RESPONSES TO EPA COMMENTS DATED 16 OCTOBER 2003 ON THE SITE 16 QAPP FOR HRC INJECTION PILOT STUDY NAVAL CONSTRUCTION BATTALION CENTER DAVISVILLE NORTH KINGSTOWN, RHODE ISLAND

NAVY'S GENERAL RESPONSE (PILOT STUDY CONSIDERATIONS AND DESIGN)

The proposed location of the HRC® injection pilot test was selected based on the available site data to test the general feasibility and overall applicability of *in situ* HRC® injection within a pilot scale field test located near the southwestern (upgradient) extent of the >1,000 µg/L portion of the detected CVOC plume (vicinity of former Building 41) to enhance biodegradation rate of the CVOC. This location would result in minimizing the amount of the detected >1,000 µg/L CVOC plume that would be located upgradient of the pilot test area. Also, the location was selected to maximize the degree of CVOC plume area cutoff and, therefore, to optimize subsequent downgradient biological attenuation effects as HRC® is transported within the aquifer. The observed concentration of total CVOC in this area (maximum of 6,200 µg/L and 2,700 µg/L of TCE at MW16-15D during the Phase I and II investigations, respectively) is reflective of dissolved-phase and sorbed-phase (to aquifer solids) CVOC mass. Based on the available site data, we do not believe that the CVOC concentrations detected in deep ground water represent the presence of DNAPL. The Phase II investigation data indicate a decrease in total CVOC concentration from the proposed test area to 23-53 µg/L approximately 100 ft toward the southeast and to 23–211 µg/L approximately 150–100 ft toward the southwest and west. Assuming an approximately 50-yr-old release, this suggests that if there is a high concentration undetected source area (DNAPL) nearby, it apparently attenuates quickly over a relatively short distance to the nearby existing monitoring wells. Given the short distance of attenuation, this scenario is not realistic, and is possible only if intrinsic biodegradation is actively occurring. However, the monitored natural attenuation scoring performed for the Phase II investigation does not support a scenario with significant intrinsic biodegradation. These findings, therefore, do not support the existence of a potential undetected DNAPL 'source area'.

Through the installation and baseline sampling of the monitoring and injection wells for the proposed pilot test, the understanding of the site character would be significantly increased. If the baseline sample results were to indicate the presence of a high concentration source area (DNAPL) at one or more of these new wells, the design and type of the pilot test would be reconsidered. Unfortunately, relocating the pilot test area would not seem to allay the EPA concern for a potential undetected nearby 'source area', because this problem would seem to be present almost no matter where the pilot test could be relocated within the main detected CVOC plume area.

Regarding a concern that the detected TCE concentrations are too high for the proposed pilot test, numerous field and laboratory enhanced bioremediation studies (see, for example, Selected Battelle Conference Papers 1999-2000 *in Accelerated Bioremediation of Chlorinated Compounds in Groundwater*, Edited by Stephen Koenigsberg) have shown that dissolved CVOC concentrations observed as high as 10 mg/L are directly susceptible to anaerobic biodegradation pathways. Therefore, the concentration of TCE and other CVOCs detected beneath the northeast end of the former Building 41 are not deemed as too high in concentration to assess the potential for and applicability of an enhanced bioremediation remedy via the proposed pilot test. Based on this information, no change is recommended for the location of the pilot test.

Based upon the available site data and the results of the "Preliminary Identification and Screening of Remedial Action Technologies IR Program Site 16, NCBC Davisville, North Kingstown, Rhode Island" dated September 2003 prepared by EA for the Navy, the Navy selected a pilot test of HRC® injection to evaluate this technology for potential future remediation of the CVOC in deep ground water at the site. The primary objective of the proposed HRC® pilot test is to directly assess the overall site-specific efficacy, site-specific ability to deliver the HRC®, and the rate of performance of enhanced bioremediation as a ground-water plume area cutoff technique (thus sufficient number of wells to reach across the plume; Figures 2 and 5 in the Draft QAPP), and secondarily, as a by-product of the pilot test, to significantly decrease the CVOC concentration in the upgradient (southwestern) portion of the CVOC plume area. The objectives would include quantification of the parameters necessary to optimize enhanced bioremediation, such as biodegradation rates, the ratio of daughter products, and the mass of HRC that would be required for implementation of this remedy method. Both the deep and rock ground-water zones were targeted in the pilot testing because the majority of the detected CVOC mass is located in these ground-water zones. However, the Navy proposes to revise the pilot test to include injection into only the deep overburden ground-water zone using the 12 locations originally planned.

As stated during the Navy's 2 October 2003 telephone conference call with EPA and RIDEM project team members, the 4-month pilot test presented in the draft QAPP was stated because it is the maximum period that could be completed and reported within the remaining time of EA's CLEAN II contract. However, this does not preclude the Navy continuing the test sampling/ monitoring field activity/data collection with another Navy contractor beyond the 4 months stated in the draft QAPP. Secondly, in general terms, a 4-month test is on the short end of HRC® pilot test duration as recommended by Regenesis. The average HRC® test duration as recommended by Regenesis is 6 months to 1 year, though this is not to say that shorter duration tests with HRC® have not been applied. The experience of Regenesis (personal communication through several conference calls regarding the pilot test design) is, however, that the geochemical alteration of the subsurface environment (to reducing conditions) and the acclimation of intrinsic microorganisms will occur within an approximate 3-month period, particularly with the use of HRC® Primer, which has an accelerated release capacity. Therefore, the evaluation criteria for the success of the pilot test over a 4-month period were proposed as stated (geochemical conversion of ground water and the onset of CVOC decline) in the draft QAPP to indicate realistic expectations for that period. However, the QAPP will be revised to include a 12-month pilot test that will begin with EA and will be completed by another Navy contractor.

The design of the pilot test is based on the use of "HRC® Design Software for Barrier Treatment" by Regenesis. All available design information and software from Regenesis was accessed and utilized to design the HRC® pilot test for Site 16. In addition, several direct conversations with Regenesis technical support were conducted to evaluate site-specific factors and test objectives. The pilot test design information (specifically the portion for the deep overburden ground-water zone) is provided as Attachment 1 to these responses to comments. The available Phase I and II slug test data, particularly that for existing wells (MW16-14D, MW16-15D, and MW16-32D) located in the proposed pilot test area, were used to estimate the range of potential transport velocities of ground water and to assess test design criteria for emplacement and transport of HRC® reagent within the deep and rock ground-water zones. The range of potential ground-water linear velocities (approximately 0.3 to 1 ft/day) was established based on review of this data. The test design criteria including injection well locations (two rows of 6 well pairs), monitoring well locations, and well spacing were originally developed based on this potential range of velocities for a 4-month pilot test duration. Although the HRC injection wells in a given injection well row are proposed on 20-ft centers (see QAPP Figure 5), the offset location of the injection wells in the adjacent downgradient row allows for an effective transverse spacing between injection wells of 10 ft. Two rows of injection wells were designed to optimize ground-water contact with emplaced HRC® reagent. The radius of influence for each injection well, therefore, was designed for approximately 5 ft. This radius of influence was determined based on site-specific information and the experience of Regenesis with HRC® injection.

Monitoring well locations were selected along and transverse to the direction of interpreted ground-water flow at varying distances from the injection array to observe the results from the injection event, ranging from locations between the 2 rows of injection wells to a maximum of approximately 200 ft downgradient (northeast) from the injection wells. Use of these distances was based on the assumption that some of the material might advance laterally with ground water flowing at the slowest estimated rates and some at the fastest estimated rates in the injection pilot test vicinity. Monitoring of both the deep overburden (D) and upper bedrock (R) ground-water zones is still proposed for the revised pilot test. The injection well array was positioned so 4 of the exiting wells could be used, decreasing the number of new monitoring wells needed. Additionally, monitoring wells screened in the intermediate (I) and shallow (S) ground-water zones will be added to the 7 monitoring well clusters located nearest the injection well array (i.e., those located between and just northeast of the injection well rows) to monitor for the formation and upward migration of vinyl chloride (VC) as a degradation product. VC will also be monitored for in existing wells MW16-14I, -16I, -21I, and -22I. The production of VC is expected; however, Regenesis' experience has been that this occurs several months after the injection of the HRC® and continues over a relatively short time (a few months). It is important to note that the elevated VC concentrations are only temporary and short-lived. Currently, the ground surface of the pilot test area is paved or grass covered and contains no buildings. If VC is found to be migrating upward so as to result in an unacceptable release to the atmosphere, it could be addressed, for example, by the injection of ORC® to accelerate the degradation of the VC.

