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October 30, 1991

MEMORANDUM

SUBJECT: Review comments pertaining to The Mustard Gas Burial Site Naval Weapons Support Center Crane, Indiana.

FROM: Kenneth W. Brown
Manager, Technology Support Center

TO: Carol Witt-Smith
Regional RCRA Project Officer (5HR-13)

Carol, as per your request please find attached comments resulting from our review of the RCRA Facility Investigation plans for the Mustard Gas Burial Site at the Naval Support Center Crane, Indiana. Attachments 1, 2, and 3 provide our comments on the Work Plan, the Quality Assurance Project Plan and the Safety and Health Plan respectively.

If you have any questions concerning the attached comments, please call Mr. John Rotert at 702/734-3201 or myself at FTS 545-2270.

Attachments

cc:
Phil Malley, LESC

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Waste Management Division
REGION V

Comments on RFI Work Plan
for
Mustard Gas Burial Ground
Naval Weapons Support Center Crane, Indiana

General Comments

- The first general comment is the same as that offered in the review of the Pest Control Area / R-150 Tank Site, and is restated below.

  The necessary elements of a work plan and a sampling and analysis plan are represented in this document. However, the organization of the document leads to confusion and redundancy. The main cause of the problem is that sampling and analysis plan information , which according to the main headings in the Table of Contents should be in Section 3.0, is actually spread out through Sections 2.0, 3.0, and 4.0. This causes the same, or nearly the same, material to be rehashed at as many as three locations. We would suggest that Section 3.0 should contain all the sampling and analysis plans and procedures. This would eliminate all of Section 2.2.0 (Technical Approach) from Section 2.0 (Management Plan). Then Section 2.0 could focus on its topic of Project Objectives and Project Management. All the contents of Section 4.0 (Well Construction) are plans and procedures for the investigation and logically belong within Section 3.0.

- The description of the site hydrogeology and the existing monitoring system should be strengthened. Suggestions are made in the Specific Comments.

- The text is inconsistent about what ground-water RFI phase is addressed in this work plan. It is referred to as Phase 2 and Phase 3 at different points in the plan. We would assume, given the number of existing monitor wells at the MGBG site, that Phase 3 (release characterization) would be more appropriate.

Specific Comments

Cover page

The title on the cover page of this work plan should identify the SWMU as the Mustard Gas Burial (not Burning) Ground.

P1, Section 1.1.2

On line 11, the figure referenced should be Figure 1.1.2b.

P8, para 1

On line 2, the text states that chemical contamination was detected. Information on what chemicals were detected and their concentrations should be provided here.

A table should be included that summarizes the construction details of existing monitoring wells such as date of completion, depth drilled, screened zone, casing and screen size and material, screen slot size, etc.

This paragraph should provide a forward reference to Figure 3.1.3 which shows the locations of the existing monitor wells on a site base map.

P8, Section 1.1.4, para 1

A base map showing the trace of the cross-sections must have been developed to accompany Figures 1.1.4a and 1.1.4d. Inclusion of this map would be helpful in cross-section orientation. Also, why is the second figure 1.1.4d? Why is it not 1.1.4b? Is there other cross-sections in Dunbar, 1984, that would be Figures 1.1.4b and 1.1.4c? If so, why are they not included?

P8, Section 1.1.4, para 2

It seems that the intent of the third sentence is to indicate that temporal fluctuations in water table levels are small. If that is the case, then add the underlined words to the end of the sentence to read- "_ground-water table is relatively uniform <u>with time</u>." As the paragraph reads now, it is confusing as to when the author is talking about spatial variability of water table levels and when he is talking about temporal variability.

This paragraph indicates that the site is expected to exhibit a strong vertical component of ground-water flow, but does not identify the direction of the lateral component of flow. One can assume what that direction might be

from the topography and the location of the existing monitor wells, but it should be stated in this section. A potentiometric map should also be provided.

In this section, the authors should describe any hydraulic connection that exists or is thought to exist between the ground water of the uppermost aquifer and the surface water.

P8, Section 1.2.1

On line 5, the reference citations for the Dunbar reports on page 57 (References) are not adequate. One citation is completely missing, the length of the reports (pp) is not given, and none of the reports are identified by a report number.

P11, para 1

In the last sentence, the underlined words should be added to read- "...and its lateral <u>and vertical</u> extent is undefined."

P13, para 1

The words on lines 4-6 do not form a sentence.

