Basinski, Ralph

From: Basinski, Ralph
Sent: Tuesday, April 24, 2001 12:08 PM
To: 'Bill Gates'; 'Tom Brent'
Cc: Johnston, Tom; Perry, Mark; Jackman, Tom
Subject: Jeep Trail/Little QAPP Creek QAPP- EPA's Comments on Responses

BILL: Following are the responses to EPA's comments on the responses. Please advise if these are OK.

The planned shipment date for the final QAPP is Friday, April 27, 2001. It should be n your hands on Monday, April 30, 2001.

-----Original Message-----
From: Ramanauskas.Peter@epamail.epa.gov
[mailto:Ramanauskas.Peter@epamail.epa.gov]
Sent: Thursday, April 19, 2001 5:13 PM
To: Gates, William (Efdsouth)
Cc: Basinski Ralph (E-mail); Brent Tom (E-mail)
Subject: Re: OJT RESPONSE TO COMMENTS

a
Gen,

I have sat down together with Allen & Mario and reviewed the relevant responses to comments.

Referring to MGBG Comment 37, I would like to see the round one sampling and cumulative risk/cumulative hazard data prior to the Navy's determination of whether or not the contamination boundary has been fully delineated.

The Navy will provide the round one sampling and cumulative risk/cumulative hazard data to U.S. EPA for concurrence on the Navy's determination of whether or not the contamination boundary has been fully delineated. This submission will be made prior to the submission of the RFI report.

No changes were made to the QAPP in response to this comment.

Referring to Comment 30, for clarification purposes, could you please change references to "HH risk" thoughout the document to "HH cumulative cancer risk"?

The term "HH risk" was used only in the figure. "HH risk" is neither used in the text of the document nor in the appendices. Instead, risk from exposure to carcinogens are referred to as "cancer risks", "incremental cancer risks (ICRs)" or "lifetime cancer risks".

Figure 1-21 has been revised to change HH risk to HH cumulative cancer risk. No changes to text were necessary.

Referring to Specific Comment 28, please confirm that the slope factor that will be used in the risk assessment for Total Aroclor is 2.0 (mg/kg-day) (superscript: -1)

The slope factor that will be used in the risk assessment for Total Aroclor is 2.0 (mg/kg-day).

No changes were made to the WAPP to address this comment.

While I have not yet received feedback on the ecological responses, the n e of the comments has no effect on the sampling work required at the OJT. As such, you may proceed with QAPP revision at your discretion. If I receive any further comments related to ecological topics, I will forward

them to you.

Thanks!
Pete

U.S. EPA COMMENTS (3/2/01) ON THE QUALITY ASSURANCE PROJECT PLAN FOR RCRA RFI PHASE III AT SWMU #3
ABG - LITTLE SULPHUR CREEK & JEEP TRAIL - DATED SEPTEMBER 2000
NAVAL SURFACE WARFARE CENTER
CRANE, INDIANA

General Comments

Comment 1:

Please verify that our agreed upon position regarding the use of one-half Method Detection Limits for non-detect analytes selected as COPCs for calculation of Exposure Point Concentrations has been noted in this QAPP.

The following sentence has been added to Section 1.4.2.2 of the QAPP (page 1-31).

"One-half the sample-specific detection limit (SDL), reported by the laboratory, will be used as a surrogate value for non-detect results when calculating the exposure point concentration".

Comment 2:

Please verify that comments pertaining to human health risk assessment sent to the Navy for other projects utilizing the same risk assessment methodology (i.e., Mustard Gas Burial Ground, Dye Burial Ground) are also addressed in this QAPP.

The Navy has reviewed EPA's comments related to the human health risk assessment on the QAPPs for the Dye Burial Grounds (DBG) and the Mustard Gas Burial Grounds (MBG). Comments specifically related to dyes, chemical agents, and radioactive substances were not considered applicable because these substances are not of concern at the Jeep Trail / Little Sulphur Creek. All remaining comments were considered potentially applicable and are listed below along with responses including descriptions of any changes to the QAPP. Comments are listed according to the comment number as described in the formal US EPA Region 5 comments on the DBG and MGBG QAPPS.

DBG Comment 16:

Section 8.1.2.1. states that the EPA Region IX screening concentrations will correspond to a hazard quotient of 0.1 for individual noncarcinogenic constituents. It should be noted that the published Region IX PRG values for noncarcinogens correspond to a hazard quotient of 1. These values would need to be multiplied by 0.1 to derive the screening concentrations proposed for use at the DBG. The proposal to use a HQ of 0.1 as a screening level is acceptable. If the Navy intended to state that the risk-based screening levels used in this study will be based on a Hazard Quotient of 0.1, instead of 1.0, to ensure that additive risk for all chemicals will not exceed 1.0 (as done for SWMUs 4, 5, 9, & 10), then this should be clarified in this section and screening values in the tables should reflect this.

The response to this comment is the same as the response to MGBG Comment 73.

This comment applies to Section C.1.2.1 Page C-6 in Appendix C of the Ammunition Burning Grounds, Little Sulphur Creek and Jeep Trail QAPP. The response is still applicable. The section and table numbers in the response below have been changed to match the Ammunition Burning Grounds, Little Sulphur Creek and Jeep Trail QAPP .

Four changes were made to address this comment.

1. The second sentence of Section C.1.2.1 was changed to read "Risk-based screening concentrations based on U.S. EPA Region IX...".

2. The following text was added before the last sentence of the first paragraph:

"It should be noted that the EPA Region IX PRGs for noncarcinogens are based on a hazard index of 1. The Region IX PRG values for noncarcinogens will be multiplied by 0.1 so that the screening concentrations will correspond to a hazard index of 0.1".

3. Figures 1-16 through 1-18 were changed to reflect that the screening for non-carcinogens will be at a HI value of 0.1. This was accomplished by replacing the text in the center decision diamond of each figure with the following text:

" Maximum concentration in any site sample > COPC screening level?**"

4. The attendant footnote (**) to each of the three changed figures now refers the reader to Appendix C, Section C.1.2.1 for details.

MGBG Comment 7:

In Section 1.1.3., a reference should also be made to the Region 9 PRG values which are alluded to elsewhere. Also, since radioactive materials are not covered under RCRA, the QAPP procedures to be followed for radiologicals, including references, should be added. This discussion does not mention how radiological materials will be handled. These decisions should be included in the QAPP.

Section 1.1.3 is, by design, to be used to identify the guidelines and requirements under which the QAPP is prepared rather than to address individual QAPP topics. Radioactive materials are not of concern for the RFI investigation at the Jeep Trail and Little Sulphur Creek. Therefore this comment is not applicable.

No changes were made to the QAPP to address this comment.

MGBG Comment 15:

Referring to Section 1.4.1., the section would benefit if an example could be presented showing how the MDL values will be calculated.

The following sentence was added as the next to last sentence in the last paragraph of Section 1.4.1.

"The CFR requires the MDL to be computed as the standard deviation of replicate analysis results multiplied by the appropriate Student's T value. Refer to Laucks SOP LTL-1011 for a numerical computation of IDL/MDL."

MGBG Comment 20:

Referring to the bullets found under the <u>Potential Current and Future Receptors of Concern and Exposure Pathways</u> subsection of Section 1.4.2.2., note that for radioactive materials, external exposure will be another, and very likely significant, pathway of exposure. It should be evaluated in every case, not "as necessary". Also note that the "Residents" receptor should be treated as a "Resident-Farmer" since it is likely they would grow some of their own food.

The "resident farmer" was not selected as a receptor of concern for 2 reasons:

- Based on the anticipated future land use, even the hypothetical future resident (this receptor was recommended for the baseline risk assessment) is a highly unlikely receptor for the site. The

evaluation of the "resident farmer" would be overly conservative. Additionally, contamination (assuming that it exists, please note that some remediation has already occurred at this site) is likely to be subsurface rather than surface (i.e., in the plow zone) given the history of the site.

- The uncertainty attached to the risk assessment results for the soil uptake/food ingestion pathways is high. Consequently, the utility of these results to risk managers is limited.

No changes were made to the QAPP to address this comment.

MGBG Comment 21:

Referring to the <u>Calculation of Exposure Point Concentration</u> subsection of Section 1.4.2.2., the second paragraph states that the primary Exposure Unit (EU) for soils will be the entire MGBG area of approximately 2 acres plus 20 feet in all directions. Will soil sampling actually occur in the zone of 20 feet? We would expect that the bulk of soil sampling would actually be performed in the areas of MGBG where contaminant releases were expected to have occurred based on historical operations. An alternative would be to employ a sample grid for use in estimating the EPC. As a starting point, a sample grid approach seems reasonable for this size area. However, if the sample grid results show that contaminant concentrations are highly skewed and that soil contaminant hot spots are likely, the RFI report must make this clear, since calculation of the EPC for the full 2-acre area would likely result in a much lower average site concentration. In such cases, the EPA project manager may elect to define a smaller area as the EU which could result in higher contaminant risks over a smaller area (i.e., higher risks over a much smaller potential remedial zone).

This comment is specific to the MGBG and does not apply to the Ammunition Burning Grounds, Little Sulphur Creek and Jeep Trail.

No changes were made to the QAPP to address this comment.

MGBG Comment 22:

Referring to the <u>Calculation of Exposure Point Concentration</u> subsection of Section 1.4.2.2., the third paragraph states that the EPC for ground water exposure under the MGBG will be the arithmetic average of wells in the highly concentrated area of a plume potentially underlying the study area. Please provide rationale for using this approach. If a plume of contaminated ground water is discovered, it would be advisable for NSWC to inform U.S. EPA about which wells would be combined to calculate the average value. The U.S. EPA project manager needs to agree that data from the appropriate wells would be selected for use in the risk assessment. Alternatively, after reviewing the available data, the U.S. EPA may elect to obtain data from additional new wells in order to ensure that the highest likely contaminant levels in the plume have been determined.

The rationale is based on accepted industry practice that takes into account the likelihood of installing a well in the most concentrated region of a contaminant plume as well as the fact that wells are not mobile. The approach is suggested in U.S.EPA Region 4 Supplemental Guidance to RAGS: Region 4 Bulletins, Human Health Risk Assessment (November 1995). The Navy agrees that NSWC should inform U.S.EPA about the wells used to calculate the average.

The following sentence has been added after the first sentence of the third paragraph in QAPP Section 1.4.2.2 on calculation of exposure point concentrations.

"This approach is based on the accepted industry practice that takes into account the fact that chemical concentrations in the ground water do fluctuate over time and the likelihood of installing a well in the most concentrated region of a contaminant plume. The approach is suggested in U.S. EPA Region 4 Supplemental Guidance to RAGs Region 4 Bulletins, Human Health Risk Assessment (November 1995)"

The following sentence has been at the end of the third paragraph in QAPP Section 1.4.2.2 on calculation of exposure point concentrations.

"The Navy will discuss with EPA Region 5 the best approach (modeling versus additional monitoring wells) to develop exposure point concentrations for specific receptor locations if it is apparent (based on the results of the proposed sampling) that significant contaminant migration is occurring."

MGBG Comment 23:

Referring to the third paragraph of the <u>Calculation of Exposure Point Concentration</u> subsection of Section 1.4.2.2., for ground water contaminant plumes that have migrated beyond the MGBG study area boundaries, it is stated that modeling techniques will be used to estimate EPCs for receptor locations. Does the current study area boundary include all areas in which ground water wells currently exist? It is recognized that modeling may be necessary to estimate ground water contaminant concentrations at locations further downgradient from the existing well network. But the U.S. EPA may decide on extension of the existing well network if significant contamination from a migrating plume is suspected, rather than relying on estimates from ground water flow/migration models.

Modeling techniques are included as an option for evaluation of EPCs at receptor locations.

The current study area boundary where monitoring wells will be sampled includes the entire area in which ground water monitoring wells currently exist. Results from the first round of ground water monitoring will be used to determine if the existing monitoring well network must be extended.

The following sentence has been added at the end of the third paragraph in QAPP Section 1.4.2.2 on calculation of exposure point concentrations.

"The Navy will discuss with EPA Region 5 the best approach (modeling versus additional monitoring wells) to develop exposure point concentrations for specific receptor locations if it is apparent (based on the results of the proposed sampling) that significant contaminant migration is occurring."

MGBG Comment 24:

Referring to the third paragraph of the <u>Calculation of Exposure Point Concentration</u> subsection of Section 1.4.2.2., the third bullet on page 1-25 states that data from multiple rounds of ground water sampling will be used to calculate an arithmetic average in the highly concentrated area of the plume unless a temporal trend is uncovered in the data, in which case only the most recent sampling event would be used. If a temporal concentration trend is proposed, the U.S. EPA needs to review and approve the criteria used in making such a decision.

The methodology for calculation of ground water exposure point concentrations (Section 1.4.2.2) states the following. "The EPC for ground water receptors will be the arithmetic average of wells in the highly concentrated areas of the plume". Additional monitoring wells may be installed if the area of contamination not bounded in order to determine the extent of contamination. The existing wells would not be resampled.

The following sentence has been added after the first sentence of the third paragraph in QAPP Section 1.4.2.2 on calculation of exposure point concentrations.

"This approach is based on the accepted industry practice that takes into account the fact that chemical concentrations in the ground water do fluctuate over time and the likelihood of installing a well in the most concentrated region of a contaminant plume. The approach is suggested in U.S. EPA Region 4 Supplemental Guidance to RAGs Region 4 Bulletins, Human Health Risk Assessment (November 1995)"

The following sentence has been added to the end of the third paragraph in QAPP Section 1.4.2.2 on calculation of exposure point concentrations.

"The Navy will discuss with EPA Region 5 the best approach (modeling versus additional monitoring wells) to develop exposure point concentrations for specific receptor locations if it is apparent (based on the results of the proposed sampling) that significant contaminant migration is occurring."

MGBG Comment 26:

The first paragraph on page 1-27 explains the criteria for recommending "no further action" and refers to the U.S. EPA's action level of 1E-4 cumulative cancer risk. IDEM's stated remedial goal of 1E-5 cumulative cancer risk (as presented in IDEM's Risk Integrated System of Cleanups: Technical Resource Guidance Document) should be used here and throughout the document, since IDEM will be involved in future decisions and remedial management at the NSWC facility.

It is the Navy's understanding that EPA Region 5 has primacy for this investigation and that the IDEM 1E-5 cumulative risk goal will not be followed. It is also the Navy's understanding that neither EPA Region 5 nor IDEM will challenge the use of a cumulative risk goal of 1E-4.

No changes have been made to the QAPP to address this comment.

MGBG Comment 27:

The first paragraph on page 1-39 states that chemical concentrations will be compared to risk based concentrations to make decisions about selecting COPCs for inclusion in the base line risk assessment. It is also stated that contour plots of individual COPCs will be plotted to represent the boundary where a risk of 1E-4 or an HI of 1.0 occurs. It is difficult to determine how useful such plots will be for making COPC selection decisions since the 1E-4 risk level and the HI of 1.0 are also proposed as the benchmarks for cumulative cancer risk and cumulative HI rather than the benchmarks for individual COPCs (See Comment 26 regarding cumulative cancer risk level). For individual COPCs, it may be more useful to show contour plots where cancer risk equals 1E-6, 1E-5, and 1E-4 and HI equals 0.1 and 1.0 in order to show the project managers the geographic relationship between concentration and risk. This could aid in showing the relative risk contribution between chemicals and in making decisions about the need for additional sampling.

This comment applies to the second paragraph in Section 1.4.4 (Page 1-45) of the Ammunition Burning Grounds, Little Sulphur Creek and Jeep Trail QAPP.

This paragraph identifies RBTLs/EDQLs as the "benchmarks" for identifying COPCs. Risk contours for individual chemicals are not suggested. Once COPCs are selected, the areas over which cumulative risk estimates for COPC concentrations yield a risk greater than the 1E-4 or HI greater than 1.0 will be identified to determine whether additional sampling is necessary (i.e., additional sampling may be warranted if risk estimates [at the boundary of the first phase of sampling] exceed the risk benchmarks).

The following sentence was added as the third and fourth sentences in the second paragraph in section 1.4.4 of the QAPP to address this comment.

"The contours will be based on cumulative risk estimates calculated for COPC concentrations at the sampled locations. At a minimum, plots representing the 1E-4 cancer risk level and a hazard index (HI) of 1 will be presented."

The existing third sentence was deleted. Allowance for plotting additional contours to gain perspective on the 1E-4/HI=1.0 risk contours is also provided in this discussion.

MGBG Comment 28:

Referring to the third sentence of the last paragraph of Section 1.4.4., how is contamination extending beyond the EU determined?

This comment applies to the third paragraph on Page 1-45 (Section 1.4.4) of the Ammunition Burning Grounds, Little Sulphur Creek and Jeep Trail QAPP.

Please see response to Comment 27. The determination that contamination exists beyond the boundary of the current EU boundaries will be based on risk estimates for the sampled locations. If, based on the first sampling event, the extent of contamination has not been adequately defined (i.e., risk estimates for locations at the EU sampling boundary exceed benchmarks, additional sampling (or modeling) may be necessary.

No change was made to the QAPP to address this comment.

MGBG Comment 29:

In Section 1.4.4.1, it is implied that contour plots for individual COPCs will be used for illustrating where (in geographic direction and depth) COPC concentrations exceed RBTLs. In that case it would be useful for the contour plots to show the locations in excess of the RBTL, 1E-6 cancer risk and HI of 0.1 as suggested in Comment 27.

This comment applies to Section 1.4.4.1 on Page 1-46 of the Ammunition Burning Grounds, Little Sulphur Creek and Jeep Trail QAPP. The response is still applicable.

Section 1.4.4.1 defines what is meant by a decision rule. It goes on to clarify what are meant by contour surfaces and medium-specific RBTLs, which are used in decision making. This definition should not be construed to imply a direct connection between contour surfaces and RBTLs. Rather, the decision rules which are presented in Sections 1.4.4.3 through 1.4.4.5 identify how various action levels are used in decision making. Please also see response to Comments 27 and 28. The referenced risk contour plots will not be used to illustrate where COPC concentrations exceed RBTLs. As discussed previously, they will be used to help determine if the nature and extent of contamination has been adequately defined.

No change was made to the QAPP to address this comment.

MGBG Comment 37:

Referring to Figure 1-18, this decision rule flow chart is related to the "nature and extent" contour plots discussed in Section 1.4.4. Does NSWC plan to calculate the COPC cumulative risk and cumulative HI at every sample point (soil, ground water, surface water, and sediment) collected for the project? From a theoretical standpoint, there would not be any objection to performing this exercise. However, we are not aware if statistical procedures can be used to determine when enough samples below the target risk limit are available outside of the risk boundary (refer to the diamond- shaped box located in the center of Figure 1-18). This seems like a potentially arduous exercise to undertake in order to provide evidence that the extent of contamination has been adequately addressed. The Agency has usually addressed the extent of contamination in terms of comparing sample concentration data to the risk-based screening concentrations (i.e., PRGs, RBTLs, EDQLs, etc.). Once the lateral and vertical extent of sampling concentrations shows that RBTLs are not exceeded, then the conclusion is that COPC selection is sufficient and the point of de minimus risk has been reached. This approach would give U.S. EPA more flexibility in deciding if and where additional samples should be taken.

This comment applies to Figure 1-21 of the Ammunition Burning Grounds, Little Sulphur Creek and Jeep Trail QAPP.

In order to construct the contours, it will be necessary to calculate cumulative risk and cumulative hazard at each sample point. The intent is to first identify COPCs by comparison of site data to RBTLs. After COPCs are identified, the union of risk and hazard index contamination boundaries for the COPCs relative to their respective action levels will be plotted. The objective is to delineate the unacceptable risk region rather than the boundary over which individual chemical concentrations exceed RBTLs. The rationale for this is that an exceedance of RBTL does not automatically indicate unacceptable risk. However, the area over which risk exceeds the 1E-4 or HI=1.0 levels is an area of significant concern. One should consider that any remediation would most cost-effectively focus on this latter area.

