INTRODUCTION

Marine Corps Installations West-Marine Corps Base Camp Pendleton serves as the Marine Corps premier amphibious training base offering comprehensive air, sea, and ground assault training to 42,000 active service members, 25,000 reservists, and over 35,000 entry level Marines (recruits) from Marine Corps Recruit Depot San Diego. It hosts over 51,000 training events annually. Overall, Camp Pendleton serves an average daytime population exceeding 85,000 personnel that includes civilians. As the busiest USMC training base on the West coast, Camp Pendleton is home to the First Marine Expeditionary Force (I MEF) supporting the day-to-day training requirements as they prepare for regular deployments with specialized units, such as three Marine Expeditionary Units. Other major commands headquartered at Camp Pendleton include 1st Marine Division and 1st Marine Logistics Group. The Base has a critical mission to provide formal schooling to Marines. Each year recruits from Marine Corps Recruit Depot San Diego conduct field training and rifle marksmanship. Recruit graduates are educated in basic warfighting techniques at the School of Infantry (West), Fleet Marine Force Navy Corpsmen are trained at the Field Medical Service School, and thousands of enlisted marines attend

Camp Pendleton's Professional Military Education.

Geographical Setting: Located in the northwest portion of San Diego County just 38 miles north of San Diego City, Camp Pendleton encompasses approximately 125,000 acres of land, including 17 miles of undeveloped coastline. The Base has more than 2,600 buildings and 500 miles of roads. .

Environmental Setting: A biological haven with over 1,000 species of flora and fauna, including 12 endangered and 4 threatened species. Ecosystems include beaches, bluffs, mesas, canyons, mountains and Southern California's only free-flowing river, the Santa Margarita River. Nearly 100% of Base drinking water is derived from on-base aquifers.

Community Setting: Sandwiched between three small communities, the Base maintains close relationships with its neighbors. The coastal cities of Oceanside and San Clemente border to the north and south respectively, while the smaller town of Fallbrook lies to the east. The Base hosts thousands of civilians each year who participate in one of several "World Famous" mud runs presented by Marine Corps Community Services.

Economic Setting: Roughly $1.2 billion annually to the local economy.

BACKGROUND

Within USMC and USN communities "environmental restoration" is referred as "installation restoration." The CERCLA program began in the early 1980's when the U.S. Environmental Protection Agency (USEPA) completed a preliminary assessment of hazardous waste storage sites. In compliance with federal requirements, the Department of Defense established the Navy's Installation Restoration (IR) Program in 1986 to identify, assess, characterize, and clean up or control contamination from past hazardous waste-disposal operations and hazardous materials spills at U.S. Navy and Marine Corps installations. In November 1989, the Base was placed on the Federal National Priorities List (NPL) due to site investigations indicating areas in which soil and groundwater contamination exceeded levels protective of human health and the environment.

Organization, Staffing, and Management Approach: In 1990 the major stakeholders entered into a Federal Facilities Agreement (FFA) for Camp Pendleton; this included the Department of the Navy (Naval Facilities Engineering Command Southwest [NAVFAC SW]), USMC, USEPA, California Department of Toxic Substance Control (DTSC), and California Regional Water Quality Control Board (RWQCB). The FFA is a legally binding document that outlines the schedule for completing investigations and cleanup of IR sites at the Base. The installation's IR program also manages the remedial actions of contaminated sites falling under the purview of RCRA to include petroleum underground storage tanks and facilities that store and use petroleum substances.

Community Involvement: Camp Pendleton maintains a Community Involvement Plan that includes a variety of techniques to network and encourage community participation and regulatory collaboration. The plan is routinely reviewed and updated in order to improve outreach and encourage additional participation.

