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LETTER AND RESPONSE TO REGULATOR COMMENTS ON FOURTH FIVE-YEAR REVIEW REPORT NIROP FRIDLEY MN (PUBLIC DOCUMENT)
9/27/2013
TETRA TECH

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September 27, 2013

Project Number 112G02583

Department of the Navy
Naval Station Great Lakes
NAVFAC MW Code EV
Attn: Mr. Harvey Pokorny
201 Decatur Avenue – Building 1A
Great Lakes, Illinois 60088

Reference: CLEAN Contract No. N624670-08-D-1001
Contract Task Order F27C

Subject: Responses to Comments - Fourth Five-Year Review Report
NIROP Fridley, Fridley, Minnesota

Dear Mr. Pokorny:

Please find enclosed two copies of the Responses to Comments for the Fourth Five-Year Review Report. The redline revisions, revised attachments, and the Quitclaim Deed are also attached to this package per the Responses to Comments. If you have any questions, please contact me at 412-921-8868.

Sincerely,

Stephanie Warino

Stephanie Warino
Project Manager

SAW/stc

Enclosures

c: Shanna Schmitt, MPCA (2 copies)
Howard Hickey, NAVFAC Midwest (2 copies)
Sheila DeSai, USEPA (2 copies)
John Trepanowski, Tetra Tech (letter only)
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RESPONSES TO COMMENTS

RESPONSES TO EPA COMMENTS ON THE FOURTH FIVE-YEAR REVIEW REPORT
DATED MAY 2013

NAVAL INDUSTRIAL RESERVE ORDNANCE PLANT
FRIDLEY, MINNESOTA

September 27, 2013

GENERAL COMMENTS

1. **Comment:** Section 7.1.1 (OU1) indicates that the remedy is functioning as intended by the Record of Decision (ROD) for Ground Water Remediation, Naval Industrial Reserve Ordnance Plant (NIROP), Fridley, Minnesota, dated September 28, 1990 (OU1 ROD); however, Table 4-3 (Detected Concentrations of VOCs in Riverside Wells – OU1 – August 2012 Sampling Event) of the Draft Fourth Five-Year Review Report, Naval Industrial Reserve Ordnance Plant (NIROP), Fridley, Minnesota, dated May 2013 (Fourth 5YRR) indicates that trichloroethene (TCE) at MS-43S [140 grams per liter (g/L)] and MS-44I (535 g/L) exceeded the Minnesota Surface Water Chronic Standard (Class B) criteria [please note, it is assumed the units presented in Table 4-3 are incorrect and should be presented in micrograms per liter (µg/L), consistent with the units of measurement presented in other sections of the Fourth 5YRR such as Section 4.2.3 (OU1 Performance Measurement), Table 4-1 (Groundwater Chemicals of Concern and Target Cleanup Levels – OU1 – August 2012 Sampling Event) and Attachment 3 (TCE Isoconcentrations Maps and Approximate Capture Zone Configurations) figures – a specific comment has been prepared to address this issue]. Section 8.1.3 (Uncertainty in Capture Zone Evaluation) states that the adequacy of capture in the shallow zone is uncertain along the northern reaches of the extraction system as evidenced by high TCE concentrations in MS-56S and MS-43, which could be indicative of inconsistent extraction system operation or partial bypass of contaminated groundwater when the extraction system is functioning consistently. Section 8.1.3 also discusses uncertainty of capture extent in the intermediate zone along the northern reaches of the extraction system near MS-34I and MS-35I. While the updates to the extraction system will likely have addressed these inconsistencies in the extraction system operation and partial bypass of contaminated groundwater, revise Section 7.0 (Technical Assessment) to acknowledge these issues as they relate to the remedy functioning as intended by the ROD.

   Response: Table 4-3 has been corrected from g/L to µg/L. Section 7 has been revised to address uncertainty in capture (see attached, revised Section 7.0 and Table 4-3). However, since the remedy is currently functioning as intended by the ROD, uncertainty in capture is not identified as an "issue" in the Five-Year Review.

2. **Comment:** The Third Five-Year Review Report, Naval Industrial Reserve Ordnance Plant, Fridley, Minnesota, dated August 2008 (Third 5YRR) stipulated that a proactive well maintenance program should be identified and implemented for the extraction wells; however, a formal proactive well maintenance program is not currently available or

referenced in the Fourth 5YRR. It should be noted that Section 5.1 (OU1 Progress Since the Last Five-Year Review) indicates that a "well maintenance program for new and existing extraction wells remains in progress," while Section 9.0 (Recommendations and Follow-Up Actions) indicates that a "proactive well maintenance program was recommended and has been implemented for the extraction wells" and "This proactive program, recommended in the previous five-year review, is in progress and is continually being re-evaluated." Revise the Fourth 5YRR to provide and/or reference the proactive well maintenance program. If the proactive well maintenance program is still under development, revise Section 9.0 to include the establishment of a formal proactive well maintenance program as a follow-up action.

Response: A formal proactive well maintenance program was not originally required or discussed by the Partnering Team; instead, the general requirements of the plan can be found in the Partnering Team meeting minutes from July 2008, and is also in the 2008 Annual Monitoring Report (AMR), Section 6.0, Extraction System Evaluation (Tetra Tech, 2009). General procedures related to implementing this plan are located in the O&M Plan (BayWest, 2013) The text referenced in the comment will be revised to state "This proactive program, recommended in the previous five-year review, is currently being implemented and is continually being re-evaluated as new conditions arise".

3. **Comment:** Section 8.1.5 [Vapor Intrusion (VI)] indicates that the site conceptual model (CSM) will be updated as appropriate based on new information and will be used to evaluate whether a complete exposure pathway for VI has resulted; however, Section 9.0 (Recommendations and Follow-Up Actions) makes no commitment to updating the CSM or evaluating whether a complete exposure pathway for VI exists. Based on the <u>Assessing Protectiveness at Sites for Vapor Intrusion: Supplement to the Comprehensive Five-Year Review Guidance</u>, OSWER Directive No. 9200.2-84, dated 2012 (Five-Year Review Guidance Supplement), the conclusions of the Fourth 5YRR should include: 1) an identification of issues; 2) recommendations and follow-up actions; and, 3) a determination of whether the vapor intrusion component and the overall site remedy are, or are expected to be, protective of human health and the environment. Revise Section 9.0 to address VI issues according to available VI guidance. In addition, Section 8.1.5 does not answer the three recommended technical assessment questions provided in Five-Year Review Guidance Supplement. Revise Section 8.1.5 to address these technical assessment questions in order to demonstrate whether an actual or potential VI exposure at the site might affect the ability of the overall site remedy to ensure protectiveness of human health and the environment.

   Response: Section 7.0 is the technical assessment where the three recommended technical assessment questions are asked (not in Section 8.1.5), and Section 7.0 has been revised to fully answer those technical assessment questions with regard to VI at the NIROP. Navy is in agreement with U.S. EPA's comment 4 (below) that since JE model results do not exceed current screening criteria (as stated in Section 7.0), Section 8.0 will not identify VI as an "issue", but will instead identify VI as a potential future issue that may need to be addressed if the NIROP building is reoccupied and or the NIROP property is redeveloped, and that the site conceptual model will be reviewed following the source investigation, which would include recalculation of the JE model. The text in Section 9 has been revised to state that following the voluntary optimization sampling, the Partnering Team will review the site conceptual model to evaluate whether a completed VI pathway exists, and if the NIROP building is reoccupied and/or the NIROP property is redeveloped, additional lines of evidence to refute VI potential and vapor mitigation strategies may be necessary.

4. **Comment:** Based on Section 7.2.1 (Exposure Assumptions – OU1), the Johnson & Ettinger Model was utilized to calculate an indoor air concentration; however, this calculated indoor air concentration should be viewed as a gross estimate. At sites where contaminated media concentrations exceed the EPA VI screening criteria, additional scrutiny is required to effectively evaluate VI potential and associated inhalation exposures. Typically, this requirement indicates the need for direct measurement of additional media, such as subslab soil gas or indoor air concentrations. The level of uncertainty associated with the Johnson & Ettinger Model has invalidated its use as a single line of evidence to refute vapor intrusion potential where screening criteria are exceeded. The Johnson & Ettinger Model has its greatest utility in derivation of a priority list of investigation targets where multiple points of exposure exist in a large facility investigation (i.e., multiple buildings). While the levels of excess risk reported in Section 7.2.1 are below the de minimis level of 1×10^{-6} and considers current toxicity criteria, revise Section 9.0 (Recommendations and Follow-Up Actions) to clarify that additional lines of evidence to refute vapor intrusion potential and vapor mitigation strategies may be necessary if the NIROP building is reoccupied and/or the NIROP property is redeveloped.

   Response: Please see the response to Comment 3.

5. **Comment:** Several components of the <u>Comprehensive Five-Year Review Guidance</u>, EPA 540-R-01-007, dated June 2001 (Five-Year Review Guidance) are not included in the Fourth 5YRR. For example,

   a. Section 1.0 (Introduction) does not include the purpose of the five-year review specific to the site or portion of the site addressed in the review.
   b. Section 1.0 does not indicate the date(s) the five-year review analysis was conducted; while the section indicates the review is based on remedial actions conducted as of December 31, 2012, the section does not specifically identify the date of the triggering action (date of signature of previous five-year review).
   c. Section 1.0 does not identify who conducted the site inspection.
   d. Section 4.0 (Remedial Actions) does not include a table documenting the total annual system operations/operation and maintenance (O&M) costs during the period preceding the current five-year review.
   e. While the Annual Monitoring Reports (AMRs) are referenced in Section 6.2 (Document Review), Section 6.3 (Data Review) does not discuss relevant trends and levels, note levels which are not currently compliant and whether future compliance can be expected without additional action, include tables summarizing monitoring and sampling data, or discuss recommended changes for future monitoring programs.
   f. Section 6.4 (Site Inspection) does not identify who participated in the site inspection or provide a summary of site conditions or conclusions.

g. Section 6.5 (Interviews) does not include a summary of the interviews or discuss the successes/problems with the system operations/O&M and/or unusual situations or problems at the site identified through the interviews.

See red-line version of Fourth 5YRR for other formatting revisions. Revise the Fourth 5YRR to include the components listed in the Five-Year Review Guidance.

Response: Responses to individual comments are listed below; however, other formatting revisions have not been made at this time as this is the Fourth Five Year Review and previous Five-Year Reviews have been deemed by all parties to meet the 2001 guidance:

a. The following text has been added to Section 1.0: "The purpose of this Five Year Review is to evaluate the implementation and performance of the remedy in order to determine if the remedy is protective of human health and the environment".
b. The following text was changed from "The triggering action for this fourth review was the date of signature of the previous five-year review" to "The triggering action for this fourth review was October 22, 2008, the date of signature of the previous five-year review".
c. The following text has been added to Section 1.0: "NAVFAC MidWest personnel conducted the site inspection, and EPA and MPCA representatives were in attendance".
d. The Navy has already included costs in Section 4.2.4.
e. Paragraphs 3 through 7 of Section 7.1.1 discuss the items listed in EPA comment 5e. This text will be moved to Section 6.3, Data Review.
f. The section will be revised to specify that NAVFAC MidWest personnel conducted the inspection. The text states that no significant issues were noted, and the Site Inspection Form summarizes site conditions and is located in Attachment 2 if the reader wishes to see additional detail.
g. Any O&M items, unusual situations or problems identified at the site are identified in Section 8.0, Issues. However, no "Issues" have been identified that impact the remedy protectiveness that would require "Recommendations" but there are items listed which have been noted for future discussion or potential future action by the Partnering Team.

6. **Comment:** Several significant submittals and actions taken at the site are not discussed in Section 2.0 (Site Chronology) of the Fourth 5YRR. For example, the United States Geological Survey (USGS) Report Simulation of Containment Well Capture at the Naval Industrial Reserve Ordnance Plant, Fridley, Minnesota, dated June 29, 2012 (Draft USGS Report) is not referenced. Similarly, the NIROP O&M "Super Soak" Extraction Well Redevelopment Process Tech Memo, Naval Industrial Reserve Ordnance Plant, Fridley, Minnesota, dated April 3, 2012 (Super Soak Memo) is not discussed. It should be noted that the Draft USGS Report is referenced on Page 7-2. Revise Section 2.0 to reference all significant submittals and actions.

   Response: Section 2.0 has been revised as requested and the References Section has also been updated.

7. **Comment:** The interview with Mr. Paul Walz of Bay West, provided in Attachment 2 (Five-Year Review Site Inspection Checklist), indicates that monitoring well caps were stolen from

Anoka County Park (ACP) in 2009. While the Navy was informed and Bay West replaced the well caps, the Fourth 5YRR does not discuss this incident of vandalism. Revise the Fourth 5YRR to discuss this incident of vandalism. In addition, provide the well location(s) where the incident of vandalism occurred and clarify if O&M procedures have been modified to ensure similar incidents are prevented and/or addressed in the future.

Response: Section 6.4, Site Inspection, has been updated to note the incidence of vandalism and repair. However, the Navy considers providing well locations are far too detailed to include in this Five-Year Review, since the incident has only occurred one time in 20 years of remediation. The monitoring wells are inspected during the annual synoptic groundwater sampling event. Monitoring well O&M procedures additional to the annual inspection are not planned or budgeted at this time.

8. **Comment:** The Fourth 5YRR discusses the ongoing or future investigations/assessments (e.g., source investigation, exit strategy, biological iron fouling assessment and vapor intrusion assessment) which are being conducted or planned for the NIROP site; however, Section 9.0 (Recommendations and Follow-Up Actions) does not include these investigations/assessments as follow-up actions. For example, Page 3 of Section 5.1 (OU1 Progress Since the Last Five-Year Review) indicates that an exit strategy will be developed for the NIROP facility; however, the development of this exit strategy is not listed in Section 9.0. Similarly, Section 8.1.2 (Biological Iron Fouling) indicates that the Navy is assessing treatment options available to address biological iron fouling; however, Section 9.0 does not discuss this assessment, or whether the assessment will be conducted as part of the proactive well maintenance program, which should also be discussed in Section 9.0. Revise Section 9.0 to include these items as follow-up actions.

   Response: These are maintenance-related items that are being tracked but are not "issues" that currently do impact protectiveness or are expected to impact protectiveness in the future. No issues have been identified for any OU that impact the current or future protectiveness of the remedy. However, text in Section 9.0 has been updated to include the items above. The proactive well maintenance program and biological iron fouling are already included under "Containment and Extraction Remediation System". The voluntary optimization sampling, vapor intrusion assessment, and exit strategy have been added to this section per EPA's comment.

9. **Comment:** Several questions in the Five-Year Review Site Inspection Checklist included in Attachment 2 (Five-Year Review Site Inspection Checklist) are not answered. For example, Subsection A (Access) of Section V [Access and Institutional Controls] questions whether access restrictions (e.g., door locks) were in place at Building 52/53; however, the question is not answered. Similarly, Subsection C [Institutional Controls (ICs)] of Section V questions how frequently the North 40 is monitored and what type(s) of monitoring is being utilized (i.e., inspection visits, drive by visits); however, the questions are not answered. For completeness, ensure all questions on the Five-Year Review Site Inspection Checklist are answered.

Response: The Site Inspection Checklist has been reviewed and missing information has been provided.

10. **Comment:** The Fourth 5YRR does not include a figure showing the locations where land use controls (LUCs) apply (i.e., Designated Restricted Areas, North 40, or Former Plating Shop). While Figure 3-1 (Site Plan) and Attachment 3 (TCE Isoconcentrations Maps and Approximate Capture Zone Configurations) figures indicate where OU2, OU3 and the approximate location of the East Plating Shop (i.e., Former Plating Shop) are located, a figure showing the specific locations where LUCs apply is not included. Revise the Fourth 5YRR to include a figure showing the specific locations where LUCs apply.

    Response: The Five-Year Review does contain this information; it is located in Attachment 2, following the Site Inspection Checklist.

11. **Comment:** Section 7.1.1 (OU1) indicates that Mann-Kendall trends from the 2006 and 2012 annual monitoring results are comparable. However, the text indicates that data from 120 wells were used in the 2012 analysis and only 113 wells were used in the 2006 analysis. As a result, it is not clear how these monitoring data results were selected for analysis. Revise the Fourth 5YRR to clarify how these results are comparable given the apparent use of different data sets.

    Response: The text will be revised to clarify that the relative proportions of downward trends, upward trends, and no trends were similar between the two datasets, even though seven additional wells were sampled during the 2012 analysis.

12. **Comment:** The Data Review section should include a summary narrative of the data with tables rather than only provide a reference to the Annual Monitoring Reports.

    Response: Please see the response to Comment 5e; text from Section 7 was moved to Section 6 to accommodate this request.

13. **Comment:** The protectiveness statements were revised per the Five Year Review Guidance, but the actions to be taken to be protective over the long term may need to be modified based on the revisions to the issues and recommended actions sections. A site-wide protectiveness statement should also be included. See red-line version of Fourth 5YRR for some revised text regarding protectiveness statements.

    Response: A site-wide protectiveness statement has been included in Section 10.0 and in the Five Year Review Summary Form.

14. **Comment:** The Issues and Recommendations sections should be clarified to clearly specify those which may affect current and/or future protectiveness, and, those which are O&M types of issues which do not affect protectiveness.

Response: The document has been revised to specify which items are O&M related or Navy voluntary actions such as the voluntary optimization sampling, and clarify that no issues have been identified which impact remedy protectiveness.

15. **Comment:** Groundwater extraction system: The Fourth 5YRR is inconsistent with respect to whether the groundwater extraction system is effectively capturing the full extent of the contaminated groundwater plume. This is identified as an issue in the Issues section. Yet on pages 7-6 and 7-7, and the discussion on pg. 4-7, would seem to indicate that this is an ongoing O&M issue and the extraction system is effectively capturing the plume. The protectiveness statement also indicates this. The narrative on the groundwater data on pgs. 7-6 and 7-7, though, seems to indicate that the extraction system is not effectively capturing the plume. This should be clarified, not only in these sections, but elsewhere in the report, including the Data Review section.

    Response: Groundwater capture was identified as an ongoing O&M item and not an issue which affects remedy protectiveness, and text was revised per the comment.

16. **Comment:** In the Protectiveness Statement in the Five-Year Review Summary Form and some other places in the Report, the Report states that the remedy for OU2 and OU3 is protective of human health and the environment and "in the interim," exposure pathways that could result in unacceptable risks are being controlled. What does "in the interim" mean? Interim between what and what? Does the Navy think that contaminant levels in the OU2 and OU3 areas will eventually decline, such that ICs will no longer be necessary? If so, by what mechanism? There is no discussion of this in the Report. The implication is that current conditions concerning soil contamination will continue indefinitely. In that case, use of the word, "interim" is not appropriate.

    Response: The words "in the interim" will be replaced by the word "currently".

17. **Comment:** On page 5-1, the Report states that, "[l]ong term protectiveness requires compliance with land use restrictions that prohibit interference with the limited industrial land use area and groundwater use restrictions." Where are the groundwater use restrictions? That is, what are the ICs that restrict groundwater use?

    Response: There are no ICs in the Groundwater ROD which restrict groundwater use; groundwater use restrictions are included in the deed under "Covenants, Conditions, and Restrictions", Section A.2, titled "Well Installation/Groundwater Extraction Restriction", of the Quitclaim Deed dated June 17, 2004. The text Comment 17 refers to is the Protectiveness Statement in the Third Five-Year Review, so it should not be changed; however, text will be added below the Third Five-Year Review Protectiveness Statement to clarify this.

18. **Comment:** On page 5-3, the Report includes a section entitled, "Exit Strategy." What does that mean? Please clarify. The natural inference is "Navy exit from the site." As long as there are ICs to be monitored and maintained, there will be no Navy exit. There is nothing in

the Fourth 5YRR that leads EPA to think that there will be an end to the need for ICs. EPA believes it is unwise to create the impression that an exit is in the offing anytime soon.

Response: The Navy's goal is that the groundwater containment system will not operate in perpetuity; and this is the intent of the exit strategy. The exit strategy is specific to the groundwater containment system operation. The Navy understands that ICs must remain in place.

19. **Comment:** Evaluating ICs for Five Year Reviews when the IC consists of a covenant or restriction contained in a deed requires that someone look at the records in the Registrar of Deeds' office to check whether any conflicting claims have been filed, e.g., easements, etc. It does not appear that there is any evidence that this was done. Moreover, there is no specific identification of the IC instrument – page 4-9 mentions "the deed" – what deed? Recorded when? The Background section of the Report mentions that the property the Navy owned has gone through two owners and one lessee – FMC, ELT and UDLP (and now Hyde Development). All the more reason to make sure the deeds and lease agreements for these transactions contain the required restrictions with no competing claims.

    Response: The Navy included all required Deed restrictions and required CERCLA and MERLA notification in the June 17, 2004 Quitclaim Deed, filed in Ramsey County, between the United States and United Defense, LP. The Navy conveyed the property in an as is condition. The Grantee also gave an express covenant that he was responsible for incorporating all restrictions in any subsequent property sales. The Navy, prior to the most recent property sale, although not required to do so, did confirm that the IC and restrictions were incorporated into the UDLP/BAE/ELT property transfer and were incorporated by reference in the recent Limited Warranty Deed. It is also noted that the original IC's and restrictions run, in perpetuity, with the property. There is no legal process (or requirement) that permits the Navy to be involved with any property transactions after the initial Government sale. Current Landowners or prospective buyers have no legal or regulatory requirement to involve the Navy in any transaction.

20. **Comment:** During the review of the Fourth 5YRR, the Land Use Control Remedial Design, Operable Unit (OU) 2 and Operable Unit (OU) 3, Naval Industrial Reserve Ordnance Plant, Fridley, Minnesota, dated March 2004 (LUC RD) was reviewed. Based on the Section 4 (Remedy Implementation Actions) of the LUC RD, the Navy or current property owner was required to provide the EPA and the Minnesota Pollution Control Board (MPCA) with annual land use control (LUC) Compliance Certifications. The Fourth 5YRR and previous five-year review report submittals do not reference these compliance certificates, and only three (for 2005) were located in the Administrative Record.

    Response: Section 4 (Remedy Implementation Actions) of the LUC RD (March, 2004) does state that the Navy or current property owner was required to provide the EPA and the Minnesota Pollution Control Board (MPCA) with annual land use control (LUC) Compliance Certifications. However, in June 2004, the Navy conveyed this responsibility in the deed, under "Covenants, Conditions, and Restrictions, 5. Required Notices/Certifications, b. LUC Compliance Certification) to the property owner. As specified in the June 17, 2004

Quitclaim deed, the property owner is to provide, to the EPA, MPCA and Navy, annually, a LUC Certification, exhibit provided in Deed. Since the LUC certifications are post-ROD, they are not required to be in the Administrative Record File. The Navy has requested the property owner/manager verify the annual submittals have been made. Also, during the multiple yearly visits to NIROP, by the Navy, the Navy has verified no LUC violations have taken place over the past several years. As specified in the LUC RD (Section 4.3, the Navy transferred the obligation to provide the certifications to the property owners in the 2004 Deed. In addition, the LUC RD makes provisions to evaluate the necessity of the annual submittal."

21. **Comment:** EPA uses the terminology *Institutional Controls* to encompass land use controls and other controls such as groundwater controls. EPA requires that an IC section be included in the document according to our model Region 5 FYR. See example in attached FYR Model Template. The IC section of the report must define ICs, explain what ICs are needed for the Site to ensure protectiveness and discusses follow-up actions required. The review should look at not only what ICs are required by the ROD but evaluate all areas where contamination from the Site is currently located which does not allow unlimited use/unrestricted exposure (UU/UE).

Restricted Area or Media (based on current Site conditions areas which are or should be restricted because it does not allow for unlimited use or unrestricted exposure (UU/UE)	**Institutional Control Objective /Restriction/Performance Standard**	**Type of IC** (in place, planned or the need for IC is under review)
OU1- groundwater at the NIROP facility. *See attached plume map in Figure X*	prohibit consumptive and other uses of the groundwater plume area until performance standards are achieved.	NEEDS TO BE COMPLETED WHETHER IN-PLACE, PLANNED OR NEED IS UNDER REVIEW
OU2 and OU3- NIROP facility *See Map of NIROP facility in Figure Y*	See specific objectives performance objectives from the ROD which includes prohibit interference with contaminated areas of the Site without prior approval and limit use of facility to commercial /industrial.	NEEDS TO BE COMPLETED WHETHER IN-PLACE, PLANNED OR NEED IS UNDER REVIEW
OU1- Area beyond boundary of NIROP facility where the groundwater plume exceeds performance standards *See attached plume map in Figure Z*	prohibit consumptive and other uses of the groundwater plume area until performance standards are achieved	NEEDS TO BE COMPLETED WHETHER IN-PLACE, PLANNED OR NEED IS UNDER REVIEW

A map is attached (OR WILL BE DEVELOPED) which depicts the current conditions of the site and areas which do not allow for UU/UE.

Response: As per previous responses, the Navy is following the June 2001 OSWER Guidance, which evaluates ICs as a part of the overall remedy assessment. Since ICs are a part of the overall remedy and overall protectiveness are based on the entire remedy, Navy believes that the intent of the Region 5 guidance has been met.

22. **Comment:** The IC Coordinators recommend that 1) the physical or geographical areas be described, along with maps, of the areas which have residual contamination that does not allow for UU/UE and that an IC table be completed as a first step to ensure that all areas which do not allow for UU/UE are properly considered. Once that analysis is completed, an analysis can proceed to determine the effectiveness of existing ICs and whether additional ICs are needed. Here is an example of how it might be approached.

    Response: Please see the response to Comments 5 and 21. ICs are evaluated as a part of the overall remedy protectiveness.

23. **Comment:** Provide a copy of the deed referred to (page 4-9) along with any other ICs for the Site. These ICs should also be summarized and analyzed in the IC Section of the FYR report.

    Response: A copy of the deed is attached to these responses to comments. Also please see the response to Comments 5, 21, and 22. ICs are evaluated as a part of the overall remedy protectiveness.

24. **Comment:** The Executive Summary should include a description of the remedy selected in each OU including required ICs, if any.

    Response: The Executive summary does include ICs for OU2 and OU3, and text was added to the Executive Summary stating that deed restrictions restrict the use of groundwater at the site.

25. **Comment:** Add the following to the acronym table:

ICs	Institutional Controls
ICIAP	Institutional Controls Implementation and Assurance Plan

Response: An ICIAP was not required per the Federal Facilities Agreement (FFA). Also please see the response to Comment 26.

26. **Comment:** Include the following statement (or the like) in the protectiveness statement. Long-term protectiveness requires compliance with effective ICs. To that end, effective ICs must be implemented, monitored, maintained and enforced. Long-term stewardship (LTS) must be assured to maintain effective ICs. Compliance with ICs will be accomplished by developing and carrying out (LTS) procedures. Although ICs are in-place, additional review is required to ensure the ICs in-place are effective, to understand whether additional ICs are s needed and to ensure that effective LTS procedures are in-place. An ICIAP will be prepared to for conducting additional IC evaluation activities, planning for additional ICs, if needed, and preparing or updating the LTS plan, if needed.

    Response: Text was added to Section 10 and the Five-Year Review Summary form to address this comment. The Navy conveyed the responsibility to ensure that effective ICs are implemented, monitored, maintained, and enforced in the deed. Also, an ICIAP was not required per the Federal Facilities Agreement (FFA).

27. **Comment: Recommendation**s. It is recommended that an ICIAP be prepared to review existing ICs and plan for additional ICs as needed to ensure long-term protectiveness. Add this to the Recommendations. Also, see guidance mentioned below which is attached.

    Response: Please refer to the response to Comments 25 and 26.

28. **Comment:** Following are references which should be consulted in conducting IC evaluations during the FYR.

    Region 5, *Model FYR Template and Guide.*

    OSWER Directive "Recommended Evaluation of Institutional Controls: Supplement to the "Comprehensive Five-Year Review Guidance"'; 2011.

    OSWER Directive 9355.0-89 EPA-540-R-09-001. "Institutional Controls: A Guide to Planning, Implementing, Maintaining, and Enforcing Institutional Controls at Contaminated Sites; December 2012.

    Response: Comment noted. However, the basis of the Region 5 Five-Year Review template is the June 2001 EPA OSWER Comprehensive Five-Year Review Guidance, and the Region 5 template has included additional steps and guidance to address ICs separately. The original 2001 guidance includes ICs as part of the overall remedy assessment. It is Navy's position that the Five Year Review as written meets the intent of the Region 5 guidance in that it complies with the OSWER June 2001 guidance.

SPECIFIC COMMENTS

1. **Comment: Section 2.0, Site Chronology, Page 6 of 7:** The 2003 events listed in Section 2.0 do not include the issuance of the Second Five-Year Review Report, Naval Industrial Reserve Ordnance Plant, Fridley, Minnesota, dated September 11, 2003 (Second 5YRR). Revise Section 2.0 to include the Second 5YRR.

Response: Section 2.0 has been updated as requested.

2. **Comment: Section 3.0, Background, Page 3 of 5:** The second paragraph on Page 3 of Section 3.0 indicates that risk in one subarea of OU2 was inordinately influenced by a single data point; however, the subarea of OU2 and single data point are not specified. Revise Section 3.0 to clarify the subarea and single data point that influenced the risk at OU2.

   Response: The text will be revised as follows: "A risk assessment for OU2 was conducted in 1996. Following a revision of that risk assessment, it was determined that risk in subarea A4 of OU2 was inordinately influenced by a single data point, specifically AB032. Therefore, during summer 2002, the Navy conducted a time-critical removal action to remove approximately 35 cubic yards of soil around location AB032 to a depth of 3 feet.

3. **Comment: Figure 3-2, Site Plan:** Figure 3-2 includes three arrows to signify the commingled Navy and BAE Plumes; yet sufficient evidence has not been provided at this time to substantiate that the plumes are commingled. Revise Figure 3-2 to remove the arrows from the figure.

   Response: These arrows are included because adjacent sites may be contributing contamination to the NIROP plume; the Partnering Team has historically acknowledged the possibility that commingling is occurring or that off-site sources may be contributing contamination to the NIROP plume. MPCA's recent July 8, 2013 letter regarding "Calendar Year 2013 groundwater Elevation Measurements, Southwest Fridley Groundwater Program" requested all parties, including BAE Systems, to conduct synoptic groundwater elevation measurements within a two-week time period for the purposes of providing all parties information on the entire area, not just their own sites, allowing for a better understanding of plume migration and groundwater hydraulics.

4. **Comment: Section 4.2.3, OU1 Performance Measurement, Page 4 of 9:** The third paragraph indicates that a subset of 17 monitoring wells located in the ACP nearest the bank of the Mississippi will be used as measurement points for the purpose of identifying groundwater COC concentrations potentially migrating into the river; however, Section 4.2.3 does not specifically reference or identify the locations of the 17 wells. Revise Section 4.2.3 to cite the tables and figures which identify the 17 measurement points and reference the figures that show historical results for monitoring of these wells.

   Response: Table 4-3 lists the 17 wells included monitoring wells located in the ACP nearest the bank of the Mississippi will be used as measurement points for the purpose of identifying groundwater COC concentrations potentially migrating into the river. Historical results for these wells can be found in each year's Annual Monitoring Report. The text was revised as requested.

5. **Comment: Section 4.2.5, OU1 Vegetable Oil Pilot Testing, Page 8 of 9:** Section 4.2.5 does not reference a figure showing the location of the small area where vegetable oil was applied. Revise Section 4.2.5 to reference Figure 3-2 (Site Plan).

Response: The text has been revised as requested.

6. **Comment: Section 4.3, OU2 and OU3 Remedial Actions, Page 9 of 9:** The text indicates that "COCs for OU2 and OU3 are identified in Table 4-1;" however, Table 4-1 (Groundwater Chemicals of Concern and Target Cleanup Levels – OU1 – August 2012 Sampling Event) does not provide the COCs for OU2 or OU3. Revise the Fourth 5YRR to include a table providing the COCs for OU2 and OU3.