The Navy also knows of no available statistical computations for determining an "adequate" number of samples outside of the contamination boundary.

The decision diamond on Figure 1-21 has been reworded to say "Contamination boundary delineated in all directions?".

MGBG Comment 73:

Section D.1.2.1. states that U.S. EPA Region IX screening concentrations will correspond to a hazard quotient of 0.1 for individual noncarcinogenic constituents. It should be noted that the published Region IX PRG values for noncarcinogens correspond to a hazard quotient of 1. These values would need to be multiplied by 0.1 to derive the screening concentrations proposed for use at the MGBG. The proposal to use a HQ of 0.1 as a screening level is acceptable.

This comment applies to Section 1 and Appendix C of the QAPP. Four changes were made to address this comment.

- The first sentence of Section C.1.2.1 was changed to read "Risk-based screening concentrations based on U.S. EPA Region IX...".

- The following text was added before the last sentence of the first paragraph:

"It should be noted that the EPA Region IX PRGs for non-carcinogens are set at a hazard index of 1. These values will be multiplied by 0.1 so that the screening concentrations will be set at an HI=0.1."

- Figures 1-16 through 1-18 were changed to reflect that the screening for non-carcinogens will be at a HI value of 0.1. This will be accomplished by replacing the text in the center decision diamond of each figure with the following text:

" Maximum concentration in any site sample > COPC screening level?***"

- The attendant footnote (***) to each of the three changed figures now refers the reader to Appendix C, Section C.1.2.1 for details.

Comment 3:

Please provide a discussion of the potential for air deposition of particulates from the two burn areas as an airborne release pathway and how these effects would be assessed in an appropriate section of the QAPP.

Air deposition of particulates from the two Burn Areas was considered in the selection of sampling locations. In the case of the Burn Area the sample locations selected included locations on an adjacent hillside which may have been impacted from air deposition of particulates,

The following sentences were added after the first sentence of paragraph 4 in Section 4.4.1.

"Open burning did not take place at the hillside. However, this location could have been impacted by airborne deposition of particulate from open burning at the Burn Area because the bomb casings were oriented toward the hillside during treatment."

The following sentences were added after the second sentence in paragraph 5 in Section 4.4.1.

"Open burning at the Burn Pit was conducted by burning materials in a wood pile. Therefore, the potential for airborne deposition of partiulates would be the same as for a wood fire. In this case, most airborne deposition of particulate would be expected to occur in the immediate vicinity of the Burn Pit."

Specific Comments

Comment 1:

The full complement of required signatories is missing from the QAPP Title page.

The following signatories have been added to the QAPP Title Page.

- Paul Frank – TtNUS Quality Assurance Manager
- Allen Debus – EPA Quality Assurance Coordinator
- Peter Ramanauskas – EPA Permitting Project Manager
- Tom Brent – NSWC Crane Site Manager
- Kathy Krepps – Laucks Testing Laboratory Director
- Patty L. Ragsdale – Triangle Project Manager
- Eric Wenderland - APCL Laboratory Project Manager

Comment 2:

Section 1.0, Page 1-4, Project Approach states, "The spatial regions in soils and ground water over which the COPC concentrations are greater than acceptable human health risk levels will be bounded". It is unclear why the spatial distribution of risk levels associated with ecological receptors has not also been identified in the approach. Revise the text to clarify why ecological receptors have not been taken into account.

The extent/spatial distribution of contamination will be based on the exceedance of a human health risk level of 1E-4 (cancer risk) or a HI of 1.0 (non-cancer risk), but not on ecological risk. Because ecological risks are based on factors such as habitat, species' home range, etc., in addition to comparisons with risk criteria (EDQLs), ecological risk determinations are not as quantifiable as human health risks. If chemical concentrations are less than EDQLs, unacceptable risks do not exist. But, if chemical concentrations exceed EDQLs, risks may still be acceptable, pending an evaluation of additional factors, such as habitat, species' home range, etc. By contrast, chemical concentrations that exceed a human health risk level of 1E-4 or a HI of 1.0 indicate that an unacceptable risk exists. Therefore, it is more appropriate to delineate the contaminated area based on human health risk comparisons, which are quantifiable, than to base the extent of contamination on ecological risk evaluations, which consider other subjective factors.

No changes to the QAPP are necessary to address this comment..

Comment 3:

On Page 1-11, second sentence of the second full paragraph, fix date of Baedke citation to 1998.

The date of the Baedke citation has been revised to 1998.

Comment 4:

On Page 1-17, Section 1.3.4.2, there appears to be an inconsistency. It sounds as if the samples taken in 1995 were taken to relieve the data gap created in consequence to the historical data review performed two years later. Also see similar statement in Section 1.3.4.3.

The samples collected both in 1995 and 1997 were taken to fill data gaps for preparation of a risk assessment. In 1995 sample location data gaps were identified after a review of the historical database. These sample locations data gaps were filled by collection of additional samples. After these data gaps were filled, EPA evaluated the original historical database and determined that some of the data was not useable for risk assessment because it did not meet data validation requirements. These data gaps were then filled in the 1997 sampling.

The first sentence of the third paragraph of Section 1.3.4.2 has been modified to read as follows.

"After the samples were collected in 1995 four additional samples were collected in 1997 to fill data gaps resulting as a consequence of the 1997 U.S. EPA Technical memorandum."

The following sentence has been added as a fourth paragraph in Section 1.3.4.3.

"No additional supplemental sampling of springs was necessary as a consequence of the U. S. EPA technical Memorandum."

Comment 5:

On Page 1-20, "rationale" is misspelled.

The misspelling has been corrected.

Comment 6:

The rationale for the key target parameters for each medium to be sampled should be presented in Section 1.4.1. of the QAPP. Some basis for establishing a key target parameter list is provided on Page 1-25, under "sources of Environmental Contamination".

The following information changes were made to the QAPP to address this comment.

The title of Section 1.4.1 has been changed to read as follows.

1.4.1 "Project Target Parameters and Rationale for Selection."

The following text discussing the rationale for selection of project target parameters has been added to the beginning of Section 1.4.1.

"Key target parameters for the Jeep Trail and Little Sulphur Creek for each media were selected based on historical activities, types of contaminants that may have been released as a result of the activity conducted, and available historical monitoring data.

<u>Jeep Trail</u>

Open burning treatment took place at two adjacent locations at the Jeep Trail. Ground water monitoring and soil sampling have taken place at the Jeep Trail. The monitoring data show that chlorinated solvents, explosives, and metals were detected in the ground water and soils (Tetra Tech NUS, 1999). Future ground water contamination could occur as the result of releases of contaminants from both the Jeep Trail Burn Area and Burn Pit soils.

Jeep Trail Burn Area – Soils

In one location, the Burn Area, bomb casings containing explosive residues were open burned using black powder to remove any explosive residues. The bomb casings may have been placed on creosote treated poles. Following are the parameters selected for analysis in soils at the Jeep Trail Burn Area and the rationales for selection of the parameters.

- SVOCs – Creosotes from the poles may have been released into the soils.
- Explosives – Untreated explosives may have been released. Explosives have been found in data from past ground water monitoring activities at the Jeep Trail.
- Nitrate/Nitrite – Residues of explosive treatment include nitrate and nitrite.
- Depositional environment and Grain Size – Provide information for potential use in corrective Measures Study and for comparison to background concentrations (for naturally-occurring inorganics).

Jeep Trail Burn Pit - Soils

In the second location (the Burn Pit), explosive-contaminated materials including small munitions items and components, solvent contaminated rags and packaging material were burned using wood dunnage in a pit. Ash was periodically removed from the pit and taken to the main ABG treatment area for disposal. The pit was closed by removal of ash and backfilling with dirt. Following are the parameters selected for analysis in soils at the Jeep Trail Burn Pit and the rationales for selection of the parameters.

- SVOCs – SVOCs may have been present in the materials treated or formed during open burning treatment.
- VOCs – Untreated solvents may have been released from solvent-contaminated rags before treatment. Data from past ground water monitoring activities at the Jeep Trail shows the presence of chlorinated solvents in ground water.
- Explosives – Explosives contained in small munitions items may have been released during open burning treatment. Data from past ground water monitoring activities at the Jeep Trail shows the presence of explosives in ground water.
- Dioxins/Furans – Burning of chlorinated solvents may have resulted in the formation of dioxins
- Metals – Materials treated contained metals, which may have been released during the course of treatment. Data from past ground water monitoring activities at the Jeep Trail shows the presence of metals in ground water.
- Nitrate/Nitrite – Residues of explosive treatment include nitrate and nitrite.
- Depositional environment and grain size – Provide information for potential use in corrective Measures Study and for comparison to background concentrations (for naturally-occurring inorganics).
- Perchlorate – Small munitions items may have contained perchlorate.

Jeep Trail – Ground Water

Following are the parameters selected for analysis in ground water at the Jeep Trail and the rationales for selection of the parameters.

- SVOCs – SVOCs may be released into ground water from soils at the Burn Area and Burn Pit
- VOCs – Untreated solvents may be released into ground water from soils at the Burn Area and Burn Pit. Data from past ground water monitoring activities at the Jeep Trail shows the presence of chlorinated solvents in ground water.
- Explosives – Explosives may be released form soils at the Burn Area and Burn Pits. Data from past ground water monitoring activities at the Jeep Trail shows the presence of explosives in ground water.

- Dioxins/Furans – Dioxins/Furans may be released into ground water from soils at the Burn Pit.
- Metals – Metals may be released into ground water from soils at the Burn Area and Burn Pit. Data from past ground water monitoring activities at the Jeep Trail shows the presence of metals in ground water.
- Nitrate/Nitrite – Nitrates/Nitrites may be released into the ground water from soils at the Burn Area and Burn Pit.
- Perchlorate – Perchlorate may be released into ground water from soils at the Burn Pit.
- General Water Quality Parameters (Dissolved Oxygen, Oxidation Reduction Potential (ORP), pH, Specific Conductance, Temperature, Turbidity, and Water Level) – Information on general water quality parameters is necessary to evaluate the overall quality of ground water at the Jeep Trail.

Jeep Trail – Little Sulphur Creek Surface Water and Sediment

Contaminants deposited onto surface soils at the Jeep Trail may migrate as the result of overland flow into Little Sulphur Creek, which is adjacent to the Jeep Trail. These contaminants may be present in surface water and sediments. Following are the parameters selected for analysis in surface waters and/or sediment in the portion of Little Sulphur Creek nearest the Jeep Trail.

- SVOCs (surface water and sediments) – SVOCs may be released into surface waters and accumulated in sediments.
- VOCs – (surface water and sediments) – VOCs may be released into surface waters and accumulated in sediments.
- Explosives – (surface water and sediments) – Explosives may be released into surface waters and accumulated in sediments.
- Dioxins/Furans – (surface water and sediments) – Dioxins may be released into surface waters and accumulated in sediments.
- Metals – (surface water [total and dissolved] and sediments [total]) – Metals may be released into surface waters and accumulated in sediments.
- Nitrate/Nitrite – (surface water and sediments) – Nitrates may be released into surface waters and accumulated in sediments.
- Perchlorate – (surface water and sediments) – Perchlorates may be released into surface waters and accumulated in sediments.
- General Surface Water Quality Parameters (Dissolved Oxygen, Oxidation Reduction Potential (ORP), pH, Specific Conductance, Temperature, Turbidity, and Flow Rate) – Information on general water quality parameters is necessary to evaluate the overall quality of Little Sulphur Creek surface water and provide information on contaminant masses (flow rate).

Little Sulphur Creek Surface Water and Sediment (main ABG Treatment Area)

Little Sulphur Creek receives runoff from the main ABG treatment. Until the early 1990s, the main ABG treatment area and surrounding areas were kept free of vegetation. During precipitation events, ABG surface soil eroded into Little Sulphur Creek. The Phase III Soils RFI conducted by the U.S. Army Corp of Engineers (U.S. ACE) (U.S.ACE, September 1998) showed that the soils contained explosives and metal contaminants. The Phase III Ground Water RFI (U.S. ACE, 1994) showed that explosives, solvents, and metals have contaminated the ground water underlying the main ABG treatment area. This ground water is in a karst system that discharges to Spring A, which then drains into Little Sulphur Creek.

Contaminants deposited onto surface soils may have migrated as the result of overland flow into Little Sulphur Creek from the main ABG treatment area . These contaminants may be present in surface water and sediments. Following are the parameters selected for analysis in surface waters and/or sediment in areas of Little Sulphur Creek adjacent to the main ABG treatment area and downstream of Spring A and the rationales for selection of the parameters.

- Herbicides (surface water and sediments) - Herbicides used to control vegetation at the main ABG treatment area may have been released into surface waters and accumulated in sediments.
- Pesticides/PCBs (surface water and sediments) - Pesticides/PCBs may have been released from the main ABG treatment area into surface waters and accumulated in sediments.
- SVOCs (surface water and sediments) – SVOCs may be released from contaminated soils into surface waters during storm events and accumulated in sediments.
- VOCs – (surface water and sediments) – VOCs may be released from contaminated soils into surface waters and accumulated in sediments. Data from past ground water monitoring activities at the main ABG treatment area shows the presence of VOCs in ground water.
- Explosives – (surface water and sediments) – Explosives may be released from contaminated soils into surface waters and accumulated in sediments. Data from past ground water monitoring activities at the Jeep Trail shows the presence of explosives in ground water.
- Dioxins/Furans – (surface water and sediments) – Dioxins resulting from the open burning treatment of chlorinated solvents may have released from contaminated soils into surface waters and accumulated in sediments.
- Metals – (surface water [total and dissolved] and sediments [total]) – Metals may be released into surface waters and accumulated in sediments. Data from past ground water monitoring activities at the main ABG treatment area shows the presence of metals in ground water.
- Nitrate/Nitrite – (surface water and sediments) – Nitrates may be released into surface waters and accumulated in sediments.
- Total Organic Carbon (TOC) – (surface water and sediments) – TOC content provides information for use in corroborating absence or presence of contamination and potential bioavailability.
- Depositional environment and Grain Size (sediment) – Provide information for potential use in corrective Measures Study and for comparison to background concentrations (for naturally-occurring inorganics).
- Grain Size and, Bulk Density, % of Coverage, and Average Depth (sediment) – Provide information for fate and transport.
- General Surface Water Quality Parameters (Dissolved Oxygen, Oxidation Reduction Potential (ORP), pH, Specific Conductance, Temperature, Turbidity, and Flow Rate) – Information on general water quality parameters is necessary to evaluate the overall quality of Little Sulphur Creek surface water and provide information on contaminant masses (flow rate). "

Comment 7:

In Section 1.4.1., second paragraph, the statement, "All field and laboratory target parameter results greater than or equal to method detection limits will be reported," should be revised to reflect that all proposed data will be reported. Otherwise the Completeness DQO will appear to have not been achieved.

All field and laboratory target parameter results will be reported. Target parameters not detected will be reported at the method detection limits.

The first sentence in Section 1.4.1 second paragraph has been revised to reflect this response.

Comment 8:

Referring to the first sentence of the second paragraph of Section 1.4.1.2., for clarification it should be noted that "naturally occurring metals" will be compared to basewide background levels.

The words "naturally occurring metals" has been added to the end of the first sentence.

Comment 9:

It appears as if many ecological data quality target level exceedances are planned. Crane should present a strategy for dealing with data assessment & decision making circumstances in which proposed ecological data quality levels may not be achieved. Also see Section 1.4.3.2 on Pages 1-39 to 1-40, and 1-47. Why shouldn't such compounds automatically be regarded as COPCs?

Chemicals with MDLs/IDLs greater than the risk criteria will not be retained as COPCs. If a constituent is non-detected at the MDL/IDL in all of the samples in a particular media, the constituent, its MDL/IDL, and the risk criteria will be summarized in a table and qualitatively discussed in the uncertainty analysis section. The constituent will not be quantitatively carried through the risk assessment as a COPC because of the high amount of uncertainty involving the non-detected data. If a constituent is detected in at least one sample at levels greater than the MDL/IDL, one-half of the MDL/IDL will be substituted for the non-detects.

The following sentences were added after the fourth sentence in the second paragraph in Section 1.4.3.2 Ecological Effects Evaluation:

"If a chemical is non-detected at the MDL/IDL in all of the samples in a particular media, and the MDL/IDL exceeds the EDQL, the chemical will not be quantitatively carried through the risk assessment as a COPC. However, the chemical, its MDL/IDL, and the EDQL will be summarized in a table and qualitatively discussed in the uncertainty analysis section. If a chemical is detected in at least one sample at levels greater than the MDL/IDL, one-half of the MDL/IDL will be substituted for the non-detects for calculating summary statistics (e.g., mean concentrations)."

Also, the following sentence was added to the end of the first paragraph in Section 1.4.4.3 Decision Rules for Selecting COPCs, Non-detected Chemicals:

"However, if a chemical is non-detected at the MDL/IDL in all of the samples in a particular media, and the MDL/IDL exceeds the risk-based level, the chemical will be qualitatively discussed in the uncertainty analysis section."

Comment 10:

On Page 1-28 it is assumed that off-base residents may be exposed to the air inhalation route for contaminant transport. Please update Figure C-2 to reflect this assumption.

Agreed. The referenced figure has been corrected.

Comment 11:

The first sentence of the last paragraph on Page 1-29 states that the EPC for ground water exposure under the Jeep Trail study area will be the arithmetic average of wells in the highly concentrated area of a plume potentially underlying the study area. Please provide rationale for using this approach. If a plume of contaminated ground water is discovered, it would be advisable for NSWC to inform U.S. EPA about which wells would be combined to calculate the average value. The U.S. EPA project manager needs to agree that data from the appropriate wells would be selected for use in the risk assessment. Alternatively, after reviewing the available data, the U.S. EPA may elect to obtain data from additional new wells in order to ensure that the highest likely contaminant levels in the plume have been determined.

The rationale is based on accepted industry practice that takes into account the likelihood of installing a well in the most concentrated region of a contaminant plume as well as the fact that wells are not mobile. The approach is suggested in U.S.EPA Region 4 Supplemental Guidance to RAGS: Region 4 Bulletins, Human Health Risk Assessment (November 1995). The Navy agrees that NSWC should inform U.S.EPA about the wells used to calculate the average.

The following sentence has been added after the first sentence of the third paragraph in QAPP Section 1.4.2.2 on calculation of exposure point concentrations.

"This approach is based on the accepted industry practice that takes into account the fact that chemical concentrations in the ground water do fluctuate over time and the likelihood of installing a well in the most concentrated region of a contaminant plum. The approach is suggested in U.S. EPA Region 4 Supplemental Guidance to RAGs Region 4 Bulletins, Human Health Risk Assessment (November 1995)"

The following sentence has been added at the end of the third paragraph in QAPP Section 1.4.2.2 on calculation of exposure point concentrations.

"The Navy will discuss with EPA Region 5 the best approach (modeling versus additional monitoring wells) to develop exposure point concentrations for specific receptor locations if it is apparent (based on the results of the proposed sampling) that significant contaminant migration is occurring."

Comment 12:

On Page 1-30, it is stated that modeling techniques will be used to estimate EPCs for receptor locations for ground water contaminant plumes that have migrated beyond the OJT study area boundaries. It is recognized that modeling may be necessary to estimate ground water contaminant concentrations at locations further downgradient from the existing well network. But the U.S. EPA may decide on extension of the existing well network if significant contamination from a migrating plume is suspected, rather than relying on estimates from ground water flow/migration models.

Significant groundwater contamination beyond the OJT study areas is not anticipated. However, the QAPP will be adjusted to state that the Navy will discuss with EPA Region 5 the best approach (modeling versus additional monitoring wells) to developing exposure point concentrations for specific receptor locations if it is apparent (based on the results of the proposed sampling) that significant contaminant migration is occurring.

