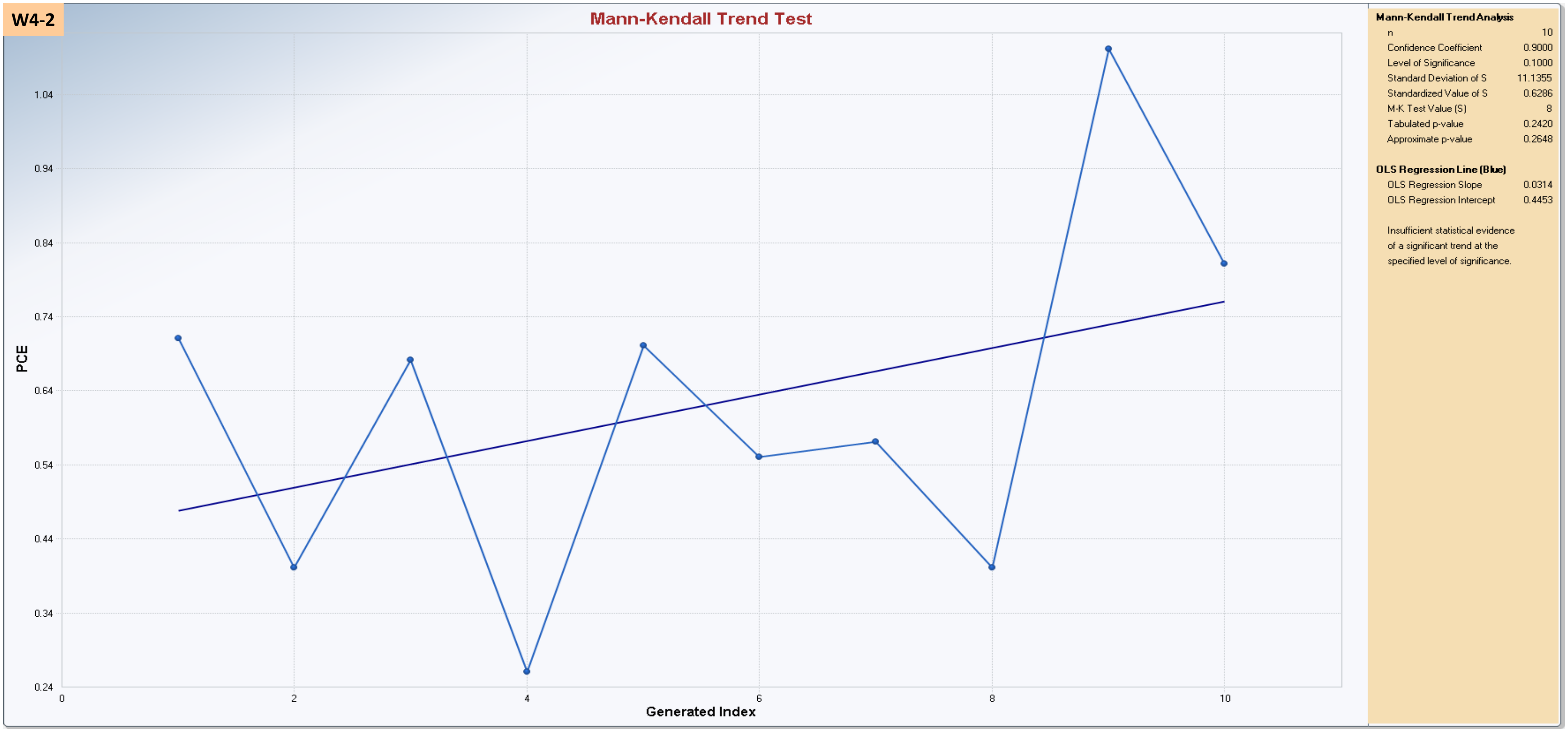
EXW-3
Mann-Kendall Trend Test
VC
Generated Index
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
0
2
4
6
8
10
Mann-Kendall Trend Analysis
n 10
Confidence Coefficient 0.9500
Level of Significance 0.0500
Standard Deviation of S 11.1355
Standardized Value of S -3.3227
M-K Test Value (S) -38
Tabulated p-value 0.0000
Approximate p-value 0.0004
OLS Regression Line (Blue)
OLS Regression Slope -0.2452
OLS Regression Intercept 2.1807
Statistically significant evidence
of a decreasing trend at the
specified level of significance.



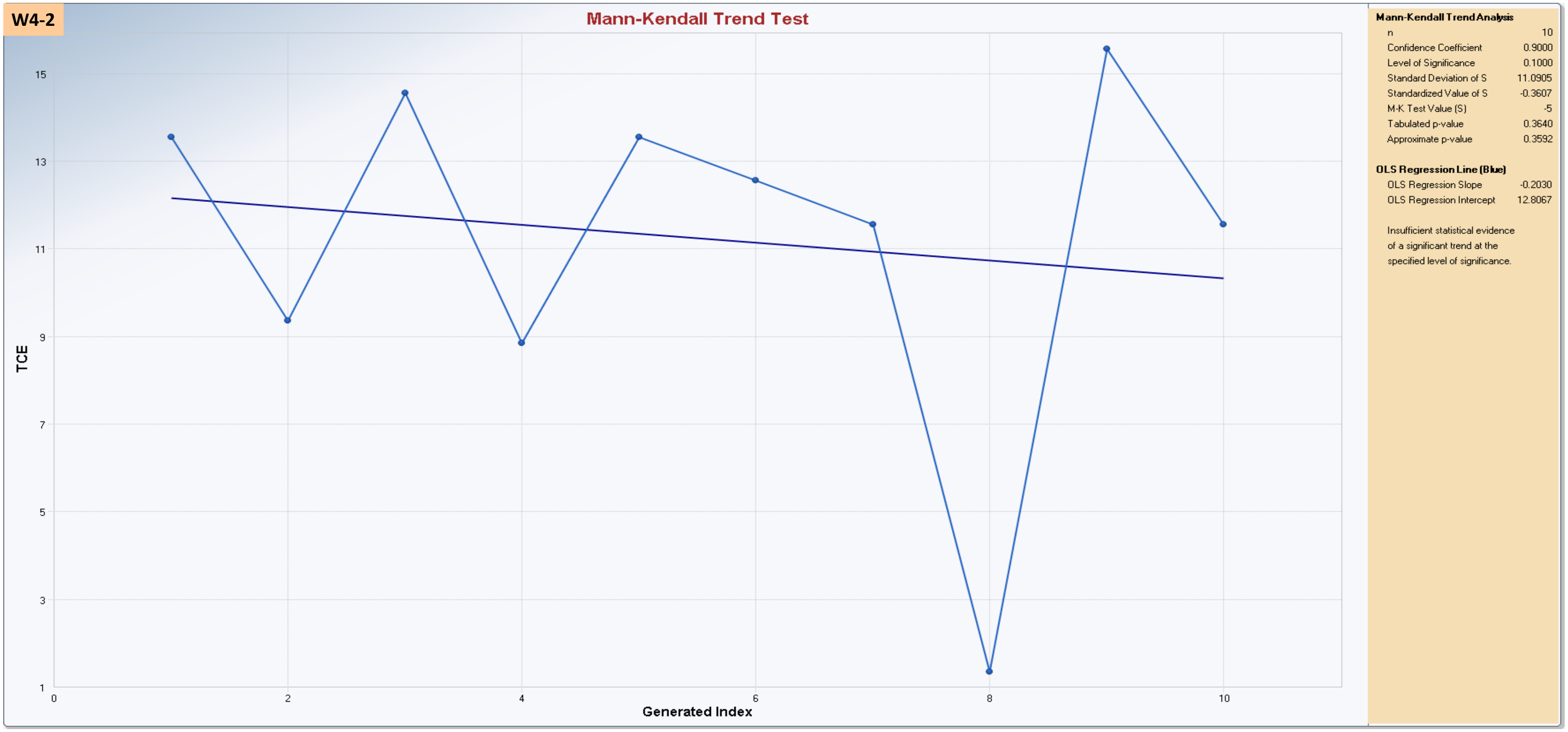
W3-21
Mann-Kendall Trend Test
TCE
Generated Index
6.4
5.8
5.2
4.6
4.0
3.4
2.8
0
2
4
6
8
10
Mann-Kendall Trend Analysis
n 10
Confidence Coefficient 0.9500
Level of Significance 0.0500
Standard Deviation of S 11.1355
Standardized Value of S 2.6043
M-K Test Value (S) 30
Tabulated p-value 0.0020
Approximate p-value 0.0046
OLS Regression Line (Blue)
OLS Regression Slope 0.2806
OLS Regression Intercept 3.2267
Statistically significant evidence of an increasing trend at the specified level of significance.

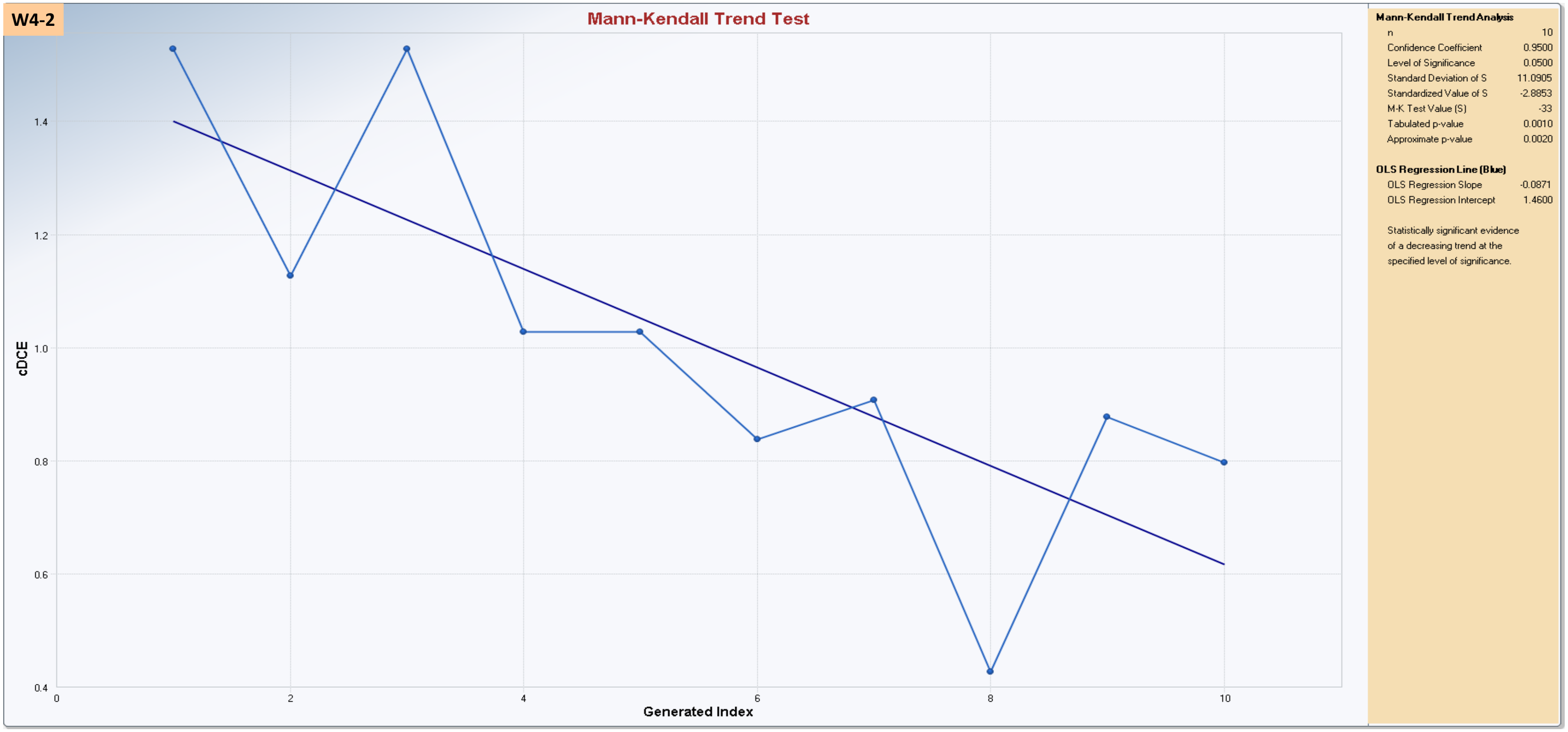

W3-21
Mann-Kendall Trend Test
cDCE
Generated Index
Mann-Kendall Trend Analysis
n 10
Confidence Coefficient 0.9000
Level of Significance 0.1000
Standard Deviation of S 11.0454
Standardized Value of S
M-K Test Value (S) 0
Tabulated p-value 0.5000
Approximate p-value
OLS Regression Line (Blue)
OLS Regression Slope -0.2752
OLS Regression Intercept 3.8733
Insufficient statistical evidence of a significant trend at the specified level of significance.


W3-21
Mann-Kendall Trend Test
tDCE
0.383
0.333
0.283
0.233
0.183
0.133
0
2
4
6
8
10
Generated Index
Mann-Kendall Trend Analysis
n 10
Confidence Coefficient 0.9000
Level of Significance 0.1000
Standard Deviation of S 11.0905
Standardized Value of S 0.7213
M-K Test Value (S) 9
Tabulated p-value 0.2420
Approximate p-value 0.2354
OLS Regression Line (Blue)
OLS Regression Slope 0.0047
OLS Regression Intercept 0.2220
Insufficient statistical evidence of a significant trend at the specified level of significance.



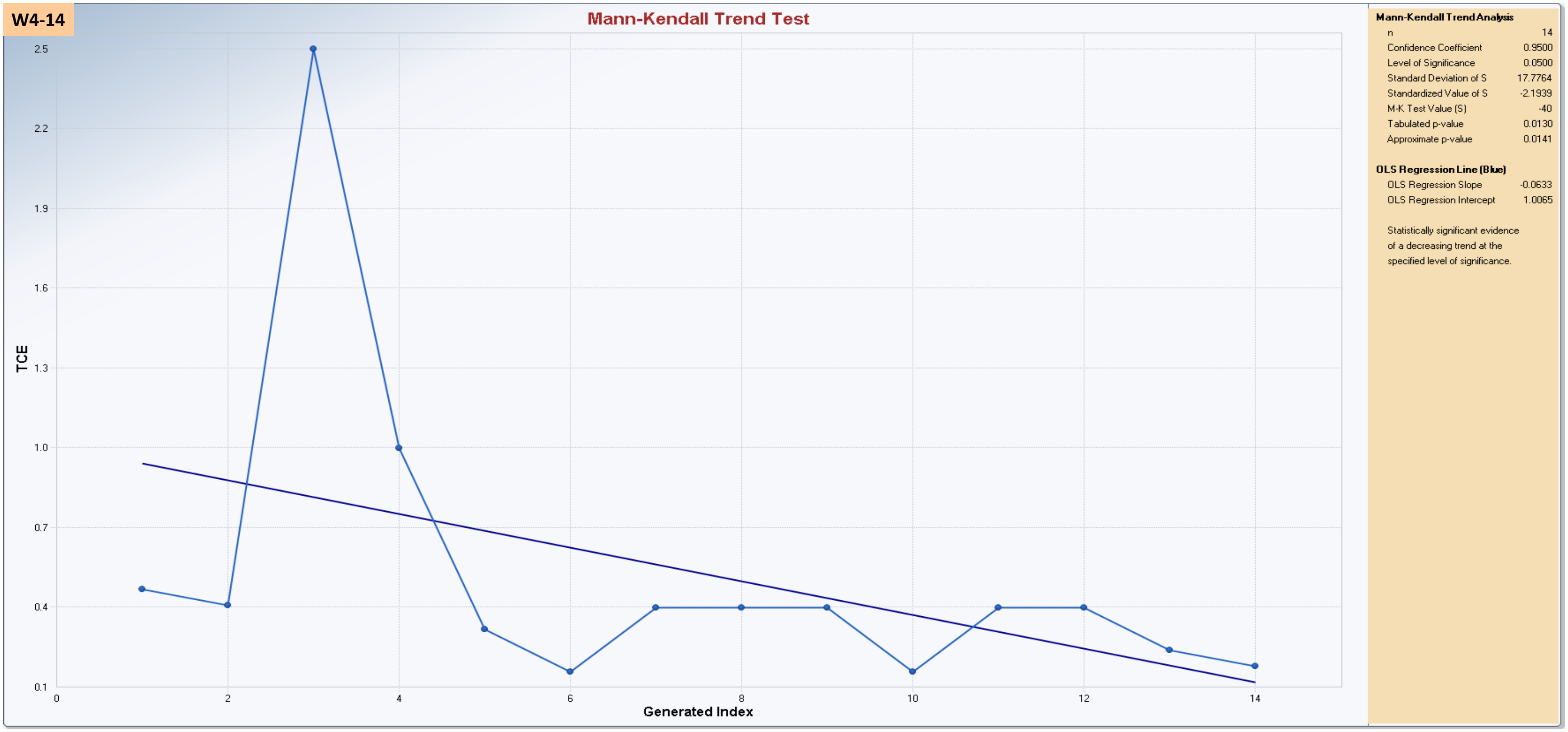
W4-2
Mann-Kendall Trend Test
1.04
0.94
0.84
0.74
0.64
0.54
0.44
0.34
0.24
PCE
0
2
4
6
8
10
Generated Index
Mann-Kendall Trend Analysis
n 10
Confidence Coefficient 0.9000
Level of Significance 0.1000
Standard Deviation of S 11.1355
Standardized Value of S 0.6286
M-K Test Value (S) 8
Tabulated p-value 0.2420
Approximate p-value 0.2648
OLS Regression Line (Blue)
OLS Regression Slope 0.0314
OLS Regression Intercept 0.4453
Insufficient statistical evidence
of a significant trend at the
specified level of significance.

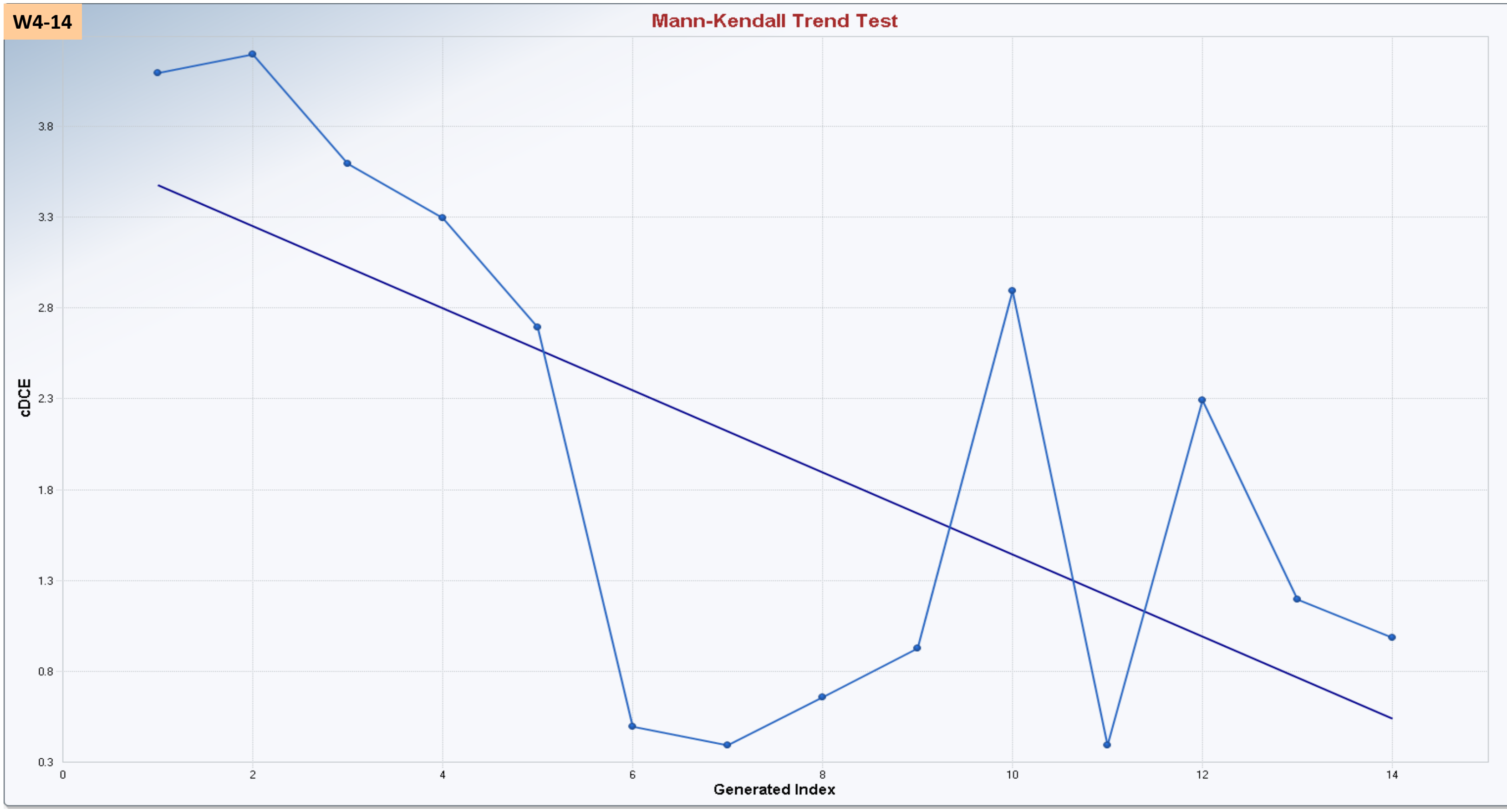

W4-2
Mann-Kendall Trend Test
TCE
Generated Index
15
13
11
9
7
5
3
1
0
2
4
6
8
10
Mann-Kendall Trend Analysis
n 10
Confidence Coefficient 0.9000
Level of Significance 0.1000
Standard Deviation of S 11.0905
Standardized Value of S -0.3607
M-K Test Value (S) -5
Tabulated p-value 0.3640
Approximate p-value 0.3592
OLS Regression Line (Blue)
OLS Regression Slope -0.2030
OLS Regression Intercept 12.8067
Insufficient statistical evidence
of a significant trend at the
specified level of significance.



W4-2
Mann-Kendall Trend Test
cDCE
Generated Index
0
2
4
6
8
10
0.4
0.6
0.8
1.0
1.2
1.4
Mann-Kendall Trend Analysis
n 10
Confidence Coefficient 0.9500
Level of Significance 0.0500
Standard Deviation of S 11.0905
Standardized Value of S -2.8853
M-K Test Value (S) -33
Tabulated p-value 0.0010
Approximate p-value 0.0020
OLS Regression Line (Blue)
OLS Regression Slope -0.0871
OLS Regression Intercept 1.4600
Statistically significant evidence
of a decreasing trend at the
specified level of significance.


W4-2
Mann-Kendall Trend Test
tDCE
0.91
0.81
0.71
0.61
0.51
0.41
0.31
0
2
4
6
8
10
Generated Index
Mann-Kendall Trend Analysis
n 10
Confidence Coefficient 0.9500
Level of Significance 0.0500
Standard Deviation of S 11.1355
Standardized Value of S -2.2451
M-K Test Value (S) -26
Tabulated p-value 0.0080
Approximate p-value 0.0124
OLS Regression Line (Blue)
OLS Regression Slope -0.0463
OLS Regression Intercept 0.7927
Statistically significant evidence
of a decreasing trend at the
specified level of significance.


W4-14
Mann-Kendall Trend Test
TCE
Generated Index
Mann-Kendall Trend Analysis
n 14
Confidence Coefficient 0.9500
Level of Significance 0.0500
Standard Deviation of S 17.7764
Standardized Value of S -2.1939
M-K Test Value (S) -40
Tabulated p-value 0.0130
Approximate p-value 0.0141
OLS Regression Line (Blue)
OLS Regression Slope -0.0633
OLS Regression Intercept 1.0065
Statistically significant evidence
of a decreasing trend at the
specified level of significance.



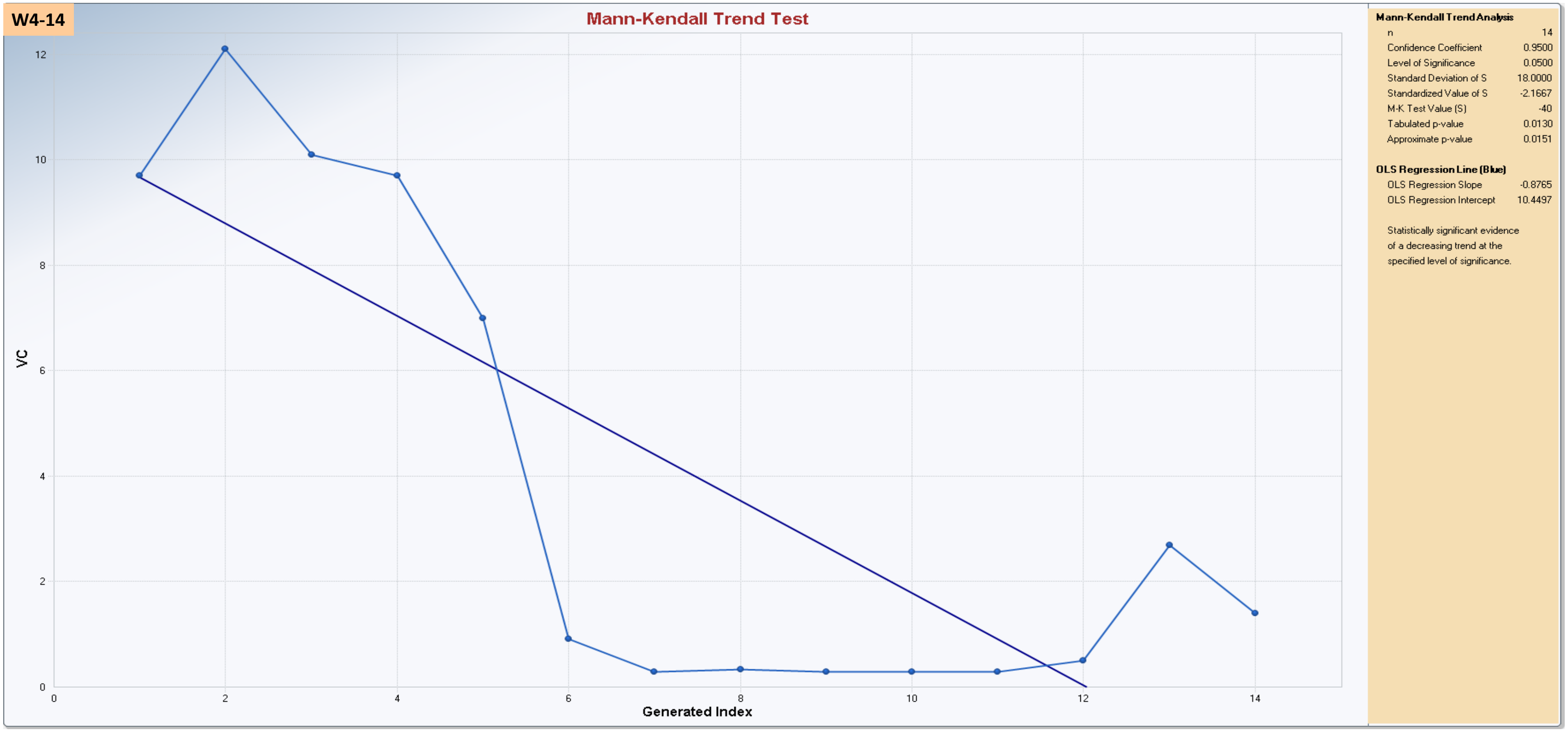
Mann-Kendall Trend Analysis

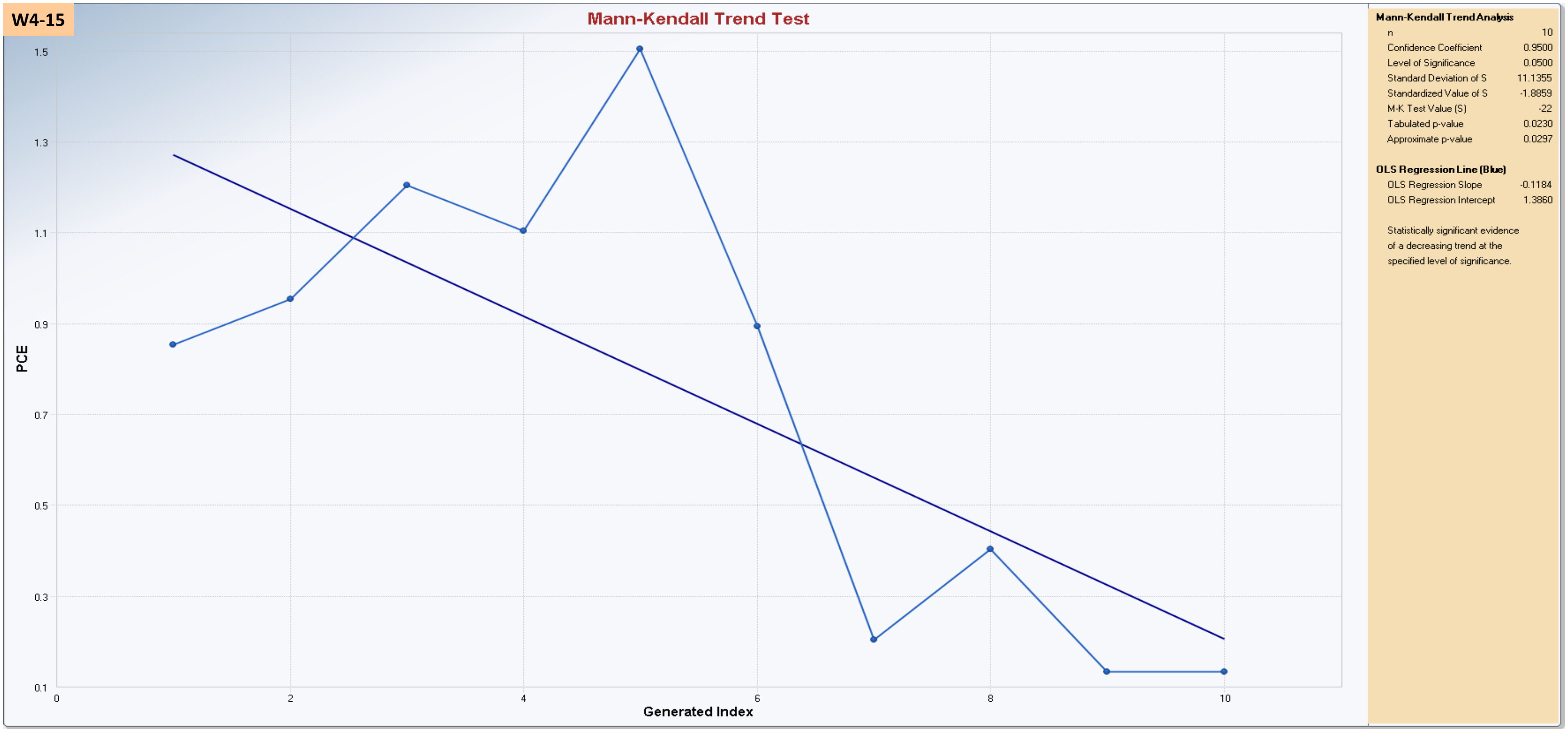
n	14
Confidence Coefficient	0.9500
Level of Significance	0.0500
Standard Deviation of S	18.2392
Standardized Value of S	-2.0286
M-K Test Value (S)	-38
Tabulated p-value	0.0180
Approximate p-value	0.0212

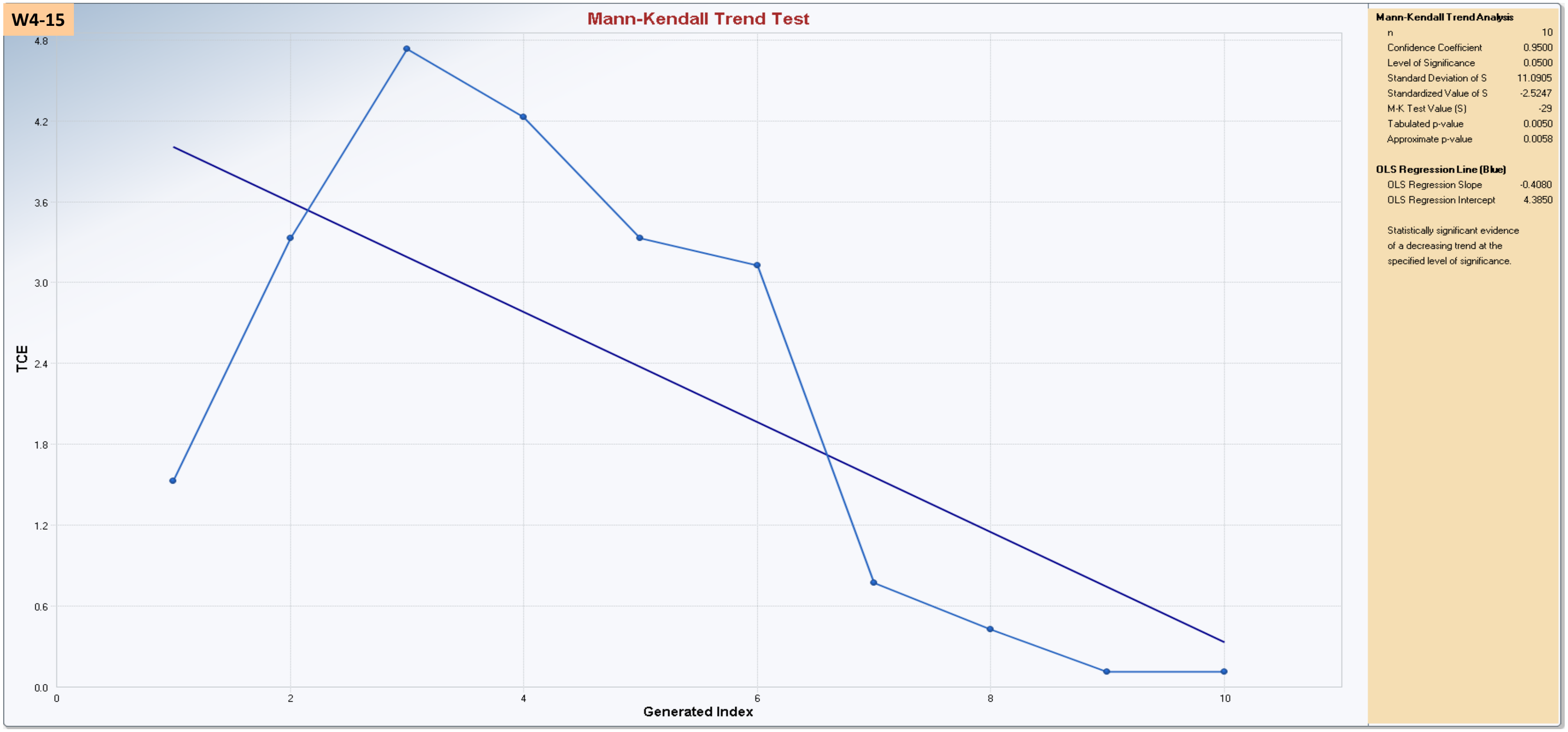
OLS Regression Line (Blue)

OLS Regression Slope	-0.2261
OLS Regression Intercept	3.7087

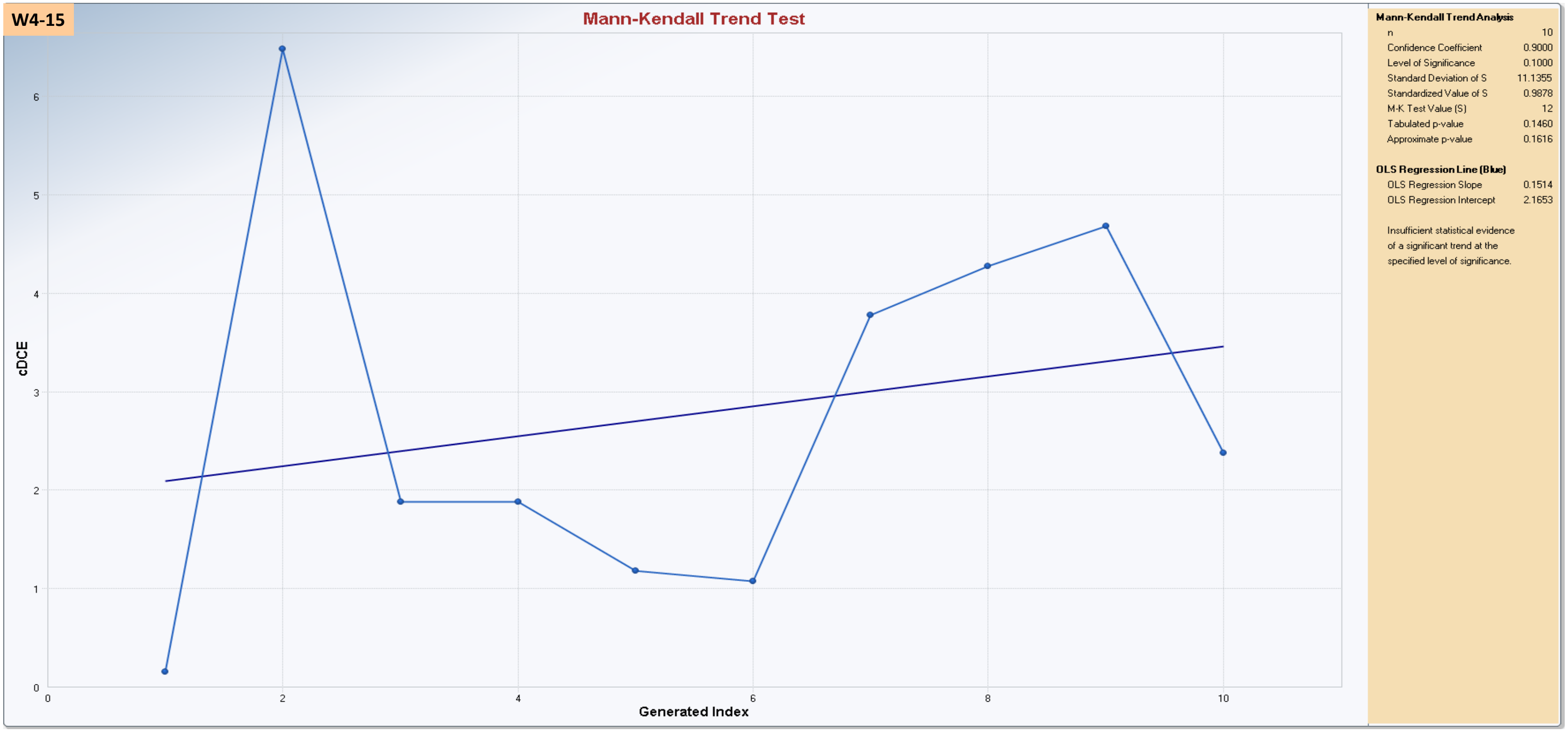
Statistically significant evidence of a decreasing trend at the specified level of significance.

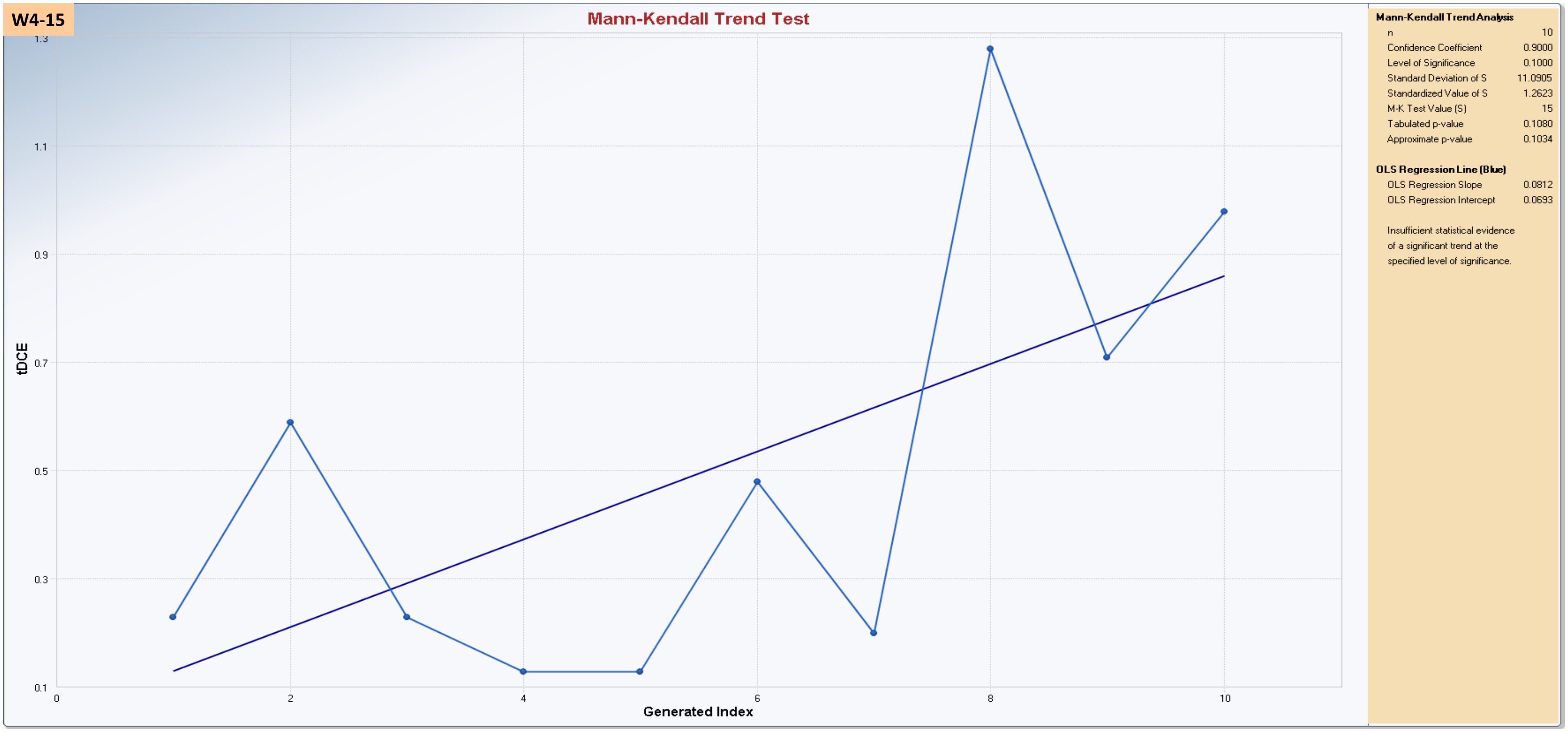

W4-14
Mann-Kendall Trend Test
VC
Generated Index
0
2
4
6
8
10
12
14
Mann-Kendall Trend Analysis
n 14
Confidence Coefficient 0.9500
Level of Significance 0.0500
Standard Deviation of S 18.0000
Standardized Value of S -2.1667
M-K Test Value (S) -40
Tabulated p-value 0.0130
Approximate p-value 0.0151
OLS Regression Line (Blue)
OLS Regression Slope -0.8765
OLS Regression Intercept 10.4497
Statistically significant evidence
of a decreasing trend at the
specified level of significance.