   Response: The text will be revised as follows: "COCs for OU2 and OU3 are the same as the COCs for groundwater".

7. **Comment: Table 4-3, Detected Concentrations of VOCs in Riverside Wells – OU1 – August 2012 Sampling Event:** Based on Section 4.2.3 (OU1 Performance Measurement), Table 4-1 (Groundwater Chemicals of Concern and Target Cleanup Levels – OU1 – August 2012 Sampling Event), and the Attachment 3 (TCE Isoconcentrations Maps and Approximate Capture Zone Configurations) figures, the volatile organic compound (VOC) concentrations presented in Table 4-3 appear to be in micrograms per liter (μg/L) rather than grams per liter (g/L). Revise Table 4-3 to ensure the correct units are utilized.

   Response: The table has been revised to show the correct units.

8. **Comment: Section 5.1, OU1 Progress Since the Last Five-Year Review, Pages 1 of 5 and 2 of 5:** Section 5.1 indicates that the pump-and-treat system is operational and that the system improvements enhanced performance; however, the text does not provide and/or reference information to substantiate that the system was sufficiently operational or quantify how the improvements enhanced the system. Section 5.1 also states that "The new extraction wells (AT-11, AT-12, and AT-13) and associated equipment and other equipment upgrades, added to the containment system are the outcome of continued operation of the OU1 remedy to meet ROD objectives;" however, the text does not specifically identify the other equipment upgrades or demonstrate that the new extraction wells and associated equipment and other equipment upgrades results in the Operable Unit (OU) 1 remedy meeting ROD objectives. While this information is provided in the AMRs, the Fourth 5YRR does not clarify where in the AMRs this information can be found. Revise Section 5.1 to reference specific sections in the AMRs where quantitative information to support these discussions can be found.

   Response: Quantitative information supporting this statement is included in the Five-Year Review on the figures in Attachment 3. The text has been revised to state this.

9. **Comment: Section 6.1, Community Notification and Involvement, Page 1 of 2:** The text states that "The Draft Fourth Five-Year Review Report will be provided to EPA and MPCA for review and comment in February 2013;" however, the Fourth 5YRR was not provided to EPA until June 2013. Revise the Section 6.1 to clarify that the Fourth 5YRR was provided to EPA in June 2013, not February 2013.

   Response: The section has been revised as requested.

10. **Comment: Section 7.1.1, OU1, Pages 2 of 9:** The text states that "There is some evidence to suggest that PCE [tetrachloroethene] may originate from an off-NIROP source;" however, information to substantiate this assumption is not provided and/or referenced in the Fourth 5YRR. Revise the Fourth 5YRR to provide information to substantiate that PCE may originate from an off-NIROP source.

    Response: Text has been added to this section referring to the 2012 AMR.

11. **Comment: Section 7.2.4, Cleanup Levels – All OUs, Page 5 of 9:** The text states that "The updated surface water criteria and standards identified in the first Five-Year Review Report changed per a letter from the MPCA on December 15, 2009." Since this letter documents a change in the cleanup levels established in the OU1 ROD, the letter should be included in the Fourth 5YRR as an attachment. Revise the Fourth 5YRR to include the referenced letter as an attachment.

    Response: The letter has been included as Attachment 5. Text has been added to refer to the attachment.

12. **Comment: Section 7.2.5.1, Problem B: Effectiveness of the Capture Well System, Page 7 of 9:** The last sentence of Section 7.2.5.1 references Attachment 3 as support that the system continues to show significant improved performance; however, Attachment 3 (TCE Isoconcentration Maps and Approximate Capture Zone Configurations) includes TCE isoconcentration maps and the approximate capture zone configurations. These do not show significant improved performance of the system. Revise Section 7.2.5.1 to reference figures and tables which support that the system continues to show significant improved performance.

    Response: The following text has been added just before the reference to Attachment 3: "and effectiveness in capturing contaminated groundwater". The figures are meant to show substantial capture of contaminated groundwater.

RESPONSES TO MINNESOTA POLLUTION CONTROL AGENCY COMMENTS ON FOURTH FIVE-YEAR REVIEW REPORT NAVAL INDUSTRIAL RESERVE ORDNANCE PLANT, FRIDLEY, MINNESOTA DATED MAY 30, 2013

September 27, 2013

General Comments:

1. **Comment:** The Minnesota Pollution Control Agency (MPCA) generally agrees with the protectiveness conclusion reached by this Five-Year Review and believes that the document satisfies the intent and purpose of a Five-Year Review. However, MPCA believes that additional clarification and information requested by specific comments listed below would better serve to inform the public and document the remarkable progress achieved at the site over the past five years.

   Response: Comment noted, specific comments are addressed below.

2. **Comment:** The MPCA recommends that interviews with the City of Fridley be conducted and discussed to provide background of recent community concerns expressed by both the city and the residents. Community involvement with respect to groundwater quality within the city of Fridley has dramatically increased during this review period and should be documented in the Five-Year Review.

   Response: Although interviews with city of Fridley personnel were not conducted, there were public meetings conducted during this Five-Year Review period in which information was exchanged.

3. **Comment:** The Five-Year Review refers to the 2012 Annual Monitoring Report in several instances. The 2012 AMR has not been submitted to MPCA (and the U.S. Environmental Protection Agency (EPA)). The MPCA recommends that this fact be noted in the Five-Year Review for clarification.

   Response: The AMR was submitted to MPCA and U.S. EPA on July 10, 2013. The 2012 AMR reference was updated in the Five-Year Review text. Please see the attached Five-Year Review sections and references.

Specific Comments:

Five Year Review Summary Form

1. **Comment:** The MPCA recommends that this Five-Year Review document include the most recent version of the Five-Year Review Summary Form developed by U.S. EPA. The new summary form aids in tracking progress of issues and recommendations identified in the Five-Year Review.

Response: The most recent version of the Five-Year Review Summary Form has been used. Please see the attached, revised Five-Year Review Summary Form.

Section 2.0 – Site Chronology

2. **Comment:** This section contains multiple references to events which are not administratively linked to the Naval Industrial Reserve Ordnance Plant (NIROP) facility. For example: the second item in June 1986, and the second item in September 1987. The MPCA recommends that all references not specific to the historic or remedial chronology for NIROP be removed or provide an explanation why it should be included.

   Response: These items are included because adjacent sites may be contributing contamination to the NIROP plume; the Partnering Team has historically acknowledged the possibility that commingling is occurring or that off-site sources may be contributing contamination to the NIROP plume. MPCA's recent July 8, 2013 letter regarding "Calendar Year 2013 groundwater Elevation Measurements, Southwest Fridley Groundwater Program" requested all parties, including BAE Systems, to conduct synoptic groundwater elevation measurements within a two-week time period for the purposes of providing all parties information on the entire area, not just their own sites, allowing for a better understanding of plume migration and groundwater hydraulics. Navy agrees with MPCA that a holistic approach to understanding the sites is the most efficient path forward.

3. **Comment:** Besides the date a given document was submitted to the Regulators, the MPCA believes the chronology should include the date a given document was finalized. The current version only includes when draft document was submitted by the Navy.

   Response: Section 2 contains a general chronology; adding a finalized version for each document in this section, given the long history at NIROP, would significantly lengthen this section. Navy recently established the Administrative Record (AR) online at http://go.usa.gov/DyNY, so the public can access all versions of relevant documents.

4. **Comment:** Please correct the installation and pumping test dates for AT-11, AT-12, and AT-13. These wells were installed during 2011.

   Response: The date has been changed to 2011. Refer to the attached, revised Section 2.

Section 3.0 - Background

5. **Comment: Page 1, Paragraph 3:** The site property boundary is a lot less than 2000 feet from the Mississippi River as stated in the text in Section 3.0. The MPCA recommends that Navy check the distance from the Mississippi River to the western NIROP boundary and revise the text in this section to better reflect the location of the site.

   Response: The text will be changed from "....and 2,000 feet east of the Mississippi River...." to "....and between 750 and 900 feet east of the Mississippi River...". Please refer to the attached, revised Section 3.

6. **Comment: Page 3, Paragraph 5:** Please clarify the first sentence of this paragraph to provide a reference to the technology evaluated during the pilot test.

   Response: The text "...this technology..." will be changed to "...addition of refined soybean oil to enhance reductive dechlorination...". Please refer to the attached, revised Section 3.

Section 4.0 – Remedial Actions

7. **Comment: Page 1, Paragraph 1:** Please use the OU-1 definition as described in the Record of Decision (ROD), which includes all groundwater contaminated due to NIROP.

   Response: The text will be changed from "Groundwater is identified as OU1" to "OU1 is identified as contaminated groundwater from the NIROP", as stated in the ROD. Please refer to the attached, revised Section 4.

Section 5.0 – Progress Since the Last Five-Year Review

8. **Comment: Page 5-3, Item 4. Exit Strategy:** The MPCA recommends that this section includes the text of the Vision statement/Exit Strategy.

   Response: The NIROP Vision and Goals, adopted during the Tier I and Tier II meeting in Chicago on June 22, 2011, and edited during the Tier I and Tier II meeting in St. Paul on December 8, 2011, will be added to the Exit Strategy section. Please refer to the attached, revised Section 5.

Section 6.0 – Five-Year Review Process

9. **Comment: Section 6.1 Community Notification and Involvement:** Please update this section, specifically the date which the draft document was submitted for review to the U.S. EPA and MPCA.

   Response: The date was updated from February 2011 to May 30, 2011. The date of this response to comments letter and the date of the U.S. EPA's response to comments letter was also be added to Section 6.1. Please refer to the attached, revised Section 6.

10. **Comment: Section 6.4 Site Inspection:** The MPCA recommends that the damage to monitoring wells noted during the site inspection be included in this section.

    Response: The following text was added to Section 6.4, at the end of the paragraph: "Monitoring well 8-IS was missing its cover during the site inspection, and in 2009, monitoring well caps were stolen from some monitoring wells in Anoka County Park. The Navy was informed and BayWest replaced the caps. The cover will be replaced for monitoring well 8-IS." Please refer to the attached, revised Section 6.

11. **Comment: Section 6.5 Interviews:** The MPCA believes the reference to Restoration Advisory Board (RAB) are not appropriate as NIROP does not have an active RAB. The RAB has not met in the last seven years. However, the MPCA recommends that this

section include a reference to community involvement and concerns which have occurred during the previous five years, for example formation of a Community Action Group for Fridley Superfund Sites and the concerns expressed by the city of Fridley with regard to increasing use of nearby Fridley Municipal Well 13 (Attachment 1).

Response: Attachment 1, referred to by MPCA in their Specific Comment 11, above, was not included in the pdf. Although there have not been RAB meetings for some time, one RAB member still remains on Navy's document distribution list. The RAB member should continue to receive documents until they request otherwise. Navy encourages RAB and other community involvement. The section has been updated as follows: "A Community Action Group for Fridley Superfund Sites was formed during this Five-Year Review Period to exchange information about site activities and local concerns. The city of Fridley has also expressed concerns during Partnering Team meetings about the NIROP plume with regard to their intent to increase use of municipal well Fridley Well 13. Currently, the city of Fridley's water is supplied by the Mississippi River and excess water from New Brighton. Water from New Brighton is supplied from the groundwater treatment plant at the Twin Cities Army Ammunition Plant (TCAAP). Groundwater from the TCAAP TCE plume is pumped and treated to residential drinking water standards and supplied for municipal use. According to city of Fridley Water Works personnel, reductions in TCAAP plume contaminant concentrations will result in decreased pumping, decreasing the water supply available to the city of Fridley and increasing the demand on Fridley's municipal wells." Please refer to the attached, revised Section 6.

<u>*Section 7: Technical Assessment*</u>

12. **Comment: Section 7.1.1 – OU-1, Last Paragraph:** The Draft USGS groundwater model is not previously discussed in this document. The MPCA recommends that Navy discuss the genesis of and the current status of the USGS model, as well as the expected completion date for the Model.

    Response: Per U.S. EPA General Comment 5e, the data discussion in this section was moved to Section 6.3, Data Review, and the following text has been added to this section: "The United States Geologic Survey (USGS) was contracted to construct a numerical model intended to be used as a tool by the Partnering Team to evaluate contaminant concentrations, groundwater flow pathways, and probable capture zones for extraction well pumping under different scenarios. The purpose of this model is that it be used to determine the most effective pumping rate/pumping well configuration to ensure that maximum capture of the contaminant plume is achieved. The modeling is complete and a draft report has been prepared and peer reviewed. The draft report is currently being revised, then the USGS supervisory review process will begin and the report will be published. Report approval is anticipated by the end of fiscal year 2013." Please refer to the attached, revised Section 6.

13. **Comment: 7.2.1 – Exposure Assumptions, Page 7-4, Second Paragraph:** Parameters discussed in the Johnson-Ettinger model do not consider the known soil impacts below the building slab. The MPCA believes that the vapor intrusion evaluation provided

should be discussed as a preliminary assessment as only groundwater concentrations were considered as potential vapor intrusion sources. Since all potential sources for vapor intrusion were not evaluated, the MPCA recommends that Vapor Intrusion from soils be identified as an issue and have a corresponding recommendation for further evaluation.

Response: A preliminary evaluation for soil under the building has been conducted and included in the Five-Year Review, and a discussion of the results was added in the exposure assumptions section for OU2 and OU3. Since the evaluation results are below EPA's target risk level, it is unnecessary to identify vapor intrusion as an issue with an associated recommendation. However, the voluntary optimization sampling will yield additional soil data which will then be used to update the Johnson-Ettinger model, if the Partnering Team determines that is necessary. The following text has been added to Section 7.2.1: "The presence of TCE and other VOCs in surface and subsurface soil also renders the compounds potentially viable to volatilize and migrate into the indoor air of a building. Using the maximum detected soil concentrations of each detected VOC at depth intervals of 0 to 4 feet, 4 to 8 feet, and 8 to 12 feet from samples collected in 1997 (as reported in the 2002 Remedial Investigation), indoor air concentrations were predicted. The indoor air concentrations were determined using the Johnson-Ettinger Model and were based on the same assumptions listed for OU-1. The maximum exposure concentration and risk from each depth interval for each VOC were used to conservatively estimate potential risk associated with exposure to indoor air concentrations (Attachment 4). The exposure concentrations correspond to a carcinogenic risk of 1×10^{-7} and a hazard index of 0.1, below EPA's target risk levels". Please see the attached, revised Section 7.

14. **Comment: 7.2.4 – Clean Up Levels – All OUs:** Discussion of the proposed changes to the surface water standard referencing the MPCA letter dated December 2009 should note that the proposed changes to the applicable surface water standard are conditional. The 2009 letter required the Navy to implement a surface water sampling plan in order to document that the proposed change of the surface water standard will be protective of human health and the environment. A surface water sampling plan was not submitted or implemented by the Navy during this review period. The MPCA recommends the Five-Year Review identify the proposed change to this applicable standard as an issue and provide a corresponding recommendation to implement a surface water sampling plan.

    Response: The Minneapolis Water Works Intake is located just downstream from the site in the Mississippi River, and samples are collected regularly by Minneapolis Water Works. Samples from this intake have not shown any detection in several years, and Navy feels that the sampling being conducted currently is adequate to evaluate surface water in the Mississippi River. The proposed change to this applicable standard is not an "issue" that affects remedy protectiveness; therefore it will not be noted as an "issue" with an associated recommendation.

15. **Comment: 7.2.5.1 – Problem B: Effectiveness of Capture Well System:** Discussion in this section does not define Problem B or discuss what criteria are utilized to evaluate Problem B. The discussion provided requires that the reader have previous knowledge of

the contents of the RAWP. Discussion in the Five-Year Review should be understandable to the general public without requiring review of additional documents. The MPCA recommends that summary of RAWP be included in this section.

Response: A full summary of the RAWP might be too extensive for this section; the Navy suggests adding text explaining each problem statement. For Problem Statement B, the following text has been added after the first sentence in Section 7.2.5.1: "Each "problem" is defined by stating a problem or asking a question as a part of the project planning/design process, which is then used to develop decision rules. The study question for Problem B is: "Is the capture system with the newly installed wells effective at preventing groundwater contamination from passing through the capture system?" The criteria used to evaluate Problem B are the following:

- Hydraulic heads
- Chemical concentrations
- Physical parameters
- Stratigraphy
- Removal rate
- Drawdown
- Historical data
- Pumping rate
- Borehole flow velocity
- Tracer study
- 3-dimensional numerical model
- Plume dimension and location
- Concentrations that constitute contamination and delineate the plume

16. **Comment: 7.2.5.2 – Problem C: Groundwater Monitoring for Overall Contamination at NIROP Fridley (Effectiveness of the Groundwater Monitoring Network):** See comment regarding Problem B.

Response: A full summary of the RAWP might be too extensive for this section; the Navy suggests adding text explaining each problem statement. For Problem Statement C, the following text will be added before the first sentence in Section 7.2.5.2: "Each "problem" is defined by stating a problem or asking a study question as a part of the project planning/design process, which is then used to develop decision rules. The problem statement for Problem C is: "…to optimize the groundwater monitoring program while providing sufficient data to determine whether the following are being achieved:

1. contaminated groundwater is prevented from leaving the site,
2. contaminated groundwater is prevented from reaching the Mississippi River,
3. change in the shape, size, and location of plume are being tracked,
4. contaminant levels are being evaluated relative to surface water and groundwater standards,

5. performance of remedial system is assessed (system = existing ongoing remedial actions and any future remedial actions which are implemented)
6. practicability of achieving complete remediation is assessed (won't completely address this under groundwater optimization)

17. **Comment: Paragraph following Decision Rule 5:** This paragraph references the document as an AMR rather than a Five-Year Review. Is the Navy referring to the 2012 AMR? The Navy may want to review the draft Five-Year Review to correct similar references.

    Response: The document was reviewed and other similar errors were corrected. The word "...this..." in the second paragraph were changed to "...the 2012..." and a document reference was added to the end of the sentence.

Section 8.0 - Issues

18. **Comment: 8.0 – Issues:** All issues identified in this section should provide discussion of whether the issue affects current or future protectiveness of the remedial action for the site. MPCA suggests inclusion of a table similar to those provided in U.S. EPA Five-Year Review template for this section.

    Response: Comment noted. However, the basis of the Region 5 Five-Year Review template is the June 2001 EPA OSWER Comprehensive Five-Year Review Guidance, and the Region 5 template has included additional steps and guidance to address ICs separately. The original 2001 guidance includes ICs as part of the overall remedy assessment. It is Navy's position that the Five Year Review as written meets the intent of the Region 5 guidance in that it complies with the OSWER June 2001 guidance. The text in Section 8 will state that these are maintenance-related items that are being tracked but are not "issues" that currently do impact protectiveness or are expected to impact protectiveness in the future. No issues have been identified for any OU that impact the current of the remedy; text to this effect has been added to Section 8.0, and therefore; no table will be needed.

19. **Comment: 8.1.4 – Source Remediation:** The MPCA is unclear as to the purpose of the discussion of the veggie oil pilot study, how it relates to source remediation and why source remediation is listed as an issue in the first place. The Site team has not had serious discussions regarding potential source remediation technologies and the Navy has been very clear in the past that the main reason it is conducting the source investigation under the building is for internal Navy purposes. Therefore, the MPCA recommends that Navy provide more details and clarity to this section. Please note that MPCA continues to believe source remediation has the ability to shorten the lifespan of the pump and treat system and therefore should be evaluated.

    Response: Navy agrees that source remediation would shorten the timeline of the pump and treat system, but source remediation is not an "issue" in terms of a Five-Year Review, but a follow-up action that has potential to shorten the remedial timeframe. Text has been added to Section 8 to clarify this.

20. **Comment: 8.2 OU2 and OU3 Issues:** The MPCA recommends that the Vapor Intrusion be listed as an OU3 (unsaturated soils under the building) issue as some of the highest levels of Trichloroethene (TCE) were found in the unsaturated soils under or near the East Plating Shop.

    Response: The text "No issues affecting remedy protectiveness have been identified for OU2 or OU3" is correct, because the Johnson-Ettinger model results for both soil and groundwater were below U.S. EPA screening levels.

21. **Comment:** The MPCA recommends that damaged monitoring wells observed during the site inspection should be identified as an issue and have a corresponding recommendation to repair the damage.

    Response: Damaged monitoring wells have not been listed as an issue, because they do not affect remedy protectiveness, but have been noted in the Five-Year Review as a maintenance item. The Navy will follow up on this item by repairing the damage to monitoring wells.

<u>*Section 9.0 - Recommendations*</u>

22. **Comment: 9.0 – Recommendations:** Many issues identified in this Five-Year Review do not have corresponding recommendations which address protectiveness or future protectiveness of the selected remedies. MPCA recommends that Navy include a table similar to those provided in the U.S. EPA Five-Year Review template.

    Response: No issues have been identified in this Five-Year Review which affect remedy protectiveness; therefore, a table will not be required.

23. **Comment:** The MPCA recommends that Navy include in the current Five-Year Review, the recommendations from the previous Five-Year Review that are yet to be completed or listed as ongoing.

    Response: Recommendations from the previous Five-Year Review that are yet to be completed or listed as ongoing are already listed in Section 9 as maintenance items. These items do not affect remedy protectiveness, and are not "issues" that require "recommendations". However, these items do support the Navy in confirming remedy protectiveness. Text to this effect has been added to this section.

24. **Comment:** Please include recommendations to repair and document repairs to damaged monitoring wells.

    Response: Monitoring wells will be repaired but this is not an issue that affects remedy protectiveness.

<u>*Attachment 3 – Figures*</u>

25. **Comment:** OU-1 as presented in the figures should match the ROD defined boundaries of OU-1. The ROD definition includes the aerial extent of the groundwater plume and is not confined to the limits of the former NIROP property boundary as depicted in the figures. Please revise all figures in the Five-Year Review to accurately reflect the ROD defined OU boundaries.

    Response: Comment noted. However, MPCA, U.S. EPA, and the Navy have discussed the issue of potential upgradient sources and commingled plumes many times in the past. Portrayal of the NIROP plume to include off-site portions of the plume, which may or may not be the Navy's responsibility, would not accurately represent the site to the general public.

26. **Comment:** No discussion of the BAE site or groundwater plume is provided in this Five-Year Review. The MPCA requests that all references to the BAE site should be removed from the figures unless further discussion is provided which clearly supports the references in the figures.

    Response: Please see the response to Specific Comment 25.

27. **Comment:** The hash marks utilized to represent OU-2 and OU-3 do not match those provided in the legend of the figures. Please revise the figure for accuracy in the event this figure is reproduced in black and white.

    Response: The figures have been revised (see attached) and they will be included in the Final Five-Year Review.

28. **Comment:** The MPCA recommends that Attachment 3 includes a figure with PdC TCE levels during the review period, including the Fridley Well 13.

    Response: Attachment 3 will include a figure of the Prairie du Chien monitoring wells and their TCE concentrations (see attached figure).

QUITCLAIM DEED

COPY

QUITCLAIM DEED

STATE DEED TAX DUE HEREON: $ EXEMPT

Date: June 17, 2004

KNOW ALL MEN BY THESE PRESENTS that the UNITED STATES OF AMERICA, acting by and through the Administrator of General Services, under and pursuant to the general authority contained in the provisions of the Federal Property and Administrative Services Act of 1949, (63 Stat. 377, 40 USC 471 et. seq.) as amended, and Public Law 98-181, approved November 3, 1983, (97 Stat. 1175), Public Law 105-50, approved October 6, 1997, Public Law 105-119 Section 118, approved November 26, 1997, Public Law 106-113, approved November 29, 1999, and the rules, regulations and orders promulgated thereunder, having an address of General Services Administration, New England Region, Thomas P. O'Neill Federal Building, 10 Causeway Street, Boston, Massachusetts 02222, on behalf of the United States of America and all of its agencies, including but not limited to the U.S. Navy, (the "Grantor") for and in consideration of Six Million Five Hundred Thousand and No/100 Dollars ($6,500,000.00), the receipt of which is hereby acknowledged, does hereby GRANT, GIVE, REMISE, RELEASE, CONVEY, AND QUITCLAIM, without warranties or representations of any kind or nature, express or implied, unto UNITED DEFENSE, L.P., a Delaware limited partnership, with an address of 4800 East River Road, Minneapolis, Minnesota, 55421 (the "Grantee"), its successors and assigns all such right, title, and interest as the Grantor has in and to certain real property, totaling 80.35 acres, located in the City of Fridley, Anoka County, State of Minnesota and more particularly described in **Exhibit 1** of this Deed, together with any improvements located thereon (the "Property").

CONDITION OF PROPERTY. The Grantee, in accepting this Deed, acknowledges and attests that it has inspected, is aware of, and accepts the condition and state of repair of the Property. It is understood and agreed that the Property is conveyed 'as is' and 'where is' without any representation, warranty or guarantee of any kind or nature, express or implied, including, without limitation, any representation, warranty or guarantee as to quantity, quality, character, condition, size or kind, or that the same is in any particular condition or fit to be used for any particular purpose. The Grantee, in accepting this Deed, acknowledges that the Grantor has made no representation or warranty concerning the condition or state of repair of the Property that has not been fully set forth in this Deed.

EASEMENTS, LICENSES AND PERMITS. The Property is conveyed subject to any and all existing reservations, easements, restrictions, covenants, and rights, recorded or unrecorded, including those for roads, highways, streets, railroads, power lines, telephone lines and equipment, pipelines, drainage, sewer and water mains and lines, public utilities and rights-of-way, and including but not limited to, any specific easements, reservations, rights, and covenants described herein; any state of facts that would be disclosed by a physical examination of the Property; any state of facts that an accurate and adequate survey of the Property would disclose; and any and all other matters of record. The U.S. Navy ("Navy") shall be responsible for obtaining and maintaining applicable permits and licenses associated with Federal Facility Agreement (FFA) activities, although nothing herein shall be construed to preclude a subsequent agreement between any third party (including Grantee or subsequent grantees) and the Navy for the acquisition, transfer and/or maintenance of such permits or licenses with appropriate regulatory review and concurrence.

COVENANTS, CONDITIONS AND RESTRICTIONS. The Property is conveyed subject to the following further covenants, conditions, matters and restrictions. All of the covenants, conditions, restrictions and obligations described in this Deed run with the Property and are binding upon the Grantee and its heirs, successors and assigns. Grantee's acceptance of this Deed is an acknowledgement that it is bound by all such covenants, conditions, restrictions and obligations:

A. LAND USE CONTROLS (LUC)

1. <u>Categorical Land Use Restriction</u>:

Grantee on behalf of itself, its lessees, licensees, successors and assigns covenants that the Property shall be used only for industrial or restricted commercial uses unless the U.S. Environmental Protection Agency (EPA) and the Minnesota Pollution Control Agency (MPCA) determine that the concentrations of hazardous substances in the soils on the Property allow for less restrictive uses. Permissible industrial uses shall include, but not be limited to, the following types of uses: public utility services, rail and freight services, raw storage facilities, refined material storage facilities, and manufacturing facilities engaged in the mechanical or chemical transformation of materials or substances into new products. Permissible restricted commercial uses shall include those where access or occupancy by non-employees is less frequent or is restricted, including a wide variety of uses, ranging from non-public access and both outdoor and indoor activities (e.g., large scale warehouse operations), to limited public access and indoor worker activities (e.g., shopping mall, retail outlet, bank, dentist office). Strictly prohibited uses under either category shall include any child care or pre-school facility, playground, any form of housing, churches, social centers, hospitals, elder care facilities or nursing homes.

2. **Well Installation / Groundwater Extraction Restriction:**

Grantee on behalf of itself, its lessees, licensees, successors and assigns covenants that no water supply wells shall be installed on the Property nor shall any groundwater be extracted from beneath the Property without prior written approval from the EPA, MPCA and the Minnesota Department of Health. Notwithstanding the foregoing, treated groundwater meeting State surface water requirements may be used for non-contact cooling purposes if it is subsequently discharged into the Mississippi River. This restriction shall also not apply to Grantee's installation of any new groundwater monitoring wells on the Property upon request of the Navy, where the Navy has already obtained all necessary regulatory approvals for such installations.

3. **Soil Disturbance Restrictions:**

a. Soils Beneath Main Industrial Building

Grantee on behalf of itself, its lessees, licensees, successors and assigns covenants that no soil disturbance or alteration of any nature shall take place beneath the concrete pit floor (approximately 8 to 12 feet below floor grade) where metal finishing operations previously occurred at the former Plating Shop within the Main Industrial Building without the prior written approval of the EPA and MPCA. **Exhibit 2** which is attached and incorporated herein by reference reflects the area to which this restriction applies. Any soils excavated from any Designated Restricted Area as identified in **Exhibit 2** shall not be removed from the Property unless such removal is approved in writing in advance by the EPA and MPCA at the time such removal and disposal is proposed.

b. Soils Outside Main Industrial Building

Grantee on behalf of itself, its lessees, licensees, successors and assigns covenants that no soil disturbance or alteration of any nature shall take place greater than the depths in those Designated Restricted Areas as identified in **Exhibit 2** which is attached and incorporated herein by reference, without the prior written approval of the EPA and MPCA. Any soils excavated from any Designated Restricted Area shall not be removed from the Property unless such removal is approved in writing in advance by the EPA and MPCA at the time such removal and disposal is proposed.

c. Soils Outside Designated Restricted Areas

This restriction does not apply, and no prior approval of the EPA or MPCA shall be required with respect to activities on any portion of the Property outside of these Designated Restricted Areas, including without limitation activities related to maintenance or repair of existing buildings, structures, underground sewer, water, gas, electrical or telephone services, or installation of fencing and signage when such activities are not expected to, or are not reasonably likely to result in, any disturbance of or intrusion into soil/groundwater within the Designated Restricted Areas.

4. Non-Interference Restriction:

Grantee on behalf of itself, its lessees, licensees, successors and assigns covenants that it shall not unreasonably hinder or prevent the Navy from constructing, upgrading, operating, maintaining and monitoring any groundwater treatment facilities and groundwater monitoring network or engage in any activity that would (i) cause the Navy to violate any Health and Safety Plan put into effect and directly related to its performance of the Federal Facilities Agreement at the Property or (ii) otherwise disrupt or hinder further remedial investigation, response actions or oversight activities related to its performance of Federal Facility Agreement activities on the Property.

5. Required Notices / Certifications:

a. Desired Change in Land Use

Grantee on behalf of itself, its lessees, licensees, successors and assigns covenants that it will provide advance written notice to the EPA, MPCA and the Navy of its desire to use the Property for anything other than industrial or restricted commercial use. Such notice shall include a description of its plans for undertaking any environmental investigation and/or cleanup activities necessary to permit such a change in land usage. Grantee on behalf of itself, its lessees, licensees, successors and assigns ensure that such activities will not conflict with or adversely affect any ongoing remedial systems or future investigative or remedial activities to be undertaken by the Navy on the Property.

b. LUC Compliance Certification

Grantee on behalf of itself, its lessees, licensees, successors and assigns covenants that it shall provide annual written certifications by March 1st of each year to the EPA, MPCA and the Navy regarding continued compliance with those Land Use Controls (LUCs) implemented through deed recordation for as long as such LUCs remain in place to ensure adequate protection of human health and the environment. Such annual certifications shall be based upon annual physical inspections of the Property and shall be provided using the form in **Exhibit 3.**

6. LUC Remedial Design Acknowledgment

Grantee on behalf of itself, its lessees, licensees, successors and assigns acknowledges that it has been provided with a copy of the Navy's Land Use Control Remedial Design (LUC RD) for the Property dated March 2004, which contains certain information pertaining to, and specific representations made by, the Navy to EPA and MPCA officials regarding LUC performance objectives, LUC maintenance, and specific conditions for future LUC modification / termination and enforcement.