P13, Section 2.2.2

On line 6, the underlined words should be added to read- "Accuracy <u>of the lateral survey</u> must be ± 0.5 ft. Accuracy of the ground surface <u>and top of casing</u> elevation must be ± 0.01 ft."

P13, Section 2.2.3

The first three sentences of this section should be rewritten. We suggest replacing them with the following- Geophysical surveys will be conducted at the MGBG site to locate and define the boundaries of the subsurface features (burial pits), and to evaluate the completeness of past surveys and exhumations.

P14, para 2

On line 5- "...are that its data <u>are</u> not..."

On line 6- confirmatory

On line 9- develop

P14, para 4

On line 5- recorded

On line 10 affected

P15, Section 2.2.6

The compressed air and filter-in-line method of well development is cited by the authors at other points in this and other work plans as potentially causing down-hole contamination. This is given as a reason why it will not be used. This section states that the method will be used if needed. Plans regarding the method must be consistent throughout the work plan.

The authors should define the data set on which the ranking of the least-to-most contaminated well is based.

P16, Section 2.2.9

Is the "agent" referred to in the first sentence mustard gas agent? This sentence cites experience at other chemical agent sites regarding the agents immobility. This should be referenced.

This section does not specify whether the water samples are to be filtered or not filtered prior to analysis.

P18, Section 2.2.10, para 1

The Bouwer and Rice Method should be appropriately referenced.

P22, Section 3.1.0

The title of this section is "Selection Procedures". We feel it should be more accurately called "Selection of Methods".

P22, Section 3.1.2

On line 2, add the underlined word to read- "...Terrain Conductivity Systems are the inductive..."

P25, para 1

On line 6, "WES-1-81" is supposedly referring to monitor well WES-1-1-81 in Figure 3.1.3. We suggest using the same well numbers in the text and the figures. To do otherwise could lead to unnecessary confusion.

P25, para 1

Reading this paragraph leads me to believe that the future monitor well locations have already been determined. However, the first sentence in paragraph one on page 15 states that "The location of these additional drilling sites both for soil borings and well installation will be dependent on the results of the early round of ground-water sampling and the geophysical investigation." This sentence describes the manner in which the investigation should proceed. But, according to the program schedule shown in Diagram 2.3.2, the existing wells will be sampled during 10-13 April, 1992. Monitor well installation is shown on the schedule to occur during 24 April - 28 May, 1992. A block of time is not identified in the program schedule in which the samples from the existing monitor wells will be analyzed and the data will be used to make well placement decisions. We would suggest that a block of time be shown on the program schedule for analysis of the samples from the existing wells, and that it precedes the installation of the new monitor wells. We also suggest that this paragraph state that the proposed locations of new monitor wells is tentative and pending the review of the analytical data from the existing wells.

Given the number of monitor wells existing at the MGBG site, we are assuming that the ground-water investigation is in RFI Phase 3. One of the purposes of a phase 3 ground-water investigation is to determine the lateral and vertical extent of saturated zone contamination. Limiting the number of cluster well installations to only two may severely restrict the determination of contamination extent. We suggest keeping you options open for additional well cluster installations as needed. The text should probably indicate that the attainment of phase 3 objectives may require remobilization of monitor well installation plant and personnel.

P27, Table 3.1.4

Although it is implied from the discussion in the text, it might be appropriate to indicate that the "analysis" designation in the Table refers to EPA SW-846. It also might be appropriate to add EPA SW-846 to the list of References on page 57.

Rather than stating that there is no EPA methodology, the table should list (and reference) the method that will be used for Thorium. This comment also applies to Mustard Agent.

P28, Section 3.1.5

This section contains misused terms, incoherent sentences, and redundancies. It should be rewritten and should also include the information provided in Section 2.2.10.

P28, Section 3.1.6

In rock classification element number 1, the word destination should be designation.

P30, Section 3.2.1, para 2

On line 2, the words in parenthesis "(see Paragraph c.(1) above)" identify an undefined point in the text. This reference is not compatible with the work plan format.

P31, Section 3.2.3

In the first sentence, we suggest adding the underlined words to read- "A preliminary test will be conducted with the ground penetrating radar unit at the test site."

P32, Section 3.3.1, para 2

During the drilling of the soil borings, this paragraph states that samples will be taken from several intervals, among them the base of the filled zone, the last six inches directly above the water table, or the last six inches directly above the top of rock. How will the investigators determine, prior to drilling through a zone, if it is one of these three.