MARINE CORPS BASE CAMP PENDLETON MAINTAINS ACTIVE OUTREACH

Information Repository at the Oceanside Public library

Technical Review Committee (TRC)

Administrative Record at NAVFAC SW in County of San Diego

Camp Pendleton public website

Earth Day public outreach annual event

Site tours, public meetings, fact sheets published in local newspapers

SUMMARY OF ACCOMPLISHMENTS

During FY15-16, multiple projects were completed contributing directly to the protection of human health and the environment. These projects included non-time critical removal actions, innovative technology pilot projects, RCRA site closures, and implementation of green remedial actions. Many of the companies completing these projects are small disadvantaged businesses working with larger companies under mentor-protégé contracts. These contracts are administered by NAVFAC SW and increase opportunities for small businesses to compete on technically challenging projects. Installation restoration program managers, NAVFAC SW, and regulatory stakeholders fostered a close partnership over the years to achieve expedited, cost effective, and environmentally protective remedial actions.

Action Item	Award period	Total
CERCLA ROD Signed	3	10
CERCLA Site Closed, NFA (no further action)	1	65
CERCLA Site Under Remedial Action	12	15
RCRA/UST Site Closed, NFA	15	370
RCRA/UST Site Under Remedial Action	10	13

ACCELERATED ENVIRONMENTAL CLEANUP

In Situ Thermal Remediation at IR Site 1115. IR Site 1115 includes two groundwater plumes, one shallow and one deep, underneath pavement near the 13 Area at Camp Pendleton. The site once served as a motor pool for vehicle maintenance and a repair, painting, washing, and fuel service station for the base. A total of nine underground storage tanks (USTs), which stored a variety of fuels and solvents, were used to support previous activities at the site. All buildings and USTs have been removed or closed in place. The site is currently paved with asphalt and used for vehicle and equipment staging.

80 thermal conductive heating (TCH) wells supplied heat, via natural gas, from grade to a depth of 35 ft. bgs.

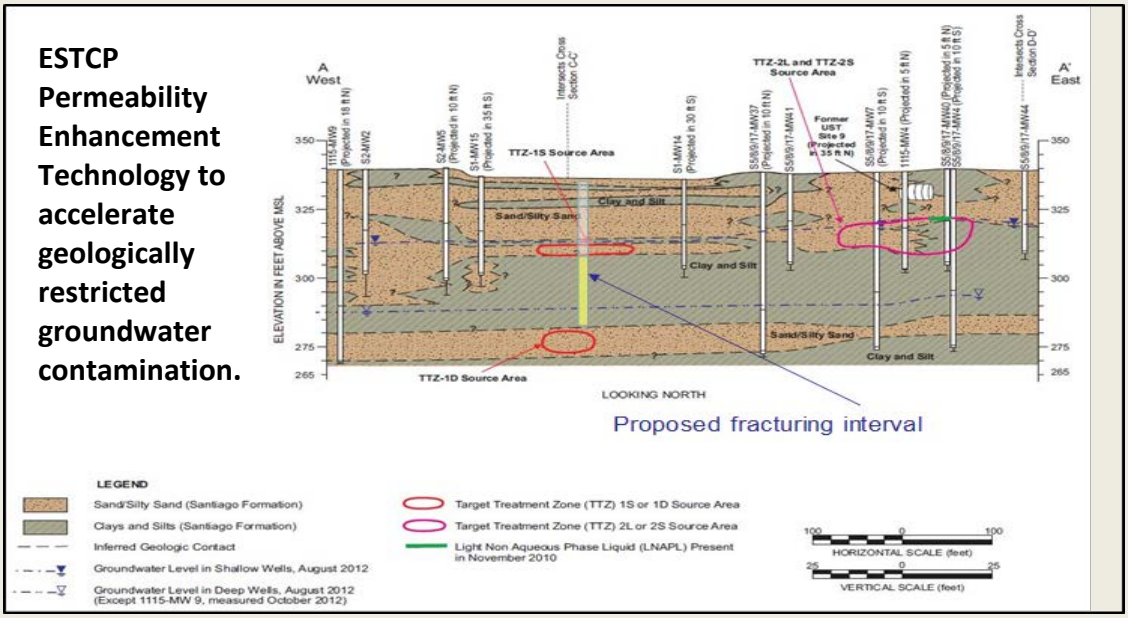
Dense soil conditions, which were not conducive to conventional in situ treatment technologies, coupled with and the variety of groundwater contaminants, merited testing of an innovative treatment technology to accelerate cleanup and avoid costly dig