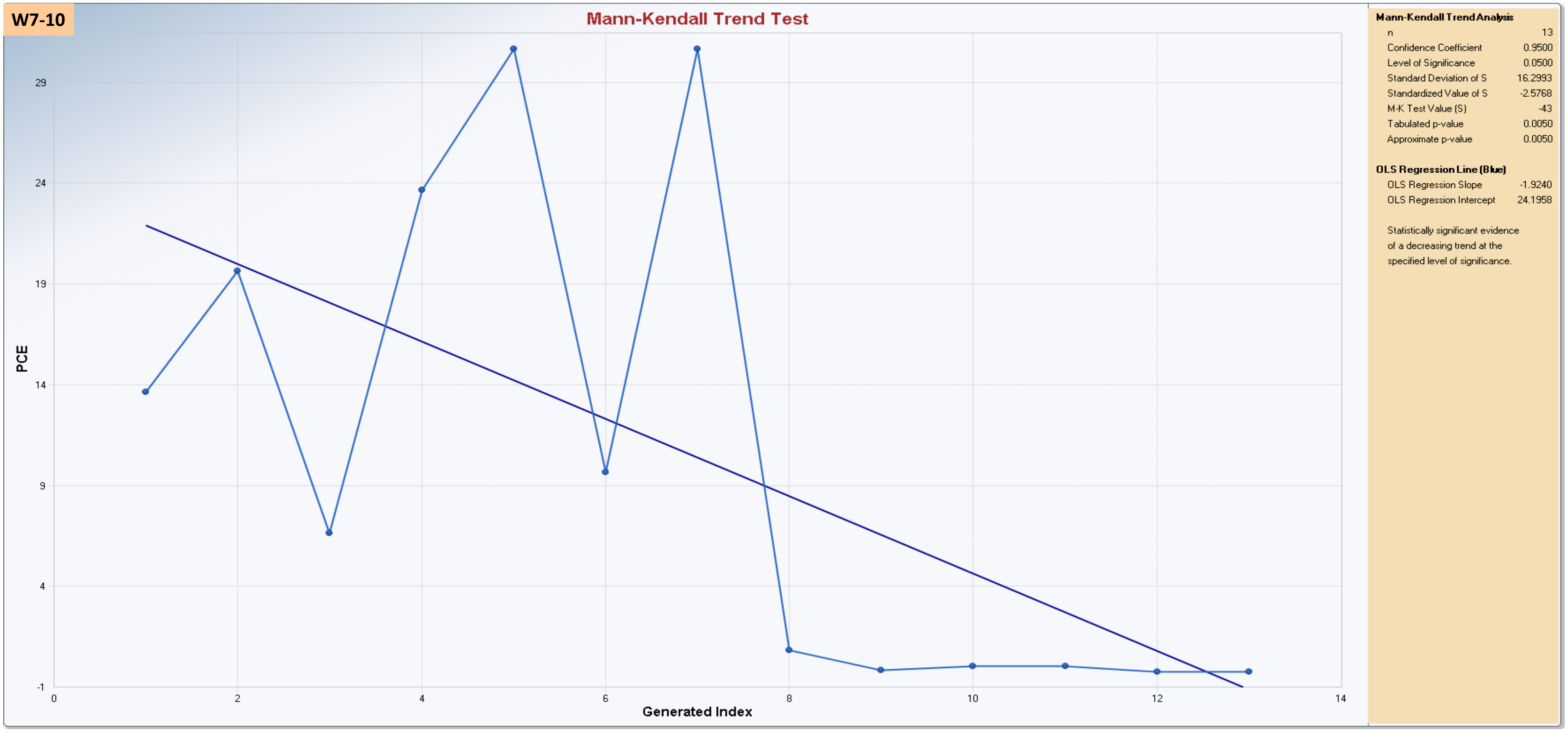

W4-15
Mann-Kendall Trend Test
PCE
Generated Index
1.5
1.3
1.1
0.9
0.7
0.5
0.3
0.1
0
2
4
6
8
10
Mann-Kendall Trend Analysis
n 10
Confidence Coefficient 0.9500
Level of Significance 0.0500
Standard Deviation of S 11.1355
Standardized Value of S -1.8859
M-K Test Value (S) -22
Tabulated p-value 0.0230
Approximate p-value 0.0297
OLS Regression Line (Blue)
OLS Regression Slope -0.1184
OLS Regression Intercept 1.3860
Statistically significant evidence
of a decreasing trend at the
specified level of significance.

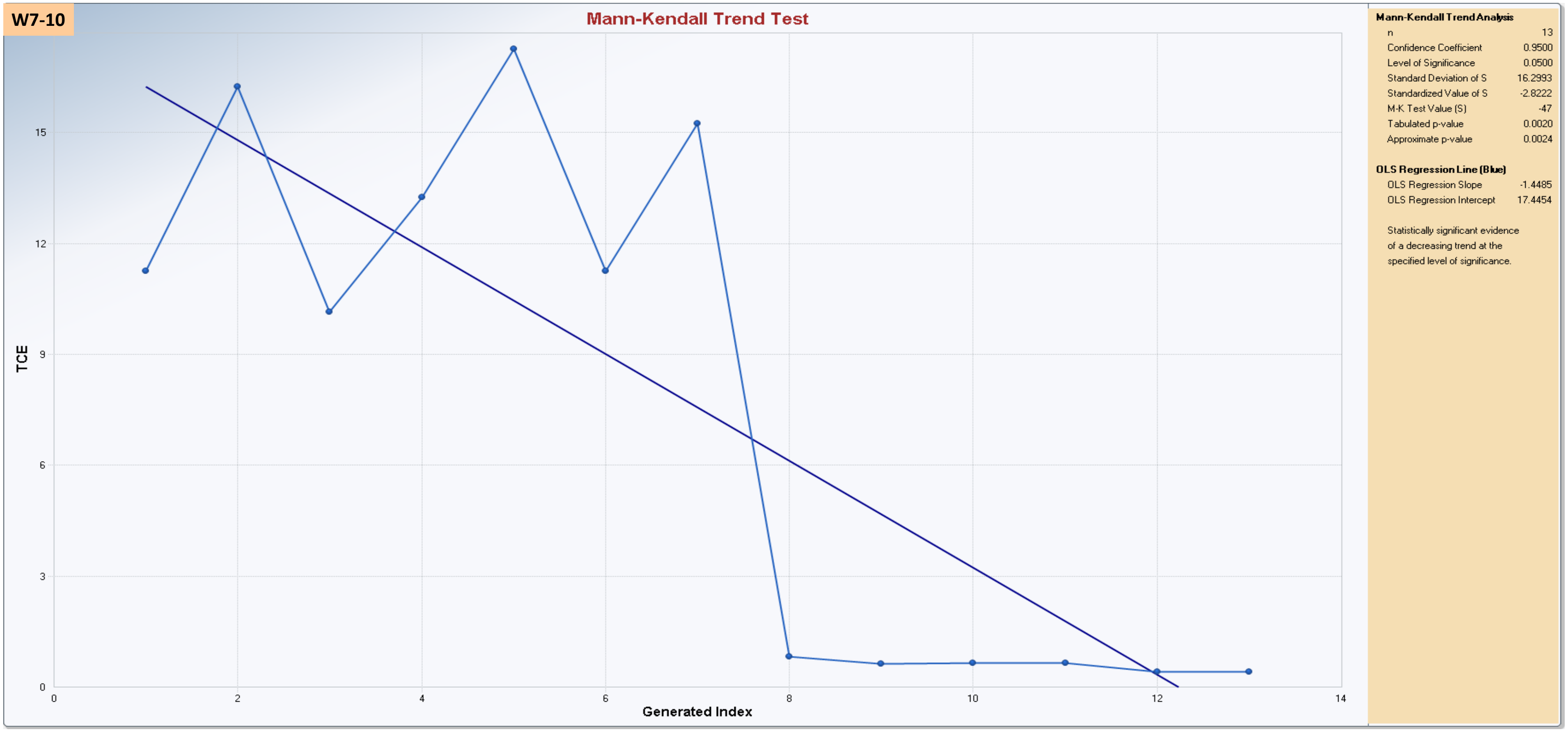


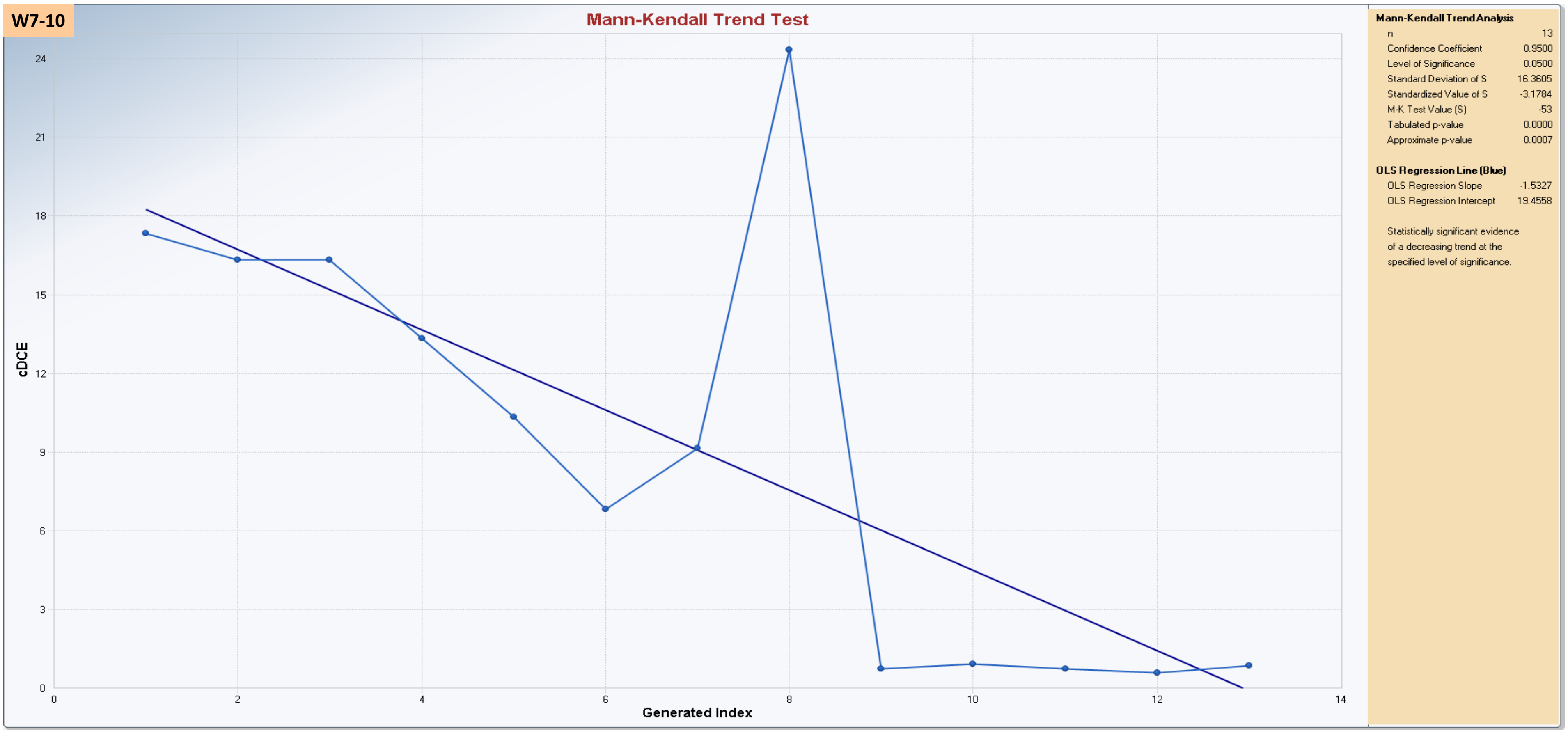
W4-15
Mann-Kendall Trend Test
TCE
Generated Index
4.8
4.2
3.6
3.0
2.4
1.8
1.2
0.6
0.0
0
2
4
6
8
10
Mann-Kendall Trend Analysis
n 10
Confidence Coefficient 0.9500
Level of Significance 0.0500
Standard Deviation of S 11.0905
Standardized Value of S -2.5247
M-K Test Value (S) -29
Tabulated p-value 0.0050
Approximate p-value 0.0058
OLS Regression Line (Blue)
OLS Regression Slope -0.4080
OLS Regression Intercept 4.3850
Statistically significant evidence of a decreasing trend at the specified level of significance.

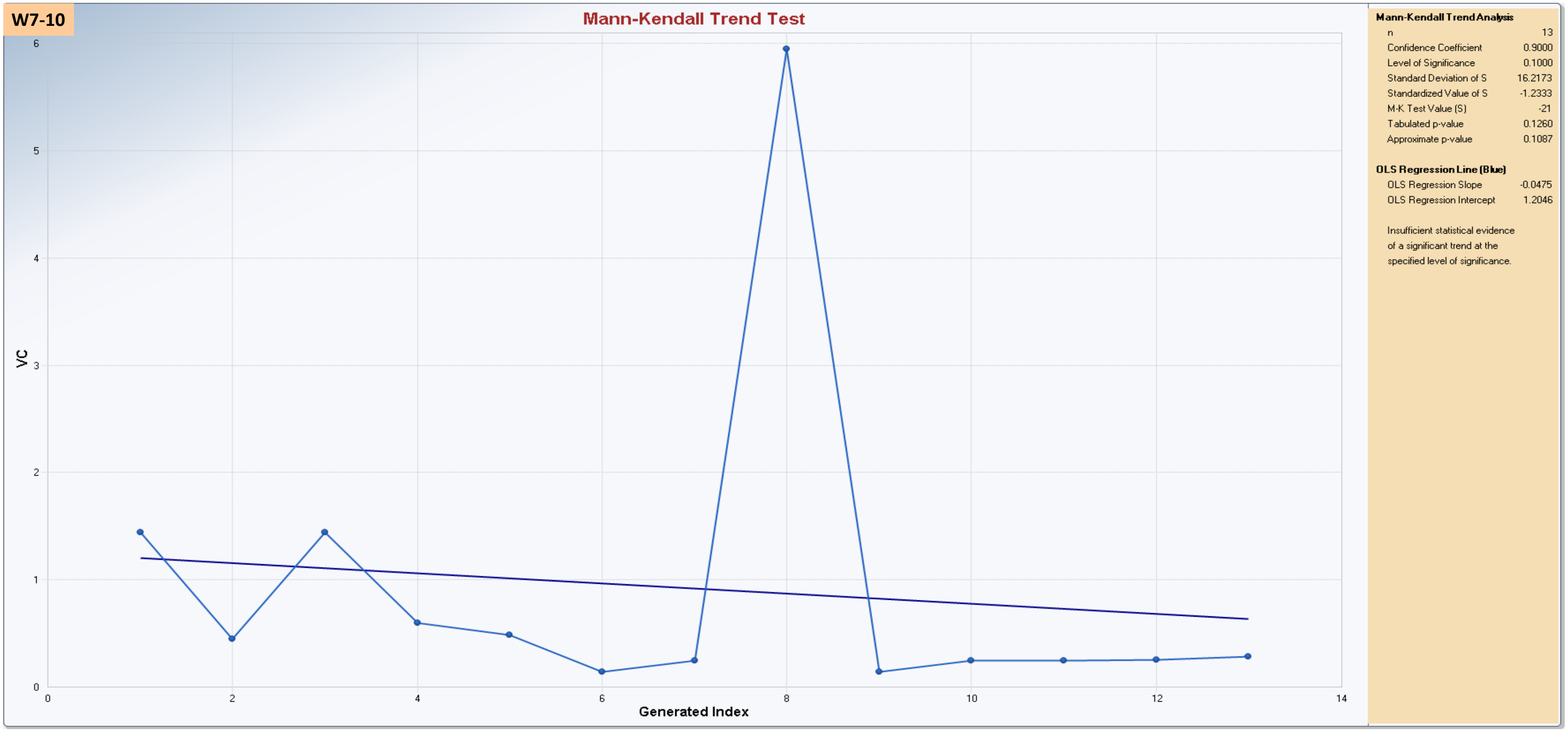

W4-15
Mann-Kendall Trend Test
cDCE
Generated Index
0
1
2
3
4
5
6
0
2
4
6
8
10
Mann-Kendall Trend Analysis
n 10
Confidence Coefficient 0.9000
Level of Significance 0.1000
Standard Deviation of S 11.1355
Standardized Value of S 0.9878
M-K Test Value (S) 12
Tabulated p-value 0.1460
Approximate p-value 0.1616
OLS Regression Line (Blue)
OLS Regression Slope 0.1514
OLS Regression Intercept 2.1653
Insufficient statistical evidence
of a significant trend at the
specified level of significance.

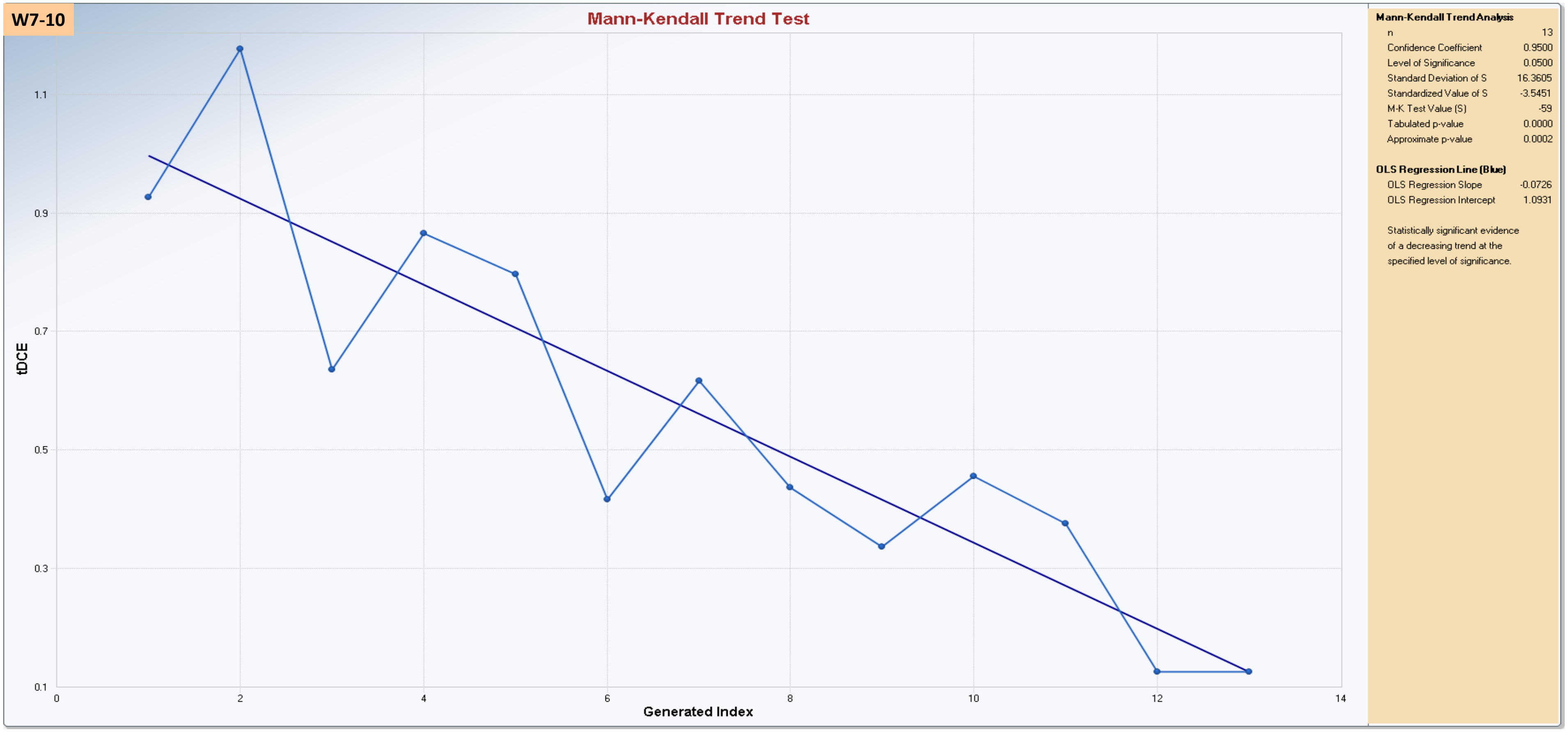

W4-15
Mann-Kendall Trend Test
tDCE
Generated Index
0.1
0.3
0.5
0.7
0.9
1.1
1.3
0
2
4
6
8
10
Mann-Kendall Trend Analysis
n 10
Confidence Coefficient 0.9000
Level of Significance 0.1000
Standard Deviation of S 11.0905
Standardized Value of S 1.2623
M-K Test Value (S) 15
Tabulated p-value 0.1080
Approximate p-value 0.1034
OLS Regression Line (Blue)
OLS Regression Slope 0.0812
OLS Regression Intercept 0.0693
Insufficient statistical evidence
of a significant trend at the
specified level of significance.

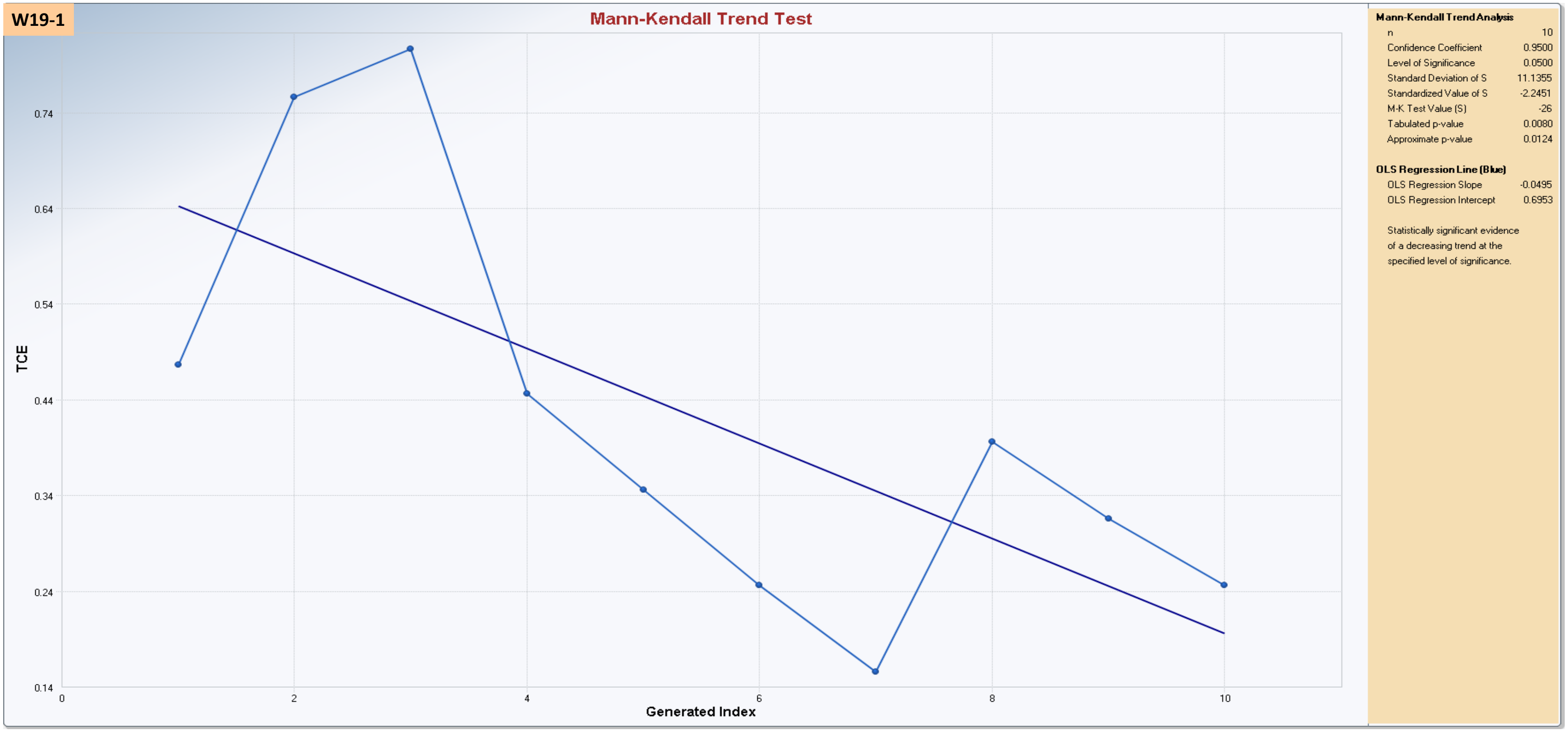

W7-10
Mann-Kendall Trend Test
PCE
Generated Index
Mann-Kendall Trend Analysis
n 13
Confidence Coefficient 0.9500
Level of Significance 0.0500
Standard Deviation of S 16.2993
Standardized Value of S -2.5768
M-K Test Value (S) -43
Tabulated p-value 0.0050
Approximate p-value 0.0050
OLS Regression Line (Blue)
OLS Regression Slope -1.9240
OLS Regression Intercept 24.1958
Statistically significant evidence
of a decreasing trend at the
specified level of significance.

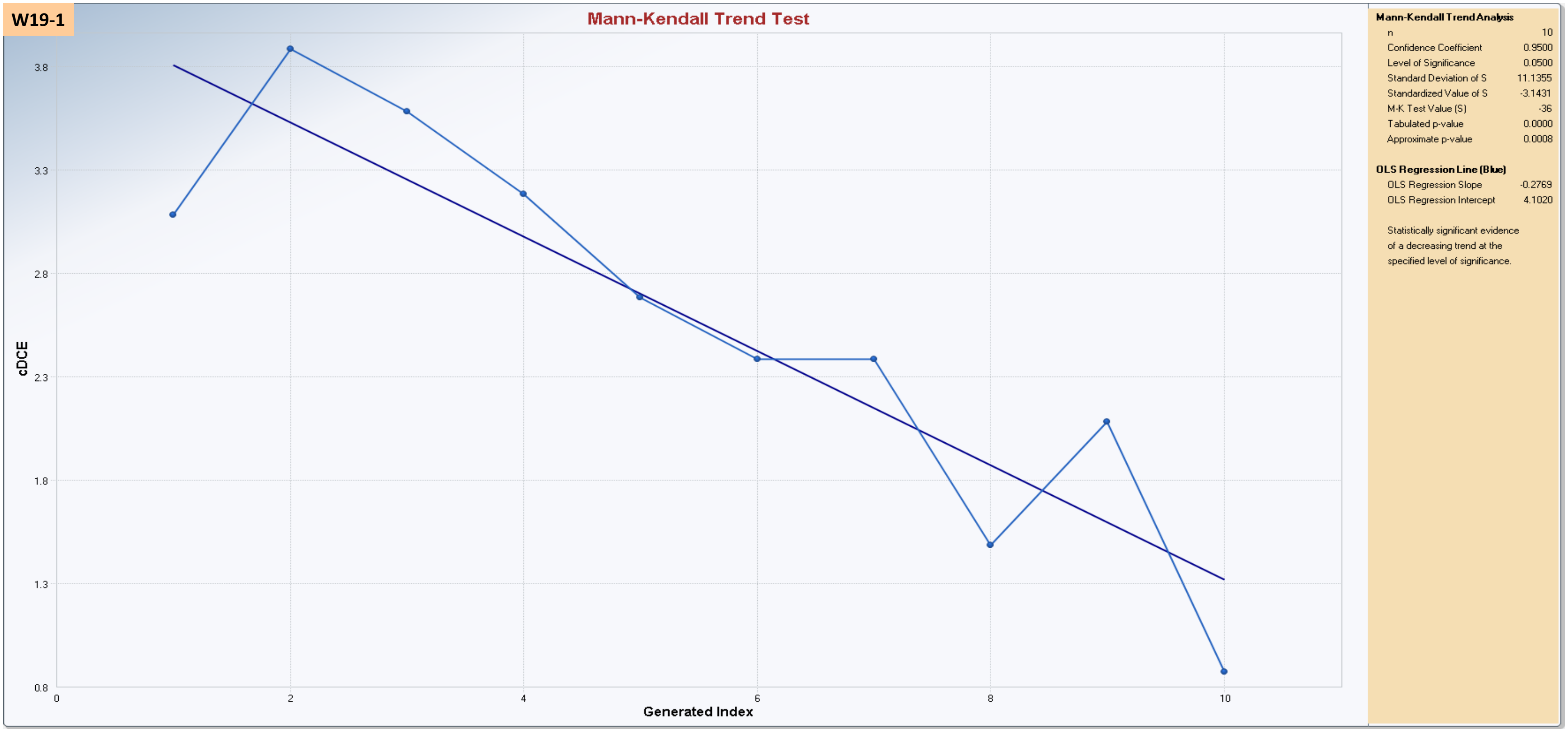

W7-10
Mann-Kendall Trend Test
TCE
Generated Index
0
3
6
9
12
15
0
2
4
6
8
10
12
14
Mann-Kendall Trend Analysis
n 13
Confidence Coefficient 0.9500
Level of Significance 0.0500
Standard Deviation of S 16.2993
Standardized Value of S -2.8222
M-K Test Value (S) -47
Tabulated p-value 0.0020
Approximate p-value 0.0024
OLS Regression Line (Blue)
OLS Regression Slope -1.4485
OLS Regression Intercept 17.4454
Statistically significant evidence
of a decreasing trend at the
specified level of significance.


W7-10
Mann-Kendall Trend Test
cDCE
Generated Index
0
3
6
9
12
15
18
21
24
0
2
4
6
8
10
12
14
Mann-Kendall Trend Analysis
n 13
Confidence Coefficient 0.9500
Level of Significance 0.0500
Standard Deviation of S 16.3605
Standardized Value of S -3.1784
M-K Test Value (S) -53
Tabulated p-value 0.0000
Approximate p-value 0.0007
OLS Regression Line (Blue)
OLS Regression Slope -1.5327
OLS Regression Intercept 19.4558
Statistically significant evidence
of a decreasing trend at the
specified level of significance.


W7-10
Mann-Kendall Trend Test
VC
Generated Index
0
1
2
3
4
5
6
0
2
4
6
8
10
12
14
Mann-Kendall Trend Analysis
n 13
Confidence Coefficient 0.9000
Level of Significance 0.1000
Standard Deviation of S 16.2173
Standardized Value of S -1.2333
M-K Test Value (S) -21
Tabulated p-value 0.1260
Approximate p-value 0.1087
OLS Regression Line (Blue)
OLS Regression Slope -0.0475
OLS Regression Intercept 1.2046
Insufficient statistical evidence
of a significant trend at the
specified level of significance.


W7-10
Mann-Kendall Trend Test
tDCE
Generated Index
Mann-Kendall Trend Analysis
n 13
Confidence Coefficient 0.9500
Level of Significance 0.0500
Standard Deviation of S 16.3605
Standardized Value of S -3.5451
M-K Test Value (S) -59
Tabulated p-value 0.0000
Approximate p-value 0.0002
OLS Regression Line (Blue)
OLS Regression Slope -0.0726
OLS Regression Intercept 1.0931
Statistically significant evidence of a decreasing trend at the specified level of significance.


W19-1
Mann-Kendall Trend Test
TCE
0.14
0.24
0.34
0.44
0.54
0.64
0.74
0
2
4
6
8
10
Generated Index
Mann-Kendall Trend Analysis
n 10
Confidence Coefficient 0.9500
Level of Significance 0.0500
Standard Deviation of S 11.1355
Standardized Value of S -2.2451
M-K Test Value (S) -26
Tabulated p-value 0.0080
Approximate p-value 0.0124
OLS Regression Line (Blue)
OLS Regression Slope -0.0495
OLS Regression Intercept 0.6953
Statistically significant evidence
of a decreasing trend at the
specified level of significance.


W19-1
Mann-Kendall Trend Test
cDCE
3.8
3.3
2.8
2.3
1.8
1.3
0.8
0
2
4
6
8
10
Generated Index
Mann-Kendall Trend Analysis
n 10
Confidence Coefficient 0.9500
Level of Significance 0.0500
Standard Deviation of S 11.1355
Standardized Value of S -3.1431
M-K Test Value (S) -36
Tabulated p-value 0.0000
Approximate p-value 0.0008
OLS Regression Line (Blue)
OLS Regression Slope -0.2769
OLS Regression Intercept 4.1020
Statistically significant evidence
of a decreasing trend at the
specified level of significance.

W19-1

Mann-Kendall Trend Analysis

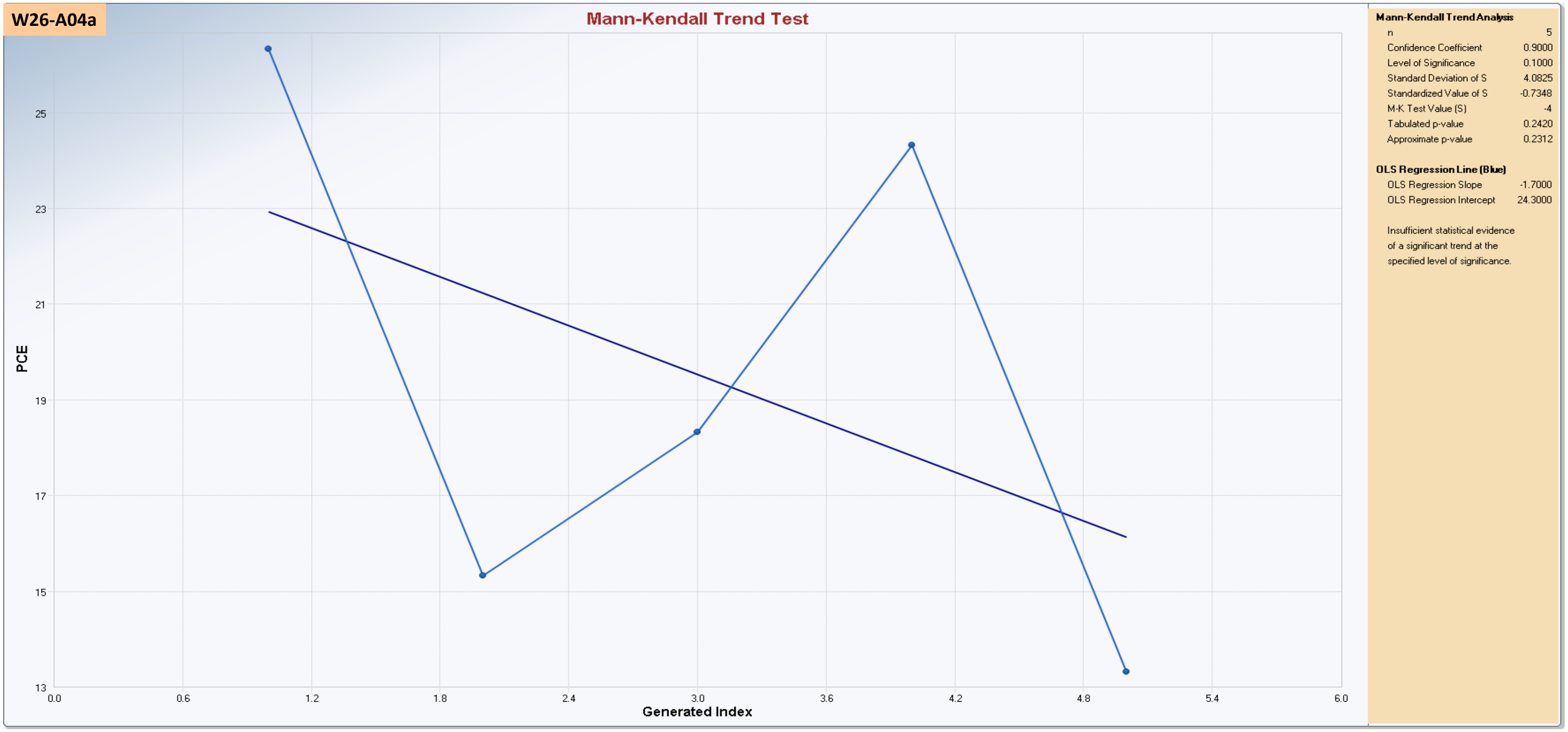
n	10
Confidence Coefficient	0.9500
Level of Significance	0.0500
Standard Deviation of S	11.1355
Standardized Value of S	-2.2451
M-K Test Value (S)	-26
Tabulated p-value	0.0080
Approximate p-value	0.0124

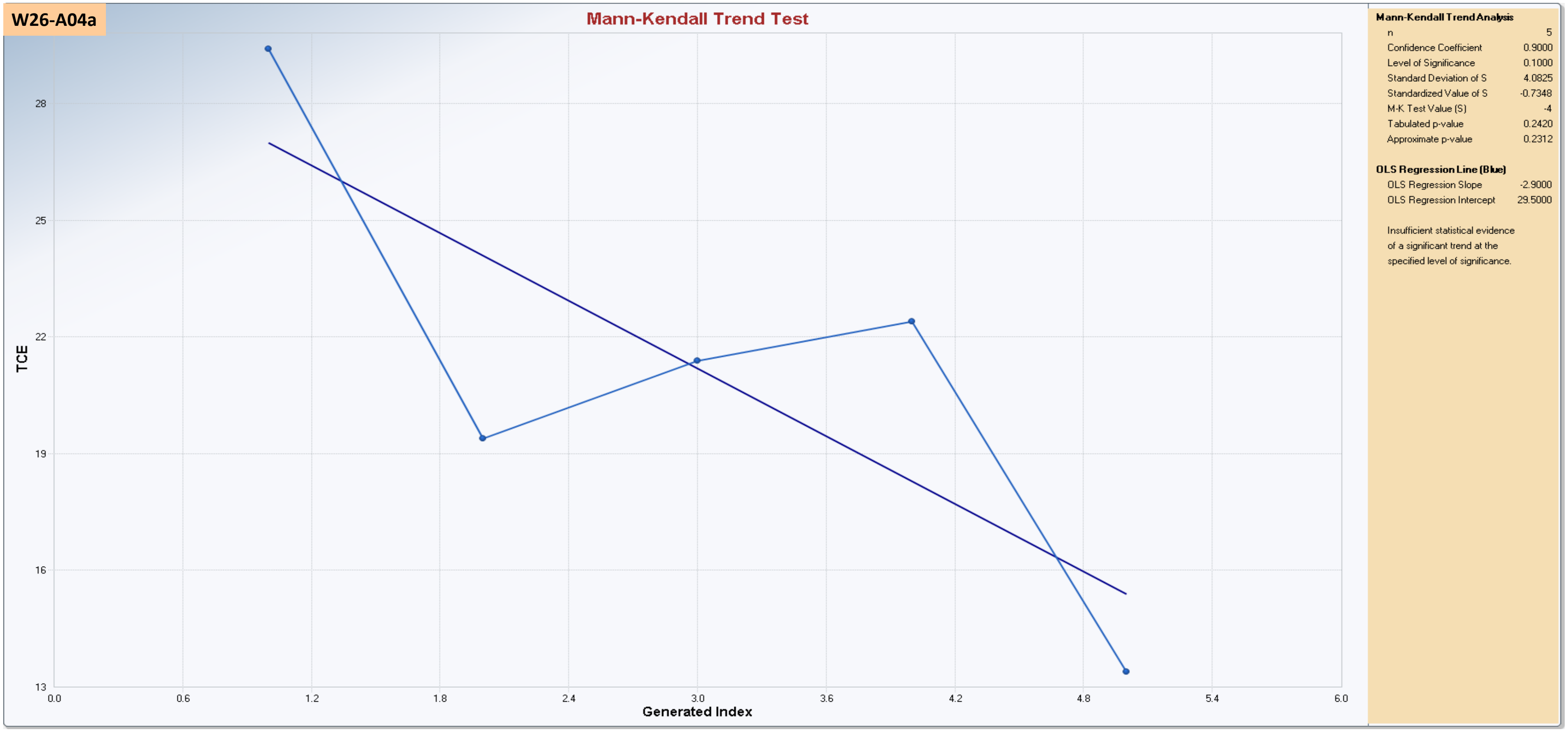
OLS Regression Line (Blue)