EPA's GENERAL COMMENTS

EPA does not concur with the proposed HRC Injection Pilot Study. There are several issues that are described in detail in the paragraphs below. The first concern is that the proposed study has the potential to generate significant mass of vinyl chloride in site groundwater if the degradation process is successful. A second concern is that the pilot study has not been designed rigorously enough to yield significant useful data. An additional concern is that the proposed location of the study is in a potential zone of discharge of chlorinated volatile organic compound (CVOC) contamination emanating from an up gradient location. A fourth concern is that the proposed "pilot study" actually appears to be a full-scale remedial effort.

Comment 1: Vinyl Chloride Generation

The QAPP mentions in several locations that while vinyl chloride will be generated, its production is not a concern. In particular, it refers to the existing vinyl chloride present in site groundwater as a result of ambient degradation of CVOC contaminants. Review of the Phase II Remedial Investigation, however, indicates that vinyl chloride in groundwater is limited primarily to the "Central Area" of Site 16 with the highest concentrations being detected at 36 micrograms per liter (μg/L) at MW16-41S. Down gradient of the proposed pilot study location the highest vinyl chloride concentrations were found at MW16-29D which had a measured concentration of 1.0 μg/L.

Review of the literature for HRC® indicates that significant vinyl chloride will be produced if the material is successful at degrading trichloroethylene (TCE). An example is the case study supplied in the HRC® literature contained in Attachment 1. The case study "Enhanced Bioremediation of TCE at Department of Defense Landfill Site" includes a depiction on a graph titled "VOC Concentration Graph Down gradient Monitoring Well 14." This graph shows depletion of 135 milligrams (actually micrograms?) per liter (mg/L) of TCE and 101 mg/L of DCE with subsequent generation of approximately 30 mg/L of vinyl chloride. This occurred in 372 days (approximately one year) with only one injection of HRC®. This suggests a conversion ration of approximately 13% of the TCE/DCE mass to vinyl chloride. Ultimately, vinyl chloride may be converted to innocuous end products. However, in the interim, this data suggests that extremely high concentrations of vinyl chloride may be produced upon implementation of this pilot study.

The proposed study is targeted for a location where TCE has recently been detected at a concentration as high as 6,300 μg/L of CVOC. This concentration was found in groundwater at MW16-15D. Conversion of this TCE mass to vinyl chloride at the ratio provided on the literature graph will result in a value of 819 μg/L. Conversion of TCE to this concentration of vinyl chloride represents a potentially far greater risk to down gradient receptors than the TCE. In addition, the mobility of vinyl chloride is faster than TCE and will likely migrate relatively rapidly away from the pilot study area. Further, the Navy appears to be of the opinion that a source exists at the northeast end of the former Building 41 where they have suggested that solvents were either dumped to the ground or into a storm catch basin. If that is the case, then the concentrations of TCE in the source area are likely to be higher than those detected in down or cross gradient monitoring wells with associated higher concentrations of vinyl chloride.

Response— Please refer to the last paragraph of the Navy's General Response to EPA's comments.

Comment 2: Pilot Study Basis of Design

There are several concerns related to the basis of design for this pilot study. These concerns are related to the stated objectives, design values used or not provided, and pilot study layout. While a layout of wells has been provided, and literature from the vendor enclosed in the attachments, there is no accompanying design information and no reference to any other literature other than that provided by the vendor, even though guidance documents and literature articles providing design guidelines have been published and are readily available. Regenesis provides basic instruction for design of HRC® application. At a minimum, this analysis should be provided in an attachment to support the proposed pilot study. From review of the QAPP it is not clear that the proposed HRC® injection pilot study will yield significantly meaningful data commensurate with the expenditure of funds.

Response— Please refer to the Navy's General Response to EPA's comments.

Comment 2A: Seepage Velocity

The design of the pilot study relies on several parameters as detailed in the Regenesis HRC® literature and software program (Version 3.1, 2002). Included as input parameters are values of hydraulic conductivity, contaminant concentration, and contaminant mass. In particular, the QAPP states that it used a value of 1 foot per day for "time of HRC® release dosing requirements and injection well spacing." However, review of the data in the Phase I and Phase II Remedial Investigations appears to show a conflict with that value.

The geometric mean of the hydraulic conductivity values for the monitoring wells within the area of the proposed pilot test is approximately 13.5 feet/day. This value is for MW16-14D, MW16-15D, MW16-21D, MW16-22D, and MW16-32D (Table 3-5 of the Phase II Remedial Investigation). The hydraulic gradient through the site area from MW16-32D to MW16-21D and/or MW16-22D is approximately 0.006 feet/foot. Using an effective porosity of 0.25 this results in a groundwater seepage velocity of approximately 0.324 feet/day, not 1 foot/day.

However, even this value is somewhat uncertain when using the values of hydraulic conductivity provided by the Navy in the Phase I Remedial Investigation (Table 3-4). That table gives much higher values of hydraulic conductivity for the four wells slug tested at that time (MW16-32D was not constructed). The geometric mean of the rising head slug test hydraulic conductivity values from the Phase I report result in a hydraulic conductivity of approximately 121.5 feet/day. These values are an order of magnitude higher than those provided in the Phase II report. However, this discrepancy was never explained in the Phase II report. Using this value for hydraulic conductivity, the seepage velocity is approximately 2.92 feet per day.

Review of the proposed groundwater monitoring wells shown on Figure 5 shows that the down gradient wells are located approximately 30 and 110 feet away for the first line and the second line of wells. If the groundwater seepage velocity is 1 foot/day, groundwater will be detected at the first line within one month, less time than what Regenesis states is sufficient time for acclimation of microorganisms and for significant biodegradation to occur. Travel time to the second line of wells is approximately four months, the maximum length of the pilot test. If the groundwater seepage velocity is only 0.33 feet/day, groundwater will reach the first line in just over three months but not reach the second line during the time frame of the pilot test. On the other hand, if the groundwater seepage velocities using data from the Phase I report are the most correct, groundwater will have migrated past the second line of monitoring wells in just over five weeks, again, less time than is necessary for microbial populations to acclimate to the HRC® and begin significant biodegradation.

It is recognized that HRC® will be continually released and any effects may be observed at the four month interval. However, this may only occur is the groundwater seepage velocity is slow. If considerable transport is occurring, there will not be effective monitoring down gradient since the reactions will not be significant until sufficient elapse time has occurred. Groundwater velocity also affects dispersion. Since dispersion is the mechanism for HRC® distribution this has the potential to affect injection well spacing. While a worse case scenario can be used for injection well spacing, this approach may result in excessive numbers of wells.

Response— Please refer to the Navy's General Response to EPA's comments.

Regarding the hydraulic conductivity values presented in the Phase II Hydrogeological Report for Site 16, the slug test data from both the Phase I and II investigations were re-calculated during the writing of the Phase II Investigation Report using the same software and method (AquaSolv) for consistency, resulting in the values shown in Table 3-5 which were used in the design of the pilot test. The recalculated hydraulic conductivity values for the Phase I slug test data supercede those presented in the Phase I report. This will be noted in the text of the next version of the Phase II investigation report. Also, refer to Attachment 1 for the pilot test design information.

Comment 2B: HRC® Injection and Monitoring Well Layout

Review of the proposed location of the HRC® injection and monitoring wells (Figure 5) does not result in an understanding of the Navy's design approach. There is also no supporting documentation in the text or attachments relative specifically to this site (i.e. vendor literature only). There is no design documentation for the spacing of the injection wells. At present, they are shown 25 feet apart with the rows 25 feet apart. The separation of the injection points and rows of points should be based on site conditions including groundwater seepage velocity and also contaminant mass in the groundwater. Effective use of HRC® requires that it be installed in accordance with established design procedures. The analysis performed, if any, should be included in the attachments.

Although the source for the CVOC in groundwater has not been identified, the Navy appears to assert that it is at the northeast corner of the former Building 41. If that assumption is correct, it also implies that the groundwater at that location likely has CVOC concentrations higher than that detected in surrounding groundwater, to date. How is this contaminant mass known for use in the pilot study design? Additionally, this creates a problem in that injection of HRC® is proposed for locations just up gradient of this "source" area (Figure 5). Also, at least four and possibly seven of the new monitoring wells are located up gradient of this suspected "source" area.

