N60211_000164
CROWS LANDING
SSIC NO. 5090.3.A

Tetra Tech EM Inc.

1099 18th Street, Suite 1960 ◆ Denver, CO 80202 ◆ (303) 295-1101 ◆ FAX (303) 295-2818

June 30, 1998

Mr. Bernard Tong
Engineering Field Activity West
Naval Facilities Engineering Command
900 Commodore Drive, Building 210
San Bruno, California 94066-2402

CLEAN Contract Number N62474-88-D-5086
Contract Task Order 0319

Subject: **Naval Auxiliary Landing Field (NALF) Crows Landing**
Final Corrective Action Plan (CAP)
Underground Storage Tank (UST) Sites
UST Cluster 1, Cluster 2, 109, and 117

Dear Mr. Tong:

Included with this cover letter is the final CAP for NALF Crows Landing UST sites. The final CAP was prepared by Tetra Tech EM Inc. on behalf of the U.S. Navy.

The final CAP has been revised in response to technical review comments submitted by the U.S. Navy and Central Valley Regional Water Quality Control Board on the draft final CAP. Attached to this cover letter is a summary of responses to the technical review comments.

Please call me at (303) 312-8877 if you have any questions regarding the final CAP.

Sincerely,

Neil Bingert
Project Manager

NB/jed

cc: Ray Leclerc, Department of Toxic Substances Control
Robert Reeves, Central Valley Regional Water Quality Control Board
Jim Simpson, Stanislaus County Department of Environmental Resources
Sandy Olliges, National Aeronautics and Space Administration
Hubert Chan, Engineering Field Activity West
Don Chuck, Engineering Field Activity West
Keith Reamer, Tetra Tech EM Inc.
NALF Crows Landing Administrative Record, 2 copies

contains recycled fiber and is recyclable

N60211_000164
CROWS LANDING
SSIC NO. 5090.3

ENCLOSURE 1

FINAL
CORRECTIVE ACTION PLAN
UNDERGROUND STORAGE TANK SITES
UST CLUSTER 1, CLUSTER 2, 109 AND 117

DATED 30 JUNE 1998

THIS RECORD IS ENTERED IN THE DATABASE AND FILED AS

RECORD NO. N60211_000165

RESPONSE TO TECHNICAL REVIEW COMMENTS
DRAFT FINAL CORRECTIVE ACTION PLAN
UNDERGROUND STORAGE TANK SITES
NAVAL AUXILIARY LANDING FIELD CROWS LANDING

1.0 INTRODUCTION

This document presents responses to technical review comments on the Naval Auxiliary Landing Field (NALF) Crows Landing draft final corrective action plan (CAP) for underground storage tank (UST) sites. The draft final CAP, dated February 27, 1998, was prepared for the U.S. Navy by Tetra Tech EM Inc. (TtEMI). The technical review comments reproduced below were received from the U.S. Navy June 1, 1998. In addition, comments were received from the Central Valley Regional Water Quality Control Board (RWQCB) April 22, 1998.

RESPONSES TO COMMENTS FROM THE U.S. NAVY

GENERAL COMMENT

Comment 1: **Due to the overlapping and close relationship between Cluster 1, UST 117, and IRP Site 17, any evaluation of remedial methods should regard this area as a whole. It is unrealistic to treat each site separately since any remedial action at one site will affect the actions at the other site. This is especially true at Site 17 and UST 117 where the contamination is overlapping. Remedial activities at these sites should complement each other. By integrating these sites together, the evaluations of the various technologies presented in this report may change. Thus, while one technology may look superior to another on a stand-alone basis, that technology may actually be less efficient or even a hindrance when viewed in an integrated fashion.**

When doing comparative analyses of various technologies, language that tends to bias one technology over another must be avoided. Statements that describe one technology as *far* more expensive or *far* more efficient must be avoided. The evaluations should also be realistic. Using an extraction well network that may be more extensive than the hydrological conditions require can inflate the costs of groundwater extraction as a treatment when compared to other technologies. The evaluations should be as objective as possible.

Conclusions on the viability or effectiveness of a technology need to be supported by facts as much as possible. Assumptions should be realistic. As an example of unsupported conclusions, see Comment 8.