The following sentence has been at the end of the third paragraph in QAPP Section 1.4.4.2 on calculation of exposure point concentrations.

"The Navy will discuss with EPA Region 5 the best approach (modeling versus additional monitoring wells) to develop exposure point concentrations for specific receptor locations if it is apparent (based on the results of the proposed sampling) that significant contaminant migration is occurring."

Comment 13:

Referring to the first bullet on Page 1-30, provide clarification if this means that the maximum detected concentration will be used in EPC calculation if there are less than 10 positively detected parameters regardless of whether 10 or greater samples are taken.

The first bullet on Page 1-30 refers only to the number on samples collected in a given medium, regardless of the number of parameters found.

No changes were made to the QAPP to address this comment.

Comment 14:

Can the first two sentences after the bullet on Page 1-31 be clarified? What is meant by "sample-specific detection limits"? Is this a reference to undetected analytes for which the proposed RLs are greater than the target levels?

The text is referencing the detection limit (SDL) reported for a "non-detect" result by the analytical laboratory. Generally, one-half the SDL is used as a surrogate value for non-detect results when calculating the exposure point concentration.

The referenced text was modified as follows:

"One-half the sample-specific detection limit (SDL), reported by the laboratory, will be used as a surrogate value for non-detect results when calculating the exposure point concentration."

Comment 15:

Referring to Section 1.4.3.1., Page 1-36, Screening-Level Problem Formulation, the description of springs/surface water does not indicate whether the area is reflective of amphibian/reptile habitat. Revise the text to include a discussion of the habitat in terms of potential sensitive receptor usage.

In Section 1.4.3.1 Screening-Level Problem Formulation, Springs/Surface Water, the following sentences have been added to the end of the second paragraph:

"Amphibians are likely to inhabit both the intermittent and perennial sections of Little Sulphur Creek; reptiles are likely to inhabit these aquatic environments, as well as surrounding terrestrial habitats. Amphibians and reptiles could be exposed to contaminants in the surface water by direct contact or ingestion of water."

Comment 16:

Section 1.4.3.1, Page 1-38, Screening-Level Problem Formulation states that Appendix D presents more information on assessment endpoints, including identification of protected or endangered species such as the Indiana bat. Although Section D.2.1.2 describes threatened and endangered (T&E) species that may be present at the facility, it should be clearly specified whether any special federal or state species, or possible habitat, may exist in the *investigation area.* Revise the document to include T&E species use or presence of habitat within the investigation area in Appendix D.

Section D has been modified to provide information on the Indian Bat.

In Section D.2.1.2 Basewide Environmental Setting, the third sentence in the fourth paragraph was replaced by the following sentences:

"Also, the Indiana bat, a Federal endangered species, is known to forage along Little Sulphur Creek within the bounds of the investigation area. As part of an ecological risk assessment in support of the RCRA Subpart X permit, a single male Indiana bat was captured along Little Sulphur Creek south of the Ammunition Burial Grounds during a mist net survey in June 1996 (Current Contamination Conditions Risk Assessment, [TtNUS, Feb. 1999]). Because streams and associated flood plain forests are preferred foraging habitats for Indiana bats, Little Sulphur Creek provides suitable habitat for both pregnant/lactating females, and male Indiana bats."

Comment 17:

Section 1.4.4.2, Page 1-47, Decision Rules For Establishing background Concentrations indicates that background sediment and surface water samples will be collected upstream of the Jeep Trail and *downstream of the ABG treatment area* to allow evaluation of the Jeep Trail impacts surface water and sediments (emphasis added). However, it is not clear that background samples are being collected in areas considered unimpacted by site activities. Revise this section to provide clarification.

Understanding the text requires understanding that the term "site" is a relative term. It is expected that obtaining data from multiple background locations along the anticipated and known flow gradients will facilitate the association of contaminants with the individual SWMUs. Hence, samples collected in LSC tributaries upgradient of the ABG will serve as background for the entire LSC/OJT area. Samples collected between the ABG and OJT will represent background for the OJT. This could facilitate decision making about the individual SWMUs. To facilitate this understanding the first sentence was changed to read as follows:

"Background locations for sediment, ground water and surface water have been selected to represent locations not influenced by operations at a particular SWMU."

Comment 18:

On Page 1-47, in the second to last sentence of Section 1.4.4.2., please provide further explanation of how well 03-16 will be considered a background well for this study. If it is the same rationale as is described for background sediment and surface water samples, that is, to determine further Jeep Trail impacts on the ground water quality, then this should be stated. Referring to the last sentence of this paragraph, how will the determination that the "data from...any of those media do not represent background concentrations" be made?

Additional text has been added that emphasizes well 03-16's geographical position as being upgradient to the Jeep Trail. The fourth sentence of the subject paragraph has been modified to read as follows:

"Background ground water samples for the Jeep Trail will be collected from existing monitoring well 03-16 to represent water entering the Jeep Trail SWMU."

Regarding the determination as to whether any particular background well does not represent background concentrations, there are various ways to make the determination. One way is to review ground water flow directions based on water elevations. If flow directions do not support the well as being background to the corresponding SWMU, its selection as a background well for that SWMU must be re-evaluated. Another way is to compare the concentrations of analytes at the downgradient SWMU with the background well concentrations of the same analytes. If the analyte concentrations are greater in the background well, the use of the well as a background water source must be re-evaluated. These re-evaluations will necessarily involve professional judgment. Hence, the statement that the ..."Navy may consult with the U.S. EPA Region 5 to agree on the most appropriate course of action." It is important to note that a re-evaluation does not automatically preclude the use of a particular well as a background water source. Rather, it simply indicates that the selection of the well as a background well would be questioned and re-evaluated to ensure that it is not incorrectly maintained as a background water source.

No change was made to the QAPP to address this issue.

Comment 19:

Section 1.4.4.4., Page 1-50, Decision Rules for Establishing the Nature and Extent of COPCs states, "The extent of contamination is based on human health risk comparisons". Thus, it appears that the process for selecting chemicals of potential ecological concern (COPECs) will begin <u>following</u> an initial screening using risk levels associated with human health. However, Figures 1-19 and 1-20 indicate that COPCs will be selected using ecological screening benchmarks. The text should be clarified.

As presented in Section 1.4.4.3, the selection of COPECs will be based on comparisons of site data to Ecological Data Quality Levels (EDQLs), regardless of whether or not the data exceed human health risk levels. The extent/spatial distribution of contamination will be based on health risk comparisons, not ecological risk comparisons (For a complete explanation, see response to Specific Comment #2).

No changes to the QAPP were made based on this comment.

Comment 20:

The last two sentences on Page 1-52, Section 1.5.1 should be clarified. What is the rationale for averaging field duplicate results? QC sample data is not intended to count as investigational sample data. Instead, % difference QC criteria should be developed for the field duplicate samples.

The Navy does establish project acceptance criteria for field duplicates and laboratory duplicates. These acceptance criteria are presented in Section 3 of the QAPP, Tables 3-6, 3-8, 3-10, 3-12, 3-14, and 3-16.

The last two sentences in Section 1.5.1 have been revised to state that only the "original" of a duplicate field sample pair will be used as the concentration value at a given sampling point.

Comment 21:

Referring to Table 1-1, a conclusion of the 1997 Current Contamination Conditions Risk Assessment is that off-facility residents have a cancer risk only if ABG Alluvium groundwater or Little Sulphur Creek surface water is used as a primary drinking water source. What is the Padanaram commune's drinking water source?

The source of the Padanaram commune's drinking water source is presently unknown. However, an evaluation of groundwater and surface water flow from the ABG Study Area toward the Padanaram Commune was performed to determine the potential for shallow groundwater or surface water at the ABG / Jeep Trail study area to flow toward the Padanaram commune. The evaluation was performed based on a review of existing hydrogeologic information for the facility, as provided in the references in the rear of this response. Following is the evaluation. Appendix 1 to this comment response document contains figures and attachments referenced in the evaluation.

The ABG / Jeep Trail study area is located in the eastern portion of the NSWC, and lies within the Little Sulphur Creek Watershed, which is part of the Sulphur Creek Complex Drainage Basin. Little Sulphur Creek originates as two forks upstream of the study area and flows south past the ABG, the Jeep Trail, and beyond the facility boundary for approximately 4.6 miles, until discharging into Sulphur Creek (see Figures 1 and 2 attached).

The Padanaram commune is located approximately 1.5 miles east of the ABG study area along Sulphur Creek, at a distance more than three miles upstream of the intersection of Little Sulphur Creek with Sulphur Creek (Figure 2). The ABG / Jeep Trail study area is separated from the Padanaram community by a north - south topographic ridge located between Little Sulphur Creek and Sulphur Creek. The terrain in the area can be characterized as rugged relief with moderately incised valleys. Ground surface elevations range from 500 feet msl in the valleys to about 850 msl on the ridges (Figure 2).

Groundwater and surface water is not expected to flow from the ABG / Jeep Trail study area to the Padanaram Commune for the reasons described below:

1) Existing reports, including Hunt (1988) and Murphy (1994) have shown groundwater in the Beech Creek Aquifer (middle aquifer) to flow to the east in the ABG study area proper, then to the south, following Little Sulphur Creek. The Beech Creek Aquifer is the most significant aquifer of interest, as it immediately underlies the ABG study area. These maps are attached for reference as Figures 3 and 4. With all groundwater and surface water from the site flowing southward along Little Sulphur Creek, there is no flow component continuing in an easterly direction.

2) A north – south topographic ridge physically separates the ABG / Jeep Trail study area from the Padanaram Commune. The Padanaram Commune is also located upstream of the outlet of Little Sulphur Creek with Sulphur Creek. (see Figure 2). Groundwater flow would be expected to mimic topography and flow from the topographic ridges to the valleys. Therefore, one would expect groundwater along the western flank of the North – South ridge to flow west toward Little Sulphur Creek and groundwater along the eastern flank to flow east toward Sulphur Creek. These features effectively prohibit surface water and groundwater flow from the ABG Study Area toward the Padanaram Community.

3) The potential for groundwater beneath the ABG study area to flow to the east, underneath the topographic ridge, and toward the Padanaram Community, is unlikely. As stated previously, ground water in the Beech Creek Aquifer at the ABG study area flows southward following the Little Sulphur Creek watercourse. Groundwater in the deeper, Beaver Bend Aquifer (see attached Figure 5), also flows toward the south, as detailed in Murphy (1994). Furthermore, Murphy also states that bedrock in the study area dips to the south - southwest. The Padanaram commune is located updip of the ABG / Jeep Trail study area.
4) A tracer test study conducted by Baedke (2000), included monitoring at 14 springs, including one spring located on the east side of Sulphur Creek near the Padanaram Commune (see attached Figure 6). The test concluded that nearly all of the groundwater in the middle aquifer beneath the ABG / Jeep Trail study area discharged to one downstream spring complex located in Little Sulphur Creek. No tracer was detected in the spring located near the Padanaram Community.

In conclusion, groundwater theory, groundwater studies at the site, and a dye tracer study all indicated that groundwater in the vicinity of the ABG / Jeep Trail flows southward along Little Sulphur Creek. Surface water is also shown to follow topography, and is effectively prohibited from flowing from the ABG / Jeep Trail study area toward the Padanaram Community.

Baedke, Steven A. and Noel C. Krothe, Quantitative tracer test of the Beech Creek Aquifer at the Ammunition Burning Grounds, Naval Surface Warfare Center, Carne, Indiana, 2000.

Hunt, R.W. 1988. Geology and Hydrogeology of the Ammunition Burning Ground, Crane Naval Weapons Support Center Technical Report GL-88-27. U.S. Army Engineer Waterways Experiment Station, Vicksburg, Missouri.

Murphy, W.L., 1994. Final Report, RCRA Facility Investigation, Phase III, Groundwater Release Characterization, SWMU 03/10, Ammunition Burning Ground, U.S. Army Corps of Engineers Waterways Experimental Station, Vicksburg, Mississippi.

Tetra Tech NUS, 2000. Draft Quality Assurance Project Plan for Ammunition Burning Grounds, Little Sulphur Creek, and Jeep Trail Resource Conservation and Recovery Act, Phase III RCRA Facility Investigation Naval Surface Warfare Center Crane, Crane, Indiana. September 2000.

No changes were made to the QAPP to address this comment.

Comment 22:

What is the rationale for not performing VOCs or metals sampling & analysis in the Burn Area? (See Table 1-8.)

The burn area was used for the flashing of bomb casings to remove explosive residues. Flashing was accomplished by open burning using black powder. The explosives and the black powder did not contain any VOCs or metals. The bomb casings were recovered intact and removed from the Burn Area. Therefore, no VOCs or metals would have released as a result of the flashing operation.

No changes were made to address this comment.

Comment 23:

In footnotes 1 and 3 of Table 1-8, should the reference to Table 1-4B be Table 1-9 instead?

The footnote has been corrected to reference Table 1-9.

Comment 24:

Why wouldn't the Navy also want to include the other handful of explosive breakdown compounds that were included in another Crane RFI (i.e. beyond the standard fourteen 8330 compounds)? (See Table 1-11.)

The explosive breakdown compounds were monitored for eight quarters at the Ammunition Burning Ground. These breakdown compounds were analyzed to determine if natural attenuation of explosives is occurring in the ground water. These results are being evaluated by the US ACE WES to determine if monitored natural attenuation (MNA) is feasible as a corrective measure. The results of this study will be incorporated into the Corrective Measures Study (CMS) which will be conducted after the RFI report is prepared for the Jeep Trail and Little Sulphur Creek. Additional data from the RFI program for the Jeep Trail and Little Sulphur Creek is not necessary at the time to determine if MNA is a feasible corrective action for the ABG.

No changes have been made to the QAPP in response to this comment.

Comment 25:

It should be clarified in Table 1-11 that the MDL will in some cases become a default "RL" for reasons that we have discussed in project scoping meetings.

All compounds will be reported as nondetected at the MDL/IDL.

No changes have been made to the QAPP in response to this comment.

Comment 26:

In Table 1-11, referring to the entry for 1,1,1,2 -tetrachloroethane, (under Risk Based Soil Target level) what does the "C" following the .050 signify?

The "C" is a typo and has been removed.

Comment 27:

In Table 1-11, the derivation of the RBTLs (i.e. from human health or ecological data bases) should be distinguished.

The original Table 1-11 incorrectly referenced Appendix C as the source of the RBSL used for the RBTLs in the table. The reference has been corrected to Appendix B. The tabular presentation of RBSLs used for the derivation of RBTLs in Table 1-11 are presented in Appendix B, Tables Appendix B-1 for aqueous and Appendix B-2 for solids.

Footnote 2 on Table 1-11 was revised as follows:

1. "Value is based on the lowest human health or ecological risk-based criteria as presented in Appendix B, B-1 (aqueous) and B-2 (solids)."

Comment 28:

Referring to Table 1-11, note that PCB data reported as Aroclors may be sufficient for screening purposes, but it will not be useful in performing risk assessments. Also, the compound pentachlorophenol should be transferred to the 8151A method list.

The QAPP currently specifies the use of Method 8082 to provide PCB data in terms of the various Aroclor mixtures. However, that data will be used to develop a Total Aroclor concentration (to represent Total PCBs) to be used (if PCBs are selected as COPCs) as the exposure point concentration (EPC) in the quantitative risk assessment. (Total Aroclor concentrations will be calculated first on a sample by sample basis; one-half the sample detection limit will be assumed for non-detect results. The Total Aroclor EPC will be based on these values.) Congener-specific PCB analyses are not anticipated at this time because PCBs are not considered significant site-related contaminants. The Method 8082 analysis for Aroclors is recommended for purposes of completeness only.

Pentachlorophenol was moved to the 8151A method list. The use of PCB data in risk assessment is discussed in Appendix C, C.1.2.4.

Comment 29:

Table 1-11 identifies a comprehensive evaluation of analytical detection or reporting limits compared to risk levels. However, it is not clear whether chemicals with detection/reporting limits greater than screening levels will be retained as COPECs, or if other criteria will be established. Revise the document to address the criteria that will be established for this comparison. For example, the decision rules should clarify that chemicals with detection/reporting limits greater than a risk criterion will be retained as a COPEC.

See response to Specific Comment #9.

Comment 30:

On Figures 1-21 and 1-22, there are no footnotes for '*' and '**' respectively. On Figure 1-21, further define what is meant by "Generate the spatial risk boundary representing the union of HH risk and HI..." should the "and" be "or"?**

The "****" in Figure 1-21 and the "**" in Figure 1-22 are spurious footnote indicators and were removed.

The statement "Generate the spatial risk boundary representing the union of HH risk and HI... is correct as written. The spatial risk boundary representing 1 E-4 Risk and the spatial hazard boundary representing a hazard of 1.0 will each be generated and plotted separately. Once plotted the best fit boundary including both the spatial risk boundary and spatial hazard boundary will be generated. This represents the ".....union of HH risk and HI.....

The following footnote was added to Figure 1-21 in response to this comment.

"***The spatial risk boundary representing 1 E-4 Risk and the spatial hazard boundary representing a hazard of 1.0 will each be generated and plotted separately. Once plotted, the best fit boundary including both the spatial risk boundary and spatial hazard boundary will be generated to represent the union of HH risk and HI."

Comment 31:

Referring to Table 3-1, the 50% RPD acceptance limit criterion for field duplicates isn't very ambitious.

Based on the results of the background study performed at NSWC Crane, most RPDs for soils will fall below 35%. However, some points will exceed 35%. TtNUS elected to use a 50% acceptance criteria based on past experience with Crane soils and recognition of the fact that soils are naturally heterogeneous in nature. Exceedance of the RPD criteria does not impact the use of the data during risk assessment since exceedance of the criteria does not result in rejection of data.

No change was made to the QAPP to address this comment.

Comment 32:

Referring to Table 4-2 and Figure 4-1, soil sample 03SB18 is not associated with sampling for dioxins/furans even though other samples in the proximity of the burn pit are. Please provide rationale for this.

Five surface soil samples were selected for dioxin/furans analyses from borings located along the Burn pit perimeter, based on professional judgement. It is believed that five surface soil samples are sufficient for adequately addressing the potential for dioxin/furans contaminants in surface soils, as part of an initial investigative stage.

No changes were made to the QAPP to address this comment.

Comment 33:

Referring to Page 4-4, last paragraph on page, why wouldn't sampling be worthwhile below the Burn Pit boundary as well (i.e., below the third interval)?

It is assumed, based on the known disposal history at the site, that the ash in the pit was removed and backfilled with uncontaminated material, and no residual contamination exists under the fill. The samples collected from the second and third depth intervals are intended to target the fill and underlying material, respectively. Therefore, it is expected that the results from these intervals would reflect concentrations below RBTLs, thus defining the limits of contamination.

Soil samples collected below a third interval (depths below 15 feet) may be saturated with groundwater. It should be noted that the collection of saturated soil samples for laboratory analyses may yield analytical results that are indicative of soil and groundwater contamination, and would serve limited utility from an evaluation perspective.

It is recommended that soil sampling not be performed below the depths specified at this time. However, if contamination above RBTLs exists in the deepest soil samples collected during the investigation, it may be necessary to collect additional deeper soil samples during another round of sampling. It is believed that the present scope of sampling will collect a sufficient amount of information to meet the overall objective without risk of unnecessary data.

No changes to the QAPP were made to address this comment.

Comment 34:

On Page 4-5, provide more description of the topographically depressed area and rationale for sampling there (surface migration & deposition of contaminants)? What is the intended use of the data obtained from the reference soil borings (SB29-SB33)?