P32, Section 3.3.1, para 3

There should be some mention as to how the contamination condition of the purge water will be assessed. You might reference Section 3.6.0 or state that the purged water will be containerized until analytical results can indicate the proper disposal method.

P32, Section 3.3.2

Section 3.3.2 should be integrated into Section 3.2.0 since they both deal with geophysical procedures.

P35, Section 3.3.4

On line 6-7, this section states that " (purged) water is to be discharged to the ground surface no closer than 10 feet from the well." Appropriate changes should be made so that this statement will be compatible with Section 3.6.0 (Waste Containment).

P35, Section 3.3.4

On line 10, what is the project definition of "stable" ?

The samples to be analyzed for TOX should also be sampled first and collected in such a manner that there are no air bubbles in the bottle after it is sealed (The principal component of TOX are the volatile chlorinated hydrocarbons).

P42, Figure 3.5.3

The sample analyses planned during the investigation are specified in Table 3.1.4. These analyses are not all represented on the sample tag.

P48, Section 4.1.1

How/Why was it determined that 2 wells in the shallow zone could provide the additional information that 27 existing wells could not? This is particularly puzzling since current contamination conditions, as measured in the existing wells, have not been defined.

P48, Section 4.2.1

The sentence beginning on line 5 would be true if we were just talking about screen locations in the uppermost, unconfined aquifer; but it does not apply to deeper confined or semi-confined aquifers as the sentence indicates by using the words "in each aquifer zone".

What site-specific observations have gone into the determination to use the 0.010-inch screen slot size? It is becoming state-of-the-practice that well screen slot sizes are determined in the field on the basis of a field sieve analysis of geologic materials retrieved from the zone to be monitored.

P49, para 2

No method is presented which will be used to determine the size grading of the filter pack material. This information should be included.

The type of monitor well design where the filter pack extends the entire thickness of the aquifer may not be desirable depending on the aquifer thickness and the contamination distribution. If the aquifer is thin this design may be adequate. Multiple depth-specific completions may be required if the aquifer is relatively thick. Well completion is generally a field decision, but guidance exists as to what constitutes good practice. An excessive filter pack section above the well screen is generally not advisable.

Consideration should be given to using the same length of well screen at each sampling location. If the occurrence of contaminants varies with depth, the use of different length screens can cause variable dilution in each of the samples with the result that the concentrations in the collected samples can vary by as much as a factor of ten from that occurring in the ground water.

P49, Section 4.2.2

Something appears to be missing in the sentence on lines 3-4.

P49, Section 4.2.3, para 2

The statement on lines 2-3 ("It has been found___") should be properly referenced.

P52, first sentence

It should be mentioned that development water will be containerized until analytical results can indicate the proper disposal method. Or alternately, Section 3.6.0 can be referenced.

Comments on RFI QAPP
for
Mustard Gas Burial Ground
Naval Weapons Support Center Crane, Indiana

General Comments

- The draft QAPP discussed each of the necessary elements in a conceptual manner. That is, it defines the purpose of a field blank, or a surrogate recovery, or the need for replicate analysis. However, the draft QAPP does not specify data quality objectives for the field blanks, surrogate recovery, or precision. The QAPP should clearly state the data quality objectives for each parameter to be measured.

- Some QA factors such as completeness and accuracy are not discussed. Also, method detection limits for each sample matrix {soil and water) should be stated.

- In several places, the draft QAPP refers to the "current CLP" criteria. The problem with this statement is that the CLP standards can change with the letting of a new contract. Given the project length of the site investigation, it is possible that the "current CLP" limits could change during the course of the investigation. If the wording is not changed, this could result in the use on two or more sets of "current CLP" criteria during the investigation. Therefore, the CLP criteria to be used should be clearly stated and/or referenced to avoid ambiguity.

- The present draft QAPP is heavily dependent upon "current CLP criteria". However, several project analytes (TOX, thorium, mustard agent) are outside the scope of the CLP. Project data quality objectives should be established for these analytes.

- The draft QAPP mentions control charts several times in passing. The document should clarify how specific control chart limits will be established (i.e., two sigma warning limits and three sigma out of control limits; or some other method). The current plan states that calibration checks will be run every day to detect instrument drift but the draft plan does not specify how much drift is acceptable (or unacceptable).

Specific Comments

(Note: Roughly about the first half of the pages of the QAPP are not numbered. In order to provide comments with reference to the page on which they occur, the page titled "Element 3, Project Description" was set as page 1. For the pages that were numbered (page no. 16 and greater), those page numbers were used to reference the comments.

