Naval Facilities Engineering Systems Command
EXWC Engineering & Expeditionary Warfare Center

Open Environmental Restoration Resources (OER2) Webinar #25

Bridging the Gap from Remedy in Place (RIP) to Response Complete (RC): Part II Practical Examples

Russell Sirabian, PE
NAVFAC EXWC

Pamela Chang
Battelle

Mike Singletary, PE
NAVFAC SE

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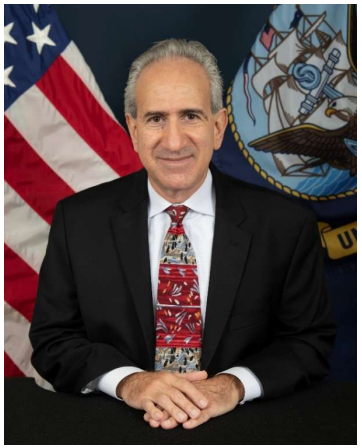
Today's Speakers



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OER2 Webinar Series

- **Why Attend?**
  - Obtain and hear about the latest DOD and DON's policies/guidance, tools, technologies and practices to improve the ERP's efficiency
  - Promote innovation and share lessons learned
  - FEEDBACK to the ERP Leadership
- **Who Should Attend?**
  - ERP Community Members: RPMs, RTMs, Contractors, and other remediation practitioners who support and execute the ERP
  - Voluntary participation
- **Schedule and Registration:**
  - Offered quarterly
  - Registration link for each topic (announced via ER T2 email)
- **Topics and Presenters:**
  - ERP community members to submit topics (non-marketing and DON ERP-relevant) to POCs (or Amy Hawkins – amy.hawkins@navy.mil)
  - Selected topic will be assigned Champion to work with presenter

Remedy-in-Place(RIP)/Response Complete (RC) Strategy – Part II

- **Part II Contents**
  - **Recap Part I**
  - **Case studies for moderate and high complexity sites**
    - Pamela Chang – Camp Pendleton
    - Mike Singletary – Former NWIRP McGregor

Remedy-in-Place(RIP)/Response Complete (RC) Strategy – Overview

Previously on RIP/RC Strategy…

SKIP RECAP

Just Kidding

- In progress task - NAVFAC Optimization and Technology Innovation (OTI) workgroup
- Goal - Provide a general strategy to meet RIP and RC milestones based on:
  - Remedy complexity - Low, Moderate, High
    - Complexity based on level of technical difficulty to achieve RIP/RC milestones
  - Performance based remedy transition and progress tracking for high complexity sites
- Webinar presented in two parts
  - Part I. General topics and case study for low complexity site - 18 NOV 2021
  - Part II. Case studies for more complex sites

Remedy-in-Place(RIP)/Response Complete (RC) Strategy – Overview (cont'd)

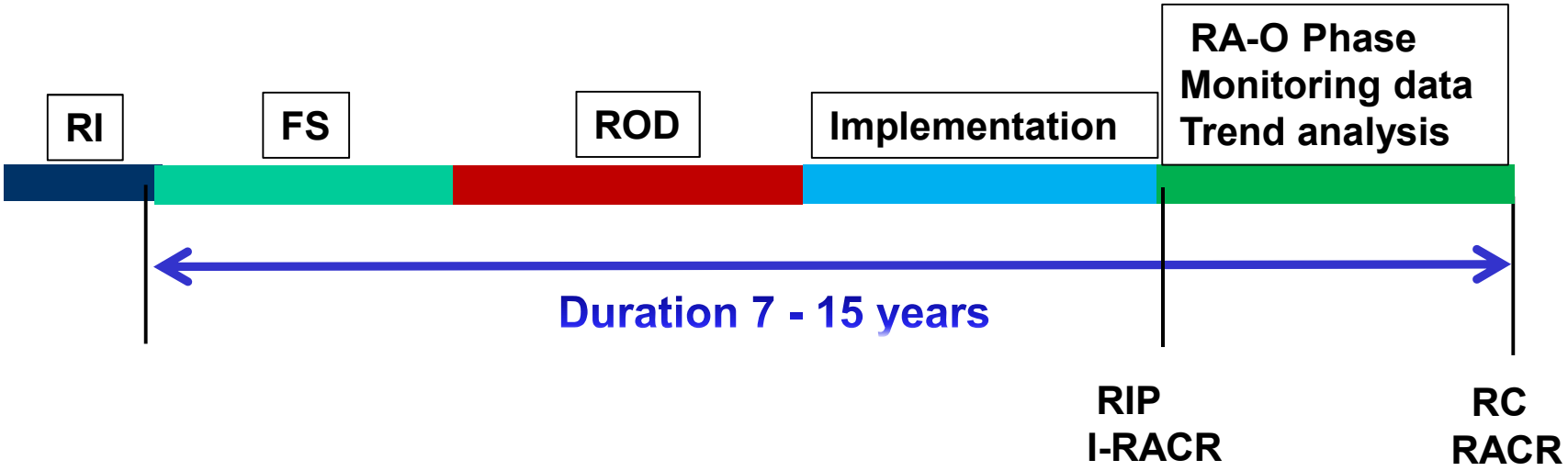
- Part I Contents
  - Navy Programmatic Goals
    - ER,N program milestones
    - New ER,N Program goals for RC milestone (May 2021)
    - Potential RIP/RC schedule for remedy scenarios based on remedy complexity
    - RA-O Phase actions for high complexity sites
  - NAVFAC Policy and Tools to Help Meet Program Goals
    - Optimization Policy
    - Optimization Guidance Documents
    - New NORM Optimization module (Intro)
  - Case Study for Low Complexity Site
  - Summary

Recap - New (Updated) ER,N Program Metric

- OSD Goal 95% RC by 2021. OSD has not yet established RC goals beyond 2021
- OPNAV N45 established ER,N program metrics in May 2021 in terms of RC milestone
  - 85% RC by FY 23
  - 87% RC by FY 26
  - 88% RC by FY 29
  - 90% RC by FY 31
- PFAS sites not included
- DON has achieved RC metric at 83.6% sites (mid year 21)
- ER,N program goal to be updated when additional OSD guidance is issued

Recap - RIP/RC - Moderate Complexity Site

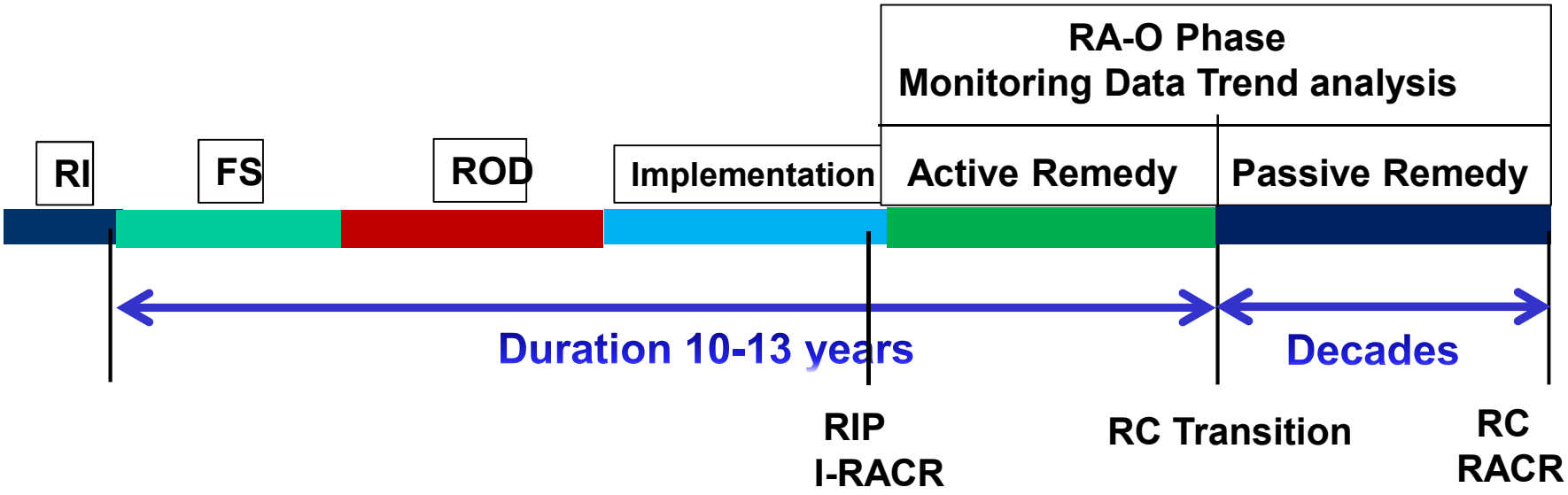
- **Moderate RA-O Phase (e.g., AS/SVE, ISCO, enhanced bio)**



