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"ANNUAL OPERATION AND MAINTENANCE STATUS REPORT FOR NUTRIENT INJECTION SYSTEM AT BUILDING 46 FORMER TANKS 46R, 46D, 46SUL AND 46UL NAS CECIL FIELD FL"

7/1/2003

TERRAINE INC ENVIRONMENTAL SERVICES

Annual Operation and Maintenance Status Report

Nutrient Injection System

Building 46, Former Tanks 46R, 46D, 46SUL, and 46UL

January 1, 2002 – December 31, 2002

Naval Air Station Cecil Field
Jacksonville, Florida

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Acronyms

acfh	actual cubic feet per hour
acfm	actual cubic feet per minute
bls	below land surface
BTEX	benzene, toluene, ethylbenzene, and xylene
CCI	CH2M HILL Constructors, Inc.
cfm	cubic feet per minute
CTO	Contract Task Order
EPA	U.S. Environmental Protection Agency
FAC	Florida Administrative Code
FDEP	Florida Department of Environmental Protection
FID	flame ionization detector
FL PRO	Florida Petroleum Residual Organic
GCTL	groundwater cleanup target level
HLA	Harding Lawson Associates
LNAPL	light non-aqueous phase liquids
μg/L	micrograms per liter
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
MTBE	methyl-tert butyl ether
NAS	Naval Air Station
NAVFAC	Naval Facilities Engineering Command
O&M	operation and maintenance
OVA	organic vapor analyzer
PAHs	polynuclear aromatic hydrocarbons
psig	pounds per square inch gauge
SAR	Site Assessment Report
SCTL	soil cleanup target level
TEP	triethylphosphate
TRPH	total recoverable petroleum hydrocarbon
TtNUS	Tetra Tech NUS, Inc.
UST	underground storage tank

1.0 Introduction

Terraine, Inc. (TERRAINE) has been contracted by the Department of the Navy, Southern Division Naval Facilities Engineering Command (NAVFAC), to provide operation and maintenance (O&M) services at Building 46, Naval Air Station (NAS) Cecil Field, Jacksonville, Florida, under Response Action Contract No. N62467-02-G-0352, Contract Task Order (CTO) No. 0001. The purpose of this Annual 2002 O&M Report is to provide a summary of activities performed at the site during the period of January 1, 2002, to December 31, 2002.

1.1 Objective

The objective of the remedial action at the Building 46 site is to reduce the concentrations of petroleum related contaminants in the groundwater and unsaturated soils to target levels specified by Florida Administrative Code (FAC) 62-777. Nutrient injection using the PHOSter Nutrient Injection System is the technology being utilized to achieve this objective.

1.2 Site History

Building 46 was the former base gas station that operated from 1946 to 1987. The station had a total of eight underground storage tanks (USTs), all of which were removed in June 1988. Four of the tanks, labeled as 46R, 46D, 46SUL, and 46UL, were installed in 1970 and were used to store regular and unleaded gasoline and diesel fuel. These tanks were located adjacent to Building 46. The other four tanks were installed prior to 1970 and the contents of these tanks are unknown. They were located just south of Building 46 (Tetra Tech NUS, Inc. [TtNUS], June 2000).

A Site Assessment Report (SAR) prepared for Building 46 (Harding Lawson Associates [HLA], 1998) concluded that operation of the USTs had resulted in contamination of soil and groundwater with fuel-related compounds, including benzene, toluene, ethylbenzene, and xylenes (BTEX), methyl-tert-butyl ether (MTBE), naphthalene, and total recoverable petroleum hydrocarbons (TRPH). The SAR determined that an area of soil approximately 5,500 square feet in size at the location of the former USTs was highly contaminated to a depth of 7 feet below land surface (bls) and acted as a source of groundwater contamination. The SAR also established that groundwater contamination extends to the shallow (7 to 25 feet bls), intermediate (25 to 50 feet bls) and deep (50 to 92 feet bls) zones of the surficial aquifer over an area approximately 25,300 square feet, 95,700 square feet, and 31,000 square feet, respectively.

A nutrient injection system was installed at the site during the period of November 2000 to January 2001 to treat the impacted soil and groundwater to achieve state mandated cleanup target levels. The nutrient injection system commenced operation on January 8, 2001.

