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January 19, 1999

Mr. Hubert Chan
Engineering Field Activity West
Naval Facilities Engineering Command
900 Commodore Drive, Building 208
San Bruno, California 94066-5006

Subject: NASA Crows Landing Flight Facility
November 1998 IRP Site 17, UST Cluster 1, and UST 117 Pilot Testing Results
CLEAN II Contract No. N62474-94-D-7609, Contract Task Order 219

Dear Mr. Chan:

This letter summarizes pilot testing results for data collected at the National Aeronautics and Space Administration (NASA) Crows Landing Flight Facility during the second and third week of November 1998. The testing corresponds to Phase 1 field pilot testing, as discussed in the field pilot test work plan submitted to the U. S. Navy on October 27, 1998.

Testing primarily focused on air sparging (AS) feasibility at Installation Restoration Program (IRP) Site 17 and AS and biosparging feasibility at Underground Storage Tank (UST) Cluster 1 and UST 117. This testing built on earlier pilot testing conducted during June 1997 and helped to demonstrate the applicability of sparging at depths of 100 to 175 feet below ground surface (bgs). Sparging at these depths was demonstrated by conducting longer-term tests and by injecting helium as a tracer to verify vertical connection between the injection points and the unsaturated zone. Helium was also useful to better estimate the design zone of influence (ZOI) at each depth for full-scale remediation system design. Volatile organic compounds (VOCs) were monitored in the unsaturated zone throughout AS testing to monitor for an increase in VOCs that would indicate successful AS. Off-site migration of VOCs due to AS was also monitored to evaluate whether lateral migration could pose potential problems with full-scale AS at depth. Another objective was to evaluate the potential correlation between IRP Site 17 testing and testing at UST Cluster 1 and UST 117.

In general, results indicate that AS is feasible at depths up to 175 feet bgs. Air was successfully injected at roughly 20, 50, 100 feet below the groundwater table at IRP Site 17. In every scenario, stable vertical connection of air channels was observed between the injection point and the unsaturated zone, and design ZOIs were calculated at all depths with a high degree of confidence. Air channeling appeared to exhibit good symmetry around the injection point at all well depths, with adequate air channel density observed throughout the air plume. Fugitive lateral air sparge channeling and preferential air pathways were not observed during any of the tests, confirming earlier observations that neither distinct continuous geologic layers nor paleochannels appear to be present at this site. An increase in VOCs in the unsaturated zone suggested that AS was removing VOCs from the saturated zone and transporting them up to the unsaturated zone. These VOCs were captured using a soil vapor extraction (SVE) system and passed through a granular activated carbon (GAC) canister prior to discharge.

Testing demonstrated that IRP Site 17 results can be extrapolated for use at UST Cluster 1 and UST 117. Therefore, with respect to the physical aspects of AS, design parameters will be similar (depths, however, may vary) for all three sites. However, UST Cluster 1 and UST 117 designs will take into account aerobic degradation of contaminants. It was demonstrated that AS will effectively elevate dissolved oxygen (DO) levels at UST Cluster 1 and UST 117, thus stimulating aerobic biodegradation of contaminants.

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A detailed discussion of Phase 1 test results is provided below. This letter is divided into sections for each AS test depth. The discussion of test results is followed by conclusions for Phase 1 pilot testing and recommendations for Phase 2 pilot testing. Reference figures are included for each test area (Figure 1 - IRP Site 17; Figure 2 - UST Cluster 1; Figure 3 - UST 117).

1.0 SHALLOW SPARGING

Shallow air sparge testing was conducted at IRP Site 17 at a depth of 20 feet below the groundwater table (bgwt) and approximate flow rates of 8 and 16 standard cubic feet per minute (scfm). Pressure was monitored over time at the injection point and monitoring network. The test well was vented after the test to estimate the percentage of air that did not immediately go into the formation and may have resided in a localized air pocket near the injection point. Helium tracer testing was conducted to demonstrate vertical connection between the injection point and the unsaturated zone and to better calculate the effective ZOI for shallow sparging. Soil gas was monitored for changes in VOCs as a result of shallow AS.