7. Transfer of LUC Responsibilities & Release

In the event the Grantee, or any successor or assigns (hereafter " Subsequent Grantors") shall convey any of the Property by deed and shall transfer to the party to whom the Property is transferred (hereafter "Subsequent Grantees") any requirements, duties and obligations identified in Section A., then as of the date of such transfer the Subsequent Grantees shall be bound by such requirements, duties and obligations and the Subsequent Grantors shall thereafter have no further responsibility with respect thereto.

B. CERCLA / MERLA NOTICES & ACCESS PROVISIONS

1. CERCLA Notice:

In accordance with Section 120(h)(3)(A)(i) of the Comprehensive Environmental Response, Compensation and Liability Act of 1980, as amended, 42 U.S.C. §9620(h)(3)(A)(i) ("CERCLA"), notice is hereby provided, based upon a complete search of Department of the Navy files believed to be relevant upon the date of transfer, as to those hazardous substances known to have been stored for one year or more, released, or disposed of on the Property; the time such storage, release or disposal took place; and those remedial action(s), if any, taken to address such contamination as follows:

a. Storage / Release

Exhibit 4 to this Deed provides notice as to those hazardous substances which it is known were stored for one year or more on the Property in excess of their respective reportable quantities as delineated under 40 CFR 373. Based upon available agency files, trichloroethene (TCE) is the most significant hazardous substance present in soil and groundwater on or beneath the Property. Although other hazardous substances have been detected in soil and groundwater on or beneath the Property, there are no available records evidencing when the hazardous substances were released or at what quantities. The Remedial Investigation ("RI") Reports for Operable Units #2 and 3 provide further

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information regarding those hazardous substances that have been found to exist in soils and/or groundwater.

b. Remedial Activities Undertaken

Exhibit 5 to this Deed summarizes those investigative and remedial activities taken to date by the Navy to address known releases to the environment of CERCLA hazardous substances on or beneath the Property. Further detailed information as to what actions have been taken may be found in the Administrative Record for the Property.

2. <u>MERLA Notice</u>:

The Grantor represents that this Deed and **Exhibits 4** and **5** to this Deed as herein provided to the Grantee for recordation, fulfill the informational requirements specified under Minnesota Statute Sec. 115B.16, subd. 2, with regard to providing information concerning known or reasonably ascertainable past hazardous substance releases on the Property.

3. <u>Access</u>

In accordance with CERCLA Section 120(h)(3)(A)(iii), Grantor reserves a right of access to the Property in any case in which a remedial action, response action or corrective action is found to be necessary by the Navy, EPA or MPCA, after the date of conveyance of the Property. Pursuant to this reservation, the Navy, EPA, and MPCA and their officers, agents, employees, contractors and subcontractors shall have the right (upon reasonable notice to the Grantee or Subsequent Grantee(s) and any authorized occupant of the Property) to enter upon the Property and conduct investigations and surveys, to include drillings, test-pitting, borings, data and record compilation, and other activities related to environmental investigation and to carry out remedial or removal actions as required or necessary under applicable authorities, including but not limited to monitoring wells, pumping wells, and treatment. While any actions required pursuant to statute or regulation to be undertaken by the Navy must take priority, such activities, responses or remedial actions, shall be coordinated with the Grantee or its successors, assigns, and tenants and the Navy shall use reasonable efforts to perform such activities in a manner that minimizes interruption with the Grantee's or its successor's activities on the Property. This access includes the right to, and use of, to the extent permitted by law, available utilities at reasonable direct (non-overhead) cost to the Navy. Subject to the availability of funds, the Navy will reimburse Grantee or Subsequent Grantee(s) on a quarterly basis, for costs incurred by Grantee or Subsequent Grantee(s) for the Navy's use of utilities in connection with the operation, maintenance, repair, replacement, modification and removal of any and all wells, pumps, piping, tanks, and other apparatus and equipment used for remediation of groundwater and soil. The Navy shall make a good faith effort to obtain funding for this purpose. Grantee, its lessees, licensees, successors and assigns shall bear all reasonable costs of replacement and/or relocation of remediation installations and equipment of Grantor necessitated by changes to the Property made by Grantee, its lessees, successors and assigns. Grantor and Grantee shall be responsible for their respective shares of liability, in accordance with applicable law (including but not limited to CERCLA, the Federal Tort Claims Act, and the federal Anti-Deficiency Act), for all property loss, damage, replacement or relocation and all personal injuries (including death) caused by their respective conduct associated with the operation, maintenance, repair, replacement, modification and/or removal of such equipment of Grantor. Grantor shall provide to Grantee, upon request, the certificates of insurance of any contractor directly employed by Grantor who may perform environmental investigative or remedial work on the Property to evidence the fact that such contractor has in effect, those insurance coverages required by Federal Acquisition Regulations under the specific government contract controlling its performance of work on the Property, but in any event and at a minimum: workers' compensation insurance at the levels required by State and Federal law; comprehensive general liability insurance in amounts not less than $500,000 and automobile liability insurance in amounts not less than $200,000 per person and $500,000 per occurrence for bodily injury including death and $20,000 per occurrence for property damage. Grantee shall be listed by its name "United Defense, L.P.," along with the "United States," as Named Insureds on all such insurance coverages.

4. **Federal Facilities Agreement**

Grantor has entered into a Federal Facilities Agreement with the EPA and the MPCA which established a procedural framework and schedule for developing, implementing and monitoring appropriate response actions at the site in accordance with CERCLA, MERLA other applicable federal law and written EPA and/or MPCA guidance and policy. These response actions will continue until they are completed to the satisfaction of the EPA and the MPCA and in accordance with the FFA.

5. **Reservation of Rights**

It is recognized that the Grantor, Grantee, and other potentially responsible parties may negotiate a subsequent CERCLA and/or MERLA liability settlement that could affect the terms of this Deed. Grantor and Grantee hereby agree that this Deed is not intended to control the terms of any such subsequent settlement and that such settlement may alter what this Deed may otherwise require or imply regarding the allocation of financial responsibility between Grantor and Grantee for environmental cleanup (including CERCLA and/or MERLA response actions). If necessary, such settlement may be recorded with the Recorder's Office, Anoka County, Anoka, MN. It is further recognized that any such settlement shall not serve to alter the LUC related provisions of this Deed without the prior approval of both U.S. EPA and MPCA. It is further recognized by the parties that the Navy's agreement herein, consistent with its FFA obligations, to take any necessary additional CERCLA response actions to address hazardous substances remaining on or beneath the property at the time of conveyance, shall not serve as a waiver of its right to recover past or future response costs from Grantee or any other responsible party under CERCLA or other applicable law. Notwithstanding any provisions in this Deed to the contrary, nothing in this deed shall be deemed to release Grantee from liability under CERCLA or any other applicable law for any release of hazardous substances, pollutants or contaminants, petroleum products, or any other hazardous constituents or forms of pollution caused, contributed to, or exacerbated by Grantee's conduct at the Property. However, Grantee will not be deemed to have assumed CERCLA "owner" liability for releases of hazardous substances, pollutants and contaminants to the environment that occurred prior to this real estate transfer, solely by the act of assuming real property ownership under this Deed. Further, Grantee and any subsequent grantee shall be liable to the Grantor for environmental response costs, as well as personal injury and property damage, to the extent that the Grantee's or subsequent grantee's post-transfer conduct exacerbates existing contamination or creates new releases to the environment at or from the Property. Nothing in this Deed addresses or shall affect the issue of the allowability or allocability of Grantee's environmental remediation/response costs in Grantee's indirect rates for pricing of U.S. Government prime and subcontracts.

C. CIVIL RIGHTS CLAUSE. Grantee covenants for itself, its heirs, successors and assigns that it, its heirs, successors and assigns shall not discriminate upon the basis of race, color, religion, sex, age, or national origin in the use, occupancy, sale or lease of the Property or in its employment practices conducted thereon. The United States of America shall be deemed a beneficiary of this covenant without regard to whether it remains the owner of any land or interest therein in the locality of the property hereby conveyed and shall have the sole right to enforce this covenant in any court of competent jurisdiction.

D. AMENDMENT OR DELETION OF LAND USE CONTROLS
Any or all of the land and groundwater use controls set forth in Section A of this document may be amended or deleted only by written agreement between the EPA, MPCA, the Navy and the then current owner of the Property.

NOTICE OF THE PRESENCE OF ASBESTOS. The Grantee, in accepting this Deed, acknowledges that it has been informed by Grantor that the Property contains asbestos-containing materials, and that Grantee has been provided with the following notice and warning by Grantor. Grantee, in accepting this Deed, acknowledges that it accepts the transfer and Deed of the Property subject to the terms and conditions contained herein:

a) The Grantee is warned that the Property contains asbestos-containing materials. Asbestos is a hazardous material. Unprotected exposure to asbestos fibers has been determined to significantly increase the risk of cancer, mesothelioma, and asbestosis. These diseases can cause serious bodily harm resulting in disability or death.

b) The Grantee is deemed to have relied solely on its own judgment in assessing the overall condition of all or any portion of the Property, including any asbestos hazards or concerns.

c) No warranties, either express or implied, are given with regard to the condition of the Property including, without limitation, whether the Property does or does not contain asbestos or is or is not safe for a particular purpose. The failure of Grantee to have inspected or to be fully informed as to the condition of all or any portion of the Property shall not constitute grounds for any claim or demand against Grantor.

d) The description of the Property as set forth herein, and any other information provided with respect to the Property was based on the best information available to the General Services Administration's Property Disposal Division and is believed to be correct, but any error or omission shall not constitute grounds or reason for any claim by Grantee against Grantor, including, without limitation, any claim for allowance, refund or deduction from the purchase price for such Property.

e) Grantor assumes no liability for damages for personal injury, illness, disability or death to Grantee or to Grantee's employees, invitees, or any other person subject to Grantee's control or direction, or to any other person, including members of the general public, arising from or incident to the purchase, transportation, removal, handling, use, disposition, or other activity causing or leading to contact of any kind whatsoever with asbestos on the Property.

f) Grantee further agrees by acceptance of the Deed to the Property that, in its use and occupancy of the Property, it will comply with all Federal, State, and local laws, ordinances, orders and regulations relating to asbestos.

NOTICE OF LEAD-BASED PAINT FOR NON-RESIDENTIAL REAL PROPERTY CONSTRUCTED PRIOR TO 1978. The improvements on the Property may contain lead-based paint. By acceptance of this Deed, the Grantee acknowledges that it has been afforded an opportunity to inspect the Property and to test for evidence of lead-based paint. Grantee acknowledges that Grantor shall have no liability for the removal of lead-based paint, nor for any damage or injury related to the existence of lead-based paint on the Property. Grantee shall be responsible for compliance with all applicable Federal, State and/or local laws, ordinances, orders and regulations relating to lead-based paint, including, if required, taking steps for its removal.

OBJECTS AFFECTING NAVIGABLE AIRSPACE. Because of the proximity of the Property to Crystal Airport, Grantee for itself, its heirs, successors and assigns, that if required by applicable law and/ or regulations it will prohibit all construction or alteration on the Property unless a determination of no hazard to air navigation is issued by the U.S. Federal Aviation Administration in accordance with Title

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14, Code of Federal Regulations, Part 77, "Objects Affecting Navigable Airspace," (14 CFR Part 77), or under the authority of the Federal Aviation Act of 1958, as amended.

IN WITNESS WHEREOF, the UNITED STATES OF AMERICA, acting by and through the Administrator of General Services has caused these presents to be duly executed for and in its name and behalf by Dennis R. Smith, Regional Administrator, New England Region, General Services Administration, who has this 15th day of June, 2004 hereunto set his hand and seal.

UNITED STATES OF AMERICA
Acting by and through the
Administrator of General Services

Witnesses:

[signature]

[signature]

By: [signature]
Regional Administrator
General Services Administration
New England Region, Boston, MA

ACKNOWLEDGEMENT

State of Massachusetts)
) SS.
County of Suffolk)

In Boston, in said County and State, on this 15th day of June, 2004, before me personally appeared Dennis R. Smith, Regional Administrator, General Services Administration, Boston, Massachusetts, duly empowered and authorized, known by me to be the party executing the foregoing instrument and by him duly executed, to be his free act and deed in his capacity as Regional Administrator, General Services Administration, Boston, Massachusetts.

Carol H. Chirico
Notary Public

My commission expires:

8-28-09

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ACCEPTANCE

UNITED DEFENSE, L.P., a Delaware limited partnership, by and through its authorized representative, does hereby accept this Quitclaim Deed and by such acceptance agrees to all the terms, covenants, conditions and restrictions therein.

UNITED DEFENSE, L.P.
By: UDLP Holdings Corp.,
its General Partner

6-16-04
Date

By K B Howe
Its Vice President and General Manager

STATE OF Minnesota)
) S.S.
COUNTY OF Anoka)

The foregoing instrument was acknowledged before me this 16th day of June, 2004, by K. B. Howe, the Vice President and General Manager *of United Defense, L.P., a Delaware limited partnership, on behalf of the partnership.

*of UDLP Holdings Corp., the general partner

JILL S. DUPAY
NOTARY PUBLIC - MINNESOTA
My Comm. Expires Jan. 31, 2005

Jill S. DuPay
Notary Public

My commission expires:
Jan 31, 2005

COPY

ACCEPTANCE

The MINNESOTA POLLUTION CONTROL AGENCY, by and through its Commissioner, hereby accepts the LUC approval authorities and Property access rights set forth herein.

June 16, 2004
Date

for By: Sheryl Corrigan
Commissioner

STATE OF MINNESOTA)
) S.S.
COUNTY OF RAMSEY)

The foregoing instrument was acknowledged before me this 16th day of June 2004, by Sheryl A. Corrigan, the Commissioner of the Minnesota Pollution Control Agency, a Minnesota body politic, on behalf of the State of Minnesota.

DIANNE M. MITZUK
NOTARY PUBLIC-MINNESOTA
My Comm. Exp. Jan. 31, 2005

Ramsey County

Notary Public

My commission expires:
January 31, 2005

This Quitclaim Deed was prepared by Joel David Malkin, Assistant Regional Counsel, General Services Administration, Great Lakes Region, 230 S. Dearborn Street, Suite 3786, Chicago, Illinois 60604.

MI-110#307.04

EXHIBIT 1
(LEGAL DESCRIPTION)

That Part of Section 27, Township 30, Range 24, Anoka County, Minnesota, described as follows: Commencing at the southeast corner of said Section 27; thence on an assumed bearing of South 89 degrees 47 minutes 23 seconds West, along the south line of said Section 27, a distance of 1444.62 feet; thence North 3 degrees 33 minutes 01 second East, at 2125.55 feet, passing through a found bronze monument, and continuing in all a distance of 2126.03 feet to the point of beginning of the land to be described; thence North 89 degrees 22 minutes 47 seconds West a distance of 69.28 feet to the centerline of a building wall in place as of January 1993; thence South 0 degrees 37 minutes 13 seconds West, along said last mentioned wall centerline, a distance of 1.83 feet; thence North 89 degrees 22 minutes 47 seconds West, along the centerline and the extension thereof, of a building wall in place as of January 1993, a distance of 84.64 feet; thence South 0 degrees 37 minutes 13 seconds West, a distance of 5.05 feet; thence North 89 degrees 22 minutes 47 seconds West a distance of 249.59 feet; thence South 0 degrees 37 minutes 13 seconds West, along the centerline and the extension thereof, of a building wall in place as of January 1993, a distance of 25.45 feet; thence North 89 degrees 22 minutes 47 seconds West, along the centerline and the extension thereof, of a building wall in place as of January 1993, a distance of 100.28 feet; thence North 0 degrees 37 minutes 13 seconds East, along the centerline and the extension thereof, of a building wall in place as of January 1993, a distance of 8.36 feet; thence North 89 degrees 22 minutes 47 seconds West a distance of 199.73 feet; thence North 0 degrees 37 minutes 13 seconds East a distance of 3.01 feet; thence North 89 degrees 22 minutes 47 seconds West a distance of 24.93 feet; thence North 0 degrees 37 minutes 13 seconds East a distance of 2.15 feet; thence North 89 degrees 22 minutes 47 seconds West a distance of 225.02 feet; thence South 0 degrees 37 minutes 13 seconds West, along the Centerline and the extension thereof, of a building wall in place as of January 1993, a distance of 13.52 feet; thence North 89 degrees 22 minutes 47 seconds West, along the centerline and the extension thereof, of a building wall in place as of January 1993, a distance of 100.40 feet; thence North 0 degrees 37 minutes 13 seconds East, along the centerline of a building wall in place as of January 1993, a distance of 20.76 feet; thence North 89 degrees 22 minutes 47 seconds West along the centerline and the extension thereof, of a building wall in place as of January 1993, a distance of 296.28 feet; thence South 0 degrees 37 minutes 13 seconds West a distance of 10.52 feet; thence North 89 degrees 22 minutes 47 seconds West a distance of 190.55 feet; thence North 23 degrees 23minutes 13 seconds West a distance of 640.80 feet to a point distant 150 feet easterly, measured perpendicularly, from a tangent-spiral point on the centerline of East River Road (county state-aid highway No. 1); thence along a line parallel to and distant 150 feet easterly from a spiral curve on said highway centerline, which centerline spiral curve is concave easterly and has a length of 150 feet and a central angle of 2 degrees 15 minutes 00 seconds, to a point distant 150 feet easterly, measured radially, from a spiral-curve point on said centerline (the chord of said last described parallel line bears North 22 degrees 39 minutes 08 seconds West and has a length of 144.10 feet); thence along a circular curve, concave easterly and having a radius of 1759.86 feet, a central angle of 5 degrees 59 minutes 44 seconds, and a chord of 184.07 feet bearing North 18 degrees 08 minutes 21 seconds West, an arc distance of 184.15 feet to a point of nontangency, from which point a found bronze monument bears North 74 degrees 51 minutes 31 seconds East a distance of 0.39 feet; thence North 0 degrees 39 minutes 06 seconds East a distance of 997.85 feet; thence South 88 degrees 58 minutes 35 seconds East a distance of 1920.50 feet; thence South 4 degrees 32minutes 59 seconds East a distance of 648.20 feet to a judicial landmark set pursuant to Torrens case No. 123; thence South 3 degrees 33 minutes 01 seconds West a distance of 1210.30 feet to the point of beginning.

ACAD:6966CP03.dwg 10/08/03 HJB PIT

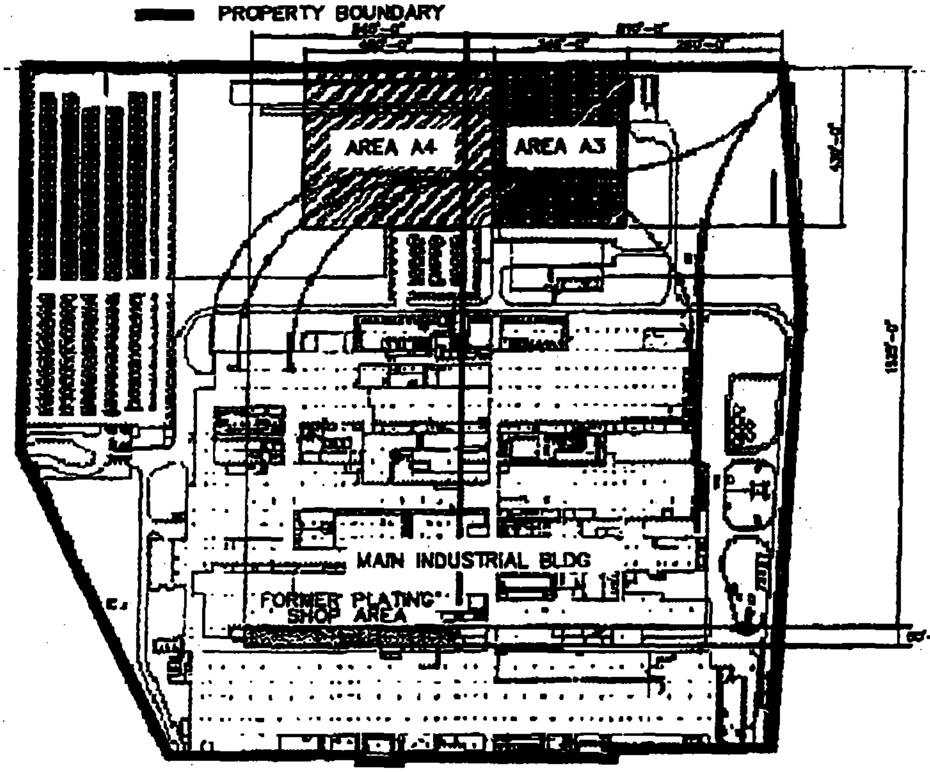
DESIGNATED RESTRICTED AREAS

FORMER PLATING SHOP AREA:
NO DISTURBANCE OF SOILS BELOW CONCRETE PIT FLOORS WITHOUT PRIOR WRITTEN APPROVAL OF EPA AND MPCA.

AREA A3:
NO DISTURBANCE OF SOILS THREE (3) FEET OR GREATER BELOW GROUND SURFACE WITHOUT PRIOR WRITTEN APPROVAL OF EPA AND MPCA.

AREA A4:
NO DISTURBANCE OF SOILS THREE (3) FEET OR GREATER BELOW GROUND SURFACE WITHOUT PRIOR WRITTEN APPROVAL OF EPA AND MPCA.

PROPERTY BOUNDARY



DRAWN BY MF	DATE 7/1/02	EXHIBIT 2 DESIGNATED RESTRICTED AREAS NAVAL INDUSTRIAL RESERVE ORDNANCE PLANT FRIDLEY, MINNESOTA	CONTRACT NO. 6966
CHECKED BY	DATE		APPROVED BY / DATE
COST/SCHED–AREA			APPROVED BY / DATE
SCALE NOT TO SCALE			DRAWING NO. / REV. 0

FORM CADD NO. SDIV_AV.DWG - REV 0 - 1/20/98

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EXHIBIT 3

Annual LUC Compliance Certification

Property Owner: ____

Property Address: 4800 East River Road, Minneapolis, MN. 55421

This Certification covers the year 1 January _____ through 31 December ______. (**Note:** Form must be submitted by 1 March of the year following the reporting period. Should there be a change in ownership during the reporting period, the certificate will only cover the period of ownership and the new owner will certify compliance for the remaining portion of the reporting period).

Owner Certification

1. The above-named owner certifies that use of the Property has been limited to industrial or restricted commercial uses, or that owner has provided written notice to the Navy, EPA and MPCA of its intent to use the Property for something other then industrial or restricted commercial uses, and has (i) provided a description of its plans for undertaking any environmental investigation and/or cleanup activities necessary to permit such a change in land usage; (ii) ensured that such activities will not conflict with or adversely affect any ongoing remedial systems or future investigative or remedial activities to be undertaken by the Navy, EPA or MPCA on the Property, and; (iii) obtained a release by the Navy of the Categorical Land Use Restriction previously placed in the owner's deed or chain of title to the property;

2. The above-named owner certifies that no soils deeper than 3 feet below ground surface have been disturbed in those two Designated Restricted Areas outside the Main Manufacturing Building shown in Figure 2-5 of the Navy's September 2003 CERCLA Record of Decision for OU2 / OU3 without having first obtained written approval from the EPA and MPCA. Owner further certifies that no soils excavated from those Areas have been removed from the facility without having first obtained written approval from the EPA and MPCA.

3. The above-named owner certifies that no soils beneath the Designated Restricted Area known as the concrete pit foundations where metal-finishing operations previously occurred at the former Plating Shop within the Main Manufacturing Building have been disturbed without prior written approval from the EPA and MPCA. Owner further certifies that no soils excavated from those Areas have been removed from the facility without having first obtained written approval from the EPA and MPCA.

4. The above-named owner certifies that the concrete pit floor (approximately 8 to 12 feet below grade floor) where metal finishing operations previously occurred at the former Plating Shop within the Main Manufacturing Building has not been removed without prior written approval from the EPA and MPCA.

5. The above-named owner certifies that no water supply wells have been installed nor groundwater beneath the property extracted or used for any purpose without prior written approvals having first been obtained from EPA, MPCA and the Minnesota Department of Health; ; This certification shall not apply to the extent the Owner installed monitoring wells at the request of the Navy.

6. The above-named owner certifies that it has not unreasonably hindered or prevented the Navy, EPA or MPCA from constructing, upgrading, operating, maintaining and monitoring any groundwater treatment facilities and groundwater monitoring network or has otherwise engaged in any activity that: (i) caused the violation of any Health and Safety Plan put into effect by the Navy, EPA or MPCA on the Property and directly related to the Federal Facilities Agreement at the Property; or (ii) disrupted or hindered any other remedial, response or oversight activities being undertaken by the Navy, EPA or MPCA on the property.

I, the undersigned, hereby certify that I am an authorized representative of the above named property owner and that the above described Land Use Controls have been complied with for the period noted. Alternatively, any known deficiencies and owner's completed or planned actions to address such deficiencies are described in the attached Explanation of Deficiency(ies).

Date

Owner's AuthorizedRepresentative

Mail completed forms to:

Director, Environmental Services Business Line
Southern Division
Naval Facilities Engineering Command
P.O. Box 190010
North Charleston, SC 29419-0010

U.S. Environmental Protection Agency
Region 5
77 West Jackson Blvd.
Chicago, IL 60604

Commissioner
Minnesota Pollution Control Agency
520 Lafayette Rd. N.
St. Paul, MN 55155

M1:1108440.01

CC

EXHIBIT 4

NOTICE OF HAZARDOUS SUBSTANCE STORAGE, RELEASE, AND/OR DISPOSAL *

Substance	Regulatory Synonym	CAS Registry Number	Quantity Kg/lbs	Date
TCE	Trichloroethene	79-01-6	Reportable	Unknown – 1987
1,1,1-TCA	1,1,1-Trichloroethene	71-55-6	Reportable	Unknown - 1993
MEK	Methyl Ethyl Ketones	78-93-3	Reportable	Unknown
Toluene	Methylbenzene	108-88-3	Reportable	Unknown
Ethylene Glycol	Ethylene Alcohol	107-21-1	Reportable	Unknown
Ammonia, Anhydrous	N/A	7664-41-7	Reportable	Unknown
Sodium Cyanide	N/A	143-33-9	Reportable	Unknown
Chromium	N/A	14977-61-8	Reportable	Unknown
Sulfuric Acid	Hydrogen Sulfate	7664-93-9	Reportable	Unknown
HCL	Hydrochloric Acid	7647-01-0	Reportable	Unknown
Nitric Acid	N/A	7697-37-2	Reportable	Unknown
Chromic Acid	Chromium Trioxide	7738-94-5	Reportable	Unknown
Phosphoric Acid	N/A	7664-38-2	Reportable	Unknown
Hydrofluoric Acid	N/A	7664-39-3	Reportable	Unknown
n-Butyl alcohol	N/A	71-36-3	Reportable	Unknown
Copper	N/A	7440-50-8	Reportable	Unknown
Dichloromethane	Methyl Chloride	75-69-4	Reportable	Unknown
Trichlorofluoromethane	Freon 113	75-69-4	Reportable	Unknown
Methanol	N/A	67-56-1	Reportable	Unknown
Methylene dissocyanate	N/A	101-68-8	Reportable	Unknown
Nickle	N/A	7440-02-0	Reportable	Unknown
Xylene	N/A	1330-20-7	Reportable	Unknown
Sodium hydroxide	Caustic Soda	1310-73-2	Reportable	Unknown

* <u>Note</u>: This notice includes only hazardous substances known to have been stored in reportable quantities, based on a complete search of agency files, in accordance with the requirements of 40 CFR 373. Information regarding constituents that have been detected in soil and groundwater, but for which agency records do not indicate storage, release or disposal in excess of reportable quantities can be found in the OU #3 Remedial Investigation (RI) Report.

EXHIBIT 5

NOTICE OF REMEDIAL ACTIONS TAKEN

For environmental investigation and remediation purposes the NIROP Fridley Facility was divided into three Operable Units (OUs). OU #1 encompasses groundwater contamination. OU #2 encompasses unsaturated source contamination outside the Main Manufacturing Building. OU #3 encompasses source contamination beneath the Main Manufacturing Building and saturated source contamination underneath and outside that same building. The Remedial Investigations ("RI's") for OU #1, OU #2 and OU#3 are complete. The status of investigative activities and a summary of the environmental conditions for each Operable Unit is further described below.

A. **OU #1:**

One hundred thirty one (131) groundwater monitoring wells were installed by the Navy from 1985 to 2000. Since then, additional wells have been installed to further assess the nature and extent of the contamination in the groundwater. These wells were installed both on and off Navy property. The wells are shallow, intermediate, and deep, and were installed in the surficial aquifer. Monitoring wells are also installed in the Prairie du Chien/Jordan Dolomite aquifer. Monitoring wells are currently sampled on a regular basis pursuant to the FFA. Seventy-four wells were sampled in calendar year 2003. Additional incremental wells are sampled in even-numbered years (2002, 2004, etc). In addition, sampling is conducted for additional wells in the vicinity of ongoing pilot study work.

Elevated concentrations of Volatile Organic Compounds (VOCs) have been detected in the groundwater throughout the Navy property and extending downgradient off-property to pre-existing United Defense, L.P. owned property and the Anoka County Riverfront Park, with trichloroethene (TCE) being the primary constituent of concern. TCE concentrations in the groundwater underneath the Navy property have historically ranged from less than 1 part(s) per billion (ppb) to 140,000 ppb. The nature and extent of contamination in off-property groundwater at Anoka County Riverfront Park was further evaluated during an investigation conducted in December, 1997 using temporary wells, and revealed elevated concentrations of TCE in screening samples up to 37,300 ppb in a 200 by 400 foot area adjacent to East River Road. These results prompted the Navy to install additional permanent monitoring wells in this area. Permanent wells are generally considered to provide more representative groundwater samples. Many of these wells are included in the annual groundwater monitoring network described above. In 2001, groundwater in well MS-46S in this area was found to contain 17,000 ppb of TCE, the highest measured in Anoka County Riverfront Park that year or in 2002. At intermediate and deep well intervals, contaminant concentrations in groundwater are consistently much less. An ongoing pilot study utilizing in-situ bioremediation technology to reduce contaminant levels is in place in the vicinity of this well.

A groundwater extraction, collection and treatment facility was installed to capture contaminated groundwater migrating offsite. There currently are seven active extraction wells located along the western property boundaries of the NIROP and United Defense, L.P. Extracted groundwater from each well is directed to, and combined in, a building where it is then pumped to a groundwater treatment facility in the northwest quadrant of the Main Industrial Building. The contaminated groundwater is treated utilizing shallow tray air strippers to remove the volatile organic compounds with the treated water discharged to the Mississippi River via the facility's storm sewer under a NPDES permit.

The second CERCLA Five Year Review for OU #1 was completed in October 2003, and determined that 'the remedial action for Operable Unit 1 continues to be protective of human health and the environment by preventing further migration of contaminated water off the NIROP facility and continuing to restore groundwater quality in the unconsolidated aquifer at the site'.

The Five Year Review also discusses the ongoing pilot study, noted above, to address contamination remaining downgradient of the NIROP facility (and downgradient of the groundwater extraction system).

B. OU #2:

The only portion of OU #2 that remains a potential concern is an area of unsaturated soils located north of the Main Manufacturing Building known as the North 40. The North 40 contained former waste disposal pits and trenches used in the early 1970's. Drums and impacted soils were removed and disposed of during four separate removal actions in 1983, 1991, 1996 and 2002. The OU #2 RI evaluated unsaturated soils to a depth of 20 feet. Like OU #1, VOCs, with TCE in particular, are the primary contaminants of concern. In general, concentrations of TCE in the North 40 soils were found to be in the range of 10 to 69,000 ppb. TCE contamination in excess of 200 ppb was found in small, localized areas, with the highest concentrations found in shallow subsurface soils (3 - 5 foot depths). In conjunction with the 1996 drum removal effort, samples taken at the bottom of the excavation pits were generally non-detect for TCE except for a single sample with an elevated TCE concentration of 96,000 ppb at an approximate depth of 12 feet. The Supplemental Remediation Investigation Information Report dated September 2001 identified potential unacceptable risk levels in sub areas A3 and A4. This resulted in an excavation of approximately thirty-five cubic yards of soil in Area A4, in June 2002, and addressed the last known location where there were unacceptable risks in surface soil. Elevated levels of contaminants remain in subsurface soil but do not pose an unacceptable risk provided institutional controls are in place to prevent future exposure. A Record of Decision (ROD) specifying these institutional controls was signed by the Navy, US EPA, and MPCA in September 2003. A single ROD addresses both OU #2 and OU #3.