Aside from the problems of uncertain groundwater seepage velocity, and unknown CVOC mass, there is no mechanism to evaluate the loss of CVOC mass in down gradient wells as a function of injection of HRC®. That is, while contaminated groundwater at a presumed known concentration of CVOC (MW16-32D?) moves through the HRC® injection well lines, and begins the acclimation process of biodegradation, it soon passes through the suspected zone of higher CVOC contamination. This zone will contribute additional CVOC mass to the moving groundwater prior to it migrating down gradient to the next set of monitoring wells. Therefore, true assessment of the loss of CVOC will not be possible.

In addition to the presumed "source" area that has no data to either support its existence or to quantify its strength, the only data available for assessment of the "plume" are from MW16-32D up gradient, MW16-14D, up and cross gradient and MW16-15D/R. Only MW16-15D/R is within the width of the apparent down gradient groundwater migration pathway from the HRC® injection lines. Even that well is located to the periphery of the down gradient flow paths of HRC® injection wells. In essence, there is no groundwater quality data for the area proposed for injection of the HRC® i.e. within the northeast end of the former Building 41, or at or in front of the HRC® injection lines.

It is not clear how evaluation of the effectiveness of the HRC® injection pilot test can be made. Certainly groundwater quality data can be obtained during installation of the proposed groundwater monitoring wells, though this approach is somewhat after the fact. This pilot test appears to be planned to be implemented "blind." For a pilot test to garner the most useful data, the starting ambient conditions must be quantified.

An additional observation is the layout of a line of the largest number of monitoring wells appears to be oriented from MW16-14D through MW16-15D to a location between MW16-21D and MW16-22D. This line of wells like MW16-15D lies on the periphery of the treatment zone. Typical design is to place a line such as this along the primary axis of plume/treatment zone migration. Therefore, this line should be centered between the injection lines and extending down gradient. The purpose of these wells along the southern boundary is not clear.

Response— Please refer to the Navy's General Response to EPA's comments.

Comment 2C: Pilot Study Objectives

The scope and scale of the proposed pilot study does not correlate with the stated objectives of the study. The stated objectives of the pilot study only require that reducing conditions be established, TCE be observed to decline, and 1, 2-*cis* DCE be observed to increase. While introduction of HRC® will likely further create reducing conditions, it is noted from the Phase II Remedial Investigation (Table 5-2) that MW16-15R is already strongly reducing. Other wells were not evaluated (scored) but do include parameters indicative of at least trending to reducing conditions. Also, the problem noted with flow through the "source" area will mask the ability to assess the diminishment of TCE such that it may be possible that no loss of TCE would be observed even if biodegradation were occurring. In addition, the uncertainties associated with the groundwater seepage velocities also limit the ability to fulfill this objective. Finally, simple "sufficient onset of the generation of CVOC daughter products (e.g. at a minimum 1, 2-cis DCE)" as stated, is a very loose and nebulous pilot test design parameter. MW16-15R already has up to 110 µg/L of 1, 2-cis DCE.

Response— Please refer to the Navy's General Response to EPA's comments.

Comment 2D: Microbial Environment

Last, the purpose of injection of HRC® is stated to enhance bioremediation of the CVOC constituents. However, review of site groundwater quality indicates that the pH of groundwater in the proposed pilot test area may not be conducive to microbial activity. Data from the Phase II Remedial Investigation gives groundwater pH values of 12.53 for MW16-32D and 12.02 for MW16-15R2. Microbial activity is usually limited to a pH value of 5.0 to 9.0 with optimal activity around 6.0 to 7.0. The pH of groundwater from several other wells does fall into the more acceptable range. However, the uncertainty presented by the elevated pH of the two wells listed calls into question the applicability of HRC® at this location. This is of particular concern since there is no groundwater quality information for the largest area where the HRC® is targeted for injection.

This table is limited to pH values above 8.0 although there are 15 wells with values above 7.0 but below 8.0 that are also documented in table 2-4 of the June 2003 Groundwater Report and several noted in the CED area ME#1&2. Several of the wells in the table are included in the area of the proposed enhanced bioremediation pilot study.

Monitoring Well	Groundwater pH value in various sampling events			
	1995/1996	2000	2001	2002
EA110R*	NI/8.83	8.48	8.67	(2003) 8.93
EA111R*	NI/6.51	7.64	6.43	(2003) 11.90
MW03-14R2*		12.3		
MW55D/R/R2*				8.08/11.12/12.37
EA116R2%		12.17		
EA112R2%		9.7		
MW16-32D@				12.53
MW16-15R2@				12.04
MW16-02R2				12.45
MW16-06R				8.24
MW16-05R				8.90
MW16-10R			8.78	7.55
MW16-23D			8.20	6.25
MW16-25R			7.32	8.54
MW16-36R				10.25
MW16-54D				10.36

NOTE:
* = Upgradient wells to the proposed site 16 pilot study.
@ = Wells included in the proposed site 16 pilot study.
NI = Not installed.
% = Wells in northeast direction from MW03-14 along bedrock trough with high contamination.

Response— Although alkaline pH conditions have been measured in a few monitoring wells in the general area of the proposed pilot test (for example, pH of 12.0 and 12.5 at MW16-15R2 and MW16-32D, respectively, in 2002), most observed pH measurements of ground water from deep and rock wells in the area are between 5 and 7, conditions which are amenable to biodegradation, including MW16-14D, -15D and -15R located at the proposed test area (Figure 8). Observations of alkaline pH conditions are likely localized resulting from well construction (e.g., grout that migrated into a few of the bedrock fractures during setting of the steel casing). Therefore, this is not believed to be representative of area-wide aquifer conditions and should not significantly effect an HRC® Pilot Test. In addition, the release of hydrogen from lactic acid upon hydration of HRC® reagents is designed to lower pH conditions to acceptable levels for anaerobic biodegradation.

Comment 3: Up Gradient Source Area Discharge Zone

The Navy apparently believes that the area at the northeast end of the former Building 41 is a source area. EPA concurs with this to the extent that it appears that highest concentrations of CVOC constituents appear to be manifesting themselves at that location. However, EPA interprets the "source" at that location to have the potential to have originated from an up gradient release area. Rationale for this interpretation have been provided previously including extremely high CVOC source(s) up gradient, up gradient/down gradient recharge/discharge relationships, alignment of a significant bedrock trough, distribution of elevated pH in groundwater combined with potential elevated pH source areas up gradient.

Additionally, review of the groundwater data for MW16-15R, located in the area of concern shows indications of documenting this interpretation. Both MW16-15D and MW16-15R have exhibited very high CVOC concentrations. There has not been any release area identified near the former Building 41 area to explain the observed CVOC concentrations. However, groundwater elevations at the MW16-15D/R are either strongly upward (discharging) or at times neutral (Phase II Remedial Investigation Table 3-4). Potentially the most telling is the chemical analyses shown on Table 4-9 of the same document. The *ethane* concentration in MW16-15R is shown to be 9.1 μg/L. Low levels of chloroethane constituents have been detected in a number of monitoring wells including up to 4.0 μg/L of 1, 1 TCA in MW16-21D. These have been dismissed by the Navy as "contaminants" to TCE production. EPA would disagree with that interpretation. It is not likely that the 9.1 μg/L of ethane suggests TCE contamination with trace chloroethanes. This concentration suggests the near end product of degradation of larger concentrations of chloroethanes. These constituents have been released in significant mass up gradient.

While there may be disagreement concerning this interpretation, there is at present insufficient data in the area to the north of the former Building 41 footprint (i.e. Davisville Road) and the northeast end of the former building footprint (i.e. area of the Navy inferred source). To that extent, implementation of the HRC® injection pilot test in the area proposed will have the potential to obfuscate the actual contaminant distribution and migration pathways. Conduct of activities in this area should not be performed until there is resolution of the contaminants' distribution and origin in this area. Understanding this is paramount to effective design of any remedial system including the proposed pilot study.

Response— Regarding the upgradient source area (former PR-58 Nike Site and Navy Site 03 areas) issue, please refer to the Navy's 12 November 2003 letter 'Site 16 Hydrogeological Concerns', the Navy's evaluation of concerns presented by EPA during the 11 September 2003 BCT meeting. As stated in the Navy's General Response to EPA's comments, through the installation and baseline sampling of the monitoring and injection wells for the proposed pilot test, the understanding of the site character would be significantly increased. If the baseline sample results were to indicate the presence of a high concentration source area (DNAPL) at one or more of these new wells, the design and type of the pilot test would be reconsidered.