8 – 10 months	12 – 20 months	12 – 14 months	4 -12 years

Recap- RIP/RC - High Complexity Site

- **Prolonged RA-O phase (e.g. complex groundwater plume)**



8 -10 months	12 – 20 months	16 - 24 months	5 - 8 years	Few years - Decades

NAVFAC
Naval Facilities Engineering Systems Command

Underground Storage Tank Program
22 Area Gas Station
Path to Response Complete

Marine Corps Base Camp Pendleton
California
December 9, 2021

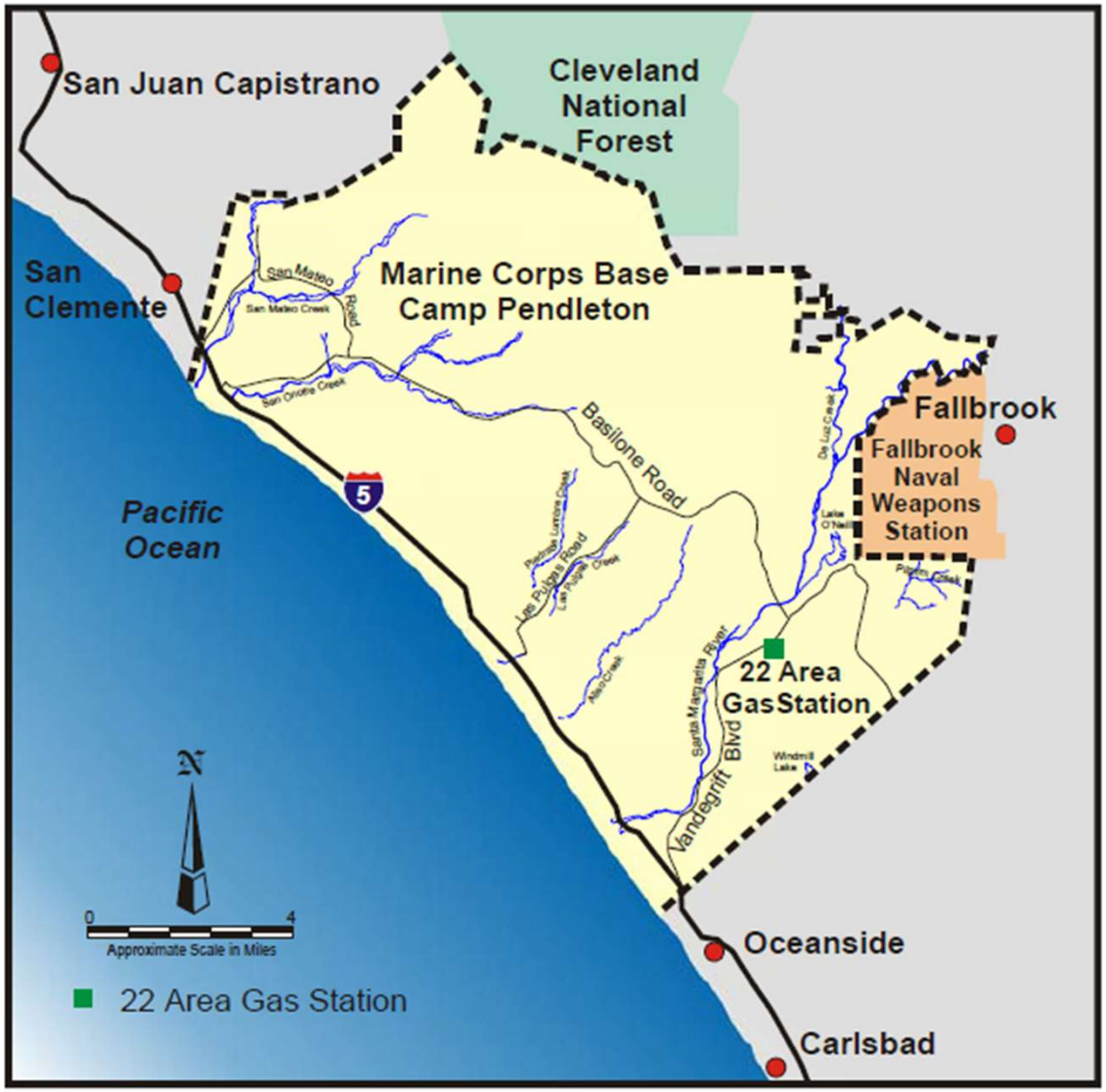
Presentation Overview

- Site Description
- RAOs and Cleanup Goals
- Selected Remedy
- Remedy Construction
- Summary of RAOs
- Monitoring Data Trends
- RC milestones
- Significant Challenges
- Optimization strategies
- Current Status

MCB Camp Pendleton 22 Area

Site Description

- MCB Camp Pendleton is in northern San Diego County, California.
- Bordered on the west by the Pacific Ocean and occupies approximately 125,000 acres of land. Nearly 60,000 personnel train there every year.
- 22 Area Gas Station site encompasses a multi use industrial area to support the installation activities.

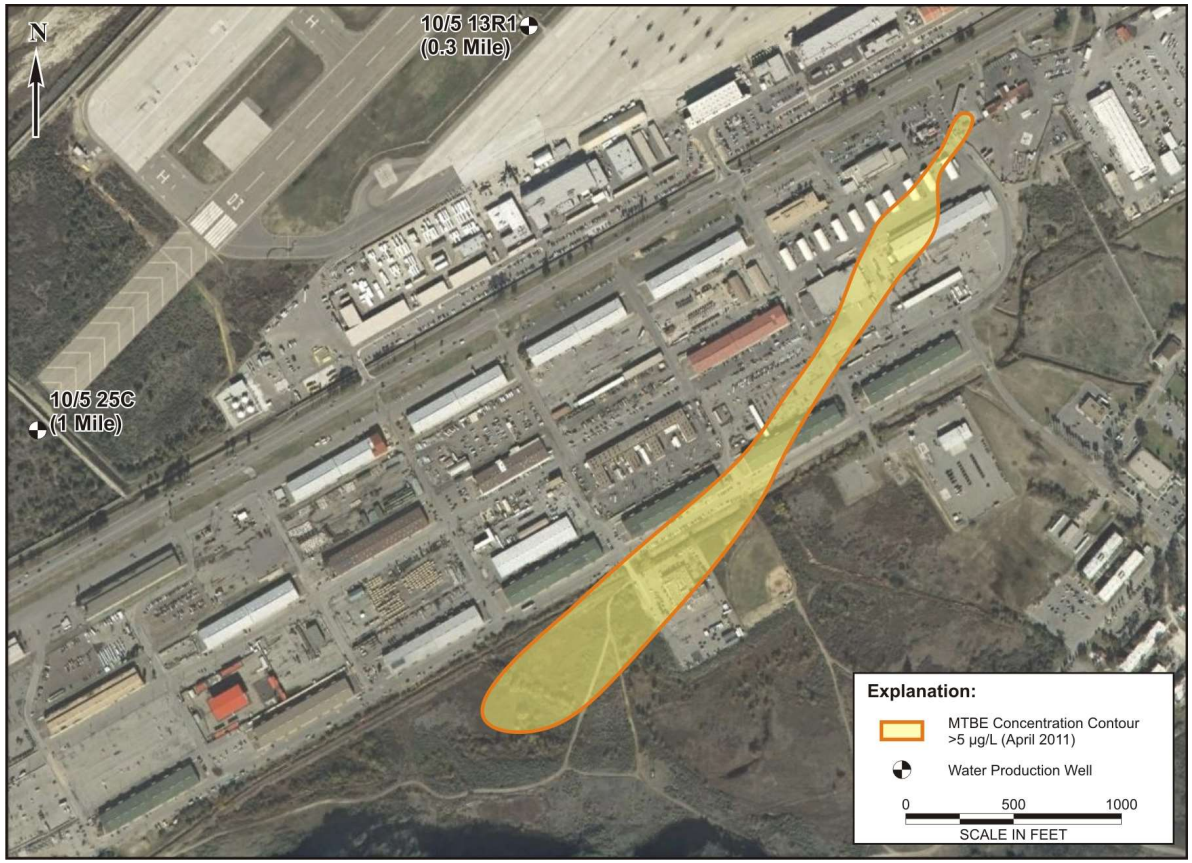


Site Description

Time Period	Major Milestones/Activities
1947	Two gas stations constructed in 22 Area - Military Gas Station (MGS) and Marine Corps Exchange (MCX) Gas Station
1986 – 1989	Gasoline releases reported from failed tank integrity testing
1991 – 1995	Site Assessments performed
1995	Quarterly groundwater monitoring began
1996	Remedial Investigation/Feasibility Study
1996	Old USTs replaced with new USTs
1997 - 2001	Interim Remedial Action – SVE and AS at source area, AS downgradient
2001	Corrective Action Plan
2003	Remedial Action Work Plan
2004 - 2016	Remedial Action – Oxygen injection biobarriers and MNA
2016	Response Complete, No Further Action

Site Description

- Diesel, gasoline, BTEX were COCs, but main concern was 3,500 ft long dissolved methyl-*tert*-butyl ether (MTBE) groundwater plume flowing parallel to the Santa Margarita Basin and multiple water supply wells.



RAOs

- The RAOs were developed based the State Water Resources Control Board Resolution 6816 (Nondegradation Policy) maximum contaminant levels (MCLs) for drinking water.
  - Benzene – 1 μg/L (primary MCL)
  - Toluene – 40 μg/L (secondary MCL)
  - Ethylbenzene – 30 μg/L (secondary MCL)
  - Xylenes – 20 μg/L (secondary MCL)
  - MTBE – 5 μg/L (secondary MCL)

22 Area Water Supply Wells

Remedy

- The remedy was implemented in multiple phases throughout the project lifetime.
  - Install and operate soil vapor extraction (SVE) and air sparge(AS) systems in source area of both gas stations. Two SVE/AS systems install and operate downgradient of source area.
  - Install and operate oxygen injection biobarriers at the mid-plume and leading-edge areas of the MTBE plume.
  - Monitored natural attenuation (MNA)

Remedy Construction

- 1997 Install soil vapor extraction (SVE) and air sparge(AS) systems in source area of both gas stations- MGS and MCX Gas Station. Two secondary SVE/AS systems installed and operated ~400 ft downgradient of source area.