Response: We agree that remedial actions at Installation Restoration Program (IRP) Site 17, underground storage tank (UST) 117, and UST Cluster 1 must be coordinated and complementary. Consequently, we have and will continue to evaluate and design remedial actions that regard the area as a whole, the same way that previous contaminant investigations were coordinated among these sites. We will continue to re-evaluate and modify our assessment of UST 117 and UST Cluster 1 cleanup alternatives as remedial alternatives are developed and evaluated for IRP Site 17. Contract task order (CTO) 219 provides the mechanism for completing the full-scale design of coordinated and complementary cleanup systems for IRP Site 17, UST 117, and UST Cluster 1.

At this time, the CAP for the UST sites must be finalized in order to move on to corrective action design. The CAP should include specific recommendations for final

cleanup of the UST sites. To fulfill this requirement, the CAP continues to recommend sparging as the most appropriate groundwater cleanup alternative for the UST sites. However, descriptions have been added to Sections 6.1 and 6.4 in the final CAP emphasizing that cleanup at UST 117 and UST Cluster 1 will be coordinated with cleanup at IRP Site 17. The final cleanup alternatives will likely be modified to promote compatibility with remedial alternatives selected for IRP Site 17.

TtEMI agrees that judgmental language that appears to favor one technology over another must be avoided. In addition to removing judgmental language as specified in comments 7, 11, 17, and 18, the final CAP has been revised to eliminate unnecessary judgmental language throughout the text.

We believe we have evaluated the viability and effectiveness of various technologies on the basis of facts to the extent possible. Providing real data for evaluating potential cleanup technologies was the rationale for completing soil vapor extraction (SVE), bioventing, passive bioventing, biosparging, air sparging, spray irrigation treatment, and aquifer pumping tests at NALF Crows Landing. Specific responses regarding unrealistic assumptions or unsupported conclusions are addressed in the responses to comments 4, 8, 14, and 15.

SPECIFIC COMMENTS

Comment 1: **Section 3.2 Paragraph 1 3rd Sentence Pg. 3-5**

The sentence states that the tanks were constructed with a concrete base. This is partially correct. The bottom of the tank was made of steel plate fastened to a concrete foundation – essentially they were steel tanks placed on a concrete foundation.

Response: The description of UST Cluster 2 tank construction has been revised as suggested.

Comment 2: **Section 3.2.1 Soil Contamination Paragraph 3 1st & 2nd Sentence Pg. 3-7**

The sentence references Plate 4 as showing the soil contamination cross section. The correct reference is Plate 2.

Response: The typographical error has been corrected as suggested.

Comment 3: **Section 3.2.1 Soil Contamination Paragraph 3 Last Sentence Pg. 3-7**

Please provide a brief explanation of the meaning of the leachable ratios.

Response: A statement has been added to Section 3.2.1 explaining that the total to leachable concentration ratios are a measure of the contaminant concentration in soil relative to its concentration in soil leachate. These ratios indicate that fuel contamination (total extractable petroleum hydrocarbons [TPH-E]) is strongly sorbed to soil and not easily leached at UST Cluster 2, although benzene, toluene, ethylbenzene, and xylene (BTEX) compounds are less strongly sorbed than the heavier fuel constituents.

Comment 4: **Section 3.2.3 Paragraph 3 Pg. 3-9**

The sentence states that anaerobic degradation at the site is evidenced by the presence of methane. Where was the presence of methane seen or reported? Please provide a reference.

Response: Low levels of methane were observed in vadose zone soil gas samples at UST 117 and UST Cluster 2 during pilot testing. However, many of the methane detections were later determined to be false positives, as the methane detector (Landtec GA-90) was responding to other petroleum fuel volatiles. Once the inlet to the detector was filtered using charcoal to remove the fuel volatiles, many wells showed no methane. Still, some (not all) soil gas samples from UST Cluster 2 showed low levels of methane, including up to 4 percent methane in soil gas samples collected from well CL2-MW-02. Results at UST 117 were inconclusive, since high volatile concentrations rapidly broke through the charcoal filters and accurate methane measurements were not possible. Although some anaerobic activity is likely, the methane data are not conclusive. Consequently, the reference to methane has been removed from the final CAP.

Comment 5: **Section 3.2.4 Biovent Testing Paragraph 2 1st Sentence Pg. 3-10**

The pressures listed in this sentence (58, 76, and 95) do not match the numbers given in Table 3-3. Why the difference?

