

**RESPONSE TO COMMENTS ON
PILOT-TEST REPORT FOR
THE CHROMIUM AND VOC GROUNDWATER OPERABLE UNIT (OU) 2
(DATED JUNE 2000)
STRATFORD ARMY ENGINE PLANT
STRATFORD, CONNECTICUT**

**U.S. ARMY CORPS OF ENGINEERS
NEW ENGLAND DISTRICT
CONCORD, MASSACHUSETTS**

by

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and
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October 2000

**RESPONSE TO COMMENTS ON
PILOT-SCALE TREATABILITY STUDY REPORT FOR
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Comment # Comment/Response

**Connecticut DEP Comments on the Pilot-Scale Treatability Study Report
for the Chromium and VOC Groundwater Operable Unit (OU) 2
SAEP, Stratford, CT**

- Comment: Expand the discussion of hydraulic containment. The demonstration of hydraulic containment of the injected chemicals on the basis of head measurements only addresses the center part of the test cells. Please also evaluate how the measured heads relate to the predicted heads, based on the groundwater flow model, to document containment at the periphery of the cell as predicted by the model. This evaluation should also take into account the actual extraction rates, which were less than those used in the model prediction. What are the implications of the significant variance in differences in head reported for the two different but similarly operated cells; is this associated with precipitation fouling of the well or aquifer? Consider also the implications of detected injection chemicals in areas beyond their predicted locations when making your evaluation; is this due to diffusion or convection, and what are the implications for containment? Demonstration of containment/control is a necessary element for DEP permitting of the injection element of the project.

Response: Hydraulic containment for either the pilot scale or a fully implemented hot-spot treatment cell depends ultimately on the overall water balance of the components of flow, (i.e., the injection and extraction rates), and also the natural flow of groundwater through the cross-sectional area of the injection/extraction zone. The extraction rate needs to be slightly in excess of the sum of the injection and natural flows. At an assumed hydraulic conductivity of 15 feet per day (ft/d), a cross-sectional area (capture zone) of about 40 feet in width and 10 feet in height, and a hydraulic gradient of 0.002 ft/ft, the estimated natural flow through the cell is approximately 0.06 gpm. The total extraction rate should exceed the natural flow through plus the injection rate, at a minimum, if the flow is to be contained. Total extraction rates during the pilot test could not be maintained at the planned 5 gpm (due to fouling of the extraction well), which would have satisfied this criterion. In any further testing or implementation of this technology, extraction well design and maintenance improvements will be effected in order to maintain sufficient excess extraction versus injection rates.

Differences in observed drawdowns at extraction and observation points within the chromium and TCE test cells are likely attributable to local variations in hydraulic conductivity, fouling of well screens (particularly at the Chromium test cell), particulate precipitation within the aquifer matrix after reactions have taken place, and vertical anisotropy. Sharp increases in drawdowns

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at EW-99-03 appear to be accompanied, in some cases, by substantial increases in turbidity.

Modeling results suggest that there would tend to be some flow of injected reactants outward from the cell. Over longer periods of time, the excess extraction rates produce closed paths for these reactants. However, over a short period of time, some of these reactants would remain in the aquifer. However, due to the high capacity of the aquifer over stoichiometric requirements for conversion of either Cr(VI) or TCE, residual reactants in the aquifer over the duration of a pilot test are likely to have measurable impacts only within a short distance of the treatment cell. Implementation of a long-term hot-spot remedy may conclude with a period of extraction only, or of continued operation with injection of potable water, to cleanse the cell prior to shutting off the system. This is more important with residual permanganate, which has the potential of oxidizing chromium back to the hexavalent state under appropriate conditions.