1.3 Remediation System/Technology Description

The PHOSter Nutrient Injection System provides subsurface delivery of oxygen, nitrogen, and phosphorus to enhance the development of naturally occurring heterotrophic bacteria that have the capability of metabolizing petroleum wastes. A compressor is used to inject air as the oxygen source and the air flow is mixed with nitrous oxide and vapor-phase triethylphosphate (TEP) to provide nitrogen and phosphorus, respectively. Toward the end of cleanup operations, when contaminant concentrations have been reduced to the point where insufficient food (contaminants) is available to sustain and effective microorganism population, propane is also injected as a carbon source (TtNUS, June 2000).

The Building 46 Nutrient Injection System consists of two separate systems, labeled as the west system and the east system. Two separate systems allow for even gas distribution and more effectively treat the relatively large extent of the contaminant plume. The west system consists of 8 intermediate injection wells (labeled CEF-46-I1 through CEF-46-I8) and 3 deep injection wells (labeled CEF-46-D1 through CEF-46-D3) and a temporary trailer containing air compressors, injection gas storage containers, and associated piping and instrumentation. The east system consists of 8 intermediate injection wells (labeled CEF-46-BI1 through CEF-46-BI8) and 11 deep injection wells (labeled CEF-46-BD1 through CEF-46-BD11); and a temporary trailer containing air compressors, injection gas storage containers, and associated piping and instrumentation. The intermediate injection wells are 40 feet in depth with a screen interval from 35 to 40 feet bls and the deep injection wells are 90 feet in depth with a screen interval of 85 to 90 feet bls. The nutrient injection system is designed for each injection well to operate at a flow rate of 3 to 5 cubic feet per minute (cfm) at an injection pressure of 20 pounds per square inch gauge (psig) for the intermediate wells and 50 psig for the deep wells. A map showing the locations of the injection wells is provided in Appendix A.

2.0 System Performance Monitoring

O&M checks of the system were performed daily for the first week of operation and periodically thereafter. System checks were performed daily during the first week of operation and periodically thereafter to coincide with the O&M check.

During an O&M check, a preventative maintenance checklist (based upon manufacturer's recommendations) is completed, and any required maintenance activity is performed. A system check consists of an O&M check and system performance monitoring, including reading of all meters and gauges.

2.1 Operational Efficiencies

2.1.1 Nutrient Injection System—West System

	Period	To Date
Hours of Possible Operation	8760	17,112
Hours of Actual Operation	8417.3	15,359.3
Percent hours of Operation	96.1	89.8

NOTE: Hours of operations does not include second and third quarter data.

2.1.2 Nutrient Injection System—East System

	Period	To Date
Hours of Possible Operation	8760	17,112
Hours of Actual Operation	8417.3	14,819.3
Percent hours of Operation	96.1	86.6

NOTE: Hours of operations does not include second and third quarter data.

2.2 Summary of Maintenance and System Downtime

2.2.1 Nutrient Injection System—West System

During the period of January 1, 2002, to December 31, 2002, the west nutrient injection system ran a total of 350.7 days out of a possible 365 days, experiencing 342.7 hours of downtime. The system downtime was mainly the result of manual shutdowns for sampling and data collection. Other causes of downtime were power outages from electrical storms and equipment maintenance.

2.2.2 Nutrient Injection System—East System

During the period of January 1, 2002, to December 31, 2002, the east nutrient injection system ran a total of 350.7 days out of a possible 365 days, experiencing 342.7 hours of downtime. The system downtime was mainly the result of manual shutdowns for sampling and data collection. Other causes of downtime were power outages from electrical storms and equipment maintenance.

2.3 Pressure/Flow Rate Monitoring

The nutrient injection systems total for the year 2002 do not include data from the second and third quarters.

2.3.1 Nutrient Injection System – West System

The west injection system is divided into two manifold legs. Leg #1 consists of intermediate injection wells CEF-46-I1, CEF-46-I2, CEF-46-I3, CEF-46-I4, CEF-46-I5, and CEF-46-I8. Leg #2 consists of intermediate injection wells CEF-46-I6 and CEF-46-I7, and deep injection wells CEF-46-D1, CEF-46-D2, and CEF-46-D3. During the first year of operation, the injection pressure at the compressors averaged 42.3 psig. The design pressure is 20 psig for intermediate injection wells and 50 psig for deep injection wells. Each individual injection well has its own separate pressure regulator. Individual injection well pressures are not measured; adjustments are based upon flow rates not pressure. The total gas injection flow rate averaged 10 actual cubic feet per minute (acfm) for Leg #1 and 6.5 acfm for Leg #2, compared to the combined design total gas injection flow rate of 18 to 30 acfm. The nitrous oxide injection rate averaged 0.97 actual cubic feet per hour (acfh) which is 0.098 percent by volume of airflow, compared to the design nitrous oxide injection rate of 0.07 to 0.10 percent by volume of airflow. The TEP injection mass for the first year of operation totaled 2.92 pounds, compared to the design injection mass of 99 pounds per year. The data for the injection wells and injection system are tabulated in Tables 2-1 and 2-2, respectively.