Response: In general, injection pressures fluctuated throughout biovent testing since pressures typically decrease over time as new flow pathways in the vadose zone are created that dissipate the injected air. The text in the draft final CAP listed approximate average injection pressures during the test runs, while Table 3-3 listed stable injection pressures noted at the end of each test run. The text in the final CAP has been revised to list the end of test injection pressures to match Table 3-3.

Comment 6: **Section 3.2.4 Biosparge Testing Paragraph 4 Pg. 3-12**

DO levels in the sparge well were monitored with a downhole probe with the well sealed. This data was then compared to DO readings taken from a clean well by using *ex situ* methods. Wouldn't there have been better control data from the clean well if the DO readings were also taken with a downhole probe in a sealed well? Why wasn't this done?

Response: We agree that a better control method would have been to use a downhole dissolved oxygen (DO) probe in both the background and sparge wells. However, only one downhole DO probe long enough for UST Cluster 2 testing was available from our equipment rental company, and this probe was used in the sparge well. Sufficient time was not available to rent or purchase an additional probe once testing had begun. Even though a downhole probe was not used at the background well, reliable and useful data were obtained.

Comment 7: **Section 3.3.3 Paragraph 1 5th Sentence Pg. 3-15**

The degradation occurring is described as significant. What is considered significant? Is there any data indicating that significant degradation is occurring? If not, please delete *significant* from the sentence.

Response: The judgmental term "significant" has been removed from the final CAP.

Comment 8: **Section 3.3.3 Paragraph 1 Last Sentence Pg. 3-15**

What evidence is there to assert that the soils in well 109-BV-02 previously contained petroleum compounds? Perhaps the soils were clean to begin with and the lower oxygen levels are the result of some other mechanism. Either provide better support for this statement or delete it entirely.

Response: The statement was included in the draft final CAP as a possible explanation as to why the oxygen level in biovent monitoring point 109-BV-02B (2.6 percent) was relatively low compared to other soil gas monitoring locations completed in soils showing no evidence of petroleum contamination. (For example, monitoring point 109-BV-02A contained 8.1 percent oxygen and monitoring point CL2-MW-04 contained 13.4 percent oxygen.) However, there is no direct evidence that soils in boring 109-BV-02 were previously contaminated; therefore, the statement has been removed from the final CAP.

Comment 9: **Section 5.2.1 Biosparging Paragraph 5 4th Sentence Pg. 5-7**

The sentence states that movement of groundwater back into soil pores would enable the air flow to seek different distribution paths once the system is restarted. Why would this be so? Please explain.

Response: Actual air flow patterns on a microscopic level are difficult or impossible to verify. However, some sparging experts have suggested that injected air may seek alternative pathways as a result of pulsed sparging. One potential explanation for this phenomenon is that fine sediments are moved or redistributed during sparging, thereby physically altering the pore space geometry and allowing different air flow pathways over time. However, due to the theoretical nature of this potential phenomenon, and the possibility that it may not be due to groundwater movement, the statement in the final CAP has been revised to indicate that improved groundwater mixing due to air channel expansion and collapse will result from pulsed mode operation.

Comment 10: **Section 5.2.1 Oxygen Releasing Compounds Paragraph 3 Pg. 5-8**

Oxygen releasing compounds (ORC) are dismissed in this paragraph for Cluster 1 and UST 117 due to relatively flat water table gradients and resulting low groundwater velocities. What about combining ORC with pumping to induce larger gradients and flows? Why grout up ORC holes if it may be necessary to reapply more ORC?

Response: At this time, pump and treat remains a viable cleanup option for carbon tetrachloride (CT) contamination in groundwater at IRP Site 17. An area-wide pump and treat system will be evaluated that could also become at least part of a groundwater cleanup solution for UST 117 and UST Cluster 1. Combined pump and treat and ORC will be evaluated as part of this area-wide solution. Evaluating the area-wide solution will include computer modeling of pumping system performance and will be completed as part of CTO 219. The final CAP, however, has not been revised in response to this comment.

Due to the depth to groundwater at NALF Crows Landing, ORC would be added to the aquifer through a borehole drilled by a hollow-stem auger. An open, uncased boring could not be kept open over a period of months once the hollow-stem auger is pulled. Additional ORC would be inserted through a new boring.