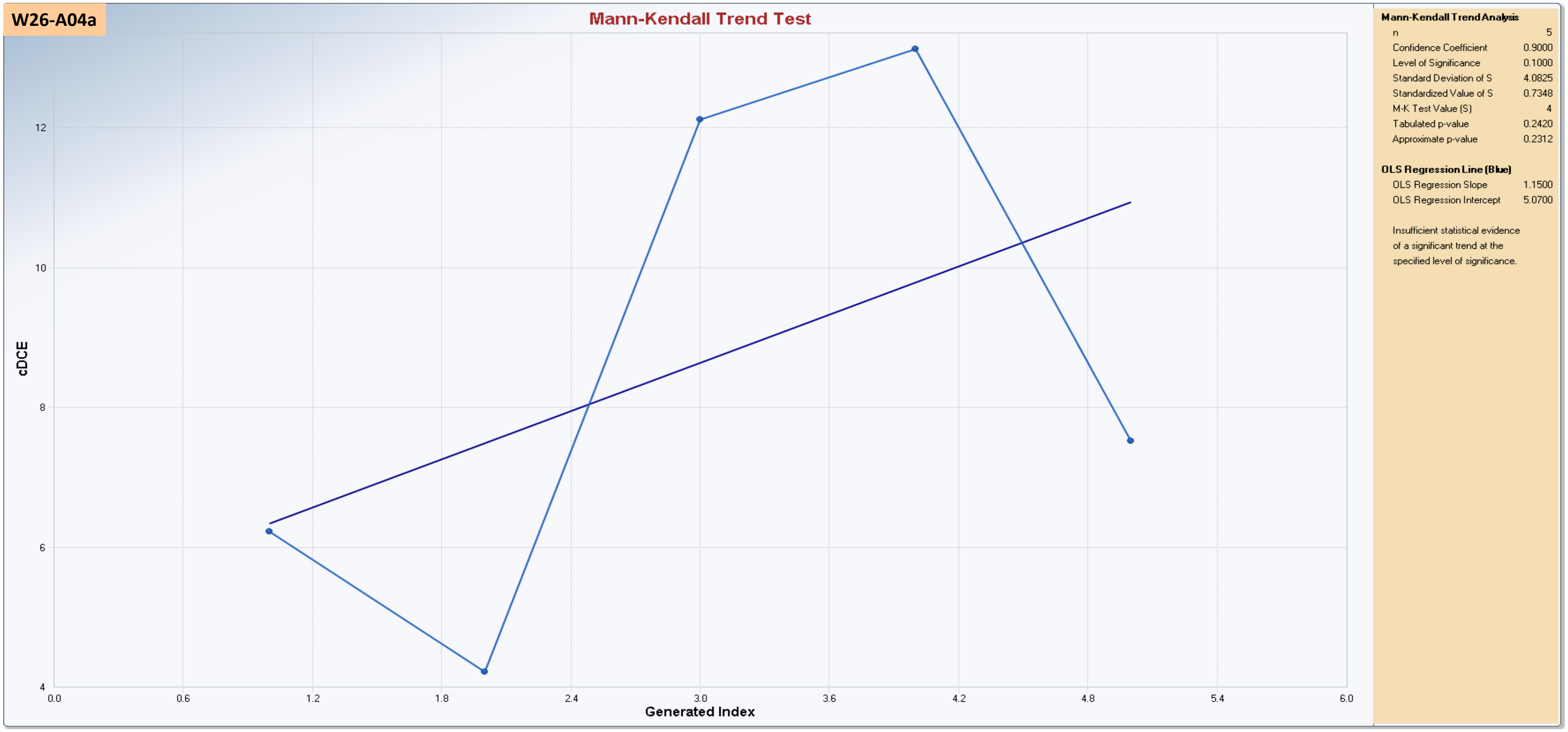
OLS Regression Slope	-0.3239
OLS Regression Intercept	4.7967

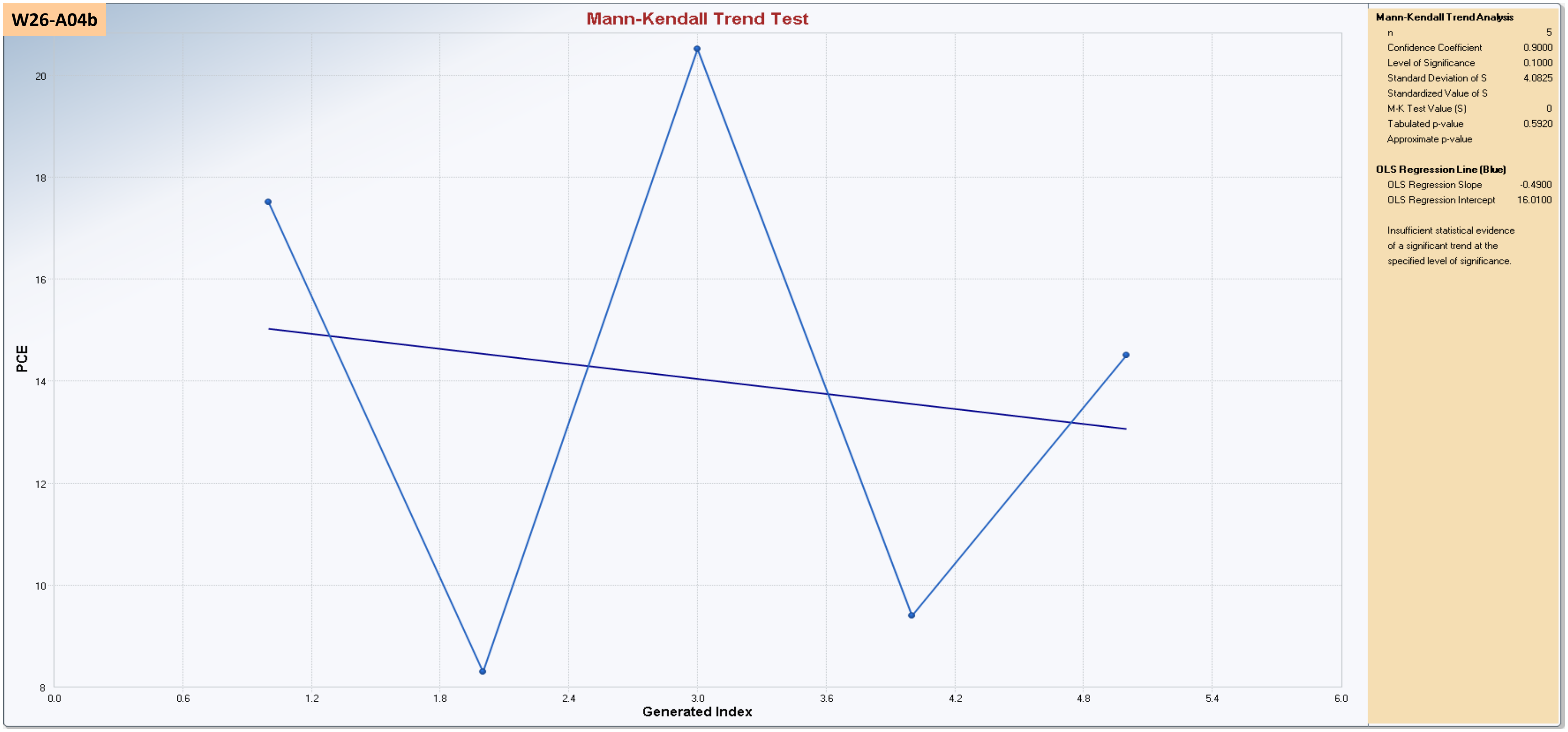
Statistically significant evidence of a decreasing trend at the specified level of significance.


W19-1
Mann-Kendall Trend Test
tDCE
0.540
0.490
0.440
0.390
0.340
0.290
0.240
0.190
0.140
0
2
4
6
8
10
Generated Index
Mann-Kendall Trend Analysis
n 10
Confidence Coefficient 0.9000
Level of Significance 0.1000
Standard Deviation of S 11.1355
Standardized Value of S -0.4490
M-K Test Value (S) -6
Tabulated p-value 0.3000
Approximate p-value 0.3267
OLS Regression Line (Blue)
OLS Regression Slope -0.0162
OLS Regression Intercept 0.4760
Insufficient statistical evidence
of a significant trend at the
specified level of significance.

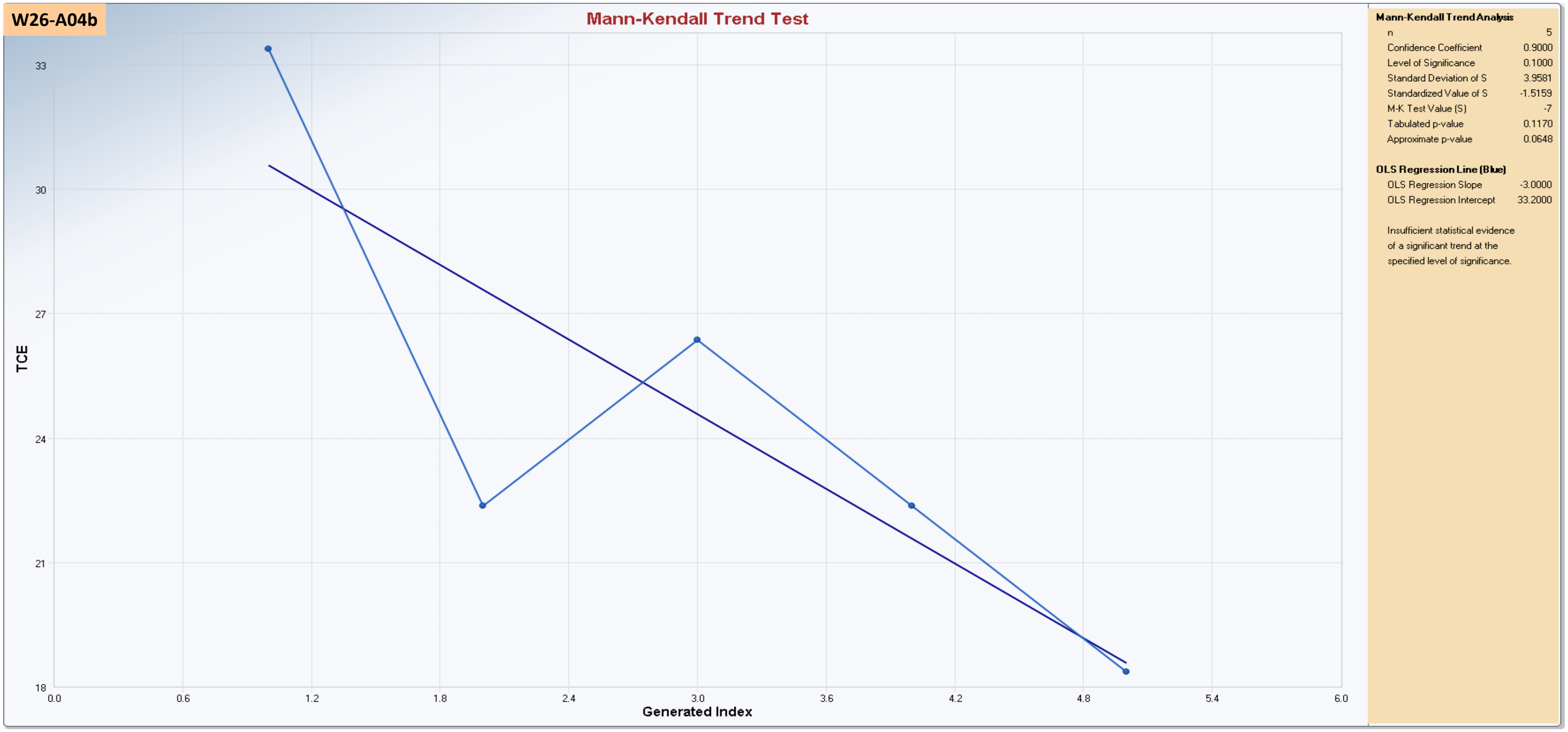

W26-A04a
Mann-Kendall Trend Test
PCE
Generated Index
25
23
21
19
17
15
13
0.0
0.6
1.2
1.8
2.4
3.0
3.6
4.2
4.8
5.4
6.0
Mann-Kendall Trend Analysis
n 5
Confidence Coefficient 0.9000
Level of Significance 0.1000
Standard Deviation of S 4.0825
Standardized Value of S -0.7348
M-K Test Value (S) -4
Tabulated p-value 0.2420
Approximate p-value 0.2312
OLS Regression Line (Blue)
OLS Regression Slope -1.7000
OLS Regression Intercept 24.3000
Insufficient statistical evidence
of a significant trend at the
specified level of significance.


W26-A04a
Mann-Kendall Trend Test
TCE
Generated Index
13
16
19
22
25
28
0.0
0.6
1.2
1.8
2.4
3.0
3.6
4.2
4.8
5.4
6.0
Mann-Kendall Trend Analysis
n 5
Confidence Coefficient 0.9000
Level of Significance 0.1000
Standard Deviation of S 4.0825
Standardized Value of S -0.7348
M-K Test Value (S) -4
Tabulated p-value 0.2420
Approximate p-value 0.2312
OLS Regression Line (Blue)
OLS Regression Slope -2.9000
OLS Regression Intercept 29.5000
Insufficient statistical evidence
of a significant trend at the
specified level of significance.

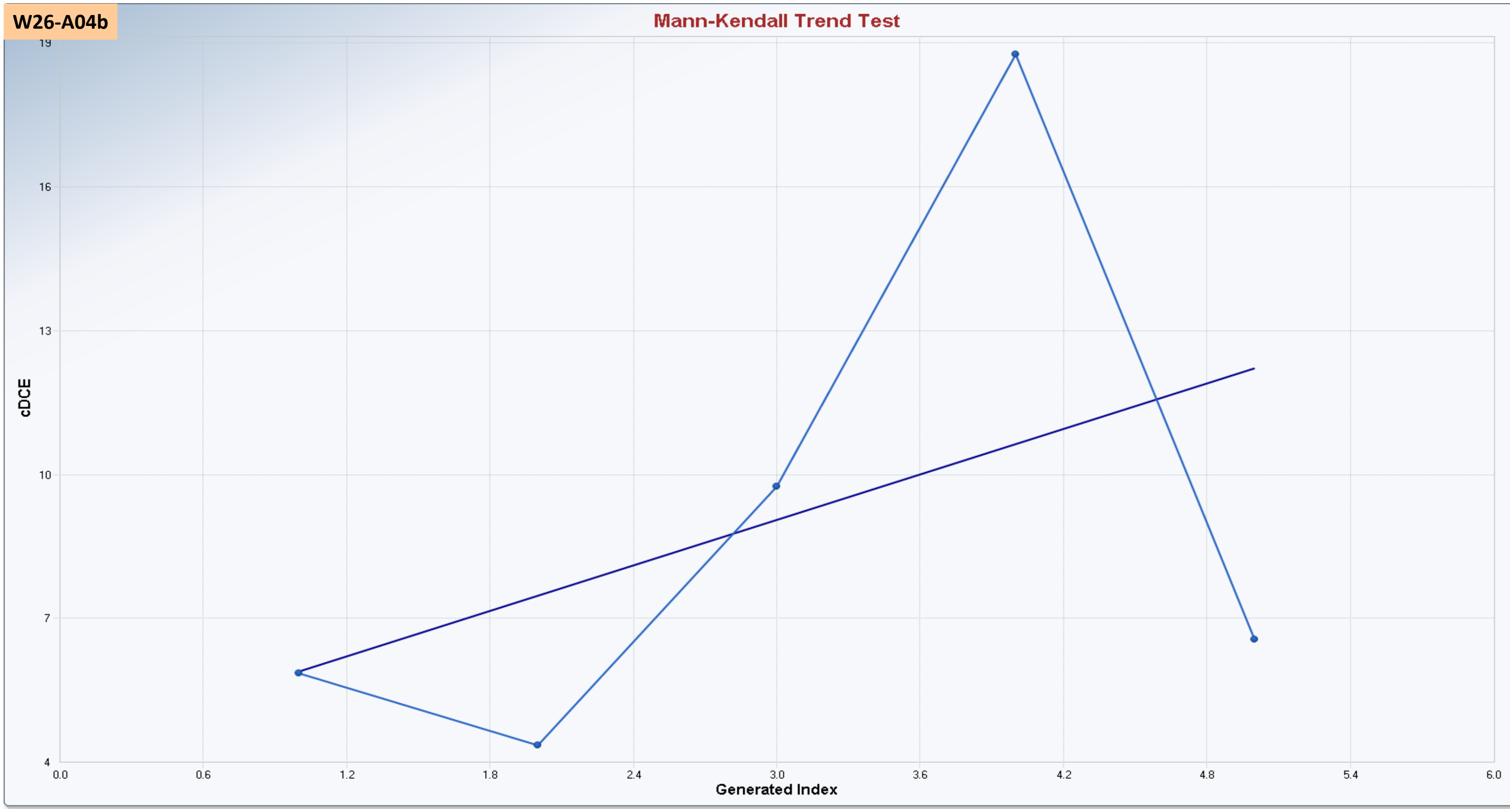

W26-A04a
Mann-Kendall Trend Test
cDCE
Generated Index
Mann-Kendall Trend Analysis
n 5
Confidence Coefficient 0.9000
Level of Significance 0.1000
Standard Deviation of S 4.0825
Standardized Value of S 0.7348
M-K Test Value (S) 4
Tabulated p-value 0.2420
Approximate p-value 0.2312
OLS Regression Line (Blue)
OLS Regression Slope 1.1500
OLS Regression Intercept 5.0700
Insufficient statistical evidence
of a significant trend at the
specified level of significance.



W26-A04b
Mann-Kendall Trend Test
PCE
Generated Index
Mann-Kendall Trend Analysis
n 5
Confidence Coefficient 0.9000
Level of Significance 0.1000
Standard Deviation of S 4.0825
Standardized Value of S
M-K Test Value (S) 0
Tabulated p-value 0.5920
Approximate p-value
OLS Regression Line (Blue)
OLS Regression Slope -0.4900
OLS Regression Intercept 16.0100
Insufficient statistical evidence of a significant trend at the specified level of significance.


W26-A04b
Mann-Kendall Trend Test
TCE
Generated Index
33
30
27
24
21
18
0.0
0.6
1.2
1.8
2.4
3.0
3.6
4.2
4.8
5.4
6.0
Mann-Kendall Trend Analysis
n 5
Confidence Coefficient 0.9000
Level of Significance 0.1000
Standard Deviation of S 3.9581
Standardized Value of S -1.5159
M-K Test Value (S) -7
Tabulated p-value 0.1170
Approximate p-value 0.0648
OLS Regression Line (Blue)
OLS Regression Slope -3.0000
OLS Regression Intercept 33.2000
Insufficient statistical evidence
of a significant trend at the
specified level of significance.

W26-A04b



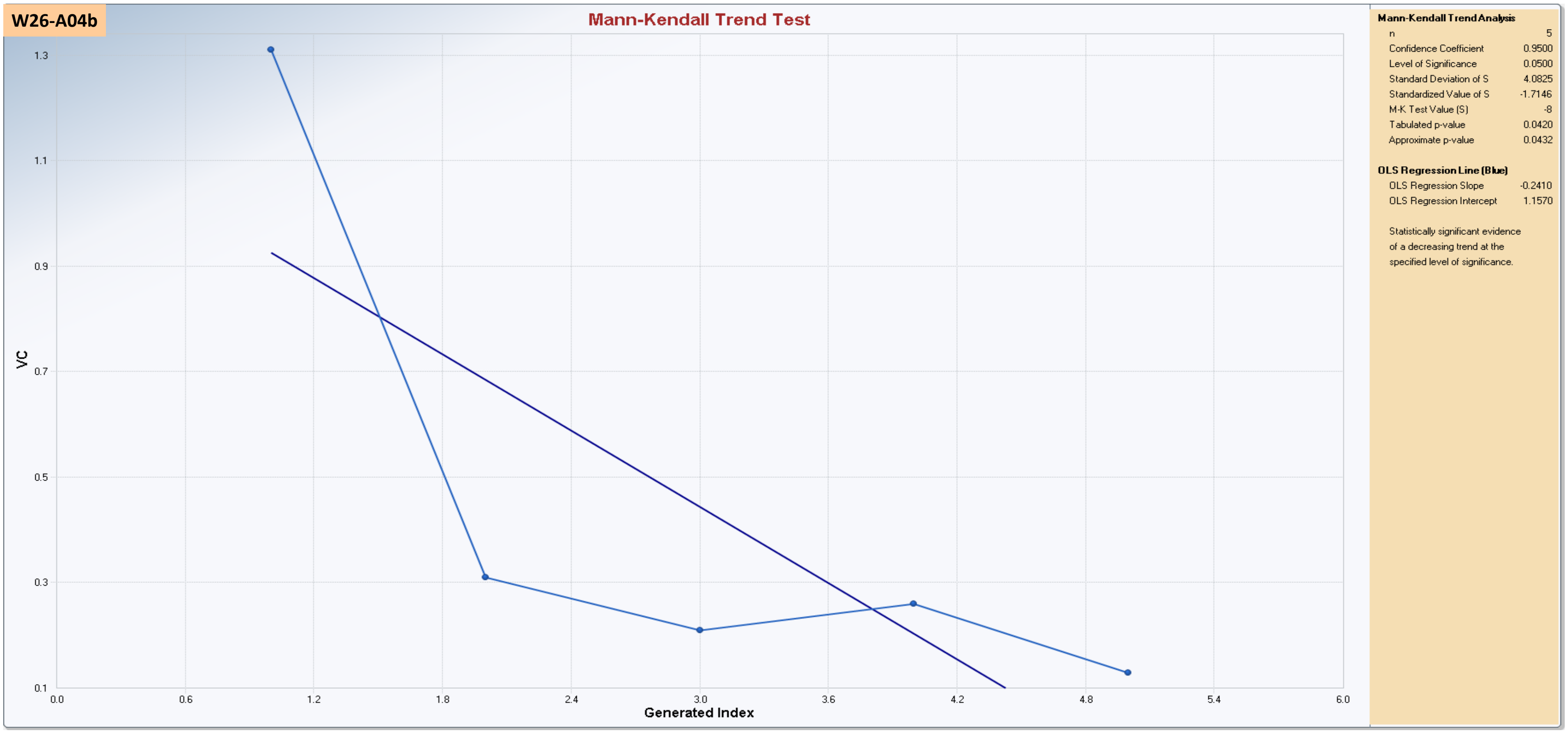
Mann-Kendall Trend Analysis

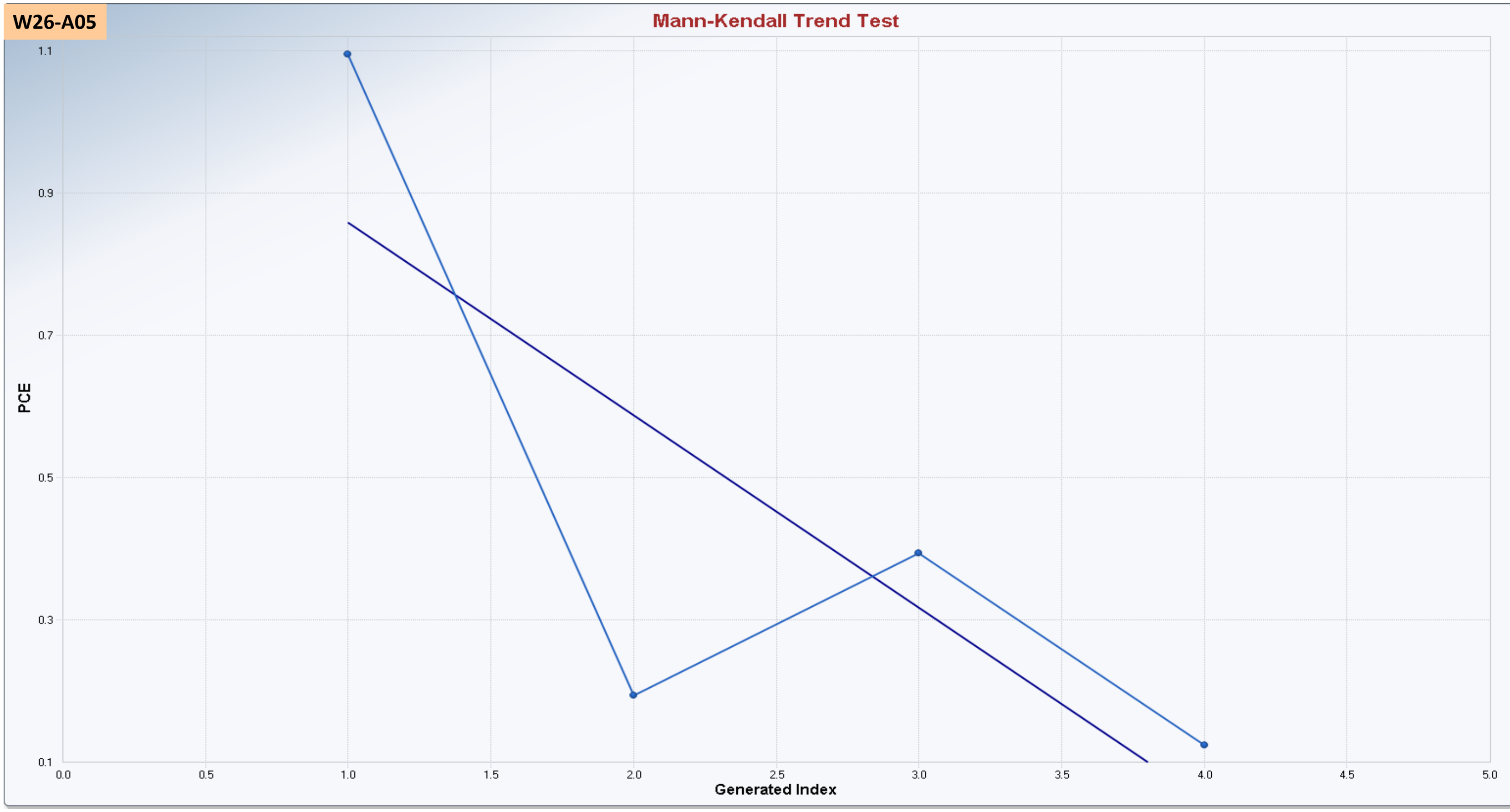
n	5
Confidence Coefficient	0.9000
Level of Significance	0.1000
Standard Deviation of S	4.0825
Standardized Value of S	0.7348
M-K Test Value (S)	4
Tabulated p-value	0.2420
Approximate p-value	0.2312

OLS Regression Line (Blue)

OLS Regression Slope	1.5800
OLS Regression Intercept	4.5600

Insufficient statistical evidence of a significant trend at the specified level of significance.


W26-A04b
Mann-Kendall Trend Test
VC
Generated Index
1.3
1.1
0.9
0.7
0.5
0.3
0.1
0.0
0.6
1.2
1.8
2.4
3.0
3.6
4.2
4.8
5.4
6.0
Mann-Kendall Trend Analysis
n 5
Confidence Coefficient 0.9500
Level of Significance 0.0500
Standard Deviation of S 4.0825
Standardized Value of S -1.7146
M-K Test Value (S) -8
Tabulated p-value 0.0420
Approximate p-value 0.0432
OLS Regression Line (Blue)
OLS Regression Slope -0.2410
OLS Regression Intercept 1.1570
Statistically significant evidence
of a decreasing trend at the
specified level of significance.

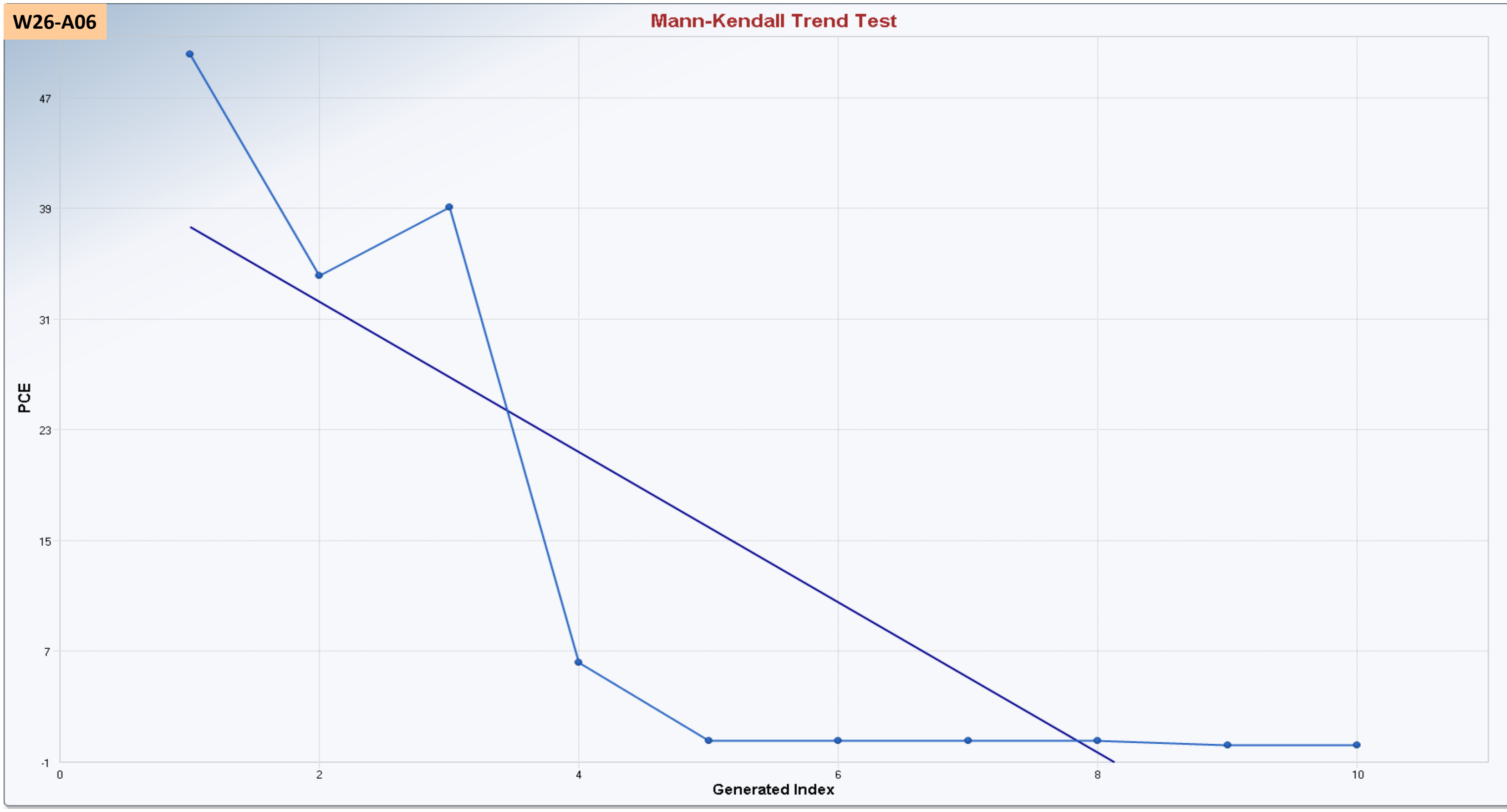


Mann-Kendall Trend Analysis	
n	4
Confidence Coefficient	0.9000
Level of Significance	0.1000
Standard Deviation of S	2.9439
Standardized Value of S	-1.0190
M-K Test Value (S)	-4
Tabulated p-value	0.1670
Approximate p-value	0.1541

OLS Regression Line (Blue)	
OLS Regression Slope	-0.2710
OLS Regression Intercept	1.1350

Insufficient statistical evidence of a significant trend at the specified level of significance.

W26-A06



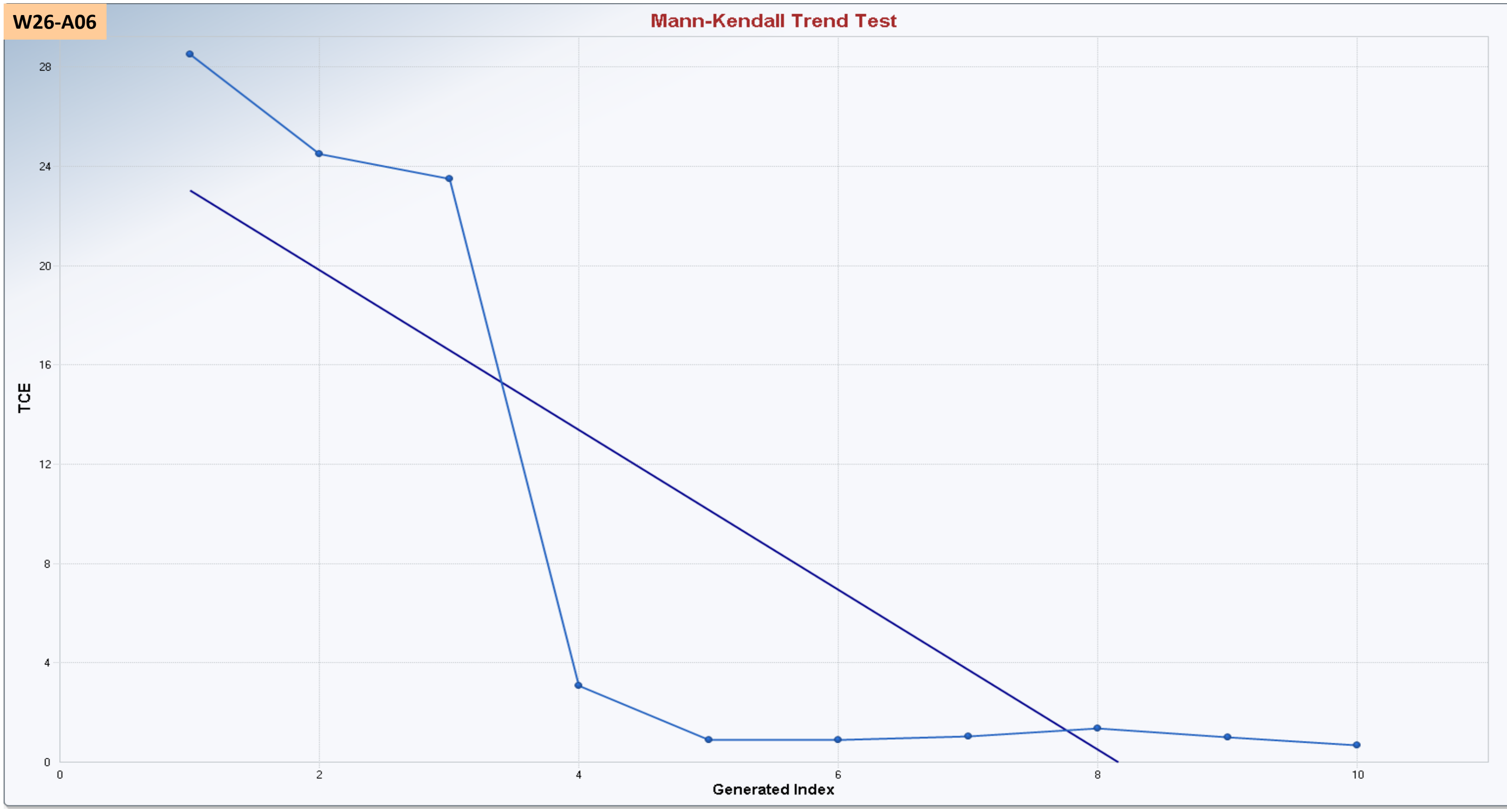
Mann-Kendall Trend Analysis

n	10
Confidence Coefficient	0.9500
Level of Significance	0.0500
Standard Deviation of S	10.7393
Standardized Value of S	-3.2590
M-K Test Value (S)	-36
Tabulated p-value	0.0000
Approximate p-value	0.0006

OLS Regression Line (Blue)

OLS Regression Slope	-5.4304
OLS Regression Intercept	42.9633

Statistically significant evidence of a decreasing trend at the specified level of significance.



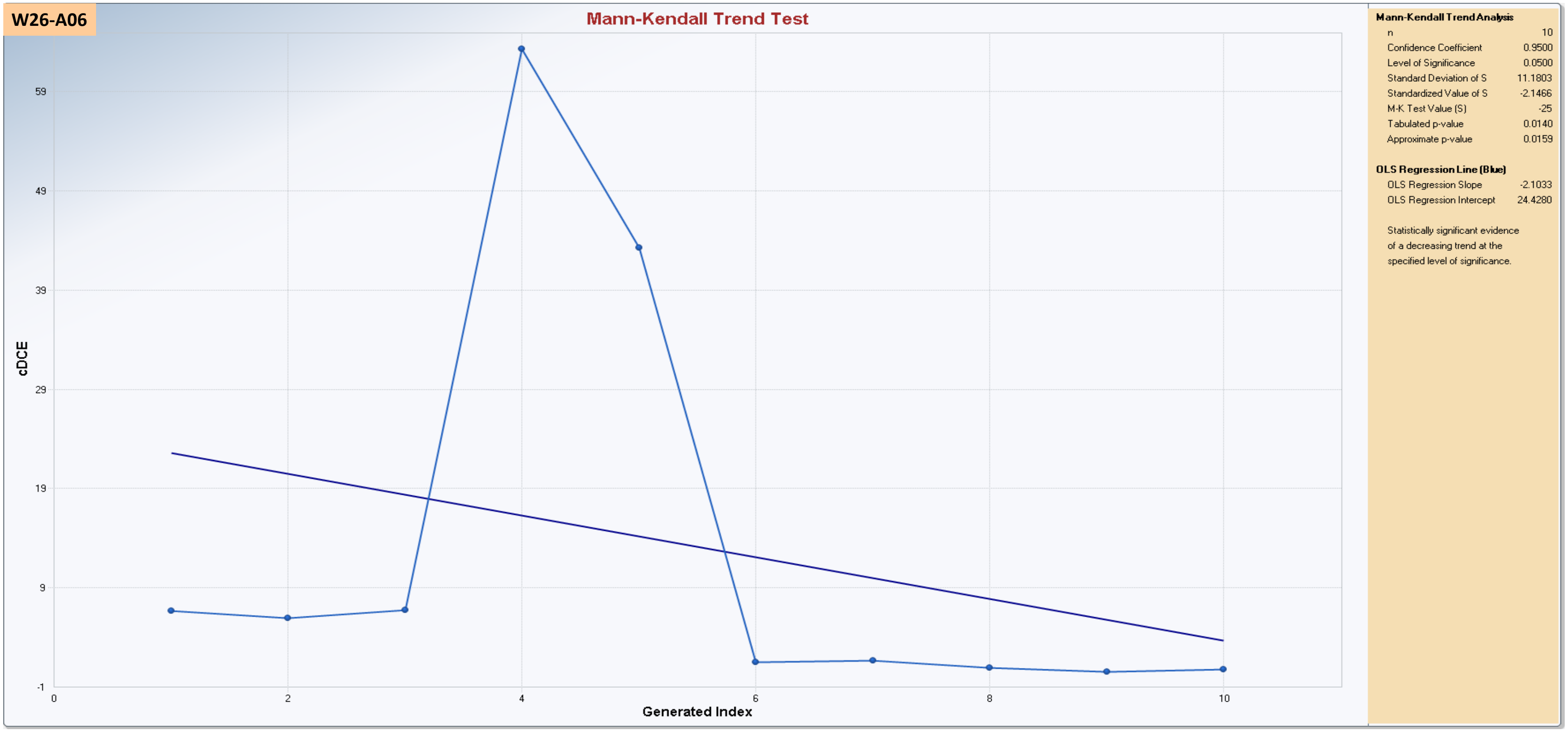
Mann-Kendall Trend Analysis

n	10
Confidence Coefficient	0.9500
Level of Significance	0.0500
Standard Deviation of S	11.1355
Standardized Value of S	-2.6043
M-K Test Value (S)	-30
Tabulated p-value	0.0020
Approximate p-value	0.0046

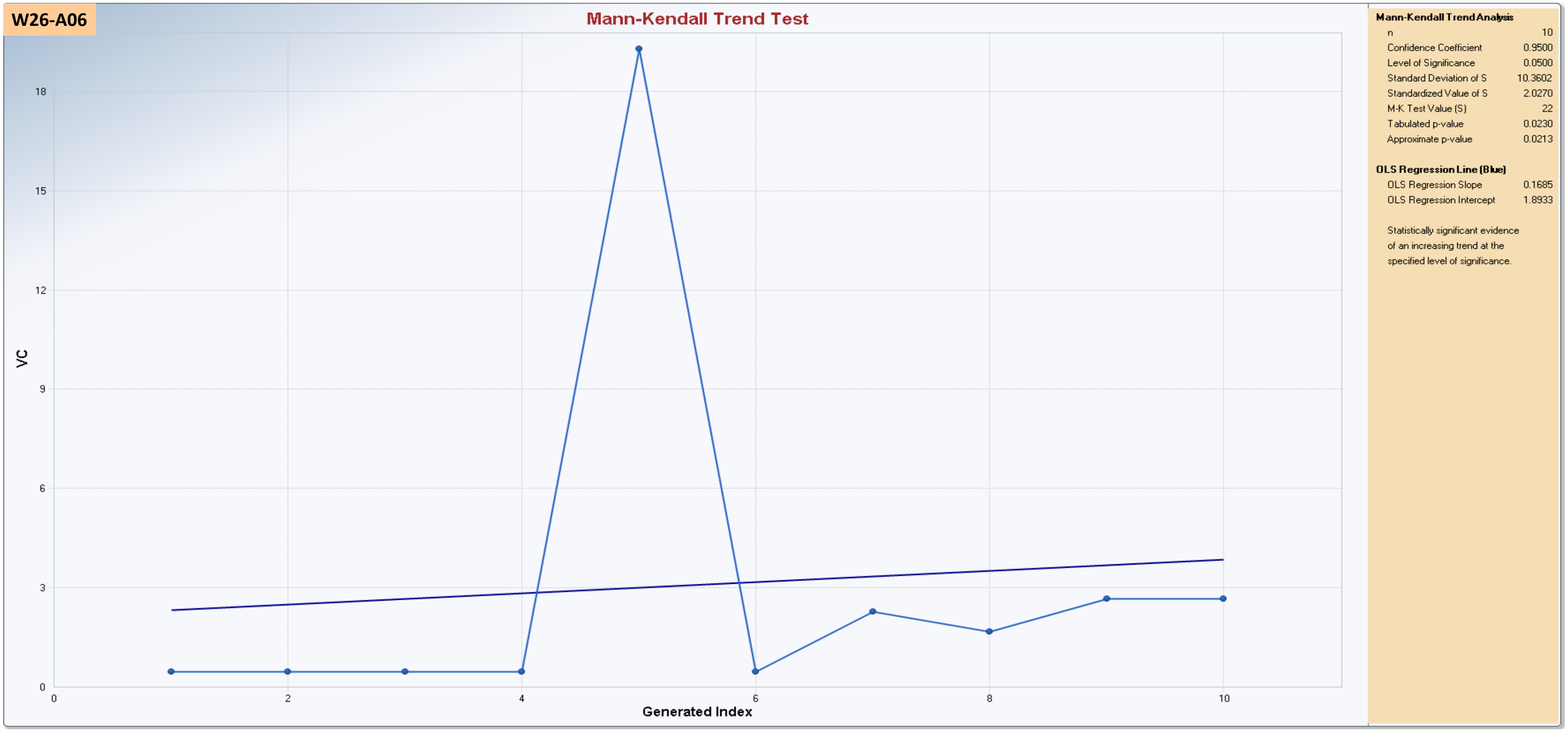
OLS Regression Line (Blue)

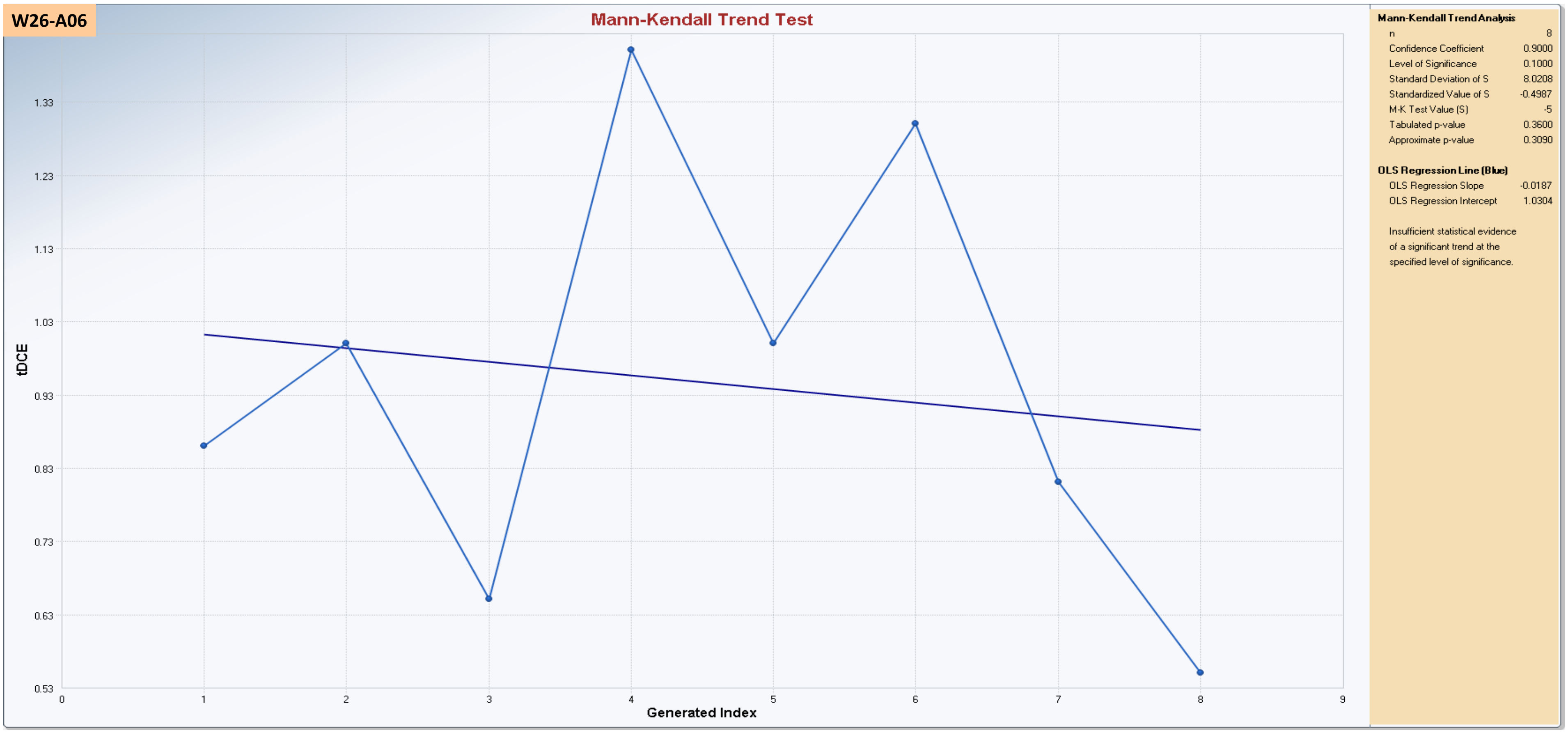
OLS Regression Slope	-3.2212
OLS Regression Intercept	25.7687

Statistically significant evidence of a decreasing trend at the specified level of significance.