2.3.2 Nutrient Injection System – East System

The east injection system is divided into two manifold legs. Leg #1 consists of intermediate injection wells CEF-46-BI2, CEF-46-BI3, CEF-46-BI4, CEF-46-BI5, CEF-46-BI6, CEF-46-BI7, and CEF-46-BI8, and deep injection wells CEF-46-BD9, CEF-46-BD10, and CEF-46-BD11. Leg #2 consists of intermediate injection well CEF-46-BI1, and deep injection wells CEF-46-BD1, CEF-46-BD2, CEF-46-BD3, CEF-46-BD4, CEF-46-BD5, CEF-46-BD6, CEF-46-BD7 and CEF-46-BD8. During the first year of operation, the injection pressure at the compressors averaged 55.3 psig. The design pressure is 20 psig for intermediate injection wells and 50 psig for deep injection wells. Each individual injection well has its own separate pressure regulator. Individual injection well pressures are not measured, adjustments are based upon flow rates not pressure. The total gas injection flow rate averaged 15 acfm for Leg #1 and 16 acfm for Leg #2, compared to the combined design total gas injection flow rate of 30 to 50 acfm. The nitrous oxide injection rate averaged 1.42 acfh which is 0.077 percent by volume of airflow, compared to the design nitrous oxide injection rate of 0.07 to 0.10 percent by volume of airflow. The TEP injection mass for the first year of operation totaled 3.2 pounds, compared to the design injection mass of 171 pounds per year. The data for the injection wells and injection system are tabulated in Tables 2-3 and 2-4, respectively.

Table 2-1, Page 1

Table 2-1, Page 2

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Table 2-1, Page 4

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2.4 Water Level Measurements

Depth to water measurements were recorded at selected monitoring wells on a monthly basis during the monitoring period. The tops of casing elevation, depth to water measurements, and calculated water level elevations are tabulated in Table 2-5. A map showing the groundwater flow direction for the deep aquifer as measured on December 15, 2002, is provided in Appendix A. The shallow aquifer could not be mapped because water level measurements were available for only two shallow monitoring wells. The intermediate aquifer could not be mapped because of anomalies caused by the injection system.

Light non-aqueous phase liquid (LNAPL) was not noted in any monitoring well during the monitoring period.

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3.0 Summary of Sampling and Laboratory Analytical Results

3.1 Soil Monitoring

Soil screening and sampling was conducted on a quarterly basis during the second year of operation. Three soil borings (SB-1, SB-2, and SB-14) were installed in the soil contamination area identified during the Site Assessment. The soil was screened using an organic vapor analyzer (OVA) meter equipped with a flame ionization detector (FID) and a sample from each soil boring was collected at 2 to 5 feet bls for laboratory analysis. The most recent (fourth quarter 2002) OVA/FID results are presented below in Table 3-1. The water table was encountered at 4.5 to 5.5 feet bls.

TABLE 3-1
Summary of OVA/FID Readings

Date	Soil Boring No.	Depth (feet bls)	OVA/FID Unfiltered	OVA/FID Filtered	OVA/FID Net
SB-1	12/13/02	2	>1000	1	999
SB-1	12/13/02	4	>1000	1	999
SB-2	12/13/02	2	>1000	1	999
SB-2	12/13/02	4	>1000	4	996
SB-14	12/13/02	2	20	1	19
SB-14	12/13/02	4	>1000	60	940

Laboratory soil samples were analyzed for BTEX and MTBE by U. S. Environmental Protection Agency (EPA) Method 8021B, naphthalene and polycyclic aromatic hydrocarbons (PAHs) by EPA Method 8310, and total recoverable petroleum hydrocarbon (TRPH) by the Florida Petroleum Residual Organic (FL PRO) Method. The results indicated that BTEX, MTBE, Naphthalene, and TRPH levels have decreased from the baseline soil sampling event conducted on January 4, 2001, but BTEX, and TRPH levels still exceed the Leachability and/or Direct Exposure Residential Soil Cleanup Target Levels (SCTLs) per Chapter 62-777 FAC. A site map showing the location of the soil borings is provided in Appendix A. Copies of the analytical laboratory report from the soil sampling event are provided in Appendix B, and analytical results are summarized in Table 3-2.