Modeling of the reduced pilot test extraction rates from 3 to 4 gpm was done with the existing groundwater model constructed for pre-pilot test design. The hydraulic conductivity used in these simulations was 15 ft/d. Model run Strat7 was performed with an extraction rate of 3 gpm and injection rate of 4 gpm (1 gpm at each of 4 injection points). Attached figures show the particle paths generated for 14 days, and 1,000 days to show longer-term particle paths and capture zones. Model run Strat8 was done with an extraction rate of 4 gpm, equal to the total injection rate. At the equal rates, the treatment cell over a long time shows only minor loss of injected fluids. Since the model was conducted at steady-state, comparisons with observed drawdowns are meaningful only when the actual pumping system approaches equilibrium. Seasonal trends of rising or falling water table are not included in field observation data for the pilot test. The model suggests an extraction well drawdown of from 2.5 ft (at 3 gpm) to 3.6 ft (at 4 gpm). Further, injection well mounding would be expected to vary from 0.8 to 0.6 feet over this extraction range. Observation piezometers, e.g., PZ-99-08, PZ-99-09, and PZ-99-11 are close to the hinge point between mounding and drawdown, and showed drawdowns of only 0.1 to 0.3 feet. Similarly, observational point piezometer PZ-99-02B would be expected to show close to zero drawdown in the range of pumping applied (0.2 ft mounding to 0.1 ft drawdown). At a distance of 3 feet from the extraction well (i.e., PZ-99-10), expected drawdown might vary between 0.7 and 1.3 feet. Extraction well drawdowns at the Chromium treatment cell were greater than expected, likely due to fouling of the screen. At the TCE treatment cell, drawdowns were not as great as expected, which may be due to a locally greater hydraulic conductivity at this location.

The above discussion has been included in Subsection 4.3 of the Pilot Test Report.

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- **Comment:** Please expand the discussion of sample age as it affects the reported results. Describe the implications of the conditions described on the interpretation of treatment chemodynamics and effectiveness. Clarify if the effects are principally associated with the TCE test cell or also affect the evaluation of the Chrome test cell. Include comparison of treatment flow lobes with the flushing-only flow lobe in your interpretation.

Response: From literature and the bench-scale test results, the kinetics for oxidation of TCE by permanganate and reduction of Cr(VI) by ferrous iron at reduced pH have been demonstrated to be relatively fast (i.e., on the order of several hours). Therefore, it would be expected that a sample of groundwater from the soil pore space that contains permanganate or ferrous sulfate would not contain significant TCE or Cr(VI) except in a narrow time frame after the chemical front reaches the well or piezometer. The expectation would be to find residual contaminant or residual reductant/oxidant in a collected sample, but not significant concentrations of both. If the sample does not contain significant concentrations of both, reaction in the sample bottles would be minimal. The fact that significant reactions appeared to be continuing to occur in the bottles indicated that the collected sample contained significant concentrations of both the contaminant and reductant or oxidant. The most plausible explanation for this is that contaminant and oxidant/reductant are pulled into the well during sampling at different screen elevations and are mixed in the well, which initiates the reaction. This suggests a limitation in the pilot test in uniform distribution throughout the treatment interval. Had a sample preservative been added it would have stabilized the contaminant concentration, but it would have affected the oxidant/reductant concentration. In addition, interpretation of the results may have indicated inadequate mass of oxidant/reductant delivered rather than inadequate distribution.

In general sample age effects were observed to affect the TCE samples when permanganate was present. Sample age effects may have affected Cr(VI) results when ferrous iron was present; however, the relationship in this case was less firmly established. Sample age effects were not generally observed for samples collected from the flushing lobes.

This discussion has been added to the text.

- **Comment:** The long-term effectiveness of the treatment cannot be fully evaluated until the rebound effects are documented. Are residual Fe and Mn concentrations providing a masking

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of potential long-term pollutant concentration rebound during the early post-injection period for phase 2?

Response: It is the intent of the technologies to provide some residual Fe(II) or KMnO₄ to further treated residual contamination in low permeability zones. See the discussion of the complete rebound data that has been added to the report.

- Comment: What is the long-term stability of the reduced and precipitated chrome under expected evolution of natural aquifer conditions? The results of chrome analyses in the TCE test cell suggests that reoxidation and mobilization of chrome may readily occur.

Response: The long-term stability of precipitated Cr(III) species is dependent on the long-term aquifer redox conditions. If natural aquifer conditions return the area to an oxidative environment, oxidation of Cr(III) to Cr(VI) is likely to occur. In general this has been shown to occur primarily when natural soil deposits contain significant concentrations of MnO₂ (s) which is capable of oxidizing Cr(III) to Cr(VI). Dissolved oxygen has been investigated as a source of oxidation of Cr(III) to Cr(VI) and has generally been shown not to promote this oxidation. Stability diagrams for iron-chrome species indicate that Cr(VI) is only favored at Eh values above approximately 0.4 V for pH values that are neutral or lower. This corresponds approximately to an ORP reading of 170 mV. Average ORP readings for site-wide groundwater samples collected at the site in the 20-40 ft. below ground surface interval have been less than this value; however, individual readings do exceed this value at some locations. Analysis for evaluation of the presence of MnO₂ in soil is a specialized procedure that has not been conducted as part of the site-investigation program.