1.1 IRP SITE 17: 17-SP-01A (SCREENED 74 TO 79 FEET BGS)

- Pressure data indicate some temporary mounding and groundwater displacement in the vicinity of the test well (17-MP-01A and B, 17-MP-02B) after about 5 minutes of sparging. As would be expected for temporary mounding, pressure increased within these monitoring wells and then dissipated within a short period of time (about 35 minutes). Steady-state pressure data suggest a relatively symmetrical pressure distribution with a ZOI of 22 to 28 feet.

- Pressure buildup during high-flow AS at well 17-MP-01B suggests the development of an air pocket in this area. However, post-test venting of the test well did not produce a substantive air volume, indicating that air pocket formation was likely localized near well 17-MP-01B.

- Helium tracer test data suggest that air channels exhibited vertical connection between the test well injection point and the overlying unsaturated zone. Based on the detection of helium at soil vapor extraction (SVE) well 17-SV-01 and the "A" and "B" level monitoring points (MPs) at wells 17-MP-01 and 17-MP-02, a 17 to 26 foot ZOI is estimated.

- Soil gas samples were collected and screened in the field for total VOCs using a flame ionization detector (FID). Data collected during the low-flow AS test shows VOCs increased at well 17-MP-01A from a baseline level of 0.9 parts per million by volume (ppmv) to 648 ppmv; however, this was the only monitoring point that showed a significant increase. An increase in soil gas concentrations was also observed during high flow AS at well 17-MP-02A. Overall, the data indicate some contaminants were successfully volatilized from the saturated zone and transported to the unsaturated zone.

- DO data collected before and after the shallow AS test suggest notable DO increases at 17-MP-01B (2.6 to 4.5 mg/L) and 17-MP-02A (4.2 to 5.2 mg/L). Given the relatively short test duration, it is not expected that a uniform increase in DO levels would occur within the test area.

Based on Phase 1 pilot testing results, it appears the design ZOI for shallow sparging (20 feet bgwt) is about 22 feet at a flow rate of 8 to 10 scfm per well. Data also suggest that AS flow rates at this depth should be no greater than 10 scfm.

2.0 MIDDLE SPARGING

Middle air sparge testing was conducted at IRP Site 17 and UST 117 at a depth of about 50 feet bgwt and an approximate flow rate of 5 scfm. Middle air sparge testing was also conducted at UST Cluster 1 at a similar depth at flow rates of approximately 7 and 14 scfm. Pressure was monitored over time at the injection points and monitoring networks. Post-test venting was monitored at UST Cluster 1 and UST 117, while post-test pressure dissipation was monitored at IRP Site 17. Helium tracer testing was conducted to demonstrate vertical connection between the injection point and the unsaturated zone and to better estimate the middle sparging ZOI. Soil gas was monitored for changes in VOCs as a result of middle AS. Oxygen and carbon dioxide were also monitored in the soil gas at UST Cluster 1 and UST 117 as indicators for biorespiration within the unsaturated zone. Pre- and post-test DO was measured at UST Cluster 1 and UST 117 to monitor for the ability to elevate DO levels near the test well and to estimate biorespiration rates in the saturated zone.

2.1 IRP SITE 17: 17-SP-01B (SCREENED 104 TO 109 FEET BGS)

- Pressure was detected at all "A" and "B" level MPs and at well 17-MW-02, indicating a good radial pressure distribution horizontally and vertically. The pressure-related ZOI for middle sparging appears to be about 25 to 28 feet.

- Pressure buildup was not detected in the "C" level MPs, indicating that confining layers above the middle sparge well are not present. However, localized pressure buildup occurred at well 17-MP-02B after about three hours of sparging, and later at well 17-MP-01B. This pressure buildup suggests that air pockets may be forming near the "B" level MPs. However, rapid pressure dissipation at the test well and other monitoring points lead to the conclusion that any air pockets formed were localized and not large in extent.

- Helium tracer test data appear to correspond well with pressure data. The distribution of helium is radial with a ZOI of about 25 feet. Most importantly, helium was detected at all of the "A" and "B" level MPs and SVE well 17-SV-01, showing good vertical connection of air channels between the test well injection point and the unsaturated zone.