The text "(resembling a man – made pond)" was added to the third sentence of the second paragraph of Section 4.4.1 to provide more description of the topographically depressed area. The sentences "Data from these borings were used to address surface runoff of contaminants from the Burn Pit area and redeposition in the ponded area." and "Data from the reference soil borings will be used to establish

baseline soil concentrations that are representative of non-site related chemical concentrations." were added to the fourth paragraph in Section 4.4.1. These sentences are intended to provide rationale for sampling in the topographically depressed and reference areas, respectively.

Comment 35:

On Pages 4-6 to 4-7, it should be clarified that the Encore samplers will still be used to collect soil for VOCs analyses immediately after the spoon is opened to minimize chances for volatilization. (Also see page 4-14, section 4.5.2.)

The sentence "All soil samples for VOC analyses will be collected immediately after opening the split spoon or DPT sampler, using an Encore sampler." was inserted before the last sentence of the last paragraph of Section 4.4.1. The sentence "The Encore samples will be collected from each core immediately after PID readings are collected." was inserted after the fifth sentence of the third paragraph of Section 4.5.2.

Comment 36:

Referring to Section 4.4.2, on Page 4-7, shouldn't there be more than one sampling round for groundwater analyses?

Additional rounds of groundwater sampling may be required to adequately characterize the site. However, it is premature to determine the specific wells that will require resampling, the parameters analyzed, and if any additional wells will require installation. An evaluation of the initial round of groundwater will be performed and a decision will be made regarding additional wells and sampling. These issues are addressed in Section 1.4.4.4 of the text.

No changes to the QAPP were made to address this comment.

Comment 37:

Referring to Section 4.2.2., are there decision rules set up to determine if/when new GW wells will be installed/sampled? What is the criteria? What happens if some wells cannot be redeveloped?

The decision rules and criteria to determine if new monitoring wells will be installed and sampled are included in Section 1.4.4.4 and Figure 1-21. The number of samples required to adequately address the risk will be based on a computation in accordance with this section. Wells that cannot be redeveloped (e.g. lost or damaged beyond repair) will be considered non-sampled data and will not be used to compute risk. The results of the data evaluation in accordance with Section 1.4.4.4 and Figure 1-21 will determine the need for additional wells.

No changes to the QAPP were made to address this comment.

Comment 38:

Referring to Table 4-2, the significance of the "????" notations in the "Sample no." column should be clarified. Also, how do these proposed samples pertain to the 16 to 29 sample range expressed in Table 4-7?

The footnote "(8) Sample depth to be determined during drilling" has been added to the last page of Table 4-2 to clarify that the sample depth will not be known until the boring is drilled. The proposed samples in Table 4-2 are soil samples whereas the proposed samples in Table 4-7 are groundwater samples, and have no relationship from a sample number perspective.

Comment 39:

Section 5.3 should include a reference to raw data and calibrations as well.

The text has been amended to include the following reference.

- Laboratory data deliverables (including raw data and calibrations)

Comment 40:

In Section 7.2.1, Page 7-1, change the reference to Table 1-9 to Table 1-11.

The reference has been changed to Table 1-11.

Comment 41:

Correct the typo references to method 8260C under the SVOC portion of Table 7-1. The method references should be 8270C and 8270C-SIM. Also, include PCP with the method 8151A parameter group.

Table 7-1 has been modified to correct the typo references to method 8260C.

Table 1-11 has been modified to include PCP with the method 8151A parameters.

Comment 42:

Referring to Section 8.1.2, discuss field duplicates for VOCs in soil. These samples should be collocated and not mixed in the field.

The following text has been added to Section 8.1.2:

"Solid field duplicates collected for VOC analysis are not mixed in the field. Two samples are taken in rapid succession from separate, but closely located positions."

Comment 43:

A narrative description of the Data Validation manager's QA/QC responsibilities should be added to Section 9.2.2, Page 9-2.

The following text has been added to the first paragraph in Section 9.2.2:

"The Data Validation Manager is responsible for ensuring that data validation deliverables are prepared in accordance with the guidance methods specified in this QAPP and are complete and correct. "

Comment 44:

Referring to Page 13-2, it should be stated (if it is truly the case) that specific procedures for laboratory corrective action are incorporated into respective laboratory SOPs. (Note that statements like "if out of control, consult with the supervisor" do not constitute corrective action.)

The following text has been added to the beginning of paragraph 1 on page 13-2.

"Specific procedures for laboratory corrective actions are specified in the associated laboratory SOP."

Comment 45:

Section D-1, Page D-1, Introduction indicates that the goal of this follow-up SERA will be to determine whether adverse ecological impacts are present as a result of exposure to chemicals released to the environment. It is not evident that the activities associated with the proposed screening-level assessment are adequate to determine whether ecological impacts are present. It will be difficult to provide definitive statements about the extent of adverse ecological impacts upon completion of the SERA. The results of the SERA should focus on whether there are exceedances of hazard quotients, where the exceedances occurred, and whether there is enough information for remedial decision making. The statement regarding the goal of the SERA more appropriately defines the results of a BERA. Revise this section to provide a more accurate statement regarding the goal of the SERA.

Section D.1 of Appendix D, third paragraph, first sentence has been revised as follows:

"The goal of this follow-up Screening-Level Ecological Risk Assessment (SERA) will be to identify the chemicals detected at concentrations that exceed the COPC screening levels, the locations of these exceedances, and the need for further investigation and/or remedial action at the Jeep Trail and Little Sulphur Creek at NSWC Crane."

Comment 46:

Section D.2.2.3, Page D-8, Semivolatile Organic Compounds discusses the possible sources of ubiquitous forms of polyaromatic hydrocarbons (PAHs). However, the text does not indicate whether any of the Navy-related releases of PAHs are expected to be associated with Little Sulphur Creek and the Jeep Trail. It is recommended that the discussion include the likelihood of whether any detected PAHs in these areas could also be associated with Navy releases. Alternatively, reference other sections of the document that provide this information.

The intent of Section D.2.2.3 Semivolatile Organic Compounds was to provide a general overview of the nature and toxicity of PAHs. Details about the past uses of the site and the specific PAHs detected during historic sampling are presented in Sections 1.3.3 and 1.3.4 of the QAPP.

In Section D.2.2 Contaminants Ecotoxicity and Fate and Transport, the bulleted list has been revised as follows:

"Based on historical site data and sampling, the following parameters are among the site-related chemical contaminants known to be present or potentially present in environmental media within the study area:

- Explosives (e.g., 2,4,5-trinitrotoluene [TNT] and HMX) and their degradation products (e.g., 2-amino-4,6,-dinitrotoluene)
- Metals (e.g., lead)
- Chlorinated volatile organic chemicals (VOCs) including, but not limited to, 1,1,2,2-trichloroethane, 1,2-dichloroethene, trichloroethene, and vinyl chloride
- Polycyclic Aromatic Hydrocarbons (PAHs) including, but not limited to, benzo(a)pyrene, fluoranthene, and pyrene"

Comment 47:

Section D.2.3.1, Page D-13, Ground Water indicates that groundwater discharges (and infiltrates) into the surface water pathway associated with Little Sulphur Creek and contaminants in groundwater will be evaluated as surface water contaminants once the groundwater discharges to the creek. It is recognized that surface water may only be available at limited times during rainfall events, however, it appears that it would be difficult to capture and characterize contamination in the surface water (due to pulse loading from groundwater in gaining portions of the stream). It is recommended that the SERA include chemicals detected in the shallow groundwater instead of only those that may have been captured in surface water sampling.

Both surface water and shallow ground water will be evaluated in the SERA. In Section D.2.3.1 Ground Water, the last sentence has been revised as follows:

"Although ecological receptors are not directly exposed to ground water (prior to it discharging from a spring or as surface water), ecological receptors can be exposed to groundwater contaminants after the water discharges to Little Sulphur Creek."

Also, several changes will be made in Section D.3 to indicate that ground water contaminants will be evaluated in the SERA. The fifth sentence in the first paragraph was revised, and a sixth sentence will be added as follows:

"As the first step in the ecological effects evaluation, Contaminants of Potential Concern (COPCs) will be selected by comparing the contaminant concentrations in the surface water, ground water, sediment, and surface soil samples in Region 5 Ecological Data Quality Levels (EDQLs) (U.S. EPA, Region 5, October 1999). Note that the ground water data will be compared to surface water EDQLs."

The heading of the first subsection was revised to include ground water as follows:

"Surface Water, Ground Water, and Sediment for Benthic Macroinvertebrates, Fish, and Terrestrial Wildlife"

Comment 48:

Referring to Section D.2.4., Page D-14, Endpoints, the text does not mention the possible presence of threatened and endangered (T&E) species in the investigation area. Although Section D.2.1.2 describes T&E species that may be present at the facility, it should be clearly specified whether any special federal or state species, or possible habitat, may exist in the *investigation area*. The assessment and measurement endpoints may need to be revised to address individual-level impacts if it is determined that T&E species may use the area.

As presented in response to Specific Comment 16, text was added to indicate that the Indiana Bat was captured along Little Sulphur Creek south of the Ammunition Burial Grounds, and Little Sulphur Creek provides suitable habitat for both pregnant/lactating females, and male Indiana bats.

The following changes were made to the QAPP to add the Indiana Bat as an assessment endpoint:

- The fourth bullet at the end of Section D.2.4.3 was changed as follows: "Carnivorous mammals: Short Tail Shrew and Little Brown Bat"
- The following sentence was added to the last line in Section D.2.4.3: "Note that the Little Brown Bat is being used as an indicator species for the Indiana Bat based on the availability of exposure parameters for the Little Brown Bat."
- The exposure parameters for the Little Brown Bat were added to Tables D-1 and Table D.A-2-1.
- A receptor profile for the Indiana Bat and Little Brown Bat was added to Attachment D-1.
- The following sentences was added to Section D.4.3 before the paragraph beginning with "The lower bound of the threshold effects....": "Because insects were collected and analyzed for metals and explosives from two locations along Little Sulphur Creek, the contaminant concentration in the insects will be used as the FC for the Little Brown Bat."
- In Sections 1.4.3.1 and D.2.3.3, Surface Soil/Sediment, the sixth sentence in the second paragraph was revised as follows: "Mammals may also be exposed to contaminants in the soil/sediment via incidental ingestion of soil and ingestion of plants or invertebrates that have accumulated contaminants from the soil/sediment."
- In Sections 1.4.3.1 and D.2.4.1, Endpoints, the sixth bullet in the list of potential receptors was revised as follows: "Soil/Sediment Invertebrate-Eating Mammals (including bats)"

Also, see the response to Specific Comment No. 16.

Comment 49:

Referring to Section D.2.4.1, Page D-15, Assessment Endpoints, the intermittent nature of Little Sulphur Creek would be expected to provide prime habitat for amphibians. The text on page D-29 states, "Risks to reptiles and amphibians will not be quantitatively evaluated because exposure factors are not established for most species and toxicity data are very limited." However, the ERA Methodology should either indicate that amphibians are not likely to use the area or include amphibians in the assessment endpoints. It is recognized that measurement endpoints associated with amphibians may not be available. However, the SERA should be revised to identify them as receptors of concern and provide a qualitative evaluation, if appropriate.

Amphibians and reptiles will be qualitatively evaluated as part of the SERA. In Section D.2.4.1 Assessment Endpoints, the bulleted list was revised to include the following bullet:

- "Amphibians and Reptiles"

In addition, the following paragraph was added to the end of Section D.2.4.1:

"Amphibians and Reptiles: Amphibians are expected to inhabit water bodies and the surrounding areas, while reptiles can inhabit both aquatic environments and terrestrial habitats. Amphibians and reptiles feed primarily on invertebrates, plants, fish, and/or small mammals. They are exposed to, and can accumulate, contaminants from the food items they consume, or from the surface water/sediment/surface soil in which they live."

In Section D.6.1 Measurement and Assessment Endpoints, the first sentence in the second paragraph was deleted, and the last sentence in the second paragraph was replaced by the following sentence:

"However, risks to reptiles and amphibians will be qualitatively evaluated as part of the SERA."

Comment 50:

Referring to Section D.2.4.2, Page D-17, Measurement Endpoints, the third bullet indicates that mortality of benthic macroinvertebrates will be evaluated. Revise the document to clarify that non-lethal endpoints will be used in the SERA.

Non-lethal endpoints (e.g., growth, development, and reproduction) as well as mortality will be evaluated in the SERA. Section 1.3.1 of the USEPA Ecological Risk Assessment Guidance for Superfund, Process for Designing and Conducting Ecological Risk Assessments (1997) indicates that NOAELs and LOAELs may be based on mortality. In Section D.2.4.2 Measurement Endpoints, the third bullet has been revised as follows to include non-lethal endpoints:

- "Sediment screening values – Mortality and other adverse effects (e.g., growth, feeding rates, behavioral changes) of benthic macroinvertebrates will be evaluated by comparing the measured concentrations (maxima and averages) of chemicals in the sediment to screening values designed to be protective of ecological receptors."

Comment 51:

Section D.3, Page D-18, Ecological Effects Evaluation states that maximum detected concentrations will be compared to Region 5 Ecological Data Quality Levels (EDQLs) as the first level screening. It is recommended that other readily available screening benchmarks (e.g., current National Ambient Water Quality, U.S. EPA EcoTox sediment values, Oak Ridge National

Laboratory (ORNL) screening values) also be used in the initial screening process. The SERA methodology should be revised to present all readily available screening values with the lowest value selected for the initial screening process.

According to EPA's Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments (1997), COPCs will be selected in Step 2 based on Region 5 Ecological Data Quality Levels (EDQLs), which should reflect the lowest screening levels available. Other available and less conservative screening benchmarks (e.g., current National Ambient Water Quality, U.S. EPA EcoTox sediment values, Oak Ridge National Laboratory (ORNL) screening values) will be used to further evaluate the data in the Step 3a Refinement, per the Navy Policy for Conducting Ecological Risk Assessment (1999), as discussed in Section D.4 (Also, see Figure D-1).

No changes to the QAPP were made based on this comment.

Comment 52:

Referring to Section D.4.1, Page D-20, Alternate Benchmarks, the alternate benchmarks are appropriate for use in the SERA. However, all available benchmarks should be combined and the lowest available screening concentration should be used for the initial screening, rather than in the proposed Step 3a. Revise the ERA Methodology to include all available benchmarks as part of the initial screening.

See response to Specific Comment #51.

Comment 53:

Referring to Section D.4.1.3, Page D-23, Sediment, the Ontario Ministry of Environment and Energy (OMOE) and the values produced by Long et al., 1995, include several no effect and severe effect levels. The SERA should include a statement indicating that only the no effect levels will be used in the initial screening level assessment or indicate how effect levels will be adjusted if they are used in the SERA.

According to EPA's Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments (1997), COPCs will be selected in Step 2 (Screening-Level Exposure Estimate and Risk Calculation) based on Region 5 Ecological Data Quality Levels (EDQLs). The Lowest Effect Levels and Severe Effect Levels (OMOE, 1993), as well as the Effects Range – Median and Probable Effects Range (Long et al., 1995), will be used in the Step 3a Refinement, per the Navy Policy for Conducting Ecological Risk Assessment (1999).

No changes to the QAPP were made based on this comment.

Comment 54:

Section D.4.3, Page D-26, Characterization of Exposure indicates that 95 percent upper confidence levels (UCLs) and average soil, surface water, and sediment concentrations will be used to assess terrestrial soil invertebrates and plants, and aquatic organisms exposure. It is agreed that soil and aquatic organisms will most likely be exposed across an average concentration throughout a given media, however, it is not known whether the sample locations or sampling and analyses methodologies necessarily represent average exposure concentrations. Therefore, it is recommended that the SERA include a comparison of both the maximum detected concentration and the average (or 95 percent UCL) to the most conservative (i.e., lowest available benchmark) for the initial selection of COPECs. The results of COPEC selection, as well as for chemicals to be used in the food chain models, should be based on the results using the maximum detected concentration. The results using average detected concentrations should be used in the risk characterization discussion following the BERA.

To evaluate the most conservative scenario, the 95 percent upper confidence levels (UCLs) or the maximum concentrations will be compared to the Region V EDQLs in the Step 2: Screening-Level Exposure Estimate and Risk Calculation. If greater than ten samples are collected per media, the 95 percent UCLs will be used (unless the 95 percent UCL is greater than the maximum concentration, then the maximum will be used); if less than ten samples are collected per media, the maximum concentrations will be used. Maximum concentrations (or 95 percent UCLs) and average concentrations will be used in the Step 3a Refinement to evaluate the data.

No changes were made to the QAPP based on this comment.

Comment 55:

Section D.4.3., Page D-27, Characterization of Exposure indicates that the prey items will be calculated using a percent lipid content in fish and percent total organic carbon (TOC) in sediment, however, the actual lipid and TOC assumptions have not been identified (in either the text or in Attachment D.A-2). Revise the document to justify and specify the use of these parameters for this assessment.

The percent lipid content in fish will be 3.6%, which is the average of various values for sunfish species presented in Appendix C, Table C-3b of The Incidence and Severity of Sediment Contamination in Surface Waters of the United States (USEPA, 1997). Percent total organic carbon (TOC) in sediment will be site-specific, based on samples collected as part of this QAPP. In Section D.4.3 Characterization of Exposure, the equation for organic constituents in sediment was revised as follows:

"For organic constituents in the sediment, the contaminant concentration of the prey items is calculated using the following equation:

$$FC = \frac{SC * \%L * BSAF}{\%TOC}$$

Where: FC = Contaminant concentration in food
SC = Contaminant concentration in sediment
%L = Percentage of lipids in fish (3.6% = the average of various species of sunfish. Attachment D-1 presents the calculation used to derive this value [USEPA, 1997])
BSAF = Biota-Sediment Accumulation Factor (chemical-specific)
%TOC = Percentage of total organic carbon in sediment (site-specific)"

Comment 56:

Section D.6.1., Page D-29, Measurement and Assessment Endpoints indicates that mortality of a shrew is used to assess mortality of the small mammal population, however, predicting mortality to a shrew may either under or overprotect the small mammal population. While it is noted that the statement is provided as an example of surrogate species, it should be noted that mortality is not considered an appropriate measurement endpoint for use in the SERA. Revise the document to either provide a more relevant example of uncertainty associated chronic endpoints or clarify that acute endpoints are not associated with the ERA methodology. In addition, it is indicated that risks to reptiles and amphibians will not be quantitatively evaluated because exposure factors are not established for most species and toxicity data are limited. It is agreed that variables associated with herptiles are not available for quantitative assessment, however, due to the presence of possible habitat, it is recommended that these receptors be discussed and included in the conceptual site model and evaluated qualitatively in the SERA.

Note that "mortality" is not synonymous with "acute endpoint;" mortality may be considered a chronic endpoint if the duration of the study on which it is based is sufficient to be considered a chronic study. Similarly, "non-lethal endpoint" is not synonymous with "chronic endpoint;" non-lethal endpoints such as growth may be based on acute studies. However, because most of the toxicity data that will be used in the food chain models are based on reproductive studies, the fourth and fifth sentences in Section D.6.1 Measurement and Assessment Endpoints have been revised as follows:

"For example, a decrease in reproduction of a shrew is used to assess a decrease in reproduction of the small mammal population. However, predicting a decrease in reproduction of a shrew may either under- or overprotect the small mammal population, resulting from differences in ingestion rates, toxicity, food preferences, etc. between different species."

Amphibians and reptiles will be qualitatively evaluated as part of the SERA. See the response to Comment 11. The conceptual site model was revised to include amphibians and reptiles as receptors.

Comment 57:

Section D.6.2, Page D-30, Exposure Characterization indicates that all chemicals are assumed to be 100 percent bioavailable at the detected concentrations. This information does not appear to correlate to the information in the table in Section D.4.3, which indicates the use of 90 percent and median values. The document should be clarified as appropriate.