- Comment: DEP recommends further evaluation of the concept of flushing chrome solely with a water injection, in a pump and treat mode. While there was some rebound during the test, possibly due to sorbed chromium or chromium isolated in low permeability zones, the test data suggest reasonable effectiveness in removal may be achieved, especially in a pulsed operational mode. Removal of the bulk of pollutant mass is a permanent remedy, as opposed to the stabilization achieved through soil washing with an organic acid as an alternative to the stabilization approach to mitigation.

Response: It is agreed that a large mass of Cr(VI) may be removed by flushing alone. In addition, injection of a reduced pH solution may mobilize additional Cr(VI). Therefore,

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implementation of a full-scale in-situ reduction alternative for the chromium hot spot would potentially follow a staged implementation, such as: 1) extract and treat Cr(VI)-contaminated groundwater; 2) flush the aquifer with water; 3) flush the aquifer with acidic water; and 4) flush the aquifer with ferrous sulfate solution. This approach would increase the mass of chromium removed, and reduce the quantity of injected iron required. In addition, this approach would remove Cr(VI) that is readily mobilized, and it would stabilize remaining chromium in the less toxic and mobile Cr(III) form; it would also reduce operational problems due to iron precipitation by reducing the amount of iron required and pre-acidifying the aquifer prior to iron injection. Overall, the alternative would still be considered an in-situ reduction alternative.

- Comment: The selection of Connecticut's Remediation Standard Regulation Surface Water Protection Criteria is an appropriate treatment performance goal for an interim remedy. However, the results of the RI evaluation of groundwater fate and transport to the tidal flat, and comparison of Connecticut's Surface Water Quality Criteria, may indicate a different performance standard is appropriate for the final remedy.

Response: Comment noted.

- Comment: It appears that aquifer heterogeneity, native groundwater flux, tidal effects, sorption, aquifer and screen fouling by precipitates, higher necessary injection rates, and other factors may significantly affect the ability to scale up the test cells to a full treatment system. The proposal for full-scale design should include contingencies to allow these issues to be addressed as necessary, and the EE/CA should carefully evaluate the practicality of the proposed remedy.

Response: Full-scale implementation of in-situ reduction or in-situ oxidation would include additional contingencies to address some of the issues raised by the pilot test.

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**USEPA Comments on the Pilot-Scale Treatability Study Report
for the Chromium and VOC Groundwater Operable Unit (OU) 2
SAEP, Stratford, CT**

GENERAL COMMENTS

- Comment: The document is principally a data report, whose purpose is to archive results of the pilot test on in-situ Cr(VI) reduction and TCE oxidation. Comparisons of observations to pre-test predictions are presented (e.g., stoichiometric ratios of injectate to contaminant required to achieve attenuation; trends in pH, conductivity, etc.), and limited interpretation of deviations between expectations and actual results are offered. The interpretations are generally well founded. While the report includes a number of explicit recommendations for improvements that could be implemented in a full-scale remediation, it does not present an overall assessment of the approach as a potential remedy based on what was learned from the pilot test. While the pilot tests demonstrated some success in reducing Cr(VI) and oxidizing TCE, it also revealed some limitations, including the need for more injectate than anticipated, a slower response time than anticipated, apparent oxidation of Cr(III) to Cr(VI) in the TCE treatment area, and fouling of the FeSO₄ injection wells. All of these phenomena clearly entail increased costs in full-scale implementation. What are the implications for full scale-up?

Response: The implications for full-scale cleanup have been incorporated in the appropriate alternatives in the EE/CA. The EE/CA alternatives include additional costs to address some of these concerns and raise the effectiveness issues in the alternative evaluations.