P1, para 4

Line 2-3 of this paragraph states that three bombs were found containing chemical agent. The text should state at this point the total number of bombs found so that the reader is not confused later in this paragraph when it says that "the original ten bombs were disposed of".

P2, para 1

Figure 1 does not show that contamination was detected nor the specific wells at which contamination was detected. Appropriate figures should be added to show the location and orientation of the plume, the contaminants detected in the plume, and the concentration of each of the plume constituents.

P2, para 3

We believe there are several problems with the statement on lines 7-8. First, Appendix IX is a lengthy list of both organic and inorganic constituents. The organic analyses required for complete Appendix IX scans would require the use of other analytical procedures in addition to 8240 and 8270. Second, Appendix IX only includes (approximately) 20 inorganic constituents. Therefore it may be presumptuous to state that <u>any</u> toxic metal present will be detected. Third, the toxicity of a metal will depend on its chemical speciation and not simply its presence. However, nothing is said in the work plan regarding chemical speciation or even whether the ground-water samples are to be filtered prior to analysis.

P7, <u>Chemical Data Quality Objectives</u>

This section does not provide any data quality objectives. The section identifies several of the issues that must be addressed in a QAPP (e.g., trip blanks, rinsate blanks, and sample replication) but it does not specify the data quality objectives to be met. Also, the list is not complete because precision and accuracy objectives are not stated, detection limits are not stated, and completeness is not mentioned.

P8, bottom

The statement that adherence to specific preservation and holding times assures the quality of the data could be argued. Not meeting the holding times would invalidate the data, but achieving the holding times does not in itself assure that the data are correct. Holding time is only one of several factors that must be met to assure the data quality.

P8, Table 1

The analytical methods to be used for mustard gas should be included in this table.

P13, Figure 5

TOX sample vials should also be checked for the absence of air bubbles.

P14, para 3

Since the CLP requirements change with time, the statement that "current CLP" practices will be followed (on line 3) should be properly referenced. This will specify the procedure to be followed during the course of the investigation.

P14, para 4

On line 4, the calibration check acceptance criteria should be specified or at least properly referenced.

On line 6, how will the correlation coefficient and response factors be evaluated? The data quality objectives to be used in this process should be clearly stated in the QAPP.

P17, Table 2

The detection limits to be achieved with each method should be stated in the QAPP for each sample matrix (i.e., soil and water). Also, analytical procedures to be used for thorium and mustard agent should be listed and/or properly referenced.

P18, <u>Field Activities</u>

The activities described in this section must be completed as part of a QA program. However, the QAPP must specify the levels to be achieved by each of these activities. For example, it is fine to state that daily calibration checks will be run and the results will be recorded to detect any drift. However, the QAPP <u>should specify</u> how much drift is acceptable and how much drift is unacceptable.

P19, Control Samples

Similar to the comment presented above, it is fine to state that 10 percent of the samples will be collected in duplicate. However, the QAPP must state the level of precision to be achieved by the duplicate analyses in order for the resultant data to be acceptable. If no data quality objectives are to be established for a QA factor (i.e., precision), this should be stated.

P19, para 4

If the process on line 6 is to be conducted as the data validation step, the outlined program is one of data definition and not data quality control.

P22, para 1

On line 4, the term "current CLP form" should be properly referenced.

P24, para 2

This paragraph states that duplicates will be run at a frequency of 5 percent, but P19, para 6 states that field duplicates will be collected at a frequency of 10 percent. A clarification would be helpful.

P24, Level C Data Validation

This discussion does not include the methods/data to be used/generated for TOX, conductivity, thorium, or mustard agent. How are the data for these parameters to be validated ?

P24, GC/MS Tuning-

Which CLP criteria?

P24, Initial Calibration-

On line 2, indicted should be indicated.

P25, para 2

What are the internal control limits set by the laboratory? They should be included in the project QAPP.

P25, para 3

What are the internal laboratory limits? Which CLP limits are being referred to here?

P25, para 4

Which CLP limits?

P25, para 5

A method blank <u>should</u> be run or a method blank <u>will</u> be run?

P25, para 6

Which CLP criteria?

P32, para 1

A QAPP should specify data quality objectives for completeness, accuracy, precision, etc. Since the current draft QAPP does not specify these parameters, how will the data be checked for acceptability.