As explained in Section D.6.2, Exposure Characterization, chemical bioavailability is dependent on characteristics of the media, such as pH, organic carbon, etc. However, for the purposes of the SERA, all chemicals will be considered 100% bioavailable in all media (the most conservative assumption). The 90th percentile and median BAFs/BSAFs presented in the table in Section D.4.3 are soil-to-plant and soil-to-invertebrate uptake factors, which represent the proportion of chemicals in soil occurring in plants and invertebrates. However, the chemical contaminants in plants and invertebrates are assumed to be 100% bioavailable to upper trophic level receptors, such as mammals and birds that consume the plants and invertebrates.

No changes were made to the QAPP in response to this comment.

Comment 58:

Referring to Section D.6.4., Page D-31, Risk Characterization, it is not agreed that a relationship between the magnitude of an ecological effects quotient (EEQ) can be used as a rough approximation of the extent of potential risks at the site, even if there is confidence in the guideline. The magnitude of effects cannot be judged since it is only known that the dose which was used to derive the toxicity reference value has been exceeded. However, the amount of the exceedance does not indicate or allow for an estimation of what the response would be based on the magnitude of the exceedance of the dose. Therefore, it should not be implied that risk is incurred due to the exceedance of the hazard quotient (HQ). Revise the document to include only a discussion of HQ exceedances greater than 1.

In Section D.6.4 Risk Characterization, the text was revised as follows:

"Risks are possible if an EEQ is greater than or equal to unity regardless of the magnitude of the EEQ. However, the magnitude of effects to ecological receptors cannot be inferred based on the magnitude of the EEQ. Rather, an EEQ greater than 1.0 simply indicates that the dose used to derive the toxicity reference value was exceeded. Finally, there is uncertainty in how the predicted risks to a species at the site translate into risk to the population in the area as a whole."

Comment 59:

Table D-1, Exposure Parameters for Test Species and Surrogate Wildlife Species, presents a list which includes four potential test species and six surrogate wildlife species. The relationship between the test and surrogate species is not evident based on the information presented in the table. Revise the table to clarify the relationship between the test and surrogate species.

As explained in Section D.4.2 Terrestrial Food Chain Modeling, body weight scaling is performed in terrestrial food chain modeling to account for the difference in body weight between the test species used to generate the NOAELs and LOAELs, and the surrogate wildlife species chosen as ecological receptors. Table D-1 presents the body weights used in this process in tabular format.

No changes were made to the QAPP in response to this comment.

Comment 60:

Referring to Figure D-2, Ecological Conceptual Site Model, it is expected that terrestrial vertebrates will have direct contact with surface water and sediment (when available). Therefore, the model should designate that complete pathways exist for terrestrial vertebrate exposures to surface water and sediment.

Figure D-2 (Ecological Conceptual Site Model) has been revised to designate complete exposure pathways for direct contact with surface water and sediment for terrestrial vertebrates.

U.S. EPA COMMENTS (4/3/01) ON THE QUALITY ASSURANCE PROJECT PLAN FOR RCRA RFI PHASE III AT SWMU #3
ABG - LITTLE SULPHUR CREEK & JEEP TRAIL - DATED SEPTEMBER 2000
NAVAL SURFACE WARFARE CENTER
CRANE, INDIANA

For OJT/Little Sulphur Creek:

14. Section D.4, Step 3A-Refinement of the SERA (Page D-19). In general, the refinement process is not considered appropriate. The section provides several lines-of-evidence to be used to help refine COPCs prior to proceeding to the baseline risk assessment. Most of the lines-of-evidence presented are necessarily incorrect and, if used correctly following a baseline risk assessment, are considered appropriate. However, the use of these lines-of-evidence prior to the BERA introduces a high degree of uncertainty and subjectivity that is not in accordance with the U.S. EPA ERA process.

The Step 3A-Refinement in accordance with Navy Policy is actually the first step in a BERA. The wording in the QAPP was meant to indicate that the Step 3A evaluation would be included as part of the initial risk assessment for the site, but not actually part of the SERA. The following sections of the QAPP were revised to clarify this issue:

- The fourth sentence in the paragraph beginning with "This SERA will consist of..." in Section 1.4.3 was revised as follows: "Step 3A is the first step of the BERA and consists of refining the list of COPCs that were retained following the SERA, as discussed in Section 1.4.3.3."

- The title of Sections 1.4.3.3 and D.4 was changed to "Step 3A – Refinement of COPCs" and the first sentences in those sections were changed to "Step 3A consists of refining the list of COPCs from the SERA using less ..."

- The words "(plus Step 3a) were removed from the first sentence in the paragraph beginning with "This SERA will consist of the first two (plus Step 3a) of eight steps required by the ..." in Section

D.1. The fourth sentence in that paragraph was revised as follows: "Step 3a is the first step of the BERA and consists of refining the list of COPCs that were retained following the SERA."

- The following sentence was added after the first sentence in the first paragraph of Section D.4 "Note that the Step 3a evaluation will be included as an attachment to the SERA."

15. Section D.4, Step 3A-Refinement of the SERA, first bullet (Page D-20). The first bullet indicates that the magnitude of criterion exceedance may be used as one of the lines-of-evidence to determine the need for further site evaluation. The magnitude of an exceedance of a benchmark is not an appropriate determination for assessment of potential risk during any portion of the ERA process. The SERA process which compares a conservative screening benchmark to the maximum detected concentration associated with a site to produce a hazard quotient is actually a qualitative assessment. It is intended to produce a "yes or no" result dependent on whether the result is above or below unity. Because the benchmark/criteria are generic (non site-specific) and are based on a wide range of values, the magnitude of the exceedance should not be misconstrued or used to ascertain any level of risk. Revise the ERA Methodology to only indicate that a hazard quotient of 1 has been exceeded.

The Navy agrees that a hazard quotient greater than 1.0 indicates the need to retain that chemical as a COPC. However, during the Step 3a evaluation, a chemical that has a relatively low hazard quotient (i.e., 1.1) may not be recommended to be carried through Steps 3b through 7 because of many factors (i.e., spatial extent of contamination, location of exceedance, etc.). Therefore, the magnitude of criterion exceedance is one factor that will be evaluated during Step 3a in a lines-of-evidence approach.

16. Section D.4, Step 3A-Refinement of the SERA, second bullet (Page D-19). The second bullet indicates that chemicals detected frequently will be given greater consideration than those detected relatively infrequently. The use of frequency of detection is not an appropriate consideration for the SERA. A limited number of sample locations have been designated and are proposed to reflect the areas that are most likely to be contaminated. Thus, even if a chemical has been detected once, it may reflect a contaminant at the site. The use of frequency of detection as a line-of-evidence for eliminating a COPC is most likely supported and appropriate if the location of the detection is surrounded by other non-detects for the same chemical (with a detection limit below an appropriate ecological benchmark) and it can be documented that the chemical is not associated with Navy activities. Since it is typically not cost effective or practical to ascertain non-detect locations surrounding all detected chemicals, frequency of detection is not used to eliminate a chemical. Rather, frequency of detection is used as one of the lines-of-evidence in the Risk characterization as part of the BERA. Revise the document to eliminate the Step 3a refinement parameters.

As indicated in the comment, the frequency of detection is one of the lines of evidence that can be used to determine if a chemical needs to be retained as a COPC during the BERA. This is also presented in the Navy Policy for Conducting Ecological Risk Assessments (U.S. Navy, 1999). Because the Step 3a evaluation is part of the BERA, the detection frequency is one factor that will be evaluated during Step 3a in a lines-of-evidence approach.

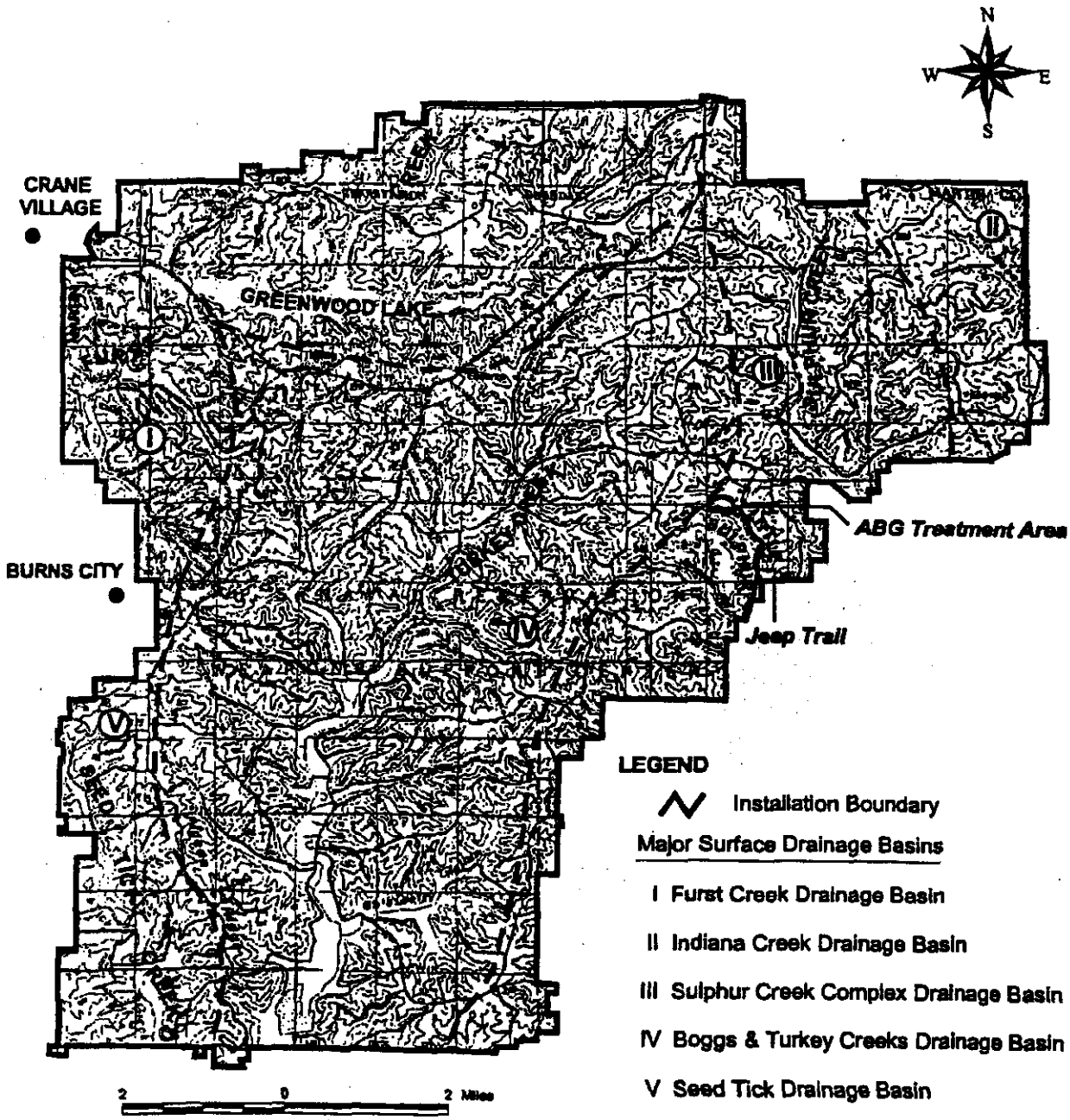
17. Section D.4, Step 3A-Refinement of the SERA, third and fourth bullets (Page D-19). Both contaminant bioavailability and habitat are typically used as lines-of-evidence following the BERA and are not appropriate for use during the SERA. For example, the determination of contaminant bioavailability is highly dependent on the collection of representative data and adequate characterization of the variable habitat media at and surrounding the site. The determination of "use of habitat" is subjective and can be highly dependent on professional judgment. The use of this criteria as a line-of-evidence during the SERA is not recommended.

Revise this section to eliminate contaminant bioavailability and habitat as a line-of-evidence criteria during the SERA.

As indicated in the comment, the contaminant bioavailability and habitat are part of the lines of evidence that can be used to determine if a chemical needs to be retained as a COPC during the BERA. This is also presented in the Navy Policy for Conducting Ecological Risk Assessments (U.S. Navy, 1999). Because the Step 3a evaluation is part of the BERA, these factors will be evaluated during Step 3a in a lines-of-evidence approach.

APPENDIX 1

Figures and Attachment referenced in response to Specific Comment No. 21



SOURCE: "Initial Assessment of Study of Naval Weapons Support Center Crane, Indiana." Naval Energy and Environmental Support Activity, May 1983.

DRAWN BY J. LAMEY DATE 8/1/00	Tetra Tech NUS, Inc.	CONTRACT NUMBER 0514	OWNER NO. CTO 126
CHECKED BY — DATE —	AOC LOCATIONS AND DRAINAGE BASINS NAVAL SURFACE WARFARE CENTER CRANE, INDIANA	APPROVED BY — DATE —	
COST/SCH/ZONE/AREA		APPROVED BY — DATE —	
SCALE AS NOTED		DRAWING NO. FIGURE 1-2	REV 0

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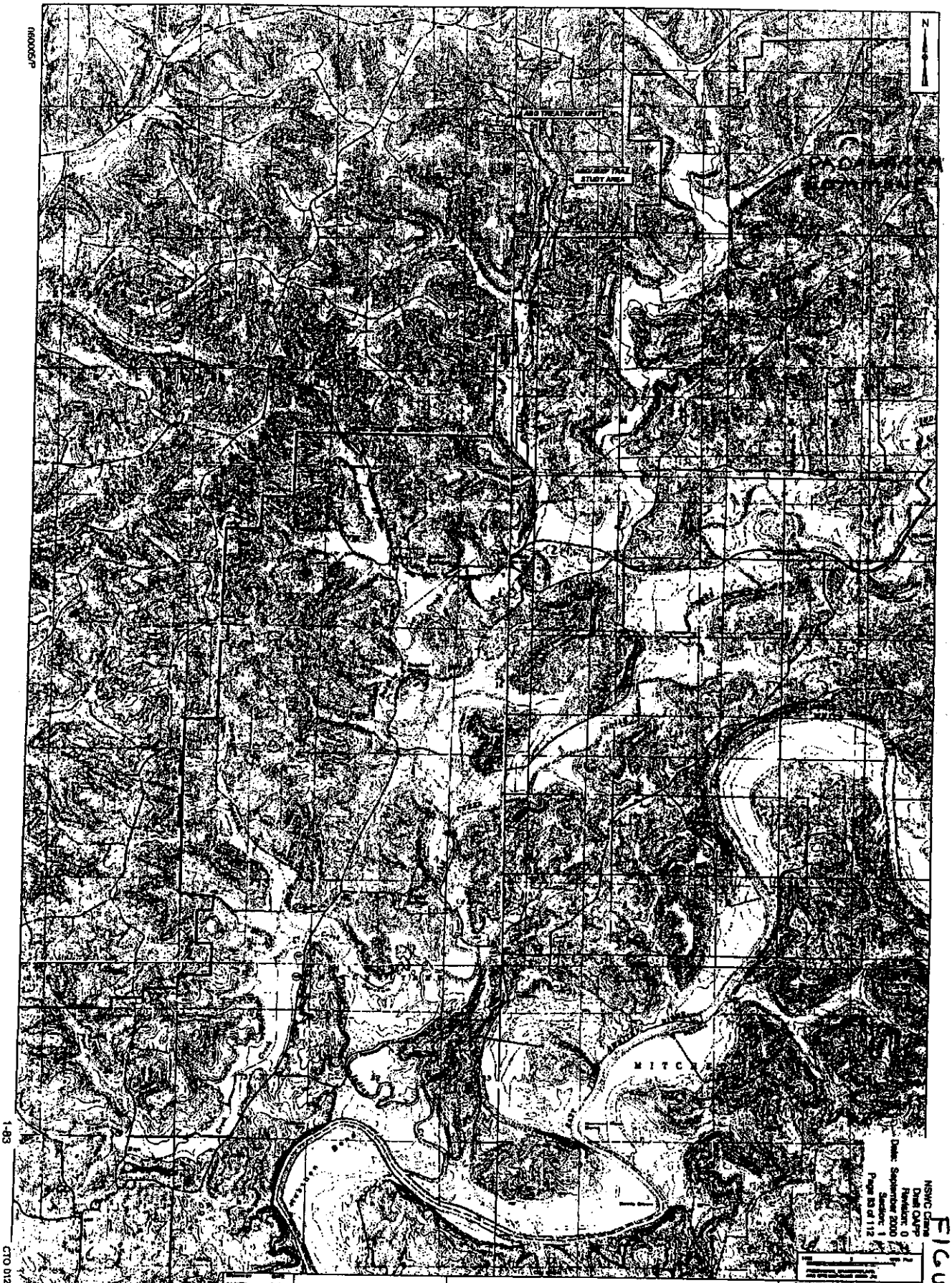

Tetra Tech NUS, Inc.

SITE MAP
AMMUNITION BURNING GROUND/JEEP TRAIL STUDY AREA
NAVAL SURFACE WARFARE CENTER
CRANE, INDIANA

FIGURE 1-3

CTO 0126

NSWC Crane
Draft OAPP
Revision: 0
Date: September 2000
Section: 1
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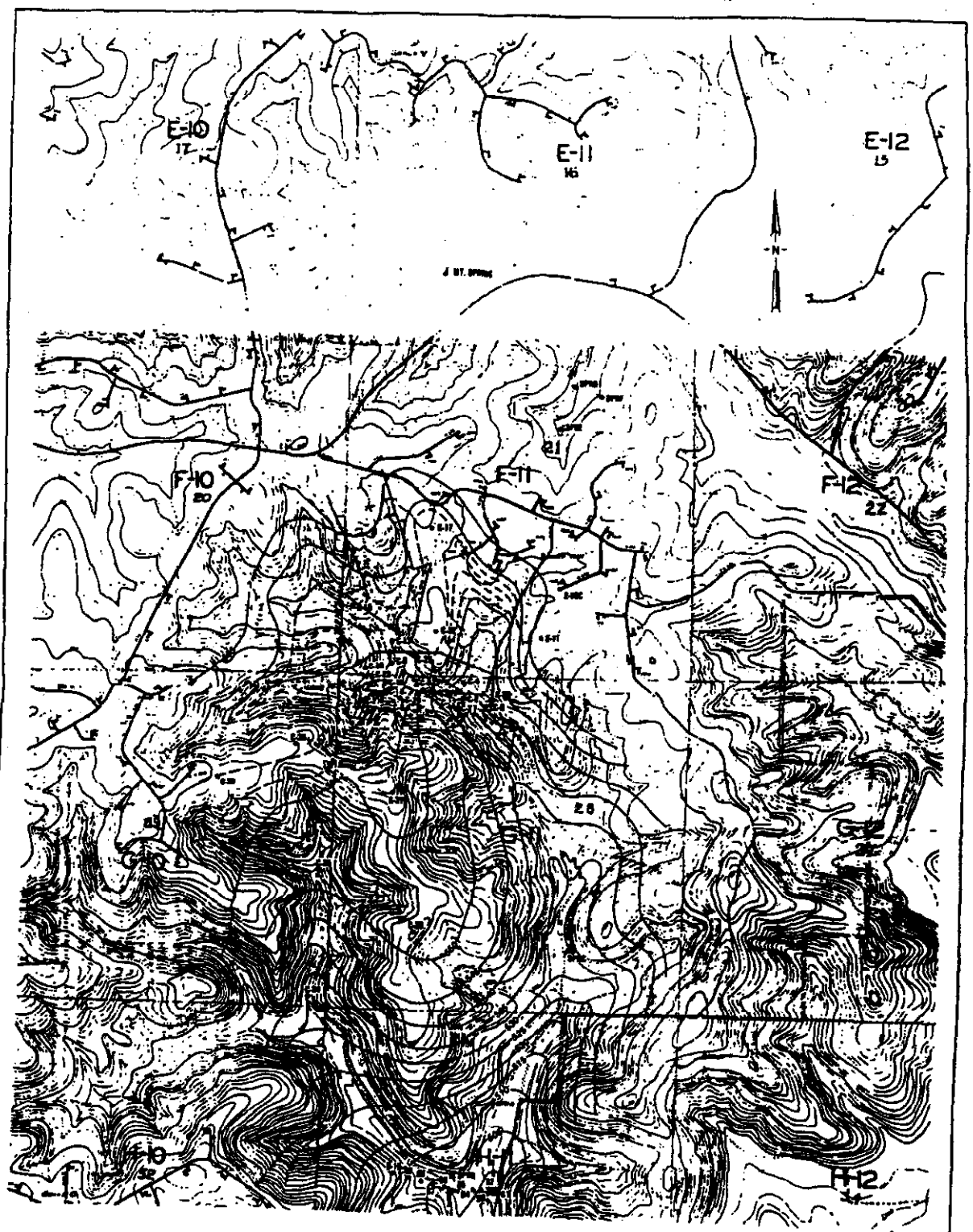
FIGURE 2