- Comment: It is suggested that the ultimate assessment of remedial alternatives for the site weigh a simple extraction scheme for the chromium against the in situ reduction scheme. While the in situ oxidation scheme for TCE offers a clear advantage over simply extracting contaminated groundwater, the parallel for the Cr(VI) reduction is not as obvious. In particular, it is recognized that a large fraction of the TCE present in the subsurface is sorbed onto the solid phase, and that the desorption rate may severely limit cleanup by simple pump-and-treat methods. In-situ oxidation offers the attractive possibility of destroying the sorbed fraction in a relatively fast treatment. Although there apparently is "sorbed" chromium present in the form of Cr(III), as evidenced by the increase in Cr(VI) accompanying the

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oxidation of TCE (see sec. 4.4), this is relatively immobile in its reduced state, and, presumably, will not be a source of "rebound" as will sorbed TCE. It appears from the results obtained in the untreated lobe of the Cr(VI) test that the simple flush with clean water is quite effective in reducing Cr(VI) concentrations. Figure 4-1 suggests that the rebound observed in PZ-99-06 (the untreated lobe) between the two phases of the test is more severe than in the treated lobes; however, the simple extraction seems to reduce Cr(VI) quite readily. Is it possible that the rebound in the treated lobes is suppressed by residual FeSO₄ following the first phase of injection that continues to reduce Cr(VI) that is transported back into the test area by dispersion? The untreated lobe obviously would not enjoy this advantage. If this is possible, then the efficacy of in situ reduction versus simple extraction should be evaluated with full consideration of the transport processes that tend to drive contaminants back into treated areas from surrounding, untreated areas. That is, site-wide treatment of the "hot" zone could mitigate the rebound, even following a simple "flush" scheme, as the remaining contaminants outside the treatment zone would be at much lower concentrations, and the length scale over which rebound driven by transport would be much larger. The obvious advantages of a pump-and-treat approach to the chromium remediation are that it may be less costly (e.g., no injected chemicals, no maintenance problems caused by fouling due to oxidation of large masses of iron, etc.), and it removes the contaminant from the subsurface, rather than simply changing its redox state and its mobility. It is noted, too, that extraction following the oxidation of TCE could also remove additional chromium that is presently in a reduced state, as suggested by the rise in Cr(VI) observed at EW-99-02.

A disadvantage that is suggested by the results of the pilot test is that a simple extraction scheme may encounter difficulty in accessing contaminants that have invaded the lower-conductivity portions of the subsurface. Of course, this will limit the in-situ reduction scheme, as well.

Response: See response to CTDEP comments. A sequential process moving from extraction to flushing to reduction may potentially be implemented. Rebound data from the pilot test indicate that ferrous sulfate addition achieves lower overall Cr(VI) concentrations than flushing alone.

3. Comment: The report does not discuss the potential impact of normal groundwater movement on the observed concentrations of trichloroethylene (TCE) and hexavalent chromium [Cr (VI)] in the study areas. Rebound, for example, may be due to normal

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groundwater flow bringing contamination from upgradient locations. This effect may not be relevant in a full scale hot spot removal project but may appear significant in this pilot test if not discussed in this report. It seems important to know if the rebound effect is from contamination moving into the study area or from contamination in the study area that has not been adequately treated or detected.

Response: The report has been updated to present and discuss interpretation of the rebound data including additional data collected since the Draft Final report was prepared. The discussion includes evaluation of whether rebound is due to inflow of groundwater from outside the treatment area.

4. Comment: This report would benefit from a statistical analysis of the test results. For example, "Are the changes in concentrations observed within and between the lobes statistically significant?" and "What proportion of the change in concentrations can be attributed to flushing alone?". Please consider using statistical analysis to evaluate the benefits of in situ chemical treatment. The benefits are not obvious from the report as currently presented.

Response: While statistical analysis can be used to provide additional insight into test results, the pilot test was not designed to support such an analysis. The quantity of data required to provide statistically significant conclusions (i.e., adequate confidence intervals) of the type indicated in the comment is greater than the amount collected, nor was it economical to collect this level of data. With the addition of the complete rebound sample data, evaluation of the treatment methods as they compare to the flushing only method is more obvious.

5. Based on the dosing requirements for each lobe compared to the pre-test contaminant mass present in each lobe, it appears that the injected chemicals may not all be impacting the target areas but perhaps are being dispersed to areas not being monitored or circuiting to adjacent lobes and providing inaccurate test results. For example, test results show that wells above and below the target depth have been impacted. Also, it has not been clearly demonstrated by water level measurements that the draw down at the extraction wells extends as far as the injection wells. The report needs to demonstrate more clearly to the reader how the validity of the groundwater model has been confirmed by the pilot test results.