Table 3-2, Page 1

3.2 Groundwater Monitoring

Laboratory Analytical Results

Fourteen monitoring wells (CEF-46-1S, CEF-46-2S, CEF-46-5I, CEF-46-6D, CEF-46-7I, CEF-46-9I, CEF-46-12I, CEF-46-13I, CEF-46-14D, CEF-46-15I, CEF-46-21I, CEF-46-24D, CEF-46-25I, and CEF-46-26I) were sampled monthly during the second year of operation.

The samples were analyzed for BTEX and MTBE by EPA Method 8021B, naphthalene and PAHs by EPA Method 8310, TRPH by FL PRO Method, and nitrate, nitrite, phosphate by EPA Method 300.0. Seven of the fourteen wells had contaminant concentrations above the Groundwater Cleanup Target Levels (GCTLs) per Chapter 62-777 FAC during the baseline sampling event conducted December 20, 2000. At the end of the second year of operation, the results of the groundwater treatment are as follows:

- Two of the seven monitoring wells that exceeded the GCTLs during the baseline event, CEF-46-5I and CEF-46-6D, are below the GCTLs for all contaminants of concern. The remaining five monitoring wells that exceeded the GCTLs during the baseline event (CEF-46-1S, CEF-46-2S, CEF-46-7I, CEF-46-13I, and CEF-46-26I) continue to have contaminant concentrations above the GCTLs.
- The contaminant concentrations in monitoring wells CEF-46-1S, CEF-46-2S, CEF-46-7I, and CEF-46-13I still exceed the GCTLs but have decreased from the baseline sampling event. Monitoring well CEF-46-1S has experienced a 96 percent decrease in benzene, 86 percent decrease in BTEX, but has incurred a 70 percent increase in naphthalene.
- CEF-46-2S has experienced a 99.7 percent decrease in benzene, 99.7 percent decrease in BTEX, 99.6 percent decrease in MTBE. CEF-46-5I experienced a 99.7 percent decrease in benzene and 99.5 percent decrease in BTEX (naphthalene did not exceed the GCTL). CEF-46-7I experienced a 85 percent decrease in benzene, 94 percent decrease in BTEX, and 80 percent decrease in naphthalene; and CEF-46-13I experienced a 25 percent decrease in MTBE from the post baseline event (no other contaminants exceed the GCTLs).
- The contaminant concentrations in monitoring well CEF-46-26I still exceed the GCTLs. The concentrations in this well have fluctuated above the baseline concentrations during the year and have now decreased to concentrations equal to the baseline concentrations.

A site map showing the locations of the monitoring wells is provided in Appendix A. Copies of the analytical laboratory reports from the groundwater sampling events are provided in Appendix C, and analytical results are summarized in Table 3-3.

Field analytical tests were performed on the monitoring wells during each sampling event. The groundwater was tested for pH, conductivity, temperature, dissolved oxygen, carbon dioxide, alkalinity, ferrous iron, and hydrogen sulfide. The results from the field analytical tests are summarized in Table 3-4.

Field Analytical Results

The following is a brief discussion of significant field parameter results and their impact on remediation progress and vice versa. The discussion focuses on results from the last four quarters as well as observed visual trends since remediation inception.

- Groundwater pH: The pH of groundwater from wells screened in the intermediate and deep zones has shown a decrease since system installation. Many of the recorded pHs in the last four quarters are below 3.0 pH units. At this pH, microbial activity becomes very strained. The lower pHs can be attributed to two causes. The first reason for the pH drop could be acid formation in the form of phosphoric and nitric acids resulting from the continual injection of nutrients in the form of TEP and nitrous oxide, respectively. The second (albeit) minor cause could be the production of metabolic acids and carbon dioxide from microbial degradation activity. Irrespective of the cause, the pH of groundwater in several area monitoring wells is too low to be

supporting much microbial activity. A noteworthy point is the relatively stable pHs (5.5 –7.0 units) in the shallow wells CEF-46-1S and CEF-46-2S. In all probability, the added gaseous nutrients are not impacting the shallow zone significantly enough to cause pH imbalances. Secondly, precipitated infiltration could be neutralizing any acidic effects in the shallow zone.