P34, para 1

It is acceptable to reference QA limits. However, since the CLP limits change with time, and the duration of the site investigation is sufficiently long that the CLP limits may change, the limits to be used during the investigation should be properly referenced.

Comments on RFI Safety and Health Plan
for
Mustard Gas Burial Grounds
Naval Weapons Support Center Crane, Indiana

General Comments

- The plan appears to be less than adequate and addresses only the very basic requirements of OSHA regulations contained in 29 CFR 1910.120 (b)(4)(ii). The Emergency Plan portion is not acceptable.

- It appears that the specific safety procedures contained in this plan appear to be "boiler plate" in nature and do not recognize the chemical or physical properties of mustard agent. The potentially very serious delayed effects of contact with mustard agent do not appear to be fully recognized in this plan. In addition, it does not appear that the site is very well characterized. A more in depth history of military chemical agent testing should identify what types of military agents were tested, stored, etc., at the site.

- We have attached an extract on mustard agent (HD) from the U. S. Army Field Manual 3-9, Military Chemistry and Chemical Compounds, that provides a much more detailed review of HD. We would also note that the military utilizes M-9 detection paper as a method of rapid field detection of mustard agents. Use of the M-9 paper would provide a cost effective adjunct to the CGM/PID instruments.

Specific Comments

Section 2

This section indicates that there is a possibility of encountering a chemical munition or other sealed container during drilling operations. The types of chemicals that may be encountered at the site should be better defined. The site safety plan should be prepared with an expectation of encountering and puncturing a container with the resulting escape of the contents under the worst credible scenario.

Section 4

The potential for drilling into a chemical weapon or other chemical/radioactive material could cause contamination of the drill bit or coring unit well beyond the "ppm" level. Therefore, the word "significant" should be inserted in the blank space at the end of the last sentence of this paragraph.

Section 5

There are 11 chemicals identified in the plan as potential on-site contaminants. Only 5 of the 11 chemicals listed in Table 1, mostly chlorinated solvents, have information available. That information is very sketchy and difficult to read. In addition, there are several variants to military blister agents. Distilled mustard (HD), is the only one identified on the list. Until it can be conclusively ruled out, consideration should be given to the potential presence of Levinstein Mustard (H); Nitrogen Mustards (HN-1, HN-2, HN-3); Mustard-T Mixture (HT); Phosgene Oxime (CX); Lewisite (L); and the arsenical compounds (PD, ED, and MD). We recommend that accurate chemical response information sheets be provided for all chemicals. Emergency information on all potential agents should be obtained from the Army Chemical Corps or Corps of Engineers.

Section 6

The required personnel have not been identified in this section. We would suggest that this section should refer to names of Site Investigation Personnel contained in an appropriate appendix. This method will allow changes to be made more efficiently.

Section 7

The plan refers to a Site Safety and Health Officer <u>or</u> Site Safety Coordinator. We recommend that one title be selected and utilized to identify the individual having responsibility for this function on the site.

Section 8

The training requirements are identified in this section, however, there is no method for verification of training. We recommend that the SSC maintain a file containing training documentation on each individual routinely working on the site. Personnel who occasionally visit the site must provide documentation of their training to the SSC prior to site entry.

Section 8, continued

The training for item 11 indicates that workers will review the Emergency Contingency Plan. We recommend that the site workers receive specific directions on <u>their</u> duties and responsibilities in the event of an emergency.

The list of Trained Personnel (8.2) is blank. We recommend that language be included in the plan that the training records are available through the SSC. If used, this list should be moved to an appendix in the back of the plan and updated to reflect the appropriate personnel.

Section 9

This section contains a great deal of unnecessary duplication of federal regulations, to include COE procedures. The medical surveillance requirements contained in 29 CFR 1910.120 (f)(3)(i)(c) specify a termination physical. We recommend that either the OSHA requirements be reprinted verbatim or incorporated by reference. The SSC should maintain documentation from employers listing the names of the on-site employees and stating that the employer maintains a medical surveillance program meeting the OSHA requirements for those personnel.

Section 10

The plan states that daily meetings will be held and daily site inspections will be conducted. We recommend that all meetings be documented and all personnel attending sign an attendance roster.

Portions of 10.2.1.3 are blank. We recommend that either these items be completed or deleted from the plan.

Paragraph 10.2.2 identifies modified Level D, to include safety glasses or chemical splash goggles as approved eyewear. Military mustard agent is extremely dangerous to the eyes. We recommend that personnel working near the borehole be required to wear chemical splash goggles.