Comment 4: Pilot Study Scale

Review of the proposed HRC® Injection Pilot Study QAPP does not suggest that the study is, in fact, a "pilot study." The level of resources being applied and the extent of the area of the study actually suggest that it is a full scale remedial effort targeted at a presumed source area. The QAPP lists a total of 12 deep overburden HRC® injection wells, 12 bedrock HRC® injection wells, 13 new deep overburden monitoring wells, and 15 new bedrock monitoring wells. Geophysical borehole logging will be performed on 27 bedrock wells. This level of effort in conjunction with soil sampling, slug testing, etc. is a major level of effort not associated with pilot studies. This work is usually associated with remediation system pre-design investigation and remedial system implementation.

Additionally, the same company that authored this document recently submitted a Draft Preliminary Identification and Screening of Remedial Action Technologies for Ground Water (EA, September 2003) for this site. The document concludes that HRC® injection is a viable remedial alternative for this site, and recommends that a treatability study be performed. A pilot study on the scale proposed in this document constitutes much more than a treatability study, even though it is referred to as such in this document. Guidance on conducting treatability studies for evaluation of anaerobic dechlorination of groundwater contaminants is provided in the literature and in publications available from the U.S. Department of Defense's Environmental Security Technology Certification Program website.

Given the stated objectives of the pilot study in this QAPP, this level of effort is excessive and is not warranted, even if the limitations expressed in the preceding paragraphs were not applicable. It would be more rational to use available resources to help resolve the source of the elevated CVOC issue (by installing more monitoring wells) prior to the pilot study. A proposed remedial program that is not founded on basic understanding of the area intended to be treated, is a "blind" approach.

Therefore, EPA does not concur with the implementation of the proposed pilot test. There is sufficient literature to document that HRC® can create reducing conditions, reduce TCE concentrations in groundwater, and generate degradation "daughter" products. This assessment does not require a pilot study, let alone one of the magnitude, limited usefulness and potential risks posed by the one described in this QAPP.

Response— Please refer to the Navy's General Response to EPA's comments.

Comment 5: Recommendation

If a pilot test has to be performed, EPA recommends one be conducted that gains useful data, minimizes potential excessive contaminant generation (i.e. vinyl chloride), and is significantly less costly to the Navy. The recommended area for conduct of this pilot test should be further to the east of the proposed site. The HRC® injection points should be no closer to the former Building 41 footprint than a line parallel to MW16-22D. Monitoring of the effects of injection can be accomplished in the area to the east toward MW16-23D and MW16-24D. The benefits of this area is that it is better defined in terms of CVOC contamination and has a lower relative starting concentration of CVOC that would result in lower potential vinyl chloride mass production.

Additionally, a smaller level of effort will yield satisfactory scale up design information. The HRC® injection can be accomplished with overburden injection wells only. To accomplish the stated objectives and develop design parameters there is no need to construct the 12 bedrock injection wells. In fact, the actual number of deep overburden injection wells may also be reduced to 8 or 10. The pilot study design also needs to be more detailed with particular attention being given to observing not only just TCE loss, and the product of degradation products, but the types of products (1, 2-cis DCE, vinyl chloride, ethylene, etc.) along with time elapsed in order to develop site specific degradation constants and also to ascertain whether vinyl chloride can actually be destroyed in a sufficient time frame.

In concert with the reduced pilot scale study, there should be an effort to resolve the issue of the origin of the CVOC at the northeastern end of the former Building 41 footprint. This activity can be incorporated into the pilot study effort without significant additional cost, and yet yield important design information relative to any possible full scale future remedial action. In addition to the reduced number of HRC® injection wells, there will be a reduced requirement for monitoring well clusters. The reduced scale pilot study can be conducted with no more than 6 or 7 new deep overburden monitoring wells. This would eliminate in addition to the 12 bedrock HRC® injection wells, 13 bedrock, monitoring wells and 6 or 7 overburden monitoring wells. Two or three of the 13 bedrock monitoring wells eliminated from the pilot study should be used to investigate the area at the northeast end of the former Building 41 footprint and along Davisville Road, as previously recommended. Two or three of the 6 or 7 eliminated overburden monitoring wells could likewise be used in this endeavor, all as part of a re-scoped pilot study.

Response— Please refer to the Navy's General Response to EPA's comments. Additionally, the injection wells have been located within the southwestern end of the area of elevated CVOC concentrations in deep ground water. A pilot test is planned, in part, to assess the site-effectiveness of a remedy technique; and therefore, would be located within an area of contaminated ground water as has been done for the proposed pilot test at Site 16. The Navy does not understand why moving the pilot test area northeast to the EPA-recommended location is better. Based on the March 2001 total CVOC results for wells in that area (MW16-21D, 1,904 µg/L; MW16-22D, 2,611 µg/L, and MW16-23D, 3,504 µg/L), it seems to have the same potential problems as EPA has voiced for the proposed injection test area.

SPECIFIC COMMENTS

Comment 6: **Page 2-8 of 2-14, Section 2-1, and Second Paragraph, All Bullets:** The description contained in the last portion of this paragraph is confusing. This location still has significant CVOC up gradient as indicated by the analytical results for MW16-32D and MW16-14D. Also, there is no documentation that an additional up gradient source that contributes to the observed contamination in the vicinity of MW16-15D/R, etc. does not exist. Secondly, the description of a pilot scale field test for future remediation of the source area does not correlate with the bulleted items. What is listed under the bullets appears to be a full scale remedial effort.

Response— The Navy disagrees. Refer to the Navy's response to EPA's General Comment No. 3. The Navy believes that a reasonable explanation for the elevated CVOC concentrations in this area is the result of spills outside former Building 41 from the historical activities in the early 1950s. Please refer to the fourth paragraph of the Navy's General Response to EPA's comments. We are not trying to create reducing conditions, but are trying to enhance (accelerate) the effects of the naturally occurring reducing conditions and document the results. The CVOC plume area covers a distance of nearly 0.25 mile. Therefore, it is difficult to understand how a pilot test at one end of that area would be considered as "a full scale remedial effort."

Comment 7: **Page 2-9 of 2-14, Bullet:** This statement suggests that the pilot test does not need to be performed at all. If the only objective is to see if HRC® works, that can be answered by detailed review of the literature and other case histories. Comparisons with similar hydrogeological and contaminant settings can be made. Also, if there is a need to actually apply HRC® to this site, there is no justification for performing the pilot study on such a large scale. A much smaller implementation would be totally sufficient to achieve the stated purpose. What is outlined in this QAPP is a full scale remedial effort. As an example there is no need for injection of HRC® in bedrock wells to prove its viability. Also, the number of overburden injection is excessive as are the number of groundwater monitoring well clusters.

Response— Please refer to the Navy's response to EPA's Comment No. 6.

Comment 8: **Page 5-4 and 5-5 of 5-5, Section 5.7:** As gleaned from the text in this section there is still no documentation identifying the location of the source of CVOC contributing to the observed contamination around the northeastern end of the former Building 41 footprint. Because of this, implementation of a pilot study at that location is not warranted. This is especially so given that the Navy has implied that is where the source of the observed CVOC contamination is located. It is totally unsound to implement a pilot study in an area of potentially high, unknown CVOC concentrations assuming that the concentrations are in range of 1,000 μg/L of CVOC. A review of Figure 5 does not show any previously existing groundwater monitoring wells in the area of the proposed HRC® injection well lines. While new monitoring wells are planned, the actual concentration of CVOC in groundwater at that location will not be known until then.

Response— Please refer to the Navy's General Response to EPA's comments and the Navy's response to EPA's Comment No. 6. The 2 rows of injection wells were purposefully located in between three existing wells (MW16-14D, -15D, and -32D) where the total CVOC was detected at 2,700–3,000 μg/L in the Nov-Dec 2002 samples and reasonably assumed to be representative of the intervening area. These three wells are located only about 55–150 ft from one another.

Comment 9: **Page 6-1 of 6-5, First Paragraph:** This paragraph states that the intent is to apply HRC® in "a potential source area." The assumption of a source area at the proposed location is total conjecture at this point. Through conduct of the Phase I and Phase II Remedial Investigations, there has been no supporting data for this interpretation. The rationale for implementing a full scale remedial effort (not a pilot study as stated) in an area of unknown CVOC concentration is not understood. This approach is contradictory to sound remedial engineering practice. If the Navy is privy to information regarding a contaminant source at this location, that information should be included in the Phase II Remedial Investigation Report.