Comment 11: Section 5.2.2 Paragraph 1 Last Sentence Pg. 5-9

It is stated that air sparging would have a significant benefit over pump and treat because both dissolved and sorbed phases are remediated. As stated earlier in the paragraph, the mechanism for air sparging is *in situ* volatilization. The heavier petroleum compounds, the ones most likely to sorb to the soil and not dissolve into the water, are also not likely to volatilize by air sparging. This does not appear to be a *significant* advantage to pump and treat. Please provide better support for this comparison between air sparging and pump and treat or delete.

Response: Descriptions of both biosparging (Section 5.2.1) and air sparging (Section 5.2.2) have been revised in the final CAP to emphasize that they are similar technologies that use similar equipment. Both technologies inject air into a contaminated aquifer. The difference is that the primary contaminant removal mechanism with biosparging is enhanced biodegradation through oxygen addition, while the primary contaminant removal mechanism when air sparging is in situ volatilization. Air sparging will also result in enhanced biodegradation from oxygen addition, while some in situ volatilization may also be expected from biosparging. The statement in question has been revised in the final CAP to explain that because biodegradation is also enhanced, air sparging has an advantage over pump and treat systems in that both sorbed and dissolved phase contaminants are remediated, rather than simply extracting dissolved phase compounds. The judgmental term "significant" has been removed.

Comment 12: Section 5.2.3 Paragraph 4 Pg. 5-10

The paragraph states that a pump and treat system at Crows Landing would be designed to extract water from all portions of the plume because of the shallow groundwater gradients and reversing flow directions. Shallow gradients should enhance the capture zone of any extraction well thus decreasing the need for a large number of wells. Steeper gradients would mean faster flows which would decrease the area of influence of an extraction well. With shallow gradients aiding the influence of the well, the flow reverses would also be minimized or eliminated. More study on the variations of flow direction throughout the year could reveal if there are any prevailing directions for groundwater flow. These prevailing directions would then provide guidance for the placement of the wells. There is a large amount of groundwater data available from preceding measurements to try to determine the prevailing flow directions. This work would be similar to determining the prevailing wind directions at a location in order to best align an airport runway. The discussion on the placement of wells needs to be revisited. This paragraph is unsatisfactory as presently written.

Response: Historical groundwater elevation and monitoring data in the IRP Site 17, UST Cluster 1, and UST 117 areas indicate oscillating flow directions and radial patterns of contaminant migration. For simplicity in completing cost estimates, it was assumed that a pumping well system at UST Cluster 1 and UST 117 should extract groundwater from all portions of a contaminant plume. For consistency, the same assumption was applied to the evaluations of other cleanup technologies as well. For example, the groundwater sparging evaluation assumed the sparge system would inject oxygen into all portions of the contaminant plume because groundwater flow could not be relied on to disperse the injected oxygen. In response to this comment, the paragraph in question has been rewritten in the final CAP as follows:

Pump and treat systems typically consist of a network of groundwater extraction wells, pumps, piping distribution networks to the treatment area, flow control valves, and related instrumentation. For purposes of this CAP, it is assumed that a pump and treat system for UST Cluster 1 and UST 117 would be designed to extract groundwater from all contaminated portions of the aquifer because shallow groundwater gradients and reversing flow directions would inhibit the effectiveness of systems designed to only capture the downgradient edge of a migrating plume. This assumption that a cleanup system must treat all contaminated portions of the aquifer will also be applied to the evaluation of other groundwater treatment options for UST Cluster 1 and UST 117.

Comment 13: Section 5.2.3 Paragraph 6 Pg. 5-11

While probably true that pump and treat systems alone can be high in operation and maintenance costs and take longer to reach goals, combining pump and treat with other technologies or processes may help decrease time and cost.

Response: As described in the response to the general comment, we will continue to re-evaluate and modify our assessment of UST 117 and UST Cluster 1 cleanup alternatives as remedial alternatives are developed and evaluated for IRP Site 17, including combinations of technologies for this area.

Comment 14: Section 6.1 Groundwater Paragraph 6 Pg. 6-4

I disagree with the statements in this paragraph. Why were pumping scenarios using 75- and 150-foot ROIs used when the pump test performed at Site 17 indicated a radius of 300 feet? The statements that the extraction well network must cover the entire plume to be effective due to shallow gradients are also not entirely correct (see Comment 12). Please revise this paragraph to reflect a more reasonable evaluation of pump and treat with more realistic spacing of wells.