- Helium and pressure were monitored but never detected at wells 17-MW-02, 17-MW-03 and several other outlying wells (17-MW-01, 17-MW-04, 17-MW-05, 17-MW-06, 17-MW-07), suggesting that fugitive air sparge channeling was not occurring. Therefore, assuming middle AS wells are not operated continuously for more than about 24 hours (based on tracer test duration), lateral spreading of contamination induced by sparging should not be a concern at this depth.

- FID soil gas readings increased in two out of five soil gas monitoring points, decreased in two others, and remained about the same in well 17-MW-02 (just outside the ZOI). Soil gas concentrations in the wells showing a decrease were still substantial and may have decreased as a result of prior shallow AS. Overall, the data suggest that contaminants were successfully volatilized from the saturated zone and transported to the unsaturated zone.

2.2 UST CLUSTER 1: CL1-MW-03 (SCREENED 101 TO 111 FEET BGS)

- Pressure data at well CL1-MW-02 indicate a response in shallow groundwater due to middle sparging. Pressure and flow at the injection point correlate closely with data for IRP Site 17 middle sparging conducted July 1997 and November 1998.

- Helium data did not show any solid connection between the injection point and monitoring well CL1-MW-02 on the day of testing. However, the following day, helium was detected at well CL1-MW-02 and test well CL1-MW-03. This helium was likely leftover from the previous day's testing. The delayed helium detection is expected, since up to 15 hours elapsed before helium was detected at overlying monitoring points when conducting helium tracer testing at 17-SP-01B.

- Post-test venting of the injection point indicates that 14 to 26 percent of the injected air did not go immediately into the formation and migrate to the unsaturated zone via air channels. Extended injection duration and higher flow rates likely resulted in the higher percentage of air that did not immediately migrate through the formation.

- Soil gas data were not useful for assessing the effectiveness of AS due to difficulties in sampling soil gas at monitoring points. However, vapor data collected at wells CL1-MW-02 and CL1-MW-03 (during post-test venting) suggest that VOCs were mobilized near the injection point as a result of AS.

- As expected, DO increased dramatically in the test well due to sparging; however, no noticeable increase was detected in well CL1-MW-02. It is likely a DO increase may have been noted at well CL1-MW-02 had the test duration been longer. DO was depleted from 8.6 milligrams per liter (mg/L) to 3.9 mg/L over nearly 7 days at well CL1-MW-03, suggesting aerobic biological degradation of petroleum hydrocarbons within the vicinity of the injection well.

2.3 UST 117: 117-MW-03 (SCREENED 98 TO 108 FEET BGS)

- No apparent pressure change was noted at the monitoring points associated with AS. However, the monitoring points (existing wells) that were available were not ideally located. There were no monitoring points at the depth of the sparge interval, and most points were 24 feet or more from the test well. Positive pressures measured at vadose zone MPs 117-EX-01 and 117-EX-02 during the pressure dissipation test were likely a delayed effect from AS.

- Pressure and flow responses at the injection point, when compared to July 1997 and November 1998 pilot testing data for test well 17-SP-01B, correlate well with IRP Site 17 middle sparging results.

- Helium was detected only at vadose zone MPs 117-MP-01A and 117-MP-01B during helium tracer testing. The detections indicate some vertical connection between the injection point and the unsaturated zone. The absence of detectable helium at the remaining monitoring points is likely due to a combination of the brief duration of helium injection (10 minutes), monitoring frequency, and relative location of the monitoring points to the injection point. Based on helium tracer testing at IRP Site 17, it is likely helium would have been detected more uniformly had there been a better network of monitoring points at a distance of less than 25 feet from the injection point.

- Findings from post-test venting of the injection point are comparable to venting at UST Cluster 1 in that 11 percent of the injected air did not go immediately into the formation and vent to the unsaturated zone via air channels. The slightly lower percentage of vented air, as compared to test well CL1-MW-03, is likely due to a 2½ hour lag time between ceasing air injection and venting versus 10 minutes at test well CL1-MW-03. It is also notable that the injection duration while testing at UST 117 was approximately 17 hours, significantly longer than testing at UST Cluster 1. These data suggest the gas pocket buildup is finite, reflecting the discontinuous nature of any potential horizontal confining lenses in the test area.