Primary MGS SVE/AS System with Thermal Oxidation

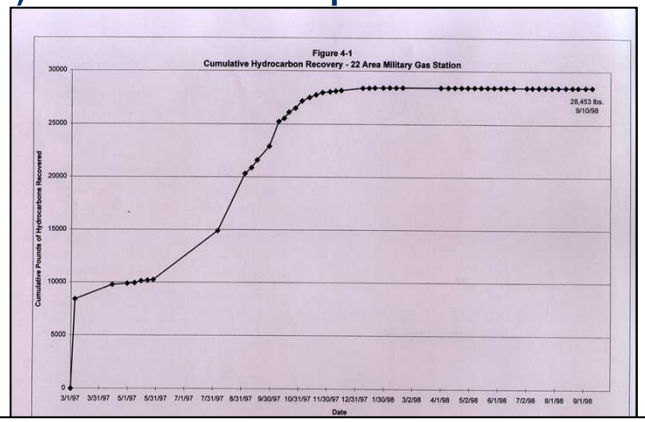
Secondary MCX SVE/AS System

Remedy Construction

- **MGS remediation systems operated from 3/1/1997 to 9/10/1998.**
  - **Removed 28,452 lbs. of petroleum hydrocarbons. Majority within first 9 months of operation.**
  - **San Diego Regional Water Quality Control Board (SD RWQCB) concurred with recommendation to discontinue active remediation and transition to MNA.**
  - **Groundwater monitoring performed from 1995 to 2010. TPH-diesel and BTEX concentrations less than reporting limits.**
  - **In 2012, performed limited soil excavation in the source area (26 cubic yards) and submitted request for No Further Action (NFA).**

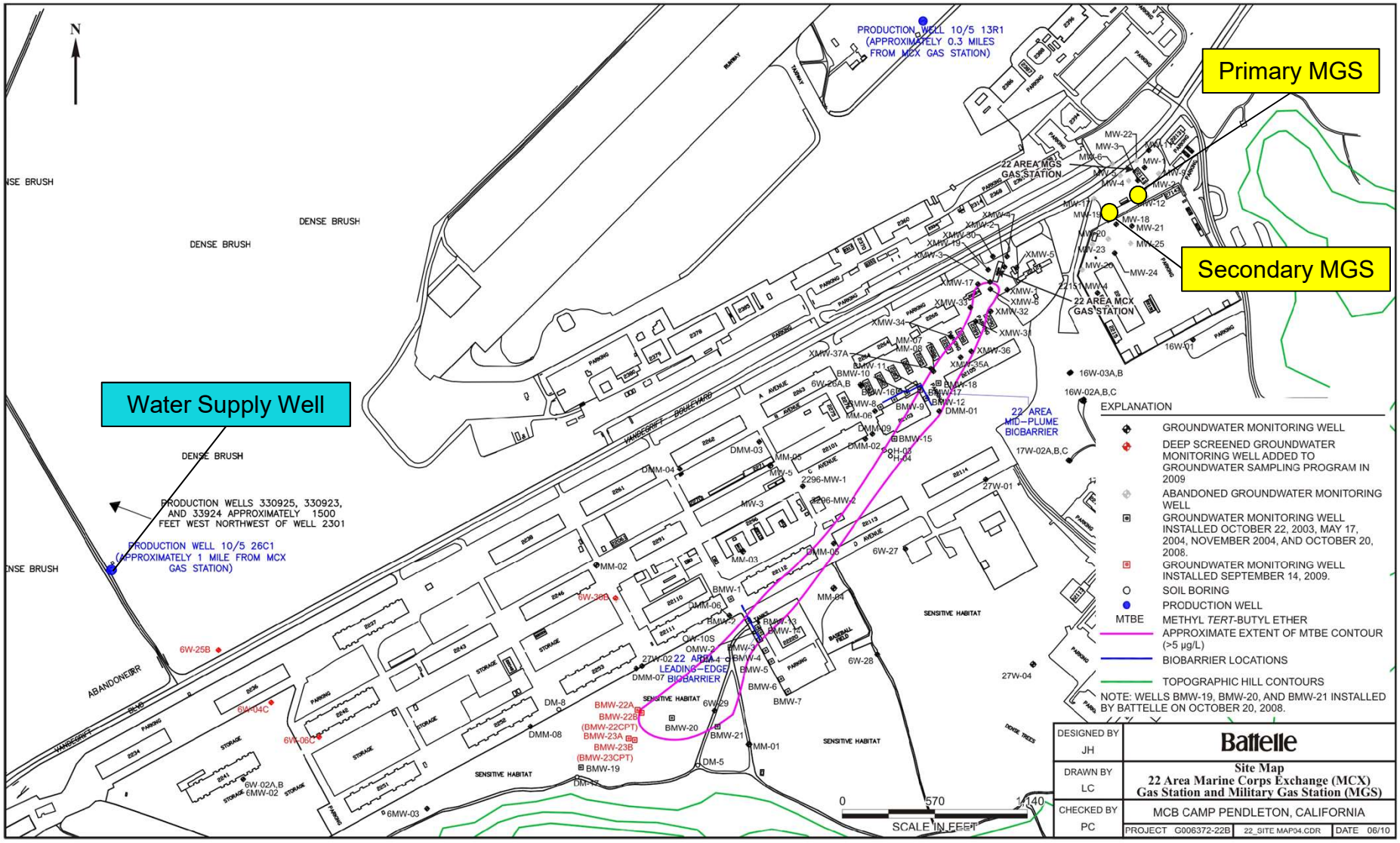
MGS source area prior to excavation

MGS source area excavation



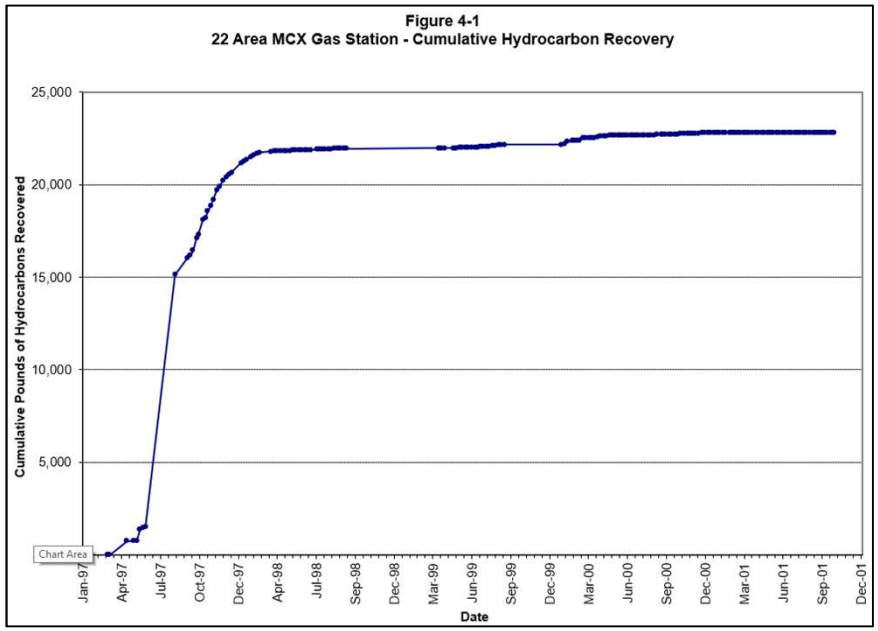
Primary MGS SVE/AS System Mass Recovery

Remedy Construction



Remedy Construction

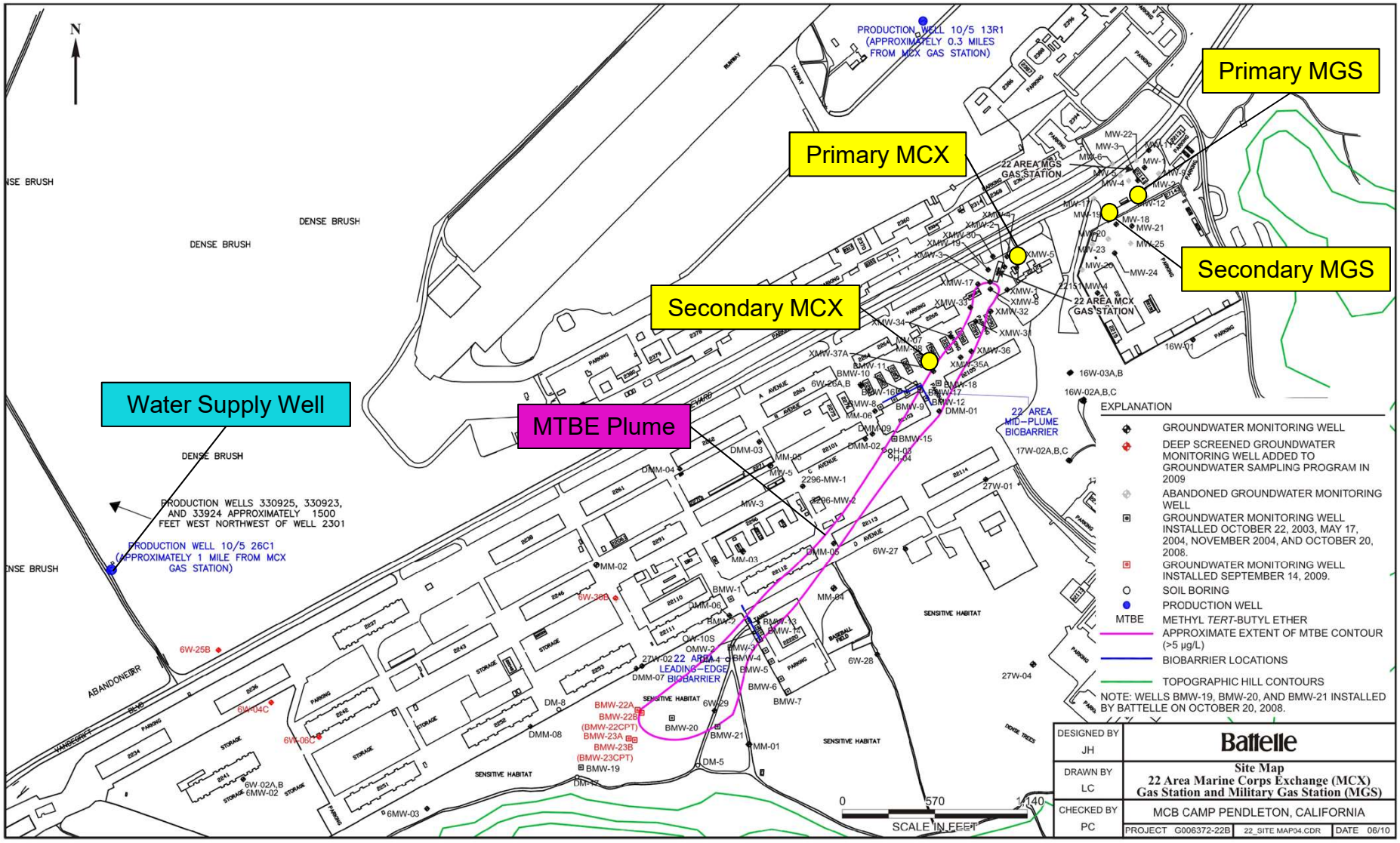
- **MCX Gas Station SVE/AS systems operated from 1997 – 2004.**
  - Removed 22,802 lbs of petroleum hydrocarbons. Majority within first 9 months of operation.
  - In 1999, transitioned from thermal oxidation SVE to carbon filters.
  - Groundwater monitoring performed from 1995 to 2016.
  - Final Remedial Action Work Plan (2003) to install and operate oxygen injection biobarriers.