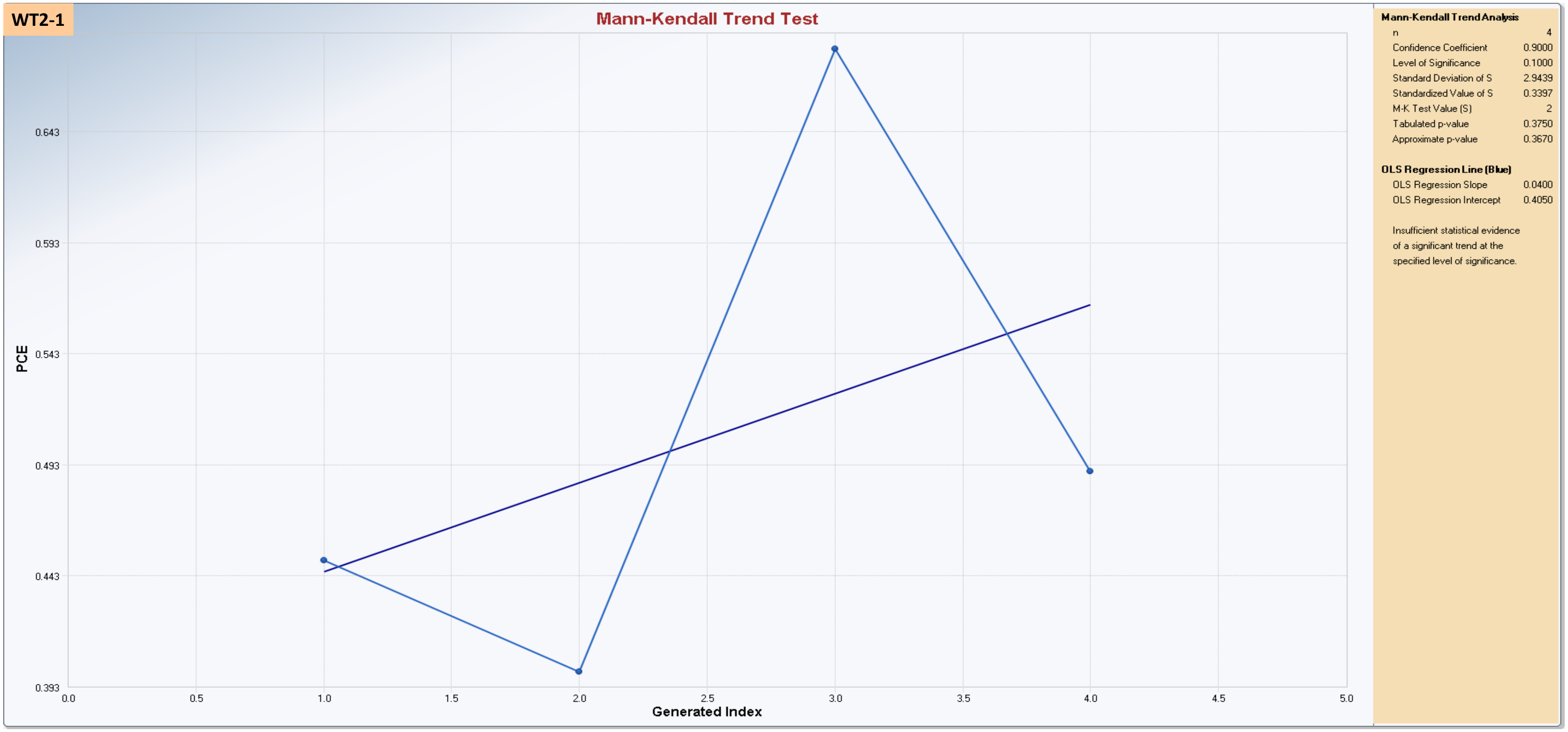


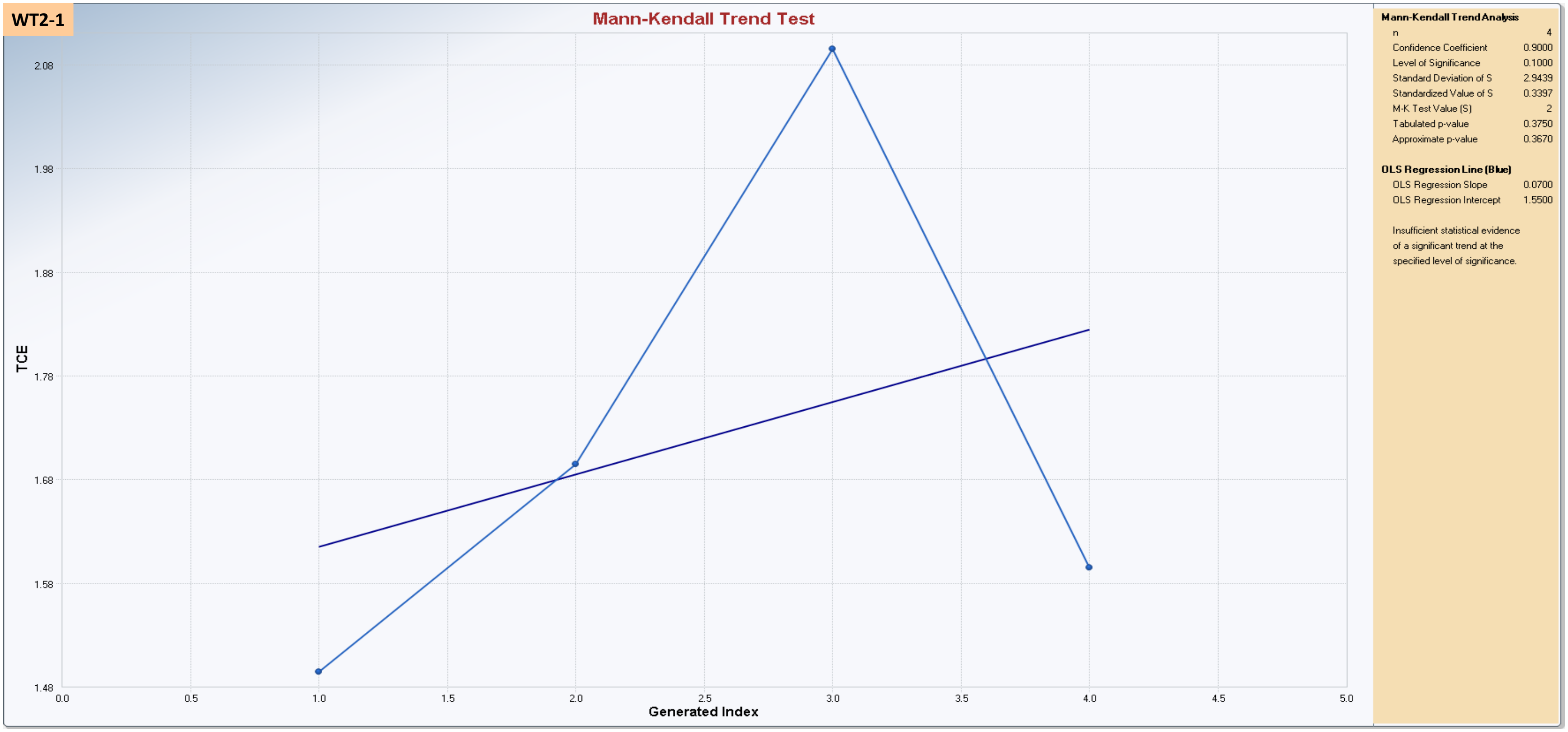
W26-A06
Mann-Kendall Trend Test
cDCE
Generated Index
Mann-Kendall Trend Analysis
n 10
Confidence Coefficient 0.9500
Level of Significance 0.0500
Standard Deviation of S 11.1803
Standardized Value of S -2.1466
M-K Test Value (S) -25
Tabulated p-value 0.0140
Approximate p-value 0.0159
OLS Regression Line (Blue)
OLS Regression Slope -2.1033
OLS Regression Intercept 24.4280
Statistically significant evidence
of a decreasing trend at the
specified level of significance.

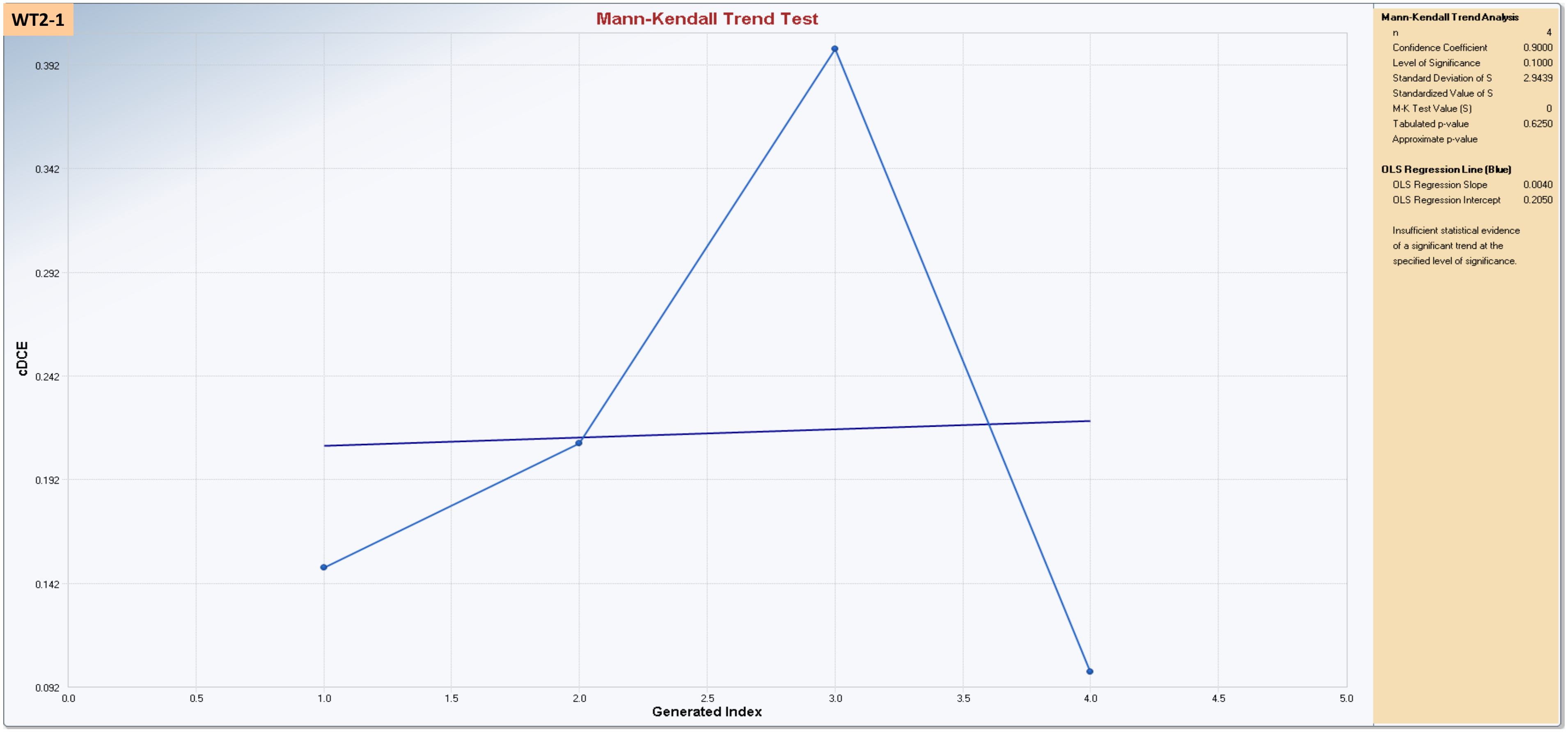

W26-A06
Mann-Kendall Trend Test
VC
Generated Index
Mann-Kendall Trend Analysis
n 10
Confidence Coefficient 0.9500
Level of Significance 0.0500
Standard Deviation of S 10.3602
Standardized Value of S 2.0270
M-K Test Value (S) 22
Tabulated p-value 0.0230
Approximate p-value 0.0213
OLS Regression Line (Blue)
OLS Regression Slope 0.1685
OLS Regression Intercept 1.8933
Statistically significant evidence of an increasing trend at the specified level of significance.

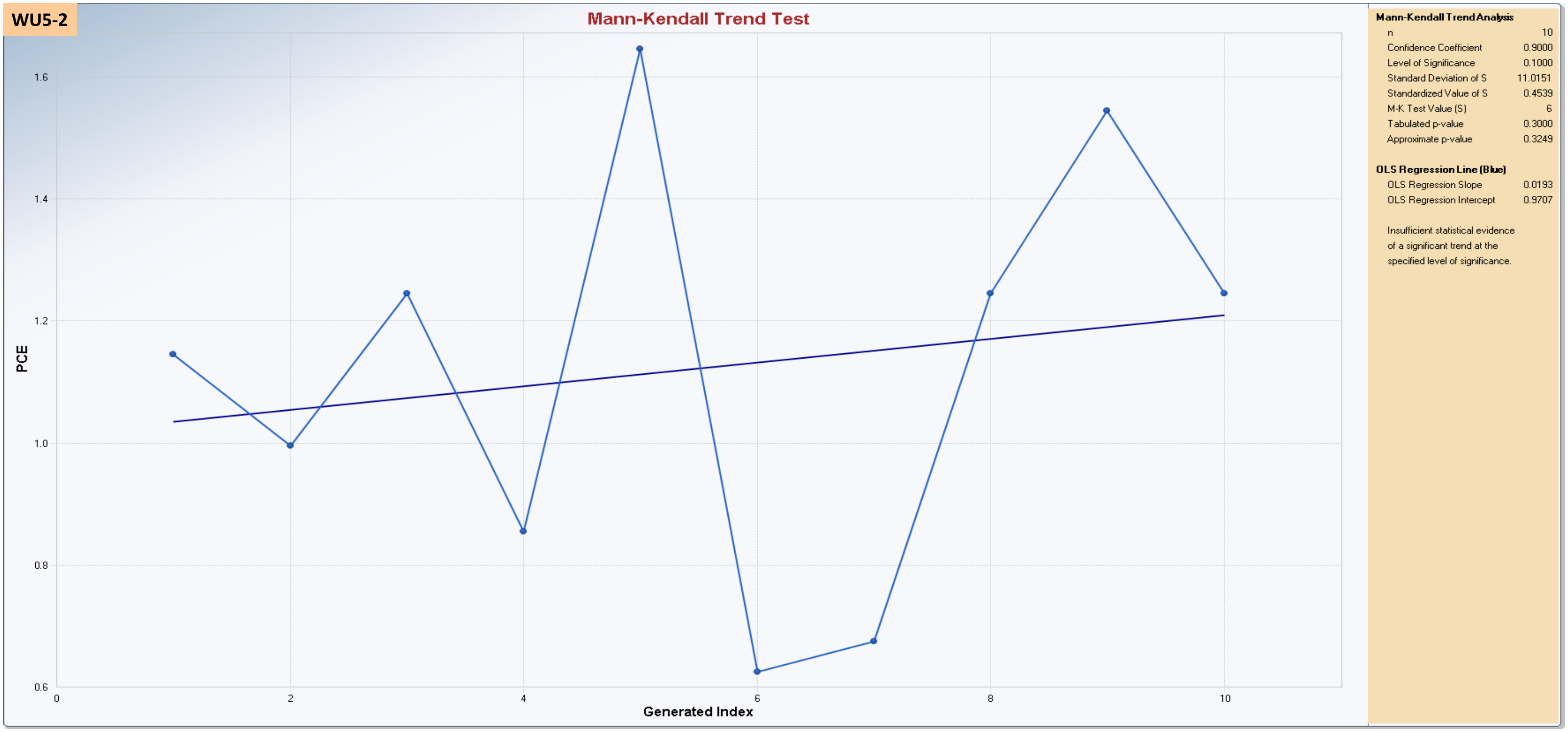


W26-A06
Mann-Kendall Trend Test
tDCE
Generated Index
1.33
1.23
1.13
1.03
0.93
0.83
0.73
0.63
0.53
0
1
2
3
4
5
6
7
8
9
Mann-Kendall Trend Analysis
n 8
Confidence Coefficient 0.9000
Level of Significance 0.1000
Standard Deviation of S 8.0208
Standardized Value of S -0.4987
M-K Test Value (S) -5
Tabulated p-value 0.3600
Approximate p-value 0.3090
OLS Regression Line (Blue)
OLS Regression Slope -0.0187
OLS Regression Intercept 1.0304
Insufficient statistical evidence
of a significant trend at the
specified level of significance.


WT2-1
Mann-Kendall Trend Test
PCE
0.393
0.443
0.493
0.543
0.593
0.643
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
Generated Index
Mann-Kendall Trend Analysis
n 4
Confidence Coefficient 0.9000
Level of Significance 0.1000
Standard Deviation of S 2.9439
Standardized Value of S 0.3397
M-K Test Value (S) 2
Tabulated p-value 0.3750
Approximate p-value 0.3670
OLS Regression Line (Blue)
OLS Regression Slope 0.0400
OLS Regression Intercept 0.4050
Insufficient statistical evidence
of a significant trend at the
specified level of significance.


WT2-1
Mann-Kendall Trend Test
TCE
2.08
1.98
1.88
1.78
1.68
1.58
1.48
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
Generated Index
Mann-Kendall Trend Analysis
n 4
Confidence Coefficient 0.9000
Level of Significance 0.1000
Standard Deviation of S 2.9439
Standardized Value of S 0.3397
M-K Test Value (S) 2
Tabulated p-value 0.3750
Approximate p-value 0.3670
OLS Regression Line (Blue)
OLS Regression Slope 0.0700
OLS Regression Intercept 1.5500
Insufficient statistical evidence of a significant trend at the specified level of significance.


WT2-1
Mann-Kendall Trend Test
cDCE
Generated Index
0.392
0.342
0.292
0.242
0.192
0.142
0.092
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
Mann-Kendall Trend Analysis
n 4
Confidence Coefficient 0.9000
Level of Significance 0.1000
Standard Deviation of S 2.9439
Standardized Value of S
M-K Test Value (S) 0
Tabulated p-value 0.6250
Approximate p-value
OLS Regression Line (Blue)
OLS Regression Slope 0.0040
OLS Regression Intercept 0.2050
Insufficient statistical evidence of a significant trend at the specified level of significance.


WU5-2
Mann-Kendall Trend Test
PCE
Generated Index
Mann-Kendall Trend Analysis
n 10
Confidence Coefficient 0.9000
Level of Significance 0.1000
Standard Deviation of S 11.0151
Standardized Value of S 0.4539
M-K Test Value (S) 6
Tabulated p-value 0.3000
Approximate p-value 0.3249
OLS Regression Line (Blue)
OLS Regression Slope 0.0193
OLS Regression Intercept 0.9707
Insufficient statistical evidence of a significant trend at the specified level of significance.

WU5-2

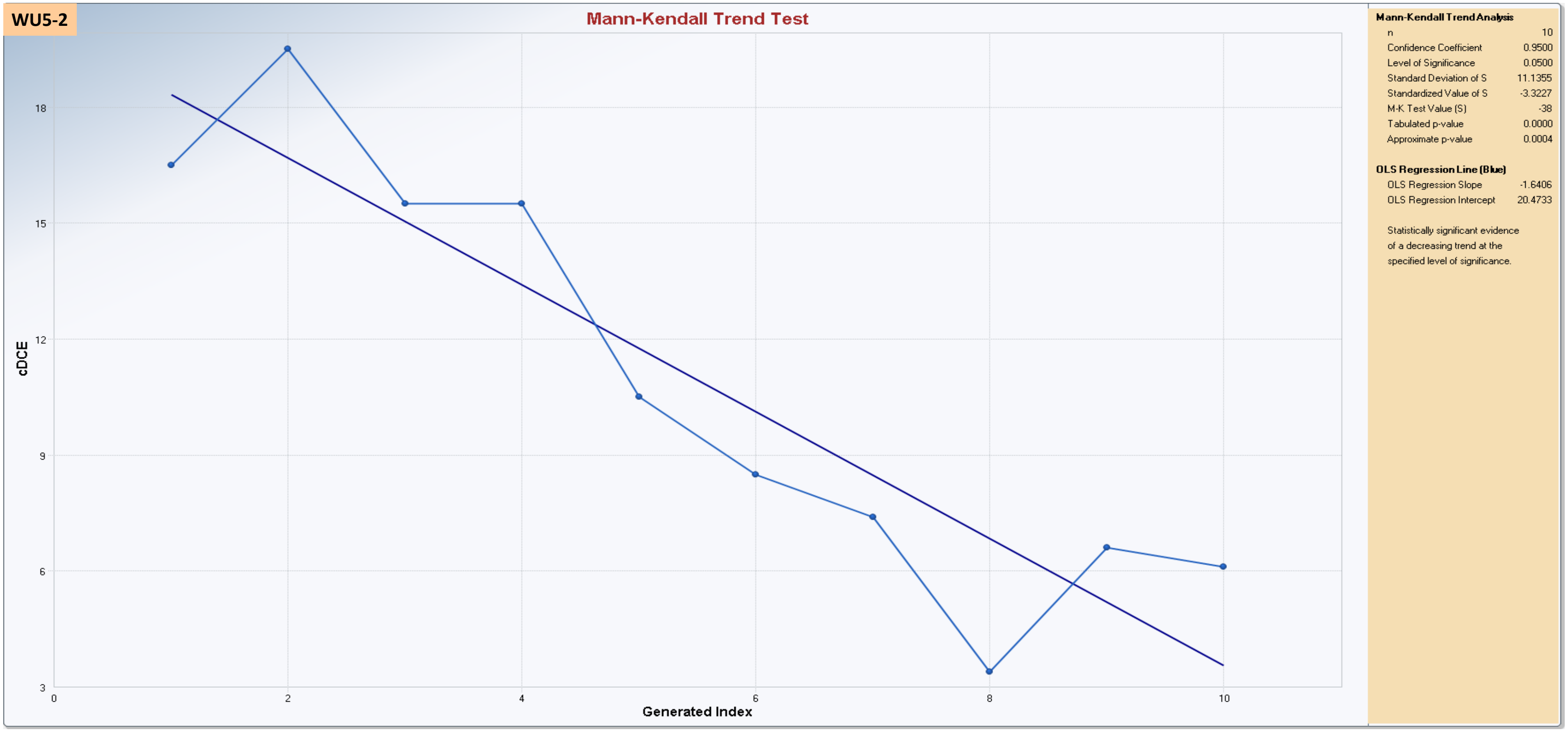
Mann-Kendall Trend Analysis

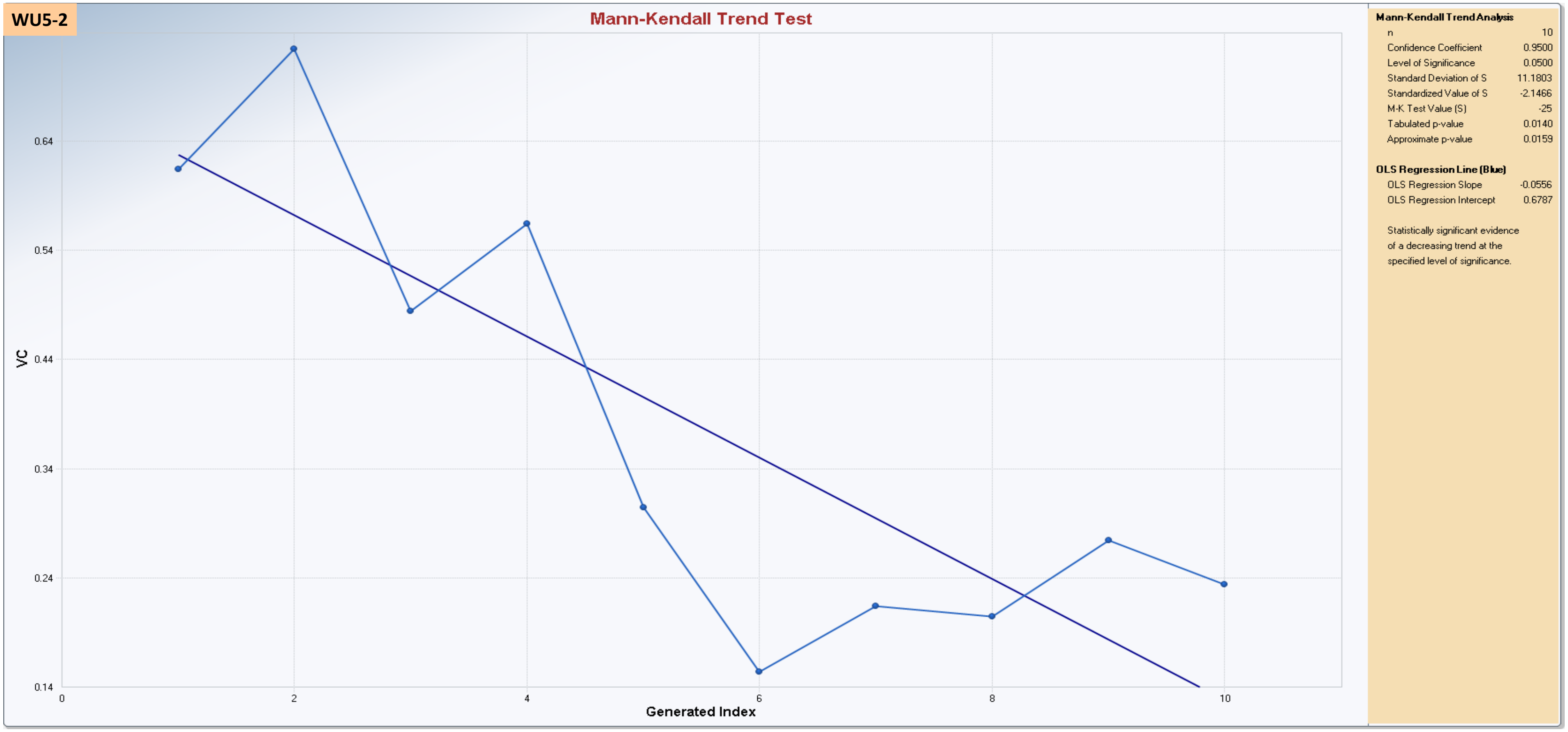
n	10
Confidence Coefficient	0.9500
Level of Significance	0.0500
Standard Deviation of S	11.0905
Standardized Value of S	-1.9837
M-K Test Value (S)	-23
Tabulated p-value	0.0230
Approximate p-value	0.0236

OLS Regression Line (Blue)

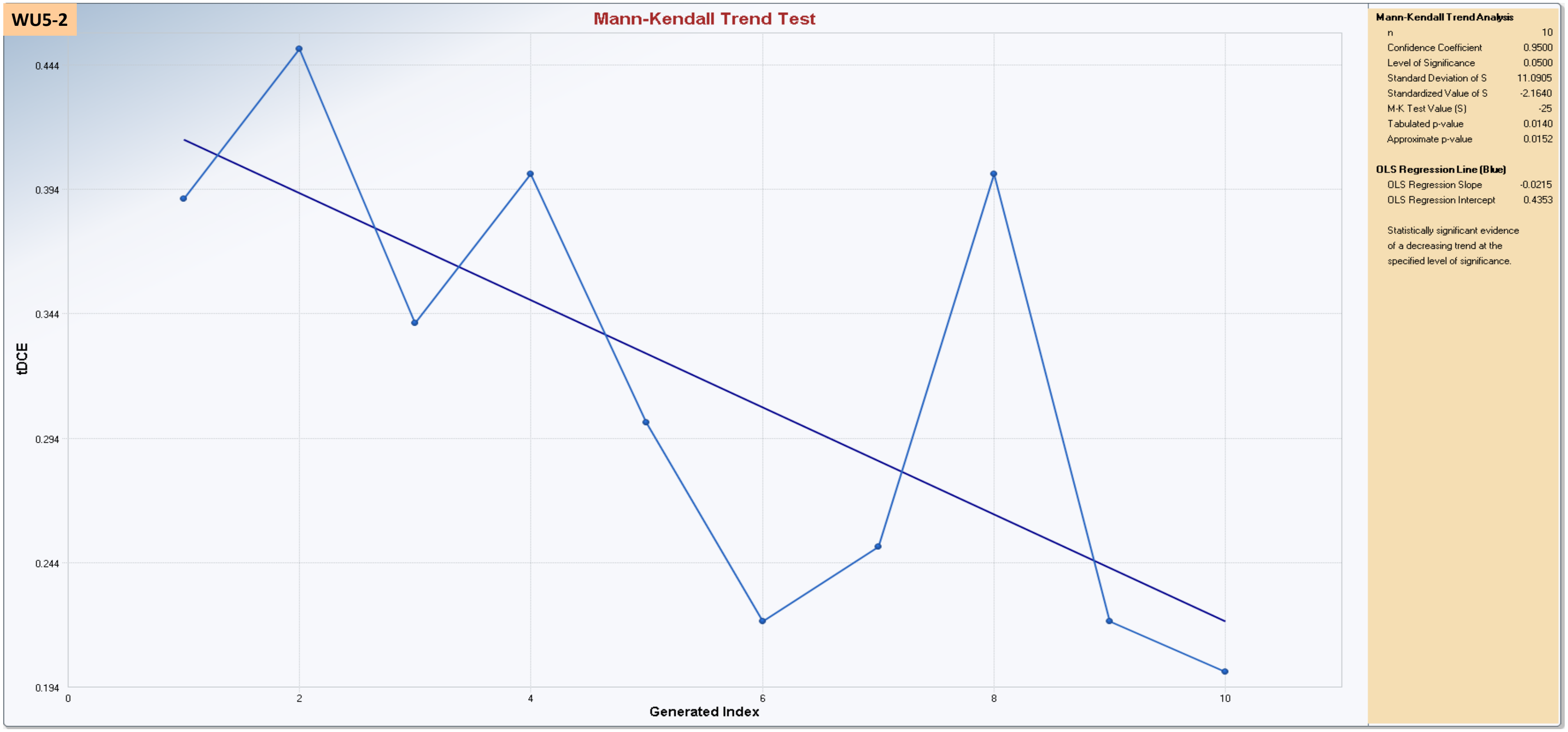
OLS Regression Slope	-0.1042
OLS Regression Intercept	3.0333

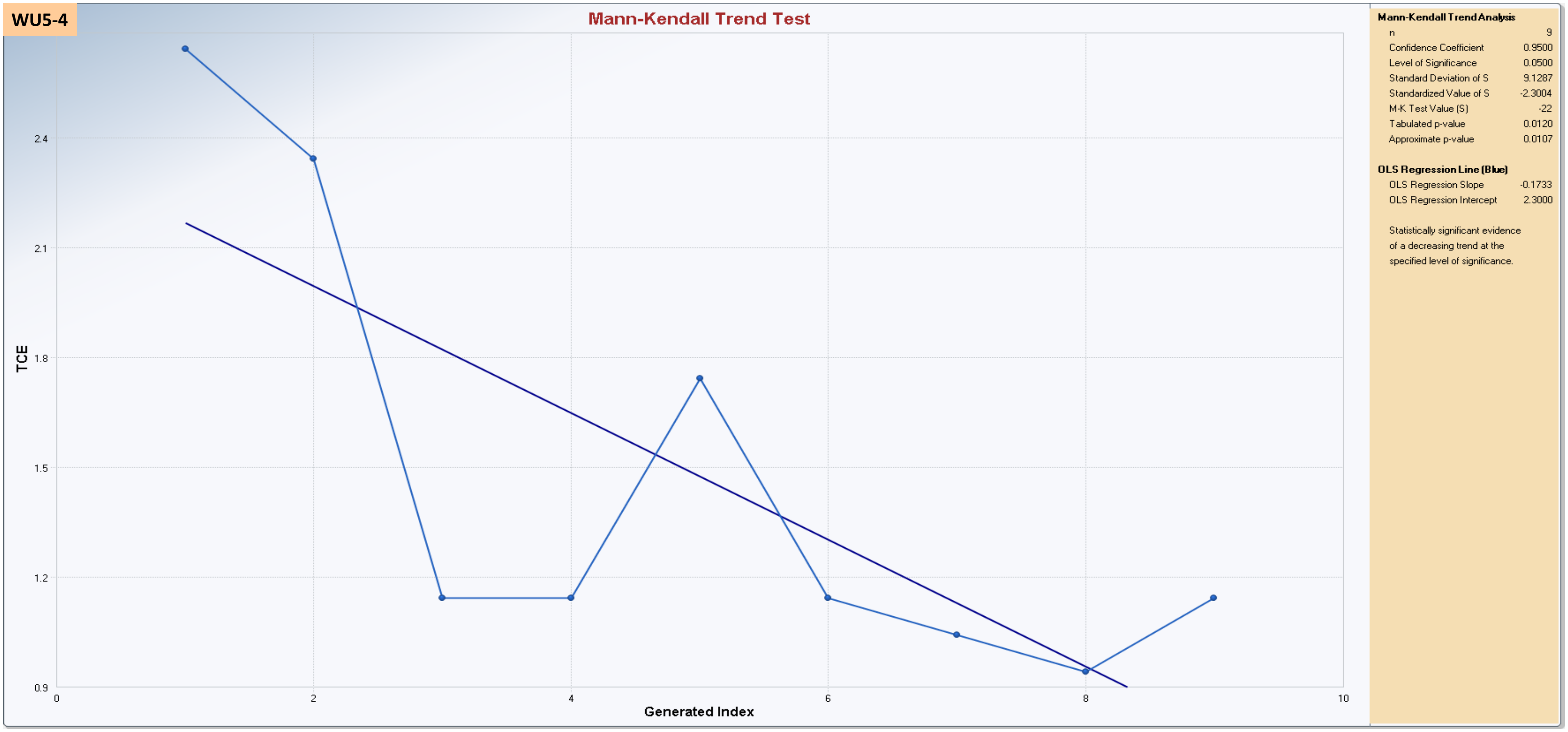
Statistically significant evidence of a decreasing trend at the specified level of significance.

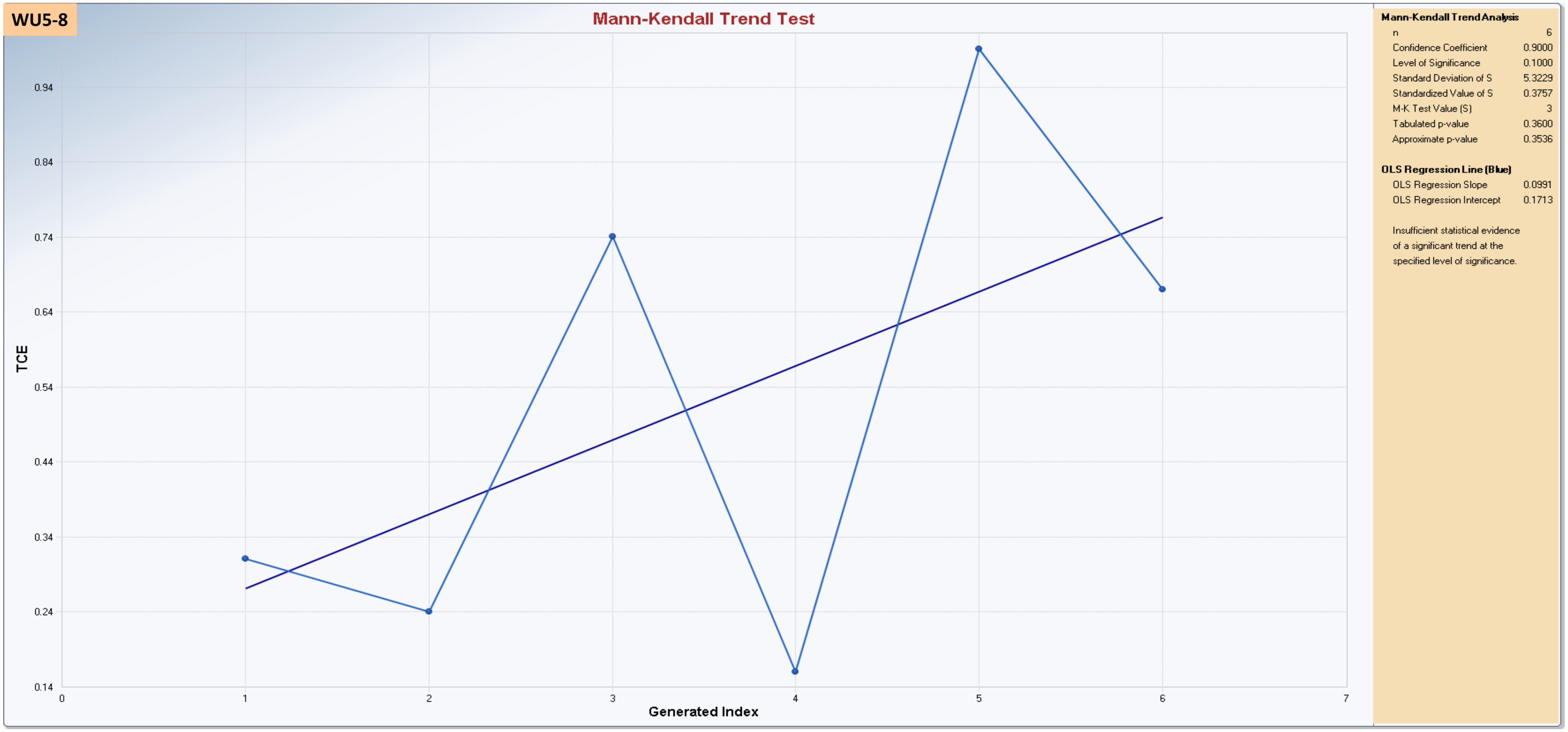

WU5-2
Mann-Kendall Trend Test
cDCE
Generated Index
Mann-Kendall Trend Analysis
n 10
Confidence Coefficient 0.9500
Level of Significance 0.0500
Standard Deviation of S 11.1355
Standardized Value of S -3.3227
M-K Test Value (S) -38
Tabulated p-value 0.0000
Approximate p-value 0.0004
OLS Regression Line (Blue)
OLS Regression Slope -1.6406
OLS Regression Intercept 20.4733
Statistically significant evidence of a decreasing trend at the specified level of significance.