Response— Please refer to the Navy's response to EPA's Comment No. 6. Yes, it is assumed to be a 'potential source area' with a concentration of 3–6 mg/L total CVOC based on the March 2001 and Nov-Dec 2002 samples that resulted from historical releases in the immediate vicinity. However, the specific location of the release(s) has not been encountered and may never be; although it is currently believed that because of the distances between these three wells and the similar CVOC concentrations detected in samples from them, the original source(s) has dispersed/diffused into what is currently detected here.

Comment 10: **Section 6.1 Project Overview Page 6-2:** The HRC material appears to have a high viscosity. It is unclear whether the HRC moves slower than ground water or whether the HRC mixes with ground water and moves as fast or faster. If the contaminant moves without being interacted (or retarded), then any injected fluid will just displace but barely mix with the contaminant. Please provide the mechanism on how the HRC material interacts with contaminated ground water at depth.

Response— For a summary of the mechanism, please refer to Attachment 1 of the QAPP—specifically, the Regenesis insert entitled "How It Works" and "Distribution of HRC in the Aquifer."

Comment 11: **Page 6-2 of 6-5, Third Paragraph:** The use of a groundwater seepage velocity of 1 foot/day is not supported by the data provided in the Phase I or Phase II Remedial Investigations. Hydraulic conductivity and gradient data from the Phase II results in a groundwater seepage velocity of approximately 0.33 feet/day. Somewhat perplexing though is that the hydraulic conductivity values given in the Phase I Remedial Investigation for the same monitoring wells conflict with values given in the Phase II Remedial Investigation report. Those values result in a velocity of almost 3 feet/day. The Navy has not explained this differential. The knowledge of actual groundwater seepage velocity is critical to design of the pilot study in order to establish appropriate groundwater monitoring points to maximize data from the test.

Response— Slug test data from both the Phase I and II investigations were recalculated during the writing of the Phase II Investigation Report using the same software and method (AquaSolv) for consistency, resulting in the values shown in Table 3-4. This will be noted in the text of the report. Please refer to the Navy's response to EPA's Comment No. 2B.

Comment 12: **Page 6-2 of 6-5, Fourth Paragraph:** This paragraph is somewhat dismissive of the potential threat due to vinyl chloride generation. Review of the site data in the Phase II Remedial Investigation data shows that vinyl chloride is present only at a concentration of 1.0 µg/L in MW16-29D down gradient from the proposed pilot test location. Vinyl chloride is somewhat higher at several locations in the Central Area of Site 16, but even then, no higher than 36 µg/L of vinyl chloride. Conversion of high concentrations of TCE is likely to generate very high concentrations of vinyl chloride at least as interim degradation products. Review of the HRC® literature enclosed in the Attachment shows that even with a single application of HRC® significant concentrations of vinyl chloride existed in the down gradient monitoring well a year after HRC® application. The production of vinyl chloride is not an insignificant issue. The pilot study must not result in generation of significant quantities of degradation products that pose a greater risk to down gradient receptors. This is a major concern and needs to be addressed prior to implementation of the pilot study, especially since the Navy implies that the pilot test will be conducted in a "potential source area" which has not been quantified.

Response— Please refer to the Navy's responses to EPA's Comment Nos. 1 and 9.

Comment 13: **Page 6-2 of 6-5, Second Bullet, First Paragraph:** Groundwater sampling is scheduled to end with a final sampling round conducted four months after HRC® application. The information regarding HRC® supplied in Attachment 1 indicates that HRC® may augment bioremediation in an aquifer for at least a year after injection. The proposed length of the pilot study will very likely not provide complete information on the results of the HRC® injection.

Response— Please refer to the fifth paragraph of the Navy's General Response to EPA's comments.

Comment 14: **Page 6-2 of 6-5, Second Bullet, Last Paragraph:** MW16-32D is not, as stated, an "up gradient" monitoring well. This well has had significant concentrations of CVOC constituents (TCE) recently detected in groundwater.

Response— MW16-32D is located upgradient of the injection wells. Please refer to the Navy's responses to EPA's General Comment No. 5.

Comment 15: **Page 6-3 of 6-5, Last Paragraph:** See Specific Comment above.

Response— Please refer to the Navy's response to EPA's 'Specific Comment above'.

Comment 16: **Page 6-4 of 6-5, Section 6.1.2:** The description of pilot testing is totally inadequate. It appears that the pilot study is being implemented in a "cookie cutter" approach. There is no data to provide information on groundwater quality in the "potential source area" where the HRC® injection will occur. There is no identification of what design parameters are intended to be monitored for (degradation rates? ratio of daughter products? mass of HRC® required? etc.). There is also no documentation for the proposed layout of HRC® injection wells, mass of material to be injection, rationale for monitoring frequency (correlated with groundwater seepage velocities), spacing of the injection wells, etc. At a minimum, a brief description of the pilot study design calculations and assumptions, including Regenesis software results (if used) should be provided. Furthermore, justification for the scope/scale of the proposed pilot test should be provided. Given the stated purpose of this pilot test, there is no justification provided for the injection of HRC® in bedrock and even the total number of overburden injection wells. Why will extensive slug testing and geophysical logging be performed after the fact, i.e. after design of the pilot test?

Response— Please refer to the Navy's General Response to EPA's comments.

Comment 17: **Page 7-1 of 7-1, Section 7.2:** The performance criteria set forth in this section does not support the conduct of a pilot study. The second paragraph of this section states "Pilot testing will be deemed successful if there is "a significant onset of the generation of the chlorinated daughter products (i.e., cis-1, 2-DCE) within the pilot test area by the conclusion of the pilot test." This is an extremely loose criterion that does not justify the scale of the proposed test. This information can be deduced from the literature. If a field test is desired, the objective can be accomplished on a far smaller scale.

Response— Please refer to the Navy's General Response to EPA's comments, particularly the fifth paragraph.

Comment 18: **Page 7-1 of 7-1, Section 7.2, Item 1:** The deep and bedrock groundwater at the site is known to be either strongly reducing (i.e. MW16-15R) or somewhat reducing. Application of any biodegradable organic material, whether HRC®, methanol/ethanol, molasses, etc. will create "strongly reducing conditions." This criterion does not warrant application of HRC®.

Response— Please refer to the Navy's General Response to EPA's comments.

Comment 19: **Page 7-1 of 7-1, Section 7.2, Item 2:** Because of the planned location of the pilot test injection wells in a "potential source area" or in a discharge area from migrating up gradient releases, there is a strong possibility that "onset of decline of dissolved parent chlorinated (TCE)" will be masked and not observed.

Response— Please refer to the Navy's response to EPA's Comment Nos. 3 and 14.

Comment 20: **Page 7-1 of 7-1, Section 7.2, Item 3:** What does "sufficient onset of the generation of CVOC daughter products (e.g. at a minimum 1, 2-cis DCE)" mean? This daughter product is already present in MW16-15R. What constitutes "sufficient"?

Response— The Navy considered "sufficient" to be increasing concentration of cis-1,2-DCE, not just the few parts per billion present under ambient conditions. However, the QAPP will be revised to include a 12-month pilot test. Please refer to the Navy's General Response to EPA's comments, particularly the fifth paragraph.

Comment 21: **Page 7-1 of 7-1, Last Sentence:** The 50 to 70 percent reduction of parent CVOC over a 6 to 8 month time frame suggests that there may be minimal reduction in the much shorter time frame of 1 to 4 months. What percent of parent CVOC reduction then would be considered "successful" in the shorter time frame?

Response— The QAPP will be revised to include a 12-month pilot test. Please refer to the Navy's General Response to EPA's comments, particularly the fifth paragraph.

Comment 22: **Section 7.2 Measurement Performance Criteria:** The monitoring period should be extended more than 1 year as long or as HRC resides within soil matrix.

Response— Please refer to the fifth paragraph of the Navy's General Response to EPA's comments.

Comment 23: **Page 8-1 of 8-2, Third Paragraph:** This paragraph states that the pilot test will be at a location with minimal input of CVOC from up gradient. However, this dismisses the potential for contribution from up gradient such as the Nike PR-58 site and/or Site 03 or some other contributor. It also does not explain the past high concentrations of CVOC (TCE) observed at MW16-32D an "up gradient" well. Additionally, this assumption is made even though the Navy calls this location a "potential" source area. Finally, there is no data provided in either the Phase I or Phase II Remedial Investigations to support the assumption that the area at the northeast corner of the former Building 41 footprint is a "potential source area." The logic of this approach is not understood

Response— Please refer to the Navy's responses to EPA's Comment Nos. 3 and 14.