Primary MCX SVE/AS System Mass Recovery

Primary MCX SVE/AS System with Carbon Filters

Remedy Construction



Remedy Construction

– **Final Remedial Action Work Plan (2003) to install and operate two oxygen injection biobarriers.**

Mid-plume Oxygen Injection Biobarrier System

Leading-edge Oxygen Injection Biobarrier System

Mid-plume Well Vault Installation

Oxygen Injection Wells in Vault

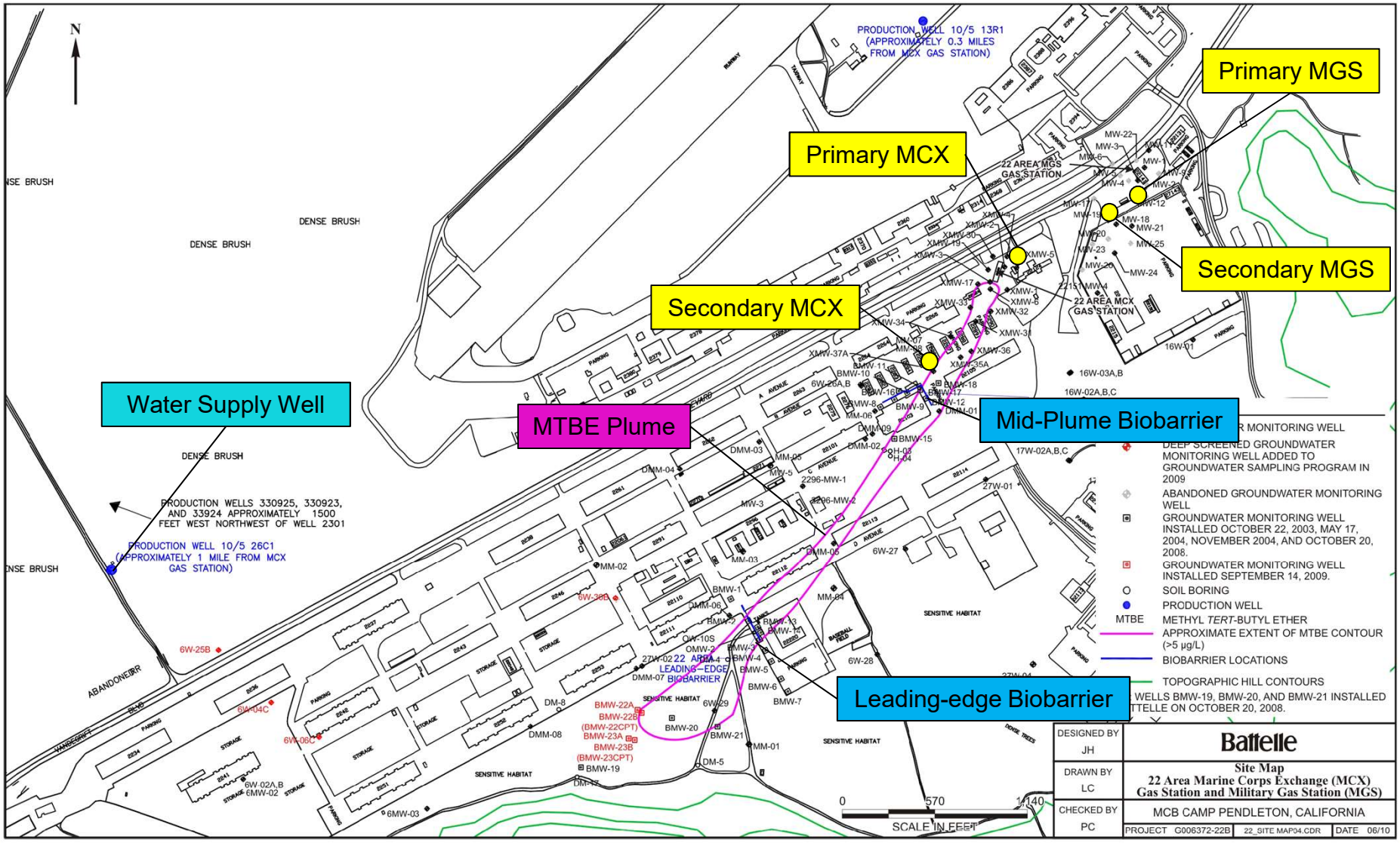
Remedy Construction

Biobarriers operated from 2004 to 2010 and successfully controlled plume migration and reduced TPH-G and BTEX to below action levels, while continuing to reduce dissolved-phase MTBE concentration

Compressor and oxygen holding tanks

99% Oxygen generator

Remedy Construction



Remedial Action Operation Summary

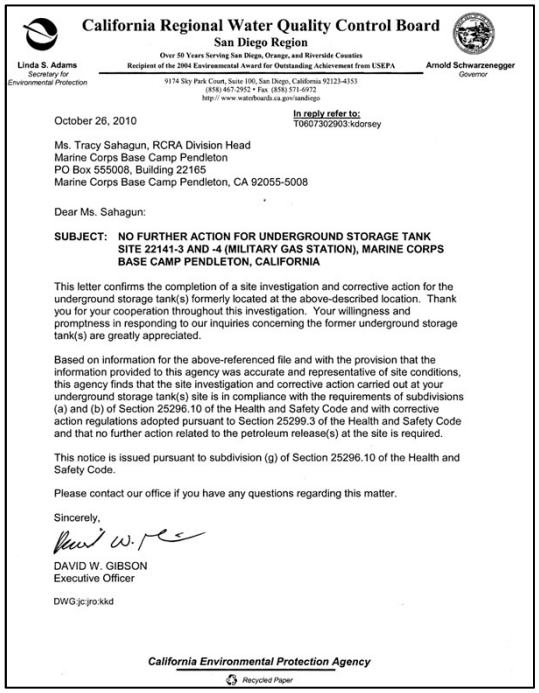
- MGS and MCX SVE and AS remediation systems operated from 1997 to 2004.
- MCX mid-plume and leading-edge biobarrier oxygen injection systems operated from 2004 to 2010.
- MNA performed from 2010 to 2016.

Monitoring Trend

- No ongoing site monitoring occurring.
- No five year reviews for UST sites.

Response Complete Milestones

- MGS – October 2010, received NFA concurrence from SD RWQCB.
- MCX – September 2016, received NFA concurrence from SD RWQCB.



California Regional Water Quality Control Board
San Diego Region

Over 50 Years Serving San Diego, Orange, and Riverside Counties
Recipient of the 2004 Environmental Award for Outstanding Achievement from USEPA

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http:// www.waterboards.ca.gov/sandiego

October 26, 2010

In reply refer to:
T0607302903:kdorsey

Ms. Tracy Sahagun, RCRA Division Head
Marine Corps Base Camp Pendleton
PO Box 555008, Building 22165
Marine Corps Base Camp Pendleton, CA 92055-5008

Dear Ms. Sahagun:

SUBJECT: NO FURTHER ACTION FOR UNDERGROUND STORAGE TANK SITE 22141-3 AND -4 (MILITARY GAS STATION), MARINE CORPS BASE CAMP PENDLETON, CALIFORNIA

This letter confirms the completion of a site investigation and corrective action for the underground storage tank(s) formerly located at the above-described location. Thank you for your cooperation throughout this investigation. Your willingness and promptness in responding to our inquiries concerning the former underground storage tank(s) are greatly appreciated.

Based on information for the above-referenced file and with the provision that the information provided to this agency was accurate and representative of site conditions, this agency finds that the site investigation and corrective action carried out at your underground storage tank(s) site is in compliance with the requirements of subdivisions (a) and (b) of Section 25296.10 of the Health and Safety Code and with corrective action regulations adopted pursuant to Section 25299.3 of the Health and Safety Code and that no further action related to the petroleum release(s) at the site is required.

This notice is issued pursuant to subdivision (g) of Section 25296.10 of the Health and Safety Code.

Please contact our office if you have any questions regarding this matter.

Sincerely,

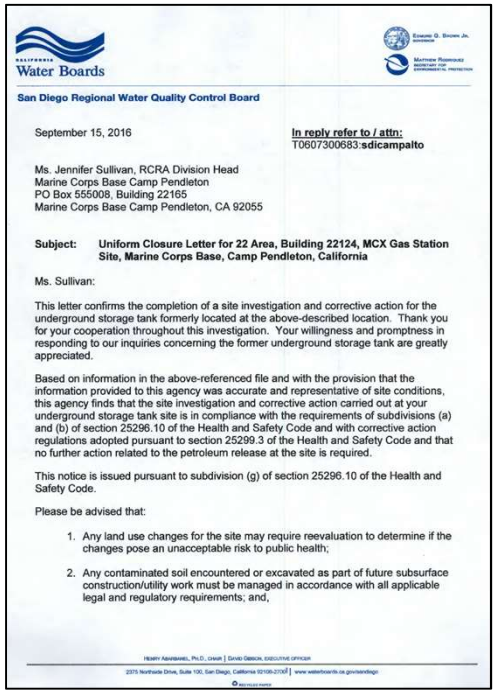
DAVID W. GIBSON
Executive Officer

DWG:jc:jro:kkd

California Environmental Protection Agency

Recycled Paper

MGS NFA Letter



Water Boards

San Diego Regional Water Quality Control Board

September 15, 2016

In reply refer to / attn:
T0607300683:**sdicampalto**

Ms. Jennifer Sullivan, RCRA Division Head
Marine Corps Base Camp Pendleton
PO Box 555008, Building 22165
Marine Corps Base Camp Pendleton, CA 92055

Subject: Uniform Closure Letter for 22 Area, Building 22124, MCX Gas Station Site, Marine Corps Base, Camp Pendleton, California

Ms. Sullivan:

This letter confirms the completion of a site investigation and corrective action for the underground storage tank formerly located at the above-described location. Thank you for your cooperation throughout this investigation. Your willingness and promptness in responding to our inquiries concerning the former underground storage tank are greatly appreciated.