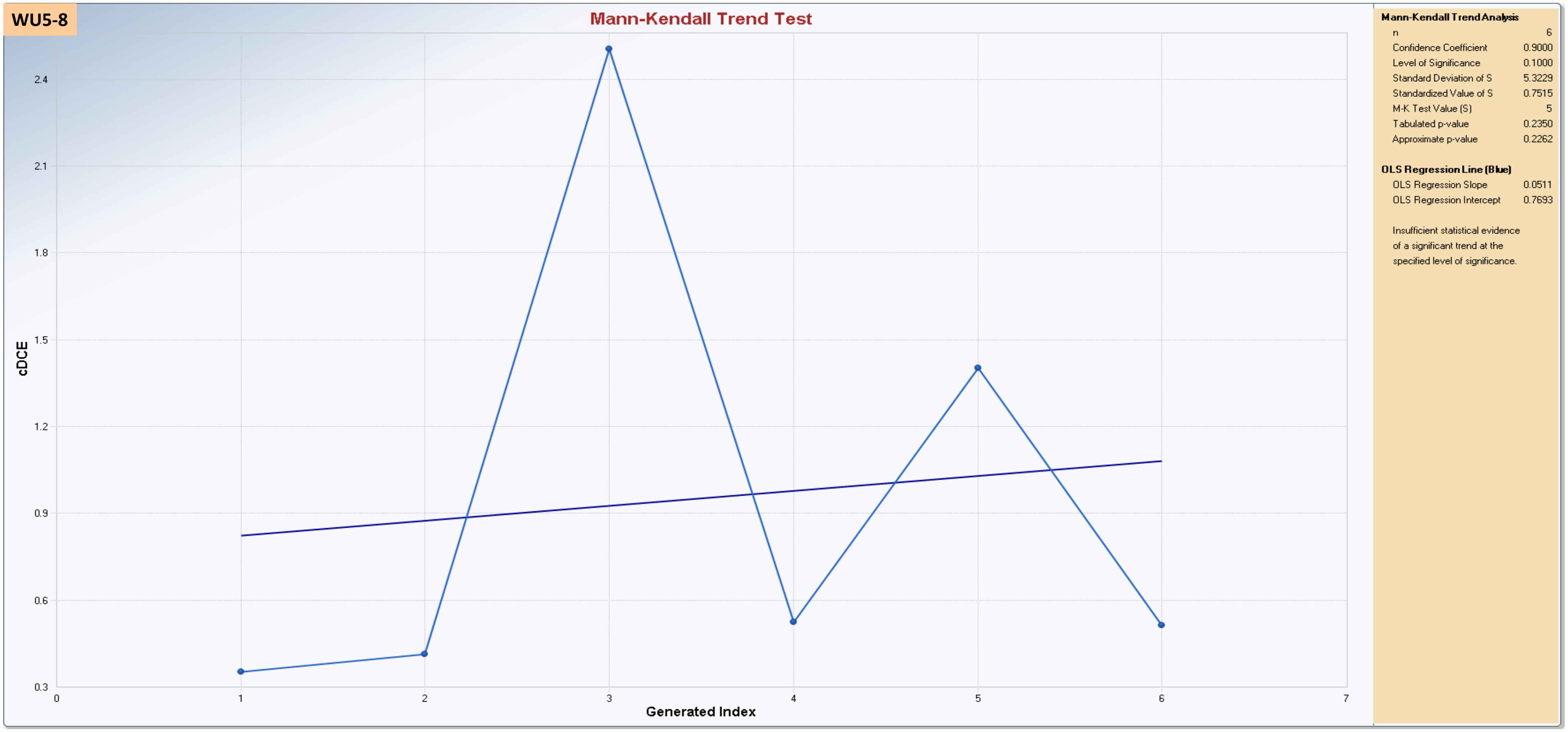


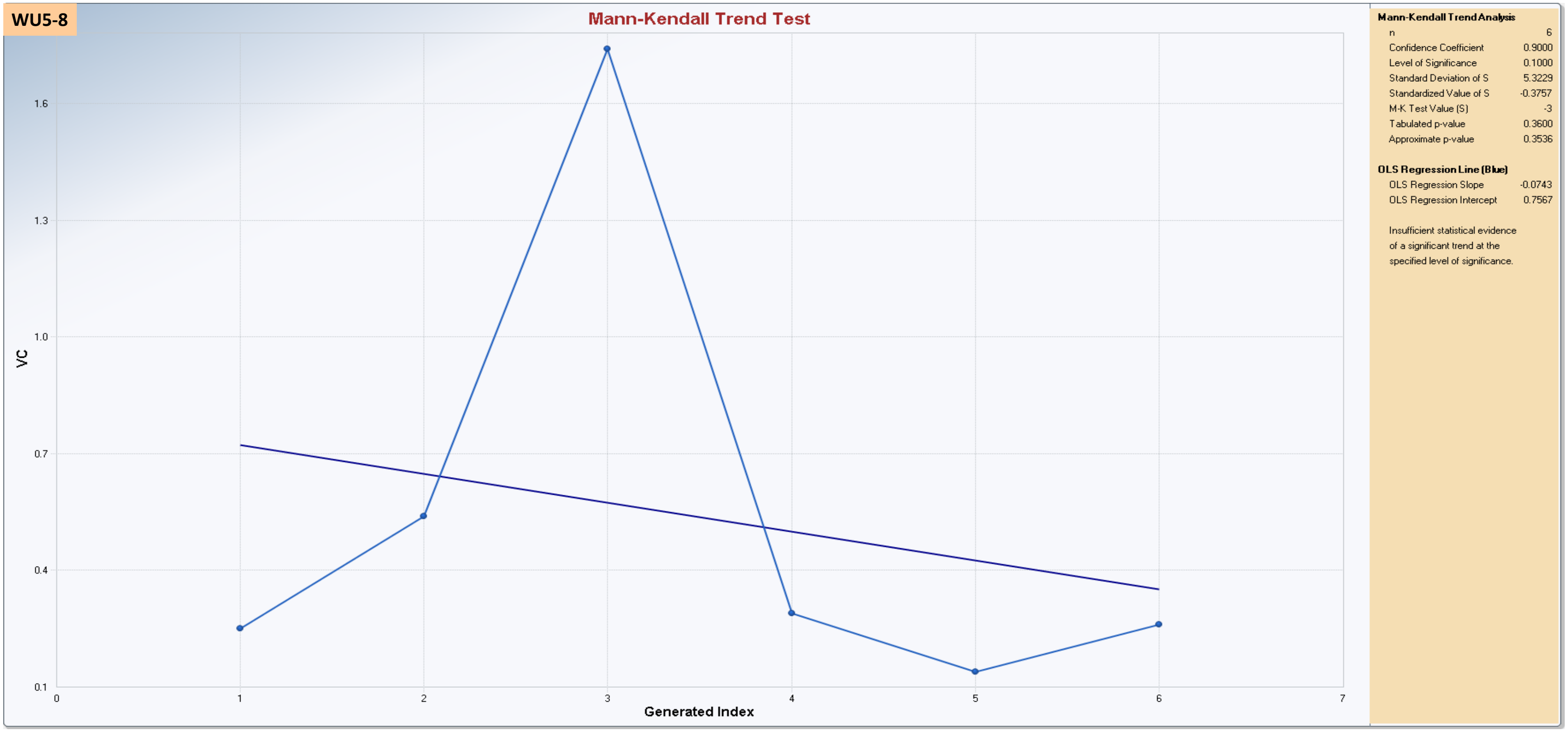
WU5-2
Mann-Kendall Trend Test
VC
0.64
0.54
0.44
0.34
0.24
0.14
0
2
4
6
8
10
Generated Index
Mann-Kendall Trend Analysis
n 10
Confidence Coefficient 0.9500
Level of Significance 0.0500
Standard Deviation of S 11.1803
Standardized Value of S -2.1466
M-K Test Value (S) -25
Tabulated p-value 0.0140
Approximate p-value 0.0159
OLS Regression Line (Blue)
OLS Regression Slope -0.0556
OLS Regression Intercept 0.6787
Statistically significant evidence of a decreasing trend at the specified level of significance.

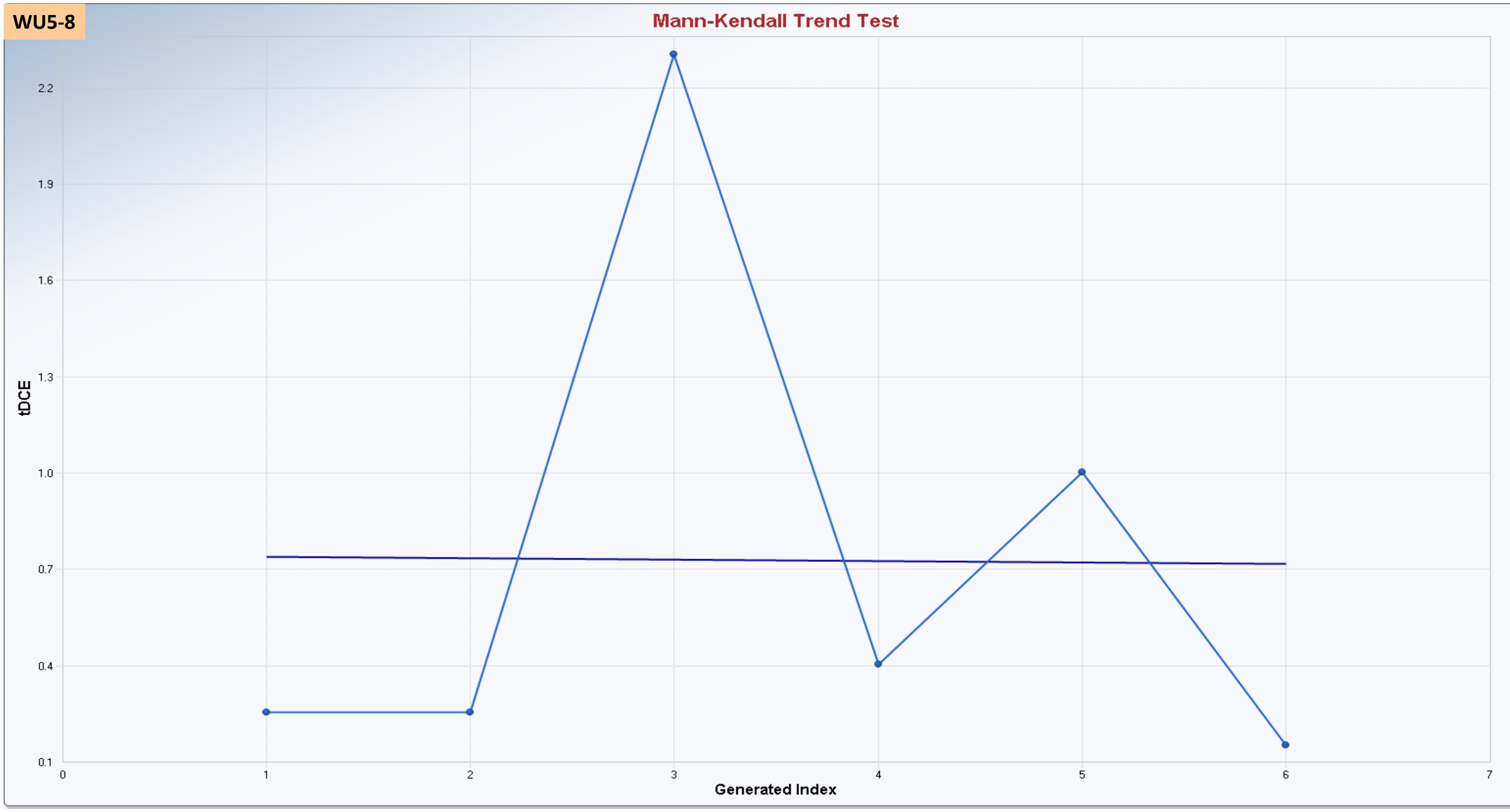

WU5-2
Mann-Kendall Trend Test
tDCE
0.444
0.394
0.344
0.294
0.244
0.194
0
2
4
6
8
10
Generated Index
Mann-Kendall Trend Analysis
n 10
Confidence Coefficient 0.9500
Level of Significance 0.0500
Standard Deviation of S 11.0905
Standardized Value of S -2.1640
M-K Test Value (S) -25
Tabulated p-value 0.0140
Approximate p-value 0.0152
OLS Regression Line (Blue)
OLS Regression Slope -0.0215
OLS Regression Intercept 0.4353
Statistically significant evidence
of a decreasing trend at the
specified level of significance.


WU5-4
Mann-Kendall Trend Test
TCE
2.4
2.1
1.8
1.5
1.2
0.9
0
2
4
6
8
10
Generated Index
Mann-Kendall Trend Analysis
n 9
Confidence Coefficient 0.9500
Level of Significance 0.0500
Standard Deviation of S 9.1287
Standardized Value of S -2.3004
M-K Test Value (S) -22
Tabulated p-value 0.0120
Approximate p-value 0.0107
OLS Regression Line (Blue)
OLS Regression Slope -0.1733
OLS Regression Intercept 2.3000
Statistically significant evidence
of a decreasing trend at the
specified level of significance.


WU5-8
Mann-Kendall Trend Test
TCE
Generated Index
Mann-Kendall Trend Analysis
n 6
Confidence Coefficient 0.9000
Level of Significance 0.1000
Standard Deviation of S 5.3229
Standardized Value of S 0.3757
M-K Test Value (S) 3
Tabulated p-value 0.3600
Approximate p-value 0.3536
OLS Regression Line (Blue)
OLS Regression Slope 0.0991
OLS Regression Intercept 0.1713
Insufficient statistical evidence of a significant trend at the specified level of significance.


WU5-8
Mann-Kendall Trend Test
cDCE
Generated Index
0.3
0.6
0.9
1.2
1.5
1.8
2.1
2.4
0
1
2
3
4
5
6
7
Mann-Kendall Trend Analysis
n 6
Confidence Coefficient 0.9000
Level of Significance 0.1000
Standard Deviation of S 5.3229
Standardized Value of S 0.7515
M-K Test Value (S) 5
Tabulated p-value 0.2350
Approximate p-value 0.2262
OLS Regression Line (Blue)
OLS Regression Slope 0.0511
OLS Regression Intercept 0.7693
Insufficient statistical evidence
of a significant trend at the
specified level of significance.

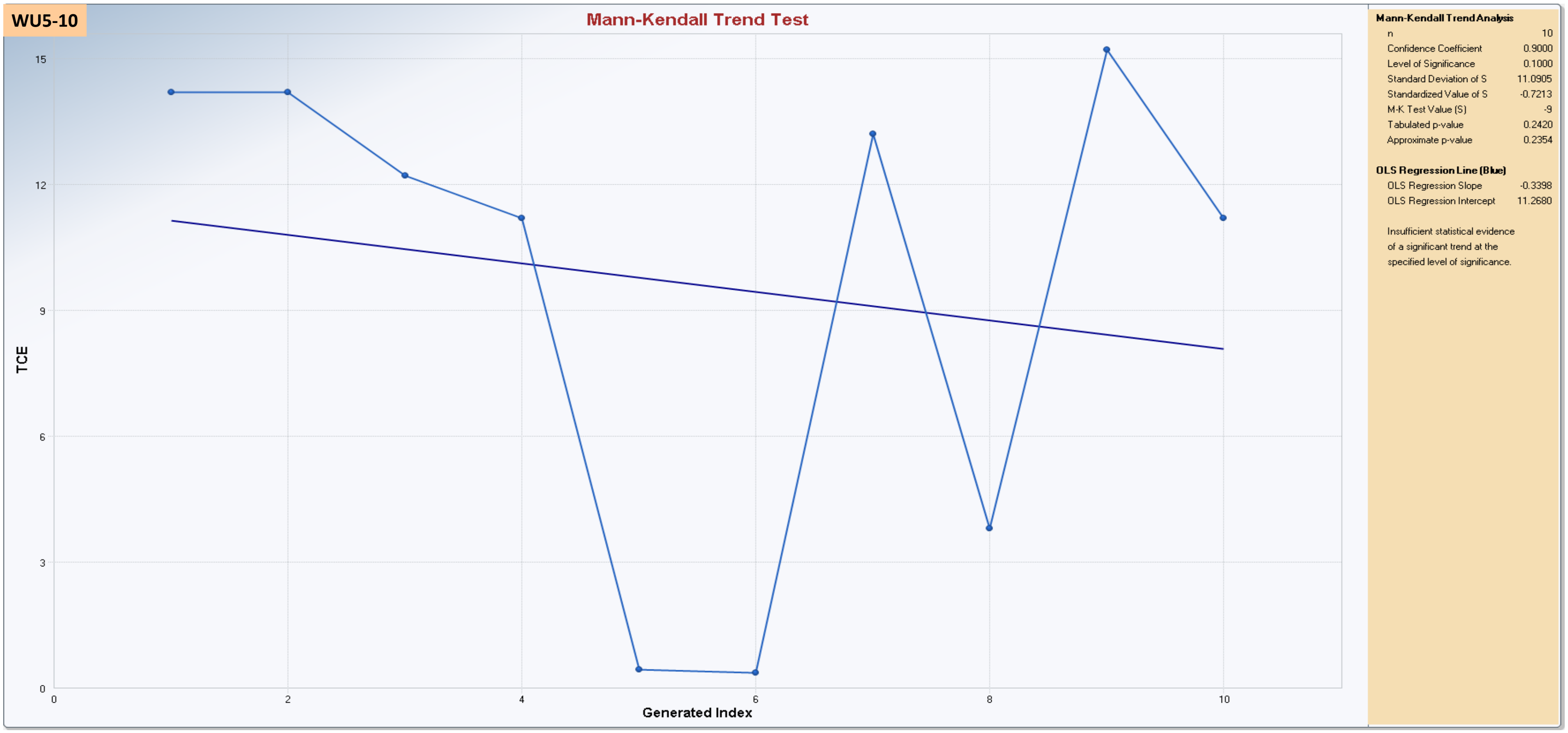

WU5-8
Mann-Kendall Trend Test
VC
1.6
1.3
1.0
0.7
0.4
0.1
0
1
2
3
4
5
6
7
Generated Index
Mann-Kendall Trend Analysis
n 6
Confidence Coefficient 0.9000
Level of Significance 0.1000
Standard Deviation of S 5.3229
Standardized Value of S -0.3757
M-K Test Value (S) -3
Tabulated p-value 0.3600
Approximate p-value 0.3536
OLS Regression Line (Blue)
OLS Regression Slope -0.0743
OLS Regression Intercept 0.7567
Insufficient statistical evidence
of a significant trend at the
specified level of significance.



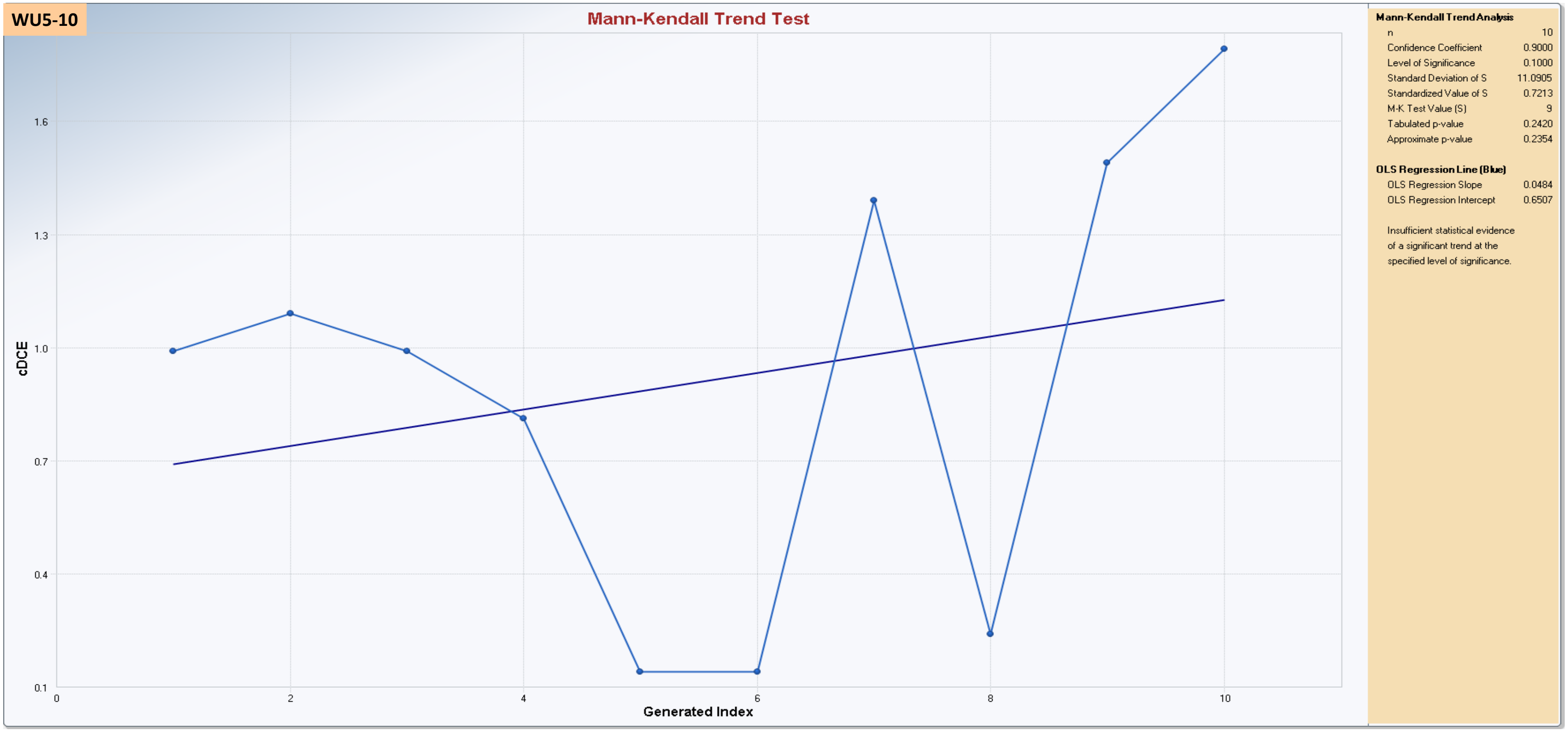
Mann-Kendall Trend Analysis	
n	6
Confidence Coefficient	0.9000
Level of Significance	0.1000
Standard Deviation of S	5.2281
Standardized Value of S	
M-K Test Value (S)	0
Tabulated p-value	0.5000
Approximate p-value	

OLS Regression Line (Blue)	
OLS Regression Slope	-0.0043
OLS Regression Intercept	0.7400

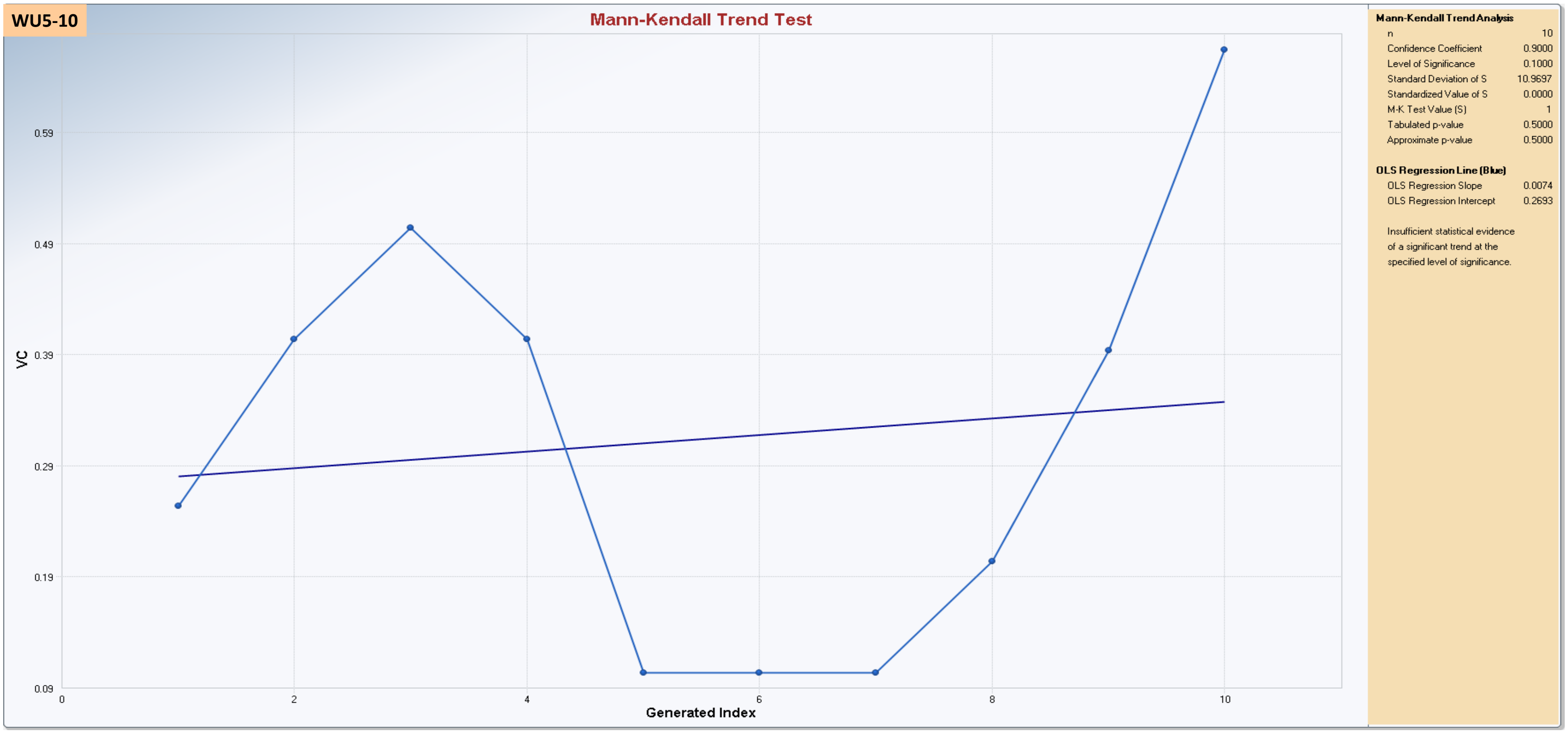
Insufficient statistical evidence of a significant trend at the specified level of significance.



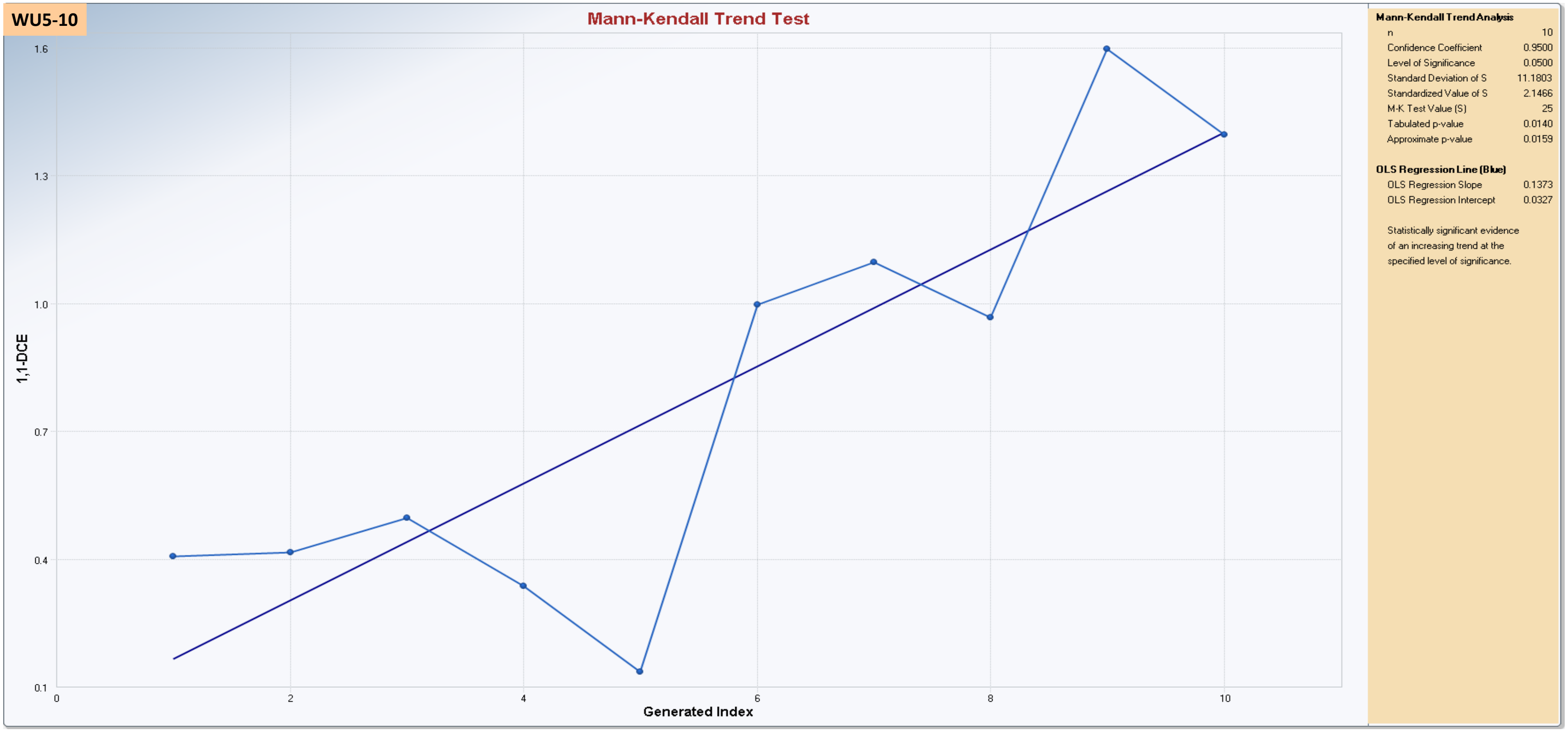
WU5-10
Mann-Kendall Trend Test
TCE
Generated Index
15
12
9
6
3
0
0
2
4
6
8
10
Mann-Kendall Trend Analysis
n 10
Confidence Coefficient 0.9000
Level of Significance 0.1000
Standard Deviation of S 11.0905
Standardized Value of S -0.7213
M-K Test Value (S) -9
Tabulated p-value 0.2420
Approximate p-value 0.2354
OLS Regression Line (Blue)
OLS Regression Slope -0.3398
OLS Regression Intercept 11.2680
Insufficient statistical evidence
of a significant trend at the
specified level of significance.

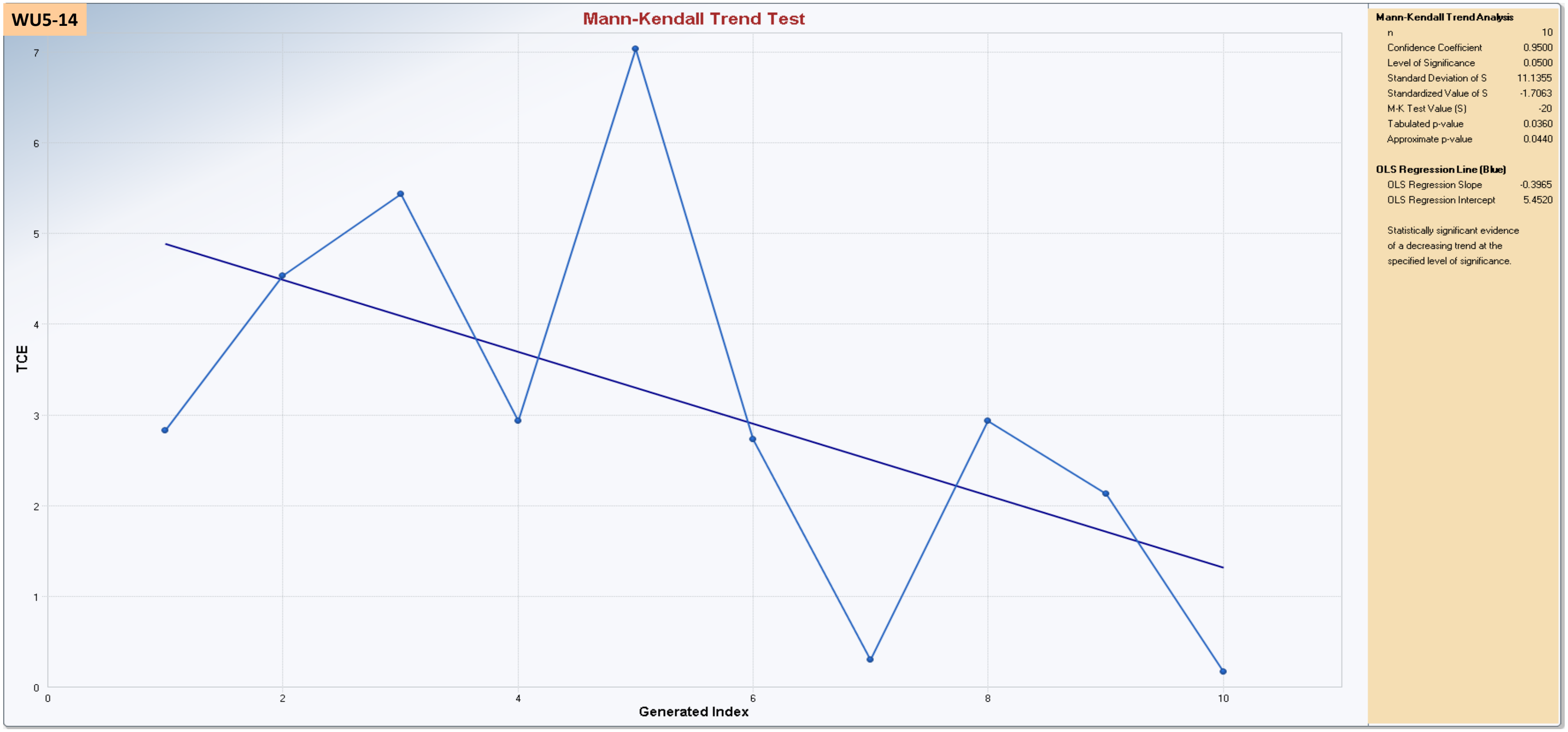


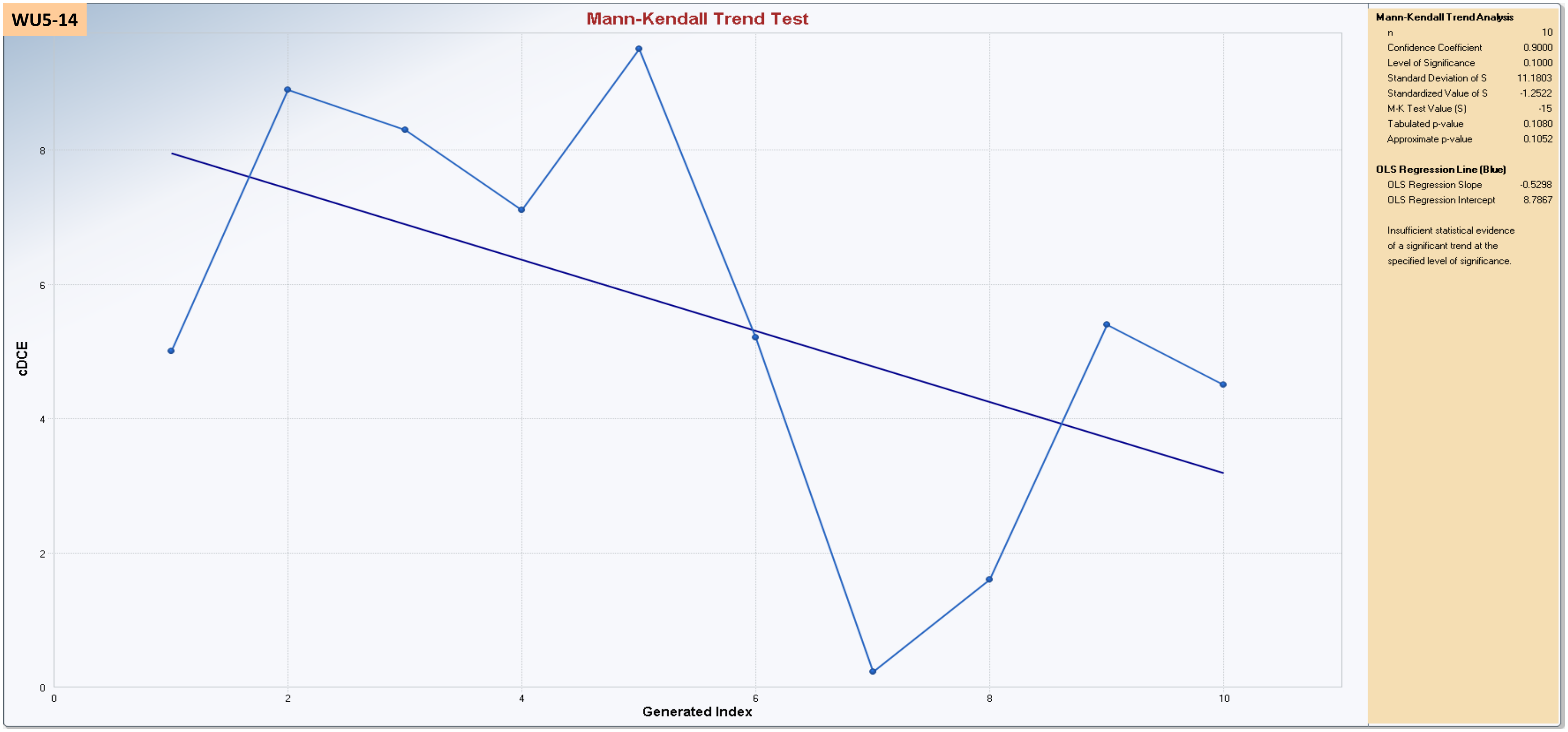
WU5-10
Mann-Kendall Trend Test
cDCE
Generated Index
Mann-Kendall Trend Analysis
n 10
Confidence Coefficient 0.9000
Level of Significance 0.1000
Standard Deviation of S 11.0905
Standardized Value of S 0.7213
M-K Test Value (S) 9
Tabulated p-value 0.2420
Approximate p-value 0.2354
OLS Regression Line (Blue)
OLS Regression Slope 0.0484
OLS Regression Intercept 0.6507
Insufficient statistical evidence of a significant trend at the specified level of significance.