C. OU #3:

In 1995, an investigation was conducted of the soils and groundwater beneath the former Plating Shop within the Main Manufacturing Building as identified in Exhibit 2 (the "Main Building"). This investigation revealed that soils and shallow groundwater are contaminated primarily with TCE. TCE concentrations from 4 to 100,000 ppb were detected in soil. TCE concentrations ranging from 1,200 to 140,000 ppb were detected in shallow groundwater. The highest soil concentrations were found adjacent to a former wastewater collection sump at an approximate depth of 13 feet below ground surface and the highest groundwater concentration was found slightly down gradient from the former sump at the top of the surficial groundwater table, at approximately 16 feet below the former Plating Shop pit floor.

A RI was conducted to assess the condition of soils and groundwater beneath the Navy owned portion of the Main Building. Field efforts were completed by the end of April 1998. The RI indicates that VOCs (primarily chlorinated hydrocarbons, aromatics and ketones) were detected in soils. Semi-volatile organic compounds (SVOC), primarily polyaromatic hydrocarbons (PAH) were also detected in soils ranging from 10 to 5,600 ppb as were metals such as arsenic, chromium, copper and mercury. Chlorinated hydrocarbons were the primary chemicals detected in groundwater samples.

As of December 2003, there have been no soil removal actions or other 'active' remedial action taken concerning OU#3, and as of that date none are anticipated. The unsaturated contaminated soils are secured underneath the Main Manufacturing Building floor and do not pose an unacceptable risk provided institutional controls are in place to prevent future exposure. A ROD specifying these institutional controls was signed by the Navy, US EPA, and MPCA in September 2003. A single ROD addresses both OU #2 and OU #3.

COPY

QUITCLAIM BILL OF SALE

THIS BILL OF SALE is made and executed as of the 15th day of June 2004, from UNITED STATES OF AMERICA acting by and through the General Services Administration ("Grantor"), to UNITED DEFENSE, L.P., a Delaware limited partnership ("Grantee").

RECITALS:

A. Grantor and Grantee have entered into an Offer to Purchase dated as of April 21, 2004 (the "Agreement"), pursuant to which Grantor has agreed to transfer to Grantee certain real property located in Fridley, Minnesota; and

B. In connection with the transactions contemplated by the Agreement, Grantor has agreed to convey and quitclaim to Grantee all of its right, title and interest, if any, to certain personal property more particularly described in Exhibit A attached hereto.

The Personal Property is being conveyed on an "as is, where is" basis, without warranty or representation of any kind including, without limitation, warranty as to condition or suitability for any particular purpose.

NOW, THEREFORE, for good and valuable consideration, the receipt and sufficiency of which are hereby acknowledged, Grantor does hereby convey and quitclaim to Grantee, and its successors and/or assigns, the personal property described in Exhibit A.

IN WITNESS WHEREOF, Grantor has executed this Bill of Sale as of the day and year first written above.

UNITED STATES OF AMERICA acting by and through the Administrator of General Services

By: [signature]
Name: Dennis R. Smith
Its: Regional Administrator
General Services Administration
New England Region, Boston, MA

EXHIBIT A

LIST OF MACHINERY AND EQUIPMENT

EQNUM	DESCRIPTION	NAVY ID
00051	BORING AND TURNING MACHINE, VERTICAL; 72	91192-001030
00054	BORING AND TURNING MACHINE, VERTICAL; 96	91192-001026
00055	BORING AND TURNING MACHINE, VERTICAL; 10	91192-001029
00057	BORING & TURNING MACHINE, VERTICAL; 144"	91192-001023
00203	SHAPER VERTICAL, MECHANICAL, PLAIN RAM,	91192-001186
03446	BORING & TURNING MACHINE, VERTICAL; WIDE	91192-001013
04179	HONING MACHINE, INTERNAL, VERTICAL, 14"	91192-000712
04372	BORING, DRILLING & MILLING MACHINE, HORIZ	91192-004788
04414	DRILLING MACHINE, RADIAL, PLAIN HEAD, FL	91192-004839
04427	BORING AND TURNING MACHINE, STANDARD HEA	91192-004851
13015	BORING, DRILLING, MILLING MACH	91192-004941
13023	STRENGTH MATERIALS TESTING MACHINE, IMPA	91192-004950
13186	HONING MACHINE, VERTICAL, INTERNAL, HYDR	91192-005111
13224	BORING & MILLING MACHINE, JIG, WITH VERT	91192-005149
13225	BORING AND TURNING MACHINE, VERTICAL; 12	91192-005150
13255	BORING & TURNING MACHINE, VERTICAL, TURR	91232-001288
13357	DRILLING MACHINE, RADIAL	91192-005259
13376	GRINDING MACHINE, EXTERNAL, CYLINDRICAL,	91192-005276
13393	GEAR SHAPER, EXTERNAL & INTERNAL, SPUR &	91192-005291
13458	BORING AND MILLING, JIG, HORIZONTAL; 4"	91192-005353
13475	GRINDING MACHINE, JIG, VERTICAL, PNEUMAT	91192-005367
13668	GRINDING MACHINE, CYLINDRICAL, INTERNAL	91192-005537
13744	JIG BORING MACHINE	96971-107482
13767	BORING & TURNING MACHINE, VERTICAL, TURR	92666-000755

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13829	GEAR SHAPER, EXTERNAL & INTERNAL SPUR GE	96971-105996
13865	JIG BORING & MILLING MACHINE, CAP. 55" M	91192-005605
13868	BORING,DRILLING AND MILLING MACHINE; OPT	91192-005608
14174	BORING, DRILLING AND MILLING MACHINE, PL	00111-317189
14191	JIG BORING MACHINE, OPTICAL, NUMERICALLY	91192-005863
14197	DEVLIEG HORIZ BORING MACH	91192-005862
14404	HORIZONTAL BORING, DRILLING & MILLING MAC	91192-006053
14521	RADIAL DRILL	91192-006170
14573	ROTARY TABLE, HORIZONTAL PLAIN, 12' DIAM	91192-006222
14672	LATHE TRACER SEMI AUTO	000AF-573965
14964	ROCKFORD SINGLE SPINDLE PLANING MILL	91192-006599
14979	MEASURING MACHINE, COORDINATE TYPE, CNC,	91192-006609
14980	ROTARY TABLE, INDEXING, CIRCULAR, POWER F	91192-006610
14986	GRINDER MACHINE, SURFACE, RECIPROCATING,	91192-006614
40035	COMPARATOR, PROJECTION, CONTOUR & MEASUR	91192-006629
40058	MILLING MACHINE, BED TYPE, HORIZONTAL,	91192-006639
40061	MAGNETIC PARTICLE INSPECTION UNIT, STATI	91192-006641
40076	MEASURING SYSTEM, LASER RAY TYPE	91192-006654
40079	SPECTROMETER, ULTRAVIOLET SPECTRUM, .173	91192-006657
40083	POSITIONER, WELDING, TABLE TYPE, POWER	91192-006661
40089	MAGNETIC PARTICLE INSPECTION UNIT, STATI	91192-006663
40092	ROTARY TABLE	91192-006672

M1:1098097.03

FIVE-YEAR REVIEW REDLINE REVISIONS

Five-Year Review Summary Form

SITE IDENTIFICATION		
Site Name: Naval Industrial Reserve Ordnance Plant, Fridley		
EPA ID: MN3170022914		
Region: 5	**State:** MN	**City/County:** Fridley/Anoka County

SITE STATUS	
NPL Status: Final	
Multiple OUs? Yes	**Has the site achieved construction completion?** Yes

REVIEW STATUS
Lead agency: Other Federal Agency **If "Other Federal Agency" was selected above, enter Agency name:** Department of Defense/United States Navy
Author name (Federal or State Project Manager): Naval Facilities Engineering Command Midwest
Author affiliation: Lead Agency
Review period: 11/15/2012 – 10/20/2013
Date of site inspection: 01/17/2013
Type of review: Statutory
Review number: 4
Triggering action date: 10/22/2008
Due date *(five years after triggering action date)*: 10/22/2013

Five-Year Review Summary Form (continued)

The table below is for the purpose of the summary form and associated data entry and does not replace the two tables required in Section VIII and IX by the FYR guidance. Instead, data entry in this section should match information in Section VII and IX of the FYR report.

Issues/Recommendations

OU(s) without Issues/Recommendations Identified in the Five-Year Review:
OU 1, OU 2, OU 3

Issues and Recommendations Identified in the Five-Year Review: None

Protectiveness Statement(s)

Operable Unit: OU1	*Protectiveness Determination:* Protective	*Addendum Due Date (if applicable):* NA
Protectiveness Statement: The OU1 remedy is currently protective of human health and the environment because the groundwater extraction system is functioning as intended by the ROD. Currently land use is consistent with commercial/industrial land use and no elements of residential land use are present, including residential drinking water wells. The groundwater remedy will achieve long-term protectiveness when the groundwater cleanup standards are achieved throughout the plume area. For the remedy to remain protective in the long term, hydraulic containment must be maintained and compliance with effective Institutional Controls (ICs) must be maintained.		

Operable Unit: OU2	*Protectiveness Determination:* Protective	*Addendum Due Date (if applicable):* NA
Protectiveness Statement: The remedy at OU2 is protective of human health and the environment and exposure pathways that could result in unacceptable risks are being controlled via LUCs. Compliance with effective ICs must be maintained.		

Operable Unit: OU3	*Protectiveness Determination:* Protective	*Addendum Due Date (if applicable):* NA
Protectiveness Statement: The remedy at OU3 is protective of human health and the environment and exposure pathways that could result in unacceptable risks are being controlled via LUCs. Compliance with effective ICs must be maintained.		

Operable Unit: Sitewide – all OUs	*Protectiveness Determination:* Protective	*Addendum Due Date (if applicable):* NA
Protectiveness Statement: The overall remedies at NIROP Fridley are protective of human health and the environment because exposure pathways that could result in unacceptable risks are being controlled via LUCs, and because the groundwater extraction system is functioning as intended by the ROD. For the remedies to remain protective in the long term, hydraulic containment must be maintained and compliance with effective ICs must be maintained.		

EXECUTIVE SUMMARY

Three operable units (OUs) have been identified at NIROP Fridley. Groundwater is identified as Operable Unit 1. The land outside of the main NIROP manufacturing building but within the legal boundaries of the facility, from ground surface down to groundwater elevation, has been identified as OU2. The land underneath the main NIROP building, and soils at elevations below groundwater elevation (the saturated zone) either under the building or outside the building, but within the legal boundaries of the facility has been designated as OU3. The Record of Decision (ROD) for OU1 was signed in September 1990. The ROD for OU2 and OU3 is combined in a single document, and was signed in September, 2003. The selected remedy for both OU2 and OU3 is Land Use Controls. Additional chronology details are provided in Section 2 of this Five Year Review.

The groundwater remedy for Naval Industrial Reserve Ordnance Plant (NIROP) Fridley in Fridley, Minnesota included installation and operation of ground water recovery wells, with a two-phased plan for disposal of the ground water from the system. The site achieved construction completion in August 1991. The trigger for this Fourth Five Year Review was the last signature date of the Third Five Year Review on October 22, 2008. Groundwater use for industrial, commercial, or residential purposes is restricted by the deed.

The assessment of this Five Year Review found that the remedy was constructed in accordance with the requirements of the OU1 Record of Decision. The remedy at OU1 currently protects human health and the environment because there are no known completed pathways to receptors. However, for the remedy to be protective in the long-term, hydraulic containment must be maintained ~~and optimal performance of the extraction system must be achieved~~ to ensure long-term protectiveness.

Although the results of the conservative screening indicate that no unacceptable Vapor Intrusion (VI) exposures are occurring, the Navy will work with EPA and MPCA to review the site conceptual model and evaluate whether a completed VI pathway exists. The site conceptual model may change based on the results of a Navy proposal to conduct ~~limited~~ voluntary optimization sampling beneath the building foundation. The ~~limited~~ voluntary optimization sampling will mainly be in the vicinity of the plating shop. In addition, the CSM may also be impacted by ~~a potential~~the property transfer in 2013, and subsequent property redevelopment (anticipated between 2013-2019). Although not resulting in a specific recommendation, the site conceptual model will be updated as appropriate based on new information and will be used to evaluate whether a complete exposure pathway for VI has resulted.

The ROD for OU2 and OU3, specifying Land Use Controls, was signed in September, 2003. This fourth five year review evaluation of protectiveness of the OU2 and OU3 remedy indicates that the Land Use Control remedies for these OUs are functioning as intended and remain protective.

1.0 INTRODUCTION

The United States Navy, Naval Facilities Engineering Command Midwest, has conducted a Five-Year Review of the remedial actions implemented at all Operable Units (OUs) at the Naval Industrial Reserve Ordnance Plant (NIROP) Fridley site in Fridley, Minnesota. The purpose of this Five Year Review is to evaluate the implementation and performance of the remedy in order to determine if the remedy is protective of human health and the environment.

This Five-Year Review Report includes the following:

- Determination of whether the remedies for OU1, OU2, and OU3 at NIROP Fridley remain protective of human health and the environment.
- Identification of methods and conclusions of reviews.
- Identification of issues found during the review, if any, and identification of recommendations to address them.
- Any other information determined by the Navy to be important with regard to the assessment of remedy protectiveness.

The Navy (Lead Agency) prepared this Five-Year Review Report pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Section 121 and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). CERCLA Section 121 states:

> If the President selects a remedial action that results in any hazardous substances, pollutants, or contaminants remaining at the site, the President shall review such remedial action no less often than each five years after the initiation of such remedial action to assure that human health and the environment are being protected by the remedial action being implemented. In addition, if upon such review it is the judgment of the President that action is appropriate as such site in accordance with section [104] or [106], the President shall take or require such action. The President shall report to the Congress a list of facilities for which such review is required, the results of all such reviews, and any actions taken as a result of such reviews.

The United States Environmental Protection Agency (EPA) interpreted this requirement further in the NCP, 40 Code of Federal Regulations (CFR) 300.430(f)(4)(ii), which states:

> If a remedial action is selected that results in hazardous substances, pollutants, or contaminants remaining at the site above levels that allow for unlimited use and unrestricted exposure, the lead agency shall review such action no less often than every five years after the initiation of the selected remedial action.

- This Five-Year Review is required because hazardous substances, pollutants, or contaminants remain on site in excess of levels that allow for unlimited use and unrestricted exposure.

- This Five-Year Review was prepared based on remedial actions conducted as of December 31, 2012.

- This Five-Year Review is the fourth Five-Year Review to address OU1 (the groundwater OU), but only the second to address OU2 and OU3 (soil OUs) at NIROP Fridley because the Record of Decision (ROD) for OU2 and OU3 was signed just prior to completion of the second Five-Year Review Report.

- The initial triggering event for five-year reviews at NIROP Fridley was completion of construction of the OU1 remedy. The triggering action for this fourth review was October 22, 2008, the date of signature of the previous five-year review.

- This Five-Year Review was prepared in accordance with EPA's Comprehensive Five-Year Review Guidance (2001).

- The Five-Year Review site inspection was conducted by NAVFAC MidWest personnel, and EPA and MPCA representatives were in attendance.

The OU2/OU3 ROD was signed in September 2003. OU2 generally corresponds to soil outside the main plant building, and OU3 generally corresponds to soil underneath the main plant building. More specific information about the extents of OU2 and OU3 is included in NIROP's 1991 Federal Facility Agreement (FFA). The selected remedy for both OU2 and OU3 is land use controls (LUCs). OUs 1, 2, and 3 are the only OUs at NIROP Fridley.

OU1 consists of the groundwater under the NIROP property. The 1991 FFA between the EPA, Minnesota Pollution Control Agency, (MPCA) and United States Department of the Navy, which primarily addressed OU1, requires that an Annual Monitoring Report (AMR) be submitted by the Navy to EPA and MPCA each year following commencement of the groundwater remedial action at NIROP Fridley. The AMR includes summaries and copies of operating, maintenance, and monitoring data for the groundwater extraction and treatment system from the identified calendar year. In addition, a Remedial Action Work Plan (RAWP), also required by the FFA, provides an annual evaluation of the performance of the extraction well system in achieving hydraulic containment of contaminated groundwater. The RAWP is a primary document under the FFA that describes how the Navy will implement the ROD. The RAWP is modified periodically, as necessary, and is typically focused on the number and frequency of groundwater monitoring wells sampled to support the AMR process.

2.0 SITE CHRONOLOGY

The National Superfund Database Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS) identification number for NIROP Fridley is MN317002291400. NIROP Fridley was proposed for inclusion on the National Priorities List (NPL) on July 14, 1989, and was listed on November 21, 1989. The Federal Register Notice appeared on November 21, 1989.

The following chronology includes actions taken with respect to all OUs at the site.

Date	Event
1940 to 1941	Naval ordnance manufacturing facility was constructed.
1947	Navy purchased what is now the federally owned portion of NIROP.
1942 to 1964	Northern Ordnance, Inc., a subsidiary of Northern Pump Company, operated the naval ordnance manufacturing complex.
1964	FMC Corporation purchased the southern portion of the manufacturing facility property from Northern Pump Company.
Early 1970s	Limited disposal of paint sludge and chlorinated solvents in pits and trenches at NIROP.
1980	
September	Navy implemented a program to identify and control environmental contamination from past use and disposal practices.
1981	
March	Anonymous phone call to MPCA regarding disposal practices at the FMC-operated facility.
March 16 to April 23	Three production wells at the site were sampled by MPCA. Trichloroethene (TCE) was detected at 0.035 to 0.200 mg/L.
April 24	Wells FMC-1 and NIROP-2 and -3 were discontinued for drinking water usage. Well FMC-1 was intermittently used for process cooling water until June 1983.
December 31	TCE was detected at 0.0012 mg/L at the Minneapolis water supply intake, just downriver from NIROP. Earlier in 1981, TCE was detected at the water works intake at unquantifiable levels during four sample rounds.
	Storm sewer outfalls were sampled for several constituents. Quantifiable levels of volatiles were detected in the sanitary sewer underneath NIROP and at National Pollutant Discharge Elimination System (NPDES) outfall 20200, at the NIROP property line.
	Site was divided into the North Study area (government-owned property) and South Study Area (FMC-owned property) for additional investigations.
1982	
March 31	Investigation of the North Study area began.

Date	Event
1983	
May	Navy authorized the Installation Restoration (IR) Program.
June	Initial Assessment Study (IAS) for the NIROP site was completed.
	As a result of the IAS, United States Army Corps of Engineers (USACE) was assigned to manage remediation at NIROP Fridley. USACE installed 33 monitoring wells on and around the site over the next 3 years.
1983 - 1984	
November 18, 1983 to March 1984	Approximately 1,200 cubic yards of soil considered hazardous and 43 drums were excavated from the North 40 (i.e., North Study) area and disposed of at an off-site Resource Conservation and Recovery Act (RCRA)-permitted facility. Samples were analyzed from the soils at the base of each excavation. Soil samples from the floors of several trenches had total volatile organic compound (VOC) concentrations greater than 1 mg/L.
May 22, 1984	MPCA issued a Request for Response Action at the site to the Navy and FMC Corporation.
1983 to 1986	Eight rounds of groundwater sampling were completed. The last round was conducted in November 1986 by RMT, Inc.
1986	
June	RMT was retained by USACE to complete the Remedial Investigation (RI)/Feasibility Study (FS) for OU1 (groundwater).
	FMC established an agreement with MPCA to pump contaminated groundwater until total VOC levels in certain wells were less than 0.270 mg/L. Pumped water was discharged to the local sanitary (Pig's Eye) wastewater treatment plant.
1987	
March	All use of TCE at NIROP discontinued; 1,1,1-trichloroethane (TCA) put into use in place of TCE.
June	RI Report (RMT, June 1987) issued for OU1.
September	During excavation of an on-site utility trench, a strong odor was detected in the trench by construction workers. Soil exposed during the excavation was later monitored by MPCA using an HNu photoionization detector (PID). The trench is along the northern property line of NIROP.
	An anonymous phone call to FMC directed the MPCA's attention to a potential hazardous waste site in the vicinity of the Dealers Manufacturing facility located approximately 1,000 feet east of NIROP.
November	Results of a soil pore gas survey were included in the Quality Control Summary Report for the Soil Gas Survey (RMT, February 1988).
1988	
July	FS Report (RMT, July 1988) issued for OU1.
1989	
February 8	Navy established the Technical Review Committee (TRC) for the project and convened the first meeting. TRC meetings were held every 3 months until the beginning of the Restoration Advisory Board (RAB) in 1995.
May 22	Public meeting to present the RI/FS is held in Fridley, Minnesota.
July 14	NIROP proposed for listing on the NPL by EPA.

Date	Event
July 31	Public Repository is established at Anoka County Branch Library, 410 N. E. Mississippi St., Fridley, Minnesota.
November 21	NIROP listed on NPL by EPA.
1990	
May1	Navy issues final Proposed Plan for groundwater remediation for OU1 after review by MPCA and EPA.
May 9	Public meeting to present the Proposed Plan is held in Fridley, Minnesota.
May 1 to May 30	Public comment period for the proposed groundwater remedial action is held.
September	A ROD was signed for OU1 by the Navy, MPCA, and EPA. A groundwater pump-and-treat alternative was selected in the ROD.
October to November	Fifty-five soil borings were advanced to assess the extent of soil contamination in four areas of the facility (background area, North 40 area, Hazardous Waste Storage Area C, and southeastern area near Well 9-S). The North 40 area included 22 soil borings to investigate potential soil contamination due to past disposal practices, the locations of former Hazardous Waste Storage Area C included 28 soil borings to investigate potential soil contamination associated with the storage area, and the Southeast Area included four soil borings to attempt to delineate the source(s) of volatiles in groundwater monitoring wells in the area. Concentrations of VOCs up to 62,000 µg/kg were detected near the decontamination pad (RMT, 1991a).
1991	
March	FFA issued for NIROP Fridley (EPA, MPCA, and U.S. Navy, March 1991).
August	An initial aerial photographic review was conducted by RMT that included photographs from 1945 to 1977.
	Installation of four groundwater recovery/containment wells and additional groundwater monitoring wells was completed in late 1991 for OU1.
December	A second review of additional aerial photographs was performed jointly by representatives of the Navy, EPA, MPCA, FMC, and RMT. As a result of the review and subsequent discussions, additional areas of investigation were identified as OU2 and OU3.
May	Community Relations Plan issued (RMT, 1991b).
1992	
January	A RAWP (RMT, January 1992) was issued for OU2. The RI for the soils OUs addressed soil contamination in the unsaturated zone (i.e., above the water table) in areas of NIROP Fridley not covered by buildings or other surface structures. The scope of the soil RI was to investigate potential outdoor sources that may contribute to groundwater contamination.
August 20	An Emergency Removal Operation Report (Bay West, August 1992) was issued that discussed investigation of the North 40 area. Thirty-one drums were excavated, sampled, and overpacked, and the drums, along with approximately 900 cubic yards of soil and debris, were removed from the excavation. Excavated drums were disposed of via incineration at an EPA RCRA-licensed facility. Associated debris (screened material) was disposed of at a sanitary landfill or RCRA-secure landfill based on analytical results.
September	The groundwater recovery system was completed, and OU1 monitoring began.

Date	Event
December	A 90-Day Determination Document (RMT, December 1992) was prepared that evaluated the effectiveness of the OU1 recovery system over the first few months of operation.
1993	
September	An RI (RMT, September 1993) was issued for OU2. Results indicated that volatile, semivolatile, pesticide, hydrocarbon, and metals contamination was present in soil at several locations.
1994	
September	Results of East Plating Shop soil sampling were issued to the Navy in a letter report (Bay West, 1994). Two soil borings were completed, and several metals and cyanide were identified at concentrations greater than background levels determined during the OU2 RI.
1995	
March	A Work Plan (Halliburton NUS, March 1995) was issued for investigation of soil and groundwater beneath the East Plating Shop. Proposed field activities included the installation of six soil borings and three temporary monitoring wells.
April 16	First NIROP Fridley RAB meeting was held.
April 1, 1995 to May 4, 1995	MK added extraction wells AT-5A and AT-5B to improve hydraulic containment of the Ground Water Treatment Facility (GWTF).
May	Results of East Plating Shop soil and groundwater investigation were issued (Halliburton NUS, May 1995). The report identified soil and groundwater contamination under the East Plating Shop; TCE was the primary contaminant. Other VOCs, including 1,1,1-TCA, acetone, and styrene and metals (chromium, lead, and cyanide) were detected at concentrations greater than background levels.
June	Thirty former Areas of Concern (AOCs) located within the NIROP facility were identified on a Solid Waste Management Unit (SWMU) map (UDLP, 1995) to ensure that all AOCs were being addressed in future investigations.
September	Results of a site evaluation conducted at the NIROP facility in August 1995 were presented in the Site Evaluation Report (Brown & Root Environmental, September 1995). Fifty-nine AOCs, the sanitary sewer system, and the storm sewer system were identified as potential areas requiring further investigation.
1996	
February	Revisions to the Final Site Evaluation Report (Brown & Root Environmental, September 1995) identified nine additional potential AOCs (AOCs 60 to 68) that were not previously reported because they were not suspected sources of TCE contamination.
April to June	MK conducted a North 40 drum removal action. Twenty-three drums and 12 smaller containers were removed along with 100 cubic yards of soil.
1997	
February	Community Relations Plan was updated and reissued (RMT, February 1997).
June	The Final Field Sampling Plan for the OU3 RI/FS (Brown & Root Environmental, June 1997) was issued.
June 25, 1997 to March 25, 1998	Phases I and II of the field investigation for the OU3 RI/FS were completed.

Date	Event
July	Work Plan for the OU3 RI/FS (Brown & Root Environmental, July 1997) was issued.
September to January 1998	Phase 1 of MK contract to construct GWTF (outside portion of work) was issued.
1998	
March 30, 1998 to November 14, 1998	Phase II of MK contract to construct GWTF (inside portion of work) was issued.
August	OU3 RI Report, Revision 0 (Tetra Tech, August 1998) was issued.
September	First Five-Year Review Report was issued (Tetra Tech, 1998).
November	Community Relations Plan was updated and issued (Tetra Tech, 1999).
1999	
August	OU3 RI Report, draft final Revision 0 (Tetra Tech, August 1999), was issued.
September	Community Relations Plan was updated and reissued (Tetra Tech, September 1999).
2000	
February	OU3 FS issued – EPA and MPCA subsequently request Focused FS instead.
March	1999 AMR issued; Revision 6 RAWP issued.
April	Anoka County Park (ACP) Groundwater Investigation Report issued.
May	Basewide Work Plan (CH2MHILL Constructors, Inc., May 2000) issued.
June	Focused FS issued - Partnering Team subsequently shelves the FS because EPA determines that proceeding directly to a Proposed Plan is appropriate for this site.
August	Final Work Plan Addendum 1 Modification to the Extraction System and Abandonment of Production Wells (CH2MHILL Constructors, Inc., August 2000) was issued.
December	CH2MHILL Constructors, Inc., completed installation of extraction wells (AT-7, AT-8, AT-9, and AT-10), abandoned AT-2, and abandoned production wells No. 2 and No. 3.
2001	
March	2000 AMR was issued; Minor Modification Fact Sheet for OU1 Remedy was issued.
April	Technical Memorandum that finalizes the 1999 AMR and ACP Groundwater Investigation Report issued.
May	Final Work Plan Field Application to Enhance In-Situ Bioremediation of Chlorinated Solvents Via Vegetable Oil Injection (Parsons Engineering Science, Inc., September 2001) was issued.
May	CH2MHILL Constructors, Inc., completed abandonment of extraction wells AT-1A and AT-4, installed packer at extraction well AT-3A, and upgraded software/hardware for the GWTF system. Start-up period for the GWTF system with new extraction wells begins.
September	Vegetable Oil Pilot Study Work Plan for Anoka County Park finalized.
December	ACP Vegetable Oil Pilot Study – vegetable oil injected in southern portion of ACP.

Date	Event
2002	
March	2001 AMR issued.
April	RI for OU3 and Supplemental RI Information Report (OU2) were finalized (Tetra Tech, April 2002).
June	Excavation of PAH-contaminated soil in Area A4 of the North 40 was completed per an Action Memorandum issued (Tetra Tech, June 2002).
August 2002	Proposed Plan for OU2 and OU3 was finalized, and the Public Meeting for the Proposed Plan was held on August 22.
2003	
March	Revised OU1 RAWP was finalized.
September	ROD for OU2 and OU3 was signed.
September	Draft Work Plan for Installation of New Wells to Confirm Groundwater Capture was provided to support ongoing capture analysis.
September	Second Five-Year Review Report issued, dated September 11, 2003
December	Draft report on capture evaluation was issued (USGS, December 2003).
2004	
January	USGS Report, Cross-Borehole Radar to Monitor Field-Scale Vegetable Oil Injection, issued.
March	Draft 2003 AMR issued
17 June	NIROP plant sale to United Defense Limited Partnership (UDLP) completed.
August	MPCA informal regional bedrock aquifer study was unable to confirm that bedrock PCE contamination at the northeastern NIROP boundary was from the Kurt Manufacturing Site.
2005	
March	Draft 2004 AMR issued.
June	Sale of property to ELT Minneapolis LLC.
September	Five additional groundwater monitoring wells (and three additional borings) installed just beyond the line of groundwater extraction wells to help confirm capture efficiency.
September	Revision 1 of the 2003 RAWP was issued.
2006	
March	Final Vegetable Oil Pilot Test Technical Memorandum issued.
April	Pump test at wells 11-S and 17-S pump test completed. The test was designed to determine which aquifer zone influences these wells and concluded that both are more heavily influenced by intermediate-zone pumping wells.
April	Draft 2005 AMR issued.
August	Draft 2006 RAWP update issued.
November	Final Vegetable Oil Application Report issued.
2007	
July	Draft 2006 AMR issued (delayed due to federal budget continuing resolution).
September	Final USGS Report, Evaluation of the Contributing Area for Recovery Wells, is issued.

Date	Event
2008	
April	Draft 2007 AMR issued.
October	Final Third Five-Year Review Report signed.
2009	
March	Draft 2008 AMR issued.
2010	
April	Draft 2009 AMR issued.
2011	
May	Draft 2010 AMR issued.
July	Pre-Final Design for installation of new intermediate-zone extraction wells was provided to support ongoing capture analysis.
November	Installation of new intermediate-zone extraction wells complete.
December	Pump testing of the new intermediate-zone extraction wells AT-11, AT-12 and AT-13 conducted. Construction of AT-11, AT-12, and AT-13 completed. Extraction well AT-13 begins pumping.
2012	
April	NIROP O&M "Super Soak" Extraction Well Redevelopment Process Tech Memo, Naval Industrial Reserve Ordnance Plant, Fridley, Minnesota, dated April 3, 2012 (Super Soak Memo) was issued.
June	Draft Pump Test Evaluation Memo issued. USGS Report Simulation of Containment Well Capture at the Naval Industrial Reserve Ordnance Plant, Fridley, Minnesota was issued (USGS, June 29, 2012)
July	Draft 2011 AMR issued.
~~December~~	
August-September	Annual groundwater sampling event completed to support the Five-Year Review.