Based on information in the above-referenced file and with the provision that the information provided to this agency was accurate and representative of site conditions, this agency finds that the site investigation and corrective action carried out at your underground storage tank site is in compliance with the requirements of subdivisions (a) and (b) of section 25296.10 of the Health and Safety Code and with corrective action regulations adopted pursuant to section 25299.3 of the Health and Safety Code and that no further action related to the petroleum release at the site is required.

This notice is issued pursuant to subdivision (g) of section 25296.10 of the Health and Safety Code.

Please be advised that:

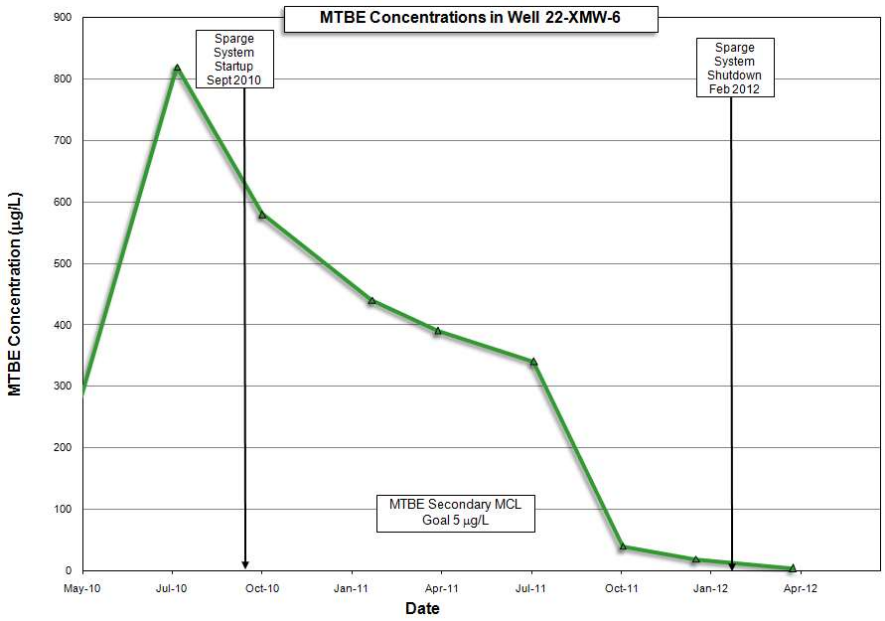
1. Any land use changes for the site may require reevaluation to determine if the changes pose an unacceptable risk to public health;
2. Any contaminated soil encountered or excavated as part of future subsurface construction/utility work must be managed in accordance with all applicable legal and regulatory requirements; and,

MCX NFA Letter

Significant Challenges

- Negotiating cleanup levels with regulatory agency. This was made more difficult with regulator personnel changes.
- Hot spot in source area of MCX that persisted. Treatment from 2010-2012 using a portable sparge system. Decreased "hot spot" concentrations from 820 µg/L to 18 µg/L MTBE during that time.

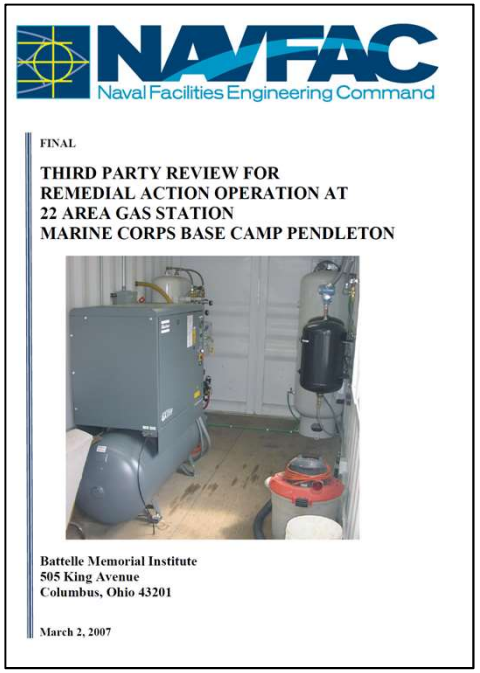
Portable Sparge System



MTBE Concentrations During Sparging

Remedy Optimization Strategies

- **2007 Navy performed a third party optimization on remedial action. Recommendations included:**
  - **Increasing the leading-edge oxygen injection barrier system cycling**
  - **Shutdown mid-plume oxygen injection biobarrier system**
    - Achieved April 2010
  - **Optimize the groundwater monitoring program**
    - Reduce the number and frequency of groundwater wells sampled using trend analysis and decision tree diagrams
  - **Updating the Conceptual Site Model**
    - Performed Cone Penetrometer Testing (CPT) to identify data gaps


NAVFAC
Naval Facilities Engineering Command

FINAL

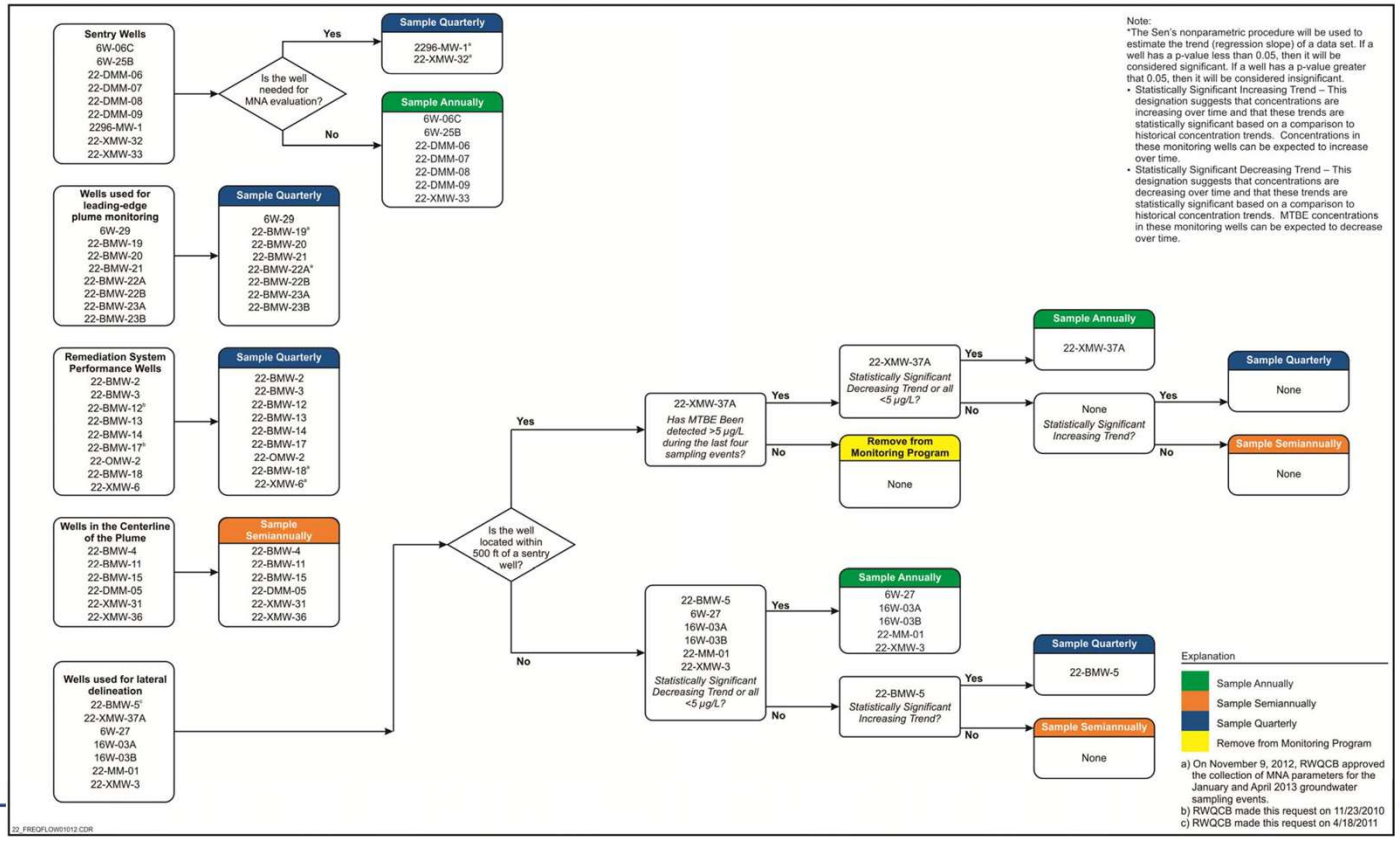
THIRD PARTY REVIEW FOR
REMEDIAL ACTION OPERATION AT
22 AREA GAS STATION
MARINE CORPS BASE CAMP PENDLETON