- As expected, DO levels increased dramatically in the test well; however, no noticeable increase was detected in well 117-MW-02. It is likely a DO increase may have been noted at well 117-MW-02 had the test duration been longer.

Based on Phase 1 pilot testing results, it appears the design ZOI for middle AS (50 feet bgwt) is about 25 feet at a flow rate of approximately 5 scfm per well. This design ZOI will not vary for IRP Site 17, where volatilization is the primary means of contaminant removal. However, a larger design ZOI (for example, 30 to 35 feet) may be used within lower contaminant concentration areas of UST Cluster 1 and UST 117 because biosparging will likely be the primary application for contaminant removal at these sites. A biosparging ZOI is typically larger than an AS ZOI because dissolved oxygen, the primary driving force for biosparging, will diffuse over time outside of the "stripping" zone of the AS ZOI. This diffusion, combined with groundwater mixing, results in an overall larger ZOI for biosparging applications. In the higher-concentration areas of UST Cluster 1 and UST 117, a larger design ZOI is not recommended since contaminant removal via volatilization and biodegradation will be equally important. Additionally, these areas will have a much higher dissolved oxygen demand than the less-concentrated areas of the contaminant plume.

Pilot test data suggest AS flow rates at this depth be no greater than 5 scfm. Appropriate cycle times are estimated at 2 to 4 hours per cycle with at least 6 hours off between cycles. However, extended air sparge testing will provide more conclusive information regarding optimal long-term operational flow rates and cycle times.

3.0 DEEP SPARGING

Deep air sparge testing was conducted at IRP Site 17 at a depth of about 100 feet bgwt and an approximate flow rate of 6 scfm. Deep AS was also tested at UST Cluster 1 at a depth of 110 feet bgwt and approximate flow rates of 8.5 and 17 scfm. Pressure was monitored over time at the injection points and monitoring networks. Post-test venting was monitored at UST Cluster 1, and post-test pressure dissipation was monitored at IRP Site 17. Helium tracer testing was conducted to evaluate vertical connection between the injection point and the unsaturated zone and to better calculate the deep sparging ZOI. Soil gas was monitored for changes in VOCs as a result of deep AS. Pre- and post-test DO was measured at UST Cluster 1 to monitor for the ability to elevate DO levels near the test well and to estimate biorespiration rates in the saturated zone.

3.1 IRP SITE 17: 17-SP-01C (SCREENED 153 TO 158 FEET BGS)

- Pressure was detected at all MPs and at SVE well 17-SV-01 during the 22 hours of sparging. The pressure-related ZOI for deep sparging was greater than 25 feet with a good radial distribution of air channels horizontally and vertically.

- Pressure data indicate that a continuous air pocket formed at the "D" level MPs over 20 hours of continuous AS at a flow rate of about 6 scfm. Data also indicate this air pocket may have spread upward toward the "C" level MPs. Pressure data suggest air pockets may have formed near wells 17-MP-01C and 17-MP-02C since well pressures were greater than the static hydraulic head for these wells after about 25 to 45 hours of AS. However, based on the volume of air injected through the test well, it is not possible that a continuous air pocket formed from the "D" level wells all the way up to the "C" level wells. More likely, localized air pocketing was observed near the "C" level MPs.

- Although approximately 24 hours elapsed before helium injected at the test well was detected at all of the MPs and SVE well 17-SV-01, data suggest there is adequate lateral coverage within the saturated zone and vertical connection between the injection well and the unsaturated zone. The ZOI based on helium data is estimated at 25 to 35 feet.

- Helium and pressure were monitored but never detected at wells 17-MW-02, 17-MW-03, and several other outlying wells. Therefore, it is likely that fugitive air sparge channeling was not occurring at these locations. Therefore, assuming deep AS wells are never operated continuously for more than about 40 hours (based on tracer test duration), lateral spreading of contamination induced by sparging should not be a concern at this depth.

- FID soil gas VOC readings increased in three out of four unsaturated zone soil gas monitoring points and remained about the same in the fourth point during the first 27 hours of testing. These data suggest that contaminants were successfully volatilized from the saturated zone and transported to the unsaturated zone.