Comment 24: **Page 18-1 of 18-1, 1st Paragraph:** The text states that data validation "is not anticipated for data obtained from the pilot test." However, page 14-1 of 14-1 states that groundwater data collected "will be added to the site database for comparison of before and after" concentrations, and "soil data will be added to the database for additional characterization of the nature and extent of CVOC in deep soil in the specific area of the HRC pilot test." If there is an intention to rely upon this data for long term remedial decision-making, the appropriate validation should be conducted on this laboratory data set.

Response— The data are planned for assessment of the pilot test, not for long-term remedial decision-making.

Comment 25: **Figure 2:** Inspection of this figure in conjunction with Figure 5 shows that the proposed locations of the HRC® injection wells are not up gradient of the CVOC mass. MW16-32D has a concentration of 2,711 µg/L of CVOC. The concentration was even higher during the last sampling of this well. MW16-14D has significant CVOC at a concentration of 3,003 µg/L of CVOC. This well is also "up gradient" of the line of injection wells. Both of these concentrations are equal to or higher than the one down gradient well, MW16-15D with a concentration of 2,703 µg/L of CVOC. The distribution of CVOC depicted on this figure in concert with other remedial investigation data actually suggests an input to this area from the west northwest of MW16-15D along Davisville Road. Investigations within the former Building 41 did not identify a source beneath the building (i.e. MW16-32D). No source was identified at the MW16-15D location. While CVOC was identified at the MW16-37D location, it was interpreted to be noncontributory to the pilot study area. Since MW16-32D and MW16-14D lie up gradient of the HRC® injection lines and no surface release source area has been identified, the origin of this CVOC contamination can only be from a direction to the northwest of the northeastern end of the former Building 41. The Navy should provide a rationale (data) to support their interpretation that the location of the HRC® injection well lines are in the area of a "potential source."

Response— Please refer to the Navy's response to EPA's Comment No. 14.

Comment 26: **Figure 5:** The rationale for the HRC® injection well and groundwater monitoring well layout is not understood. Why are the injection wells located down gradient of the two highest contaminated wells, i.e. MW16-32D and MW16-14D? If the "potential source area" is presumed to lie just down gradient of the injection wells shown, why is the majority of the groundwater monitoring wells situated along the southeastern periphery of the flow path from the injection wells? Why are the bulk of the injection wells installed over an area for which there is no data? The majority of the wells are positioned within the former Building 41 footprint in an area for which there are no monitoring wells or soil borings.

Also not explained is the basis of design for the number and location of injection wells. The "Design Manual" supplied by Regenesis states that design is impacted by groundwater velocity, plume size, contaminant mass, and time to reach target CVOC reduction goals. It is also affected by microbial and electron acceptor demand for the organic material in HRC®. The major design issues are (1) the amount of HRC® or HRC X (S) that will be required to support biodegradation for a given CVOC mass and associated additional demands such as dissolved oxygen, iron, etc; and (2) the number and configuration of the HRC® delivery locations to effectively distribute the HRC® to the zone of contamination. Nowhere in this QAPP is this analysis provided. The design arrangement appears to be a barrier configuration. What is the basis for injection well spacing? What is the basis for the mass of HRC® to be placed into each injection well? How far down gradient are loss of TCE and production of 1, 2-cis DCE and vinyl chloride expected to occur for the soils, groundwater velocities, contaminant mass, electron acceptors, microbial population etc. present?

Response— The two northeasternmost monitoring wells will be moved slightly toward the northwest so they are closer to the centerline of the flow from the test area. Please refer to the Navy's General Response to EPA's comments and the Navy's response to EPA's Comment No. 14.

Comment 27: **Figure 6:** What is the rationale for construction and injection into competent bedrock? This figure suggests that there is minimal potential for effective use of HRC® to be injected at this interval. That is, the bedrock is depicted as being "competent" versus weathered or highly fractured. Injection of HRC® into the bedrock, even if weathered or highly fractured will not yield significantly increased information for the stated purpose of this pilot study.

***Response*—** Injection into the upper bedrock ground-water zone has been deleted from the revised pilot test.

Comment 28: **Tables 7-1 and 8-1:** EPA Region 1 has replaced RSK-175 (the method listed in these tables for methane) with an updated method that is also used to analyze for ethane and ethene. The method can be found at the following website: www.epa.gov/region1

***Response*—** The new method will be used and added to the QAPP.

Comment 29: **Table 7-4, Page 2 of 2:** The table refers to comparability criteria, which most likely do not apply to the soil sampling event since the soil at each specific sampling location cannot be sampled more than once.

***Response*—** Agreed; it will be deleted.

Comment 30: **Attachment 1, Regenesis Literature, Enhanced Bioremediation of TCE at Department of Defense Landfill Site:** This case study suggests that in addition to 1, 2-cis DCE being produced during degradation significant mass of vinyl chloride is produced. This production peaks approximately one year after the initial, single application of HRC®. This presents two concerns. The first is the vinyl chloride itself. At the ratio of production shown on the graph, the concentrations of vinyl chloride will dramatically increase in down gradient groundwater. The second is that this will occur long after the completion of the pilot study. Therefore, there is no mechanism to evaluate the adverse impacts of remedial activity using HRC®.

Regenesis literature dismisses the vinyl chloride problem as stating that it has not been a problem on any of its sites. There is a caveat though that if there is a problem it can be corrected with installation of oxygen (i.e. injection wells using ORC® or oxygen release compound also supplied by Regenesis. With all due respect to Regenesis, the vendor, vinyl chloride can exist for significant time without degradation. It should be noted that degradation of vinyl chloride is not favored in reducing or anaerobic environments. Also vinyl chloride will have a greater mobility in groundwater. Therefore, there is the risk that implementation of this relatively large scale pilot study will pose a greater hazard to down gradient receptors. How will this risk be mitigated given that the pilot study will be over for some time?

***Response*—** Please refer to the Navy's response to EPA's Comment No. 1.

Comment 31: **Attachment 1 Section 5.4.1 HRC Injection:** Typo? Change the heating temperature from "95 C" to "95 F."

***Response*—** The typo will be changed from "95 C" to "95°F."

Comment 32: Appendix, Safety, Health, and Emergency Response Plan (SHERP), Page 18 of 27, Section 9.1, First Paragraph: The text mentions calibration and use of a PID to conduct air monitoring at the site. An FID, widely accepted as being more useful and accurate to measure CVOCs in air, is mentioned in various field sampling SOPs in Attachment 1. An FID should therefore be referred to in the SHERP rather than the PID.

Response— The PID is appropriate and will be used for health and safety monitoring. The FID also detects methane, which is not anticipated to be an issue in this part of the Site 16 investigation area.

RESPONSES TO RIDEM COMMENTS DATED 23 OCTOBER 2003 ON THE SITE 16 QAPP FOR HRC INJECTION PILOT STUDY OF SEPTEMBER 2003 NAVAL CONSTRUCTION BATTALION CENTER DAVISVILLE NORTH KINGSTOWN, RHODE ISLAND

Comment 1: **Page 6-1, Section 6.1, Project Overview, Bullet 2;** This bullet notes that the two soil samples will be collected from the soil samples with the highest headspace vapor reading. Visual and olfactory signs should also be considered when selecting the samples for laboratory analysis. In many instances high headspace readings do not necessarily translate into high analytical results.

Response— Agreed. Visual and olfactory signs will be added to the criteria for selecting the samples for laboratory analysis.

Comment 2: **Page 6-1, Section 6.1, Project Overview, Bullet 5, Paragraph 2;** This paragraph states that monitoring of the HRC pilot test will occur over a period of four months. This time period seems inadequate. Hydraulic conductivity values, in general, from Table 3-5 of Site 16 Phase II RI seem to be in the range of 10^0 to 10^1. Hydraulic gradient values in general, from Table 3-4 of Site 16 Phase II RI, seem to be in the range of 10^{-3} to 10^{-2}. This would give a groundwater velocity of less that one foot per day as noted in paragraph 4 of this section.