Response: Statements in the draft final CAP implying that drawdown was measured 315 feet from the pumping well during the IRP Site 17 aquifer pumping test (Section 5.2.3) were not correct. Subsequent evaluation of the pump test results indicates that drawdown measured in wells approximately 280 and 315 feet from the pumping well may not be attributable to pumping influences. While the cause of the water level fluctuations is unknown, the changes may have been due to diurnal atmospheric affects. Drawdown attributed to pumping influences was measured in a well approximately 84 feet from the pumping well. No other observation points existed between 84 and 280 feet from the pumping well. Computer modeling of the pump test results suggests that a radius of influence (ROI) of approximately 300 feet could be achieved only after operating the pumping well for approximately 10 years.

ROIs of 75 and 150 feet were selected to evaluate pump and treat in order to speed flushing of multiple pore volumes from the aquifer and removal of dissolved-phase fuel contaminants. When evaluating pump and treat, a primary factor influencing the removal of petroleum hydrocarbons is the tendency of petroleum hydrocarbons to partition between water and soil in the aquifer. For heavier fuel products, such as occur at UST Cluster 1, most of the petroleum constituents are strongly sorbed to soils and will dissolve back into water only very slowly. Our calculations, included in Appendix B of the CAP, indicate that many thousands of pore volumes must be flushed from the aquifer at UST Cluster 1 in order to remove these strongly sorbed contaminants via a pumping well system. The CAP did not assume a closely spaced well system to prejudice the pump and treat evaluation. On the contrary, the closely spaced pumping well system

was designed to speed aquifer flushing in order to evaluate a "best case" scenario for complete cleanup using pump and treat. As such, the evaluation still indicated that many hundreds of years would be needed to remediate to cleanup levels at UST Cluster 1 even assuming a 75-foot ROI for the pumping well system. The evaluation, however, did not account for enhanced biodegradation expected to result from drawing uncontaminated, oxygenated groundwater into the contaminant plumes via the pump and treat system. Consequently, 30 years of system operation was assumed to complete cost evaluations, although no data exist suggesting the time frame that would be appropriate if enhanced biodegradation could be accounted for. The paragraph in question has been revised in the final CAP to better explain the rationale for spacing wells in the pumping system. In addition, for completeness, a cost estimate assuming a 300-foot ROI for the pumping well system (and 30 years of operation) has been added to the final CAP for UST Cluster 1.

Comment 15: Section 6.2 Groundwater Paragraph 3 Pg. 6-7

Why is the evaluation of pump and treat virtually identical to the evaluation of Cluster 1? The situation at Cluster 2 is somewhat different with regard to water gradients and flows. At Cluster 1, it is stated that shallow gradients and flow reversals require the extraction well network to cover the entire plume. At Cluster 2, the hydrology is different in that there is a steeper gradient and no reversals to groundwater flow. This alone should change how many wells are needed and placed. Again, why are 75- and 150-foot capture zones when evidence exists that 300-foot zones are possible? Please re-evaluate this section.

Response: As discussed in the response to comment 14, ROIs of 75 and 150 feet were selected to evaluate pump and treat in order to speed flushing of the aquifer and removal of dissolved-phase fuel contaminants. The pump and treat system evaluation for UST Cluster 2 was virtually identical to the evaluation completed for UST Cluster 1, except that the contaminant plume is smaller at UST Cluster 2. Consequently, only one extraction well is necessary for the UST Cluster 2 pump and treat system, even when assuming a 75-foot ROI for the extraction well. Estimated costs for pump and treat at UST Cluster 2 are identical for either a 75-foot or 150-foot ROI extraction well system. The final CAP has been revised to include only costs for a single system assuming a 75-foot ROI for the extraction well. The cost difference between the 75-foot and 150-foot ROI systems in the draft final CAP was due to an addition error in the cost estimate.

Comment 16: Section 6.2 Groundwater Paragraph 6 Pg. 6-8

Delete the last two sentences of this paragraph.

Response: The sentences have been deleted from this paragraph in the final CAP as requested.

Comment 17: Section 6.3 Soils Paragraph 1 2nd Sentence Pg. 6-8

Delete the word *far*. It is sufficient to note that excavation is more expensive than other options.

Response: The judgmental term "far" has been removed from the final CAP.

Comment 18: Section 6.3 Paragraph 2 4th Sentence Pg. 6-8

Delete the word *far*.

Response: The judgmental term "far" has been removed from the final CAP.