- Post-test pressure dissipation measurements show the pressure dissipated steadily and slowly throughout the ZOI. Based on the slow dissipation observed, it is recommended to cycle air flow to the aquifer, with off cycles being at least twice as long as on cycles. This cycling will help alleviate potentially excessive pressure buildup and air pocket formation at deeper depths.

3.2 UST CLUSTER 1: CL1-MW-07 (SCREENED 165 TO 175 FEET BGS)

- Pressure data indicate an apparent pressure connection between the deep injection point and the medium and shallow monitoring points. Pressure and flow responses at the injection point, when compared to July 1997 and November 1998 pilot testing data for test well 17-SP-01C, correlate with results for IRP Site 17 deep sparging.

- Helium data did not clearly indicate whether there was vertical connection between the injection point and the unsaturated zone. Background helium samples were not collected, making it difficult to analyze test data. Helium was detected at wells CL1-MW-02 and CL1-MW-03; however, this helium is believed to be left over from the previous day's helium tracer testing at test well CL1-MW-03. Based on helium tracer test results from test well 17-SP-01C, it is unlikely that helium injected at test well CL1-MW-07 would have had sufficient time to be detected at overlying wells due to the relatively short time frame of the test. Instead, it is likely helium may have been detected and linked to injection at test well CL1-MW-07 had testing been conducted for a longer period.

- Post-test venting of the injection point indicates about 18 percent of the injected air did not go immediately into the formation and vent to the unsaturated zone via air channels.

- Soil gas data were not useful for evaluating the effectiveness of AS due to difficulties in sampling soil gas at monitoring points. However, soil gas data collected at wells CL1-MW-02 and CL1-MW-03 suggest relatively high levels of VOCs within the soil gas.

- As expected, DO levels increased dramatically in the test well. DO readings over time remained elevated, indicating a lack of aerobic biological degradation within the vicinity of the injection well. These results are to be expected since historical data indicates non-detectable petroleum hydrocarbon concentrations within this portion of the aquifer.

Based on Phase 1 pilot testing results, it appears the design ZOI for deep AS (100 feet bgwt) is about 25 to 35 feet at a flow rate of approximately 5 scfm per well. The recommended design ZOI for IRP Site 17 and the higher concentration areas of UST Cluster 1 and UST 117, calls for a tighter spacing of 25 to 30 feet since volatilization and high oxygen demand biodegradation (UST sites only) are the primary means of contaminant removal in these areas. A larger design ZOI (about 35 to 40 feet) may be warranted within lower concentration areas of UST Cluster 1 and UST 117 since biosparging is the primary application for contaminant removal in these areas.

Pilot test data suggest AS flow rates at this depth be no greater than 5 scfm. Cycle intervals are estimated at 4 to 8 hours on and 8 to 16 hours off per cycle. However, extended air sparge testing will provide more conclusive information regarding optimal long-term operational flow rates and cycle times.

4.0 CONCLUSIONS AND RECOMMENDATIONS

Phase 1 pilot testing results indicate AS is a feasible approach for remediation of carbon tetrachloride contamination at IRP Site 17 at depths up to 175 feet bgs. Because AS is cost effective only for remediation of the hot zone (greater than 50 micrograms per liter [µg/L] carbon tetrachloride), groundwater pump and treat will likely be relied on for remediation of the large dilute carbon tetrachloride plume.

Based on pilot testing and lithologic comparisons between IRP Site 17 and the UST sites, AS and biosparging also appear to be feasible for remediation of mixed petroleum hydrocarbons at UST Cluster 1 and UST 117.

Preliminary estimates for ZOIs and operating configurations are summarized in Tables 1 and 2.