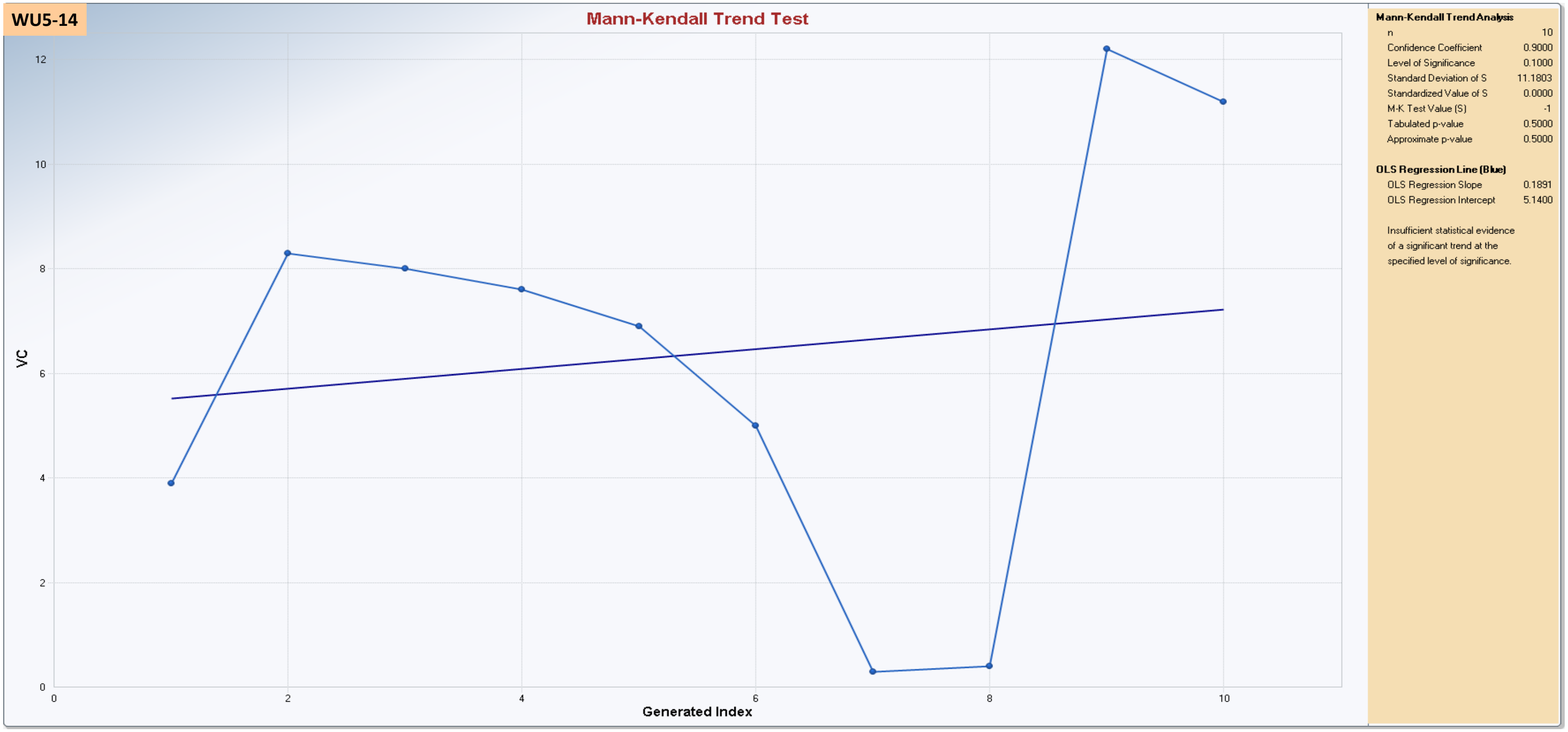


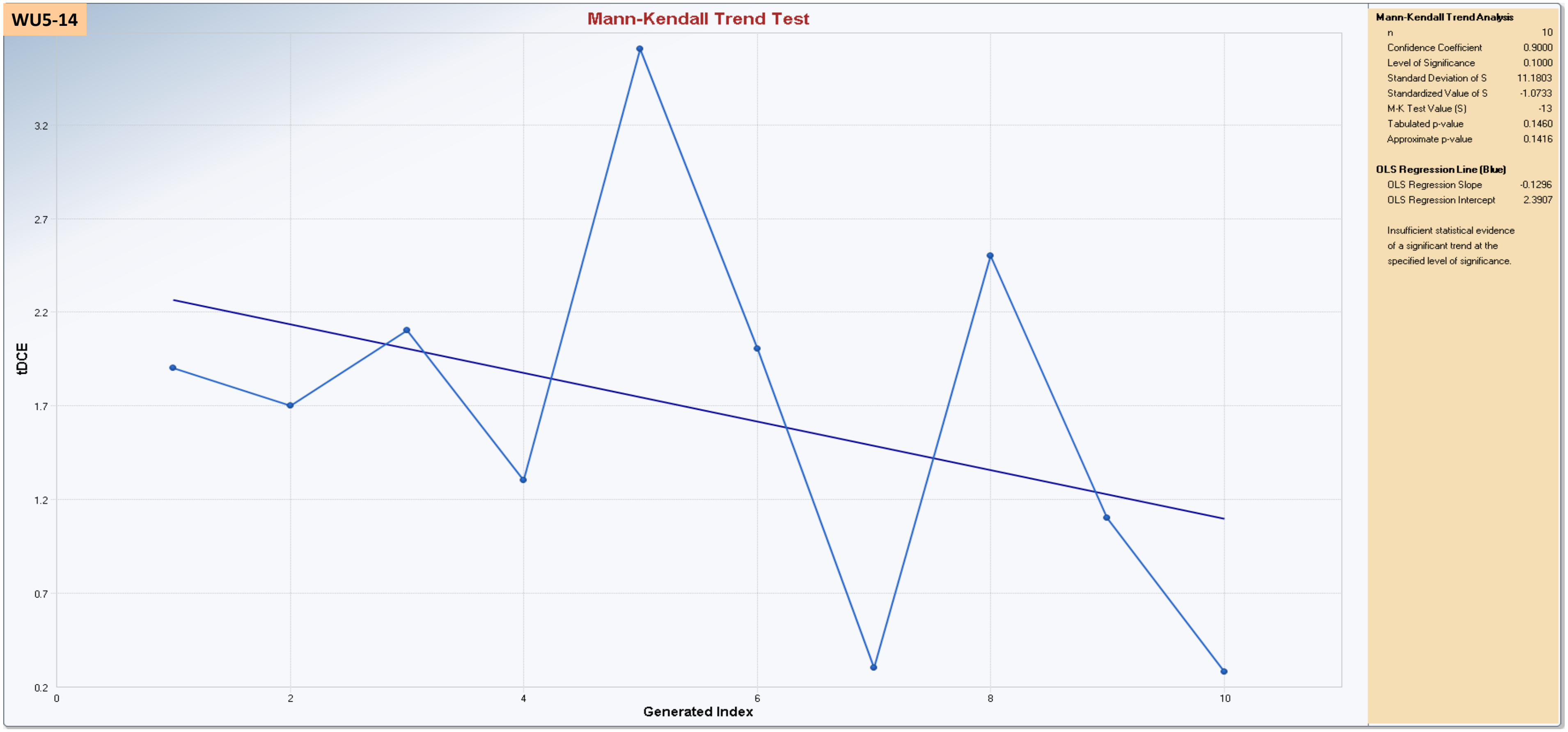
WU5-10
Mann-Kendall Trend Test
VC
0.59
0.49
0.39
0.29
0.19
0.09
0
2
4
6
8
10
Generated Index
Mann-Kendall Trend Analysis
n 10
Confidence Coefficient 0.9000
Level of Significance 0.1000
Standard Deviation of S 10.9697
Standardized Value of S 0.0000
M-K Test Value (S) 1
Tabulated p-value 0.5000
Approximate p-value 0.5000
OLS Regression Line (Blue)
OLS Regression Slope 0.0074
OLS Regression Intercept 0.2693
Insufficient statistical evidence
of a significant trend at the
specified level of significance.

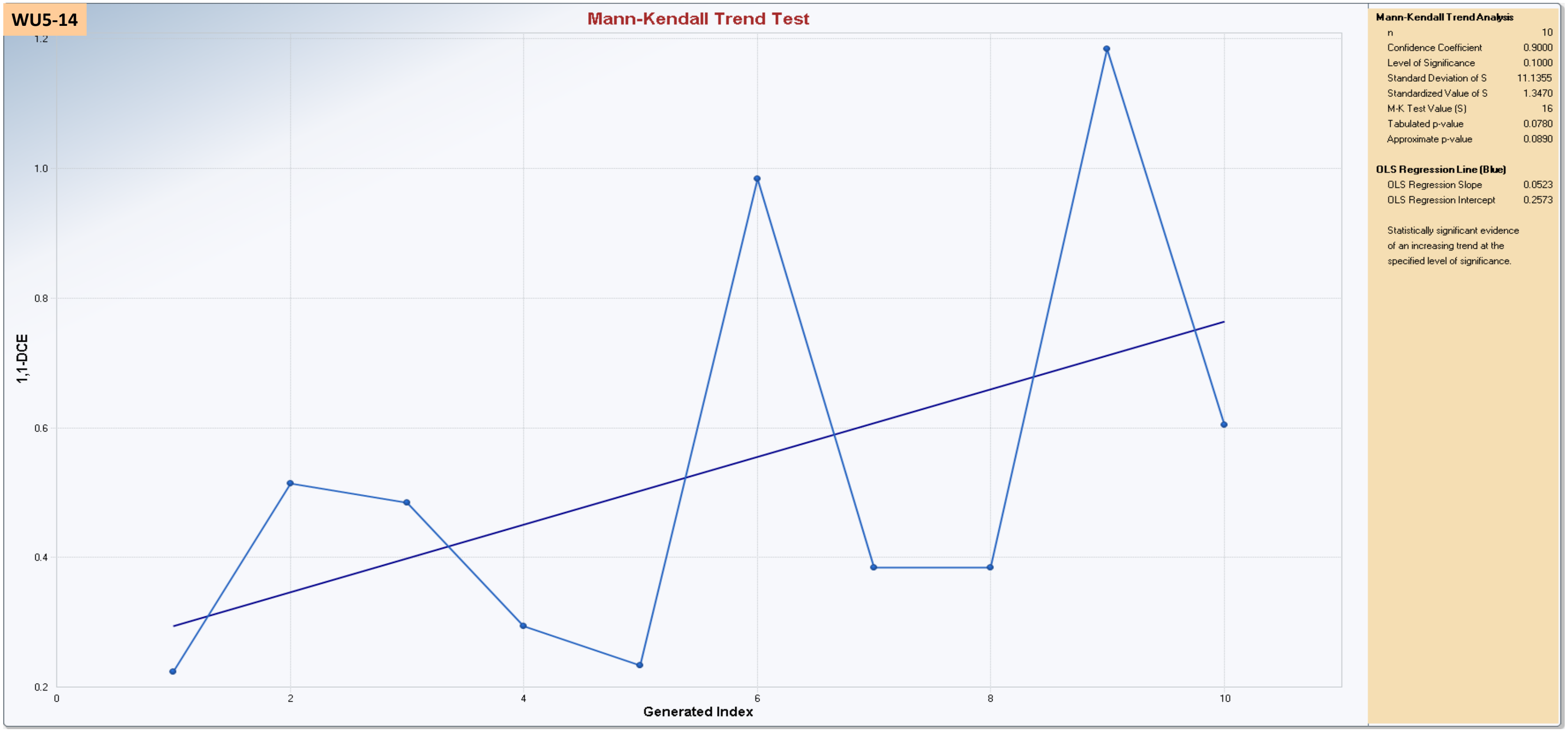

WU5-10
Mann-Kendall Trend Test
1.6
1.3
1.0
0.7
0.4
0.1
1,1-DCE
0
2
4
6
8
10
Generated Index
Mann-Kendall Trend Analysis
n 10
Confidence Coefficient 0.9500
Level of Significance 0.0500
Standard Deviation of S 11.1803
Standardized Value of S 2.1466
M-K Test Value (S) 25
Tabulated p-value 0.0140
Approximate p-value 0.0159
OLS Regression Line (Blue)
OLS Regression Slope 0.1373
OLS Regression Intercept 0.0327
Statistically significant evidence
of an increasing trend at the
specified level of significance.

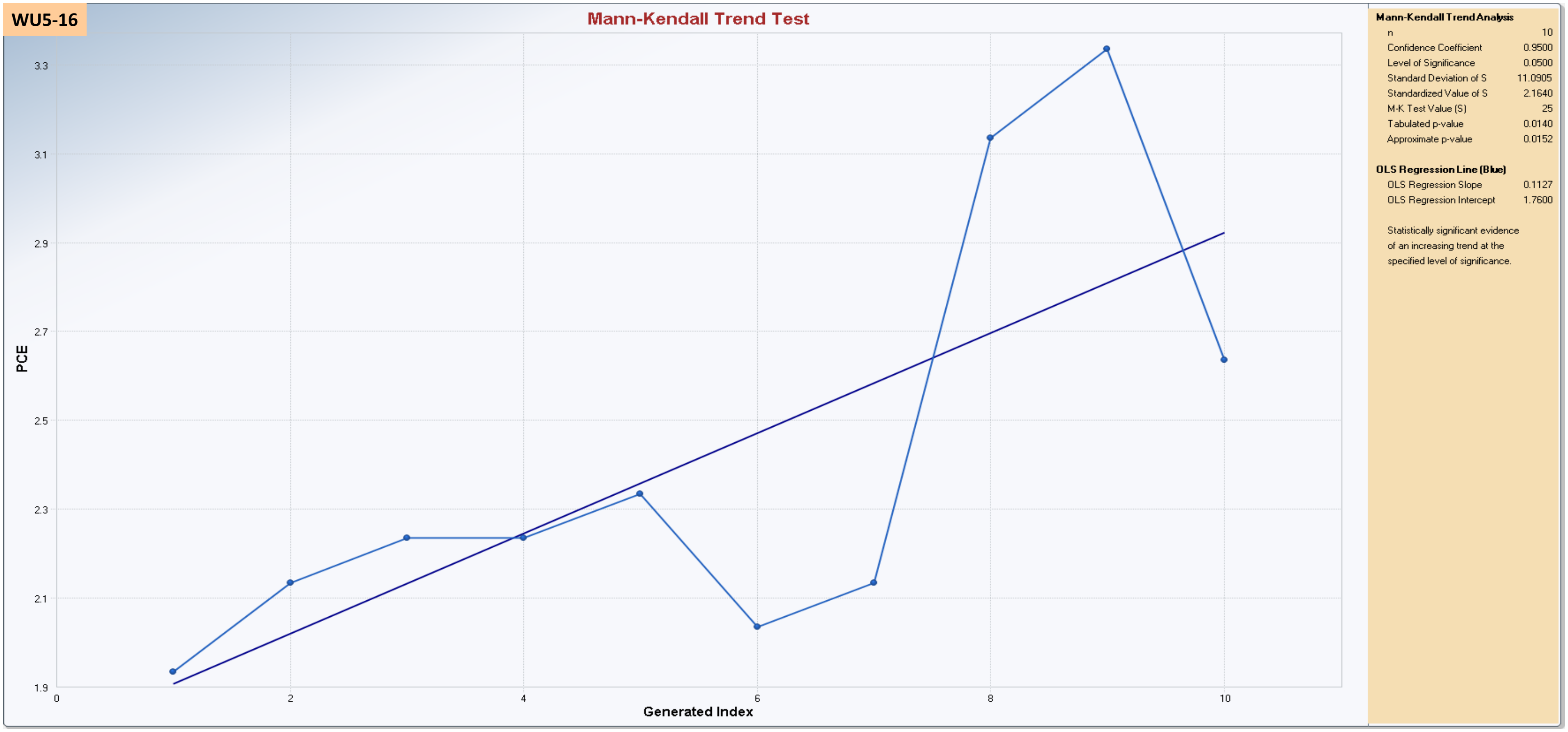

WU5-14
Mann-Kendall Trend Test
TCE
Generated Index
Mann-Kendall Trend Analysis
n 10
Confidence Coefficient 0.9500
Level of Significance 0.0500
Standard Deviation of S 11.1355
Standardized Value of S -1.7063
M-K Test Value (S) -20
Tabulated p-value 0.0360
Approximate p-value 0.0440
OLS Regression Line (Blue)
OLS Regression Slope -0.3965
OLS Regression Intercept 5.4520
Statistically significant evidence
of a decreasing trend at the
specified level of significance.


WU5-14
Mann-Kendall Trend Test
cDCE
Generated Index
0
2
4
6
8
10
Mann-Kendall Trend Analysis
n 10
Confidence Coefficient 0.9000
Level of Significance 0.1000
Standard Deviation of S 11.1803
Standardized Value of S -1.2522
M-K Test Value (S) -15
Tabulated p-value 0.1080
Approximate p-value 0.1052
OLS Regression Line (Blue)
OLS Regression Slope -0.5298
OLS Regression Intercept 8.7867
Insufficient statistical evidence
of a significant trend at the
specified level of significance.

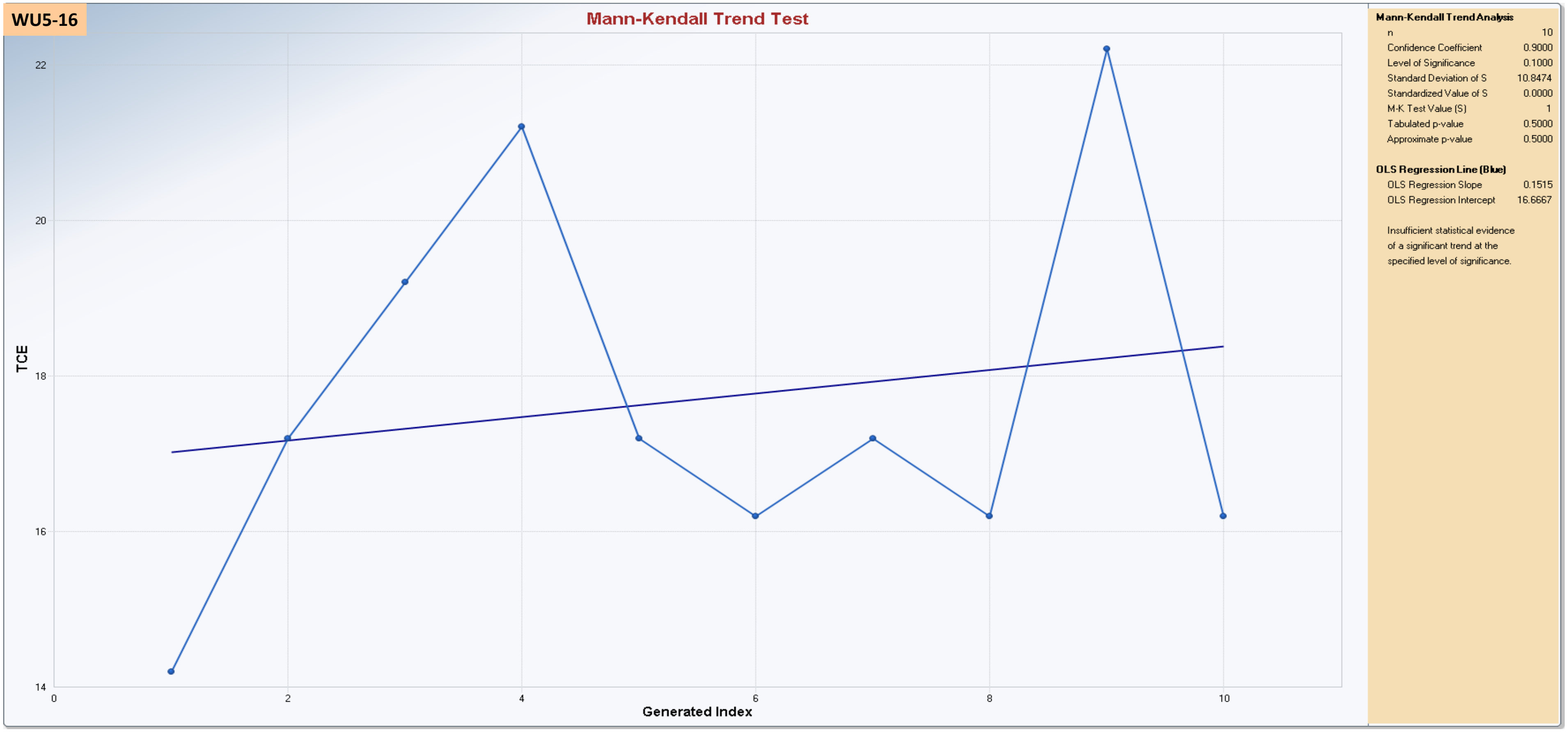

WU5-14
Mann-Kendall Trend Test
VC
Generated Index
Mann-Kendall Trend Analysis
n 10
Confidence Coefficient 0.9000
Level of Significance 0.1000
Standard Deviation of S 11.1803
Standardized Value of S 0.0000
M-K Test Value (S) -1
Tabulated p-value 0.5000
Approximate p-value 0.5000
OLS Regression Line (Blue)
OLS Regression Slope 0.1891
OLS Regression Intercept 5.1400
Insufficient statistical evidence
of a significant trend at the
specified level of significance.

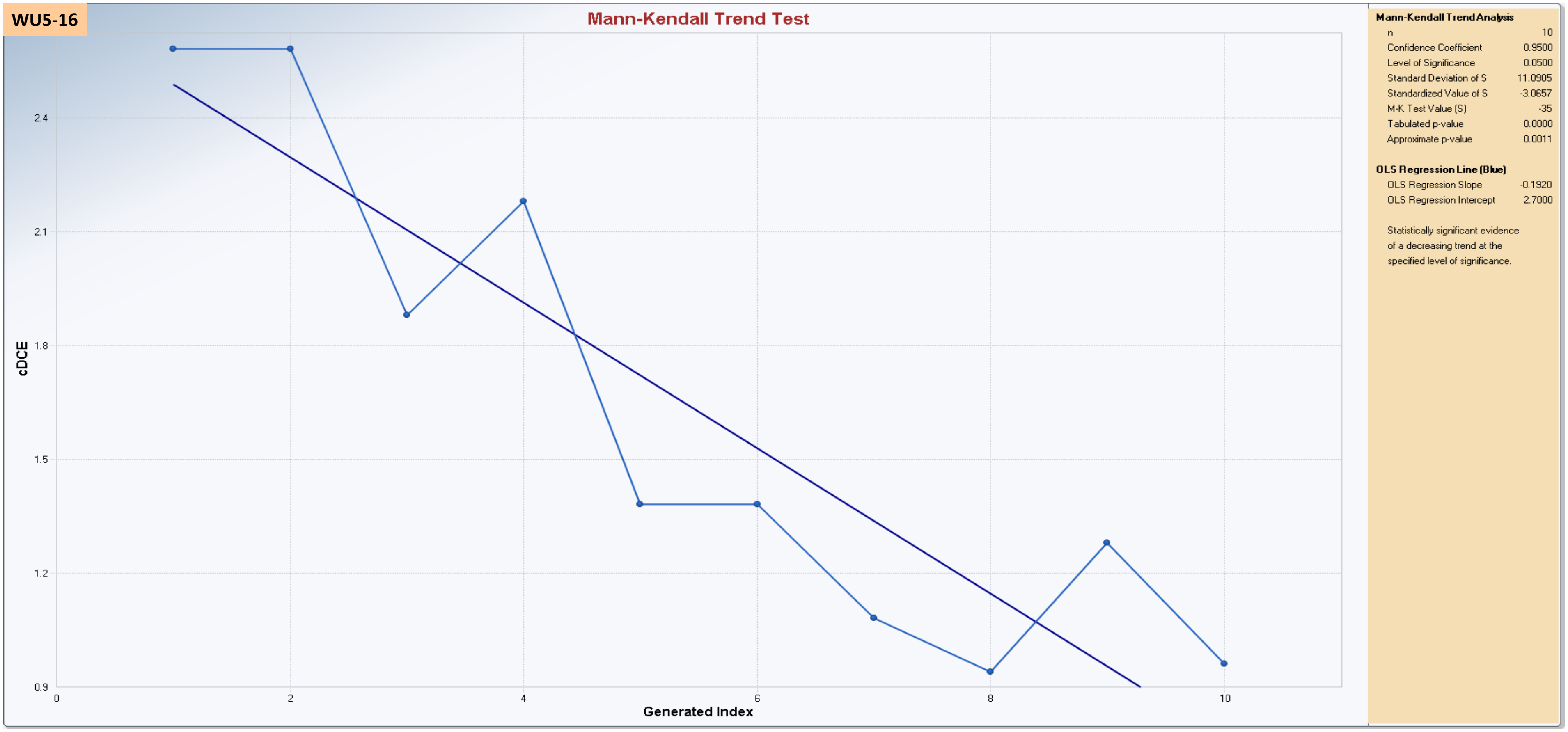

WU5-14
Mann-Kendall Trend Test
tDCE
Generated Index
0.2
0.7
1.2
1.7
2.2
2.7
3.2
0
2
4
6
8
10
Mann-Kendall Trend Analysis
n 10
Confidence Coefficient 0.9000
Level of Significance 0.1000
Standard Deviation of S 11.1803
Standardized Value of S -1.0733
M-K Test Value (S) -13
Tabulated p-value 0.1460
Approximate p-value 0.1416
OLS Regression Line (Blue)
OLS Regression Slope -0.1296
OLS Regression Intercept 2.3907
Insufficient statistical evidence of a significant trend at the specified level of significance.

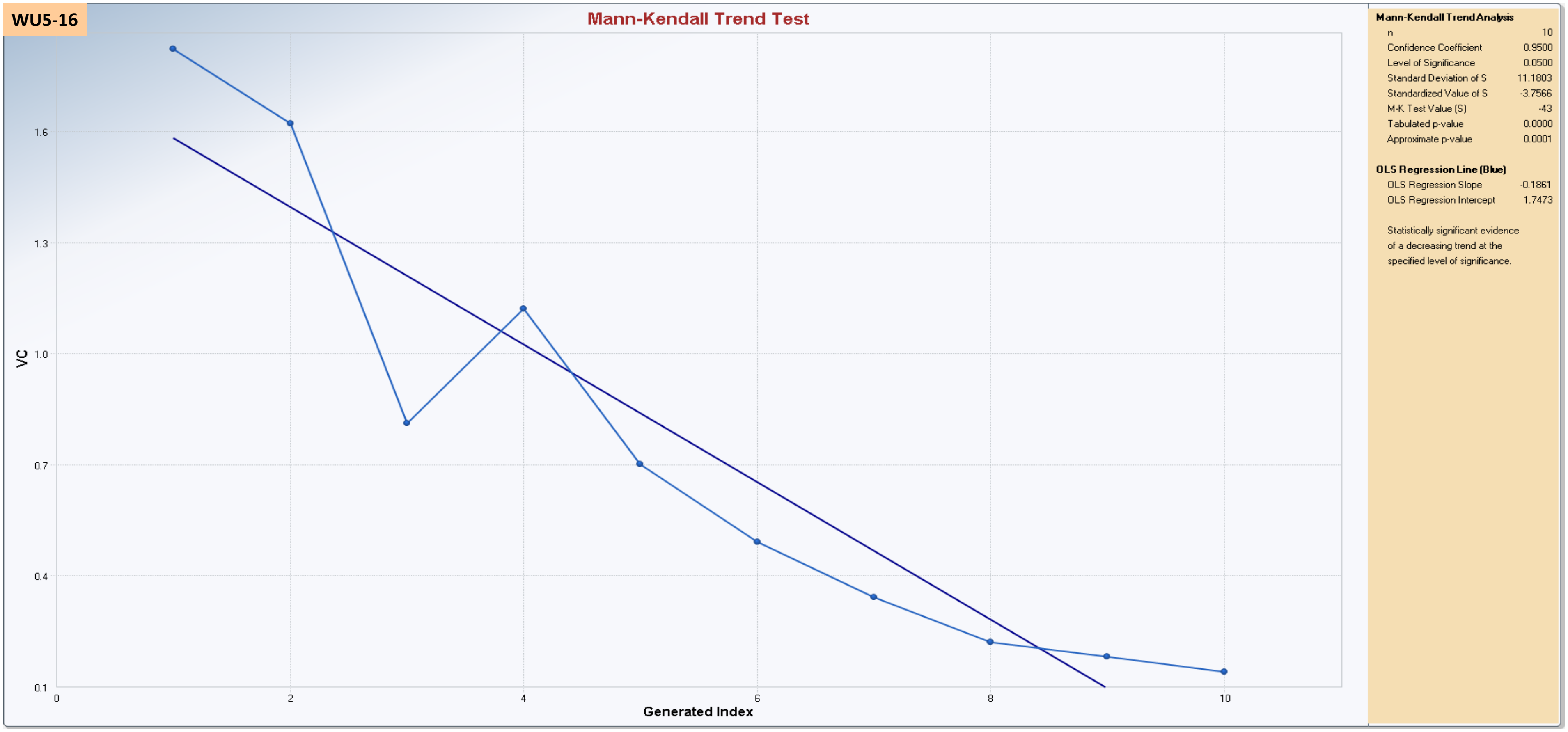

WU5-14
Mann-Kendall Trend Test
1,1-DCE
Generated Index
Mann-Kendall Trend Analysis
n 10
Confidence Coefficient 0.9000
Level of Significance 0.1000
Standard Deviation of S 11.1355
Standardized Value of S 1.3470
M-K Test Value (S) 16
Tabulated p-value 0.0780
Approximate p-value 0.0890
OLS Regression Line (Blue)
OLS Regression Slope 0.0523
OLS Regression Intercept 0.2573
Statistically significant evidence of an increasing trend at the specified level of significance.

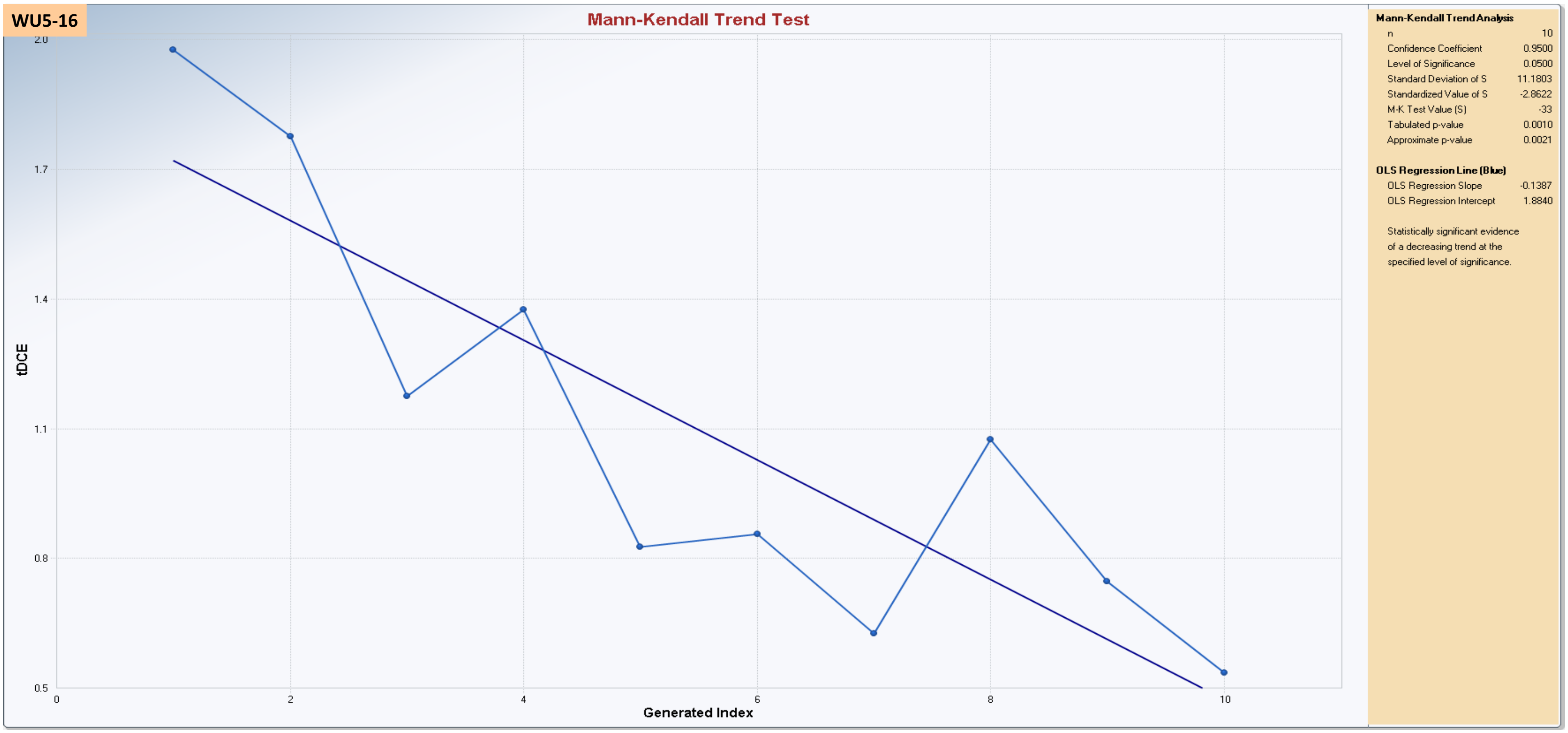


WU5-16
Mann-Kendall Trend Test
PCE
Generated Index
Mann-Kendall Trend Analysis
n 10
Confidence Coefficient 0.9500
Level of Significance 0.0500
Standard Deviation of S 11.0905
Standardized Value of S 2.1640
M-K Test Value (S) 25
Tabulated p-value 0.0140
Approximate p-value 0.0152
OLS Regression Line (Blue)
OLS Regression Slope 0.1127
OLS Regression Intercept 1.7600
Statistically significant evidence of an increasing trend at the specified level of significance.

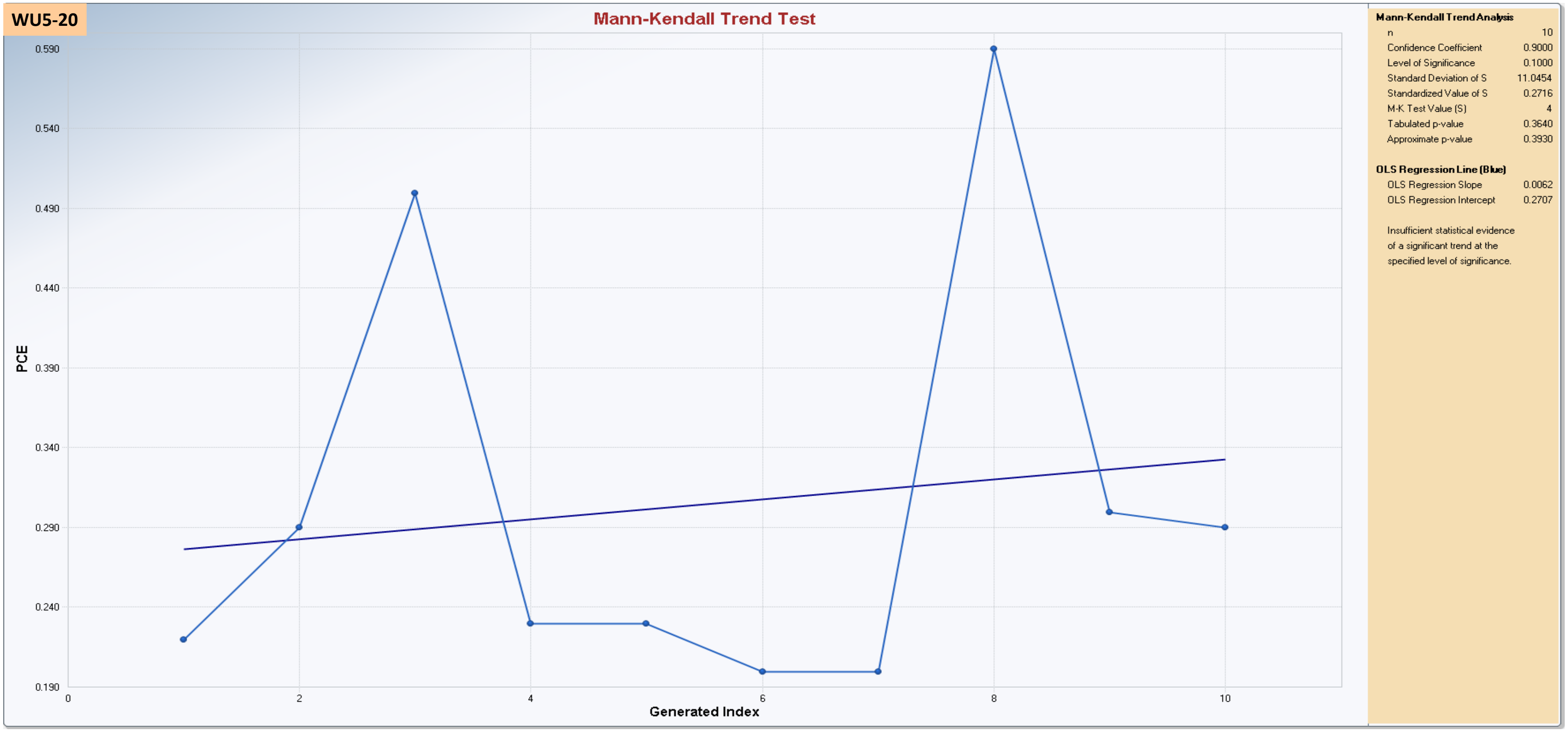

WU5-16
Mann-Kendall Trend Test
TCE
Generated Index
22
20
18
16
14
0
2
4
6
8
10
Mann-Kendall Trend Analysis
n 10
Confidence Coefficient 0.9000
Level of Significance 0.1000
Standard Deviation of S 10.8474
Standardized Value of S 0.0000
M-K Test Value (S) 1
Tabulated p-value 0.5000
Approximate p-value 0.5000
OLS Regression Line (Blue)
OLS Regression Slope 0.1515
OLS Regression Intercept 16.6667
Insufficient statistical evidence
of a significant trend at the
specified level of significance.

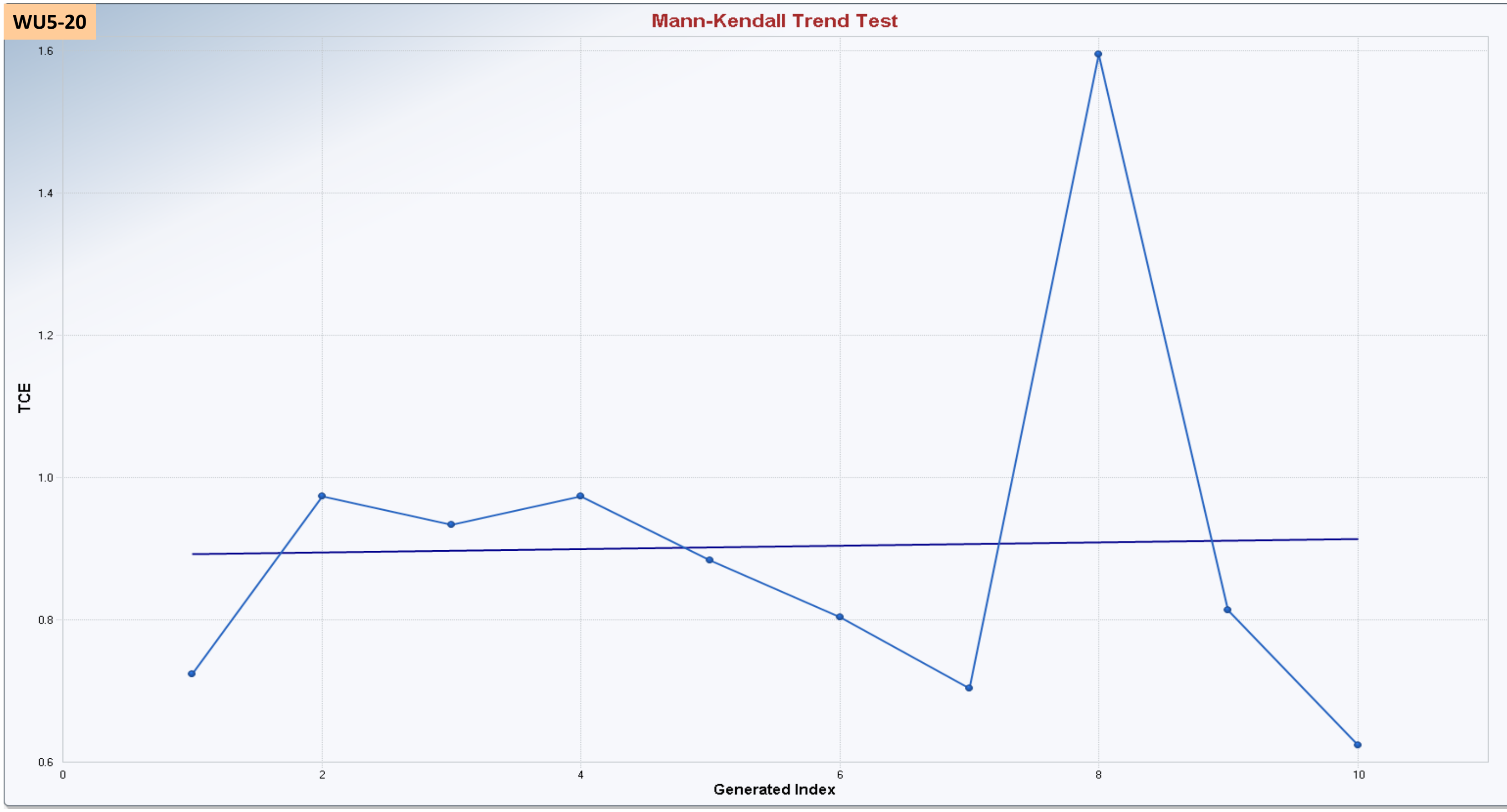

WU5-16
Mann-Kendall Trend Test
cDCE
Generated Index
0.9
1.2
1.5
1.8
2.1
2.4
0
2
4
6
8
10
Mann-Kendall Trend Analysis
n 10
Confidence Coefficient 0.9500
Level of Significance 0.0500
Standard Deviation of S 11.0905
Standardized Value of S -3.0657
M-K Test Value (S) -35
Tabulated p-value 0.0000
Approximate p-value 0.0011
OLS Regression Line (Blue)
OLS Regression Slope -0.1920
OLS Regression Intercept 2.7000
Statistically significant evidence
of a decreasing trend at the
specified level of significance.


WU5-16
Mann-Kendall Trend Test
VC
Generated Index
Mann-Kendall Trend Analysis
n 10
Confidence Coefficient 0.9500
Level of Significance 0.0500
Standard Deviation of S 11.1803
Standardized Value of S -3.7566
M-K Test Value (S) -43
Tabulated p-value 0.0000
Approximate p-value 0.0001
OLS Regression Line (Blue)
OLS Regression Slope -0.1861
OLS Regression Intercept 1.7473
Statistically significant evidence
of a decreasing trend at the
specified level of significance.


WU5-16
Mann-Kendall Trend Test
tDCE
Generated Index
2.0
1.7
1.4
1.1
0.8
0.5
0
2
4
6
8
10
Mann-Kendall Trend Analysis
n 10
Confidence Coefficient 0.9500
Level of Significance 0.0500
Standard Deviation of S 11.1803
Standardized Value of S -2.8622
M-K Test Value (S) -33
Tabulated p-value 0.0010
Approximate p-value 0.0021
OLS Regression Line (Blue)
OLS Regression Slope -0.1387
OLS Regression Intercept 1.8840
Statistically significant evidence
of a decreasing trend at the
specified level of significance.


WU5-16
Mann-Kendall Trend Test
1,1-DCE
0.69
0.59
0.49
0.39
0.29
0.19
0
2
4
6
8
10
Generated Index
Mann-Kendall Trend Analysis
n 10
Confidence Coefficient 0.9500
Level of Significance 0.0500
Standard Deviation of S 11.0905
Standardized Value of S -2.5247
M-K Test Value (S) -29
Tabulated p-value 0.0050
Approximate p-value 0.0058
OLS Regression Line (Blue)
OLS Regression Slope -0.0453
OLS Regression Intercept 0.6760
Statistically significant evidence
of a decreasing trend at the
specified level of significance.


WU5-20
Mann-Kendall Trend Test
PCE
0.590
0.540
0.490
0.440
0.390
0.340
0.290
0.240
0.190
0
2
4
6
8
10
Generated Index
Mann-Kendall Trend Analysis
n 10
Confidence Coefficient 0.9000
Level of Significance 0.1000
Standard Deviation of S 11.0454
Standardized Value of S 0.2716
M-K Test Value (S) 4
Tabulated p-value 0.3640
Approximate p-value 0.3930
OLS Regression Line (Blue)
OLS Regression Slope 0.0062
OLS Regression Intercept 0.2707
Insufficient statistical evidence
of a significant trend at the
specified level of significance.