Comment 19: Section 6.4 Soils Paragraph 1 1st Sentence Pg. 6-10

The SVE work done at UST 117 was a long-term pilot test and not a remedial action. While it is true that soils were remediated at 117 during the test, that was not the primary function of the SVE at 117. Please restate this sentence to reflect the fact that this was indeed a test run and not a remedial action.

Response: The discussion regarding the SVE long-term treatability study at UST 117 has been revised as suggested and has been updated with the final results of the now-completed study.

Comment 20: Section 6.4 Groundwater Paragraph 6 Pg. 6-11

Please explain more fully why biosparging is recommended due to the need to coordinate the clean up of Site 17. What is the connection between the two? Is it realistic to expect that UST 117 remediation will be completed before any start up of Site 17 remediation? Please delete this paragraph.

Response: Instead of deletion, the paragraph has been revised to emphasize that while sparging is the recommended groundwater cleanup option for UST 117, final selection and design of a cleanup system will be closely coordinated with and complementary to the groundwater remedial option selected for IRP Site 17.

RESPONSE TO COMMENTS FROM RWQCB

Comment 1: **As discussed in our comments on the Draft Feasibility Study Report for Sites 11 and 17, dated 9 April 1998, we are concerned that the Navy has not fully defined the extent of the carbon tetrachloride plume at Site 17. Without proper delineation of the carbon tetrachloride plume at Site 17, it is possible that implementation of biosparging at UST Cluster 1 and UST 117 could result in the spread of the carbon tetrachloride plume which appears to overlap groundwater contamination at these UST sites (Plate 3). Biosparging involves the injection of air into the contaminated aquifer zones. Although this process may promote biodegradation of some petroleum hydrocarbons, the proximity of the carbon tetrachloride contamination, coupled with the uncertain air flow patterns generated by the biosparging wells (which is dependent on the permeability of soils), could allow spreading of the carbon tetrachloride plume. Spreading of the carbon tetrachloride plume could prolong the groundwater cleanup time and add significant cost to the remediation effort.**

Response: The Navy believes that the extent of carbon tetrachloride (CT) contamination in groundwater from IRP Site 17 has been characterized adequately to proceed to the remedial design phase. In fact, characterization of the CT plume is enhanced beneath the UST sites due to the greater density of monitoring wells located there relative to other areas of the CT plume. For example, all 10 wells surrounding UST 117 are used to monitor both gasoline contamination and the CT plume. Historical groundwater sampling results show that the northwest half of the UST 117 gasoline plume commingles with the stable CT plume. In addition, selected wells at UST Cluster 1 are used to monitor both aircraft fuel and CT groundwater contamination. These wells include 17-MW-12, 17-MW-13, and CL1-MW-05. Samples from wells 17-MW-12 and 17-MW-13, located north of UST Cluster 1 roughly half way between the centers of the CT and aircraft fuel plumes, detect fuel contamination but have never detected CT. Samples from well CL1-MW-05, located west of the centers of both plumes, occasionally contain fuel contamination in concentrations near analytical detection limits, but have never contained CT. Aircraft fuel contamination from UST Cluster 1 commingles with CT contamination from IRP Site 17 only at the extreme northern edge of the fuel plume, if at all.

In summary, the Navy believes the extent of CT contamination near the UST sites is adequately characterized. Also, the Navy is not concerned that sparging the UST groundwater contaminant plumes will further spread CT groundwater contamination. Any remobilization and migration of CT due to operation of the sparge systems should be directed back toward the center of the plume since both UST sparge systems will extend beyond the maximum extent of the CT plume.

Comment 2: **The Navy should consider a groundwater remedial approach which would address IRP Site 17, UST Cluster 1 and UST 117. However, it appears that the Navy's primary concern with installing a pump and treat system at these UST sites is that a majority of the hydrocarbon mass appears to be sorbed onto soil particles. The Navy estimates that the sorbed mass of contaminants is 1,000 times greater than the dissolved phase. Although these estimates may be accurate, it appears that providing cleanup of the dissolved benzene plume should be the focus of the cleanup efforts, because of its greater mobility and lower aquifer cleanup level relative to the other constituents of concern (TPHg, TPHd, toluene, ethylbenzene, and xylene).**

Response: The Navy has coordinated efforts at IRP Site 17, UST 117, and UST Cluster 1 throughout the investigation process and will continue to coordinate future cleanup efforts. Evidence of this coordination includes the base-wide groundwater monitoring system, which uses many dual-purpose wells located to simultaneously monitor more than one site. Coordination has been pursued even though investigations at IRP and UST sites were conducted under different environmental programs and separate funding mechanisms. Recently, the Navy has consolidated remedial design funding into a single project for both IRP and UST sites at NALF Crows Landing. Consolidating the project removes the administrative barriers that existed between IRP and UST sites and will further enhance coordinated design and cleanup efforts.