Even if one were to assume that all the contamination at Site 16 came from the NIKE PR58 site, which is about one mile away, then at a groundwater flow velocity of one foot per day and initial contamination occurring approximately 50 years ago Site 16 should have been flushed through twice with this contamination. Since high concentrations of CVOC exist at both sites it is clear that CVOC does not move nearly as fast as the groundwater or there is a continuing source. In addition, the reactions must take place at a fairly slow rate since concentrations of vinyl chloride, a breakdown product, are not that high. Therefore, monitoring for four months may not be a sufficient amount of time to determine the effectiveness of this pilot study.

Response— Please refer to Navy's General Response to EPA's comments, particularly the fifth paragraph.

Comment 3: **Section 6, Project Description and Schedule, General Comment;** Please explain how it was determined that twelve injection wells are needed for the pilot study and how the number of monitoring wells were determined. Also state what area is expected to be treated and what the radius of influence of the pilot test will be.

Response— Please refer to Navy's General Response to EPA's comments.

Comment 4: **Section 6, Project Description and Schedule, General Comment;** It is noted that vinyl chloride will be produced as a by-product of the HRC injection. Since the purpose of the HRC is to enhance the degradation of CVOC please state if calculations have been prepared to determine how much vinyl chloride (degradation product) will be produced as a result of this pilot study. RIDEM considers vinyl chloride to be more toxic than TCE and therefore would be concerned about its impact on human health and the environment. In addition, please state if any contingency plans have been developed to deal with a significant increase in vinyl chloride.

Response— Please refer to Navy's General Response to EPA's comments, particularly the last paragraph.

Comment 5: **Page 6-3, Section 6.1.1, Use of HRC…., Paragraph 2;** This paragraph makes two points about the use of HRC 1) that HRC is used in tandem with other technologies, and 2) that more than one round of HRC injection could be needed. Please state what other types of technology would be used in conjunction with HRC and would this be necessary at this site and since there are five source areas would a continuing influx of new contaminated water eventually require a new application of HRC.

Response— The comment references a general statement in the QAPP about an alternative use of HRC®. Such tandem technologies have not yet been determined for Site 16. This project is a pilot test for a technology that appears to be very promising for this site. The results of this project will be included in the future Feasibility Study for this site which will recommend the remedy.

Comment 6: **Page 6-4, Section 6.1.1, Use of HRC…., Paragraph 1;** This paragraph states that VC gas would not be expected to enter the vadose zone for many years (if not decades). The rate at which gas will travel through the soil will in part be dependant on the type of soil at the site. Soil gas surveys are routinely used at sites where chlorinated solvents have been released to the environment to map out plume locations. At one such superfund site in Rhode Island, chlorinated solvents were dumped during the late 1970's. In 1985 soil gas measurements were successfully used to map out the plume (a period of less than 10 years). In order to determine the approximate amount of gas to be produced a mass balance calculation would need to be prepared in conjunction with the calculations requested in comment #4.

Response— Only trace concentrations of VC have been detected to date in ground-water samples from monitoring wells. Performance of a soil gas study in the near future to assess VC release from this proposed pilot test would not be useful, but would be considered in the future.

Comment 7: **Table 7-1;** Project action, detection, laboratory and quantitation limits are expressed in mg/l. please state if this is an error and they should be expressed as ug/l.

Response— The units for the VOC parameters will be changed to µg/L. The remainder of the table is correct with mg/L.

Comment 8: **Page 8-1, Section 8.2, Ground-Water Sampling from Monitoring Wells, Paragraph 1, Sentence 1;** This sentence states that 63 wells will be installed for the pilot study while Section 2.1, Bullet 1 implies that 52 wells will be installed. Please clarify.

Response— The referenced sentence in Section 8.2 will be changed to '52' wells.

Comment 9: **Page 9-1, Section 9.4, Field Equipment Maintenance, Testing, Calibration, and Inspection;** It is stated that each piece of equipment will be checked to determine that it is within 10% of its calibration standard. If, at then end of the day, it is found that the piece of equipment exceeds its calibration standard please state if those samples will be retaken.

Response— The soil samples would not be re-collected. There is not a way to re-collect such samples from the same borehole, and samples from an adjacent borehole would not provide the same sample because of the heterogeneity of the soil.

Comment 10: **Page 15-1, Section 15.1, Project Documentation and Records;** This paragraph states that project documentation will be retained and maintained by the contractor. Should the Navy change contractors please state if the Navy, its new contractor, and interested stakeholders will still have access to the information generated in this pilot study.

Response— The referenced sentence will be revised as follows: "The field records will be maintained and retained by EA until the end of the project or the end of the contract with the Navy, which ever comes first, at which time the field records will be transferred to the Navy."

Comment 11: **Page 16-1, Section 16, Paragraph 2;** Please note that under its authority RIDEM can issue a cease and desist order if it is found that work being performed is inconsistent with RIDEM Rules and Regulations or is adversely affecting the environment.

Response— Comment noted.

Comment 12: **Attachment 1, Sections 1.8, 1.8.1, 1.8.2, 1.8.3 Investigative Derived Waste (IDW) Management;** Each one of these sections notes that there will be temporary storage pending its disposition for proper disposal. Please define what proper disposal means in each of these sections.

Response— Depending upon whether the characterization of the material is determined to be non-hazardous or hazardous waste, a disposal method/firm will be selected that can legally handle such waste material.

Attachment 1

OBJECTIVE:
Based on site data from the Phase I and Phase II Remedial Investigations, calculate the average aquifer hydraulic conductivity, average concentration of dissolved phase CVOC, and average concentration of competing electron acceptors for input to Regenesis Software HRC Barrier Design.

ASSUMPTIONS:
Use data on the above parameters collected from deep monitoring well locations near the position of the proposed HRC Pilot Test near the northeast end of former Building 41. Deep monitoring well locations in this area include MW16-14D, MW16-15D, and MW16-32D.

PROCEDURE:
1. Calculation of Average Hydraulic Conductivity (K).
K determined by slug test method for Phase II RI data (Table 3-5).
MW16-14D 1.84 ft/day
MW16-15D 12.77 ft/day
MW16-32D 55.6 ft/day
Average K = (1.84 + 12.77 + 55.6)/3 = 23.4 ft/day

2. Calculation of Hydraulic Gradient (Dh/Dl)
Dh/Dl determined from Phase II RI Ground-Water Surface Contour Map for Deep Wells (Figure 3-26) within area of proposed pilot.
Dh/Dl = (15 ft –12 ft)/470 ft = 3 ft/470 ft = 0.0063 ft/ft

3. Calculation of Average Concentration of Dissolved Phase CVOCs.
Average concentration of CVOC compound elevated in area of pilot calculated from Phase I and Phase II RI data. Elevated CVOCs in this include TCE, PCE, and cis-12DCE.
TCE @ MW16-14D 4900 ug/L (Phase I), 3000 ug/L (Phase II)
TCE @ MW16-15D 6200 ug/L (Phase I), 2700 ug/L (Phase II)
TCE @ MW16-32D N/A (Phase I), 2700 ug/L (Phase II)
Average TCE = (4900 + 3000 + 6200 + 2700 + 2700)/5 = 3900 ug/L

PCE @ MW16-14D <1.0 ug/L (Phase I), 0.3 ug/L (Phase II)
PCE @ MW16-15D 0.7 ug/L (Phase I), 0.67 ug/L (Phase II)
PCE @ MW16-32D N/A (Phase I), 0.618 ug/L (Phase II)
Average PCE = (0.5 + 0.3 + 0.7 + 0.67 + 0.618)/5 = 0.558 ug/L

cis-12DCE @ MW16-14D 5.0 ug/L (Phase I), 1.87 ug/L (Phase II)
cis-12DCE @ MW16-15D 3.0 ug/L (Phase I), 2.18 ug/L (Phase II)
cis-12DCE @ MW16-32D N/A (Phase I), 7.03 ug/L (Phase II)
Average cis-12DCE = (5.0 + 1.87 + 3.0 + 2.18 + 7.03)/5 = 3.82 ug/L

4. Calculation of Average Concentration of Competing Electron Acceptors.

Average dissolved concentration of competing electron acceptors in area of pilot calculated from Phase I and Phase II RI ground-water quality data. Competing electron acceptors requiring evaluation in Regenesis Software include oxygen, nitrate, manganese, iron, and sulfate.