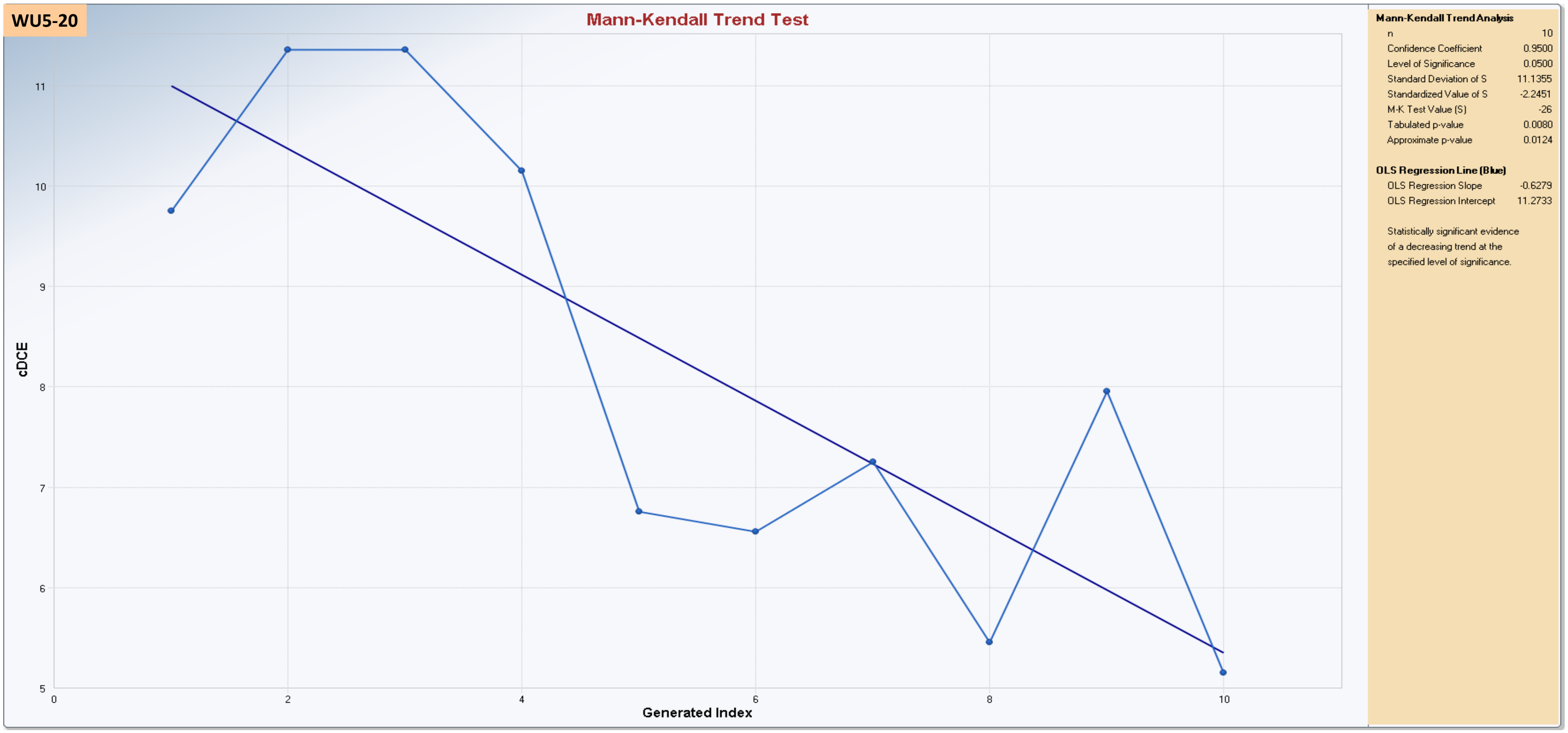
Mann-Kendall Trend Analysis

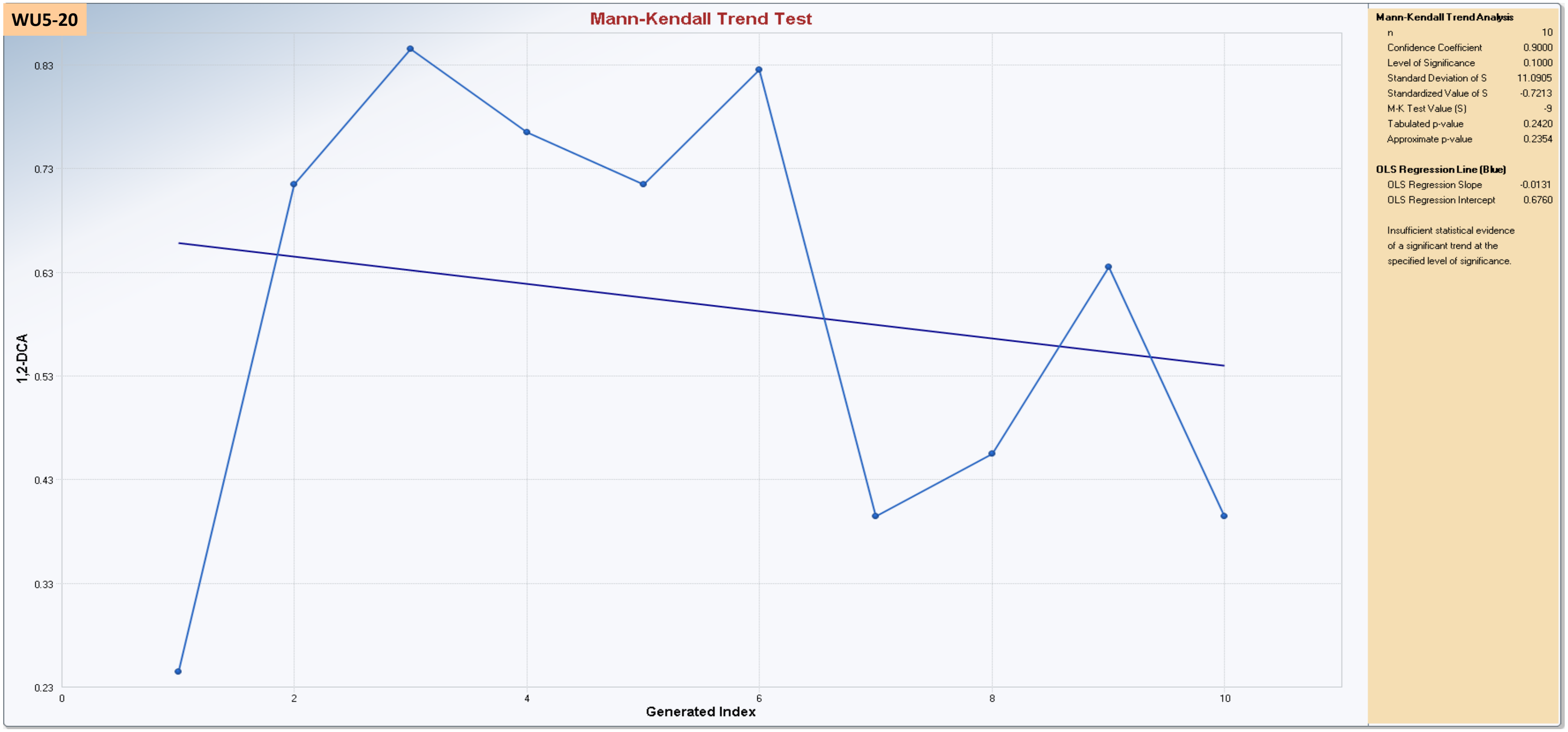
n	10
Confidence Coefficient	0.9000
Level of Significance	0.1000
Standard Deviation of S	11.1355
Standardized Value of S	-0.9878
M-K Test Value (S)	-12
Tabulated p-value	0.1460
Approximate p-value	0.1616

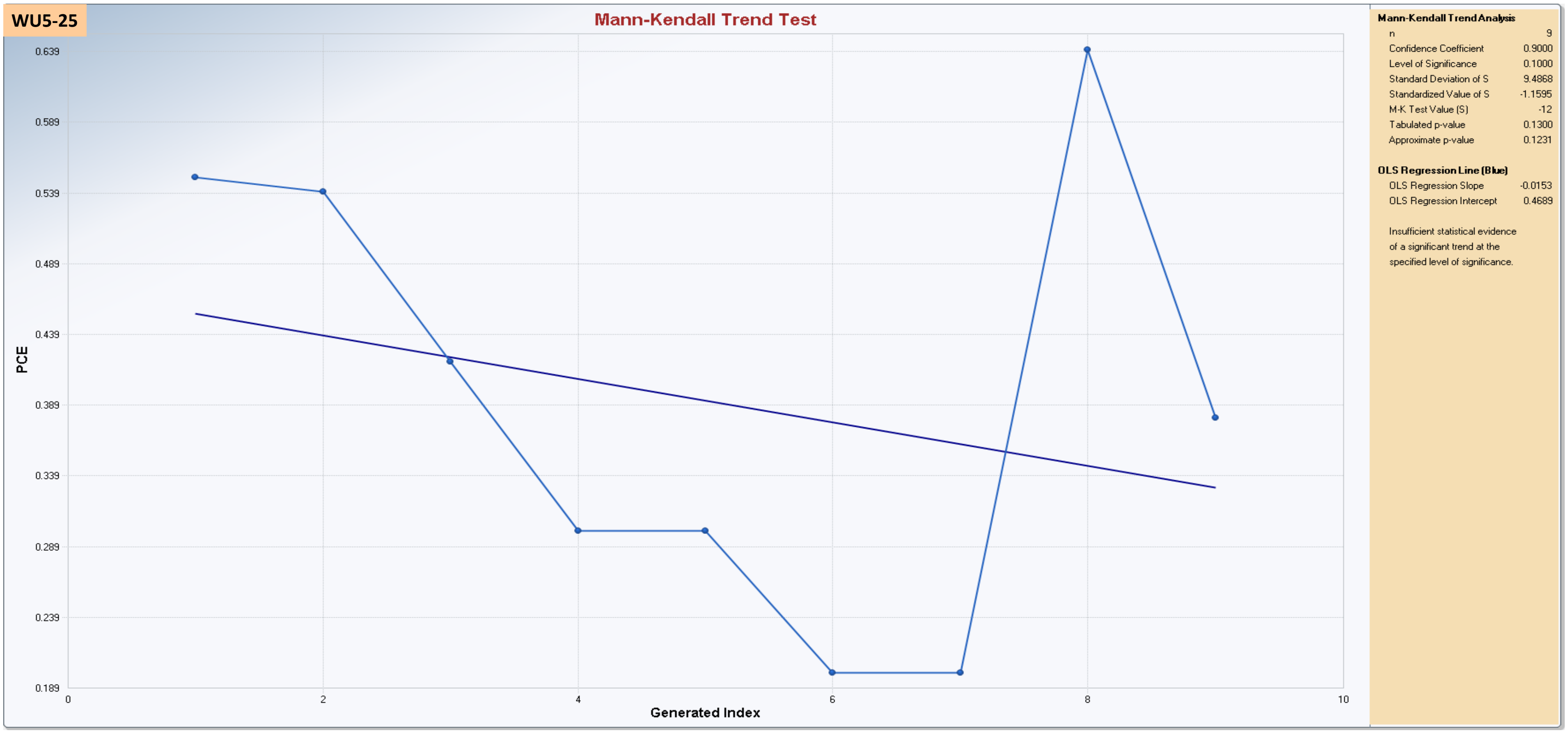
OLS Regression Line (Blue)

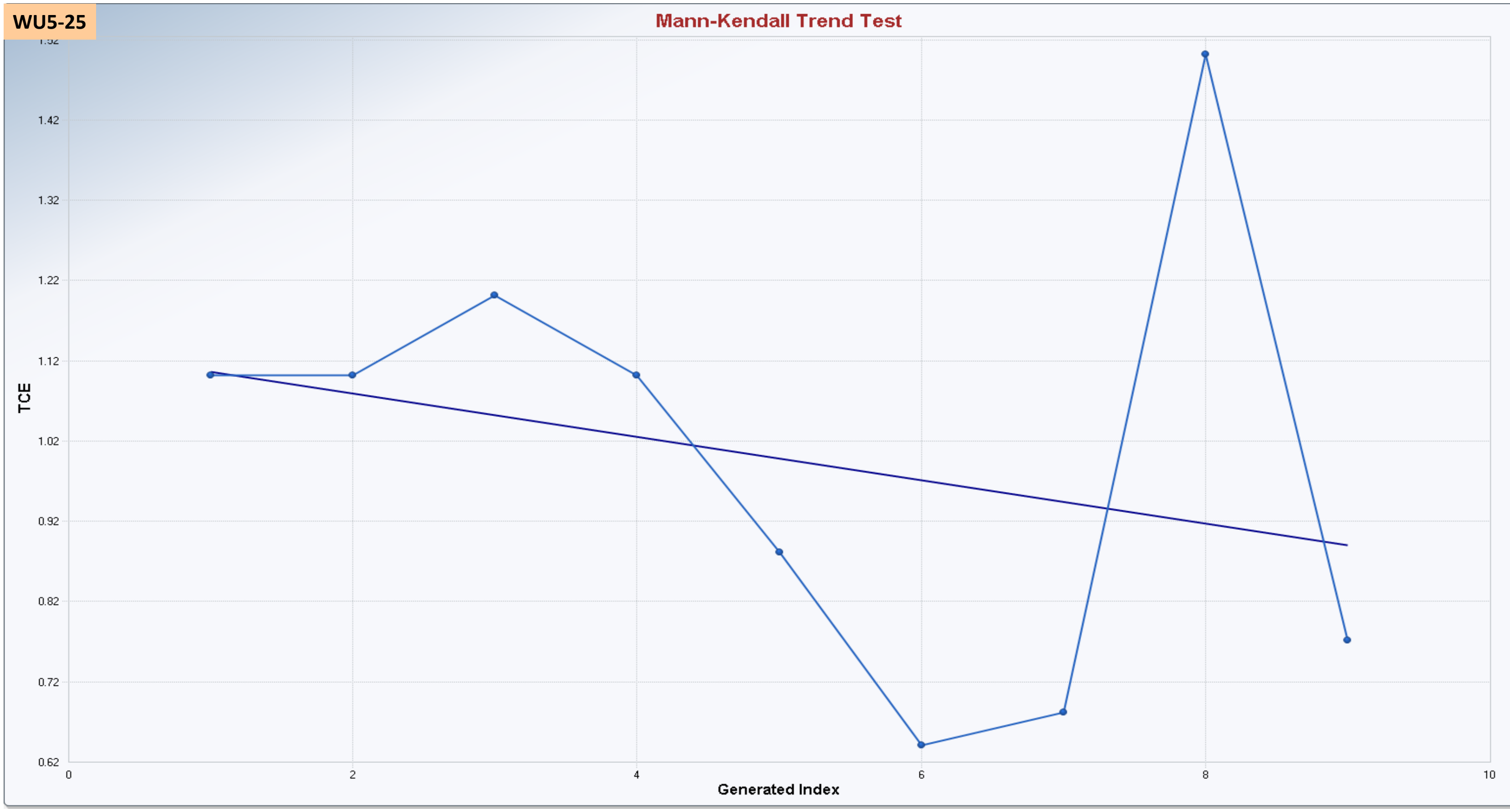
OLS Regression Slope	0.0024
OLS Regression Intercept	0.8960

Insufficient statistical evidence of a significant trend at the specified level of significance.


WU5-20
Mann-Kendall Trend Test
cDCE
Generated Index
0
2
4
6
8
10
5
6
7
8
9
10
11
Mann-Kendall Trend Analysis
n 10
Confidence Coefficient 0.9500
Level of Significance 0.0500
Standard Deviation of S 11.1355
Standardized Value of S -2.2451
M-K Test Value (S) -26
Tabulated p-value 0.0080
Approximate p-value 0.0124
OLS Regression Line (Blue)
OLS Regression Slope -0.6279
OLS Regression Intercept 11.2733
Statistically significant evidence
of a decreasing trend at the
specified level of significance.


WU5-20
Mann-Kendall Trend Test
0.83
0.73
0.63
0.53
0.43
0.33
0.23
1,2-DCA
0
2
4
6
8
10
Generated Index
Mann-Kendall Trend Analysis
n 10
Confidence Coefficient 0.9000
Level of Significance 0.1000
Standard Deviation of S 11.0905
Standardized Value of S -0.7213
M-K Test Value (S) -9
Tabulated p-value 0.2420
Approximate p-value 0.2354
OLS Regression Line (Blue)
OLS Regression Slope -0.0131
OLS Regression Intercept 0.6760
Insufficient statistical evidence
of a significant trend at the
specified level of significance.


WU5-25
Mann-Kendall Trend Test
PCE
Generated Index
0.639
0.589
0.539
0.489
0.439
0.389
0.339
0.289
0.239
0.189
0
2
4
6
8
10
Mann-Kendall Trend Analysis
n 9
Confidence Coefficient 0.9000
Level of Significance 0.1000
Standard Deviation of S 9.4868
Standardized Value of S -1.1595
M-K Test Value (S) -12
Tabulated p-value 0.1300
Approximate p-value 0.1231
OLS Regression Line (Blue)
OLS Regression Slope -0.0153
OLS Regression Intercept 0.4689
Insufficient statistical evidence
of a significant trend at the
specified level of significance.



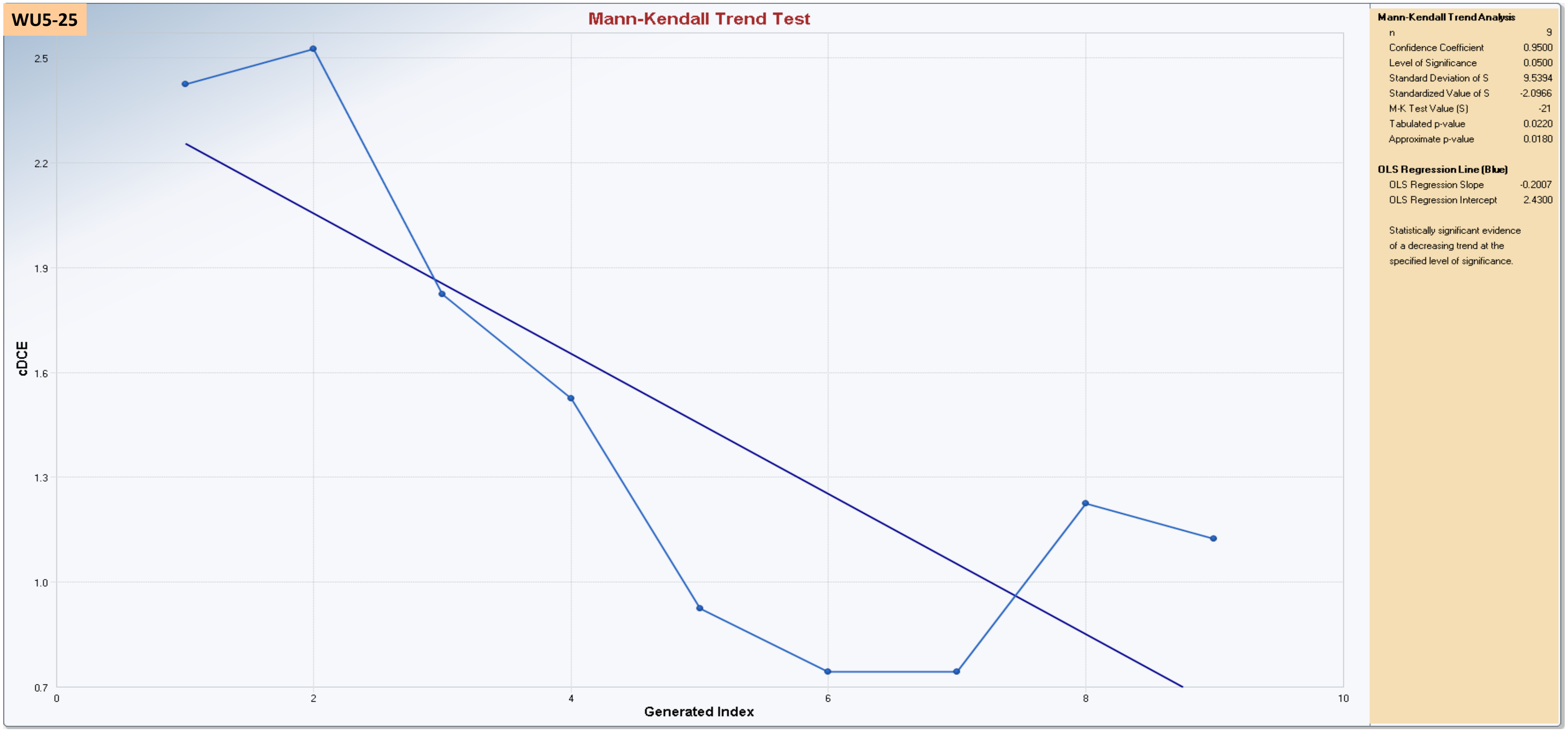
Mann-Kendall Trend Analysis

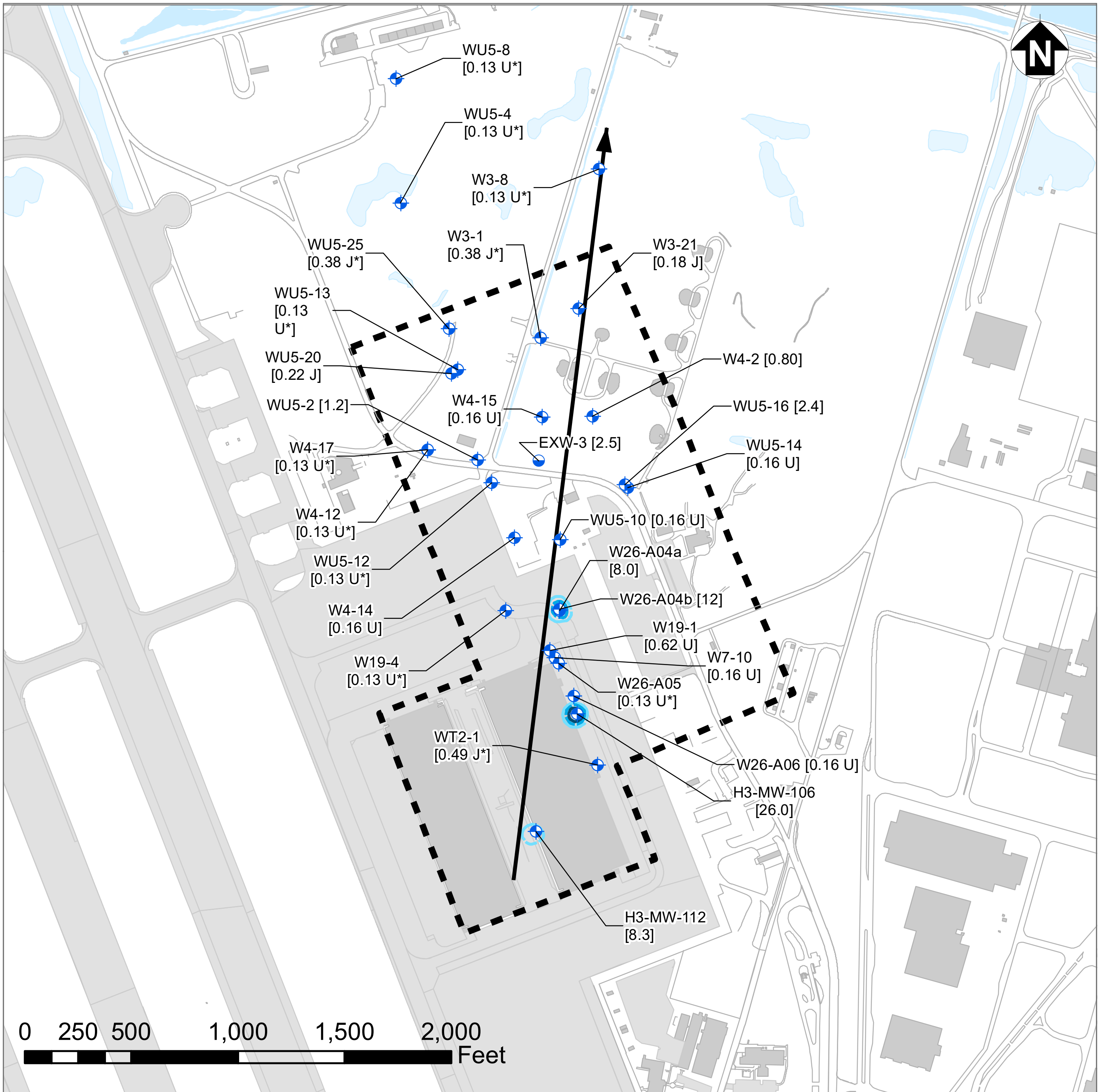
n	9
Confidence Coefficient	0.9000
Level of Significance	0.1000
Standard Deviation of S	9.3986
Standardized Value of S	-0.8512
M-K Test Value (S)	-9
Tabulated p-value	0.2380
Approximate p-value	0.1973

OLS Regression Line (Blue)

OLS Regression Slope	-0.0270
OLS Regression Intercept	1.1317

Insufficient statistical evidence of a significant trend at the specified level of significance.


WU5-25
Mann-Kendall Trend Test
cDCE
Generated Index
2.5
2.2
1.9
1.6
1.3
1.0
0.7
0
2
4
6
8
10
Mann-Kendall Trend Analysis
n 9
Confidence Coefficient 0.9500
Level of Significance 0.0500
Standard Deviation of S 9.5394
Standardized Value of S -2.0966
M-K Test Value (S) -21
Tabulated p-value 0.0220
Approximate p-value 0.0180
OLS Regression Line (Blue)
OLS Regression Slope -0.2007
OLS Regression Intercept 2.4300
Statistically significant evidence of a decreasing trend at the specified level of significance.



Former Navy Extraction Well

Navy Monitoring Well

IR Site 26 Boundary

Groundwater Flow Direction

Wetland

Water

Road

Building

Paved Area

PCE Isoconcentration Contour - 5 µg/L

Dashed Where Inferred

PCE Isoconcentration Contour - 10 µg/L

Dashed Where Inferred

PCE Isoconcentration Contour - 20 µg/L

Dashed Where Inferred

Notes:
1. Samples collected 10/24/2023.
2. For wells within 20 ft of each other, the highest concentration was contoured.
3. PCE concentration shown in µg/L
4. Concentrations marked with an asterisk(*) were collected in 2022 as part of the full Site 26 sampling suite.

µg/L - Micrograms per Liter
J - Estimated Value
U - Not Detected
IR - Installation Restoration

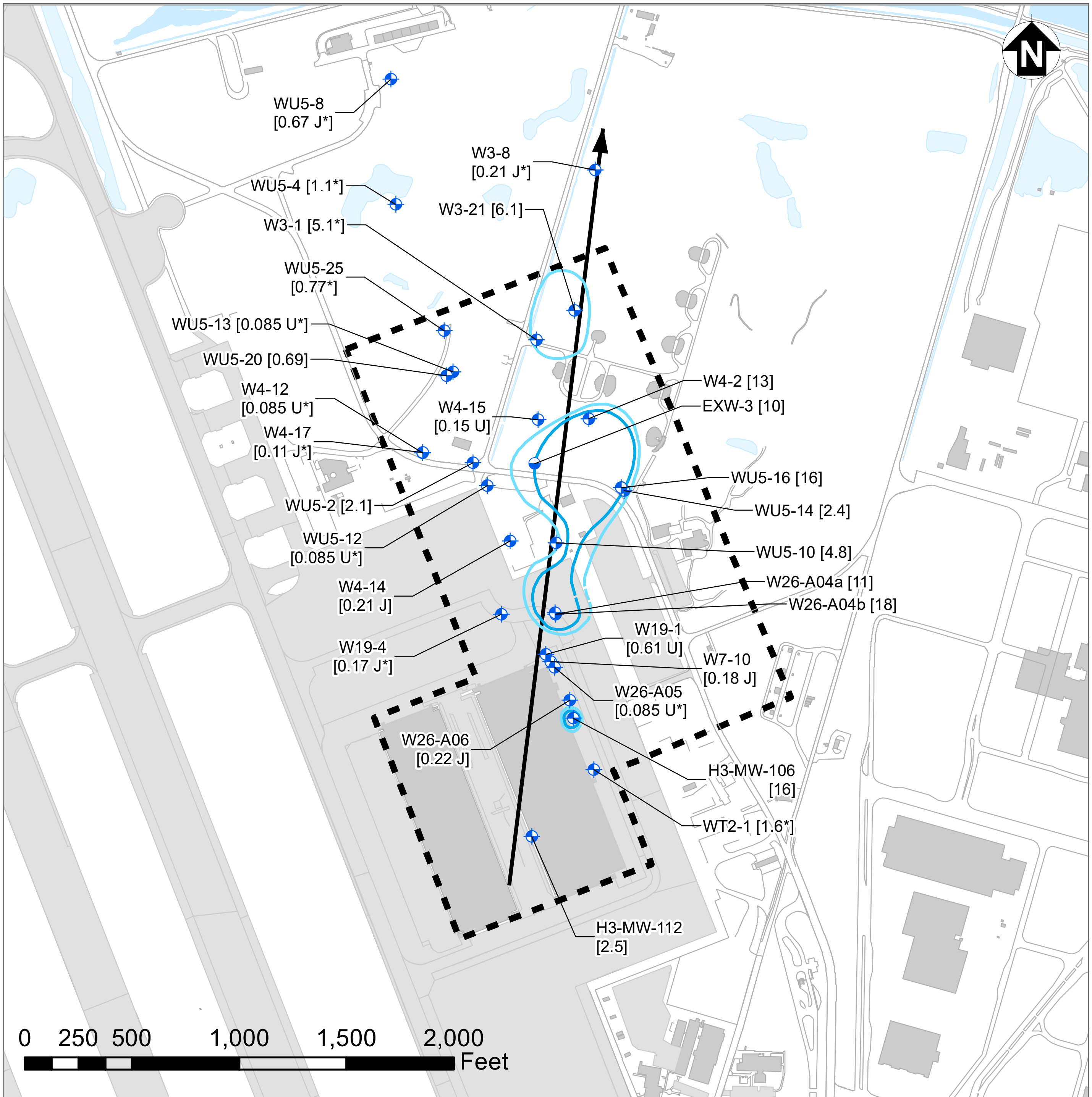
Ames Research Center
Moffett Field, CA 94035

NASA Ames Research Center
Moffett Field, California

FIGURE 3-2

TETRACHLOROETHENE (PCE) DISTRIBUTION

IR SITE 26, 2023 LTM REPORT



Former Navy Extraction Well

Navy Monitoring Well

IR Site 26 Boundary

Groundwater Flow Direction

Wetland

Water

Road

Building

Paved Area

TCE Isoconcentration Contour - 5 µg/L

Dashed Where Inferred

TCE Isoconcentration Contour - 10 µg/L

Dashed Where Inferred

Notes:
1. Samples collected 10/24/2023.
2. For wells within 20 ft of each other, the highest concentration was contoured.
3. TCE concentration shown in µg/L
4. Concentrations marked with an asterisk(*) were collected in 2022 as part of the full Site 26 sampling suite.

µg/L - Micrograms per Liter
J - Estimated Value
U - Not Detected
IR - Installation Restoration

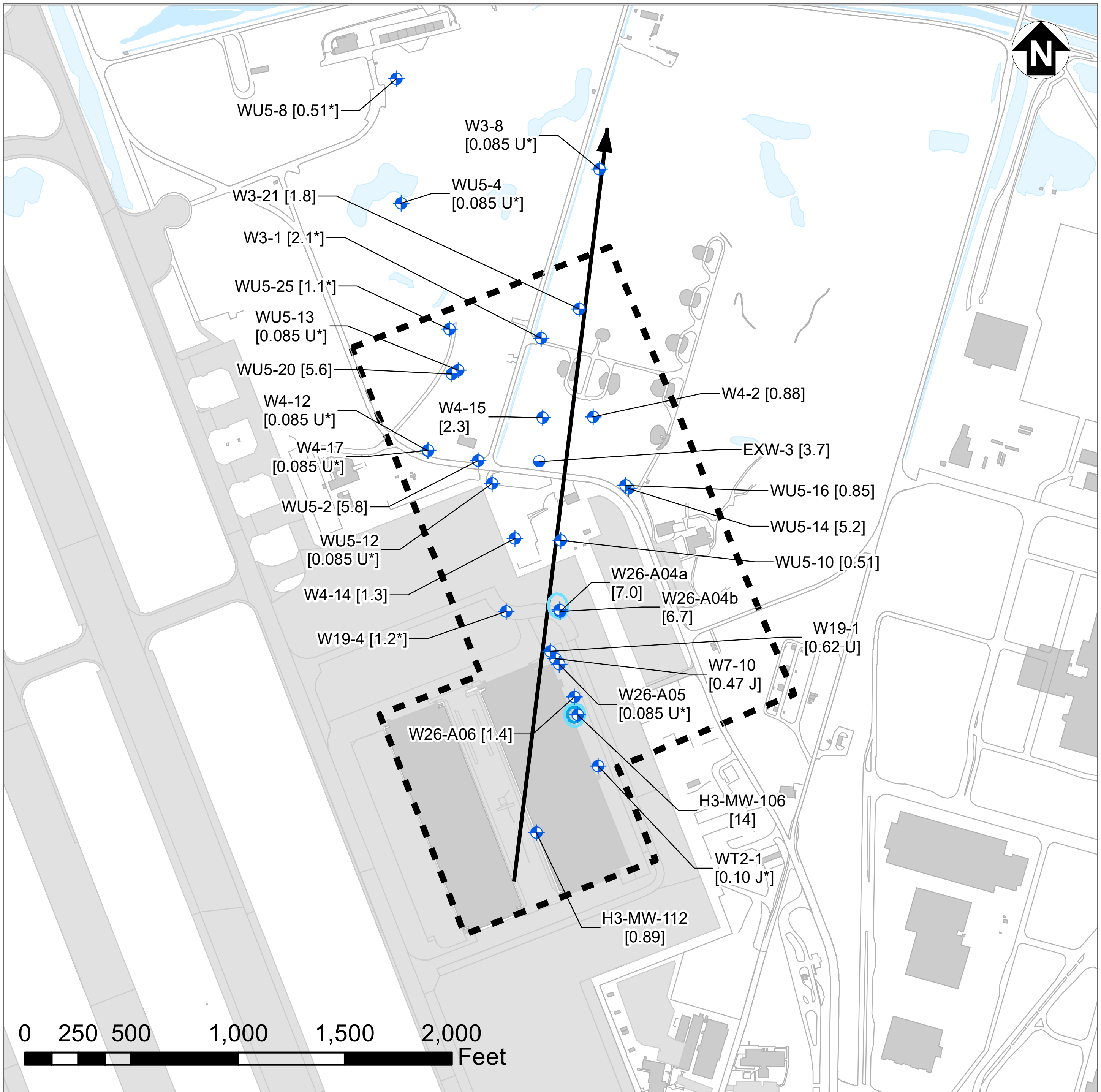
Ames Research Center
Moffett Field, CA 94035

NASA Ames Research Center
Moffett Field, California

FIGURE 3-3

TRICHLOROETHENE (TCE) DISTRIBUTION

IR SITE 26, 2023 LTM REPORT



Former Navy Extraction Well

Navy Monitoring Well

IR Site 26 Boundary

Groundwater Flow Direction

Road

Building

Paved

Wetland

Water

cis-1,2-DCE Isoconcentration Contour - 6 μg/L

Dashed Where Inferred

cis-1,2-DCE Isoconcentration Contour - 10 μg/L

Dashed Where Inferred

Notes:
1. Samples collected 10/24/2023.
2. For wells within 20 ft of each other, the highest concentration was contoured.
3. cDCE concentration shown in μg/L
μg/L - Micrograms per Liter
4. Concentrations marked withan asterick (*) were collectred in 2022 as part of the full Site 26 sampling suite.

μg/L - Micrograms per Liter
J - Estimated Value
U - Not Detected
IR - Installation Restoration

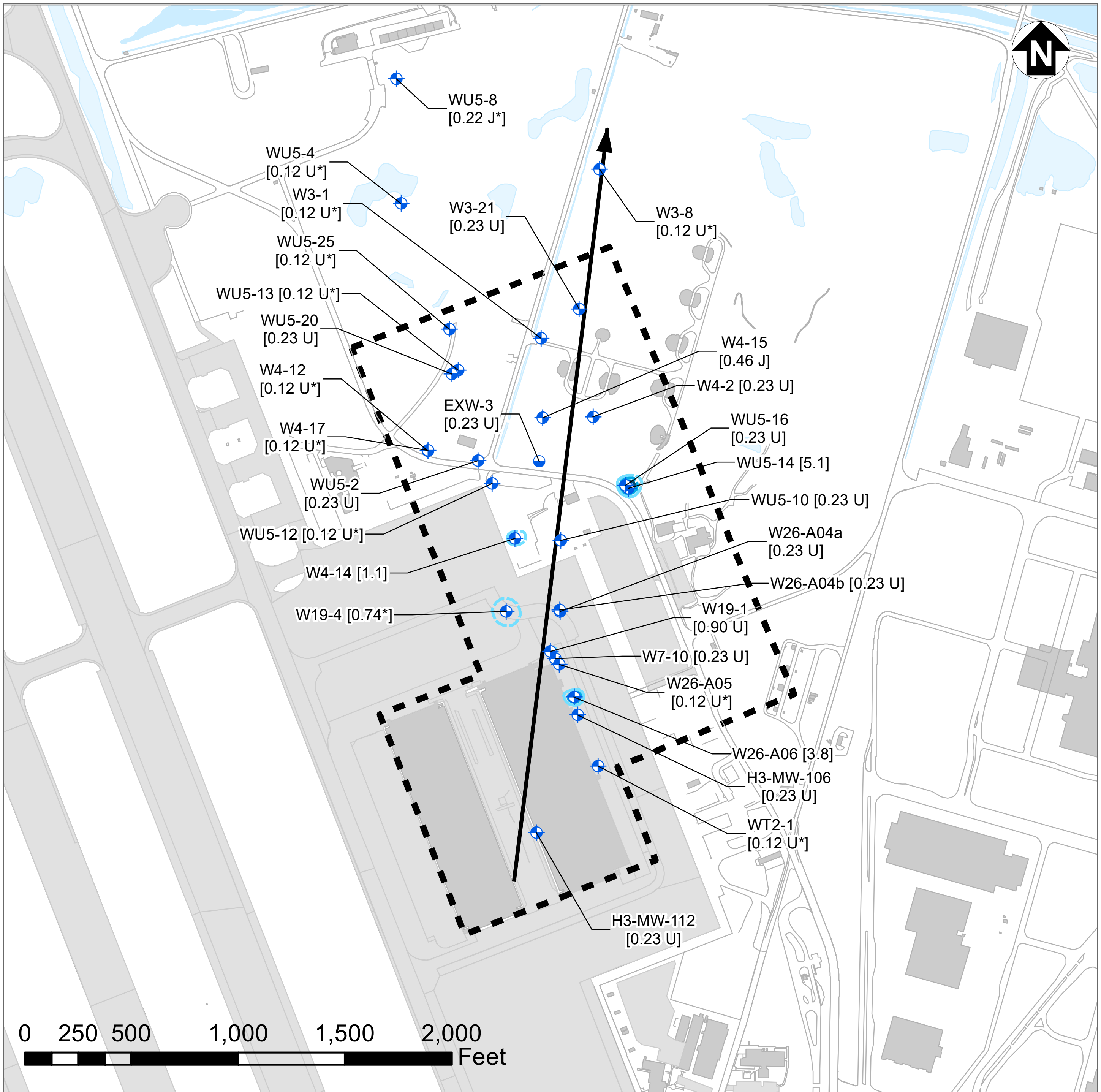
Ames Research Center
Moffett Field, CA 94035

NASA Ames Research Center
Moffett Field, California

FIGURE 3-4

cis-1,2-DICHLOROETHENE (cDCE) DISTRIBUTION

IR SITE 26, 2023 LTM REPORT



Former Navy Extraction Well

Navy Monitoring Well

IR Site 26 Boundary

Groundwater Flow Direction

Road

Building

Paved Area

Wetland

Water

VC Isoconcentration Contour - 0.5 µg/L

Dashed Where Inferred

VC Isoconcentration Contour - 1.0 µg/L

Dashed Where Inferred

VC Isoconcentration Contour - 10 µg/L

Dashed Where Inferred

Notes:
1. Samples collected 10/24/2023.
2. For wells within 20 ft of each other, the highest concentration was contoured.
3. VC concentration shown in µg/L
4. Concentrations marked with an asterisk (*) were collected in 2022 as part of the full Site 26 sampling suite.

µg/L - Micrograms per Liter
J - Estimated Value
U - Not Detected
IR - Installation Restoration

Ames Research Center
Moffett Field, CA 94035

NASA Ames Research Center
Moffett Field, California

FIGURE 3-5

VINYL CHLORIDE (VC) DISTRIBUTION

IR SITE 26, 2023 LTM REPORT

NASA RGRP

NASA RGRP data were drawn from multiple reports to illustrate changes in NASA RGRP chemical distributions and hydrogeologic conditions over time.

The following data were drawn from the *"2018 Annual Progress Report, NASA Ames Regional Groundwater Remediation Program, NASA Area of Responsibility and Site 28 WATS Area" (ERT 2019)* to support Five-Year Review NASA RGRP discussion and address EPA General Comment 6

Figure 2-23 - Capture Zone and Plume Boundary Overlay, A1 Aquifer, September 2018

Figure 2-24 - Capture Zone and Plume Boundary Overlay, A2/B1 Aquifer, September 2018

The following data were drawn from the *"2022 Annual Progress Report, NASA Ames Regional Groundwater Remediation Program, NASA Area of Responsibility and Site 28 WATS Area" (BB&E 2023)* to support Five-Year Review Site NASA RGRP discussion and address EPA General Comment 6
to support Five-Year Review NASA RGRP discussion and address EPA General Comment 6.