3.0 BACKGROUND

NIROP Fridley is located in the northern portion of the Minneapolis/St. Paul Metropolitan Area in an industrial/commercial area within the limits of Fridley, Minnesota (see Figures 3-1 and 3-2). The site is not adjacent to any residential areas and is not located in or not near any known environmentally sensitive areas.

Advanced Naval weapons systems were designed and manufactured at the NIROP. The northern portion of the facility was government owned and operated by a private contractor (UDLP - Armament Systems Division), and the remainder of the facility was owned and operated independently by UDLP (Now BAE). In 2004, the Navy sold the property to FMC (now BAE) and BAE then sold the property to ELT Minneapolis, LLC. Currently, ELT Minneapolis, LLC, owns the former NIROP property and leases space back to UDLP. The site owners and occupants are likely to change in the future, but land use is not expected to change. The formerly government-owned portion of the facility constitutes what is referred to as the NIROP Fridley site.

The site comprises approximately 82.6 acres, most of which are covered with buildings or pavement. The site is situated on a broad, flat, alluvial terrace approximately 30 feet above and ~~2,000~~between 750 and 900 feet east of the Mississippi River.

Adjacent land use is commercial and light industrial to the north, heavy industrial to the south, recreational to the west, and commercial/light industrial (including railroads) to the east. These land uses are expected to remain the same in the future.

Natural resource use in the area consists of recreational activities in the Anoka County Riverfront Regional Park (ACP), directly west of East River Road from the NIROP site and adjacent to the Mississippi River. No federal or state freshwater wetlands are within 1 mile of the site. No critical habitats of endangered species or national wildlife refuges have been identified near the site. The NIROP Fridley groundwater contamination does not limit public use of ACP.

The NIROP Fridley site is underlain by an unconsolidated sand and gravel aquifer that overlies bedrock aquifers. The water table is 20 to 25 feet below the ground surface in the unconsolidated aquifer, which has a saturated thickness of approximately 100 feet. Discontinuous silty clay aquitards are present at various depths below the ground surface. The underlying shallow bedrock consists of Prairie du Chien Dolomite and Jordan Sandstone, referred to as the PCJ aquifer. The basal unit of the St. Peter

Sandstone that overlies the PCJ aquifer across the northern portion of the site acts as a confining layer where present. Where it is absent, the unconsolidated aquifer is hydraulically connected to the PCJ aquifer. Groundwater flow in the unconsolidated aquifer is generally from the northeast to the southwest across the site toward the Mississippi River. The groundwater containment and extraction system has altered groundwater flow characteristics.

The City of Minneapolis Water Treatment Plant intake, which draws water from the Mississippi River, is located just less than 1 mile downstream (south) from the NIROP site. Approximately 500,000 people are served by this treatment plant.

Groundwater in portions of the unconsolidated aquifer beneath NIROP Fridley contains VOCs. The VOCs typically detected are as follows (from greatest frequency detected to least detected): TCE, cis-1,2-DCE, trans-1,2-DCE, 1,1-dichloroethane (DCA), 1,1-DCE, PCE, vinyl chloride, and 1,1,1-TCA. Concentrations vary widely across the site; however, TCE has been detected more frequently and at greater concentrations than any other VOC. TCE is therefore assumed to be the primary indicator parameter for monitoring contamination and remedial system performance at NIROP Fridley. Results of laboratory analyses of samples collected from groundwater monitoring and extraction wells during each calendar year are presented and discussed in the AMRs.

During the early 1970s, paint sludges and chlorinated solvents generated from ordnance manufacturing processes were disposed of in pits and trenches in the North 40 area, which is the undeveloped NIROP-area immediately north of the building. Contaminant sources in the North 40 and beneath the NIROP building were not identified until December 1980, when MPCA received information concerning historical waste disposal practices at NIROP. Results from groundwater sampling in March and April 1981 indicated that TCE was present at up to 200 µg/L in two on-site water supply wells. In December 1981, TCE was detected in Mississippi River water at the City of Minneapolis water treatment plant intake at 1.2 µg/L. The intake is located approximately 4,900 feet downstream from NIROP. The Safe Drinking Water Act (SDWA) Maximum Contaminant Level (MCL) for TCE is 5.0 µg/L. In April 1981, the NIROP water supply wells were shut down, and a municipal water supply was connected to the plant.

In May 1983, a report identified that drummed wastes were buried in the North 40. Groundwater monitoring wells were installed and sampled in the area to investigate potential impacts from drum disposal. From November 1983 to March 1984, approximately 1,200 cubic yards of contaminated soil and 43 drums were excavated and disposed of at facilities licensed to accept such wastes. An RI/FS was conducted from June 1986 to May 1989. The NIROP site was listed on the NPL in November 1989. Following the RI/FS, a Proposed Plan to hydraulically contain TCE-contaminated groundwater was presented to the public. Phase I treatment of extracted groundwater was to be conducted at a local Publicly Owned Treatment Works (POTW). Phase II involved on-site treatment with discharge of treated water in accordance with an NPDES discharge permit to the Mississippi River. The ROD for OU1 addressing groundwater contamination through hydraulic containment and treatment was signed in September 1990.

The first Five-Year Review was drafted by EPA and signed by the Navy as Lead Agency in October 1998. The first Five-Year Review determined that the OU1 remedy was protective of human health and the environment. The First Five-Year Review report recommended that residual groundwater contamination in ACP would be further evaluated. These recommendations were recounted in Section 5 (Progress Since the Last Five-Year Review) of the Second Five-Year Review (Navy, October 2003).

A risk assessment for OU2 was conducted in 1996. Following a revision of that risk assessment, it was determined that risk in one subarea A4 of OU2 was inordinately influenced by a single data point, specifically AB032. Therefore, during summer 2002, the Navy conducted a time-critical removal action to remove approximately 35 cubic yards of soil around this location AB032 to a depth of 3 feet. This removal action was completed in June 2002 and addressed the only remaining location with unacceptable risks for surface soil.

In 1997, a 48 data-point shallow groundwater study was conducted as part of the RI undertaken to define source areas beneath the NIROP building (OU3). The planned methodology was to insert a 3.5-foot screen into each temporary borehole at a depth determined to be 7 feet below the top of the encountered piezometric surface. The East Plating Shop was identified as the primary source area beneath the NIROP building. A ROD was signed in September 2003 for OU2 and OU3 requiring commercial/industrial land use restrictions and an engineering barrier the ensure that the concrete pit floor in the former Plating Shop is not removed without prior regulatory approval to prevent unacceptable worker exposures.

A pilot test was conducted voluntarily by the Navy to evaluate whether addition of refined soybean oil to enhance reductive dechlorination this technology would effectively decrease TCE concentrations in Anoka County Park. The pilot test consisted of the installation of injection and monitoring wells, baseline sampling, vegetable oil injection, and follow-up monitoring was conducted from October 2001 to November 2005, in Anoka County park. A total of 3,600 gallons of refined soybean oil and 7,200 gallons of native groundwater were injected into three injection wells in December 2001. Additional monitoring wells were installed and additional soil sampling was conducted in March and April 2005 to improve evaluate of pilot test performance.

The results of the pilot study indicated that addition of organic substrate was successful in creating conditions conducive to reductive dechlorination of chlorinated VOCs. The Vegetable Oil Pilot Project Report (Parsons, 2006) acknowledged that the induced "geochemical changes (were) neither spatially uniform nor temporally consistent." Nevertheless, significant reductions in chlorinated solvent concentrations were observed in the pilot test area. As a result, the Vegetable Oil Pilot Project Report concluded that "the vegetable oil pilot test has been successful in enhancing the destruction of chlorinated solvent mass in the subsurface and has thus been successful in reducing the overall toxicity of the groundwater plume." The Vegetable Oil Pilot Project Report recommended that "organic substrate addition in general and vegetable oil injection specifically be considered as a future remedial option at this site" and also recommended that application of this technology be limited to "defined contaminant hot spots or source areas instead of attempting to treat large areas." The report also acknowledged that the decision to implement vegetable oil technology in ACP can only be made within the context of other factors such as the decreasing levels of contamination recently observed in ACP due presumably to recent upgrades in the extraction system.

Since the previous five-year review, three new extraction wells were installed in 2011, AT-11, AT-12, and AT-13 to replace AT-3A (which was failing due to age) and enhance system performance. One investigation borehole was installed to obtain a vertical profile of groundwater contamination between the NIROP building and the extraction system.

Annual groundwater monitoring continues through each year's AMR, reporting on sampling results from a broad network of groundwater monitoring wells screened at multiple depth intervals. Each AMR also provides a description of operation and maintenance (O&M) highlights, for the current year, on the groundwater extraction system components and system performance as a whole.

NIROP RAB History

Prior to issuance of the ROD, multiple public meetings were held in Fridley to present investigation results and proposed cleanup plans and to compile comments and input from the local community. The cleanup team for NIROP (MPCA, USEPA, and the Navy) participated in the meetings. The NIROP TRC, established in 1989, was modified to become a RAB in 1995 to improve public participation by providing greater direct community involvement. RAB community members provided input on technical documents and restoration activities.

NIROP Repository History

More than 10 years ago, Navy tried several times to set up a document repository at the Anoka County Fridley public library. The Public Library was not interested and stated that they did not have the space. Dual repositories existed for a few years - MPCA (Dave Douglas) maintained a repository at MPCA while another repository was maintained at NIROP under Navy ownership. When the Navy sold the NIROP property, the new owners wanted to take over the space and so the repository remnants (which had not been maintained for several years) were shipped to Tetra Tech. In 2012, pertinent documents were assembled and a repository was established on line at http://go.usa.gov/DyNY~~http://go.usa.gov/Ywpd~~.

4.0 REMEDIAL ACTIONS

4.1 ESTABLISHMENT OF OPERABLE UNITS

Three OUs have been identified at NIROP Fridley. ~~Groundwater is identified as OU1.~~ OU1 is identified as contaminated groundwater from the NIROP. The land outside of the main NIROP manufacturing building but within the legal boundaries of the facility, from the ground surface to the water table, has been identified as OU2. The land under the main NIROP building and soil at elevations below the water table (the saturated zone) either under the building or outside the building but within the legal boundaries of the facility has been designated as OU3. The ROD for OU1 was signed in September 1990, and the OU1 remedy was evaluated in the First Five-Year Review Report signed in September 1998 and the second Five-Year Review signed in October 2003. The ROD for OU2 and OU3 was signed in September 2003 and therefore the OU2/OU3 remedy was not evaluated in significant detail in a five-year review until the Third Five-Year Review Report was signed in October 2008. Additional chronology details are provided in Section 2 of this Five-Year Review Report.

4.2 OU1 REMEDIAL ACTIONS

The remedial action specified in the 1990 OU1 ROD was 'hydraulic containment and recovery of all future migration of contaminated groundwater from the NIROP and the recovery, to the extent feasible, of groundwater contamination downgradient of the NIROP." The selected remedy included installation and operation of groundwater containment and extraction wells with a two-phased plan for disposal of groundwater from the well system. Contaminated groundwater remains downgradient of the NIROP facility in ACP. Although no time frame for dissipation of groundwater contamination was provided in the ROD, to date it cannot be clearly established that natural dissipation of this groundwater contamination is occurring as predicted in the ROD, although there is evidence to suggest that degradation of contaminants is taking place.

Natural dissipation of contaminated groundwater in ACP cannot clearly be established at this time because major improvements to the groundwater containment and extraction system occurred during 2011 and 2012. Prior to this major improvement, groundwater monitoring data downgradient of the NIROP property line indicated the possibility that limited contaminated groundwater might be bypassing the previous extraction system, which may have been due to the failing extraction well AT-3A. Although significant improvements in groundwater quality in ACP have occurred following 1995, 2001, and 2011/2012 extraction system upgrades, some evidence suggested that limited contaminant bypass continued. Reductions in the greatest ACP contaminant concentrations occurred as a result of the vegetable oil remediation described in the previous section, however, these improvements were extremely localized. It is noted that the ROD only requires "...the recovery, to the extent feasible, of groundwater contamination downgradient of the NIROP..."

There are no Land Use Control (LUC) components to the OU1 remedy.

4.2.1 Phase I of OU1 Remedial Actions

During Phase I of the groundwater extraction remedy, groundwater from the extraction system was discharged to an existing sanitary sewer system for treatment at the local POTW. The groundwater extraction system and pretreatment facilities began operating in September 1992. Monitoring of these facilities and associated monitoring wells has been performed since startup according to the procedures described in the 1995 RAWP for Groundwater Remediation as approved by EPA and MPCA. The RAWP was revised in September 2005 to refine the sampling frequency and number of monitoring wells to be sampled.

As required by the ROD, an evaluation of the effectiveness of the groundwater extraction system in achieving hydraulic containment of contaminated groundwater from the site during the initial 90-day operating period was submitted to EPA and MPCA in December 1992 (RMT, 1992). The evaluation concluded that additional groundwater extraction wells would be needed to achieve effective hydraulic containment. A work plan for upgrading the original extraction system was prepared and approved by EPA and MPCA (Morrison Knudsen, April 1995). Two additional extraction wells were installed and placed into operation in June 1995. At that time, the combined groundwater extraction system consisted of six wells. With the approval of the MCES, based on water quality, the pretreatment system was shut down in March 1995, and the combined discharge from the extraction wells was transferred directly to the sanitary sewer. Discharge to the sanitary sewer continued until the startup of Phase II in 1997.

4.2.2 Phase II of OU1 Remedial Actions

Construction of the Phase II on-site groundwater treatment facility began in September 1997. The system, was completed and the facility began operation in December 1998. The discharge to the MCES sanitary sewer system was terminated, and treated groundwater from NIROP is now discharged to the Mississippi River through Outfall 020 (NPDES/SDS Permit MN0000710).

The OU1 groundwater containment and extraction system currently consists of nine pumping wells and related piping and appurtenances. A site plan showing the approximate locations of the extraction wells and associated facilities is presented as Figure 3-2. The ROD does not specifically list remedial action objectives (RAOs) for OU1; however, it states that the objective of the selected remedy is to address the principle threat posed by the site by providing hydraulic containment to prevent further migration of contaminated groundwater from the NIROP and by recovering, to the extent feasible, contaminated groundwater beneath ACP. The ROD further states that the initial goal of the selected remedy is to contain contaminated groundwater from both the NIROP and, to the extent feasible, ACP, and that the ultimate goal is to restore groundwater quality in the unconsolidated aquifer at the site to MCLs. The ROD also states that EPA has determined that MCLs are relevant and appropriate standards for groundwater unless, under circumstances at the site, more stringent standards must be applied to ensure protection of public health and the environment.

The current extraction wells are identified as AT-5A, AT-5B, AT-7 AT-8, AT-9, AT-10, AT-11, AT-12, and AT-13. The wells are located and constructed to contain and extract contaminated groundwater along the southwestern (downgradient) portion of the NIROP site.

A schematic diagram showing the components of the groundwater extraction system and GWTF is presented as Figure 4-1. The discharge from each of the extraction wells is routed via separate forcemains to a Control House located near the security fence on the western side of the plant. Instrumentation provided at the Control House includes a flow rate indicator and flow volume totalizer for each extraction well discharge. The combined discharge from the extraction wells flows via a single pipe to a Treatment Building located near the Control House. Sampling ports are located on the piping for each extraction well and on the combined discharge to the Treatment Building.

The major components of the current treatment system include a feed tank, air stripping units, and effluent system. The feed system consists of an equalization tank to collect groundwater pumped from the extraction well system and feed pumps to convey the groundwater from the equalization tank to four low-profile, tray-type, air strippers operated in parallel. The effluent water flows by gravity to the effluent sump. Effluent pumps convey the treated water from the effluent sump to an existing 72-inch-diameter storm sewer that discharges to the Mississippi River through NPDES/SDS Outfall 020.

Exhaust air is vented to the atmosphere in compliance with existing state and federal Clean Air Act regulations. Emissions are low enough that no air emission controls for the air strippers are necessary. In 2001, the air emission rates (AERs) for the GWTF were updated. The Navy determined that the emission rates from the GWTF operation were within the site-specific AERs. Site-specific AERs are emission rate limits that ensure that maximum off-site ambient air impacts are less than regulatory-defined allowable off-site concentrations (i.e., that would result in cancer risk to potential off-site receptors of greater than 1 X 10^{-5}). Site-specific AERs were calculated for carcinogenic compounds that could potentially be emitted from operation of the GWTF. The conservatively estimated allowable groundwater contaminant concentrations were all significantly greater than measured groundwater concentrations. Therefore, no emission control measures are required for the GWTF. Samples of the air stripper influent and effluent were collected during startup of the GWTF to confirm that site-specific AERs were met. Additional samples of groundwater influent and effluent are collected quarterly to meet NPDES permit requirements. Based on these data, AERs have not been exceeded in the period addressed by this five-year review or in the periods addressed by the second or third five-year reviews.

4.2.3 OU1 Performance Measurement

Table 4-1 identifies OU1 groundwater COCs and their respective MCLs pursuant to the federal SDWA. This table also identifies the state Health Risk Limits for these COCs.

Table 4-2 identifies the current OU1 GWTF COCs, their respective daily maximum concentration limits as identified in the facility's NPDES/SDS Permit, and the ranges of concentrations of each COC detected during the last NPDES/SDS permit sampling event.

It has been agreed by the Navy, EPA, and MPCA that a subset of 17 monitoring wells located in ACP nearest the bank of the Mississippi River will be used as measurement points for the purpose of identifying groundwater COC concentrations potentially migrating into the river. These wells are listed in Table 4-3. Historical results for these wells can be found in each year's Annual Monitoring Report. This approach was chosen because to the Navy, EPA, and MPCA could not agree on a representative sampling approach within the river or at the riverbank interface that included the Navy's desire to consider a mixing zone and MPCA's requirements for protecting surface water. The remedial objectives for groundwater COCs (Table 4-1) are the surface water To-Be-Considered (TBC) shown in Table 4-3. Minnesota TBCs for TCE include the following: the chronic standard of 120 µg/L; acute maximum aquatic life standard of 6,988 µg/L; final acute aquatic life criterion of 13,976 µg/L; and the range of concentrations of each COC detected during the last appropriate sampling event in the riverside monitoring wells used for monitoring the discharge of contaminated groundwater to the river. A letter from the MPCA on December 15, 2009, stated that MPCA indicated that meeting the Class 2B Chronic Standard in the riverside wells is protective of aquatic life in the Mississippi River and protective of Class 2Bd drinking water standards in the Mississippi River.

As stated by the ROD, "[t]he remedy will comply with the ARARs by meeting the MCL for TCE as the target cleanup level for the site. The alternative [OU1 remedy] will reduce the toxicity, mobility, and volume of TCE in the aquifer. By meeting the MCL for TCE, other VOCs will also be reduced proportionately." The objectives of groundwater monitoring, as further interpreted in the September 2005 RAWP, are as follows:

- Evaluate the ability of the groundwater extraction system to effectively contain downgradient migration of contaminants and provide water quality improvement.
- Assess the potential for contamination from on-site sources and upgradient (off-site) sources.
- Evaluate air stripper emissions to the atmosphere.
- Evaluate whether the remedy complies with the ROD.
- Evaluate whether the remedy is protective of human health and the environment.
- Evaluate the progress of the remedy in achieving the goals specified in the ROD.
- Evaluate whether project permit requirements are met.
- Evaluate the relative contaminant concentrations along the flow path in relation to the following: upgradient groundwater conditions; known and potential source areas; capture and non-capture of the groundwater contaminant plume; residual contamination beyond the effectiveness of the capture of the remedial system and discharge to the river; and vertical head relationships and the potential flow of contaminants from one aquifer interval to another.

The objectives for the monitoring system were originally refined based on the data quality objectives (DQOs) decision-making process completed by the NIROP Partnering Team. Meetings held on March 19 to 23, 2001, July 17 to 19, 2001, and March 6 and 7, 2002, were used to better define the objectives and formal decision-making process for the site. As determined at these meetings, "DQO Problem C: Groundwater Monitoring for Overall Contamination at NIROP" defined the following six items that should be addressed, at least in part, by groundwater monitoring at this site:

1. Determination of capture system performance.

2. Determination of contaminant concentrations at Mississippi River compliance wells.
3. Determination of changes in the plume shape, size, and location.
4. Determination of contaminant concentrations relative to surface water and groundwater standards.
5. Determination of capture system performance, evaluation of system modifications, evaluation of alternative approaches, evaluation of technical impracticability and/or an alternative concentration limit (ACL).
6. Determination of the practicability of the remedy and evaluation of an ACL.

4.2.4 OU1 Operations and Maintenance

As discussed in Section 4.2.2, air stripper emissions to the atmosphere are evaluated using site-specific AERs established to ensure that maximum off-site ambient air impacts are less than regulatory-defined allowable off-site concentrations. The allowable groundwater concentration is the level, determined based on modeling, that will not cause the allowable air concentration to be exceeded.

The Navy requires their O&M Contractor to develop and provide to the Navy a monthly operations and maintenance report detailing O&M activities associated with the wastewater treatment plant (WWTP). These reports include a narrative overview, summary of scheduled maintenance, summary of problems and solutions, and operating statistics. Operating statistics including monthly and cumulative treated water volumes, electrical meter readings, and well performance indicators. The Navy O&M status reports are provided, as a courtesy, to EPA and MPCA.

Current annual O&M costs for treatment plant operation are approximately $400,000 but continue to vary from year to year based on required significant mechanical item replacements. For fiscal year 2012, the Navy expended more than $1.3 million to install three new extraction wells and associated equipment.

It is not appropriate to compare current O&M costs to estimated costs developed for the 1990 ROD for the following reasons:

- The original design anticipated use of granular activated carbon (GAC) to treat air from the strippers. To date, air emissions from the strippers have not warranted the use of GAC; therefore, costs have not been incurred for use and periodic replacement of GAC.

- Two new pumping wells, AT-5A and AT-5B, were added in 1995 to improve system performance. Four new pumping wells, AT-7, AT-8, AT-9, and AT-10 were installed in 2000 to enhance system performance. Three new wells were installed in 2011: AT-11, AT-12, and AT-13 to replace AT-3A and enhance system performance.

- The treatment system was designed to process a capacity of 750 gpm, but extraction well capacity is significantly greater, which allows the Navy flexibility to adjust extraction well rates and optimize plume capture.

- Biological iron fouling has resulted in significantly increased maintenance requirements for pumps and well screens.

- Mineral hardness fouling of pipes and appurtenances has resulted in significantly increased maintenance requirements for cleaning and replacement of these components. A food-grade polymer addition system to prevent mineral deposits partially mitigates this situation for downstream units.

Over the past five years, the system has experienced an increase in interruptions to flow rates, primarily caused by fouling of wells, aging equipment, or failure of other equipment. The most significant disruptions in pumping durations were reported to be caused by the failure of extraction well AT-3A and the installation of the new extraction wells. Fouling of the other extraction wells also contributed because this fouling resulting in intermittent well shutdown to accommodate redevelopment activities. Other interruptions to individual components or system-wide shutdowns were caused by mechanical and electrical problems. These interruptions have necessitated the replacement of transducers, reprogramming of flow meters, and replacement of the air flow sensor-pressure transducer tubing. An automated system was installed in 2010, allowing the Navy to remotely observe and document system performance, resulting in less down time for the GWTF. There are no indications that these sporadic failures have impaired the long-term performance of the system. However, the potential exists for these extraction rate reductions to limit capture during periods when the system is malfunctioning. System and plume monitoring and impact evaluations of these failures on the long-term performance of the system is continuing. The majority of the system ~~issues~~ items are routine maintenance matters encountered when operating a complex industrial system that is aging. With the 2011/2012 installation of three new extraction wells, the extraction system is expected to perform to a level previously unachievable before.

The ROD specifies if a water supply well system is installed in ACP, that the Navy will control health risks in the future by implementation of a groundwater treatment system or other appropriate measures. To date, no additional water supply systems have been installed in ACP; therefore, this component of the remedy has not been necessary.

4.2.5 OU1 Vegetable Oil Pilot Testing

A Vegetable Oil Pilot Study was initiated in December 2001, as a voluntary action by the Navy and not a ROD requirement, to determine whether a full-scale vegetable oil injection remedy could remediate contaminated groundwater in ACP. The Vegetable Oil Pilot Testing Area is shown on Figure 3-2. Groundwater monitoring was conducted for approximately 1 year subsequent to the injection, and the results were summarized in the Final Report for a Field Application to Enhance In-Situ Bioremediation of Chlorinated Solvents via Vegetable Oil Injection (Parsons, 2006). The results of the monitoring indicated that the pilot study was somewhat successful in accelerating biologically mediated reductive dechlorination of chlorinated ethenes. However, it was also determined that vegetable oil-derived organic carbon was not effectively distributed within the pilot test area and that complete reductive dechlorination was only induced in a relatively small area. In that small area, application of vegetable oil decreased TCE concentrations in groundwater from over 17,000 µg/L to less than 600 µg/L.

4.3 OU2 AND OU3 REMEDIAL ACTIONS

The remedial action specified in the August 2003 ROD for NIROP's OU2 and OU3 was LUCs, consisting of both engineering controls and institutional controls. The LUC performance objectives from the ROD are as follows:

- To restrict the use of the property to industrial or restricted commercial use until and unless EPA and MPCA determine that concentrations of hazardous substances in the soils have been reduced to levels that allow for a less restrictive use.

- To prohibit the disturbance of soils deeper than 3 feet below ground surface in Designated Restricted Areas or the removal of any soils excavated in those Areas from the facility without the prior written approval of EPA and MPCA.

- To prohibit the disturbance of soils beneath the Designated Restricted Area known as the concrete pit foundations where metal-finishing operations previously occurred at the former Plating Shop within the NIROP Building without the prior written approval of EPA and MPCA.

- To ensure that the concrete pit floor (approximately 5 to 12 feet below floor grade) where metal-finishing operations previously occurred at the former Plating Shop within the NIROP Building is not removed without the prior written approval of EPA and MPCA. This floor serves as an engineering control.

The ROD states that the property will be restricted to only industrial or restricted commercial uses. Industrial property uses generally include, but are not limited to, the following types of uses: public utility services, rail and freight services, raw storage facilities, refined material storage facilities, and manufacturing facilities engaged in the mechanical or chemical transformation of materials or substances into new products. Restricted commercial use is defined as use where access or occupancy by non-employees is less frequent or is restricted, including a wide variety of uses ranging from non-public access and both outdoor and indoor activities (e.g., large-scale warehouse operations) to limited public access and indoor office worker activities (e.g., bank, dentist office). In general, restricted commercial property use excludes uses such as day-care centers, churches, social centers, hospitals, elder care facilities, and nursing homes. The required LUCs are incorporated into the deed, and these restrictions run with the land such that any subsequent owner is bound by the same restrictions.

COCs for OU2 and OU3 are the same as the COCs for groundwateridentified in Table 4-1. A LUC Remedial Design was finalized in March 2004 that provided information on how the remedy will be implemented, maintained, and enforced.

The LUCs for OU2 and OU3 remain in force, and no breach of the remedy has occurred. The Navy has confirmed OU2 and OU3 LUC compliance throughout the review period via regular communication with BAE, operator of the NIROP site.

TABLE 4-3

DETECTED CONCENTRATIONS OF VOCs IN RIVERSIDE WELLS
OU1 - AUGUST 2012 SAMPLING EVENT
NAVAL INDUSTRIAL RESERVE ORDNANCE PLANT
FRIDLEY, MINNESOTA

MN SW Criteria[1] (µg/L)	Volatile Organic Compounds (µg/L)				
	cis-1,2-DCE	trans-1,2-DCE	PCE	TCE	Vinyl Chloride
Chronic Standard (Class 2B)	NA	NA	8.9	120	9.2
Maximum Standard	NA	NA	428	6,988	NA
Final Acute Value	NA	NA	857	13,976	NA
Domestic Consumption	NA	NA	5	5	2
Wells in the Shallow Monitoring Zone (Shallow Unconfined Aquifer)					
27-S	84	3.4	ND	27	0.12
MS-43S	38	2.9	ND	140	0.08 J
MS-44S	1.1	0.16 J	0.62	6.9	ND
MS-47S	3.2	0.28 J	0.36 J	17	ND
MS-49S	14	3.9	0.14 J	110	ND
USGS-5	ND	ND	0.15 J	0.5	ND
Wells in the Intermediate Monitoring Zone (Shallow Unconfined Aquifer)					
16-IS	17	0.62	1.3	28	ND
MS-43I	16	0.74	ND	22	ND
MS-44I	270	24	ND	535	0.39
MS-47I	1.6	0.38 J	2.2	21	ND
MS-49I	1.6	0.35 J	2.1	21	ND
Wells in the Deep Monitoring Zone (Deep Confined Aquifer)					
16-D	2.4	0.4 J	4.6	23	ND
MS-43D	2	0.46 J	1	2.1	ND
MS-44D	4.9	0.49 J	0.73	14	0.08 J
MS-47D	4	0.48 J	7.2	32	ND
MS-49D	0.22 J	ND	0.4 J	3.8	ND
Wells in the PC Bedrock Aquifer					
MS-48PC	1.5	0.29 J	0.36 J	5.8	ND

1 Minnesota Surface Water Criteria source: http://www.revisor.leg.state.mn.us/arule/7050/0220.html.
Minnesota Rule 7050.0220, Specific Standards of Quality and Purity By Association Use of Classes.

Chronic Standard - The highest water concentration of a toxicant to which organisms can be exposed indefinitely without causing chronic toxicity.

Maximum Standard - The highest concentration of a toxicant in water to which aquatic organisms can be exposed for a brief time with zero to slight mortality.

Final Acute Value - An estimate of the concentration of a pollutant corresponding to the cumulative probability of 0.05 in the distribution of all the acute toxicity values for the genera or species from the acceptable acute toxicity tests conducted on a pollutant.

Domestic Consumption - Standard for domestic consumption of Class 1 drinking water.

NA - Not applicable
ND - Not detected.
NS - Not sampled.
J - Estimated concentration.
Shaded results indicate an exceedance of Minnesota Surface Water Criteria.
Shaded results do not reflect a comparison to the Domestic Consumption criteria (provided for reference only).

5.0 PROGRESS SINCE THE LAST FIVE -YEAR REVIEW

5.1 OU1 PROGRESS SINCE THE LAST FIVE-YEAR REVIEW

The protectiveness statement for OU1 from the Third Five-Year Review Report (Tetra Tech, October 2008) was as follows:

> The remedy at OU1 is currently protective of human health and the environment because there is no evidence of inconsistent uses with the objectives of the commercial and industrial land use restrictions and the groundwater standards. Long term protectiveness requires compliance with land use restrictions that prohibit interference with the limited industrial land use area and groundwater use restrictions. The groundwater remedy will achieve long-term protectiveness when the groundwater cleanup standards are achieved throughout the plume area. However, in order for the remedy to be protective in the long-term, effective ICs need to be demonstrated to be in-place and compliance with effective ICs will be ensured through long term stewardship by maintaining, monitoring and enforcing effective ICs for the site and until groundwater cleanup goals are attained. In addition, there are no known completed pathways to receptors. However, for the remedy to be protective in the long-term, hydraulic containment must be maintained and optimal performance of the extraction system must be achieved to ensure long-term protectiveness.

It should be noted that there are no ICs in the Groundwater ROD which restrict groundwater use; groundwater use restrictions are included in the deed under "Covenants, Conditions, and Restrictions", Section A.2, titled "Well Installation/Groundwater Extraction Restriction".

The last Five Year Review Report (Third Five-Year Review Report) included the following recommendations which were based on the identified issues (each recommendation is followed by a current status summary). During this Fourth Five-Year Review it was determined, as a part of the evolving Five-Year Review process that these are maintenance items inherently required by the remedy, or, items which had potential to improve remedy performance and/or decrease the time the remedy needed to be in-place, and not Five-Year Review "issues" requiring recommendations. Therefore, the following items are listed in this Fourth Five-Year Review to provide a current status summary, but beginning in this Fourth Five-Year Review, will not be carried over as "issues" requiring "recommendations":

1. Extraction of Contaminated Groundwater: The pump-and-treat system must remain in operation because key groundwater contaminant concentrations continue to exceed federal MCLs.