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Response: Only PZ-99-02C showed a significant effect from the pilot test that suggested the treatment chemicals were being distributed outside the intended zone. See response to CTDEP comments for further discussion on validation of the model by test results.

6. Comment: The text does not appear to discuss initial setting and maintenance of the chemical feed pumps. Each pump was set to a different flow rate. The pumping rates were apparently initially set by calibrating the chemical feed pumps. Subsequent monitoring of the chemical feed pumps is not discussed but presumably periodic checks of the pumping rates were made. Please edit the text to include a discussion of the initial, on going, and final calibration checks for the chemical feed pumps.

Response: Text has been added regarding the metering pump calibration.

SPECIFIC COMMENTS

1. Comment: **Page 2-1, §2.1** In the first bullet, add to the end of the last sentence "... and distribution of $KMnO_4$ to locations where it was not originally planned to go." It appears from the data that areas outside of the planned 10-foot thickness have been impacted during the treatability study.

Response: The data for PZ-99-01A and PZ-99-01C do not substantiate that areas outside the planned 10-foot thickness were significantly affected by the treatment. There were some minor indications that some oxidant may be reaching these intervals based on ORP results; however, most of the data, including TCE concentration, temperature, pH, and Mn concentration, show very little change throughout the test. It is important to recognize that these zones contained significantly less TCE prior to the test than the 10-foot zone that was treated.

2. Comment: **Page 2-2, §2.2** For the discussion in the second bullet, please note that a prior EPA comment pointed out that MnO_2 has been shown to oxidize Cr (III) to Cr (VI), which may raise concern with this plan.

Response: FWENC/HLA has been aware from the beginning of the treatability scope

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development that oxidation of Cr(III) to Cr(VI) was possible due to MnO₂ as well as MnO₄. This is a recognized disadvantage for this technology at this site, and is raised in the EE/CA.

3. **Comment:** Page 3-3, §3.2.2, Paragraph 3 The report notes that, "A key measure of success of the treatment will be the ability to meet [target] concentrations and maintain them." While maintaining the groundwater below remediation goals is certainly an important objective of the full-scale remedy, this assessment of "success" cannot be uncoupled from the transport processes that drive "rebound." One such process is certainly transport from untreated, low-permeability domains back into adjacent treated zones. It should also be noted that, at a larger scale, there is also transport from surrounding untreated areas into the treatment zone. This is particularly significant for the pilot test, which treated a small spot within a large domain of contaminated groundwater. Presumably, an effective full-scale remediation is less prone to this source of rebound, as the in-situ reduction scheme would be aimed at concentrations down to some maximum tolerable value, and rebound would not be as severe as that observed in the pilot test. It is noted that a credible assessment of the predominant transport processes at the site may need to consider dispersion due to tidally driven fluctuations in groundwater movement. At this site, with very small mean groundwater flux toward the estuary, dispersion associated with the mean flow (as represented in the widely used, classical model for dispersion) may be much smaller than that driven by tidal fluctuations.

Response: Comment noted. Dispersion due to tidally influenced fluctuations in groundwater is likely to be more dominant than dispersion due to horizontal groundwater flow, particularly closer to the Housatonic River. However, as distance from the river increases, tidally influenced fluctuations in groundwater are not as dominant a process. For instance, tidal fluctuations appear to result in groundwater elevation fluctuations on the order of 0.1 foot in the vicinity of the Chrome Plating Facility (see Appendix J - Aquifer Testing Report in the OU 2 Final Pre-Design Investigation Report, 2000).

4. **Comment:** Page 3-3, §3.2.3 As was done for Section 3.2.2, add a sentence presenting the amount of KMnO₄ required based on the bench scale test results and the stoichiometric requirement.

Response: The requested sentence has been added.

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5. Comment: Page 3-6, §3.6.2 In the second last sentence, edit the text to state “Variations between and within lobes” because the data indicates this to be true and this variation is also noteworthy.

Response: Agreed. The requested change has been made.