Paragraph 10.2.2.1 does not provide for an emergency supply of air for escape purposes. We recommend that the modified Level D PPE include an escape mask with air supply.

First aid supplies/equipment for the site are not identified. We recommend that the contents of the first aid kits be approved by a physician, as required by OSHA [29 CFR 1910.151(b)].

Section 10, continued

Paragraph 10.2.2 states that the Site Safety Coordinator (SSC) may upgrade the level of protection to Level C upon "detection and identification" of contaminants. Table 8-4 of the NIOSH/OSHA/USCG/EPA Occupational Safety and Health Guidance Manual for Hazardous Waste Sites defines the conditions under which canister type air purifying respirators may be used. Essentially, the contaminant must be detected, identified, and quantified;

allowing for proper selection of canisters, prior to operating at Level C. We recommend that Level B protection be identified for monitoring of unidentified air contaminants.

The final sentence of the first paragraph in Section 10.2.2.1, referring to an emergency (??), is incomplete. The sentence should be completed and reference should be made to a listing of emergency equipment that will be kept on site. The listing should be contained in the emergency plan portion of this document.

Paragraph 10.2.3 does not identify a monitoring method for the drill stem components to rapidly identify the presence of mustard agent. We recommend that the paragraph be rewritten to include a specific test on sections of the drill stem being withdrawn from the borehole. The test procedure must include a method for detecting gross liquid contamination.

The decontamination portion of the plan is poorly worded and incomplete. We recommend that this portion of the plan be completely rewritten by a knowledgeable decontamination specialist.

Paragraph 10.2.3.3, Agent Contamination, refers to an Aberdeen Proving Grounds SOP which is supposed to be attached. Only one page of the SOP is attached and it is barely readable. Without a complete copy of the SOP, it is impossible to evaluate its applicability to the site. We recommend that a complete, readable copy of the SOP be attached. This is a critical portion of the plan.

Paragraph 10.2.4.1, Decontamination SOP, is written for Level C and B PPE. The plan indicates that work will be conducted at a modified Level D posture. We recommend that the decontamination plan identify the procedures for removing the Level D PPE for breaks, end of the work shift, and emergency exit.

Section 10, continued

The decontamination procedure on page 20 identifies an optional equipment decontamination with methanol or acetone. Both chemicals present a fire hazard when utilized out of a container. We recommend that specific permission of the Site Safety Coordinator be obtained prior to the use of these chemicals.

The decontamination procedure does not identify the types of decontamination solutions to be utilized. Testing of contaminated solutions or water prior to disposal and method of disposal are not identified. We recommend that approved decontamination solutions be identified, to include acceptable pH ranges, and that disposal procedures be identified for decon water/solution.

Section 11

The document contained in Appendix B is the Spill Contingency Plan for the NWSCC and is not adequate for the on-site work covered in this Safety Plan. We recommend that the Contingency Plan should be contained as a separate appendix to the Safety Plan prepared specifically for on-site emergencies.

The Emergency Information in Section 11.4 does not indicate a method for immediate determination of wind direction in the event of a chemical release. We recommend that wind socks be installed at the site to provide for rapid identification of wind direction. Site workers must be instructed to proceed into the wind away from the release site in the event of an emergency.

The emergency plan needs to contain a "worst credible scenario" for planning purposes. Procedures and equipment must be included in the Safety Plan that recognize a worst credible scenario of rupture of a chemical weapon with rapid release of the contents, injuring and/or contaminating personnel near the drill rig. Rapid rescue, decontamination, and evacuation procedures must be spelled out.

The emergency plan must be amended to reflect spill reporting procedures. We recommend that a portion of the emergency plan be devoted to identifying who must be notified in the event of a chemical release and who is to make the notification.

Section 11, continued

The emergency procedures identify the use of a vehicle horn for emergency warning. Generally speaking, this type of alarm system does not work during an emergency. We recommend that a portable air horn system , whistles, or other system be implemented.

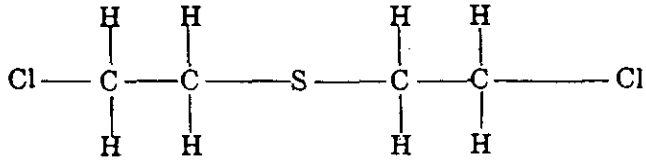
c. Distilled Mustard (HD).