   Status: The pump-and-treat system remains in operation. The Navy has upgraded system performance with the addition of new pumping wells AT-11, AT-12, and AT-13, new bldg. 52/53 piping, a significant computer control system upgrade and the replacement of three air stripper sumps.

2. Vegetable Oil Pilot Study: Certain monitoring wells have been added to the semi-annual and annual groundwater monitoring program that will continue to measure contaminant concentrations. While the potential use of the vegetable oil technology in ACP may be re-evaluated in the future, the use of this technology will not actively be considered at this time. However, the potential application of vegetable oil technology to source areas beneath the NIROP building will be considered as part of an exit strategy now being developed by the Navy.

   Status: The monitoring wells that would be expected to exhibit impacts of vegetable oil substrate injections continue to be monitored. A documented downward trend is continuing, with levels currently less than 600 µg/L from pre-injection concentrations of greater than 17,000 µg/L.

3. Containment and Extraction Remediation System: (a) A proactive well maintenance program should be identified and implemented for the extraction wells. (b) An evaluation will be made of water elevation data and trends in groundwater quality obtained in the next 2 years to determine if adequate capture, particularly along the northern reaches of the extraction system, is being achieved. (c) The Navy will continue to collect data to identify system life-cycle ~~issues~~ maintenance items and will resolve these ~~issues~~ as appropriate.

   Status: (a) A well maintenance program for new and existing extraction wells remains in progress. To reflect the system upgrades, the O&M plan was revised in 2012 and is currently under review. The addition of the new extraction wells provides an opportunity to use proactive maintenance for these wells starting the day they were commissioned and also gather data on operability performance and impacts to the geologic units around each well. (b) The evaluation of water elevation data and trends in groundwater quality supported the addition of new extraction wells AT-11, AT-12, and AT-13 to achieve adequate capture (as shown on the figures in Attachment 3), although the need was primarily driven by the recurring mechanical failure of AT-3A. (c) Collection of data to identify life-cycle ~~issues~~ maintenance items continues.

The Third Five-Year Review stated that the Navy will continue the following activities (each activity is followed by a status summary):

- Operation, routine maintenance, and repair of the OU1 remedy to meet ROD objectives.

  Status: The new extraction wells (AT-11, AT-12, and AT-13) and associated equipment and other equipment upgrades, added to the containment system are the outcome of continued operation of the OU1 remedy to meet ROD objectives.

- Operation and monitoring of the performance of the OU1 GWTF in relation to NPDES permit requirements to determine if surface water quality standards required in the GWTF discharge have been met.

  Status: The GWTF discharge remain in compliance with the NDPES permit and the industrial discharge permit when discharging to the sanitary system.

- Calculation and reporting of GWTF air emission rates of COCs to ensure that AERs are not being exceeded.

  Status: This evaluation continues to be included in AMRs. AERs remain in compliance.

- Sampling and reporting data from riverside wells to determine whether surface water TBCs are met prior to groundwater discharge to the Mississippi River.

  Status: The Navy continues to sample and report the contaminant concentrations in the riverside wells. The Navy, EPA, and MPCA continue to monitor and discuss surface water COC levels.

- Monitor hydraulic heads, groundwater chemistry, chemical trends, and pumping rates according to reporting requirements of the AMRs.

  Status: This evaluation continues to be included in each AMR.

4. Exit Strategy: An exit strategy will be developed for the NIROP facility. To this end, the Navy, EPA and MPCA (the Team) have tentatively agreed on a consensus statement: The team commits to continually evaluate the efficacy of the current remedies with the intention of moving the site to

delisting. As part of this effort, the team will consider a wide range of options from optimizing the current remedies to potential modifications as appropriate.

Status: Navy informed the EPA and MPCA that they intend to perform a ~~limited subsurface~~voluntary optimization sampling event that will target specific locations in order to provide new information to help optimize remediation of groundwater. The investigation is expected to provide important inputs to exit strategy development. The Team also adopted the "NIROP Vision and Goals" during the Tier I and Tier II meeting in Chicago on June 22, 2011. The NIROP Vision and Goals were then edited during the Tier I and Tier II meeting in St. Paul on December 8, 2011. The Vision and Goals are listed below:

Vision

Achieve MCLs throughout the plume; protect human health and the environment until MCLs are achieved.

Goals

1. Reliable O&M operation by September 2012
2. Complete the pump and treat system evaluation and implement upgrades by September 2012
3. Confirm that all wells installed prior to September 2012 are operating in accordance with their design, by September 2013
4. Achieve MCLs throughout the plume in a reasonable timeframe
    a. Capture Contaminants of Concern (COCs) above 100 parts per billion (ppb) by September 2012, as an interim step to achieving MCLs
    ~~a.~~b. Meet Class 2B surface water standards in compliance wells by September 2018

The Team also developed the following schedule for specific activities in the last Five-Year Review Report. The fifth column has been added to update the progress on the recommendations for this fourth five-year review. As stated above, these are maintenance items inherently required by the remedy, or, items which had potential to improve remedy performance and/or decrease the time the remedy needed to be in-place, and not Five-Year Review "issues" requiring "recommendations". Therefore, the following items are listed in this Fourth Five-Year Review to provide a current status summary, but beginning in this Fourth Five-Year Review, will not be carried over as "issues" requiring "recommendations":

Issue	Recommendation or Follow-Up Action	Party Responsible	Milestone Date	Status
1	Employ preventative maintenance practices	Navy	1 June 2009	This has occurred and is ongoing.
2	Operate system within newly specified operating range	Navy	1 June 2009	The system was operated within the specified operating range, however, due to the addition of new extraction wells the newly specified operating range is no longer applicable. The Navy is continuing to adjust the pumping rates and monitor the plume in order to maximize contamination removal. This will be an ongoing continuous action.
3	Update procurement of O&M contractor	Navy	1 June 2009	This was completed with no loss of service (downtime).
4	Evaluate system capture in 2 years to address potential bypass concerns	Navy	1 June 2011	Ongoing capture evaluations contributed to the decision to add new extraction wells AT-11, AT-12, and AT-13. System capture is evaluated on an annual basis in the AMR.
5	Add NAVFAC technical resources	Navy, with EPA and MPCA support	Ongoing	This has occurred and is ongoing.
6	Develop exit strategy	Navy, with EPA and MPCA support	Ongoing	This has occurred and is ongoing.
7	Track extraction system downtime to verify improvement by system and by well	Navy	Ongoing/continuous	This activity was anticipated to provide data for the decision about whether to replace extraction wells. Because new extraction wells AT-11, AT-12, and AT-13 are now in place, in part to replace AT-3A, this specific analysis is no longer necessary. The Navy continues to monitor system operations, as a routine matter, in order optimize the system to the extent practicable.

Issue	Recommendation or Follow-Up Action	Party Responsible	Milestone Date	Status
8	Provide more detailed reporting on system performance	Navy	Ongoing	This has occurred and is ongoing.
9	Continue the Facilitated Partnering Process	Navy	Ongoing	This is in progress (ongoing).
10	Perform annual review of adequacy of spare parts inventory	Navy	Ongoing	Completed and incorporated into O&M contract.

5.2 OU2 AND OU3 PROGRESS SINCE THE LAST FIVE-YEAR REVIEW

The protectiveness statements for OU2 and OU3 from the previous Five-Year Review Report (Tetra Tech, October 2008) were as follows:

> The remedy at OU3 is protective of human health and the environment and in the interim, exposure pathways that could result in unacceptable risks are being controlled.
>
> The remedy at OU2 is protective of human health and the environment and in the interim, exposure pathways that could result in unacceptable risks are being controlled.

For the OU2 and OU3 LUC remedy, no actions were recommended in the Third Five Year Review.

6.0 FIVE-YEAR REVIEW PROCESS

6.1 COMMUNITY NOTIFICATION AND INVOLVEMENT

A public notice that the fourth five-year review was being conducted was published on Thursday, November 15, 2012, in the Fridley Columbia Heights Sun Focus newspaper in Fridley, Minnesota. A public notice that the fourth five-year review was being conducted was also published on Thursday, November 15, 2012, and Sunday, November 18, 2012, in the Star Tribune newspaper. The Draft Fourth Five-Year Review Report will bewas provided to EPA and MPCA for review and comment on May 30, in February 2013. MPCA comments on this Fourth Five-Year Review were provided to the Navy on July 2, 2013, and U.S. EPA provided comments on this Fourth Five Year Review on July 23, 2013. Responses to comments and proposed revisions to the Fourth Five-Year Review text and attachments were provided to MPCA and U.S. EPA on September 27, 2013.

The document has been available for public review throughout the process. The Navy will sign the document in September 2013. The Navy, EPA, and MPCA may agree to adjust some of the dates, provided that final signature is attained by October 20, 2013, 5 years after the signing of the previous Five-Year Review Report.

6.2 DOCUMENT REVIEW

To prepare this Five-Year Review Report, the following documents were reviewed:

- Groundwater OU ROD – September 1990
- FFA – March 1991
- OU2 and OU3 ROD – August 2003
- Basis of Design – June 1997
- Third Five-Year Review – October 2008
- LUC Remedial Design for OU2 and OU3 – March 2004
- RAWP – September 2005
- Hydrogeologic Analysis for Replacement of Extraction Well AT-3A – March 2011
- CH2MHILL Construction Completion Report – February 2013
- Aquifer Performance Test Evaluation AT-11, AT-12, and AT-13 – February 2013
- Draft 2012 AMR – March July 2013

As discussed in Section 1, each AMR includes summaries and copies of operating, maintenance, and monitoring data for the groundwater extraction system and treatment system from the previous calendar year. These data were being prepared and reviewed concurrently with preparation of this Five-Year Review Report. The TCE isoconcentration maps and the approximate capture zone configurations from the annual monitoring event conducted in August 2012 are provided as Attachment 1 to this Five-Year Review Report.

6.3 DATA REVIEW

Data reviewed for the fourth five-year review included O&M data, summarized in each AMR.

The groundwater monitoring well sampling program for the upcoming year is proposed in each AMR by the Navy and subsequently reviewed by EPA and MPCA. In addition, in each AMR, the Navy evaluates the adequacy of the monitoring program and in the future will propose modifications as necessary. EPA and MPCA review and comment on each AMR.

A summary of the estimated amount of TCE and total VOCs removed from extracted groundwater since the start of operations is provided in each AMR. The 2012 AMR (Tetra Tech, July 2013) reported that the cumulative amount of TCE and total VOCs removed by the system were 34,063 and 38,341 pounds, respectively, based on a cumulative pumping volume of 4.335 billion gallons.

Geographically, TCE continues to be the most widespread contaminant in site groundwater. TCE was present above the MCL in 90 of 124 wells sampled in August 2012 and is also present at the greatest overall concentrations. To provide a perspective of historical site conditions, the most elevated concentration in presumed source area monitoring well MS-33I was approximately 60,000 µg/L in 1998 and in August 2012 was 4,600 µg/L. 1,2-DCE (primarily cis-1,2-DCE) was the contaminant detected at the greatest concentration in 36 of the 124 wells with VOC detections. PCE was the primary VOC in 11 of 124 wells (mostly deep and bedrock wells). There is some evidence to suggest that PCE may originate from an off-NIROP source, as stated in the 2012 AMR (Tetra Tech, 2013).

A summary comparison between Mann-Kendall trends from annual monitoring conducted in 2006 and 2012 (the data used in the Third Five-Year Review and in this Five Year Review, respectively), are presented in Table 7-1. The wells which were used in the 2006 and 2012 Mann-Kendall analysis are comparable (i.e., nearly all of the same wells were used in each analysis); however, in 2006, Mann-Kendall analysis used all available data for all wells (in some cases VOC data was available from 1983) and in 2012, only data from 2001 to 2012 was used. Because concentrations of VOCs were significantly more elevated in early years of monitoring as compared to 2012, limiting the dataset used in 2012 produces results for recent trends. When comparing the trend results for 2006 and 2012, the number of downward trends has increased from 2006 to 2012 for both TCE and DCE. This is notable in terms of overall site progress because more downwards trends are still evident in 2012 even though the early data with more elevated concentrations was not used for 2012 trend evaluation. The relative proportions of downward trends, upward trends, and no trends were similar between the 2006 and 2012 datasets.

Current operating procedures maintain the remediation system's effectiveness. Temporary shutdown of individual extraction wells or of the complete well system has been necessary for regular maintenance or repair of wells, piping, or the entire treatment system on various occasions. To date, there is no evidence that downtime for system repairs places protectiveness at risk. The Navy is currently spending approximately $400,000 per year on O&M costs, including preventative maintenance that minimizes downtime, such as replacing aging components, ensuring adequate spares are available, and cleaning components, such as pipes, before they become a significant problem. Additionally, the Navy spent over $1.3 million dollars in 2011 and 2012 to install three new extraction wells (AT-11, AT-12, and AT-13) and integrate them into the groundwater treatment system.

The United States Geologic Survey (USGS) was contracted to construct a numerical model intended to be used as a tool by the Partnering Team to evaluate contaminant concentrations, groundwater flow pathways, and probable capture zones for extraction well pumping under different scenarios. The purpose of this model is that it be used to determine the most effective pumping rate/pumping well configuration to ensure that maximum capture of the contaminant plume is achieved. The modeling is complete and a draft report has been prepared and peer reviewed. The draft report is currently being revised, then the USGS supervisory review process will begin and the report will be published. Report approval is anticipated by the end of fiscal year 2013.

6.4 SITE INSPECTION

A formal inspection using a checklist based on an example in the EPA Five-Year Review guidance was conducted January 17, 2013 for all three OUs. NAVFAC Midwest personnel conducted the inspection, and EPA and MPCA representatives were in attendance. No significant issues were identified during the inspection, since the OU1 groundwater extraction system requires intense operator interface, resulting in frequent communication between the O&M contractor and the Navy. In other words, the system operators are already in regular communication with Navy to address issues potential maintenance problems as they emerge. No significant issues potential problems were identified for OU2 and OU3 as Navy personnel have had frequent opportunity to visit the facility throughout the review period and could plainly observe that the LUCs at OU2 and OU3 were being maintained and enforced. Photographs (Attachment 1) and the Site Inspection Form (Attachment 2) are included in this Five-Year Review. Monitoring well 8-IS was missing its cover during the site inspection, and in 2009, monitoring well caps were stolen from some monitoring wells in Anoka County Park. The Navy was informed and BayWest replaced the caps. The cover will be replaced for monitoring well 8-IS.

6.5 INTERVIEWS

Interviews were conducted with the O&M Manager, Paul Walz of Bay West, and Tim Ruda of BAE Systems, Inc., during the five-year review site inspection. Because NIROP is a fenced operating plant with controlled access, there is limited access to remedy components (extraction wells, treatment buildings, controls systems) within NIROP. There are no institutional controls identified in the groundwater OU ROD; however, the Navy and MPCA [via communication with Minnesota Department of Health (MDH)] ensure that no drinking water wells are installed at NIROP or in ACP. Representatives of the ACP board are included on the RAB mailing list and frequently attended RAB meetings, although none have been held since 2006. All wells and injection points in ACP must be approved by the ACP board, in addition to meeting MDH requirements. Interview results are located in Attachment 4.

A Community Action Group for Fridley Superfund Sites was formed during this Five-Year Review Period to exchange information about site activities and local concerns. The city of Fridley has also expressed concerns during Partnering Team meetings about the NIROP plume with regard to their intent to increase use of municipal well Fridley Well 13. Currently, the city of Fridley's water is supplied by the Mississippi River and excess water from New Brighton. Water from New Brighton is supplied from the groundwater treatment plant at the Twin Cities Army Ammunition Plant (TCAAP). Groundwater from the TCAAP TCE plume is pumped and treated to residential drinking water standards and supplied for municipal use. According to city of Fridley Water Works personnel, reductions in TCAAP plume contaminant concentrations will result in decreased pumping, decreasing the water supply available to the city of Fridley and increasing the demand on Fridley's municipal wells.

7.0 TECHNICAL ASSESSMENT

7.1 QUESTION A: IS THE REMEDY FUNCTIONING AS INTENDED BY THE DECISION DOCUMENTS?

7.1.1 OU1

As stated in the OU1 ROD, "[t]he objective of this alternative [the OU1 remedy] is to address the principal threat posed by the site by providing hydraulic containment to prevent further migration of contaminated ground water off the NIROP [facility] and by recovering, to the extent feasible, contaminated ground water beneath the Anoka County Parkland...The ultimate goal is to restore ground water quality in the unconsolidated aquifer at the site to Maximum Contaminant Levels..."

The remedy is functioning as intended by the ROD, as described above. However, during the past five years, adequacy of capture along the northern reaches of the extraction system in the shallow zone (as evidenced by the elevated TCE concentrations in MS-56S and MS-43S), and in the intermediate zone (as evidenced by elevated TCE concentrations near MS-34I and MS-35I) has been uncertain. Per the ROD, the remedy was designed to provide hydraulic containment and recovery of groundwater. Since the ROD was signed, the Navy has conducted various evaluations of system efficiency. These evaluations resulted in the addition of extraction wells AT-5A and AT-5B prior to the first five-year review and wells AT-7, AT-8, AT-9, and AT-10 prior to the second five-year review. Prior to this fourth five-year review, extraction wells AT-11, AT-12, and AT-13 were added to the extraction system to replace AT-3A, and AT-3A was removed from the system due to aging system components, which appears to be addressing the potential bypass situation noted above. The Navy continues to evaluate hydraulic containment on an annual basis in each AMR. Prior to and in conjunction with the installation of the three new extraction wells, the Navy recently decided to increase the sampling frequency for several monitoring wells for 1 year after new extraction wells, AT-11, AT-12, and AT-13, began pumping to further refine the containment transport evaluation.

The remedy was not intended to address VI at NIROP; and does not address VI from groundwater at NIROP.

~~A summary of the estimated amount of TCE and total VOCs removed from extracted groundwater since the start of operations is provided in each AMR. The 2011 AMR reported that the cumulative amount of TCE and total VOCs removed by the system were 33,506 and 37,514 pounds, respectively, based on a cumulative pumping volume of 4.335 billion gallons.~~

~~Geographically, TCE continues to be the most widespread contaminant in site groundwater. TCE was present above the MCL in 90 of 124 wells sampled in August 2012 and is also present at the greatest overall concentrations. To provide a perspective of historical site conditions, the most elevated concentration in presumed source area monitoring well MS-33I was approximately 60,000 µg/L in 1998 and in August 2012 was 4,600 µg/L. 1,2-DCE (primarily cis-1,2-DCE) was the contaminant detected at the greatest concentration in 36 of the 124 wells with VOC detections. PCE was the primary VOC in 11 of 124 wells (mostly deep and bedrock wells). There is some evidence to suggest that PCE may originate from an off-NIROP source.~~

~~A summary comparison between Mann-Kendall trends from annual monitoring conducted in 2006 and 2012 (the data used in the Third Five-Year Review and in this Five Year Review, respectively), are presented in Table 7-1. The wells which were used in the 2006 and 2012 Mann-Kendall analysis are comparable; however, in 2006, Mann-Kendall analysis used all available data for all wells (in some cases VOC data was available from 1983) and in 2012, only data from 2001 to 2012 was used. Because concentrations of VOCs were significantly more elevated in early years of monitoring as compared to 2012, limiting the dataset used in 2012 produces results for recent trends. When comparing the trend results for 2006 and 2012, the number of downward trends has increased from 2006 to 2012 for both TCE and DCE. This is notable in terms of overall site progress because more downwards trends are still evident in 2012 even though the early data with more elevated concentrations was not used for 2012 trend evaluation.~~

~~Current operating procedures maintain the remediation system's effectiveness. Temporary shutdown of individual extraction wells or of the complete well system has been necessary for regular maintenance or repair of wells, piping, or the entire treatment system on various occasions. To date, there is no evidence that downtime for system repairs places protectiveness at risk. The Navy is currently spending approximately $400,000 per year on O&M costs, including preventative maintenance that minimizes downtime, such as replacing aging components, ensuring adequate spares are available, and cleaning components, such as pipes, before they become a significant issue. Additionally, the Navy spent over $1.3 million dollars in 2011 and 2012 to install three new extraction wells (AT-11, AT-12, and AT-13) and integrate them into the groundwater treatment system.~~

~~Also, as previously addressed in this document the updated draft USGS groundwater model for NIROP was completed in September 2012.~~

7.1.2 OU2 and OU3

NIROP remains a fenced controlled-access facility which serves to prevent exposure to contamination remaining in the soil OUs. LUCs remain in place and protect against unacceptable exposure to these soils during normal industrial operations. There are no known violations of these LUCs. There are no other actions necessary, and no immediate threats have been identified.

The Navy has confirmed OU2 and OU3 LUC compliance throughout the review period. The EPA and MPCA, as the approval authorities for any LUC modifications, have not received any requests for LUC modifications.

No breaches have been identified and therefore, Navy concludes that the LUC remedies are functioning as intended. The Navy therefore concludes that the LUC performance objectives as presented the ROD and Section 4.3.

7.2 QUESTION B: ARE THE EXPOSURE ASSUMPTIONS, TOXICITY DATA, CLEANUP LEVELS, AND REMEDIAL ACTION OBJECTIVES USED AT THE TIME OF REMEDY SELECTION STILL VALID?

There have been no changes in the physical conditions of the OUs that would impact the protectiveness of the remedies.

7.2.1 Exposure Assumptions – OU1

Two potential human pathways related to contaminated groundwater were identified in the OU1 ROD.

- The first is contaminated groundwater from NIROP discharging into the Mississippi River, migrating to Minneapolis Water Works (MWW) intakes, then to finished water from the MWW, and finally the water is consumed by humans. Prior to construction of the OU1 remedy, TCE had been detected at concentrations less than MCLs in the MWW intake; however, in limited sampling since then (none in the past 5 years), COCs were not detected at the MWW intake in excess of method detection limits.

- The second groundwater pathway in the ROD is direct consumption of NIROP-contaminated groundwater. Exposure assumptions involving these two potential groundwater pathways are still valid.

Another potential human pathway discussed in the ROD was inhalation of COCs from the OU1 treatment facility. The federal Clean Air Act is cited as an action-specific ARAR. The inhalation pathway exposure also remains valid. AERs are designed to evaluate emissions associated with operation of the OU1 groundwater treatment system to ensure that humans are protected from unacceptable exposure via pathway.

The ROD also discussed a surface water pathway involving human consumption of contaminated fish and drinking water and an ecological pathway to organisms in the Mississippi River via discharge of contaminated groundwater into the river. These pathways were more clearly identified and discussed in Attachment 1 to the Five-Year Review dated October 27, 1998. These potential exposure pathways remain valid.

Vapor intrusion is an exposure pathway that was not previously evaluated. The presence of TCE in groundwater at sufficiently high concentrations renders the compound potentially able to volatilize, migrate through the soil column, and infiltrate the indoor air of a building located over the groundwater contamination. Using the maximum detected concentration of TCE in shallow groundwater samples collected during 2011 (1,800 µg/L), the modeled indoor air concentration is 0.75 µg/m^3 (Attachment 4). This indoor air concentration was determined using the Johnson-Ettinger Model and based on the following assumptions:

- The building is slab-on-grade construction.
- The floor surface is 1 foot thick.
- The depth to shallow groundwater is approximately 20 feet.
- The soil is classified as sand.
- The average groundwater temperature is 10 degrees Celsius (°C).
- The building size is 2,000,000 square feet.
- The air exchange rate is one per hour.

The modeled indoor air concentration of 0.75 µg/m^3 corresponds to an exposure concentration of 0.06[1] µg/m^3 for carcinogenic risk and an exposure concentration of 0.17[2] µg/m^3 for noncarcinogenic effects.

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[1] Derived by using standard default exposure assumptions for industrial exposure: 0.75 µg/m^3 * (8 hr/24 hr) * (250 d/365 d) * (30 yr/70 yr) = 0.06 µg/m^3.

[2] Derived by using standard default exposure assumptions for industrial exposure: 0.75 µg/m^3 * (8 hr/24 hr) * (250 d/365 d) * (30 yr/30 yr) = 0.17 µg/m^3

These exposure concentrations correspond to an industrial carcinogenic risk of 32 x 10^{-78} and a non-carcinogenic hazard index of 0.092, below EPA's target risk levels. The risks were derived by using a risk-ratio technique and comparing to EPA's industrial Regional Screening LevelsVapor Intrusion Screening Level Calculator.

The assumptions used to predict an indoor air concentration are conservative toward the protection of human health. In some areas of the building, the foundation thickness is reported to be up to 82 inches, and the building is generally wide open with much greater air exchange rates. These two factors alone can significantly reduce indoor air concentrations, regardless of whether the source of contamination is a result of vapor intrusion or indoor chemical use.

7.2.2 Exposure Assumptions – OU2 and OU3

Three potential human pathways related to contaminated soils were identified in the OU2/OU3 ROD. The first two pathways consist of ingestion of and dermal contact with contaminated soils. The other soil pathway cited in the ROD is inhalation of COCs from fugitive dust generated from subsurface soils. Exposure assumptions involving these potential soils pathways are still valid. Other potential human pathways discussed in the ROD involved VOCs from subsurface soils entering groundwater, resulting in hypothetical ingestion, inhalation, and dermal contact exposures. These hypothetical exposure pathways remain valid but become inseparable from existing OU1 pathways.

Similar to the OU1 analysis above, a hypothetical surface water pathway results from VOCs entering groundwater that then enters surface water, resulting in potential ingestion, inhalation, and dermal contact. The potential exposure pathway remains valid but also becomes inseparable from existing OU1 pathways.

The presence of TCE and other VOCs in surface and subsurface soil also renders the compounds potentially viable to volatilize and migrate into the indoor air of a building. Using the maximum detected soil concentrations of each detected VOC at depth intervals of 0 to 4 feet, 4 to 8 feet, and 8 to 12 feet from samples collected in 1997 (as reported in the 2002 Remedial Investigation), indoor air concentrations were predicted. The indoor air concentrations were determined using the Johnson-Ettinger Model and were based on the same assumptions listed for OU-1. The maximum exposure concentration and risk from each depth interval for each VOC were used to conservatively estimate potential risk associated with exposure to indoor air concentrations (Attachment 4). The exposure concentrations correspond to a carcinogenic risk of 1 x 10^{-7} and a hazard index of 0.1, below EPA's target risk levels.

7.2.3 Toxicity Data – All OUs

The toxicity data for TCE changed since the last five-year review was submitted. EPA released its Final Health Assessment for TCE on September 28, 2011. Updated toxicity values have been published in the Integrated Risk Information System (IRIS) database for use in risk assessment, and EPA updated its Regional Screening Levels (RSLs) for all media.

Similar changes have occurred for other media, most notably for indoor air, which was not addressed at the time of the ROD. The new risk-based industrial indoor air RSL for TCE is 3 µg/m^3 at a 10^{-6} risk level. At higher target risk levels used in many regulatory programs, the non-cancer RSL of 8.8 µg/m^3 becomes limiting because regulatory programs use the lesser of the cancer and non-cancer risk-based levels for site evaluation. This has subsequent impacts resulting in lower screening levels for soil gas and groundwater for the vapor intrusion pathway.

7.2.4 Cleanup Levels – All OUs

The COC cleanup levels for human consumption of water remain valid and are designed to protect all pathways identified above and also to protect the Mississippi River as a drinking water source. It is noted that the cleanup goals represent a contaminant level "at the tap" and the NIROP groundwater and untreated Mississippi River water are not used for drinking water. However, the cleanup levels in the OU1 ROD for the pathway involving human consumption of contaminated fish and the ecological pathway to organisms in the Mississippi River identified in the ROD were clarified and modified in the first Five-Year Review Report dated October 27, 1998. The updated surface water criteria and standards identified in the first Five-Year Review Report have changed per a letter from the MPCA on December 15, 2009. The letter stated that MPCA indicated that meeting the Class 2B Chronic Standard in the riverside wells is protective of aquatic life in the Mississippi River and protective of Class 2Bd drinking water standards in the Mississippi River. This letter is included as Attachment 5 of this Fourth Five-Year Review.

No cleanup levels were identified in the ROD for indoor air.

There has been no change to the cleanup levels for COCs soil supporting the OU2/OU3 ROD.

7.2.5 Remedial Action Objectives – All OUs

There have been no changes in land use at the facility. No new human health or ecological routes of exposure or receptors have been identified. No new contaminants or contaminant sources have been identified. There are no previously unanticipated toxic byproducts of the remedy to address. There have been no changes to physical site conditions or the understanding of these conditions.

Issues at some commercial manufacturing sites in Minnesota (with no Navy affiliation) have at least in part lead MPCA to consider broader assessment of several emerging contaminants at manufacturing sites. At present, Navy is not aware of any MPCA plans to conduct additional sampling for emerging contaminants at NIROP.

The overall RAOs for NIROP have not changed in the past 5 years. An analysis of the attainment of DQOs is included in each year's AMR. The 2012 AMR (the most recent report evaluated for this review, Tetra Tech, July 2013) contains the following information for two separate but related problems (Problems A and D) identified in the RAWP. Problem A and Problem D are also defined in the RAWP but are not used for analysis of attainment of DQOs. Attainment of DQOs is the mechanism by which the Navy is tracking key performance metrics related to remedy performance.

7.2.5.1 Problem B: Effectiveness of the Capture Well System

Evaluation of Problem B from the RAWP identifies a significant list of data to be collected or calculated (Decision Inputs/Study Boundaries). Each "problem" is defined by stating a problem or asking a question as a part of the project planning/design process, which is then used to develop decision rules. The study question for Problem B is: "Is the capture system with the newly installed wells effective at preventing groundwater contamination from passing through the capture system?" The criteria used to evaluate Problem B are the following:

- Hydraulic heads
- Chemical concentrations
- Physical parameters
- Stratigraphy
- Removal rate
- Drawdown
- Historical data
- Pumping rate
- Borehole flow velocity
- Tracer study
- 3-dimensional numerical model
- Plume dimension and location

- Concentrations that constitute contamination and delineate the plume

During the 2012 AMR evaluation of DQO attainment, it was confirmed that all required data have been collected and calculated.

The DQO solution requires that the well network be adjustable to accommodate refined site conceptual models and changing site conditions. The 2012 AMR evaluation of DQO attainment confirms that some minor modifications of the sampling network have occurred, and ~~this AMR~~ recommends additional modification. Therefore, this element is operating as designed to support the DQOs.

The Decision Rule for Problem B, as presented in the RAWP, is as follows:

> If the capture well system is effective at substantially preventing the flow of contaminated groundwater from NIROP beyond the capture well system, then optimize the system by selecting different pump rates, deselecting wells from the list of monitoring/pumping, etc., as appropriate based on best professional judgment using data analysis. If the capture well system is not effective at substantially preventing the flow of contaminated groundwater from NIROP beyond the capture well system, evaluate potential system enhancements, source control, etc., as appropriate.

The DQOs are being met. The capture well system is effective at substantially preventing the flow of contaminated groundwater from NIROP beyond the capture well system. The capture has been enhanced by the most recent 2012 upgrade. The system continues to show significantly improved performance and effectiveness in capturing contaminated groundwater (Attachment 3).