NOTE: ELEVATIONS IN FT MSL

NOTE: ARROWS SHOW PROMINENT FLOW DIRECTIONS THROUGH ABG IN BEECH CREEK AQUIFER.
ARROW WIDTH INDICATES ESTIMATED RELATIVE FLOW VOLUME.
CONTOUR INTERVAL = 5 FT
(1 FT WHERE DASHED)

NAVAL WEAPONS SUPPORT CENTER
CRANE, INDIANA

ELEVATION OF TOP OF WATER TABLE
IN BEECH CREEK AQUIFER
ABG Study Area

PLATE 23

FIGURE 3

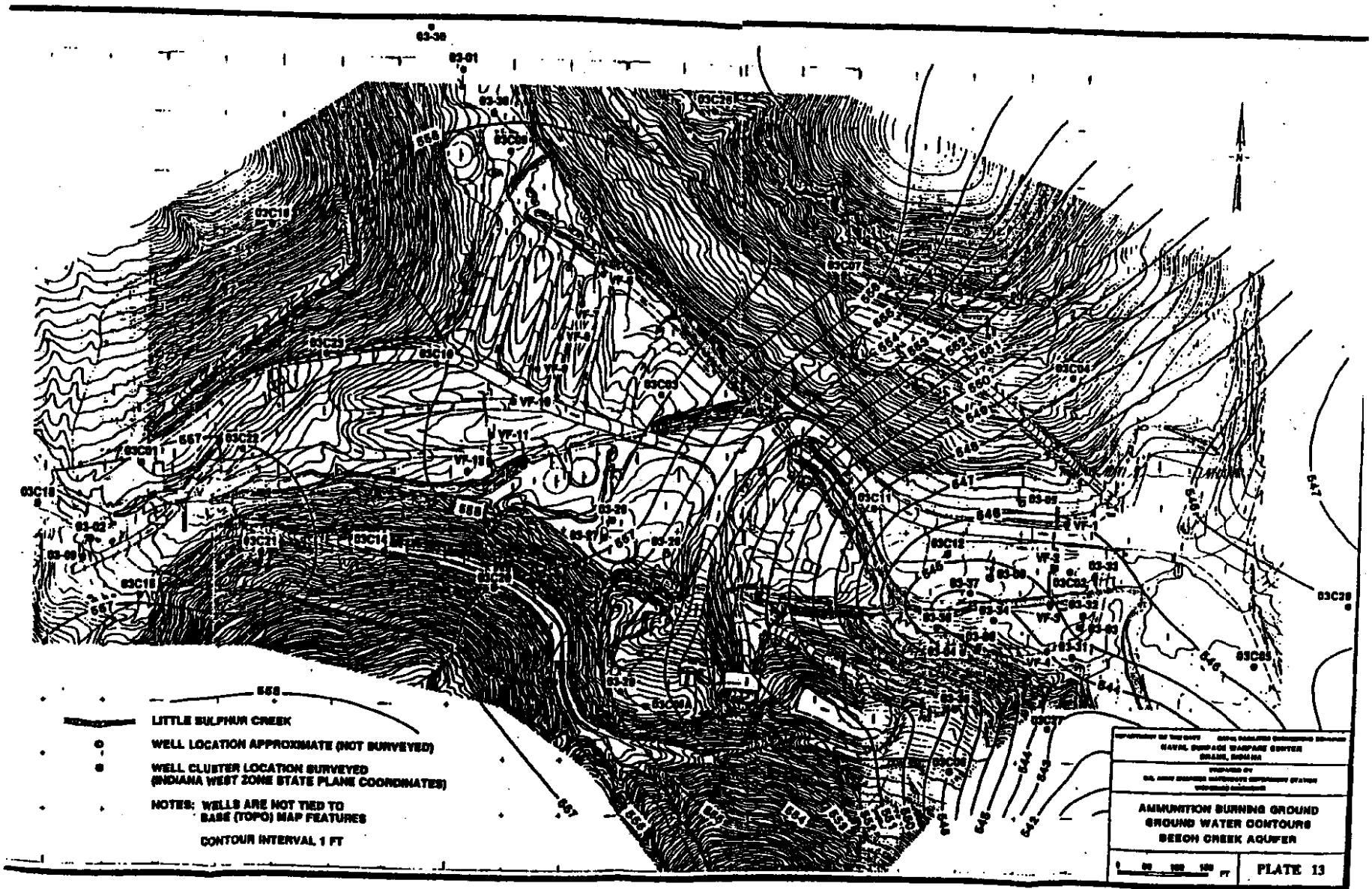

LITTLE SULPHUR CREEK
WELL LOCATION APPROXIMATE (NOT SURVEYED)
WELL CLUSTER LOCATION SURVEYED
(INDIANA WEST ZONE STATE PLANE COORDINATES)
NOTES: WELLS ARE NOT TIED TO
BASE (TOPO) MAP FEATURES
CONTOUR INTERVAL 1 FT
NAVAL SURFACE WARFARE CENTER
AMMUNITION BURNING GROUND
GROUND WATER CONTOURS
BEECH CREEK AQUIFER
PLATE 13

FIGURE 4

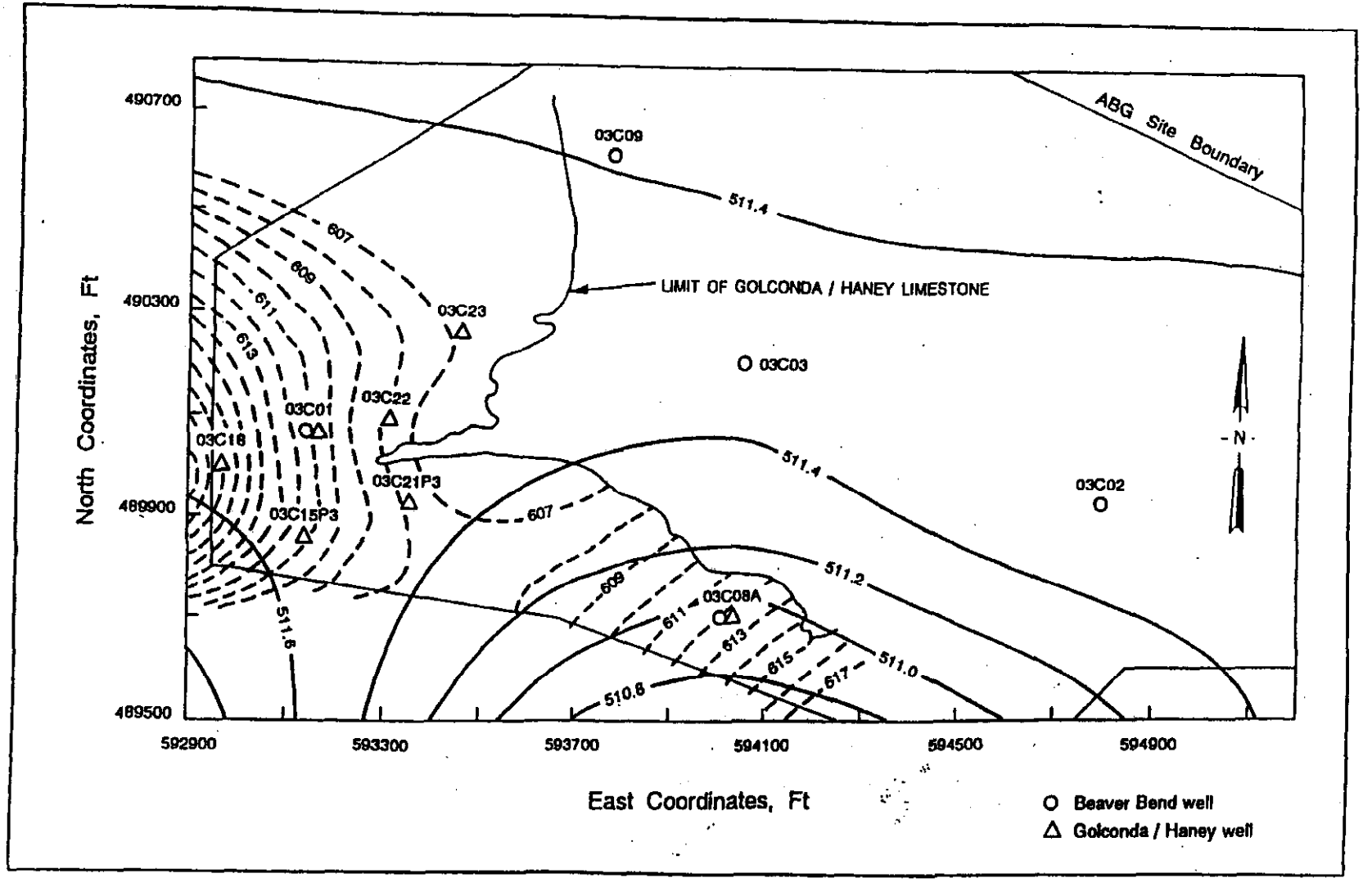


Figure 9. Piezometric surfaces, Golconda/Haney (dashed) and Beaver Bend (solid) limestones, Ammunition Burning Ground, for 12/28/89

FIGURE 5

FIGURE 6

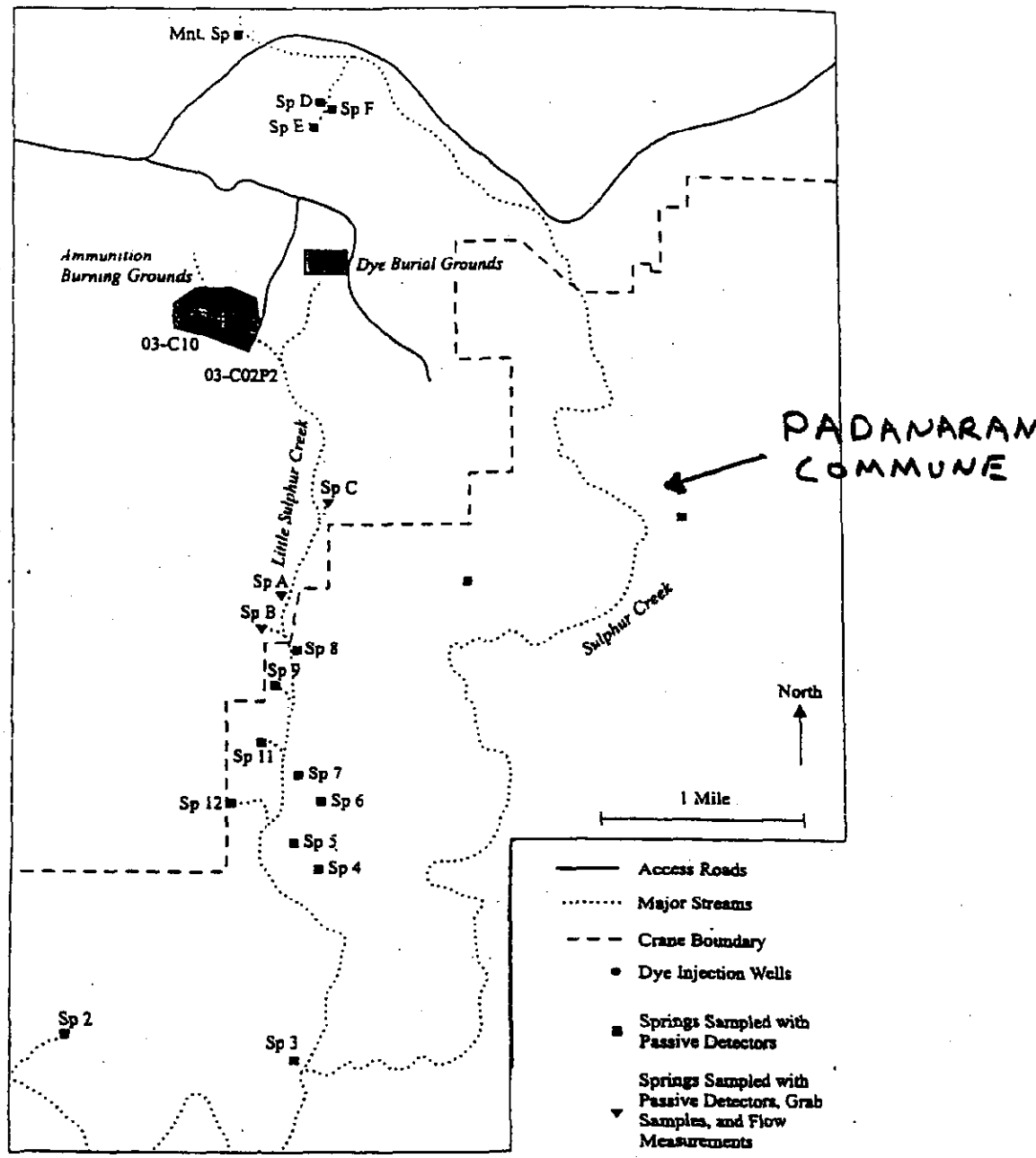


Figure 5. Location of injection wells and location of springs used for monitoring during the tracer test at the Ammunition Burning Grounds.

ATTACHMENT 1

GROUND WATER FLOW AND CONTAMINANT TRANSPORT IN CARBONATE AQUIFERS

Groundwater Flow and Contaminant Transport in Carbonate Aquifers

Edited by
IRA D. SASOWSKY
Department of Geology, University of Akron, Ohio, USA
CAROL M. WICKS
Department of Geological Sciences, University of Missouri, Columbia, Mo., USA

OFFPRINT

Ralph -
Here is the published report we talked about during our conference call.
Thanks,
Jennifer

A.A. BALKEMA/ROTTERDAM/BROOKFIELD/2000

Quantitative tracer test of the Beech Creek aquifer at the Ammunition Burning Grounds, Naval Surface Warfare Center, Crane, Indiana

STEVEN J. BAEDKE
Department of Geology and Environmental Studies, James Madison University, Harrisonburg, USA
NOEL C. KROTHE
Department of Geological Sciences, Indiana University, Bloomington, USA

ABSTRACT: A quantitative tracer test was conducted on the karst system in the Beech Creek aquifer at the Crane Naval Surface Warfare Center, Indiana. A mixture of 1.6 kilograms of Rhodamine WT (20%) and 18.3 kilograms of Br^- ionic tracer were injected into a cased well situated on a karst conduit. Tracers were collected at 14 spring orifices in the study with a combination of passive dye detectors, or passive dye detectors with continuous water sampling and continuous discharge measurements.

Rhodamine WT and Br^- were detected at one spring, consisting of a complex of 2 major orifices (Spring A and Spring A') and several diffuse seeps approximately 2000 meters from the injection well. The Br^- tracer breakthrough occurred 7 hours after injection, which is one half-hour before Rhodamine detection. The Br^- pulse dissipated within approximately 14 hours while Rhodamine WT was still detected days later. Using the time of first arrival for the Br^- tracer, the effective conductivity for this system is 286 m hr^{-1}. Approximately 80% of the injected Br^- recovered at the 2 major spring orifices and an additional 10-15% of Br^- is believed to have issued from the diffuse seeps in the area of the springs that could not be measured for discharge. Calculations suggest that approximately 110% of the injected Rhodamine dye was recovered from the same springs. The near total recovery of the injected tracers from the Spring A complex indicates that this karst system has only one significant outlet. This conclusion is substantiate since dye has not been detected on any of the 14 springs after one year of sampling. The early arrival and short lived Br^- tracer pulse, compared to Rhodamine, illustrates the more conservative nature of the ionic tracer.

1 INTRODUCTION

Predicting the pattern of groundwater flow in a karst aquifer is difficult since flow may cross typical flow boundaries defined by the porous media (i.e. groundwater divides), and the direction of flow can change temporally. Tracer tests are generally the most practical and satisfactory method to provide information about the movement of water in a karst aquifer system because of the unique hydrologic characteristics of karst terrains.

Tracing groundwater flow is accomplished by adding a distinctive substance, or tracer, to groundwater and monitoring down-gradient locations of concern. Injection of such

distinctive substances, either intentionally or accidentally, has often served to identify point to point connections between input points and resurgences such as springs or pumped wells. If establishing a hydrologic connection between a specific inflow point and a discharge point is all that is desired from the experiment, then simply injecting the tracer and looking for it downstream is all that is needed. This techniques defines a qualitative tracer test. Qualitative tracing techniques use tracers (commonly organic dyes) and passive detectors for tracer recovery to establish approximate flow-routes and groundwater basin boundaries.

To accurately establish water budgets, travel times and flow velocities of the tracer, and/or the amounts of tracer recovered, measurements of the concentration of tracer and discharge at a recovery point need to be measured. This technique defines a quantitative tracer test. Quantitative tracing techniques commonly use tracers (either organic dyes or ionic solutions), automatic samplers taking samples at known time intervals, and continuously recorded discharge measurements to establish parameters of the tracer results. Both qualitative and quantitative tracing techniques have been used in this study.

The injection of the Rhodamine WT constitutes the qualitative portion of the test. The fact that organic dyes can be absorbed on activate charcoal allows for detection of minute quantities of dye in distant areas from the injection point long after injection. Since Rhodamine is absorbed onto soil and rock materials it does not allow for a complete recovery of the dye during the test since as much as 50% of the dye may be absorbed. In this test an ionic tracer (Br^- was injected simultaneously with the Rhodamine since it is not absorbed to soil or rock materials and travels at the velocity of the water in which it is dissolved. Although many qualitative tests have been conducted in karst aquifers few quantitative tests have been conducted or the results published. The advantages of a quantitative test are:

1. The true velocity of flow in the conduit can be ascertained since there is no retardation.
2. Since the ionic tracer is not absorbed to rock or soil materials the percentage of tracer can be determined for each resurgence.
3. If all of the tracer is recovered then doubts about cross-basin flow can be dispelled.

2 HYDROGEOLOGIC SETTING

The study area includes the ABG within the Crane Naval Surface Warfare Center locatec in southern Indiana. The geology of this area has been well studied by Hunt (1988), Mur phy & Ciocco (1990), Murphy (1994), and Barnhill & Ambers (1994). The ABG i within the unglaciated region of the Crawford Upland which is dominated by rugged tc pography. Rock units observed in the area include Illinois Basin deposits ranging fro Mississippian to Pennsylvanian Age (Fig. 1). The West Baden, Stephensport, and Racoc Creek Groups comprise the underlying bedrock. The ammunition burning ground is l cated at the headwaters of the Little Sulphur Creek drainage valley (Fig. 2). This draina receives the majority of surface runoff within the ABG and has the potential to spre any contamination from the ABG to off-base locations (Hunt, 1998).