Figure 2-13 - 2022 Estimated Iso-concentration Contours, Trichloroethene (TCE) in the A1 Aquifer

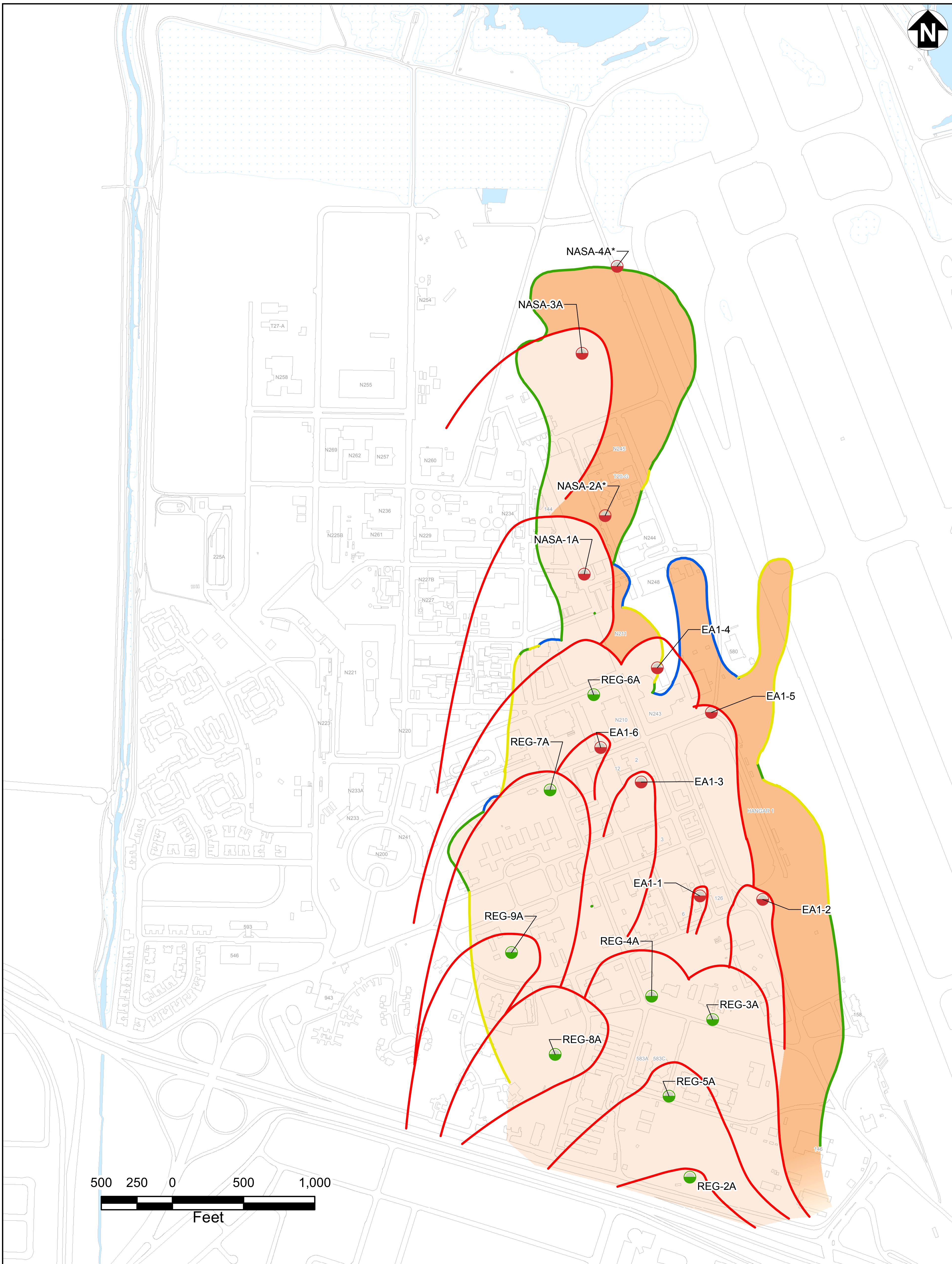
Figure 2-14 - 2022 Estimated Iso-concentration Contours, Trichloroethene (TCE) in the A2/B1 Aquifer

Figure 2-23 - Capture Zone and Plume Boundary Overlay, A1 Aquifer, September 2022

Figure 2-24 - Capture Zone and Plume Boundary Overlay, A2/B1 Aquifer, September 2022

Appendix L - Mann-Kendall Statistical Results Summary

Table 2-11 - Mann-Kendall Summary Statistics



MEW Extraction Well

NASA Extraction Well

Plume Margin Inside Capture

Plume Margin Outside Capture

building

water

wetland

DCE MCL (6 µg/L)

TCE MCL (5 µg/L)

VC MCL (0.5 µg/L)

ESTIMATED CAPTURE ZONE

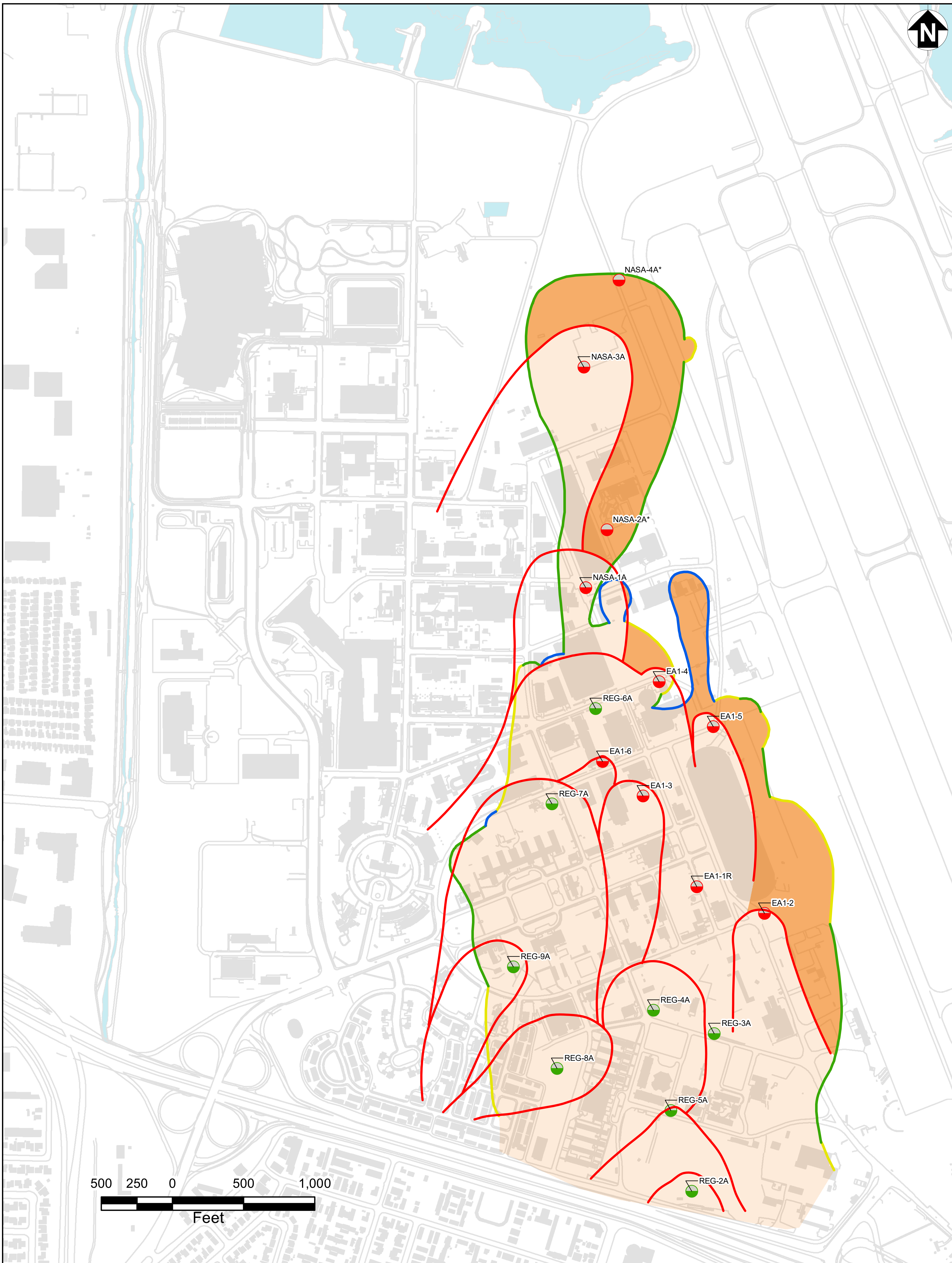
Notes:
MCL - Maximum Contaminant Level
DCE - CIS-1,2-Dichloroethene
TCE - Trichloroethene
VC - Vinyl Chloride
MEW - Middlefield-Ellis-Whisman
NASA - National Aeronautics and Space Administration
* - Extraction well not in operation

Ames Research Center
Moffett Field, CA 94035

2018 ANNUAL PROGRESS REPORT
NASA RGRP

FIGURE 2-23
CAPTURE ZONE AND PLUME BOUNDARY OVERLAY, A1 AQUIFER
SEPTEMBER 2018

NASA AMES RESEARCH CENTER, MOFFETT FIELD, CALIFORNIA



MEW Extraction Well
NASA Extraction Well
Plume Margin Outside Capture
Plume Margin Inside Capture
Road
Water
Building

ESTIMATED DCE MCL (6 µg/L)
ESTIMATED TCE MCL (5 µg/L)
ESTIMATED VC MCL (0.5 µg/L)
ESTIMATED CAPTURE ZONE

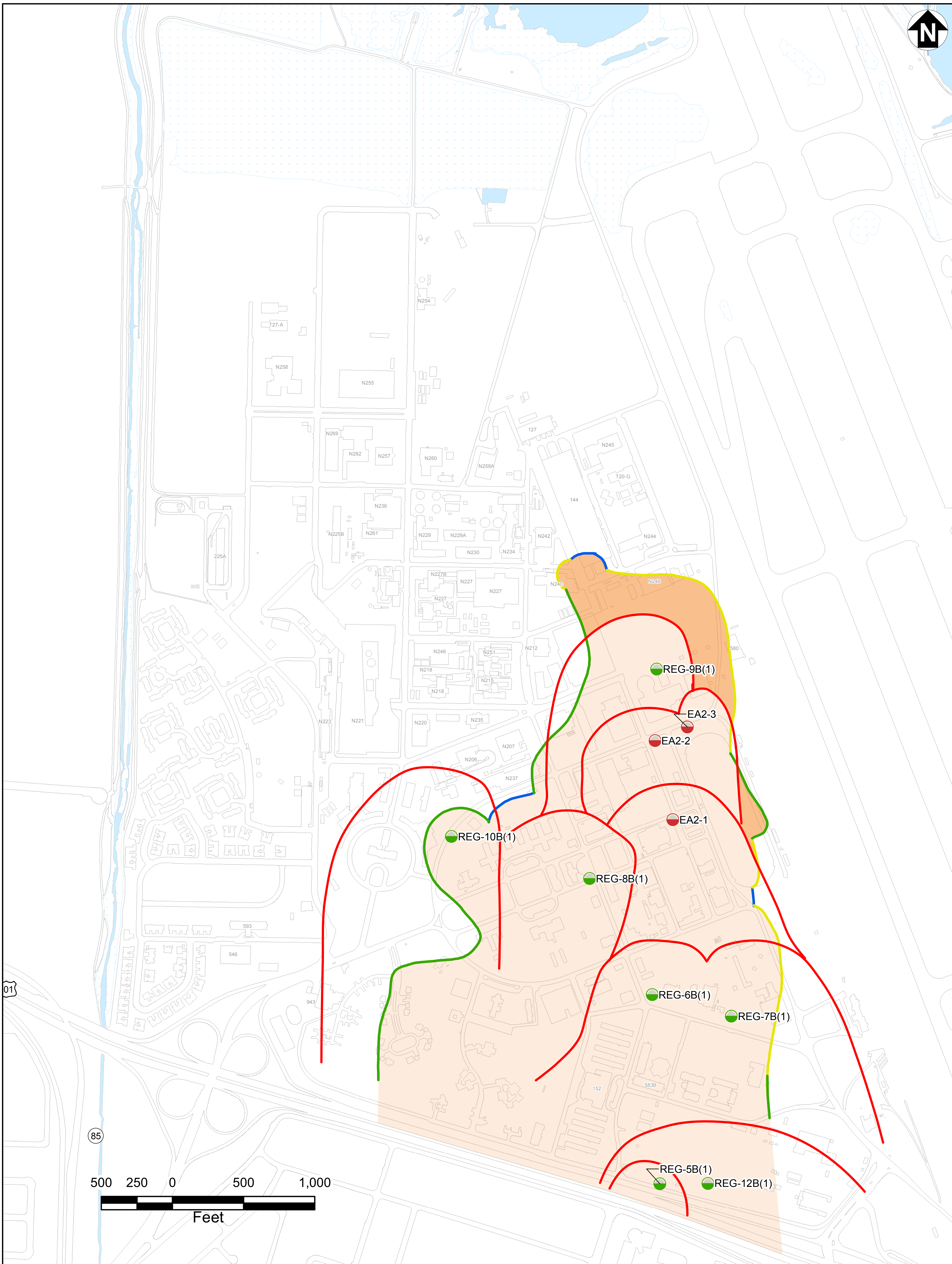
Notes:
MCL - Maximum Contaminant Level
DCE - CIS-1,2-Dichloroethene
TCE - Trichloroethene
VC - Vinyl Chloride
MEW - Middlefield-Ellis-Whisman
NASA - National Aeronautics and Space Administration
* - Extraction well not in operation

Ames Research Center
Moffett Field, CA 94035

2022 ANNUAL PROGRESS REPORT
NASA RGRP

FIGURE 2-23
CAPTURE ZONE AND PLUME BOUNDARY OVERLAY, A1 AQUIFER
SEPTEMBER 2022

NASA AMES RESEARCH CENTER, MOFFETT FIELD, CALIFORNIA



MEW Extraction Well

NASA Extraction Well

Plume Margin Inside Capture

Plume Margin Outside Capture

building

water

wetland

DCE MCL (6 µg/L)

TCE MCL (5 µg/L)

VC MCL (0.5 µg/L)

ESTIMATED CAPTURE ZONE

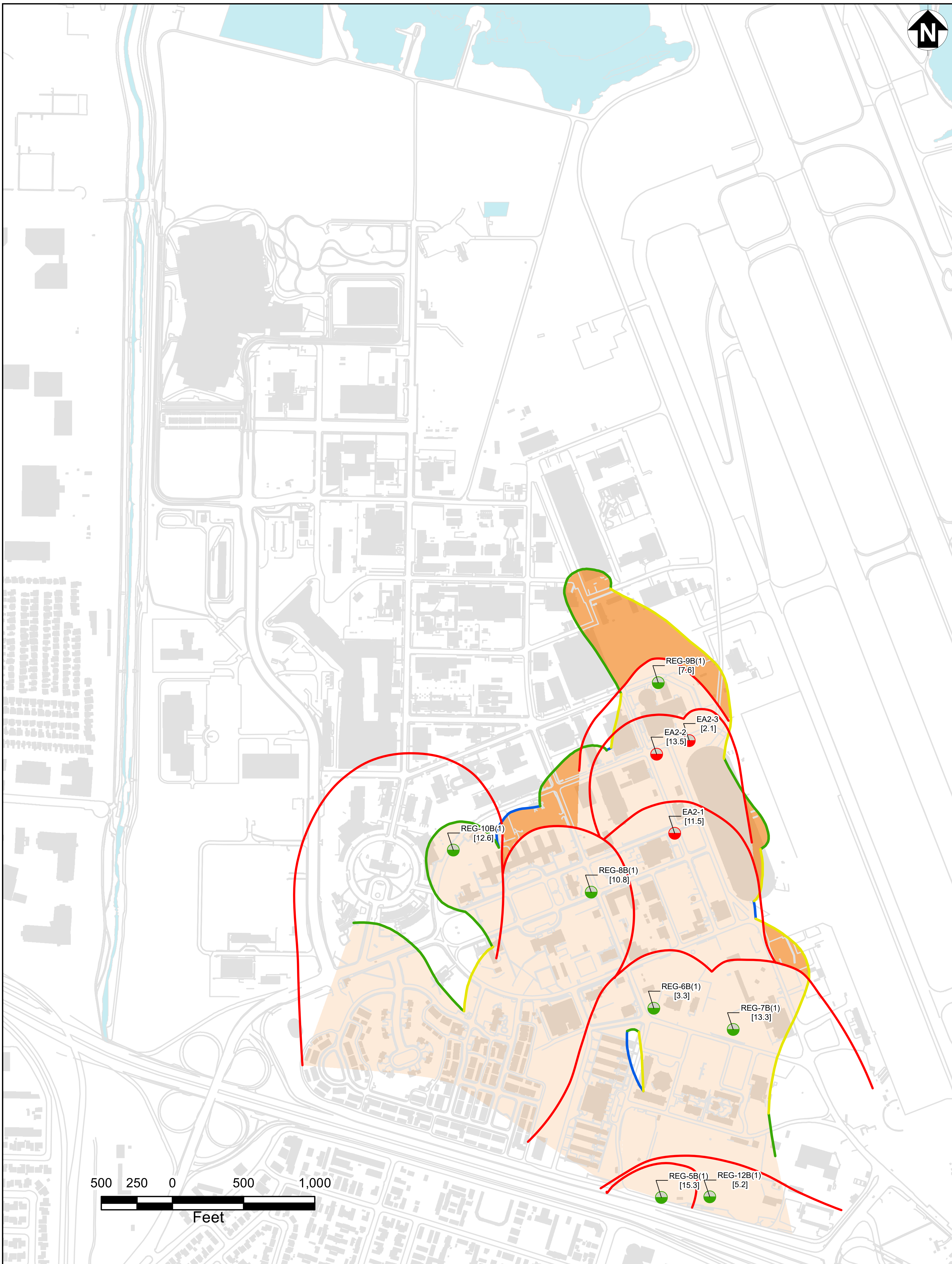
Notes:
MCL - Maximum Contaminant Level
DCE - CIS-1,2-Dichloroethene
TCE - Trichloroethene
VC - Vinyl Chloride
MEW - Middlefield-Ellis-Whisman
NASA - National Aeronautics and Space Administration

Ames Research Center
Moffett Field, CA 94035

2018 ANNUAL PROGRESS REPORT
NASA RGRP

FIGURE 2-24
CAPTURE ZONE AND PLUME BOUNDARY OVERLAY, A2/B1 AQUIFER
SEPTEMBER 2018

NASA AMES RESEARCH CENTER, MOFFETT FIELD, CALIFORNIA



MEW Extraction Well
NASA Extraction Well
Plume Margin Outside Capture
Plume Margin Inside Capture
Road
Water
Building

ESTIMATED DCE MCL (6 µg/L)
ESTIMATED TCE MCL (5 µg/L)
ESTIMATED VC MCL (0.5 µg/L)
ESTIMATED CAPTURE ZONE

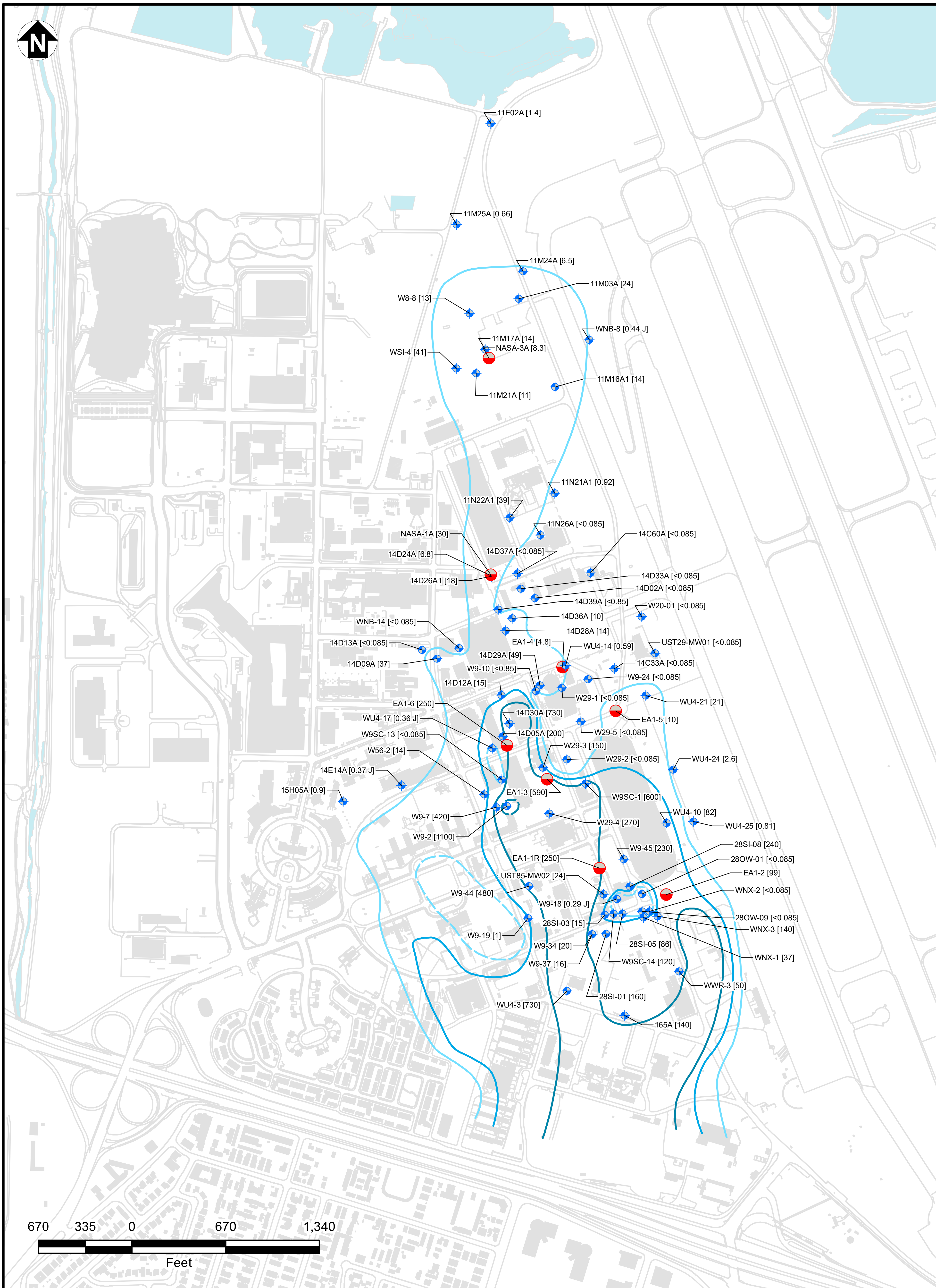
Notes:
MCL - Maximum Contaminant Level
DCE - CIS-1,2-Dichloroethene
TCE - Trichloroethene
VC - Vinyl Chloride
MEW - Middlefield-Ellis-Whisman
NASA - National Aeronautics and Space Administration
* - Extraction well not in operation

Ames Research Center
Moffett Field, CA 94035

2022 ANNUAL PROGRESS REPORT
NASA RGRP

FIGURE 2-24
CAPTURE ZONE AND PLUME BOUNDARY OVERLAY, A2/B1 AQUIFER
SEPTEMBER 2022

NASA AMES RESEARCH CENTER, MOFFETT FIELD, CALIFORNIA



Monitoring Well

Extraction Well

TCE ISO-CONCENTRATION CONTOUR - 1,000 µg/L

TCE ISO-CONCENTRATION CONTOUR - 250 µg/L

TCE ISO-CONCENTRATION CONTOUR - 50 µg/L

TCE ISO-CONCENTRATION CONTOUR - 5 µg/L

ROAD

FACILITY INFRASTRUCTURE

Notes:

1. Samples collected in Sept-Oct. 2022
2. TCE concentrations shown in µg/L

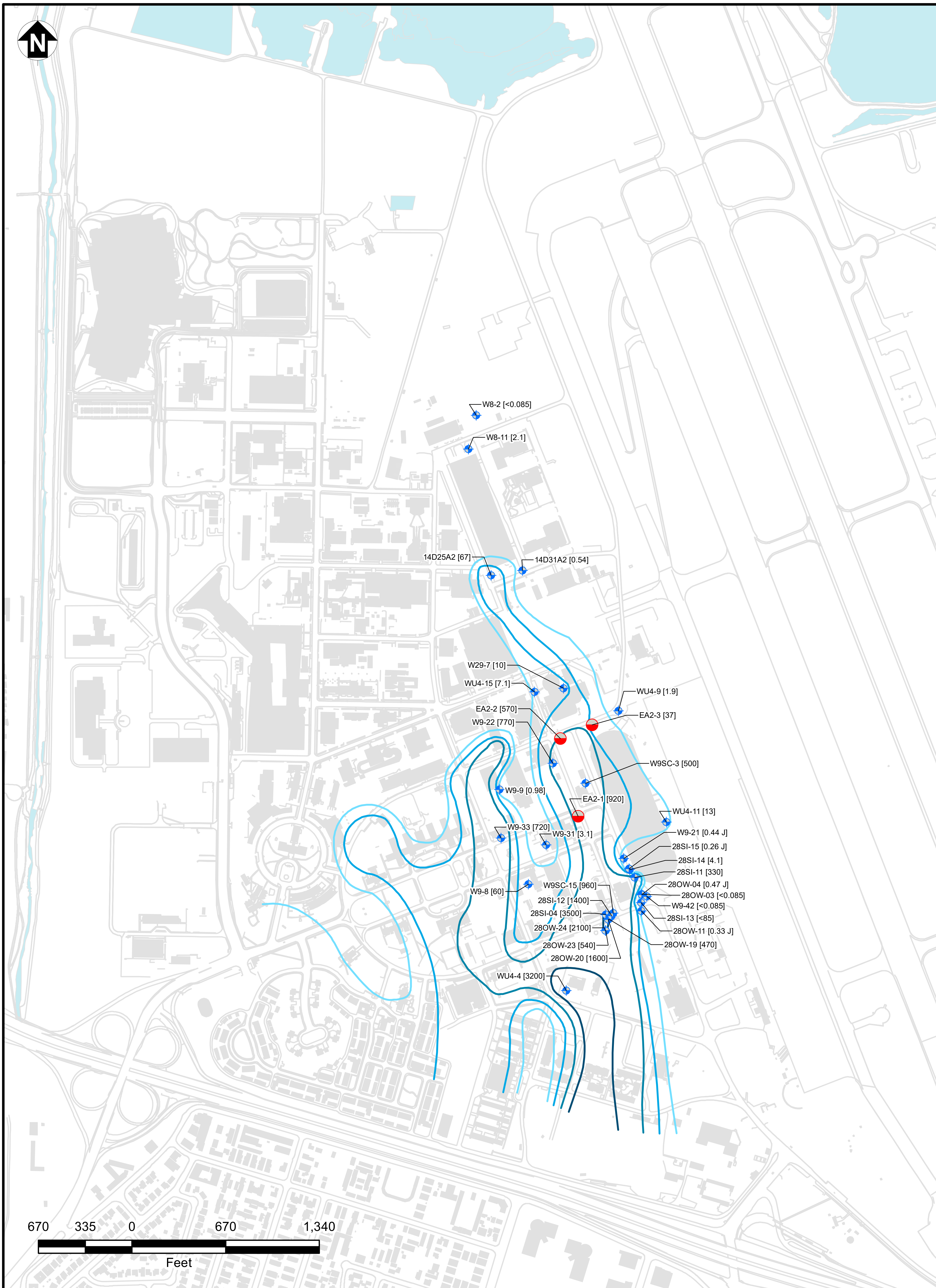
µg/L- Micrograms per Liter
J - Estimated Value
MEW - Middlefield-Ellis-Whisman
NS - Not Sampled
NASA - National Aeronautics and Space Administration

Ames Research Center
Moffett Field, CA 94035

2022 ANNUAL PROGRESS REPORT
NASA RGRP

FIGURE 2-13
2022 ESTIMATED ISO-CONCENTRATION CONTOURS
TRICHLOROETHENE (TCE) IN THE A1 AQUIFER

NASA AMES RESEARCH CENTER, MOFFETT FIELD, CALIFORNIA



Monitoring Well

Extraction Well

TCE ISO-CONCENTRATION CONTOUR - 1,000 µg/L

TCE ISO-CONCENTRATION CONTOUR - 250 µg/L

TCE ISO-CONCENTRATION CONTOUR - 50 µg/L

TCE ISO-CONCENTRATION CONTOUR - 5 µg/L

ROAD

FACILITY INFRASTRUCTURE

Notes:

1. Samples collected in Sept-Oct. 2022
2. TCE concentrations shown in µg/L

µg/L- Micrograms per Liter
J - Estimated Value
MEW - Middlefield-Ellis-Whisman
NS - Not Sampled
NASA - National Aeronautics and Space Administration

Ames Research Center
Moffett Field, CA 94035

2022 ANNUAL PROGRESS REPORT
NASA RGRP

FIGURE 2-14
2022 ESTIMATED ISO-CONCENTRATION CONTOURS TRICHLOROETHENE (TCE) IN THE A2/B1 AQUIFER

NASA AMES RESEARCH CENTER, MOFFETT FIELD, CALIFORNIA

APPENDIX L

Mann-Kendall Statistical

Results Summary

APPENDIX L
MANN-KENDALL CONCENTRATION TRENDS

Well Number	Aquifer	PCE	TCE	*c* DCE	VC
11E02A	A1	ND (ND)	S (S)	S (S)	ND (ND)
11M03A	A1	ND (ND)	I (I)	S (I)	ND (ND)
11M16A1	A1	ND (ND)	S (S)	S (S)	ND (ND)
11M17A	A1	ND (ND)	S (D)	S (S)	ND (ND)
11M21A	A1	ND (ND)	S (S)	S (S)	ND (ND)
11M24A	A1	ND (NED)	I (NED)	S (NED)	ND (NED)
11M25A	A1	D (S)	D (S)	ND (ND)	ND (ND)
11N21A1	A1	ND (ND)	PD (D)	S (S)	ND (ND)
11N22A1	A1	ND (ND)	D (D)	D (D)	ND (ND)
11N26A	A1	ND (ND)	ND (ND)	ND (ND)	ND (ND)
14C33A	A1	ND (ND)	ND (ND)	ND (ND)	S (I)
14C60A	A1	ND (ND)	ND (ND)	PI (S)	I (PI)
14D02A	A1	ND (ND)	ND (ND)	D (D)	ND (ND)
14D05A	A1	ND (ND)	I (NT)	D (S)	S (S)
14D09A	A1	ND (ND)	PD (S)	S (S)	D (PD)
14D12A	A1	S (S)	S (D)	D (D)	NT (D)
14D13A	A1	ND (ND)	D (D)	D (NT)	ND (ND)
14D24A	A1	ND (ND)	PD (D)	D (D)	NT (PD)
14D26A1	A1	ND (ND)	S (S)	S (S)	PD (NT)
14D28A	A1	S (S)	D (D)	D (D)	D (D)
14D29A	A1	S (NT)	S (NT)	S (S)	NT (NT)
14D30A	A1	S (S)	PD (S)	S (S)	S (S)
14D33A	A1	ND (ND)	ND (ND)	S (PI)	S (S)
14D36A	A1	S (S)	S (D)	D (D)	PD (D)
14D37A	A1	ND (ND)	ND (ND)	ND (ND)	I (S)
14D39A	A1	ND (ND)	ND (ND)	S (S)	ND (ND)
14E14A	A1	ND (ND)	PD (NT)	PD (S)	ND (ND)
15H05A	A1	ND (ND)	I (I)	I (I)	ND (ND)
165A	A1	ND (ND)	S (PD)	PD (D)	ND (ND)
28OW-01	A1	ND (NED)	NT (NED)	NT (NED)	NT (NED)
28OW-09	A1	PD (S)	D (S)	D (D)	NT (S)
28SI-01	A1	S (S)	S (S)	D (D)	I (I)
28SI-02	A1	S (S)	S (S)	S (S)	S (S)
28SI-03	A1	S (ND)	S (S)	D (PD)	I (I)
28SI-05	A1	NT (NT)	NT (NT)	S (S)	PD (NT)
28SI-08	A1	S (NT)	NT (NT)	S (S)	S (I)
EA1-1R	A1	NED	NED	NED	NED
EA1-2	A1	S (S)	D (S)	D (S)	S (I)
EA1-3	A1	I (S)	I (PI)	I (S)	S (D)
EA1-4	A1	S (S)	NT (PI)	D (S)	D (S)
EA1-5	A1	ND (ND)	S (S)	D (S)	D (D)
EA1-6	A1	ND (ND)	I (S)	S (D)	S (S)

APPENDIX L
MANN-KENDALL CONCENTRATION TRENDS

Well Number	Aquifer	PCE	TCE	*c* DCE	VC
NASA-1A	A1	ND (ND)	D (D)	D (D)	S (S)
NASA-3A	A1	ND (ND)	D (D)	D (S)	ND (ND)
UST29-MW01	A1	ND (ND)	ND (ND)	S (S)	ND (ND)
UST85-MW02	A1	ND (ND)	S (D)	D (PD)	NT (NT)
W8-8	A1	ND (ND)	S (S)	ND (ND)	ND (ND)
W9-2	A1	S (NT)	D (D)	S (PD)	I (PI)
W9-7	A1	ND (ND)	PI (NT)	PD (S)	S (S)
W9-10	A1	ND (ND)	PD (NT)	PD (S)	S (S)
W9-18	A1	ND (ND)	ND (ND)	D (D)	D (D)
W9-19	A1	ND (ND)	S (S)	S (S)	S (S)
W9-24	A1	ND (ND)	ND (ND)	D (D)	D (D)
W9-31	A1	ND (ND)	ND (ND)	D (D)	PD (PD)
W9-37	A1	ND (ND)	NT (NT)	D (S)	D (S)
W9-44	A1	S (S)	D (D)	PD (D)	S (S)
W9-45	A1	NT (S)	S (D)	S (S)	PI (NT)
W9SC-1	A1	S (PD)	PD (S)	D (D)	ND (ND)
W9SC-13	A1	ND (ND)	ND (ND)	NT (NT)	NT (NT)
W9SC-14	A1	S (ND)	NT (NT)	D (D)	D (S)
W20-01	A1	ND (ND)	ND (ND)	D (D)	ND (ND)
W29-1	A1	ND (ND)	ND (ND)	ND (ND)	ND (ND)
W29-2	A1	ND (ND)	ND (ND)	NT (NT)	NT (NT)
W29-3	A1	NT (PD)	NT (D)	S (S)	I (I)
W29-4	A1	ND (ND)	D (D)	PD (D)	PI (S)
W29-5	A1	ND (ND)	ND (ND)	NT (NT)	NT (NT)
W56-2	A1	ND (ND)	S (PI)	S (S)	PI (PI)
WIC-1	A1	S (S)	D (S)	PD (S)	PI (I)
WNB-8	A1	ND (ND)	D (D)	I (I)	ND (ND)
WNB-14	A1	ND (ND)	ND (ND)	S (D)	S (S)
WNX-1	A1	ND (ND)	D (PD)	D (D)	ND (NT)
WNX-2	A1	ND (ND)	PD (NT)	D (S)	S (S)
WNX-3	A1	ND (ND)	S (S)	PD (S)	S (PI)
WSI-4	A1	ND (ND)	D (D)	S (S)	ND (ND)
WU4-3	A1	NT (NT)	D (S)	S (S)	NT (NT)
WU4-10	A1	ND (ND)	D (D)	D (D)	S (S)
WU4-14	A1	S (PD)	PD (D)	PD (PD)	D (D)
WU4-17	A1	ND (ND)	ND (ND)	D (PD)	D (NT)
WU4-21	A1	ND (ND)	I (I)	D (D)	S (PI)
WU4-24	A1	ND (ND)	PI (S)	S (S)	ND (ND)
WU4-25	A1	ND (ND)	I (I)	I (I)	I (PI)
WWR-3	A1	ND (ND)	S (S)	S (D)	PI (S)
14D25A2	A2	ND (ND)	S (S)	PI (S)	I (I)
14D31A2	A2	ND (ND)	S (S)	I (S)	ND (ND)

APPENDIX L
MANN-KENDALL CONCENTRATION TRENDS

Well Number	Aquifer	PCE	TCE	*c* DCE	VC
28OW-03	A2	D (D)	D (D)	D (D)	NT (NT)
28OW-04	A2	D (D)	D (D)	D (D)	PD (PD)
28OW-11	A2	D (NT)	D (S)	S (S)	I (I)
28OW-19	A2	S (S)	NT (NT)	S (S)	D (S)
28OW-20	A2	S (S)	D (D)	S (S)	S (S)
28OW-23	A2	NT (NT)	NT (NT)	D (D)	PI (S)
28OW-24	A2	PD (NT)	PD (S)	S (S)	NT (NT)
28SI-04	A2	PD (S)	S (S)	S (S)	I (I)
28SI-11	A2	NT (NT)	NT (NT)	S (S)	PI (NT)
28SI-12	A2	NT (NT)	NT (NT)	S (S)	S (S)
28SI-13	A2	D (D)	D (D)	S (S)	I (I)
28SI-14	A2	NT (NT)	NT (NT)	S (PD)	S (S)
28SI-15	A2	D (D)	PD (PD)	D (D)	D (D)
EA2-1	A2	S (D)	D (D)	D (D)	S (S)
EA2-2	A2	S (S)	D (D)	D (D)	D (D)
EA2-3	A2	I (PI)	S (S)	D (S)	D (D)
W8-2	A2	ND (ND)	ND (ND)	ND (ND)	ND (ND)
W8-11	A2	ND (ND)	S (S)	S (S)	ND (ND)
W9-8	A2	ND (ND)	NT (PD)	D (D)	I (S)
W9-9	A2	ND (ND)	PD (NT)	NT (NT)	D (S)
W9-14	A2	ND (ND)	S (S)	S (S)	S (NT)
W9-20	A2	D (D)	PD (D)	D (PD)	S (S)
W9-21	A2	NT (S)	NT (NT)	D (D)	PD (S)
W9-22	A2	NT (NT)	S (NT)	S (S)	I (I)
W9-33	A2	ND (ND)	S (S)	S (S)	PI (S)
W9-34	A2	ND (ND)	S (NT)	D (S)	S (S)
W9-42	A2	NT (NT)	D (PD)	PD (NT)	D (S)
W9SC-15	A2	PD (D)	D (D)	S (S)	S (S)
W9SC-3	A2	D (D)	D (D)	S (S)	PI (I)
W29-7	A2	ND (ND)	NT (NT)	PD (S)	PD (D)
WU4-11	A2	ND (ND)	I (S)	S (S)	ND (ND)
WU4-15	A2	PD (D)	D (D)	PD (D)	D (D)
WU4-4	A2	NT (PD)	S (S)	I (I)	NT (PD)
WU4-9	A2	ND (ND)	S (S)	S (I)	NT (NT)
28SI-06	B2	NT (NT)	PD (D)	S (S)	I (PI)
28SI-07	B2	D (D)	D (D)	D (NT)	NT (NT)
28SI-09	B2	D (D)	D (D)	NT (NT)	ND (ND)
28SI-10	B2	D (PD)	D (D)	D (NT)	NT (NT)
45B2	B2	ND (ND)	ND (ND)	ND (ND)	ND (ND)
W9-12	B2	ND (ND)	S (NT)	ND (ND)	ND (ND)
W9-15	B2	ND (ND)	ND (ND)	ND (ND)	ND (ND)

APPENDIX L
MANN-KENDALL CONCENTRATION TRENDS

Well Number	Aquifer	PCE	TCE	*c* DCE	VC
W9-39	B2	ND (ND)	ND (ND)	ND (ND)	ND (ND)
W9-40	B2	ND (ND)	ND (ND)	ND (ND)	PI (NT)
W88-1	B2	D (D)	D (D)	D (D)	D (D)
W9-5	B3	ND (ND)	ND (ND)	ND (ND)	ND (ND)
W9-3	C	(ND)	(ND)	(ND)	(ND)

PCE = Tetrachloroethene
TCE = Trichloroethene
c DCE = *cis* -1,2-Dichloroethene
VC = Vinyl Chloride

2022 trend listed first, 2020 trend in parenthesis.
D = Declining
PD = Probably Declining
I = Increasing
PI = Probably Increasing
ND = Non-Detect
NT = No Trend
S = Stable
NED = Not Enough Data (at least four data sets required for statistical analysis)

TABLE 2-11
MANN KENDALL SUMMARY STATISTICS

	PCE (% of wells)	TCE (% of wells)	*c* DCE (% of wells)	VC (% of wells)
ALL WELLS (130)				
Increasing	2%	8%	6%	18%
Decreasing	13%	35%	43%	19%
Stable/NT/ND	85%	56%	51%	62%
Non-Detect	58%	19%	11%	28%
A1 WELLS (82)				
Increasing	1%	12%	6%	15%
Decreasing	2%	32%	48%	17%
Stable/NT/ND	96%	56%	46%	68%
Non-Detect	70%	22%	7%	32%
A2/B1 WELLS (36)				
Increasing	3%	3%	8%	28%
Decreasing	31%	42%	39%	28%
Stable/NT/ND	67%	56%	53%	44%
Non-Detect	33%	3%	3%	11%
B2 WELLS (10)				
Increasing	0%	0%	0%	20%
Decreasing	40%	50%	30%	10%
Stable/NT/ND	60%	50%	70%	70%
Non-Detect	50%	40%	50%	50%
B3 WELLS (1)				
Increasing	0%	0%	0%	0%
Decreasing	0%	0%	0%	0%
Stable/NT/ND	100%	100%	100%	100%
Non-Detect	100%	100%	100%	100%
C WELLS (1)				
Increasing	0%	0%	0%	0%
Decreasing	0%	0%	0%	0%
Stable/NT/ND	100%	100%	100%	100%
Non-Detect	100%	100%	100%	100%

PCE = Tetrachloroethene
TCE = Trichloroethene
DCE = Dichloroethene
VC = Vinyl Chloride

NT = No Trend
ND = Non-Detect