(1) *General.* HD is H which has been purified by washing and vacuum distillation. HD has less odor and a slightly greater blistering power than H and is more stable in storage.

(2) *Chemical name.* Bis(2-chloroethyl) sulfide.

(3) *Formula.*

(*a*) *Structural.*



(*b*) *Molecular.* $(ClCH_2CH_2)2^S$.

(4) *Molecular weight.* 159.08.

(5) *Vapor density (compared to air).* 5.4.

(6) *Liquid density.* 1.2685 at 25° C.

(7) *Solid density.* 1.37 at 0° C.

(8) *Freezing point.* 14.45° C.

(9) *Boiling point.* 217° C. calculated; decomposes.

(10) *Vapor pressure.* 0.072 mm Hg at 20° C.

(11) *Volatility.* 75 mg/m³ at 0° C. (solid); 610 mg/m³ at 20° C. (liquid); 2,860 mg/m³ at 40° C. (liquid).

(12) *Flash point.* 105° C. Low enough to cause occasional ignition if explosive charges in the shell are too great.

(13) *Decomposition temperature.* 149° to 177° C.

(14) *Latent heat of vaporization.* 94 calories per gram. (This property is not of great importance in a chemical agent of low volatility, as the sustained vapor concentration is essentially a function of the temperature of the surroundings.)

(15) *Rate of hydrolysis.* Half-life is 8.5 minutes in distilled water at 25° C. and 60 minutes in salt water at 25° C.

(16) *Hydrolysis products.* Hydrogen chloride and thiodiglycol.

(17) *Stability in storage.* Stable in steel or aluminum containers.

(18) *Action on metals or other materials.* Very little when pure.

(19) *Odor.* Garlic-like.

(20) *Median lethal dosage* (LCt_{50}).

(*a*) *Inhalation.* 1,500 mg-min/m³.

(*b*) *Skin absorption (masked personnel).* 10,000 mg-min/m³.

(21) *Median incapacitating dosage* (ICt_{50}).

(*a*) *Eye injury.* 200 mg-min/m³.

(*b*) *Skin absorption (masked personnel).* 2,000 mg-min/m³. Wet skin absorbs more mustard than dry skin. For this reason, HD exerts a casualty effect at lower concentrations in hot humid weather, since the body is then moist with perspiration. The dosage given above for skin absorption applies to temperatures of approximately 21° to 27° C., as the body would not be perspiring excessively at these temperatures. Above 27° C., perspiration causes increased skin absorption. The incapacitating dosage drops rapidly as perspiration increases; at 32° C., 1,000 mg-min/m³ could be incapacitating.

(22) *Rate of detoxification.* Very low. Even very small, repeated exposures are cumulative in their effects or more than cumulative due to sensitization. This has been shown in the postwar case histories of workers in mustard-filling plants. Exposure to vapors from spilled HD causes minor symptoms, such as "red eye." Repeated exposure to such vapors produces 100 percent disability by irritating the lungs and causing a chronic cough and pain in the chest.

(23) *Skin and eye toxicity.* Eyes are very susceptible to low concentrations; higher concentrations are required to produce incapacitating effects by skin absorption than by eye injury.

(24) *Rate of action.* Delayed—usually 4 to 6 hours until first symptoms appear. (Latent periods have been observed, however, up to 24 hours and, in rare cases, up to 12 days.)

(25) *Physiological action.* Mustard acts first as a cell irritant and finally as a cell poison on all tissue surfaces contacted. The first symptoms of HD poisoning usually appear in 4 to 6 hours; the higher the concentration, the shorter the interval of time from the exposure to the first symptoms. The physiological action of HD may be classified as local and systemic. The local action results in conjunctivitis or inflammation of the eyes; erythema (redness of the skin) which may be followed by blistering or ulceration; and inflammation of the nose, throat, trachea, bronchi, and lung tissue. Susceptibility also varies with individuals. Injuries produced by HD heal much more slowly and are more liable to infection than burns of similar intensity produced by physical means or by most other chemicals. Systemic effects of mustard may include malaise, vomiting, and fever, with the time of onset about the same as that of the skin erythema. With amounts approaching the lethal dose, injury to bone marrow, lymph nodes, and spleen may result. Such damage is reflected in the peripheral blood by a drop in the white blood cells. Because these cells are essential in the body for preventing infections, a significant

drop in the white blood cells will cause the mustard casualties to be far more susceptible to local and overwhelming infections than the normal individual.