and haul disposal costs. An in situ thermal remediation treatment system was installed to determine if groundwater contaminants could be reduced or eliminated. The treatment system was installed in a target treatment zone (TTZ), which encompassed approximately 4,800 square feet (ft^2). Contaminants of concern (COCs) included TCE, DCE, Naphthalene, Ethylbenzene, and Benzene. Thirty three multi-phased extraction (MPE) wells were collocated in the TTZ and operated as the primary COC extraction points. MPE wells began extraction four weeks before the start of active subsurface heating. Extracted groundwater and LNAPL product were separated onsite, with aqueous phase liquids also treated and discharged. The project's design subsurface temperature was 100°C. Steam stripping and a decrease in COC viscosity were key elements for contaminant removal. Extracted off-gas, laden with chlorinated and petroleum VOCs was treated with patented technology to meet rigorous emissions criteria.

Operation of the MPE system prior to active subsurface heating effectively controlled groundwater migration through the TTZ and reduced the heating systems energy consumption. 100% of the subsurface volume reached the design temperature of 100°C in approximately 36 days, with different depths achieving very uniform heating rates. During 104 days of active heating, the effluent extraction and treatment system processed 1.4E+08 cubic feet of contaminant laden off-gas and 1.8E+05 pounds of extracted liquids. Confirmation soil, soil gas, and groundwater sampling verified concentration reductions for both chlorinated and petroleum VOCs.

INNOVATIVE TECHNOLOGY DEMO

ESTCP Permeability Enhancement Technology to accelerate geologically restricted groundwater contamination.



Permeability Enhancement Technology at IR Site 1115. The objective of this pilot-scale demonstration project was to determine whether hydraulic fracturing could effectively enhance subsurface permeability to allow for in-situ treatment. A viscous fluid was introduced into a borehole at high pressure, resulting in the formation of a small fracture. In this application, guar and sand was injected simultaneously with a chemical oxidizer, persulfate, to maintain the integrity of the propagated fractures, which can otherwise become restricted or closed up entirely, particularly in non-porous geologic sites.

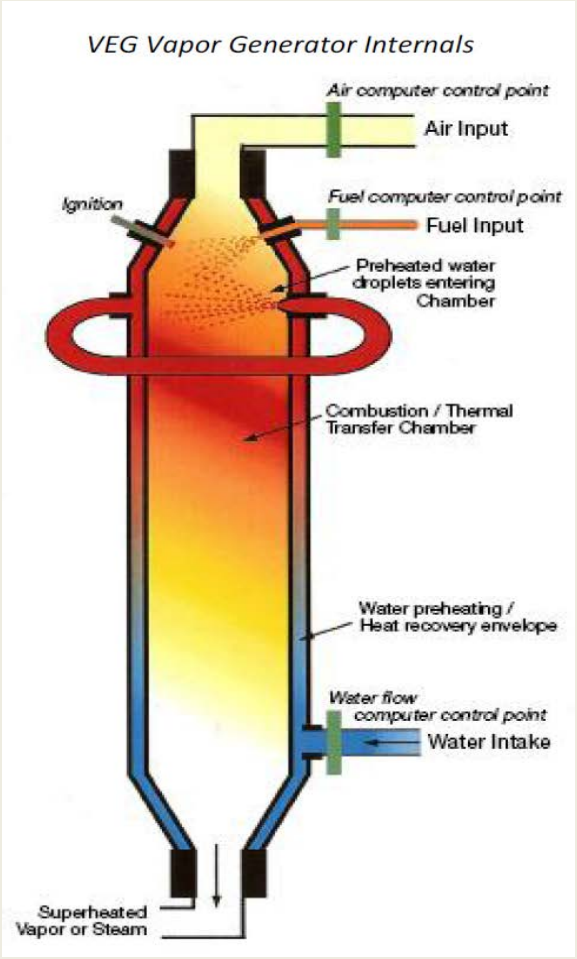
When reagents that stimulate chemical destruction of contaminants can be mixed with target contaminants in the subsurface, remediation practitioners can have a high degree of confidence that treatment will be effective. Conventional injection wells are typically adequate for delivering reagents in homogeneous geologic formations with a bulk hydraulic conductivity of 10-4 centimeters per second (cm/s) or greater; however, practitioners are