The Navy's evaluation of groundwater pump and treat, presented in the CAP, indicates that pump and treat is not an efficient groundwater cleanup option compared to sparging for the UST sites. The Navy has focused groundwater cleanup efforts toward accelerating benzene removal by recommending that sparge systems at UST 117 and UST Cluster 1 be operated initially to optimize benzene volatilization. Sparge systems optimized for benzene volatilization would operate in conjunction with SVE systems to remove sparged vapors transported to the vadose zone. A sparge system optimized for benzene volatilization would also volatilize CT beneath UST 117, where the contaminant plumes are commingled.

The Navy continues to consider groundwater pump and treat a viable cleanup option for CT at IRP Site 17. Also, as described above, the Navy is committed to coordinating cleanup efforts among IRP Site 17, UST 117, and UST Cluster 1. Coordinated cleanup scenarios currently being evaluated include combining groundwater pump and treat with air sparging and SVE to simultaneously address cleanup at IRP Site 17, UST 117, and UST Cluster 1. Descriptions have been added to Sections 6.1 and 6.4 in the final CAP emphasizing that cleanup at UST 117 and UST Cluster 1 will be coordinated with IRP Site 17, and that the final cleanup alternatives may be modified to ensure compatibility with remedial alternatives selected for IRP Site 17.

Comment 3: **The Navy has not provided any groundwater flow and contaminant transport modeling to evaluate the number of extraction wells that would be required to remediate groundwater at UST 117, UST Cluster 1 and UST Cluster 2 and to estimate remediation times. This type of evaluation is critical for comparing the technical and economic feasibility of this alternative with other alternatives. Predictions of remediation times for the hydrocarbon contamination associated with these UST sites (30 years for UST Cluster 1) and the number of extraction wells (30 extraction wells for UST Cluster 1) predicted necessary to remediate some of these sites requires supporting information. In order to provide a more meaningful comparisons of the remedial alternatives and to more accurately predict the number of extraction wells and corresponding remediation times, the Navy should provide groundwater flow and contaminant transport modeling which should incorporate capture of the benzene and carbon tetrachloride plumes that are associated with IRP Site 17, Cluster 1 and UST 117.**

Response: Basic groundwater flow and contaminant transport modeling was used to evaluate the groundwater pump and treat option for the UST sites. Specifically, a model was used to evaluate petroleum desorption characteristics and subsequent removal via pumping wells. These modeling results are included in Appendix B in the final CAP. In addition, the number of wells necessary for a pumping well system was based on aquifer pumping test results. Various well system configurations were evaluated based on how aggressively water was to be extracted from the aquifer. The results of these efforts

indicated that for UST Cluster 1, many hundreds of years would be necessary to remediate to cleanup levels even assuming an aggressive extraction well system with closely spaced wells. The evaluation, however, did not account for enhanced biodegradation expected to result from drawing adjacent, oxygenated groundwater into the contaminant plume via the pump and treat system. Consequently, 30 years of system operation was assumed to complete cost evaluations, although no data exist suggesting the time frame that would be appropriate if enhanced biodegradation could be accounted for.

The Navy believes these evaluations are adequate for purposes of the CAP. However, the Navy agrees that more sophisticated modeling is necessary to complete designs of full-scale treatment systems. Additional modeling will be included as part of upcoming corrective action design efforts.

Comment 4: **Soil cleanup activities for UST Site 117 and UST Cluster 1 could also be incorporated with remedial action for IRP Site 17. SVE pilot testing conducted at UST 117, suggests significant mass removal of petroleum hydrocarbons from this site. Pilot test operations should be expanded to include remediation of Site 17 and UST Cluster 1.**

Response: As described in the response to comment 2, the Navy is committed to a coordinated cleanup effort between IRP Site 17, UST 117, and UST Cluster 1. Area-wide operation of SVE systems will be part of this evaluation of coordinated cleanup systems.