6. Comment: Page 4-2, §4.1.2 The fourth sentence in the second paragraph states that the referenced lobes may contain significantly different initial masses of TCE. In fact the data can be evaluated grossly to prove that is true. By taking the average of three concentrations from each lobe (at the injection well, one piezometer, and the extraction well) an average initial mass in each lobe can be calculated. Such a calculation (from data in Table 3-6) shows that the lobe injected with the smallest KMnO₄ concentration initially contained 1.28 kg of TCE (soil and groundwater), the lobe injected with the mid-range KMnO₄ concentration initially contained 4.37 kg of TCE, and the lobe injected with the greatest KMnO₄ concentration initially contained 3.46 kg of TCE. The mass of KMnO₄ required to demonstrate treatment at the referenced piezometers, as stated in the second sentence of the second paragraph of this section, is way out of proportion to the mass of TCE initially in each lobe. This seems to suggest that the KMnO₄ is dispersing to areas of the subsurface other than the target area.

Response: The data can be evaluated grossly to suggest that the lobes contain different masses of TCE as stated in the comment. HLA briefly evaluated whether to dose the different lobes based on an average of the type described above; however, the conclusion reached was that the variations described above could also be a result of the limited number of samples available for each lobe and random sampling. In other words, a significantly higher number of samples from each lobe are necessary, from a statistical standpoint, to establish reliable estimates of TCE mass in each lobe and prove that variations between lobes exist. The variations observed could have been a result of random variations in concentrations at sample locations, rather than spatially significant trends. For this reason, HLA averaged the data from all four lobes and used this mass as the basis for estimating oxidant demand. Nevertheless, variation in mass between lobes may be an explanation of observed results.

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7. Comment: **Page 4-2, §4.1.2** Contrary to the statement in the fourth sentence in the third paragraph, the data in the third sentence do not appear to indicate an advantage to injection at higher concentrations over a short time period. PZ-99-10 is on the lobe receiving the highest FeSO₄ concentration but required more than 50% more FeSO₄ to achieve treatment than PZ-99-08, which is in the lobe receiving the lowest FeSO₄ concentration. PZ-99-10 is only slightly farther from its injection well than PZ-99-08 is. Also, PZ-99-09 is in the lobe receiving the mid-range FeSO₄ concentration, yet it required more than five time more FeSO₄ to achieve treatment than PZ-99-08. This suggests that the character of the subsurface may have the most significant impact on the performance of the in situ chemical treatment. Chemical injected into a particular target area may be dispersing outside that area in significant quantities.

Response: The use of the words, “suggest” and “possible” in the sentence were intended show that the relationship between injected concentration and treatment is not strongly demonstrated, but may exist. The example cited in the comment is the only comparison that does not agree with the statement. Although PZ-99-10 required a greater amount of FeSO₄ than PZ-99-08 for complete treatment, evidence of the chemical front was observed earlier in the test at PZ-99-10 than it was in PZ-99-08. Subsurface spatial variations undoubtedly play a significant role in chemical distribution.

8. Comment: **Page 4-2, §4.1.2** The report acknowledges clearly that much greater masses of FeSO₄ and KMnO₄ were required than anticipated, and offers some speculation on possible reasons for this (e.g., higher contaminant mass than estimated, higher organic carbon in the soil that consumed oxidant, etc.). In view of the magnitude of this discrepancy, it would be useful to provide a summary of the actual masses injected in the text. It is noted that Table 3-7 does provide this information in terms of planned versus actual mass injected. An additional column in the table showing the actual molar ratio injected (i.e., moles of oxidant or reductant actually injected divided by the estimated moles of contaminant in the treatment area) would provide another useful measure of the modifications required. These figures will fold back into cost estimates for scale-up, as it appears that four to eight times the anticipated injectate was required to meet the pilot test objectives.

Response: Additional information has been added to the text and table as suggested.

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9. Comment: **Page 4-3, §4.1.3** Can the difference between field observations and the original groundwater model be attributed to a reduction in the extraction rate compared to the modeled rate, or was the model deficient because the geology of the study area is so variable, or is there another explanation? Please suggest how the model and the field result can be brought into better synchronization.

Response: See response to Connecticut DEP comments.

10. Comment: **Page 4-5, §4.2.6** The text could clarify this discussion by stating: At the acidic pH levels present in the subsurface when chemicals are being introduced through the injection wells, the low pH will inhibit the oxygen in the dilution water from oxidizing the Fe (II). When chemical injection stops, the pH will rise allowing the residual oxygen to slowly oxidize the surplus Fe (II).