well acquainted with the shortcomings of amendment injection using conventional wells in lower permeability settings.

Preliminary analysis indicated that significant increases in hydraulic conductivity were observed at not only the permeability enhancement location but also at nearby monitoring wells.

GREEN REMEDIATION

IR Site 1120 is composed of 15 subsites located within 664 acres of former agricultural fields referred to as the Stuart Mesa Agricultural Fields. Upon termination of the agricultural field lease, several excavation events occurred to remove pesticide contaminated soils to support the conversion of the property to family housing and military training. However, during March 2011 a Phase I Environmental Site Assessment (ESA) and subsequent Phase II ESA was performed to confirm the existence of remaining contaminants. Based on the analytical results from the Phase II ESA, OCPs, chlorinated herbicides, and total petroleum hydrocarbons quantified as diesel and motor oil were detected in various locations at concentrations exceeding project screening levels.



Vapor Energy Generator (VEG) system. VEG system is a mobile ex-situ technology that is an effective remediation method to lower concentrations of pesticides below detection limits to allow the onsite reuse of impacted soils. This innovative technology is fully sustainable, relying on vapors generated through thermal treatment of soils to serve as fuel for operation of the system. VEG Technology employs a series of patented treatment processes, relying first on a green and sustainable thermal process to desorb contaminants from soil, followed by a series of patented treatment processes and filters which treat or otherwise transform all contaminants thermally removed from soils, rendering the soil as uncontaminated and available for unrestricted onsite reuse. Specifically, the technology employs a unique and patented combination of indirect-fire thermal treatment to desorb the full range of organic chemicals and select metals from soils, and subsequently treats the vapors, including acidic gases and CO2, through chemical reduction, thermal oxidation, and transformation treatment processes and associated filtration whereby emissions are eliminated. Next, the patented technology transforms select chemicals in the vapor stream into a synthetic gas, which serves as a renewable source of fuel to run the VEG treatment operations. These thermal desorption, chemical treatment, thermal oxidation, and transformation processes occur in a continuous and repeating looping system, such that no vapors are emitted to the atmosphere.