Comment 5: **Based on our experience at similar sites, it is common that sites contaminated with chlorinated VOCs [volatile organic compounds] or fuel hydrocarbons are initially remediated by SVE and that these systems are later converted to bioventing systems, to remediate the non-volatile components. However, the Navy must carefully evaluate such an approach at UST Cluster 1 and UST 117. We have provided the following SVE/bioventing implementation criteria which were developed for SVE/bioventing sites at Mather AFB [Air Force Base]. We believe the decision criteria used at Mather AFB could be applied at Crows Landing. The approach involves vadose zone modeling at various stages of the remedial action to evaluate if the remaining mass of contaminants could threaten groundwater quality. The approach also uses a wellhead vapor concentration criteria (greater than 2500 ppmv [parts per million by volume] Total Volatile Hydrocarbons) and is not applicable until the carbon tetrachloride contamination at Site 17 is remediated, as discussed in our comments on the *Draft Feasibility Study Report for Sites 11 and 17*, dated 8 April 1998 (please see narrative cleanup standards language for VOCs provided with our comment letter). Further, the decision to switch the SVE system to bioventing must also be based on soil gas monitoring data, to evaluate residual soil gas concentrations, and estimated mass of contaminants, remaining in the vadose zone. Also, costs associated with optimizing the SVE system should be considered prior to converting the system to bioventing.**

Response: The criteria provided appear to be appropriate for evaluating SVE/bioventing system performance at NALF Crows Landing. The criteria will be included as part of upcoming cleanup system design efforts. Specifically, the criteria can be included in upcoming design basis reports and specifications, or treatment system operation and maintenance manuals.

In addition, it should be noted that the UST 117 long-term SVE treatability study was recently halted because the objectives of the study were achieved. These objectives

included evaluating thermal oxidation for off-gas treatment, and evaluating long-term system performance. A removal rate of roughly 50 pounds of gasoline per day was reached by the end of the study. The UST 117 SVE extraction and monitoring points are currently operating as a passive biovent system to enhance the biodegradation of any petroleum contamination remaining in the vadose zone. The system can be converted back to SVE operation if groundwater sparging, optimized to volatilize benzene and CT, is implemented at UST 117. However, based on the relatively low gasoline removal rate achieved by the end of the study, continued operation of the SVE system is warranted only if accompanied by groundwater sparging.

Comment 6: **The decision to convert an SVE system to bioventing must be evaluated based on which approach is used to remediate the adjacent carbon tetrachloride plume. The groundwater contaminant plume (carbon tetrachloride) for IRP Site 17 overlaps the petroleum hydrocarbon plume for UST 117 and UST Cluster 1, suggesting the possibility that the vadose zone contamination for these three sites may also overlap. An overlap of contaminants may allow spreading of chlorinated VOCs in the vadose zone at IRP Site 17, if bioventing is implemented at the adjacent UST sites. Therefore, the Navy may not want to remediate UST 117 or UST Cluster 1 by bioventing until the vadose contamination at IRP Site 17 is remediated by SVE to the extent technically and economically feasible (see narrative cleanup standard provided with the FS Report comment letter, dated 8 April 1998).**

Response: The Navy estimates that a total of approximately 2.6 pounds of CT exist in the vapor phase in the vadose zone above the IRP Site 17 groundwater contaminant plume. The vapor phase CT probably results from volatilization from underlying contaminated groundwater. Consequently, operation of an SVE system at IRP Site 17 is warranted only if accompanied by groundwater sparging optimized to volatilize CT. As described in the response to comment 5, continued SVE at UST 117 is also warranted only if accompanied by sparging optimized to volatilize benzene and CT. Combined sparging and SVE can be completed where the gasoline and CT plumes commingle beneath UST 117 prior to optimizing the systems for enhanced biodegradation to complete gasoline cleanup.

The Navy also remains committed to coordinating cleanup between UST Cluster 1 and IRP Site 17. However, groundwater monitoring data indicate that fuel contamination at UST Cluster 1 is probably isolated from IRP Site 17 CT contamination. Commingling of contamination, if any, would be restricted to the northernmost extent of the UST Cluster 1 contaminant plume. As a practical matter, however, the Navy will coordinate design, construction, and operation of cleanup systems for UST Cluster 1 with IRP Site 17 and UST 117.