Table 1. Recommended Design ZOIs for Sparging at IRP Site 17, UST Cluster 1, and UST 117

Contaminant Plume Location	Shallow Sparging ZOI (feet)	Middle Sparging ZOI (feet)	Deep Sparging ZOI (feet)
IRP Site 17	22	25	25-30
UST Cluster 1			
- low concentration zone	22	25	25-30
- high concentration zone	25-30	30-35	35-40
UST 117			
- low concentration zone	22	25	25-30
- high concentration zone	25-30	30-35	35-40

Table 2. Recommended Sparging Operation for IRP Site 17, UST Cluster 1, and UST 117

Sparge Depth (feet bgwt)	Injection Flow Rate (scfm)	Sparge Cycle "On" Run Time (hour)	Sparge Cycle "Off" Run Time (hour)
20	8-10	2-4	2-4
50	5	2-4	6
100-110	5	4-8	8-16

Phase 1 pilot testing answered the questions intended; however, a few unanswered questions remain related to long-term operation of a deep sparge system at these sites. Questions regarding long-term rates of VOC removal, effects of AS on dissolved-phase VOCs near the AS ZOI, and optimal flow rates and pulse cycling intervals still need further investigation. Phase 2 field pilot testing is designed to answer these questions.

Phase 2 testing will begin as outlined in the existing field pilot testing work plan to help refine full-scale design parameters and operational aspects. Testing will continue to evaluate AS and soil vapor extraction in the high concentration carbon tetrachloride zone (greater than 50 µg/L) at IRP Site 17. The testing protocol for UST Cluster 1 (total petroleum hydrocarbons [TPH] greater than 1,000 µg/L) and UST 117 will further evaluate AS and biosparging for groundwater remediation and soil vapor extraction and bioventing for soil remediation.

Assuming that sparging test data from IRP Site 17 can be extrapolated to UST Cluster 1 and UST 117, Phase 2 testing will focus on long-term (about 6 weeks) sparging at IRP Site 17 only since a substantial network of monitoring points is already in existence and any new wells can be used in the full-scale remediation system. Testing at IRP Site 17 will require the installation of two nested sparge wells and three additional nested monitoring points. The new sparge wells will provide a larger test area to better evaluate various operating scenarios, repeatability of prior test results, and technology effectiveness. The additional monitoring points will enhance the system monitoring capabilities and will also be used to evaluate the effects of AS on the groundwater outside of the zone of AS.

In addition to sparge testing during Phase 2, SVE and bioventing tests will be conducted at UST Cluster 1 to further evaluate site-specific parameters necessary for design of a full-scale SVE and bioventing system that will address soil contamination. Testing at UST Cluster 1 will require the installation of one nested SVE/biovent well and three nested unsaturated zone monitoring points.

Phase 2 pilot testing is scheduled to begin on January 25, 1999 and will be completed by about mid-March 1999. Results from Phase 2 pilot testing will be summarized in a letter or technical memorandum after all field data has been received and evaluated. In the mean time, please call Dan Baker (303-295-1101 ext. 7816) or Steve Annecone (303-312-8886) with any questions or comments regarding this letter.