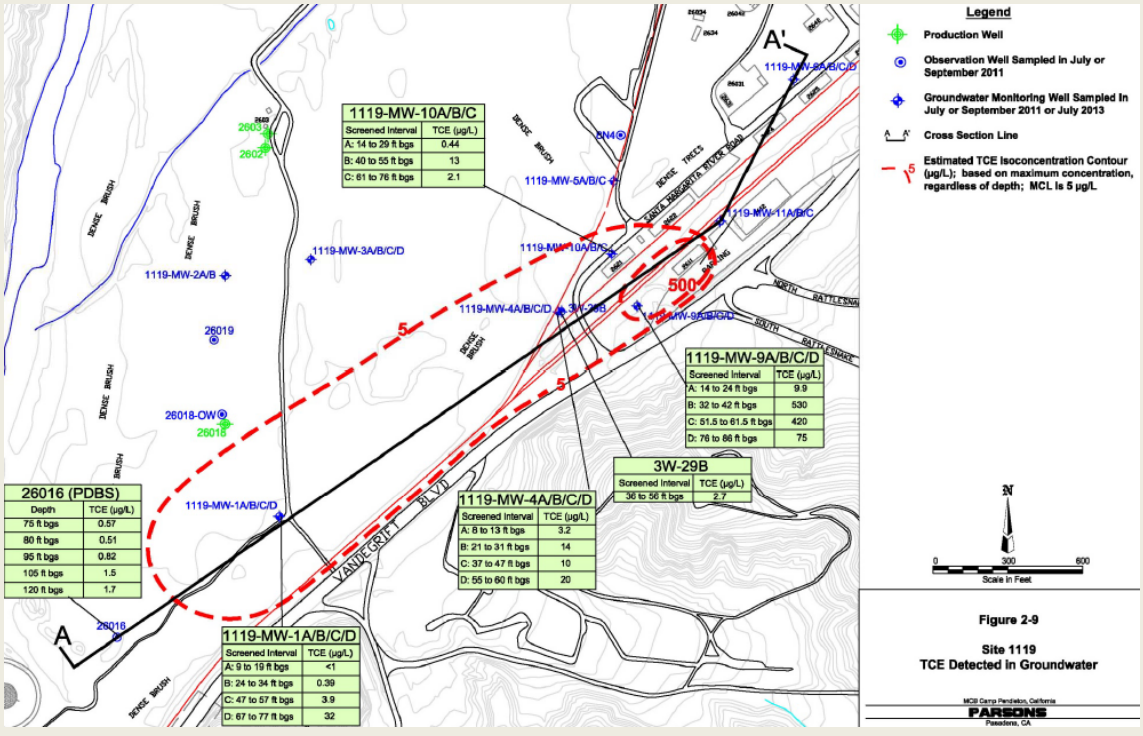
The VEG System is a fully-enclosed treatment chamber that entirely desorbs soil contaminants at specified temperatures and residence times. Contaminants are removed under vacuum via a fully enclosed looping system.

Green Attributes and Benefits

- ❖ *Eliminates offsite transport and landfill disposal of soils*
- ❖ *Eliminates landfill waste generator liability*
- ❖ *Results in unrestricted onsite reuse of soils, eliminating LUCs*
- ❖ *Patented closed loop design and patented filters eliminate air emissions, thereby easing permitting process*
- ❖ *Entirely sustainable system, transforming contaminants into syngas to fuel system operations*
- ❖ *Typical cost savings > 50% relative to landfill disposal*
- ❖ *Typical carbon footprint reductions > 80%*

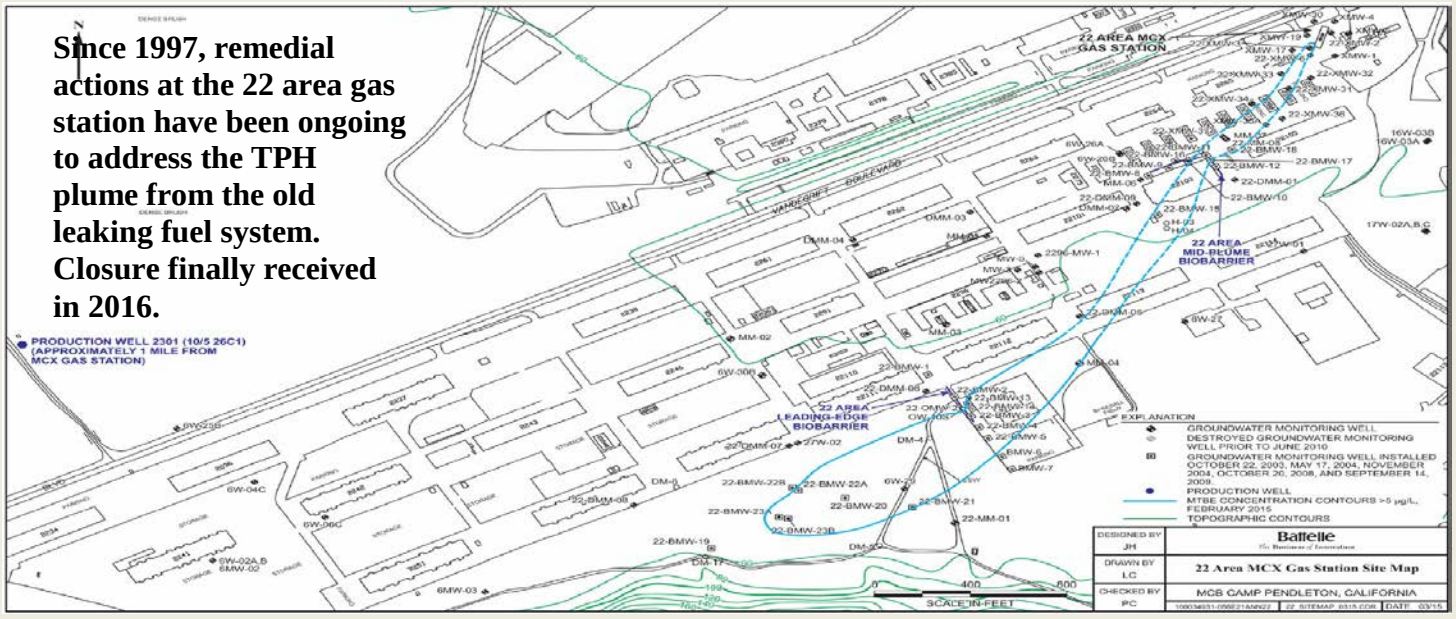
REDUCING RISK TO HUMAN HEALTH & ENVIRONMENT