Response: Agreed; the suggested text will be added.

11. Comment: **Page 4-7, §4.5** Please reconcile the apparent discrepancy between the last sentence in the first (partial) paragraph on this page with the last sentence in the second paragraph on this page in regard to chemical reactions continuing to occur in the sample bottles. Also, please explain whether or not the reaction rates are concentration dependent. If they are, then the holding times will affect samples from the different lobes differently.

Response: The last sentence of the second paragraph has been changed to read, "Samples from the chromium area generally showed some visual changes with time due to the settling of iron precipitates; however, due to the initial suspended iron particles, personnel were not able to observe whether additional iron precipitation was occurring in the bottle, which would have indicated additional reactions in the bottle. Reaction rates for reduction of Cr(VI) are concentration-dependent; however, the rates are generally fast.

12. Comment: **Figure 4-1** This figure appears to show that PZ-99-1C was impacted by the pilot test even though this well is located outside the target depth of the study. Was this expected? Was the impact from flushing or chemical treatment?

Response: PZ-99-1C is located deeper than the screened interval of the pilot test treatment

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area. TCE concentrations were fairly consistently detected in the 2,000-3,000 µg/L range throughout both phases of the pilot test (see Table 4-8). Figure 4-1 shows essentially a flat line for PZ-99-1C due to the scale of the figure. Figure 4-8 indicates that there some manganese may be moving slowly down into the piezometer PZ-99-01C zone following the tests, but that this did not occur significantly during the tests. This post-test movement may be the result of density driven movement of the chemical into the deeper zone.

13. **Comment: Figure 4-5** Is there an explanation for the significant drop then rise in the TCE concentration from November 18, 1999 to November 30, 1999 to December 1, 1999? Is there any reason to question the November 30, 1999 analytical result?

Response: Although the November 30, 1999 analytical result does not appear consistent with the November 18, 1999 result or the December 1, 1999 result, there is no other basis in the analytical records to question the validity of the datum. Neither is there a reasonable explanation for the deviation. In this case FWENC/HLA would generally avoid making interpretations based on this datum given its inconsistency with adjacent data trends.

14. **Comment: Figure 4-13** This figure appears to show that PZ-99-2A and PZ-99-2C were impacted by the pilot test even though these wells are located outside the target depth of the study. Was this expected? Was the impact from flushing or chemical treatment?

Response: Review of PZ-99-02A and PZ-99-02C data indicate there is some evidence that these areas were partially affected by the pilot test treatment (see Table 4-1). Data for PZ-99-02A does not indicate any observed ferrous iron or significant pH change. Chromium concentrations also do not appear to have a significant trend during the treatment. There is a reduction in water temperature and an increase in ORP during the pilot test which suggest a minor influence on this piezometer during the tests. Data for PZ-99-02C indicates a greater effect from the pilot test the PZ-99-02A. For PZ-99-02C, evidence of reduction in chromium concentrations, observed ferrous iron, and changes in water quality parameters indicate that both flushing and chemical treatment played a role in data collected. The rebound observed for piezometers PZ-99-02A and PZ-99-02C indicate that delivery of Fe(II) to these intervals was minimal compared to PZ-99-02B.

**RESPONSE TO COMMENTS ON
PILOT-SCALE TREATABILITY STUDY REPORT FOR
THE CHROMIUM AND VOC GROUNDWATER OPERABLE UNIT (OU) 2
(DATED JUNE 2000)
STRATFORD ARMY ENGINE PLANT
STRATFORD, CONNECTICUT**

Comment # Comment/Response

15. Comment: **Figure 4-27 to 4-30** The temperature effects cannot be viewed on photocopied versions of this report, presumably because of the color used. Is this result consistent with the groundwater flow model?

Response: Changes in temperature are generally observed at the same time or slightly before other evidence of the chemical fronts and slower than predicted by the model. The graph colors have been changed; however, color versions of the report are recommended over photocopied versions for correct interpretation.

16. Comment: **Table 4-1** For well EW-02, two samples are shown for 1/24/00 08:00AM and both have the same ID number but different analytical results for manganese. Please review and correct as required.

Response: The first sample listed was incorrectly included in the table and has been removed.