Battelle Memorial Institute
505 King Avenue
Columbus, Ohio 43201

March 2, 2007

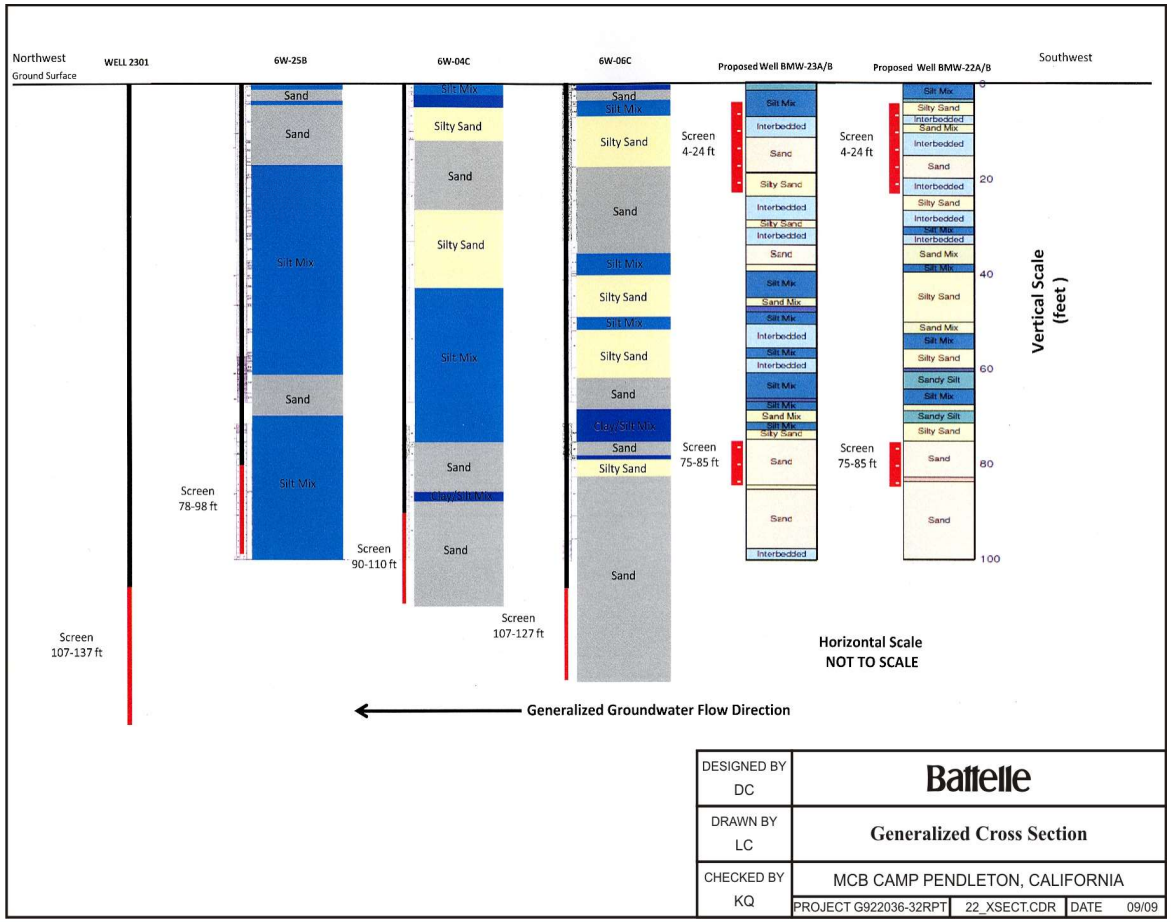
Additional Lines of Evidence to Achieve RC

- **Optimize groundwater monitoring program by using Sen's Non-Parametric MTBE Trend Analysis with Decision Tree Diagram**
  - **Reduced annual well count from 156 to 105 immediately**
  - **By 2016, annual well count 34.**



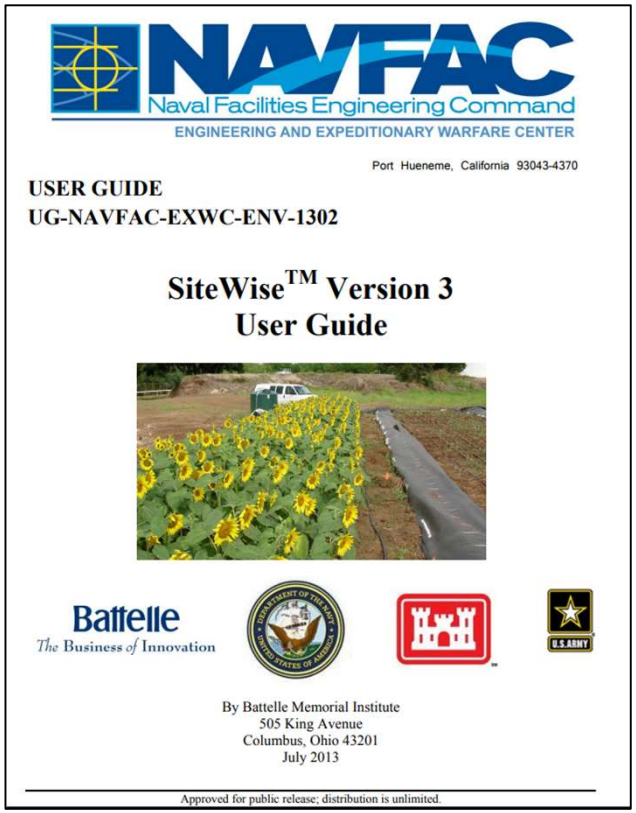
Additional Lines of Evidence to Achieve RC

- **CPT and Data Gap Analysis led to the installation of groundwater wells in the deeper aquifer to confirm no MTBE migrated vertically**



Additional Lines of Evidence to Achieve RC

- **Sustainability Analysis - SiteWise™**
  - Sum of all CO2 emissions for the Mid-plume Biobarrier = 18.6586 metric tons of CO_2e per year
  - Sum of all CO2 emissions for a SUV = 1.1760 metric tons of CO_2e per year
  - Running the Mid-plume Biobarrier for one year is equivalent to driving how many SUVs every year? (Assuming 15,000 miles driven per year.) = 18.6586 [metric tons CO2e Mid-plume] / 1.1760 [metric tons CO2e SUV] = 16 SUVs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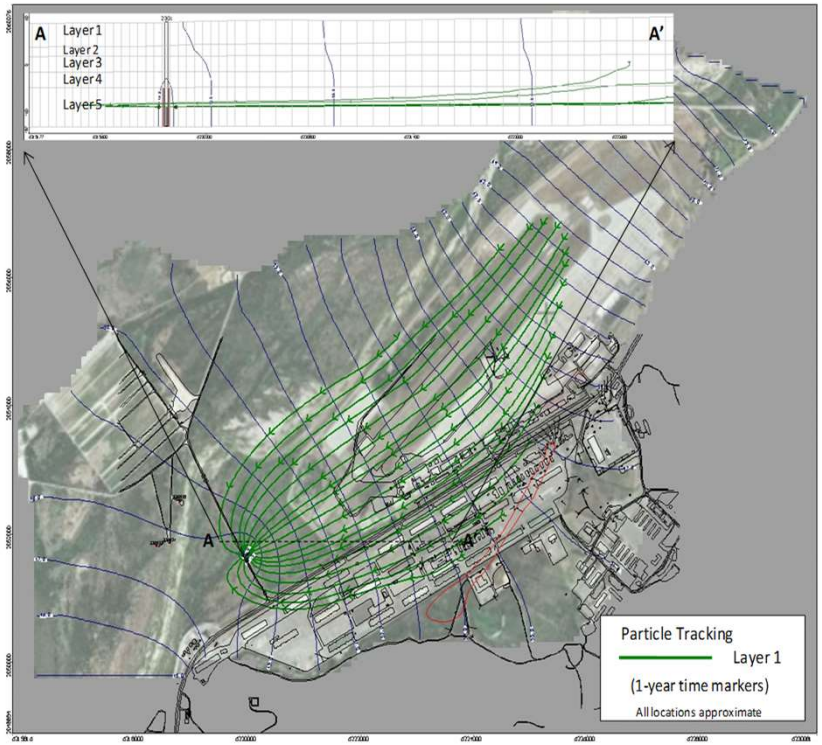
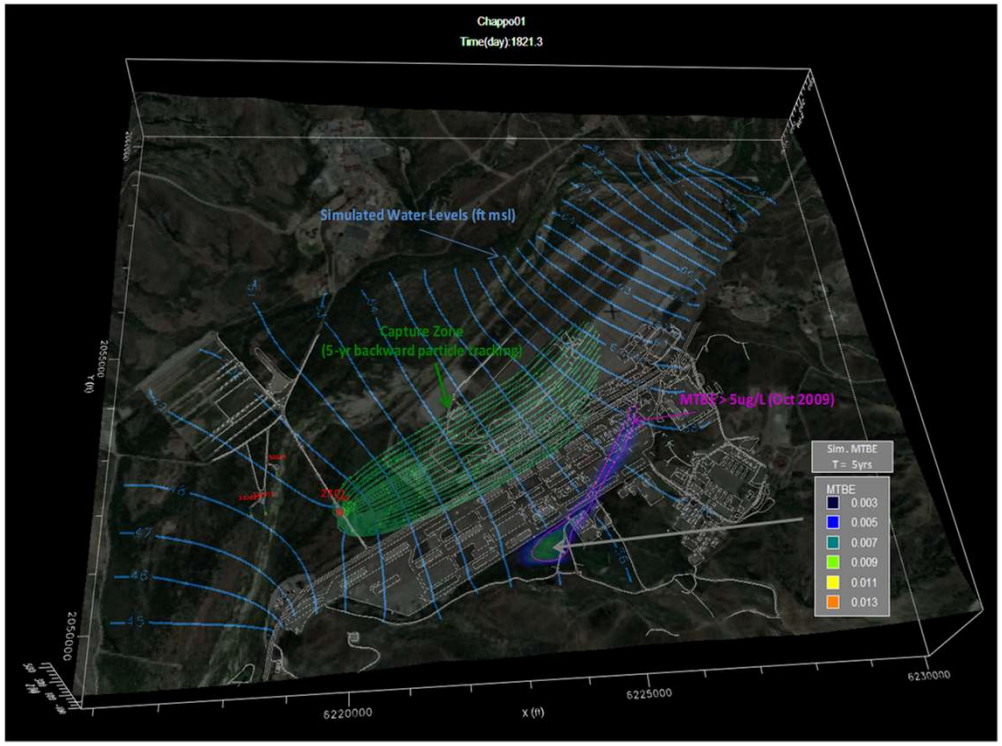
SiteWise™ Version 3
User Guide
Battelle
The Business of Innovation
By Battelle Memorial Institute
505 King Avenue
Columbus, Ohio 43201
July 2013
Approved for public release; distribution is unlimited.

Additional Lines of Evidence to Achieve RC

- **Capture Zone Analysis – MODFLOW**



MTBE Capture Zone Analysis



20-Year Backward Particle Tracking Analysis

Current Status

- Achieved goal of returning area to heavily utilized area of MCB Camp Pendleton operations.
- SD RWQCB concurred with NFA but noted that future land use changes may require re-evaluation.
  - MCB Camp Pendleton Environmental Security Office utilizes GIS platform to track all open and closed environmental sites to ensure any proposals to change land use or initiate construction are reviewed and approved by Environmental Security before implementation.