IR Site 1119 is near the southern boundary of the Base, north of Vandegrift Boulevard (Figure 3). Facilities within this area of the Base include various industrial operations, office buildings, and undeveloped land. Below this setting, TCE in groundwater exceeds the state and federal MCL of 5 micrograms per liter (µg/L). The TCE plume is spread throughout an area of approximately 30 acres at a depth of 80 feet. Critically, the site is up gradient of drinking water wells, which provide nearly half of CPENs drinking water supplies. In order to protect these critical drinking water resources, a combination of two remedial technologies, Source Area Treatment via In Situ Enhanced Bioremediation and Reactive Barrier Installed via Injection Wells Downgradient of the Source Area, are actively being implemented to actively treat the plume and prevent impact to supply wells.



ENVIRONMENTAL PARTNERSHIPS

The **CPEN 22 Area military gas station** located in the southern portion of the base was originally built in 1947 and included unleaded gasoline and diesel USTs. In 1986 and 1989, the County of San Diego recorded unauthorized releases from USTs located at the site of an estimated 600 gallons of TPH reportedly leaked from the product piping. CPEN worked extensively in partnership with NAVFAC SW and the Regional Water Quality Control Board to implement groundwater remedial technologies and appropriate monitoring frequencies. During active remediation, it was discovered that the release of 600 gallons was vastly underestimated, which caused a challenge for accelerated remediation implementation. From 1997 to 2004, SVE and air sparging system operated and proved highly effective. Approximately 51,255 pounds (7900 gallons) of TPHs were recovered from the subsurface during that time period, which is far more than originally was estimated to have leaked into the subsurface. In 2004 through 2010, a mid-plume and leading edge biobarrier oxygen injection systems were installed and consisted of 40 injection points at the mid plume and 21 injection points at the leading edge biobarrier. As a result of multiple technologies, significant reduction of the plume was achieved. The site was able to reach closure in 2010, however during construction activities in 2012, additional diesel soil contamination was discovered and the site required additional investigation and monitoring. After an additional four years of groundwater monitoring and natural attenuation, levels of the contamination finally reached a low and stable level in order to qualify under the Low Threat Underground Storage Tank Case Closure Policy and on June 24, 2016, the Regional Water Quality Control Board granted closure for the 22 Area gas station UST site.



Remedial Accomplishments

- TPH-D went from a historical maximum of 35 mg/L to 0.26 mg/L, which is a 99.26% reduction.
- Benzene concentrations went from a historical maximum of 23,500 µg/L to 0.5 µg/L (below laboratory detection limits), which is an assumed 100% reduction.
- MTBE concentrations decreased from 2,640 µg/L to 1.9 µg/L, which is a 99.93% reduction.