Three aquifers have been identified within the ABG (Hunt, 1988). The upper aquifer composed of the Golconda/Haney Formation and is underlain by the Indian Springs Sh aquiclude (Fig. 3). This aquifer is present in the western area of the ABG and has b

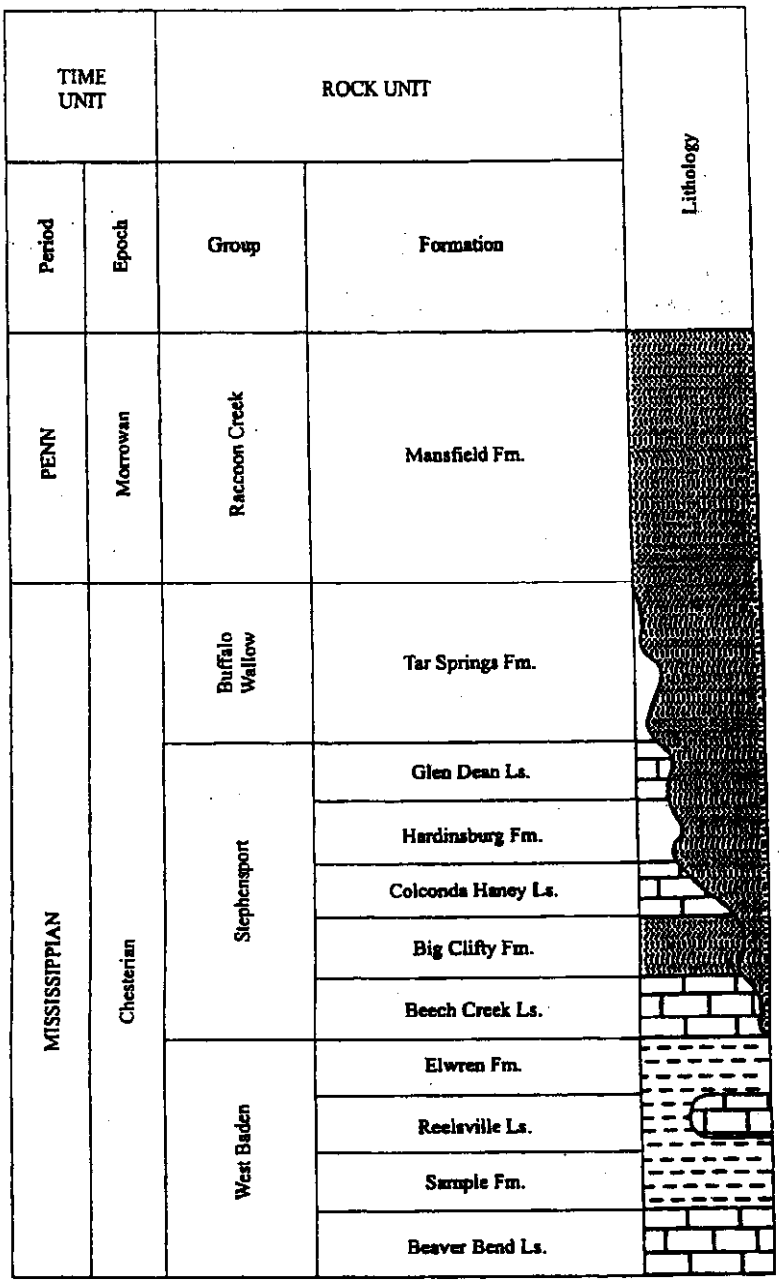


Figure 1. Stratigraphic column of rock units within the Naval Surface Warfare Center, Crane Division, Indiana.

removed by erosion in the majority of the ABG area. Downward migration of water prevented by the underlying aquiclude, however, the aquifer is open on the valley slope Water exiting the upper aquifer on the slopes has the potential for migration to lower a uifers within the ABG even though contributions from this aquifer are relatively ins nificant.

The middle aquifer consists of the lower sandstone member of the Big Clifty Form tion and the under-lying Beech Creek Limestone and is approximately 18.3 m (60f thick. This aquifer has been identified as the aquifer most likely to be contaminated fr munitions treatment practices within the ABG (Hunt, 1988). A groundwater contour m of this aquifer was created by Murphy (1994) and is presented in Figure 4. Comparison Figures 3 and 4 shows that a potentiometic low is created by the collapse in the stratig phy near the C well complex. Tracers were injected in well O3-CO2-P2 in that area. I charge to this aquifer occurs at outcrops of the Big Clifty and Beech Creek Format updip of the ABG (Hunt, 1998), and from infiltration within the ABG where the Inc Springs Shale has been eroded exposing the permeable and highly fractured Big Cl Sandstone (Hunt, 1988; Barnhill & Ambers, 1994). Solution caverns have develope the Beech Creek Limestone in areas bordering and underlying the Little Sulphur Cr

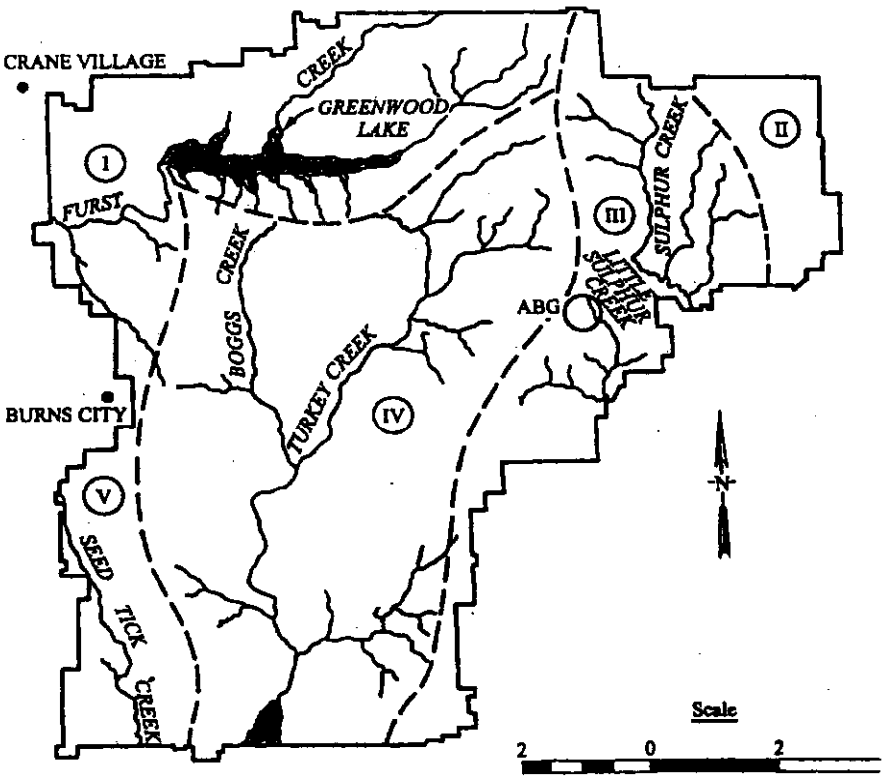


Figure 2. Location of study area and major drainages near the Naval Surface Warfare Center, Crane Indiana (modified from Hunt, 1988).

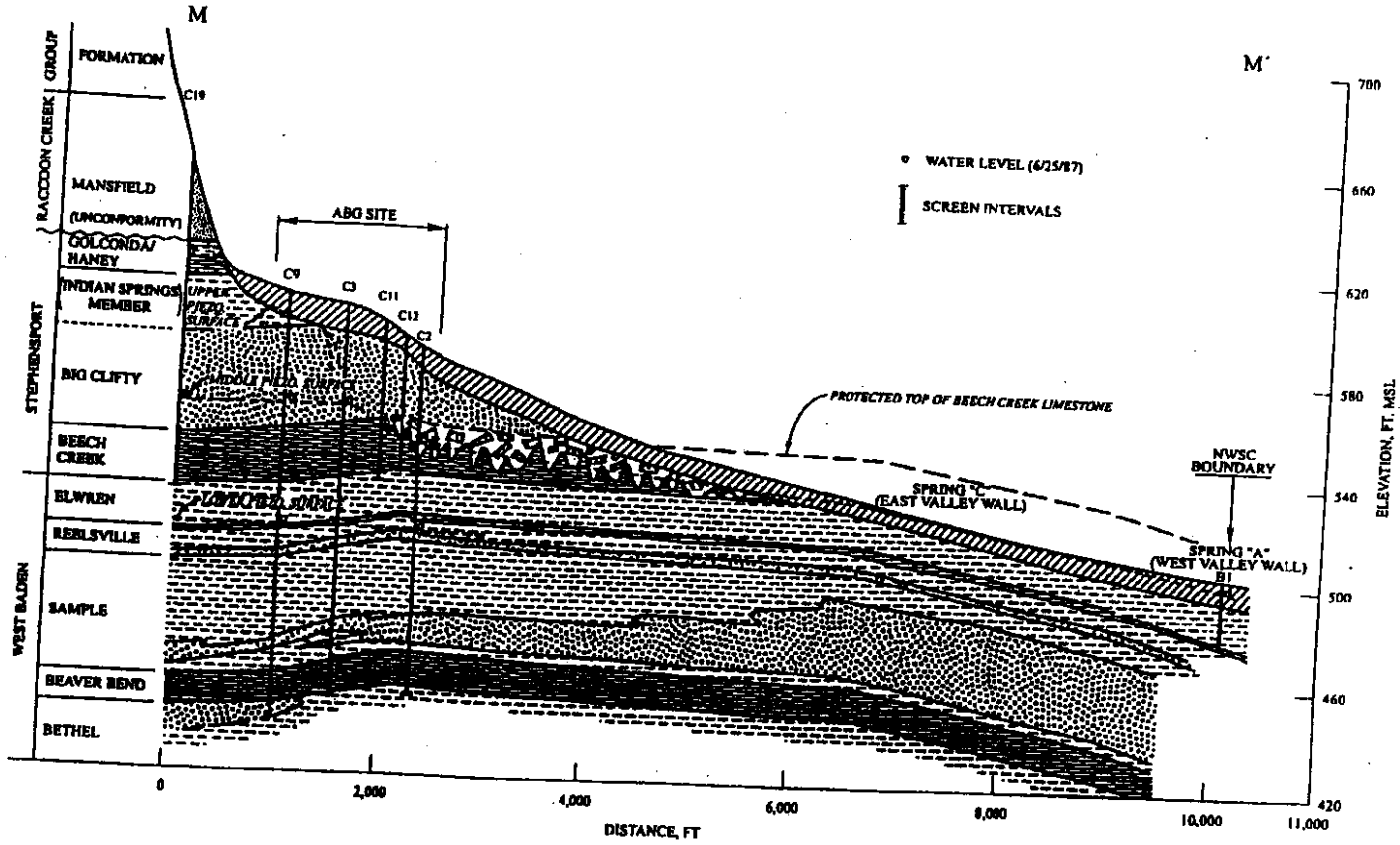


Figure 3. Geologic profile of Little Sulphur Creek Valley, Ammunition Burning Ground (Murphy & Ciocco, 1990).

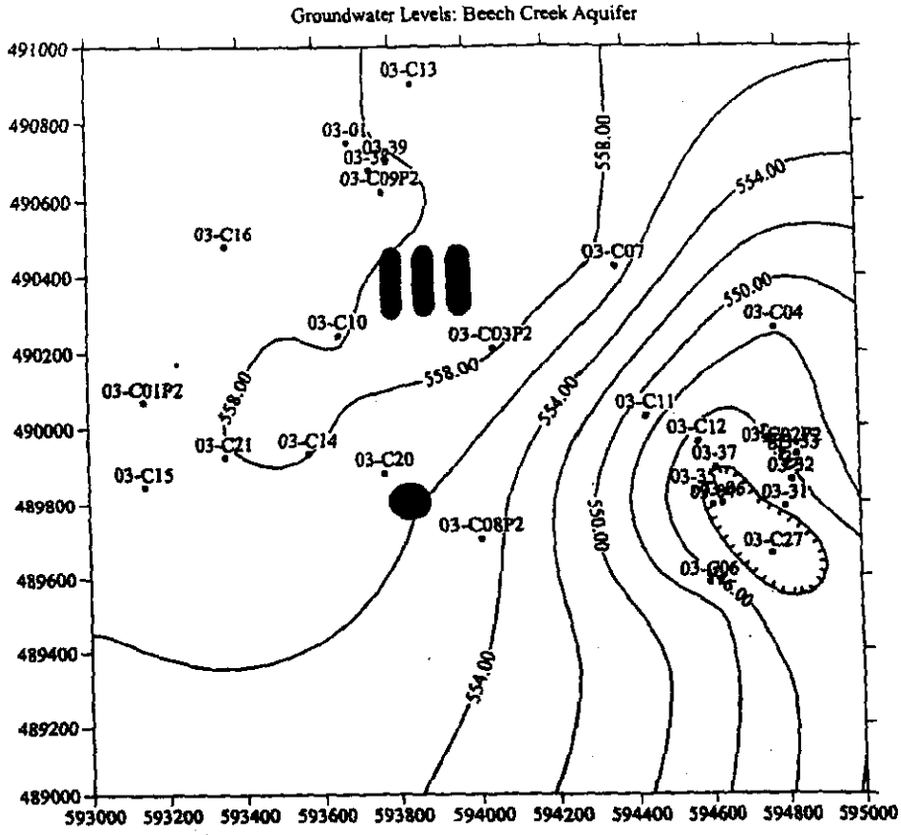


Figure 4. Groundwater contour map of the Ammunition Burning Ground (Dignazio et al., 1998) Elongate o ore the current locations of disposal activities. Contour interval is 2 feet and coordinates are in s.

drainage. Water rapidly infiltrates the overlying Big Clifty Sandstone and is force flow along limestone joints and fractures (Hunt, 1988). The Beech Creek Limestone trix has an extremely low permeability, but the overall permeability of the unit is hanced by the fractures and conduit development (Fig. 3). Therefore, the majorit groundwater within this aquifer is concentrated along these fractures and conduits (F hill & Ambers, 1994). Downward flow is prevented at the base of the aquifer by th derlying Elwren Shale aquiclude (Hunt, 1988; Barnhill & Ambers, 1994). The con have been shown to be connected to springs discharging in the lower reaches of the Sulphur Creek drainage (Murphy & Ciocco, 1990) and have the potential for con nating off-base locations (Fig. 3).

The lower aquifer is composed of the Beaver Bend Limestone and retains a co horizontal water level. Recharge to this lower aquifer comes almost entirely from F Bend Limestone outcrops updip to the north of the ABG. The Sample, Reelsvill Elwren Formations provide 70 ft of aquiclude between the lower Beaver Bend and the middle Big Clifty/Beech Creek aquifer lending little chance for hydrauli nection between these two aquifers.

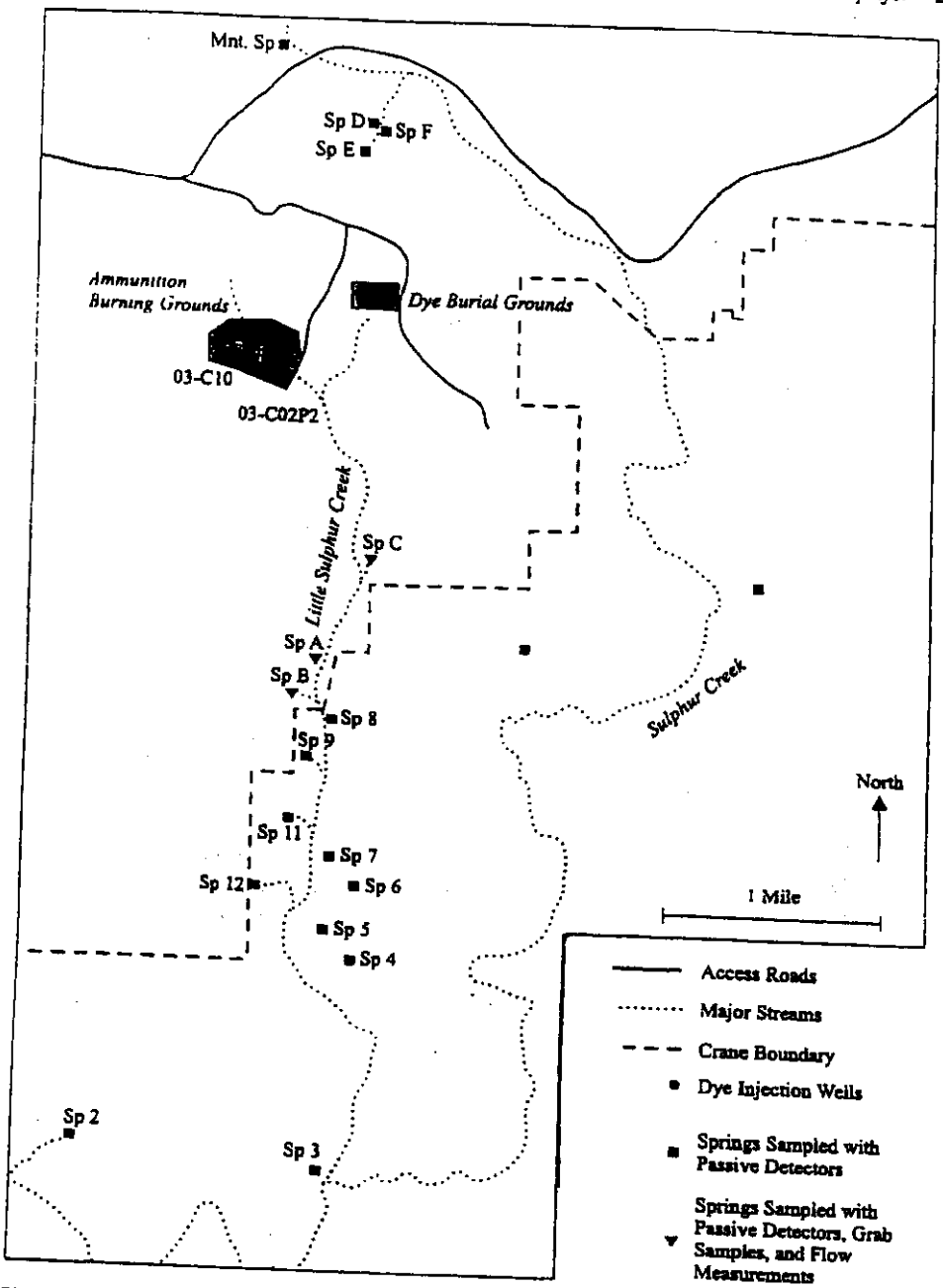


Figure 5. Location of injection wells and location of springs used for monitoring during the tracer test at the Ammunition Burning Grounds.

A hydraulic connection between the Beech Creek aquifer and a complex of springs (Fig. 5) was established by a previous qualitative dye trace at moderate flow conditions at the ABG (Murphy & Ciocco, 1990). During low flow conditions in the karst system, one pound of fluorescein dye was injected into well 03-C02P2 at the ABG. The presence of dye was visually detected between 5 and 24 hours at the Spring A complex (Sp A on Fig. 5), which consists of Spring A and Spring A' and several diffuse seeps. The fluorescein was detected under ultraviolet light from passive detectors placed at the spring orifices. Dye continued to be observed in a 'relatively high' concentration for at least 5 days (Murphy & Ciocco, 1990).

Springs B and C, also in the Little Sulphur Creek valley, were monitored but showed negative or 'weakly positive' indication of tracer. Although dye was not positively identified from Springs B and C, it was hypothesized that these springs are groundwater outlets at high flow conditions. Four springs north of the ABG (Springs E, F, G, and Mountain Spring) were also monitored and showed a 'weakly positive' indication for tracer in 'normal light'. It is, however, possible that the green coloration was caused by algae (Murphy & Ciocco, 1990). Based upon qualitative judgement, it is believed that very little of the total injected dye was recovered during this tracer test (Murphy & Ciocco, 1990).

The results of the previous dye trace have been used to design the quantitative trace experiment for this investigation.