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Former NWIRP McGregor, Area M
Path to Response Complete

Former NWIRP McGregor, TX

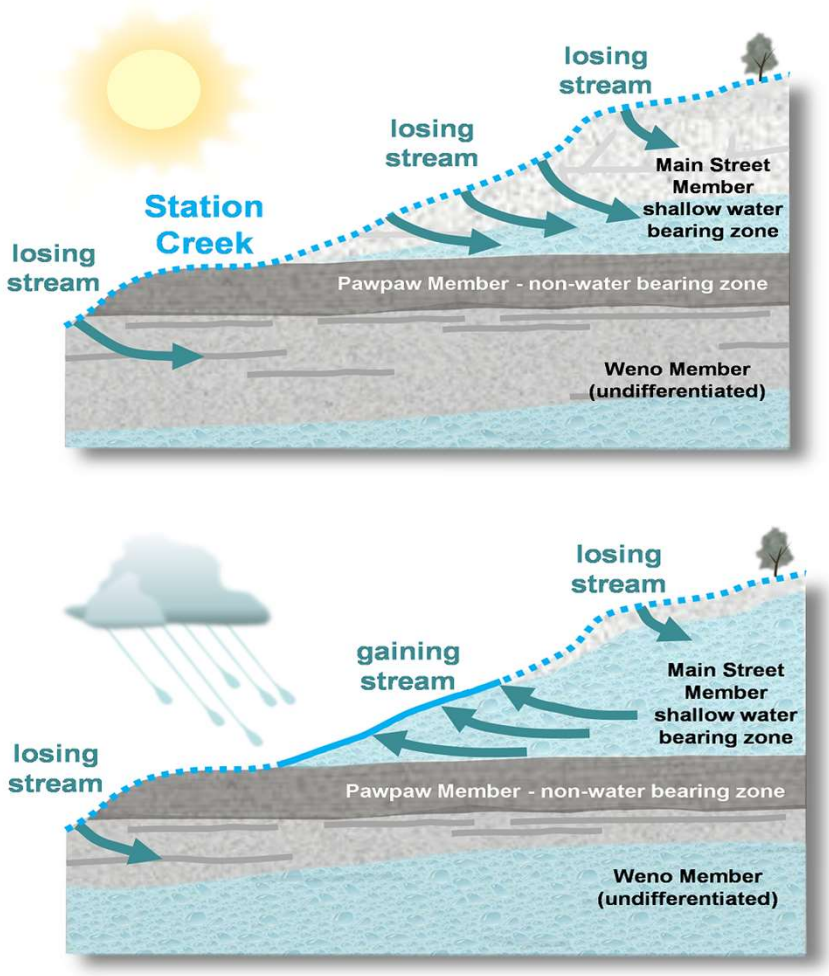
- Used until 1995 as bomb and rocket motor manufacturing facility
- 9,700 acres, 20 miles west of Waco, Texas
- Ammonium perchlorate and chlorinated solvents
- "Hog out" operations of rocket motors
- Property transferred to City of McGregor starting in 1998
- Leased portions of property to industrial and agricultural companies
- Navy maintains cleanup responsibility/liability and continues active remediation/LTM
- Groundwater collection system with fluidized bed reactor treatment of perchlorate
- Primary risk pathway (initially) off-site migration to municipal water supply

Life Cycle Optimization Timeline

- Automation and remote monitoring of fluidized bed reactor (FBR) *(2004-05)*
- LTM optimization *(2005–17)*
- Evaluate attenuation capacity of groundwater to surface water pathway *(2014-15)*
- Groundwater re-classification from Class II to Class III and reduction of Plume Management Zone (PMZ) *(2016)*
- Ecological study of perchlorate in surface water *(2016)*
- Transition pump and treat/FBR system to passive in situ bio-barriers *(2017-2021)*

NWIRP McGregor Conceptual Site Model

- Streams and tributaries at the facility experience both gaining and losing conditions
- Majority of precipitation occurs in Spring
- Perchlorate attenuated along groundwater flow direction through mixing within dynamic system



Groundwater Containment Remedy

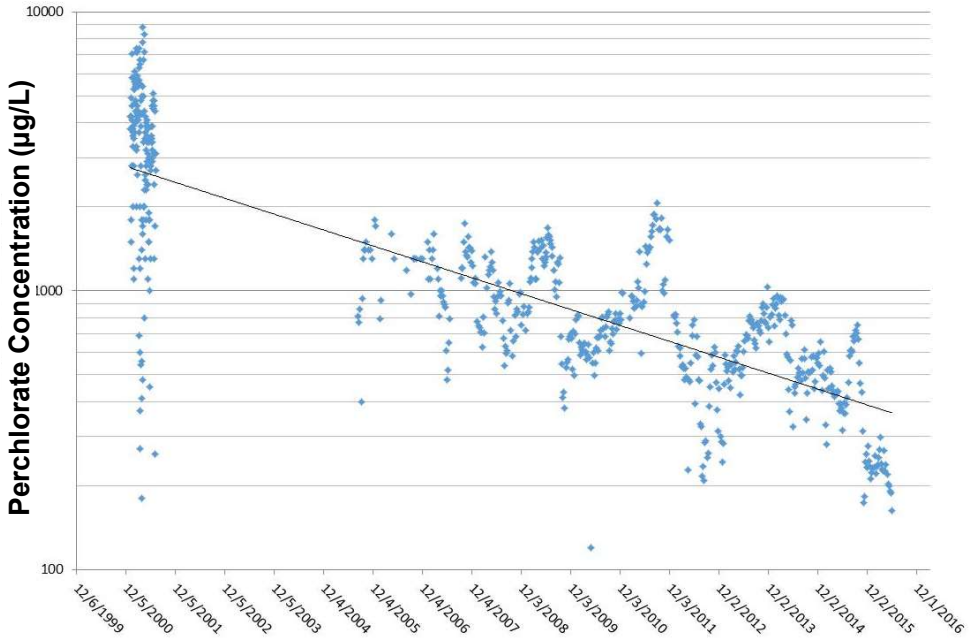
- Early action in 1999 to install groundwater collection trenches along property boundary to prevent further off-site plume migration and release to surface water
- Fluidized bed reactor to treat perchlorate impacted groundwater
- *Ex situ* anaerobic landfarming to treat perchlorate-contaminated soil in 2001

Trench excavator used to construct groundwater collection trenches

Fluidized bed reactor used for biological treatment of perchlorate (NAVFAC 2017)

Plume Response

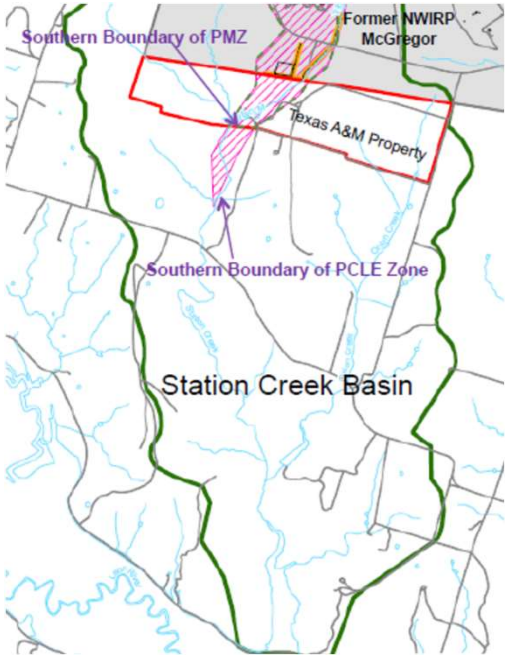
- Reduction in plume footprint (e.g., spatial footprint analysis, time series plots)
- Perchlorate source reduction efforts successful (soil treatment)
- Groundwater collection system successful in controlling off-site migration
- Natural attenuation shown to be effective in controlling plume downgradient of collection trenches



Downgradient perchlorate concentrations over time demonstrate significant plume attenuation (NAVFAC 2017)

Plume Management

- Hydraulic containment system to minimize off-site plume migration
- Plume management zone (PMZ) for areas exceeding state regulatory levels
- Deed restriction for PMZ on off-site Texas A&M property
- Groundwater re-classification based on low aquifer specific yield

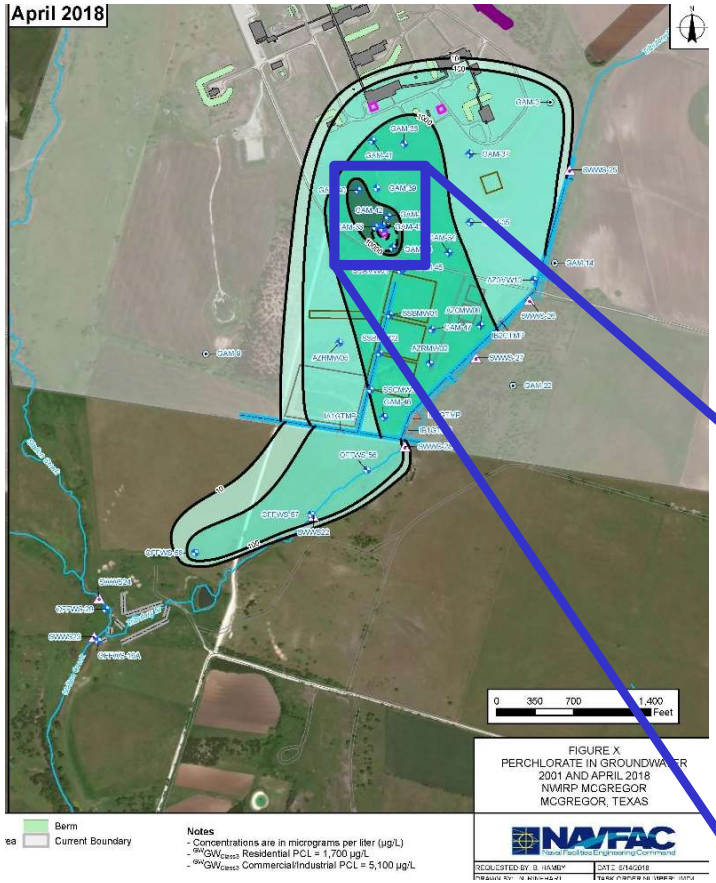


Fluidized bed reactor used for biological treatment of perchlorate (NAVFAC 2017)

TCEQ's PCLs for Perchlorate		
Media	**Commercial/ Industrial (µg/L)**	**Ecological (µg/L)**
Class II groundwater	51.1	>8,000
Class III groundwater	5,110	>8,000
Surface water	--	>8,000