7.2.5.2 Problem C: Groundwater Monitoring for Overall Contamination at NIROP Fridley (Effectiveness of the Groundwater Monitoring Network)

Each "problem" is defined by stating a problem or asking a study question as a part of the project planning/design process, which is then used to develop decision rules. The problem statement for Problem C is: "…to optimize the groundwater monitoring program while providing sufficient data to determine whether the following are being achieved:

1. contaminated groundwater is prevented from leaving the site,
2. contaminated groundwater is prevented from reaching the Mississippi River,
3. change in the shape, size, and location of plume are being tracked,

4. contaminant levels are being evaluated relative to surface water and groundwater standards,
5. performance of remedial system is assessed (system = existing ongoing remedial actions and any future remedial actions which are implemented)
6. practicability of achieving complete remediation is assessed (won't completely address this under groundwater optimization)

The Decision Rules for Problem C, as contained in the RAWP, are as follows:

1. If contaminated groundwater (greater than 100 ppb TCE) is migrating beyond the northern and southern edges of the capture well line along the NIROP compliance line, evaluate potential system enhancements, source control, etc., as appropriate to improve the containment system. If not, optimize the groundwater monitoring system by selecting different pumping rates, deselecting wells from the list of monitoring/pumping, etc., as appropriate, based on best professional judgment using data analysis tools described in Attachment 2 of Problem B: Effectiveness of Capture Well System.

2. If groundwater with contaminants exceeding surface water criteria is entering the river, evaluate/ implement a remedy to prevent this. If contaminated groundwater is not entering the river, optimize the groundwater monitoring program further.

3. If the change in shape, size, concentration, and location of the plume indicates that the remedy is deficient or groundwater monitoring is insufficient, then make adjustments to mitigate the deficiency (action depends on conditions). If no change in shape, size, and location of the plume that would indicate that a deficiency is observed, then optimize the groundwater monitoring program further. The 5 µg/L TCE concentration contour was originally designated to serve as the delineator of the plume. Based on recent data, this is still valid.

4. If groundwater COC concentrations are greater than their respective groundwater regulatory limits, then continue the remedy, evaluate remedial alternatives (e.g., LUCs, etc.), and/or petition for using ACLs. If not, recommend No Further Remedial Action Planned (NFRAP) and stop treatment.

5. If cleanup performance for the entire remedial system is unsatisfactory, then enhance system performance, evaluate the technical impracticability of the system, evaluate remedial alternatives (e.g., LUCs, etc.), and/or petition for ACLs. If the cleanup performance is satisfactory, further optimize the remedial system, if possible.

Based on evaluations of the data in this the 2012 AMR (Tetra Tech, 2013), TCE is still being the best indicator of plume size. The data evaluations lead to the following conclusions:

- Contaminant concentrations downgradient of the capture system, up to 2009, have statistically decreased to show progress toward satisfying the Decision Rule #1. Downgradient quarterly monitoring was continued to assess the impact of the reduced performance of AT-3A and the effectiveness of the implemented system upgrades, and this monitoring will continue for a period of one year following startup of the new wells. The Partnering Team will then re-evaluate monitoring frequency at that time. Note that the term "compliance wells," as defined as a part of the DQO exercise, were applied to a particular group of wells to differentiate them from other groups, and these wells are referred to in previous sections of this the 2012 AMR as "Riverside wells", to avoid the possible assumption that the "compliance wells" have any regulatory standing in documents to date.

- A groundwater treatment pilot study was evaluated as an active remedy that can potentially be used to decrease concentrations in accordance with Decision Rule #2. The capture system is also actively removing contamination from the aquifers.

- The groundwater monitoring program and cleanup performance of the remedial system are still being evaluated because of the recent additions to the extraction system. Therefore, Decision Rule numbers 3, 4, and 5 are satisfied, although concentrations less than groundwater standards have not yet been achieved.

None of the DQOs from the RAWP relate to OU2 or OU3.

7.3 QUESTION C: HAS ANY OTHER INFORMATION COME TO LIGHT THAT COULD CALL INTO QUESTION THE PROTECTIVENESS OF THE REMEDY?

No additional information has come to light that could call into question the protectiveness of the remedies. There are no newly identified human health or ecological risks. There have been no impacts from natural disasters.

8.0 ISSUES

8.1 OU1 ISSUES

There are no issues that ~~The issues discussed in the following subsections were identified as potentially~~ impact~~ing~~ the protectiveness of the OU1 remedy. The following items are follow-up actions which are related to OU1 remedy maintenance or related to potential source area reduction.

8.1.1. Electrical and Mechanical Device Failures

The Navy is closely monitoring the occurrences of electrical and mechanical device outages and failures and other system operational ~~issues~~maintenance items. If an increased level of electrical or mechanical device failures or other downtimes occur, protectiveness could be impacted. As with any large scale industrial system, age and continued use (24 hour per day/7 days per week operations) places a large demand on system components. Deterioration and failure of equipment is expected and the amount of maintenance needed to keep the system operational increased. Since fiscal year 2006, the Navy has expended over $150,000 more annually than in prior periods for O&M costs for preventative maintenance and to replace aging components, to buy and install new pumps, and to stock critical spare parts to minimize any such system downtime. The Navy, EPA and MPCA recognize that the O&M ~~issues~~ items must be continually addressed to conclude that the OU1 remedy is performing as intended by the ROD, although the addition of new extraction wells AT-11, AT-12, and AT-13 does allow retirement of equipment associated with AT-3A, a former source of many O&M ~~issues~~items.

8.1.2 Biological Iron Fouling

The groundwater extraction wells must be routinely treated to address biological iron fouling. There are several treatment options available, and the Navy is assessing which would provide the longest period of relief for the cost incurred. Comprehensive biological sampling of selected extraction wells is planned for the first quarter of 2013. Data obtained from this sampling effort will aid in long-term control of biological fouling.

8.1.3 Uncertainty in Capture Zone Evaluation

Capture zones, especially near the northern and western reaches of the extraction system in the shallow and intermediate zones, have been difficult to evaluate because of frequent operational difficulties with extraction system components. The adequacy of capture in the shallow zone is uncertain along the northern reaches of the extraction system, as evidenced by high TCE concentrations in MS-56S and MS-43S, which are located downgradient of the northernmost extraction wells. These elevated TCE concentrations could be indicative of inconsistent extraction system operation or partial bypass of contaminated groundwater when the extraction system is functioning consistently. Uncertainty of capture extent in the intermediate zone along the northern reaches of the extraction system near MS-34I and MS-35I can be attributed to the relationship between the extent of the intermediate clays and the limited zone of influence of AT-3A (now retired and replaced by AT-11, AT-12, and AT-13). The zone of influence itself is difficult to delineate downgradient of these extraction wells because of the low relief in the area. Capture in the area of the nose between AT-3A and AT-10 has also always been an area of uncertainty, thought to be an area of high-permeability sediments, but the analysis of the new hydraulic profile resulting from the new extraction wells is being evaluated and is expected to show improved performance in this area. The post installation capture zone analysis of the new wells indicates the wells are capturing the contaminated plume and meets the ROD requirements.

8.1.4 Source Remediation

Because the Vegetable Oil Pilot Project Report discussed in the prior Five-Year Review Report acknowledged that the induced "geochemical changes (were) neither spatially uniform nor temporally consistent", there has been no additional vegetable oil (or other pilot testing) implementations. Since the last five-year review, no additional remediation technologies have been determined to be viable at this site by the Navy, EPA, or MPCA. The Navy anticipates conducting voluntary ~~limited~~ optimization sampling under the building slab, in the vicinity of the plating shop, in 2013 that could provide new information to help optimize remediation of groundwater under the building via other technologies and assist the groundwater model.

8.1.5 Vapor Intrusion (VI)

Although the results of conservative screening indicate that no unacceptable VI exposures are occurring for OU1, the Navy will work with EPA and MPCA to review the site conceptual model and evaluate whether a completed VI pathway exists. The site conceptual model may change based on the results of the pending ~~limited source area investigation~~voluntary optimization sampling, ~~potential~~ property transfer, and potential subsequent property redevelopment. Although not resulting in a specific recommendation, the site conceptual model will be updated as appropriate based on new information and will be used to evaluate whether a complete exposure pathway for VI has resulted. VI may be a potential future issue that may need to be addressed if the NIROP building is reoccupied and/or the NIROP property is redeveloped, and the site conceptual model will be reviewed following the voluntary optimization sampling, which would include recalculation of the JE model.

8.2 OU2 AND OU3 ISSUES

No issues affecting remedy protectiveness have been identified for OU2 or OU3. Although the results of conservative soil screening for OU3 indicate that no unacceptable VI exposures are occurring, the Navy will work with EPA and MPCA to review the site conceptual model and evaluate whether a completed VI pathway exists. The site conceptual model may change based on the results of the pending voluntary optimization sampling, property transfer, and potential subsequent property redevelopment. Although not resulting in a specific recommendation, the site conceptual model will be updated as appropriate based on new information and will be used to evaluate whether a complete exposure pathway for VI has resulted. VI may be a potential future issue that may need to be addressed if the NIROP building is reoccupied and/or the NIROP property is redeveloped, and the site conceptual model will be reviewed following the voluntary optimization sampling, which would include recalculation of the JE model.

9.0 RECOMMENDATIONS AND FOLLOW-UP ACTIONS

There are no issues which affect remedy protectiveness that result in recommendations or follow-up actions. However, Tthe following recommendationsitems are maintenance-related items based on evaluations conducted as part of documents other than this five-year review (AMR, RAWP, source investigationvoluntary optimization sampling) but are still appropriate for discussion because they support the Navy's ability to confirm remedy protectiveness.

Extraction of Contaminated Groundwater: The pump-and-treat system must remain in operation because key groundwater contaminant concentrations continue to exceed federal MCLs.

Containment and Extraction Remediation System: A proactive well maintenance program was recommended and has been implemented for the extraction wells. Because redevelopment is costly and requires the well to be off line (and therefore not extracting contaminated groundwater) for a period of time, supplemental chemical treatments to dissolve the precipitate(s) on the pump, screen, and piping have been investigated. Assuming that initial field tests show that this treatment works, this process can be implemented on a regular schedule, which will likely decrease the frequency of redevelopment and pump downtime. This proactive program, recommended in the previous five-year review, is in progress and is continually being re-evaluated.

The Navy previously noted that some key remediation system components may be starting to experience life-cycle issuesmaintenance items. The Navy will continue to collect data to identify system life-cycle issues maintenance items and will resolve them issues as appropriate. For fiscal years 2011 and 2012, the Navy expended more than $1.6 million more than routine O&M costs for the installation of the new extraction wells and associated system upgrades. In addition, the Navy has expended additional funds for preventative maintenance and to replace aging components, buy and install new pumps, and stock critical spare parts to minimize system downtime. This proactive program, recommended in the previous five-year review, is currently being implemented and is continually being re-evaluated as new conditions arise.This proactive program, recommended in the previous five-year review, is in progress and is continually being re-evaluated.

As agreed to in the previous Five-Year Review Report, continuation of the following activities will continueis recommended based on this five-year review:

- Operation, routine maintenance, and repair of the OU1 remedy to meet ROD objectives.

- Operation and monitoring the performance of the OU1 remedy in accordance with NPDES permit requirements to determine if surface water quality standards are met in plant discharge.

- Calculation and reporting of site emission rates of airborne treatment system COCs to ensure that AERs are not being exceeded.

- Sampling and reporting data from riverside wells to compare to surface water TBCs for the Mississippi River.

- Monitoring of hydraulic heads, groundwater chemistry, chemical trends, and pumping rates according to reporting requirements of the AMRs.

Vapor Intrusion/Voluntary Optimization Sampling:

Based on the conservative screening results for OU1 and OU3, the exposure concentrations for indoor air were lower than EPA's target risk levels. Following the voluntary optimization sampling, the Partnering Team will review the CSM to evaluate whether a completed VI pathway exists, and if the NIROP building is reoccupied and/or the NIROP property is redeveloped, additional lines of evidence to refute VI potential and vapor mitigation strategies may be necessary.

Exit Strategy:

The Partnering Team have committed to planning an exit strategy. The team commits to continually evaluate the efficacy of the current remedies with the intention of eventually moving the site to delisting. As part of this effort, the team will consider a wide range of options from optimizing the current remedies to potential modifications as appropriate. The Partnering Team will continue to discuss the site in the context of this Exit Strategy, and consider feasible and reasonable methods to put the Exit Strategy in place.

10.0 PROTECTIVENESS STATEMENT

10.1 OU1 PROTECTIVENESS STATEMENT

The OU1 remedy is currently protective of human health and the environment because the groundwater extraction system is functioning as intended by the ROD. Currently land use is consistent with commercial/industrial land use and no elements of residential land use are present, including residential drinking water wells. The groundwater remedy will achieve long-term protectiveness when the groundwater cleanup standards are achieved throughout the plume area. For the remedy to remain protective in the long term, hydraulic containment must be maintained~~, and optimal performance of the extraction system must be achieved~~and compliance with effective Institutional Controls (ICs) must be maintained.

10.2 OU2 PROTECTIVENESS STATEMENT

The remedy at OU2 is protective of human health and the environment and exposure pathways that could result in unacceptable risks are being controlled via LUCs. Compliance with effective ICs must be maintained.

10.3 OU3 PROTECTIVENESS STATEMENT

The remedy at OU3 is protective of human health and the environment and exposure pathways that could result in unacceptable risks are being controlled via LUCs. Compliance with effective ICs must be maintained.

10.4 SITEWIDE PROTECTIVENESS STATEMENT

The overall remedies at NIROP Fridley are protective of human health and the environment because exposure pathways that could result in unacceptable risks are being controlled via LUCs and because the groundwater extraction system is functioning as intended by the ROD. For the remedies to remain protective in the long term, hydraulic containment must be maintained and compliance with effective ICs must be maintained.

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ATTACHMENT 2

FIVE-YEAR REVIEW SITE INSPECTION CHECKLIST

Five-Year Review Site Inspection Checklist

I. SITE INFORMATION	
Site name: NIROP Fridley	**Date of Inspection:**
Location and Region: Fridley, Minnesota / Region 5	**EPA ID:** Sheila Desai
Agency, Office, or Company Leading the FYR: U.S. Navy (Lead Agency)	**Weather/Temperature:** 7^{0}F

Site Inspection Attendees:

- ☒ Harvey Pokorny, NAVAFAC MW
- ☐ Paul Walz, Bay West
- ☐ Chris Boehm Carlson, AECOM
- ☐ Cathy Larson, AECOM
- ☐ Stephanie Warino, Tetra-Tech NUS
- ☒ Paul Lucas, Antea
- ☒ Deepa de Alwis, MPCA
- ☐ Ken Brown, AECOM
- ☒ Val Jurka, NAVFAC LANT
- ☐ Scott Tarmann, AECOM
- ☐ Dean Krebs, Antea
- ☒ Jack Knight, Antea

Remedy Includes:

Operable Unit (OU) 1 (Groundwater)

Groundwater Extraction System
- Extraction Wells
- Associated pumps, piping, and control system (Building 52/53)

Groundwater Treatment System
- Air Stripper
- Effluent discharge to Mississippi River through a National Pollutant Discharge Elimination System (NPDES)/State Disposal System (SDS) permitted outfall (Outfall 020) (i.e., NPDES/SDS Permit MN0000710).

OU2/OU3 (Soil)

Land Use Controls (LUCs) consisting of both engineering controls (ECs) and institutional controls (ICs).

- Restrict use to industrial or restricted commercial use
- Prohibit the disturbance of soils deeper than three (3) feet below ground surface (bgs) or the removal of any soils excavated in those areas from the facility [i.e., North 40 or Blue and Red areas on Figure 2-5 from the Record of Decision for Operable Unit (OU) 2 and Operable Unit (OU) 3, Administrative Record N91192_000661, dated August 2003 (OU2/OU3 ROD)]
- Prohibit the disturbance of soils beneath the concrete pit foundations where metal-finishing operations previously occurred at the former Plating Shop (Green area on Figure 2-5)
- Ensure that the concrete pit floor (approximately 8 to 12 feet below grade floor) where metal-finishing operations previously occurred at the former Plating Shop is not removed (Green area on Figure 2-5)

Attachments: Figure 2-5 from OU2/OU3 ROD

Plating Room Floor Figure

II. INTERVIEWS (Check all that apply)

Interview 1 (O&M Manager)

Interview Participant: Paul Walz
Interview Organization: Bay West
Interview Date: 1/17/13
Interview Location: ☐ Onsite ☐ Via Telephone ☒ Office
Summary of Interview:

Did any unanticipated or unusually high O&M costs occur during review period? ☒ Yes ☐ No ☐ Other

Well replacement: system is 13 years old.

Is the system functioning as expected? Why/why not?

Yes, with the exception of effluent pipe flow issues. Extraction well performance (i.e., specific capacity) generally declines as the wells age. Routine rehabilitation efforts provides some temporary (but not complete) improvement in performance.

Have any major disruptions occurred?

Yes, failure of 3A led to system disruption and subsequent system expansion/optimization

Have there been any spills or releases? If yes, what was done to minimize the potential for similar releases?

No.

Do you have any comments, suggestions, or recommendations regarding the site's management or operation?

No.

What needs to be done to optimize the system? (if not discussed for the previous question)

In process, expanded system under optimization.

Are there any critical upgrades needed in the next 5 years?

Potential well replacement due to system aging.

Are you aware of any events, incidents, or activities at the site such as vandalism, trespassing, or emergency responses from local authorities? If so, please give details.

In 2009 monitoring well caps were stolen from Anoka Park. The Navy was informed, and Bay West replaced the caps.

Are you aware of any community concerns regarding the site or its operation and administration? If so, please give details.

No.

Interview 2 (Community Representative)

Interview Participant:
Interview Organization:
Interview Date:
Interview Location: ☐ Visit ☐ Telephone ☐ Other
Summary of Interview:

What is your overall impression of the project? (general sentiment)

What effects have site operations had on the surrounding community?

Are you aware of any community concerns regarding the site or its operation and administration? If so, please give details.

Are you aware of any events, incidents, or activities at the site such as vandalism, trespassing, or emergency responses from local authorities? If so, please give details.

Do you feel well informed about the site's activities and progress?

Do you have any comments, suggestions, or recommendations regarding the site's management or operation?

Interview 3

Interview Participant: Tim Ruda

Interview Organization: BAE Systems

Interview Date: 1/17/13

Interview Location: ☒ Visit ☐ Telephone ☐ Other

Summary of Interview: Plating Room Floor

Concrete 8 to 12 inches
Sand approximately 5 to 10 feet
Concrete 8 to 12 inches
Plating floor – coated material

Interview 4

Interview Participant:

Interview Organization:

Interview Date:

Interview Location: ☐ Visit ☐ Telephone ☐ Other

Summary of Interview:

III. ON-SITE DOCUMENTS & RECORDS VERIFIED (Check all that apply)

1. **O&M Documents**

O&M Manual (Old) ☒ Available ☐ Not Available ☐ Other
As-Built Drawings ☒ Included ☐ Not Included ☐ Other

O&M Manual (Updated) ☒ Available ☐ Not Available ☐ Other
As-Built Drawings ☒ Included ☐ Not Included ☐ Other
Updated O&M Manual and As-Built drawings located on BayWest server, accessible at NIROP BayWest office.

O&M Maintenance Log (Groundwater Treatment System) ☒ Available ☐ Not Available ☐ Other
O&M Maintenance Log (Air Stripper) ☒ Available ☐ Not Available ☐ Other

Notes: *Online – old ones available through 2010.*

2. **Site-Specific Health and Safety Plan (SSHASP)**

Site-Specific Health and Safety Plan ☒ Available ☐ Not Available ☐ Other
Contingency Plan/Emergency Response Plan ☒ Included ☐ Not Included ☐ Other

Is acid treatment included in the SSHASP? ☒ Yes ☐ No ☐ Other - *Not in Bay West 2010, specific to acid.*

Notes:

3. **O&M and OSHA Training Records**

O&M and OSHA Training Records ☒ Available ☐ Not Available ☐ Other

Notes: Available offsite at Bay West office.

4. **Permits and Service Agreements**

Air Discharge Permit ☐ Available ☐ Not Available ☒ Other *Substantive requirement for air limit, no permit for air – reports air emissions.*

Effluent Discharge Permit (NPDES/SDS Permit MN0000710) ☒ Available ☐ Not Available ☐ Other

Waste Disposal Service Agreement ☐ Available ☐ Not Available ☒ Other
No hazardous waste generated.

Notes:

5. **Groundwater Monitoring Records**

Groundwater Monitoring Records ☒ Available ☐ Not Available ☐ Other
Up-To-Date ☒ Yes ☐ No ☐ Other

Bay West Monthly O&M Reports ☒ Available ☐ Not Available ☐ Other

Spot-Check:

August 2011 ☒ Available ☐ Not Available
November 2011 ☒ Available ☐ Not Available
March 2012 ☒ Available ☐ Not Available

Notes:

6. Discharge Compliance Records

Air Discharge Compliance Records ☐ Available ☐ Not Available ☒ Other **Submitted on a quarterly basis in the Monthly Status Reports. Also included *in AMR***
Up-To-Date ☒ Yes ☐ No ☐ Other

Have the site-specific air emission rates (AERs) been updated following the system modifications?
☐ Yes ☒ No ☐ Other *Not close to exceeding air emission rates, calculated with new wells.*

According to the OU1 ROD, no air emission controls were required for the air strippers. Site-specific AERs were calculated for carcinogenic compounds that could potentially be emitted from operation of the groundwater treatment facility. "Any system modifications are subject to permit approval and can result in permit modifications. These permit modifications could result in modified AERs."

Water (Effluent) Discharge Compliance Records ☒ Available ☐ Not Available ☐ Other
Up-To-Date ☒ Yes ☐ No ☐ Other *In monthly reports*
Online

Notes:

7. Daily Access/Security Logs

Daily Access/Security Logs (Interior) ☐ Available ☐ Not Available ☒ Other
Daily Access/Security Logs (Exterior) ☐ Available ☐ Not Available ☒ Other

Notes: *BAE interior – controlled locks for treatment area, and controlled access to BAE facility.*

IV. O&M COSTS

1. **O&M Organization**

O&M Organization: Bay West

2. **O&M Cost Records**

☐ To be evaluated during review of the FYR Report

O&M Cost Records ☐ Available ☒ Not Available ☐ Other

Is a funding mechanism/agreement currently in place? ☒ Yes ☐ No ☐ Other

Notes:

3. **Unanticipated or Unusually High O&M Costs During Review Period**

Did any unanticipated or unusually high O&M costs occur during review period? ☐ Yes ☐ No ☒ Other

Notes: *See Bay West interview.*

V. ACCESS AND INSTITUTIONAL CONTROLS
A. Access

Are access restrictions in place to prevent damage and/or exposure?

Monitoring Wells ☒ Yes ☐ No ☐ Other

Locks and bollards around some.

Extraction Wells ☒ Yes ☐ No ☐ Other

Locks and bollards.

Building 52/53 ☒ Yes ☐ No ☐ Other

Air Stripper ☒ Yes ☐ No ☐ Other

Locked fence

North 40 (Blue and Red areas on Figure 2-5) ☒ Yes ☐ No ☐ Other

Fence

Former Plating Shop (Green area on Figure 2-5) ☒ Yes ☐ No ☐ Other

Locked room.

Notes:

C. Institutional Controls (ICs)

1. **Implementation and Enforcement**

Based on site condition:

Has soil deeper than three (3) feet bgs been disturbed in the North 40? ☐ Yes ☒ No ☐ Other

Has any soil been excavated from the North 40? ☐ Yes ☒ No ☐ Other

Does not have signs of digging or disturbance.

Has soil beneath the concrete pit foundations in the Former Plating Shop been disturbed?
☐ Yes ☒ No ☐ Other

Has the integrity of the concrete pit foundations in the Former Plating Shop been compromised?
☐ Yes ☒ No ☐ Other

Has the integrity of the Former Plating Shop floor been compromised? ☐ Yes ☒ No ☐ Other
Settlement cracks.
Note: upper floor is intact with a crack between 7NW 11Ave and 8NW 11 Ave (see photos 1 through 3) and also between 4NW and 5NW 11 Ave (see photos 4 through 6).

Are ICs being fully enforced? ☒ Yes ☐ No ☐ Other

Type of monitoring being utilized for the North 40? ☐ Self-Reporting ☒ Inspection Visits ☐ Drive By

Frequency of monitoring? ☒ Regular ☐ Irregular ☐ Other

Reporting is up-to-date? ☒ Yes ☐ No ☐ Other

Violations have been reported? ☐ Yes ☒ No ☐ Other

Other Problems or Suggestions:

2. **Adequacy**

Are ICs adequate? ☒ Yes ☐ No ☐ Other

D. General

1. **Vandalism/trespassing**

Do any signs of vandalism/trespassing exist? ☐ Yes ☒ No ☐ Other

Notes:

2. **Land use changes on site**

Have land use changes occurred onsite? ☐ Yes ☒ No ☐ Other

Notes:

3. **Land use changes off site**

Have land use changes occurred offsite? ☐ Yes ☒ No ☐ Other

Notes:

VI. GENERAL SITE CONDITIONS

A. Roads

Are roads in good condition? ☒ Yes ☐ No ☒ Other

Not applicable

B. Other Site Conditions

IX. GROUNDWATER REMEDIES
A. Groundwater Extraction Wells, Pumps, and Pipelines
1. **Groundwater Extraction Wells** Operating as intended? ☒ Yes ☐ No ☐ Other Typical maintenance required on the groundwater extraction wells? *Site walkthrough is conducted 2-3 times per week and system is observed remotely on a daily basis. During the site walkthrough, the following items are checked: systems, flow rates, polymer feed, SCADA.* Frequency of maintenance? *ongoing* Next scheduled maintenance? *daily* Are there any signs of exterior damage? ☐ Yes ☒ No ☐ Other Are there any signs of vandalism? ☐ Yes ☒ No ☐ Other Are groundwater extraction wells labeled? ☒ Yes ☐ No ☐ Other Notes/Observations:

2. **Pumps, Wellhead Plumbing, and Electrical**

Operating as intended? ☒ Yes ☐ No ☐ Other

Typical maintenance required on the pumps, wellhead plumbing, and electrical?

Yes

Frequency of maintenance?

Ongoing

Next scheduled maintenance?

Extraction wells are gauged one time per week, and pumps and drop pipes are pulled and cleaned approximately quarterly. Electrical system observed daily.

Electrical issues? ☐ Yes ☒ No ☐ Other

Alarm system in place? ☒ Yes ☐ No ☐ Other

Frequency of alarm system testing? ☒ Yes ☐ No ☐ Other

Virtual monitoring

Alarm system back-up in place? ☒ Yes ☐ No ☐ Other

Is an automatic shut-off system in place? ☒ Yes ☐ No ☐ Other

Frequency of shut-off system testing? ☒ Yes ☐ No ☐ Other

Notes/Observations:

3. **Extraction System Pipelines, Valves, Valve Boxes, and Other Appurtenances**

Operating as intended? ☒ Yes ☐ No ☐ Other

Typical maintenance required on extraction system pipelines, valves, valve boxes, and other appurtenances?
Yes

Frequency of maintenance?
Ongoing

Next scheduled maintenance?
Ongoing

Are extraction system pipelines, valves, valve boxes, and other appurtenances labeled?
Yes

Are there any signs of leaks or staining? ☐ Yes ☒ No ☐ Other

Are electrical enclosures and panels properly rated and functional? ☒ Yes ☐ No ☐ Other

Are electrical panels properly labeled? ☒ Yes ☐ No ☐ Other

Notes/Observations:

4. **Building 52/53**

Are all doors lockable? ☒ Yes ☐ No ☐ Other

Is the building roof in good condition? ☒ Yes ☐ No ☐ Other

Are parts, equipment, chemicals properly stored? ☒ Yes ☐ No ☐ Other

Are there any signs of staining present on the floor? ☐ Yes ☒ No ☐ Other

Are signs of leaks in the building roof present? ☐ Yes ☒ No ☐ Other

Does the building floor appear to be in good condition? ☒ Yes ☐ No ☐ Other

Are there any signs of exterior damage? ☐ Yes ☒ No ☐ Other

Are there any signs of vandalism? ☐ Yes ☒ No ☐ Other

Notes/Observations:

5. **Spare Parts and Equipment**

Inventory of parts/spare parts readily available? ☒ Yes ☐ No ☐ Other

Is contact information for ordering spare parts readily available? ☒ Yes ☐ No ☐ Other

Notes/Observations:

C. Treatment System (Air Stripper)

1. **Treatment Train**

Are any additives utilized? ☒ Yes ☐ No

If yes, what type of additive is utilized? ☒ Chelation Agent ☒ Flocculent ☒ Polymers

How/where are additives stored?

Pallets and containment pads on concrete and secondary containment.

Are additives utilized to prevent dissolved metals in the groundwater from precipitating out of the groundwater in process piping? ☒ Yes ☐ No ☐ Other

Are sampling ports properly marked and functional? ☒ Yes ☐ No ☐ Other

Operating as intended? ☒ Yes ☐ No ☐ Other

Typical maintenance required?
yes

Frequency of maintenance?
ongoing

Next scheduled maintenance?
Ongoing

Are sampling/maintenance logs displayed and up-to-date? ☒ Yes ☐ No ☐ Other

Online

Is equipment properly labeled/identifiable? ☒ Yes ☐ No ☐ Other

How much groundwater is treated annually? See Annual Monitoring Report (AMR)

Notes/Observations:

2. **Electrical Enclosures and Panels** (properly rated and functional)

Are electrical enclosures and panels properly rated and functional? ☒ Yes ☐ No ☐ Other

Are electrical panels properly labeled? ☒ Yes ☐ No ☐ Other

Notes/Observations:

3. **Tanks, Vaults, and Storage Vessels**

Operating/functioning as intended? ☒ Yes ☐ No ☐ Other

Typical maintenance required on tanks, vaults, and storage vessels?

Checked for leaks/deficiencies during regular inspection.

Frequency of maintenance?

Weekly

Next scheduled maintenance?

ongoing

Secondary containment in place? ☒ Yes ☐ No ☐ Other

Notes/Observations:

4. **Treatment Building(s)**

Are parts, equipment, chemicals properly stored? ☒ Yes ☐ No ☐ Other

Are there any signs of staining present on the floor? ☐ Yes ☒ No ☐ Other

Are signs of leaks in the building roof present? ☐ Yes ☒ No ☐ Other

Does the building floor appear to be in good condition? ☒ Yes ☐ No ☐ Other

Notes/Observations:

D. Monitoring Wells

1. **Monitoring Wells**

Can all monitoring wells be assessed for sampling and/or water levels? ☐ Yes ☐ No ☒ Other
All accessible with proper clearance.

Typical maintenance required for the monitoring wells?
No.

Frequency of inspections?
Annually.

Next scheduled inspection?
November 2013 for all wellss. A limited number of wells are inspected more frequently.

Are wells that are not sampled inspected during sampling events?
All wells inspected during annual groundwater monitoring event.

Frequency of maintenance?
N/A

Next scheduled maintenance?
N/A

Are there any signs of exterior damage? ☐ Yes ☒ No ☐ Other

Are there any signs of vandalism? ☐ Yes ☒ No ☐ Other

Are monitoring wells labeled? ☒ Yes ☐ No ☐ Other

Notes/Observations:

2. Monitoring Data

Has monitoring data been routinely submitted? ☒ Yes ☐ No ☐ Other

Is the monitoring data of acceptable quality? ☒ Yes ☐ No ☐ Other

Notes:

3. Monitoring Data Suggests

☒ To be evaluated during review of the FYR Report

XI. OVERALL OBSERVATIONS
A. Implementation of the Remedy
Describe issues and observations relating to whether the remedy is effective and functioning as designed. Begin with a brief statement of what the remedy is to accomplish (i.e., to contain contaminant plume, minimize infiltration and gas emission, etc.). Remedy is functioning as designed.
B. Adequacy of O&M
Describe issues and observations related to the implementation and scope of O&M procedures. In particular, discuss their relationship to the current and long-term protectiveness of the remedy. No obvious issues.
C. Early Indicators of Potential Remedy Problems
Describe issues and observations such as unexpected changes in the cost or scope of O&M or a high frequency of unscheduled repairs that suggest that the protectiveness of the remedy may be compromised in the future. Some extraction wells are aging and may lose efficiency over time. Mechanical failure of extraction wells has also occurred. Were any early indicators of potential remedy problem observed that suggest the protectiveness of the remedy may be compromised in the future? ☐ Yes ☒ No ☐ Other Will measures be proposed to address vapor intrusion? ☐ Yes ☐ No ☒ Other Not at this time. Conservative screening results indicate exposure concentrations are lower than EPA's target risk levels.
D. Opportunities for Optimization
Describe possible opportunities for optimization in monitoring tasks or the operation of the remedy. ☒ To be evaluated during review of the FYR Report

Notes/Observations

Notes/Observations

Wells

Is the well in good condition?