3 DISPOSAL PRACTICES WITHIN THE AMMUNITION BURNING GROUND

The following discussion is summarized from the work of Murphy (1994). The ABG has been in operation since the 1940s and is currently used for the disposal of bare explosives, rocket motors, candles, flares, solvents, red phosphorous, detonators, and fuses. Murphy produced a detailed map showing the locations of all past and present operations within the ABG. A modified version of Murphy's map is presented in Figure 6 which shows the disposal sites as shaded areas with numeric labels that correspond to disposal descriptions.

The areas which have the highest potential for contamination within the ABG have been identified and include area 2, area 6, and the removed ash pile. Area 2 marks the location of 20 clay-lined pans used for the thermal treatment of bulk propellant and high explosives.

Area 6 marks the location of three lagoons which contained liquid sludges from munitions loading processes. These lagoons were modified in 1982 to include liners, covers, and leachate collection systems. The lagoons have been replaced by operations in area 1 and are currently empty. The northern lagoon was used to hold sludge water contaminated with phosphorous compounds. The two central lagoons were used to hold waters contaminated with breakdown components of TNT and RDX from manufacturing processes. Wastewater from explosive manufacturing and loading processes has been identified to have significant amounts of nitrate (Kroschwitz & Howe-Grant, 1991).

In addition, the large circular area designated as Ash Pile in the south of the ABG was used to store ash from thermal treatment operations. The pile included approximately 12,290 lb of ash before it was removed between July 1986 and February 1987. This ash pile was in direct contact with the ground surface for an extended period of time and may

have also been a significant source of contamination to the underlying Beech Creek aquifer (DiGnazio et al., 1998).

4 METHODS

The previous dye trace study did not definitively determine whether any spring, except for the Spring A complex, is hydrologically connected to the karst system that was traced. Additionally, since flow measurements were not taken for water emerging from the Spring A complex, it is not possible to quantify the amount of tracer recovered. Unknown tracer recovery is problematic in this situation since it is desirable that the results be able to direct remediation strategies for contaminants in a fracture system. Low tracer recovery could indicate either that significant amounts of tracer are being stored in the fracture system and/or that the tracer is leaving the system at unknown locations.

To improve upon the previous qualitative tracer study, a tracer test was conducted with two objectives: 1. to quantify the amount of tracer recovered from the major springs on NSWC property, and 2. to determine if any springs located on property outside the NSWC received tracer. In order to quantify the amount of tracer recovered, weirs were installed on Springs A', B, and C, and a flume was built for Spring A so that flow measurements could be made (Fig. 5). Transducers with continuous recorders were installed at each spring so that flow could be recorded remotely at frequent intervals. Each weir and flume were calibrated for the range of discharges expected during the tracer test. Calibrations were checked frequently before and during the tracer test and adjusted appropriately when needed.

Field reconnaissance in the study area revealed numerous karst springs issuing from the Beech Creek limestone. Ten additional springs within the Little Sulfur Creek valley and adjacent drainage basins were also monitored for this study (Fig. 5). These springs were monitored to determine if any tracer was moving off of the NWSC base or toward springs to the north of the ABG via conduits, therefore these springs were instrumented with only passive dye detectors (charcoal packets).

Since previous dye tracing in the ABG and activities adjacent to the Little Sulphur Creek drainage basin may produce ambient fluorescence in groundwater samples, a detailed analysis of background fluorescence was conducted to identify the concentrations of specific tracers that should be used during the test. The background analysis showed no detectable amounts of Rhodamine WT (20%) dye in the karst system. Additionally, chemical analysis of the water issuing from the springs showed that Br^- was below the detection limit for the lab equipment. Based on these results, it was determined that Rhodamine WT (20%) would be used as a dye tracer and Br^- would be used as an ionic tracer for the quantitative dye trace.

The amount of Rhodamine WT to be injected was determined by an estimation calculation established by Quinlin (1989) where 1 pound of dye is used per mile of desired trace length. The approximate distance from well 03-C02P2 to Spring 2 (Fig. 3) is 3.5 miles. Therefore it was determined that 3.5 pounds of Rhodamine (1.6 kilograms) were injected. Through consultation with researchers at the Westinghouse Project in Bloomington, IN who had traced with Br^- (McCann, personal communication), it was determined that approximately 18 kilograms of Br^- would be sufficient to trace the springs on

Figure 6. Map of disposal areas at the Ammunition Burning Grounds.

NSWC property. It was calculated that 23.5 kilograms of reagent grade NaBr (solid) dissolved in water dissociates to yield 18.3 kilograms of Br^- ion.

To obtain accurate amounts of the dyes detected in the water and charcoals, they were analyzed on a Shimadzu RF 5000 scanning spectrofluorophotometer. This instrument is extremely sensitive and can detect dyes in the part per trillion (ppt) range. A concentration curve was constructed with the dye batch purchased for this test by mixing a 1000 (mg/l) stock solution and diluting to derive concentrations. Bromide was analyzed by ion chromatography on a Dixones 4500 ion analyzer.

5 RESULTS

Well 03-C02P2 was injected with 1.6 kilograms of Rhodamine WT (20%) at 1232 hours (military time) on 5-3-97. This was immediately flushed with a 151 liter solution containing 18.3 kilograms of Br^- ion. This was flushed with an additional 19 liters of distilled water. The injection of tracers was completed at 1259 hours.

The karst system was at a high flow stage during the tracer test as 2.5 inches of rain fell the day before the test (5-2-97). The peak flow was topping the V-shaped weirs therefore flow measurements could not be taken. Once the flow receded to where it was flowing through the weirs the trace was initiated. Dye was injected into the wells when measurable discharge at each spring was within the calibrated range of the weirs and flume.

Automatic samplers (ISCO Model 2900 Sampler) at Springs A, A', B, C, and D were immediately set to sample at 30-minute intervals until dye was observed visually discharging from the spring(s). Discharge measurements were taken at Springs A, A', B, and C at 30 minute intervals. All samples were transferred to amber glass bottles, refrigerated, and transported to the lab for refrigeration until analysis. All analyses were completed within a week from the date of sampling. In addition all charcoal packages were changed in springs off the ABG at the initiation of the test.

Dye was visually detected at Spring A and Spring A' at 2000 hours on 5-3-97. A hand sample was taken at 2015. The automatic samplers were reprogrammed to then sample every 15 minutes until 0000 hours on 5-4-97, at which time the sampling interval was changed to every 30 minutes. Charcoal packages were collected weekly for 2 months, biweekly for 4 months then monthly for 12 months after dye injection.

6 DISCUSSION

Rhodamine WT dye was not detected in grab samples or passive detectors ('bugs') from any of the springs except Springs A and A'. When spring discharge, Rhodamine WT, and Br^- plotted against time, a breakthrough curve is produced. Breakthrough curves for Spring A and Spring A' sampling sites are shown in Figures 7-10. By analyzing the breakthrough curves, travel time of the tracer can be calculated. For Spring A the breakthrough (first detection) of Rhodamine (Fig. 7) and Br^- (Fig. 8) occurred simultaneously at 1930 hours (5-3-97), approximately 7.5 hours after injection. For Spring A', the breakthrough for Br^- (Fig. 10) occurred at 1900 hours. The Rhodamine WT (Fig. 9) breakthrough occurred at 1930 hours, one-half hour after the Br^- breakthrough for Spring

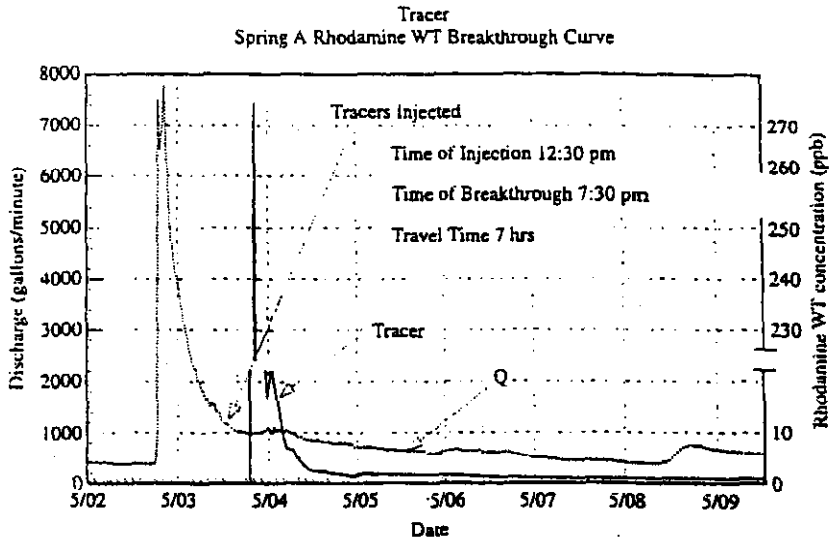


Figure 7. Rhodamine WT breakthrough curve for Spring A.

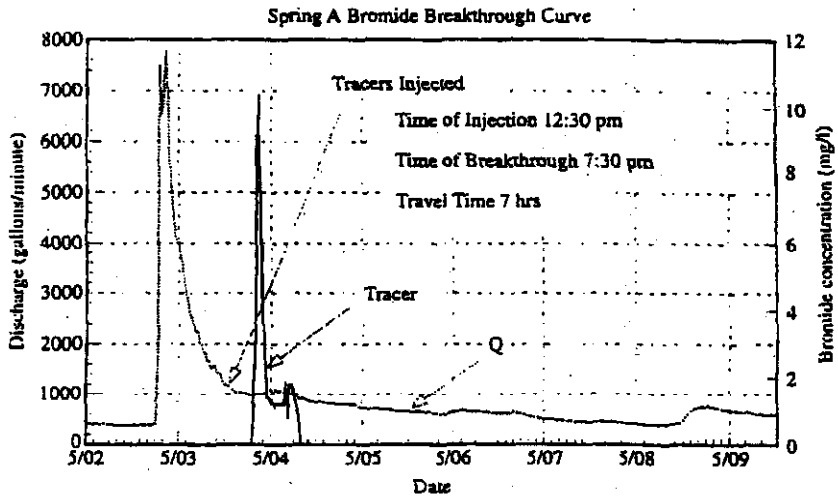


Figure 8. Bromide breakthrough curve for Spring A.

A'. The delay time in the detection of Rhodamine WT is due to the timing of sample collection by the automatic sampler and, based upon the results for Spring A, it is believed that the Rhodamine WT breakthrough occurred very shortly after arrival of the Br^- tracer dissipated after about 14 hours while the Rhodamine WT tracer was detected in grab samples for 4 days. The short-lived Br^- tracer pulse, compared to Rhodamine, illustrates the more conservative nature of the ionic tracer.

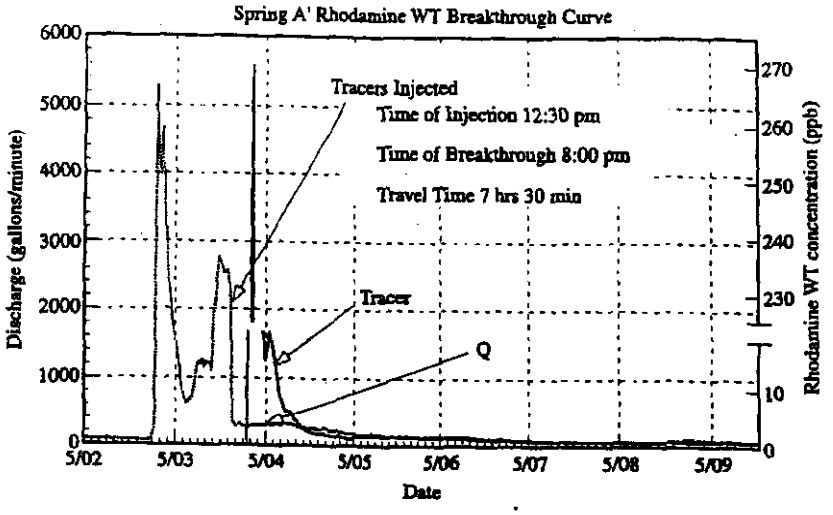


Figure 9. Rhodamine WT breakthrough curve for Spring A.

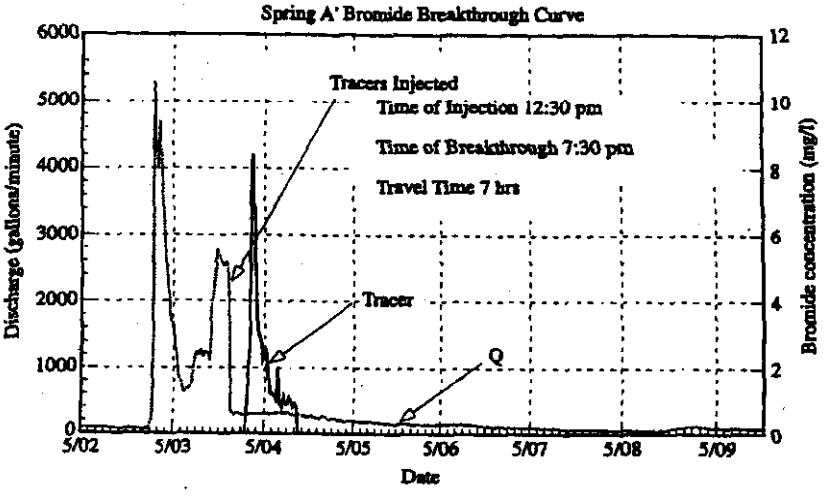


Figure 10. Bromide breakthrough curve for Spring A.

An approximate travel time can be calculated for the conduit from the breakthrough curve data. Br^- will be used for these calculations since it appears to have been a more conservative tracer than Rhodamine WT. It is approximately 2000 m from the injection well, 03-C02P2, to the Spring A complex; therefore the hydraulic conductivity is calculated to be 286 m hr^{-1} number is probably greater considering the possible sinuosity of the conduit. Murphy & Ciocco (1990) estimated the length of the conduit to be 8000 feet based on a sinuosity similar to the valley of Little Sulphur Creek.

The major objective of the quantitative tracer experiment was to determine how much of the tracers could be recovered from the springs located on NSWC property. If most of

the dye discharges down Little Sulphur Creek valley at springs on Crane property then remediation is much simpler. To calculate the recovery of tracer, the following equation is used:

$$M = \int_0^{\infty} QCdt \tag{1}$$

where M = mass of tracer recovered, Q = discharge, and C = tracer concentration at time t.

Calculations for this test show that 13.9 kilograms of injected Br^- (18 kilograms) was recovered, or 77%. During the high flow conditions of the tracer test, when the bromide peak arrived some tracer issued from the seeps between Spring A and Spring A'; therefore some bromide that discharged from the Spring A complex is not accounted for in the previous calculations. It is estimated that the recovery of tracer at the Spring A complex can be increased by an additional 10-15% to account for the discharge with tracer issuing from the seeps on the valley wall. If this is true, approximately 90-95% of the Br^- was recovered. Errors in discharge measurements can also account for not recovering the entire mass of the tracer.

The calculation of Rhodamine WT recovery is slightly more complicated than Br^- Rhodamine WT (20%) solution as purchased from the distributor is not actually a 20% solution. The stock powder that the 20% solution is made from (at the distributor) only has an average of 86% active ingredient (i.e. Rhodamine WT). Therefore, when this powder is dissolved in a liter of distilled water produces a concentration of 860,000,000 ppb. The supplier then diluted this concentration to a 20% solution and the concentration then becomes 172,000,000 ppb. The quantity of dye that was injected was 1.6 kilograms of the solution containing 172,000,000 ppb. This is only an approximate concentration since, as confirmed by discussions with the distributor of the dye, there is an acceptable range of error of about 10% on the 20% solution (i.e. the 20% solution is actually 172,000,000 ppb ± 17,200,000 ppb).

Calculations show that approximately 3.1 × 108 ppb of Rhodamine WT (= 110%) was recovered of the approximately 2.75 × 10 ppb that was injected. The over estimations is probably due, at least in part, to inexact measurements in preparing the dye. Additionally, since Rhodamine WT was detected for several days after injection, over- or underestimates in discharge measurements and/or Rhodamine WT concentrations during this extended period of time would cause the recovery calculations to be inaccurate. In the case of Br^-, the recovery calculations would likely be more accurate since the entire breakthrough occurred in 14 hours. Therefore, errors in measuring discharge and/or concentration of tracer would not be made for an extended period of time. In either case, the Rhodamine WT and Br^- tracer tests do suggest essentially complete recovery of the tracer from the Spring A complex since springs B and C received no Bromide or Rhodamine WT. Charcoal detectors were collected over weekly intervals at all other springs for two months, bi-weekly for the next four months and then monthly until present. No dye has been detected in any of the other springs including those off-site.

7 CONCLUSIONS

A quantitative tracer test of the karst system in contact with well 03-C02P2 at the ABG was conducted in which 1.6 kilograms of Rhodamine WT (20%) and 18.3 kilograms of Br^- tracer were injected into the well. A total of 14 potential discharge points (springs) in the study area (Fig. 5) were monitored with passive dye receptors. Four springs that were believed to be most likely to be hydrologically connected to the injection well were continuously monitored for discharge and continuously sampled for tracer. The remaining 10 springs were monitored with passive dye detectors.

Rhodamine and Br^- were detected at only one spring (Figs 7-10), consisting of a complex of two major orifices (Spring A and Spring A') and several diffuse seeps between the springs approximately 2000 meters linear distance from the injection well. The Br^- tracer breakthrough occurred one-half hour before the Rhodamine WT dye. The Br^- pulse dissipated approximately 14 hours after being detected while Rhodamine WT was still detected days later. Approximately 80% of the injected Br^- was recovered at the two major spring orifices. An additional 10-15% of Br^- is believed to have issued from the diffuse seeps. Thus approximately 90-95% of the injected Br^- can be accounted for. A calculated recovery of 110% of the injected Rhodamine WT dye from the same springs indicates that most of the injected tracers were recovered from the Spring A and Spring A' complex (Fig. 5). This suggests that the karst system that was injected into has only one outlet, which is located at the Spring A and Spring A' complex. This is confirmed since all of the other springs have been monitored for over one year with charcoal detectors with no detection of Rhodamine WT. Using the time of first arrival for the Br^- tracer, the travel time of water in the conduit is 286 m hr^{-1}. The other springs do not have any hydrologic connection to the karst conduit system which is confined to the valley of Little Sulphur Creek.

The short-lived Br^- tracer pulse, compared to Rhodamine WT, illustrates the more conservative nature of the ionic tracer. Therefore, the calculation of tracer recovery are probably more accurate for the Br^- tracer than the dye. Additionally, due to problems with controlling the concentration of dye that is injected into the well, it appears that the recovery calculations for the ionic tracer is more reliable than the dye. However, Rhodamine WT was not significantly retarded in this study and appears to provide a reasonable estimate of travel time in an open conduit system.

Few, if any quantitative tests have been conducted or published concerning karst aquifer systems. Most tests are qualitative with injection a tracer at some point in the flow system and detecting it at a discharge point. The quantitative tracer tests gives you a reasonable estimate of the quantity of tracer recovered in the system. In this case the flow is confined to the major conduit system and discharging at Spring A and Spring A' complex. Charcoals which accumulate the organic dye allows for detection of dye at distances from the injection site that are not practical for ionic traces or quanitative calculations.

This test provides the Crane Naval Surface Warfare Center with information necessary for remediation of the contamination problems. Previous pump and treat tests failed due to the wide range of hydraulic conductivities found in this fractured geologic setting. Results show that remediation should be implemented at the Spring A/A' complex. A quantitative tracer test coupled with a qualitative test can be used in other karst systems to provide information for site remediation.

ACKNOWLEDGMENTS

This research was funded by grants from the Army Corps of Engineers Waterways Experiment Station and the Crane Naval Surface Warfare Center, Indiana. The research was conducted under the supervision of T. Brent and J. Hunsicker of the Environmental Protection Department at Crane. M. Noriega and F. DiGnazio aided in the collection of background data for this study. We are indebted to their help.

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