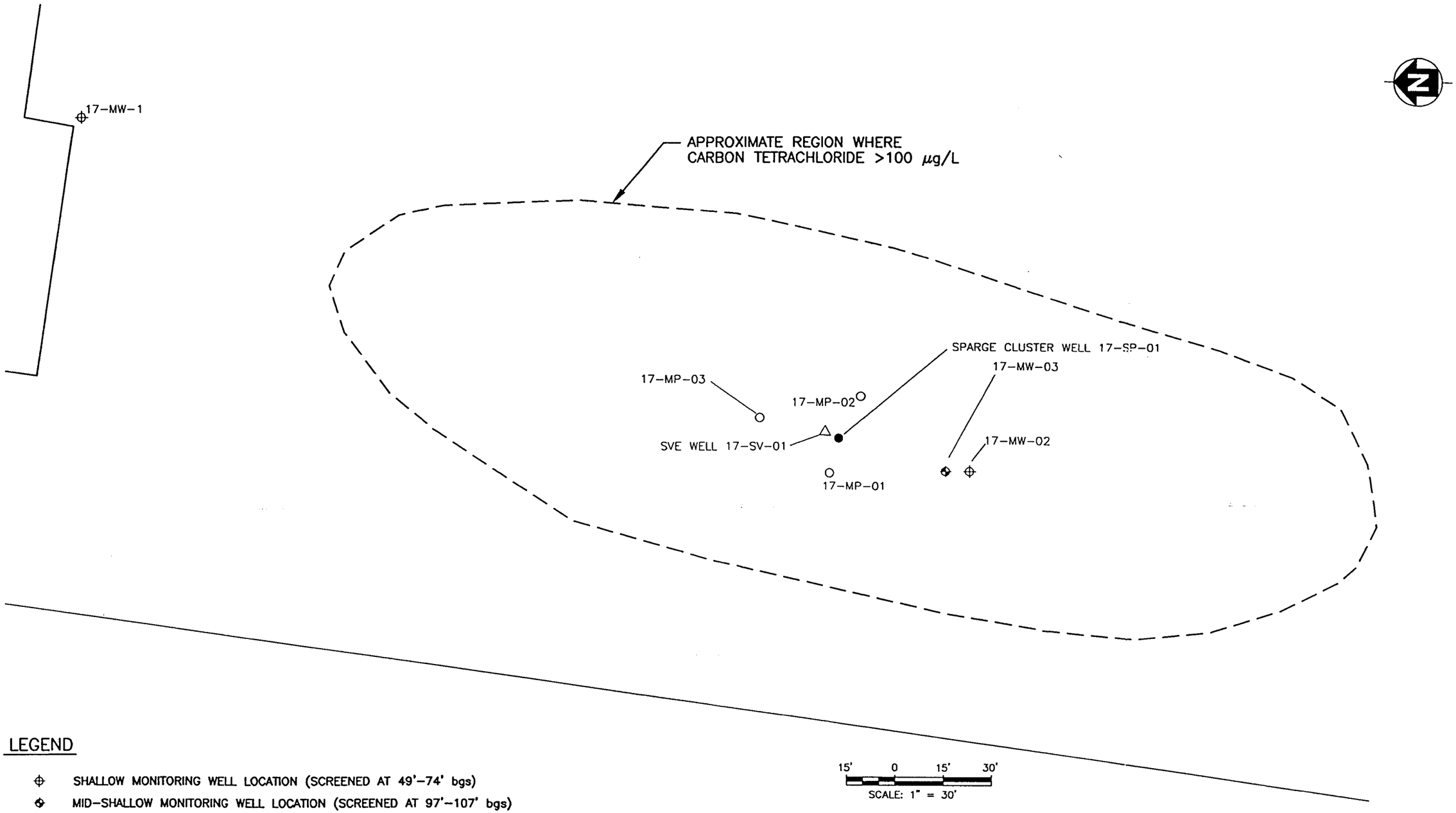
Sincerely,

Daniel M. Baker
Project Engineer

for Steve Annecone
Project Manager

DMB/rkr

cc: Don Chuck, Moffett Federal Airfield
Robert Reeves, RWQCB
Francesca D'Onofrio, DTSC



LEGEND

- ⊕ SHALLOW MONITORING WELL LOCATION (SCREENED AT 49'–74' bgs)
- ⊕ MID-SHALLOW MONITORING WELL LOCATION (SCREENED AT 97'–107' bgs)
- ○ CLUSTER WELL MONITORING LOCATION (CONTAINING A–, B–, C–, & D– LEVEL WELLS)
- ● SPARGE CLUSTER WELL LOCATION (CONTAINING A–, B–, C–, & D– LEVEL WELLS)
- △ SVE WELL LOCATION (SCREENED AT 30'–50' bgs)

NOTES: EXISTING A–, B–, C–, AND D– LEVEL MONITORING WELLS ARE SCREENED AT 35–65', 69–79', 99–109', AND 148–158' bgs, RESPECTIVELY.
SPARGE WELLS 17-SP-01A, –01B, –01C, ARE SCREENED AT 74–79', 104–109', AND 153–158' bgs, RESPECTIVELY.