DO @ MW16-14D 0.19 mg/L (Phase I), 0.57 mg/L (Phase II)
DO @ MW16-15D 1.0 mg/L (Phase I), 0.47 mg/L (Phase II)
DO @ MW16-15R 0.08 mg/L (Phase I), N/A mg/L (Phase II)
DO @ MW16-32D N/A (Phase I), 1.78 mg/L (Phase II)
Average DO = (0.19 + 0.57 + 1.0 + 0.47 + 0.08 + 1.78)/6 = 0.68 mg/L

NO_3 @ MW16-14D ND (Phase I), <0.1 mg/L (Phase II)
NO_3 @ MW16-15D ND (Phase I), <0.1 mg/L (Phase II)
NO_3 @ MW16-15R ND (Phase I), <0.1 mg/L (Phase II)
NO_3 @ MW16-32D N/A (Phase I), <0.1 mg/L (Phase II)
Average NO_3 = (0.05 + 0.05 + 0.05 + 0.05)/4 = 0.05 mg/L

Mn @ MW16-14D 0.424 mg/L (Phase I), 0.290 mg/L (Phase II)
Mn @ MW16-15D 0.190 mg/L (Phase I), 0.150 mg/L (Phase II)
Mn @ MW16-15R 0.457 mg/L (Phase I), 0.230 mg/L (Phase II)
Mn @ MW16-32D N/A (Phase I), <0.015 mg/L (Phase II)
Average Mn = (0.424 + 0.290 + 0.190 + 0.150 + 0.457 + 0.230 + 0.007)/7 = 0.25 mg/L

Fe @ MW16-14D 8.17 mg/L (Phase I), 2.4 mg/L (Phase II)
Fe @ MW16-15D 2.06 mg/L (Phase I), 1.3 mg/L (Phase II)
Fe @ MW16-15R 7.48 mg/L (Phase I), 2.2 mg/L (Phase II)
Fe @ MW16-32D N/A (Phase I), <0.1 mg/L (Phase II)
Average Fe = (8.17 + 2.4 + 2.06 + 1.3 + 7.48 + 2.2 + 0.05)/7 = 3.38 mg/L

SO_4 @ MW16-14D ND (Phase I), 20.0 mg/L (Phase II)
SO_4 @ MW16-15D ND (Phase I), 20.6 mg/L (Phase II)
SO_4 @ MW16-15R ND (Phase I), 7.73 mg/L (Phase II)
SO_4 @ MW16-32D N/A (Phase I), 2.27 mg/L (Phase II)
Average SO_4 = (20.0 + 20.6 + 7.73 + 2.27)/4 = 12.6 mg/L

CONCLUSION:

Calculated data will be utilized in Regenesis Software for HRC Barrier Design in Deep Overburden Zone. Based on lack of data for Rock Zone, will use average of Phase I and Phase II data for MW16-15R, when available, for input to Regenesis Software in Rock Zone. Additional data collected during installation of Deep and Rock Pilot Test Injection Wells will be used to refine design calculations for both the Deep and Rock Zones.

HRC Design Software for Barrier Treatment

Regenesis Technical Support: USA (949) 366-8000, www.regenesis.com

Site Name: HRC Pilot Northeast of Building 41 - Deep Overburden Zone
Location: Site 16 - NCBC Davisville, RI
Consultant:

Site Conceptual Model/Extent of Plume Requiring Remediation

Length of Barrier (intersecting gw flow direction)	120	ft	
Depth to contaminated zone	45	ft	
Thickness of contaminated saturated zone	20	ft	
Aquifer soil type	sand	<-(not recognized, enter Kh or Vs below)	
Effective porosity	0.3		
Hydraulic conductivity	23.4	ft/day =	8.3E-03
Hydraulic gradient	0.006	ft/ft	
Seepage velocity	170.8	ft/yr =	0.468

Dissolved Phase Electron Donor Demand	Contaminant Loading		Stoich. (wt/wt)
	Conc (mg/L)	Mass (lb)	contam/H_2
Tetrachloroethene (PCE)	0.00	0.00	20.7
Trichloroethene (TCE)	3.90	29.92	21.9
cis-1,2-dichloroethene (DCE)	0.00	0.03	24.2
Vinyl Chloride (VC)	0.00	0.00	31.2
Carbon tetrachloride	0.00	0.00	19.2
Chloroform	0.00	0.00	19.9
1,1,1-Trichloroethane (TCA)	0.00	0.00	22.2
1,1-Dichlorochloroethane (DCA)	0.00	0.00	24.7
Hexavalent Chromium	0.00	0.00	17.3
User added, also add stoichiometric demand	0.00	0.00	0.0
User added, also add stoichiometric demand	0.00	0.00	0.0

	Electron Acceptor Loading		Stoich. (wt/wt)
Competing Electron Acceptors:	Conc (mg/L)	Mass (lb)	contam/H_2
Oxygen	0.68	5.22	8.0
Nitrate	0.05	0.38	12.4
Est. Mn reduction demand (potential amt of Mn2+ formed)	0.25	1.92	27.5
Est. Fe reduction demand (potential amt of Fe2+ formed)	3.38	25.93	55.9
Estimated sulfate reduction demand	12.60	96.67	12.0

Microbial Demand Factor	3	Recommend 1-4x
Safety Factor	2	Recommend 1-4x
Lifespan for one application	1	Year(s)

Injection Spacing and Dose:

Number of rows in barrier	2	rows
Spacing within rows	20	ft on center spacing within rows
Effective spacing perpendicular to flow (ft)	10.0	
Total number of HRC injection locations	12	points
Minimum required HRC dose per foot (lb/ft)	5.5	

Project Summary			
Number of HRC delivery points (adjust as nec. for site)			12
HRC Dose in lb/foot (adjust as nec. for site)			5.5
Corresponding amount of HRC per point (lb)			111
Number of 30 lb HRC Buckets per injection point			3.7
Total Number of 30 lb Buckets			45
Total Amt of HRC (lb)			1,350
HRC Cost		$	7.50
T tal Material Cost		**$**	**10,125**
Shipping and Tax Estimates in US Dollars			
Sales Tax	rate: 0%	$	-
Total Matl. Cost w/Tax		$	10,125
Shipping of HRC (call for amount)		$	-
Total Regenesis Material Cost		**$**	**10,125**

Project	Site 16 HRC Injection Pilot Study – NCBC Davisville, RI	Project No.	2960107
Subject	Step 3: Calculations for Transport of HRC Reagent	Sheet No.	1 of 1
	HRC Barrier Treatment Design	Drawing No.	

Computed by FTB Date 9/03 Checked by ______ Date ______

OBJECTIVE:
Based on site data from the Phase I and Phase II Remedial Investigation Reports and output from Regenesis Software, calculate the distance of travel of HRC reagent based on observed groundwater seepage velocity and four month duration of Pilot Test.

ASSUMPTIONS:
Use calculated data on the average hydraulic conductivity (K), hydraulic gradient (Dh/Dl) and, therefore, average groundwater seepage velocity (V) within the Deep Zone (see Software Input Calculations) to determine average HRC seepage velocity for the Deep and Rock Zones. Due to lack of K data for Rock Zone, average groundwater seepage velocity will be assumed as same as Deep Zone. More specifically, average HRC reagent seepage velocity will be 170.8 ft/yr as calculated by Regenesis Software for Deep and Rock Zones. Additional data collected during installation of Deep and Rock Pilot Test Injection Wells will be used to refine design calculations for both the Deep and Rock Zones. Although Pilot Test measured only initially over four months, time duration for complete utilization of one round HRC reagent injection estimated to be one year.

PROCEDURE:
1. Calculation of Travel Distance (D_{HRC})of HRC Reagent over Time Duration (T) of Pilot Test.

D_{HRC} = V * T = 170.8 ft/yr * 0.33 yrs = 56.4 ft downgradient of HRC injection rows.

2. Calculation of Travel Distance (D_{HRC})of HRC Reagent over Time Duration (T) for complete utilization of one round of HRC reagent injection.

D_{HRC} = V * T = 170.8 ft/yr * 1.0 yrs = 170.8 ft downgradient of HRC injection rows.

CONCLUSION:
Monitoring well placement for HRC Pilot Test designed to incorporate area of HRC reagent transport from four months to approximately one year (i.e., estimated timeframe for complete utilization of one round of HRC injection). Monitoring wells for Pilot Test placed in a longitudinal and transverse array (Figure 5 of QAPP for HRC Pilot Study) to measure short term (four months) and long term (one year)effectiveness of HRC to create strongly reducing conditions and enhance anaerobic biodegradation.