Transition Assessment

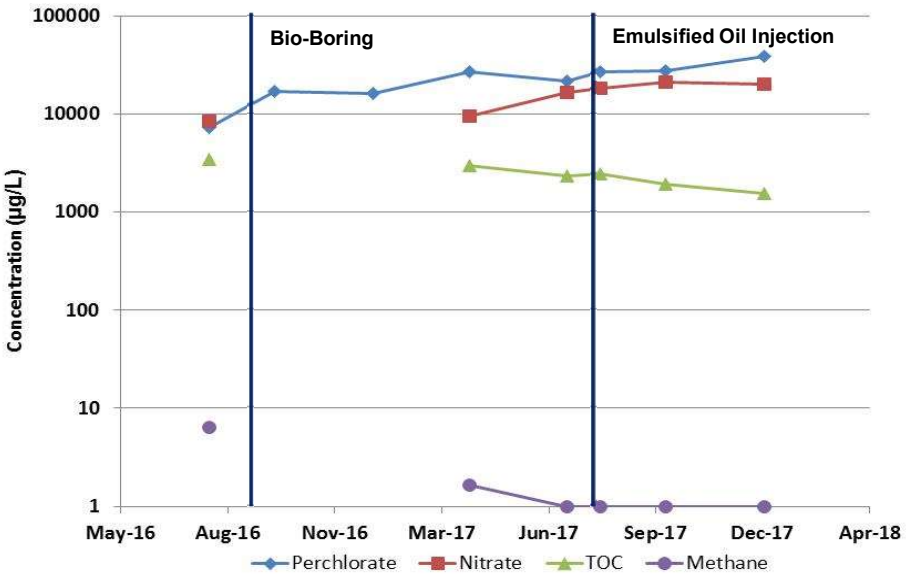
- Majority of on-site plume less than Class III C/I cleanup goal
- In situ bio-barrier treatment of perchlorate hot spot
- Decommissioning of pump and treat system
- Natural attenuation for remainder of plume



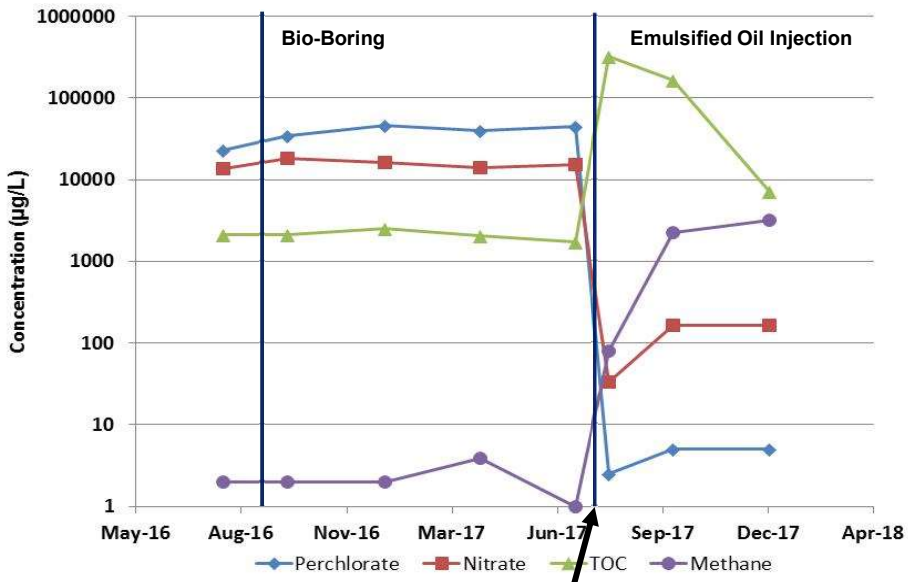
Focused treatment on remaining perchlorate hot spot

Bio-Barrier Pilot Study Results

GAM-42 (Upgradient Well)



GAM-43 (Downgradient Well)

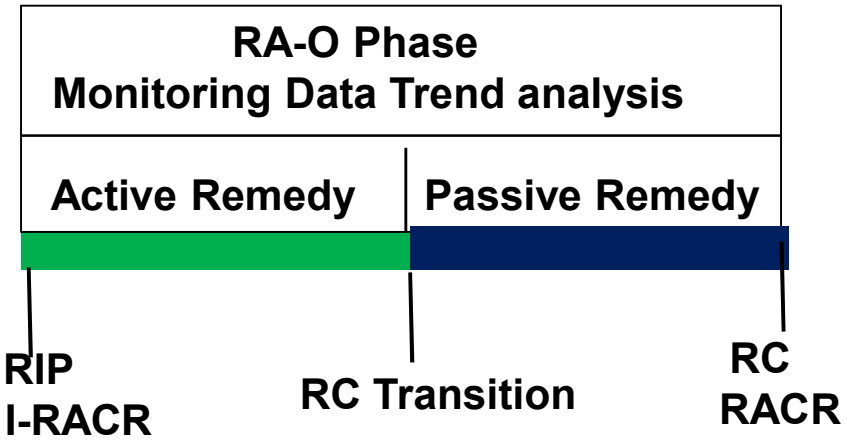


Rapid perchlorate and nitrate reduction and methane production

Source: NAVFAC SE 2017

NWIRP McGregor Summary

- Life-cycle optimization and RC achieved through combination of technology and management approaches
  - Groundwater re-classification
  - Natural attenuation conceptual model
  - Site-specific ecological risk assessment of sensitive surface water receptors
  - Plume management zone
  - Transition pump and treat system to passive in situ bio-barriers
- Long-term passive remedy result in significant annual cost avoidance while maintaining protection of human health and environment
- RC achieved once full-scale bio-barriers installed and operating successfully



1999-2017:

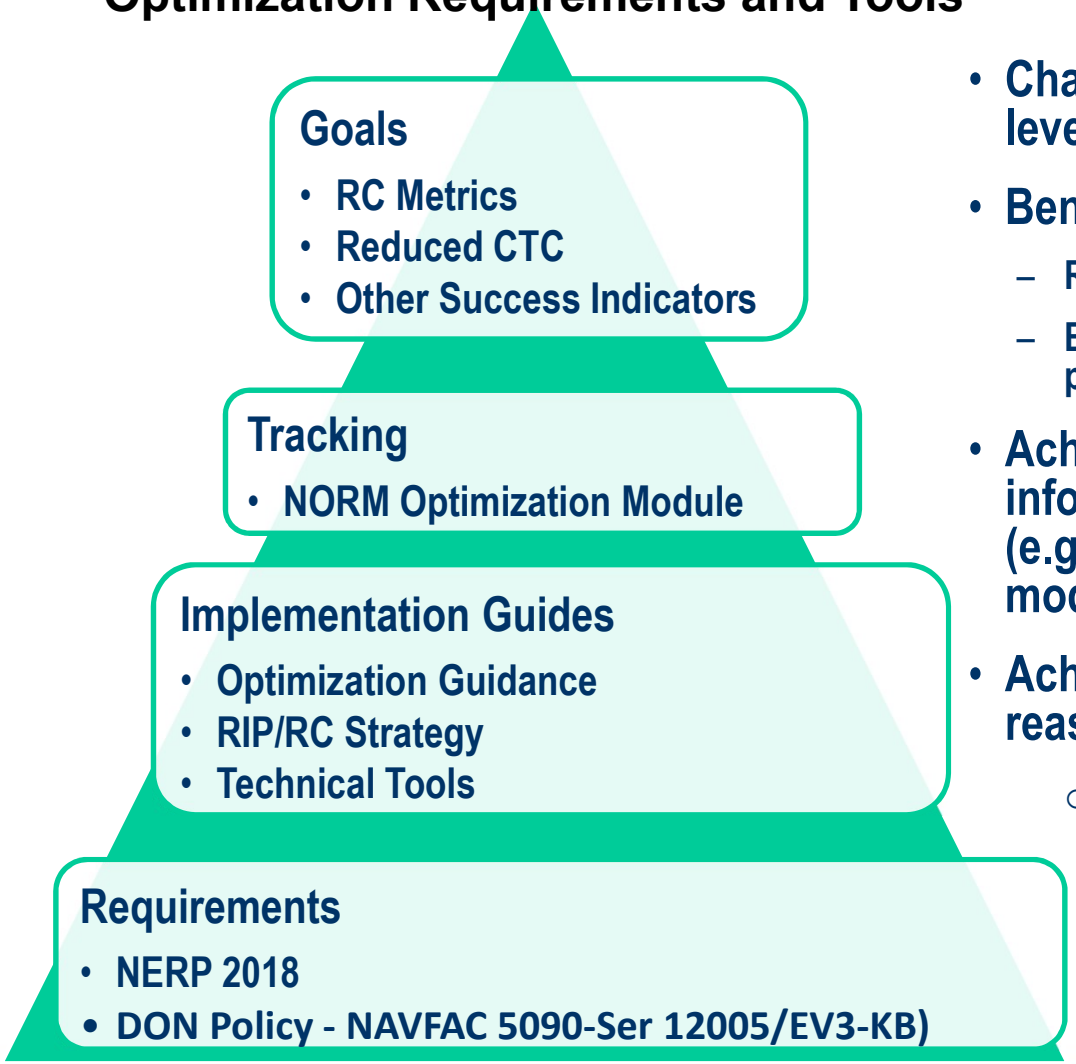
- Soil removal and on-site treatment
- Groundwater collection and FBR treatment

2017 - ??:

- Bio-barrier
- MNA
- PMZ/LUCs
- LTM

Webinar Summary

Optimization Requirements and Tools



Case Study Lessons Learned

- Challenges to Achieving RC exist for all levels of site complexity
- Benefits of Optimization during RA-O
  - Reduces cost of operation and monitoring
  - Enhances mass removal allowing subsequent passive remedies to be protective
- Achieving RC-T may require additional information to evaluate passive remedies (e.g. MNA parameters, enhanced CSM, modelling)
- Achieving RC may also require reassessment of cleanup goals
  - Non-NPL sites allow greater flexibility with risk-based criteria

Questions and Answers

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Wrap Up

You will be redirected to a brief survey when you leave the webinar.

Next OER2:

APP/SSHP

Thank you for participating!