FIGURE 1
NASA CROWS LANDING FLIGHT FACILITY
IRP SITE 17
FIELD PILOT TESTING
AIR SPARGE TEST WELL NETWORK

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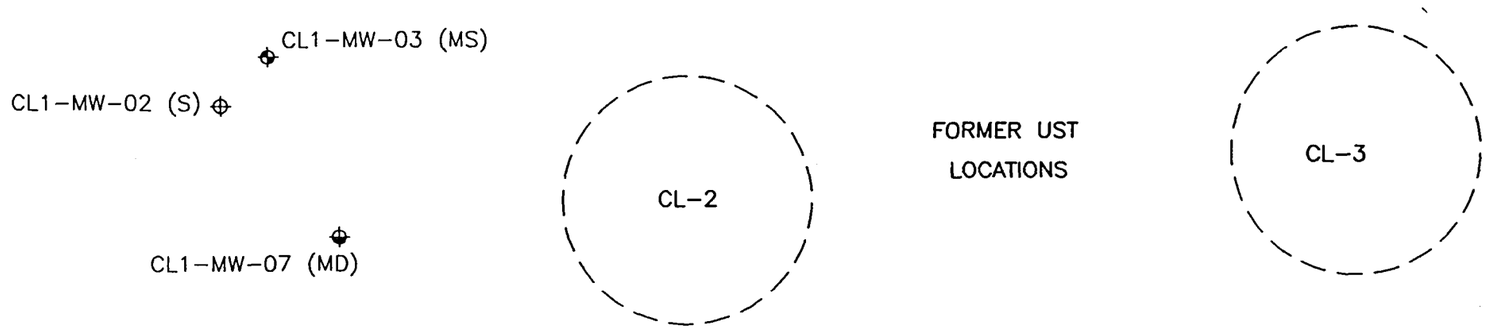


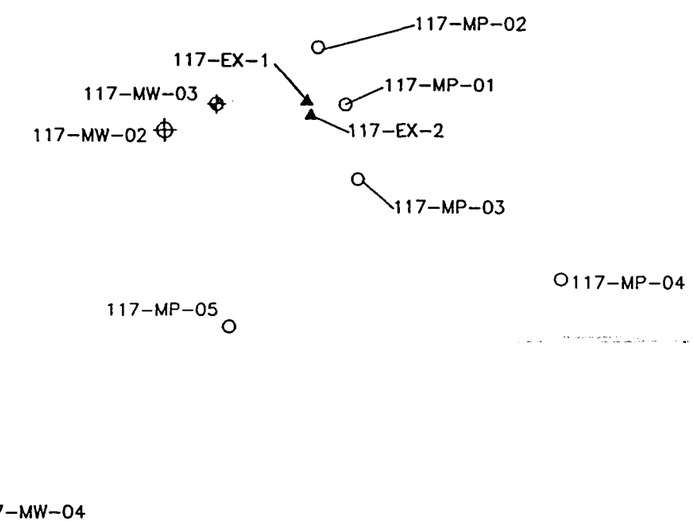
LEGEND

- SHALLOW MONITORING WELL LOCATION (S) (SCREENED AT 53'-78' bgs)
- MID-SHALLOW MONITORING WELL LOCATION (MS) (SCREENED AT 101'-111' bgs)
- MID-DEEP MONITORING WELL LOCATION (MD) (SCREENED AT 165'-175' bgs)
- SOIL BORING LOCATION

10' 0 10' 20'
SCALE: 1" = 20'

FIGURE 2
NASA CROWS LANDING FLIGHT FACILITY
UST CLUSTER 1
FIELD PILOT TESTING
AIR SPARGE TEST WELL NETWORK

DATE: 01/18/99 CLT DN FILE NAME: R:\CAD\069\2180\03\PHASE_PROP.DWG



LEGEND

- ⊕ SHALLOW MONITORING WELL LOCATION (S) (SCREENED AT 49'–74' bgs)
- ◆ MID-SHALLOW MONITORING WELL (MS) (SCREENED AT 98'–108' bgs)
- ○ SVE MONITORING POINT (MP) LOCATION (SCREENED AT 15'–25', 30'–40', AND 45'–55' bgs)
- ▲ SVE EXTRACTION POINT (EX) LOCATION (117-EX-01 SCREENED AT 20'–35' bgs, 117-EX-02 SCREENED AT 40'–55' bgs)

20 0 20 40
SCALE: 1"=40'

FIGURE 3
NASA CROWS LANDING FLIGHT FACILITY
UST 117
FIELD PILOT TESTING
AIR SPARGE TEST WELL NETWORK

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