- Groundwater temperature: Groundwater temperature in all three zones appear to be above 20 degrees centigrade at which value microorganisms function quite robustly. Temperatures remain stable throughout the year suggesting that kinetic activity should not be impacted by season.
- Conductivity: The conductivity values have remained relatively constant indicating that the groundwater samples represent the same during each sampling event.
- Dissolved Oxygen (DO): DO in groundwater has generally reduced to concentrations below 1.0 mg/L and often below 0.5 mg/L, particularly in the last three sampling events. In contrast, DO values during the first year of operation (2000) were generally greater than 1.0 mg/L. The observed drop in DO in some of the deep wells can be attributed to reconfiguration of airflow in the area to focus on areas of higher contamination. However, the low DO in shallow and intermediate wells that continue to have higher contamination (CEF-46-1S, CEF-46-2S, and CEF-46-7I) is more likely due to the fact that injected air has not been effectively diffusing into the shallower portions of the aquifer. As a result, much of the shallow zone remains anaerobic. The major implication of the anaerobic environment is lowered degradation rates because petroleum constituents such as BTEX, MTBE, and naphthalene are reduced much more gradually under such conditions. Often, DO diffusive pathways in the subsurface change during remediation and this could also be one of the reasons for the observed decrease in DO over time in the shallow zone.
- Carbon dioxide: Field test results indicate carbon dioxide levels have increased in a majority of the wells since remediation began. Compared to year 2000 values, averaging 122 mg/L, concentrations for this parameter appear to be approximately 512 mg/L for the past year.
- Alkalinity: Table 3-4 indicates a general trend of decreasing alkalinity in groundwater sampled.
- Ferrous iron: Overall, ferrous iron concentrations appear to be increasing in the aquifer since remediation inception, particularly in the deeper zone. Ferrous iron generally tends to increase in anaerobic conditions. Once again, this observation correlates with DO trends and indicates overall anaerobic conditions are prevailing in the aquifer.
- Hydrogen sulfide: Hydrogen sulfide values have increased in monitoring well CEF-46-2S and remained relatively constant in all the other wells. This may indicate that sulfate-based anaerobic degradation may be occurring at specific locales in the groundwater following DO depletion.

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4.0 Conclusions and Recommendations

4.1. CONCLUSIONS

The soil screening results performed in the soil contamination area indicated that BTEX, MTBE, naphthalene, and TRPH levels have decreased from the baseline soil sampling event; however, BTEX and TRPH levels are still considerably higher than the SCTLs.

Seven of the fourteen groundwater monitoring wells at the site exhibited groundwater contaminant concentrations greater than the GCTLs during the baseline sampling event. At the end of the second year of operation, monitoring wells CEF-46-1S, CEF-46-7I, CEF-46-13I, and CEF-46-26I continued to exhibit contaminant concentrations considerably greater than the GCTLs. The contaminant concentrations in monitoring wells CEF-46-1S, CEF-46-7I, and CEF-46-13I continue to exceed the GCTLs but have decreased from the baseline sampling event. The contaminant concentrations in monitoring well CEF-46-26I have increased above the baseline sampling event concentrations. Of significance to remediation progress is the 93 percent increase in MTBE at CEF-46-2S and the 70 percent increase in naphthalene in CEF-46-1S. LNAPL was not noted in any monitoring well during the monitoring period.

The field analytical results strongly indicate the prevalence of anaerobic conditions in the aquifer (particularly in the shallow zone which coincidentally contains more contamination) which, as discussed in Section 3, are not very conducive to rapid BTEX, naphthalene, or MTBE biodegradation.

4.2 RECOMMENDATIONS

The site is currently being reassessed by TtNUS for system optimization and CH2MHill will be making modifications to the system in accordance with recommendations provided by TtNUS.

5.0 References

CH2MHILL Constructors, Inc. September 2000. Work Plan Addendum No. 08 Nutrient Injection System Installations at Building 9, former Tanks 9L1 and 9L2 and building 46, Former Tanks 46R, 46D, 46SUL, and 46UL; Naval Air Station Cecil Field, Jacksonville, Florida.

Harding Lawson Associates. 1998. Site Assessment Report, NAS Cecil Field, Jacksonville, Florida.

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Tetra Tech NUS, Inc. June 2000. Remedial Action Plan Addendum; Building 46, Former Tanks 46R, 46D, 46SUL and 46UL; Naval Air Station Cecil Field, Jacksonville, Florida.

Appendix A

Maps

Appendix B

Laboratory Analytical Reports for Soil Samples

(provided on CD)

Appendix C

Laboratory Analytical Reports for Groundwater Samples

(provided on CD)

Appendix D

FDEP Annual Status Report Form