(26) *Protection required.* Protective mask and permeable protective clothing for vapor and small droplets; impermeable clothing for protection against large droplets, splashes, and smears.

(27) *Decontaminants.* Supertropical bleach (STB), fire, or DS2. Liquid agent on the skin may be decontaminated by use of the skin decontamination pad in the M13 Individual Decontaminating and Reimpregnating Kit, or the M258 Skin Decontamination Kit.

(28) *Persistency.* Depends upon munition used and the weather. Heavily splashed liquid persists 1 to 2 days in concentrations to provide casualties of military significance under average weather conditions, and a week to months under very cold conditions.

(29) *Use.* Delayed-action casualty agent.

d. Nitrogen Mustards. The nitrogen mustards are a group of related compounds which may be considered as derivatives of ammonia (NH_3) because the hydrogen atoms are replaced by various organic radicals. In each of these chemical agents, nitrogen is the central atom. These compounds have recently been discussed in open scientific literature because of the discovery that they possess medicinal value. Three members of the group are described individually in *e* through *g* below.

e. Nitrogen Mustard (HN-1).

(1) *Chemical name.* 2.2-Dichlorotriethylamine.

(2) *Formula.* $(CLCH_2CH_2)_2NC_2H_5$.

(3) *Molecular weight.* 170.08.

(4) *Vapor density (compared to air).* 5.9.

(5) *Liquid density.* 1.09 at 25° C.

(6) *Freezing point.* −34° C.

(7) *Boiling point.* 194° C. calculated; decomposes. At atmospheric pressure, HN-1 decomposes below boiling point.

(8) *Vapor pressure.* 0.24 mm Hg at 25° C.

(9) *Volatility.* 127 mg/m³ at −10° C.; 308 mg/m³ at 0° C., 1,520 mg/m³ at 20° C.; 3,100 mg/m³ at 30° C. HN-1 closely parallels HD in the variation of volatility with temperature and is of little value in producing a vapor hazard when weather is cold.

(10) *Flash point.* High enough not to interfere with military use of the agent.

(11) *Decomposition temperature.* Decomposes before boiling point is reached.

(12) *Latent heat of vaporization.* 77 calories per gram.

(13) *Rate of hydrolysis.* Slow due to low solubility in water.

(14) *Hydrolysis products.* Hydroxyl derivatives and condensation products. (Intermediate products, all of which are toxic, are produced during hydrolysis.)

(15) *Stability in storage.* Adequate for use in munition. Polymerizes slowly.

(16) *Action on metals or other materials.* Slight corrosion of steel at 65° C.

(17) *Odor.* Faint fishy or musty odor.

(18) *Median lethal dosage (LCt_{50}).*

(*a*) *Inhalation.* 1,500 mg-min/m³.

(*b*) *Skin absorption (masked personnel).* 20,000 mg-min/m³.

(19) *Median incapacitating dosage (ICt_{50}).*

(*a*) *Eye injury.* 200 mg-min/m³.

(*b*) *Skin absorption (masked personnel).* 9,000 mg-min/m³.

(20) *Rate of detoxification.* Not detoxified; cumulative.

(21) *Skin and eye toxicity.* Eyes are very susceptible to low concentration; higher concentrations are required to produce incapacitating effects by skin absorption than by eye injury.

(22) *Rate of action.* Delayed; 12 hours or longer.

(23) *Physiological action.* Irritates the eyes in quantities which do not significantly damage the skin or respiratory tract, insofar as single exposures are concerned. This irritation appears in a shorter time than that from HD. After mild vapor exposure, there may be no skin lesions. After severe vapor exposures, or after exposure to liquid HN, erythema may appear earlier than in HD exposure. HN, like HD, may cause irritation and itching. Later, blisters may appear in the erythematous areas. The skin lesions are similar to those caused by HD. Effects on the respiratory tract include irritation of the nose and throat, hoarseness progressing to loss of voice, and a persistent cough. Fever, labored respiration, and moist rales develop. Bronchial pneumonia may appear after the first 24 hours. Following ingestion or systemic absorption, HN causes inhibition of cell mitosis, resulting in depression of the blood-forming mechanism and injury to other tissues. Severe diarrhea, which may be hemorrhagic, occurs. Lesions are most marked in the small intestine and consist of degenerative changes and necrosis in the mucous membranes. Ingestion of 2 to 6 milligrams causes nausea and vomiting.

(24) *Protection required.* Protective mask