Monitoring Wells

Well			
1-IS	☐ Yes	☐ No	☐ Other
1-PC	☐ Yes	☐ No	☐ Other
1-S	☐ Yes	☐ No	☐ Other
1-D	☐ Yes	☐ No	☐ Other
2-IS	☐ Yes	☐ No	☐ Other
2-PC	☐ Yes	☐ No	☐ Other
2-S	☐ Yes	☐ No	☐ Other
2-D	☐ Yes	☐ No	☐ Other
3-PC	☐ Yes	☐ No	☐ Other
3-IS	☐ Yes	☐ No	☐ Other
3-S	☐ Yes	☐ No	☐ Other
3-D	☐ Yes	☐ No	☐ Other
4-IS	☐ Yes	☐ No	☐ Other
4-PC	☐ Yes	☐ No	☐ Other
4-S	☐ Yes	☐ No	☐ Other
4-D	☐ Yes	☐ No	☐ Other
5-IS	☐ Yes	☐ No	☐ Other
5-PC	☐ Yes	☐ No	☐ Other
5-S	☐ Yes	☐ No	☐ Other
5-D	☐ Yes	☐ No	☐ Other
6-IS	☐ Yes	☐ No	☐ Other
6-S	☐ Yes	☐ No	☐ Other
6-D	☐ Yes	☐ No	☐ Other
7-IS	☐ Yes	☐ No	☐ Other
7-S	☐ Yes	☐ No	☐ Other
7-D	☐ Yes	☐ No	☐ Other
8-IS	☐ Yes	☐ No	☒ Other ***Missing cover***
8-S	☐ Yes	☐ No	☐ Other
8-D	☐ Yes	☐ No	☐ Other
9-S	☐ Yes	☐ No	☐ Other
9-D	☐ Yes	☐ No	☐ Other
10-IS	☐ Yes	☐ No	☐ Other
10-S	☐ Yes	☐ No	☐ Other
10-D	☐ Yes	☐ No	☐ Other
11-SB	☐ Yes	☐ No	☐ Other
11-S	☐ Yes	☐ No	☐ Other
11-D	☐ Yes	☐ No	☐ Other
12-IS	☐ Yes	☐ No	☐ Other
12-S	☐ Yes	☐ No	☐ Other
12-D	☐ Yes	☐ No	☐ Other
13-IS	☐ Yes	☐ No	☐ Other
13-S	☐ Yes	☐ No	☐ Other
13-D	☐ Yes	☐ No	☐ Other
14-IS	☐ Yes	☐ No	☐ Other
14-S	☐ Yes	☐ No	☐ Other
14-D	☐ Yes	☐ No	☐ Other
15-IS	☐ Yes	☐ No	☐ Other
15-S	☐ Yes	☐ No	☐ Other
15-D	☐ Yes	☐ No	☐ Other
16-IS	☐ Yes	☐ No	☐ Other
16-S	☐ Yes	☐ No	☐ Other
16-D	☐ Yes	☐ No	☐ Other
17-S	☐ Yes	☐ No	☐ Other
17-D	☐ Yes	☐ No	☐ Other
18-S	☐ Yes	☐ No	☐ Other
19-S	☐ Yes	☐ No	☐ Other
20-S	☐ Yes	☐ No	☐ Other
21-S	☐ Yes	☐ No	☐ Other
22-S	☐ Yes	☐ No	☐ Other
23-S	☐ Yes	☐ No	☐ Other
24-S	☐ Yes	☐ No	☐ Other
25-S	☐ Yes	☐ No	☐ Other
26-S	☐ Yes	☐ No	☐ Other
27-S	☐ Yes	☐ No	☐ Other
PES-MW-1	☐ Yes	☐ No	☐ Other
PES-MW-2	☐ Yes	☐ No	☐ Other
PES-MW-5	☐ Yes	☐ No	☐ Other
PES-CW-2	☐ Yes	☐ No	☐ Other
UD-63S	☐ Yes	☐ No	☐ Other
USGS-1	☐ Yes	☐ No	☐ Other
USGS-2	☐ Yes	☐ No	☐ Other
USGS-3	☐ Yes	☐ No	☐ Other
USGS-4	☐ Yes	☐ No	☐ Other
USGS-5	☐ Yes	☐ No	☐ Other
USGS-6	☐ Yes	☐ No	☐ Other
USGS-7	☐ Yes	☐ No	☐ Other
USGS-8	☐ Yes	☐ No	☐ Other
USGS-9	☐ Yes	☐ No	☐ Other
USGS-10	☐ Yes	☐ No	☐ Other
MS-28S	☐ Yes	☐ No	☐ Other
MS-28I	☐ Yes	☐ No	☐ Other
MS-28D	☐ Yes	☐ No	☐ Other
MS-29S	☐ Yes	☐ No	☐ Other
MS-29I	☐ Yes	☐ No	☐ Other
MS-29D	☐ Yes	☐ No	☐ Other
MS-30S	☐ Yes	☐ No	☐ Other
MS-30I	☐ Yes	☐ No	☐ Other
MS-30D	☐ Yes	☐ No	☐ Other
MS-31S	☐ Yes	☐ No	☐ Other
MS-31I	☐ Yes	☐ No	☐ Other
MS-31D	☐ Yes	☐ No	☐ Other
MS-32S	☐ Yes	☐ No	☐ Other
MS-32I	☐ Yes	☐ No	☐ Other

MS-32D	☐ Yes	☐ No	☐ Other
MS-33S	☐ Yes	☐ No	☐ Other
MS-33I	☐ Yes	☐ No	☐ Other
MS-33D	☐ Yes	☐ No	☐ Other
MS-34S	☐ Yes	☐ No	☐ Other
MS-34I	☐ Yes	☐ No	☐ Other
MS-34D	☐ Yes	☐ No	☐ Other
MS-35S	☐ Yes	☐ No	☐ Other
MS-35I	☐ Yes	☐ No	☐ Other
MS-35D	☐ Yes	☐ No	☐ Other
MS-36S	☐ Yes	☐ No	☐ Other
MS-36I	☐ Yes	☐ No	☐ Other
MS-36D	☐ Yes	☐ No	☐ Other
MS-37S	☐ Yes	☐ No	☐ Other
MS-38S	☐ Yes	☐ No	☐ Other
MS-39S	☐ Yes	☐ No	☐ Other
MS-40I	☐ Yes	☐ No	☐ Other
MS-40D	☐ Yes	☐ No	☐ Other
MS-40S	☐ Yes	☐ No	☐ Other
MS-41D	☐ Yes	☐ No	☐ Other
MS-41S	☐ Yes	☐ No	☐ Other
MS-41I	☐ Yes	☐ No	☐ Other
MS-42I	☐ Yes	☐ No	☐ Other
MS-43S	☐ Yes	☐ No	☐ Other
MS-43I	☐ Yes	☐ No	☐ Other
MS-43D	☐ Yes	☐ No	☐ Other
MS-44S	☐ Yes	☐ No	☐ Other
MS-44I	☐ Yes	☐ No	☐ Other
MS-44D	☐ Yes	☐ No	☐ Other
MS-45S	☐ Yes	☐ No	☐ Other
MS-45I	☐ Yes	☐ No	☐ Other
MS-46S	☐ Yes	☐ No	☐ Other
MS-46I	☐ Yes	☐ No	☐ Other
MS-47S	☐ Yes	☐ No	☐ Other
MS-47I	☐ Yes	☐ No	☐ Other
MS-47D	☐ Yes	☐ No	☐ Other
MS-48PC	☐ Yes	☐ No	☐ Other
MS-49S	☐ Yes	☐ No	☐ Other
MS-49I	☐ Yes	☐ No	☐ Other
MS-49D	☐ Yes	☐ No	☐ Other
MS-50PC	☐ Yes	☐ No	☐ Other
MS-51I	☐ Yes	☐ No	☐ Other
MS-52S	☐ Yes	☐ No	☐ Other
MS-52I	☐ Yes	☐ No	☐ Other
MS-52D	☐ Yes	☐ No	☐ Other
MS-53PC	☐ Yes	☐ No	☐ Other
MS-54S	☐ Yes	☐ No	☐ Other
MS-54I	☐ Yes	☐ No	☐ Other
MS-55I	☐ Yes	☐ No	☐ Other
MS-56S	☐ Yes	☐ No	☐ Other
MS-56I	☐ Yes	☐ No	☐ Other

Extraction Wells

AT-3A	☐ Yes	☐ No	☒ Other – Abandoned in 2012
AT-5A	☒ Yes	☐ No	☐ Other
AT-5B	☒ Yes	☐ No	☐ Other
AT-7	☒ Yes	☐ No	☐ Other
AT-8	☒ Yes	☐ No	☐ Other
AT-9	☒ Yes	☐ No	☐ Other
AT-10	☒ Yes	☐ No	☐ Other
AT-11	☒ Yes	☐ No	☐ Other
AT-12	☒ Yes	☐ No	☐ Other
AT-13	☒ Yes	☐ No	☐ Other

Supplemental Information for Five-Year Review Site Inspection

Information from Records of Decision

OU1 (Groundwater)

The remedial action specified in the Record of Decision for Ground Water Remediation, Administrative Record N91192_000078, dated September 28, 1990 (OU1 ROD) was 'hydraulic containment and recovery of all future migration of contamination groundwater from the NIROP and the recovery, to the extent feasible, of groundwater contamination downgradient of the NIROP.'

The selected remedy included the installation and operation of groundwater containment and extraction wells with a two-phased plan for disposal of groundwater from the well system. Under Phase I, groundwater from the extraction system was discharged to an existing sanitary sewer system for treatment at a local wastewater treatment facility. Under Phase II, a groundwater treatment system was constructed and is being operated to provide longer-term groundwater treatment. Treated groundwater from the on-site treatment facility is discharged to the Mississippi River through a National Pollutant Discharge Elimination System (NPDES)/State Disposal System (SDS) permitted outfall (Outfall 020) (i.e., NPDES/SDS Permit MN0000710).

No air emission controls were required for the air strippers. Site-specific air emission rates (AERs) were calculated for carcinogenic compounds that could potentially be emitted from operation of the groundwater treatment facility. "Any system modifications are subject to permit approval and can result in permit modifications. These permit modifications could result in modified AERs."

According to the Five Year Review Report, dated November 13, 1998 (1998 FYR), the remedial objectives include:

- Installation and operation of a groundwater containment and recovery system to hydraulically contain TCE contaminated groundwater to prevent further migration and to ultimately restore groundwater quality in the aquifer to MCLs.
- Installation and operation of a groundwater containment and recovery system to recover, to the extent feasible, TCE contaminated groundwater beneath Anoka County Park.

OU2/OU3 (Soil)

The remedial action specified in the Record of Decision for Operable Unit (OU) 2 and Operable Unit (OU) 3, Administrative Record N91192_000661, dated August 2003 (OU2/OU3 ROD) was Land Use Controls (LUCs) consisting of both engineering controls and institutional controls. The LUC performance objectives are:

- To restrict the use of the Property to industrial or restricted commercial use, until and unless EPA and MPCA determine that concentrations of hazardous substances in the soils have been reduced to levels that allow for a less restrictive use.
- To prohibit the disturbance of soils deeper than 3 feet below ground surface in those Designated Restricted Areas shown in Figure 2-5 or the removal of any soils excavated in those Areas from the facility without the prior written approval of the U.S. EPA and MPCA.
- To prohibit the disturbance of soils beneath the Designated Restricted Area known as the concrete pit foundations where metal-finishing operations previously occurred at the former Plating Shop within the Main Manufacturing Building without the prior written approval of the U.S. EPA and MPCA.
- To ensure that the concrete pit floor (approximately 8 to 12 feet below grade floor) where metal finishing operations previously occurred at the former Plating Shop within the Main Manufacturing Building is not removed without the prior written approval of U.S. EPA and MPCA. That floor will serve as an Engineering Control.

<u>Information from Comprehensive Five-Year Review Guidance, EPA 540-R-01-007, dated June 2001 (FYR Guidance)</u>

Technical Assessment Questions

Question A: Is the remedy functioning as intended by the decision document?

Question B: Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives (RAOs) used at the time of the remedy still valid?

Question C: Has any other information come to light that could call into question the protectiveness of the remedy?

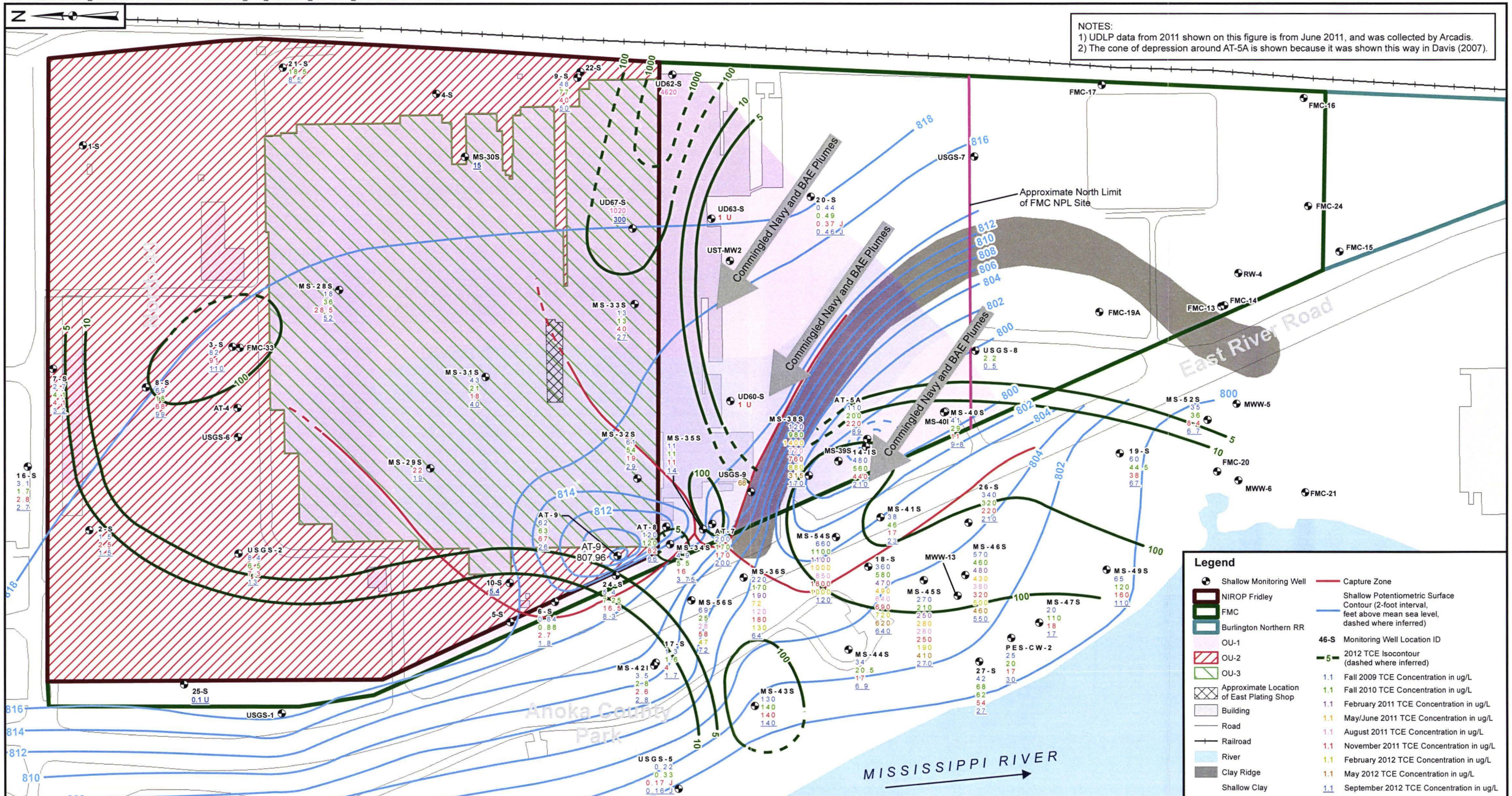
ATTACHMENT 3

TCE ISOCONCENTRATION MAPS AND APPROXIMATE CAPTURE ZONE CONFIGURATIONS

FIGURES WERE DEVELOPED FROM DATA COLLECTED DURING THE AUGUST 2012 ANNUAL SAMPLING EVENT

PGH P:\GIS\FRIDLEY_NIROP\MAPDOCS\MXD\2012 AMR\2012_TCE_SHALLOW_CAPTURE_ZONE.MXD 09/18/13 JEE

NOTES:
1) UDLP data from 2011 shown on this figure is from June 2011, and was collected by Arcadis.
2) The cone of depression around AT-5A is shown because it was shown this way in Davis (2007).



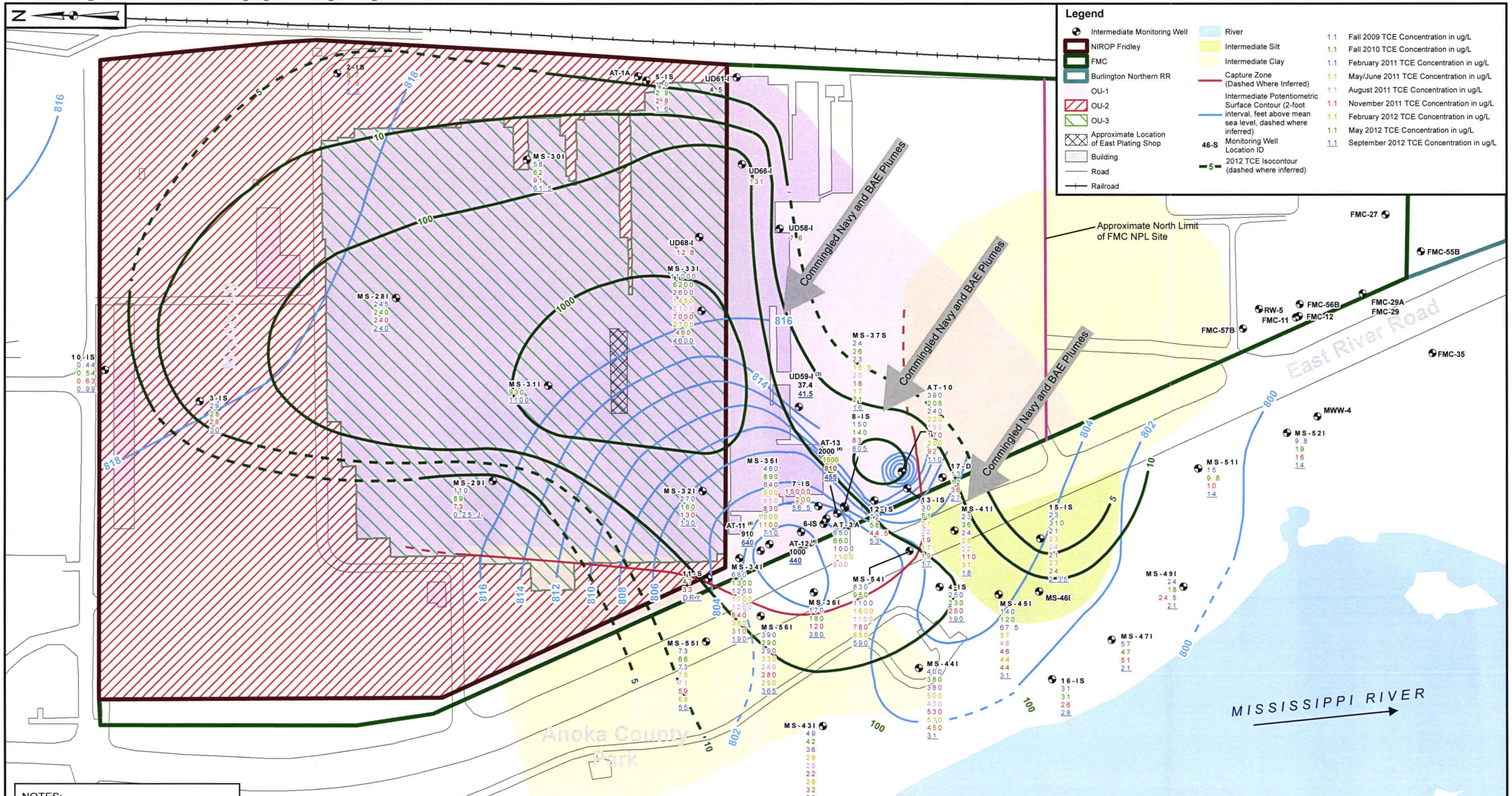
DRAWN BY	DATE
J. ENGLISH	09/27/12
CHECKED BY	DATE
S. WARINO	09/18/13
REVISED BY	DATE
J. ENGLISH	09/18/13
SCALE	
AS NOTED	

NAVFAC

APPROXIMATE CAPTURE ZONE CONFIGURATIONS
UNDER PUMPING CONDITIONS
SHALLOW ZONE EXTRACTION WELLS
2012 ANNUAL MONITORING REPORT
NIROP FRIDLEY, MINNESOTA

CONTRACT NUMBER	CTO NUMBER
2583	F27C
APPROVED BY	DATE
—	—
APPROVED BY	DATE
FIGURE NO. 1	REV 0

PGH P:\GIS\FRIDLEY_NIROP\MAPDOCS\MXD\2012 AMR\2012_TCE_INTERMEDIATE_CAPTURE_ZONE.MXD 09/18/13 JEE



NOTES:
1) UDLP data shown on this figure is from June 2011, and was collected by Arcadis.
2) Data for UD59-I is from October 2010.
3) Data for AT-11, AT-12, AT-13 from CH2M Hill Pump Test Report, June 2012.

300 0 300 Feet

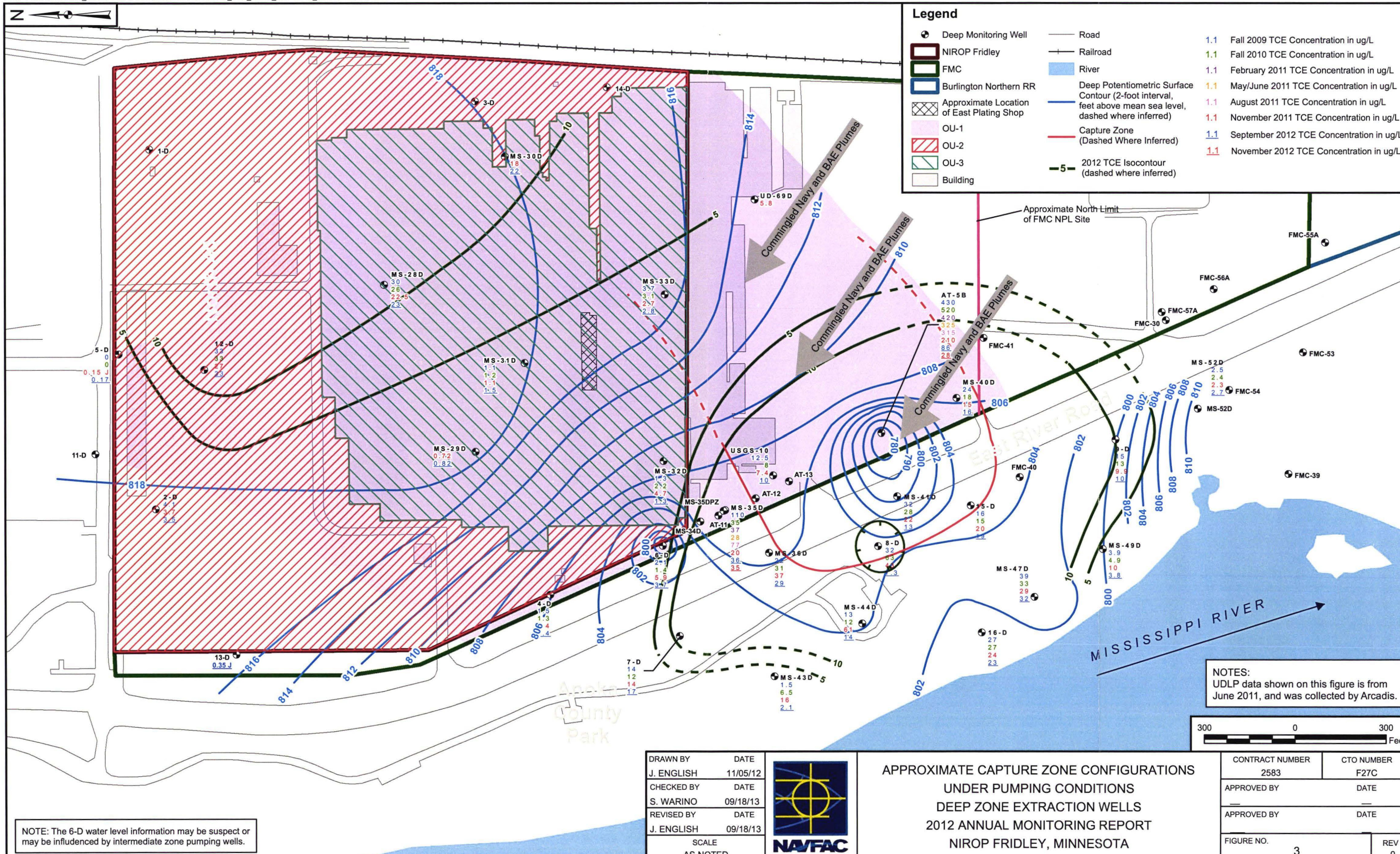
DRAWN BY	DATE
J. ENGLISH	09/27/12
CHECKED BY	DATE
S. WARINO	09/18/13
REVISED BY	DATE
J. ENGLISH	09/18/13
SCALE AS NOTED	

NAVFAC

APPROXIMATE CAPTURE ZONE CONFIGURATIONS
UNDER PUMPING CONDITIONS
INTERMEDIATE ZONE EXTRACTION WELLS
2012 ANNUAL MONITORING REPORT
NIROP FRIDLEY, MINNESOTA

CONTRACT NUMBER	CTO NUMBER
2583	F27C
APPROVED BY	DATE
APPROVED BY	DATE
FIGURE NO. 2	REV 0

PGH P:\GIS\FRIDLEY_NIROP\MAPDOCS\MXD\2012 AMR\2012_TCE_DEEP_CAPTURE_ZONE.MXD 09/18/13 JEE



Legend

- Deep Monitoring Well
- NIROP Fridley
- FMC
- Burlington Northern RR
- Approximate Location of East Plating Shop
- OU-1
- OU-2
- OU-3
- Building
- Road
- Railroad
- River
- Deep Potentiometric Surface Contour (2-foot interval, feet above mean sea level, dashed where inferred)
- Capture Zone (Dashed Where Inferred)
- 5 — 2012 TCE Isocontour (dashed where inferred)
- 1.1 Fall 2009 TCE Concentration in ug/L
- 1.1 Fall 2010 TCE Concentration in ug/L
- 1.1 February 2011 TCE Concentration in ug/L
- 1.1 May/June 2011 TCE Concentration in ug/L
- 1.1 August 2011 TCE Concentration in ug/L
- 1.1 November 2011 TCE Concentration in ug/L
- 1.1 September 2012 TCE Concentration in ug/L
- 1.1 November 2012 TCE Concentration in ug/L

NOTES:
UDLP data shown on this figure is from June 2011, and was collected by Arcadis.

300 0 300 Feet

NOTE: The 6-D water level information may be suspect or may be influenced by intermediate zone pumping wells.

DRAWN BY	DATE
J. ENGLISH	11/05/12
CHECKED BY	DATE
S. WARINO	09/18/13
REVISED BY	DATE
J. ENGLISH	09/18/13
SCALE AS NOTED	

NAVFAC

APPROXIMATE CAPTURE ZONE CONFIGURATIONS
UNDER PUMPING CONDITIONS
DEEP ZONE EXTRACTION WELLS
2012 ANNUAL MONITORING REPORT
NIROP FRIDLEY, MINNESOTA

CONTRACT NUMBER	CTO NUMBER
2583	F27C
APPROVED BY	DATE
APPROVED BY	DATE
FIGURE NO. 3	REV 0

PGH P:\GIS\FRIDLEY_NIROP\MAPDOCS\MXD\2012 AMR\2012_TCE_CONTOURS_BEDROCK.MXD 09/18/13 JEE

DRAWN BY	DATE
J. ENGLISH	11/05/12
CHECKED BY	DATE
S. WARINO	09/18/13
REVISED BY	DATE
J. ENGLISH	09/18/13
SCALE	
AS NOTED	

NAVFAC

AUGUST AND SEPTEMBER 2012 TCE CONCENTRATIONS
AND POTENTIOMETRIC SURFACE
BEDROCK WELLS
2012 ANNUAL MONITORING REPORT
NIROP FRIDLEY, MINNESOTA

CONTRACT NUMBER	CTO NUMBER
2583	F27C
APPROVED BY	DATE
APPROVED BY	DATE
FIGURE NO. 4	REV 0

ATTACHMENT 4

JOHNSON-ETTINGER MODEL RESULTS

DATA ENTRY SHEET

GW-ADV
Version 3.1; 02/04

Reset to

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION (enter "X" in "YES" box and initial groundwater conc. below)

YES [X]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial groundwater conc., C_W (μg/L)	Chemical
79016	1.80E+03	Trichloroethylene

MORE ↓

ENTER Average soil/ groundwater temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to water table, L_{WT} (cm)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum directly above water table, (Enter A, B, or C)	ENTER SCS soil type directly above water table	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
			Totals must add up to value of L_{WT} (cell G28)							
10	30	580	580	0	0	A	S			1.00E-08

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm^3)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm^3/cm^3)	ENTER Stratum B SCS soil type (Lookup Soil)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm^3)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm^3/cm^3)	ENTER Stratum C SCS soil type (Lookup Soil)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm^3)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm^3/cm^3)
S	1.66	0.375	0.054	C	1.43	0.459	0.215	C	1.43	0.459	0.215

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s²)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	36576	51206	366	0.1	1	

MORE ↓

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	30	30	350	1.0E-06	1

Used to calculate risk-based groundwater concentration.

END

INTERMEDIATE CALCULATIONS SHEET

Exposure duration, τ (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, θ_a^A (cm^3/cm^3)	Stratum B soil air-filled porosity, θ_a^B (cm^3/cm^3)	Stratum C soil air-filled porosity, θ_a^C (cm^3/cm^3)	Stratum A effective total fluid saturation, S_{te} (cm^3/cm^3)	Stratum A soil intrinsic permeability, k_i (cm^2)	Stratum A soil relative air permeability, k_{rg} (cm^2)	Stratum A soil effective vapor permeability, k_v (cm^2)	Thickness of capillary zone, L_{cz} (cm)	Total porosity in capillary zone, n_{cz} (cm^3/cm^3)	Air-filled porosity in capillary zone, $\theta_{a,cz}$ (cm^3/cm^3)	Water-filled porosity in capillary zone, $\theta_{w,cz}$ (cm^3/cm^3)	Floor-wall seam perimeter, X_{crack} (cm)
9.46E+08	550	0.321	0.244	0.244	#N/A	#N/A	#N/A	1.00E-08	17.05	0.375	0.122	0.253	175,564

Bldg. ventilation rate, $Q_{building}$ (cm^3/s)	Area of enclosed space below grade, A_B (cm^2)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. groundwater temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. groundwater temperature, H_{TS} (atm-m^3/mol)	Henry's law constant at ave. groundwater temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm^2/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm^2/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm^2/s)	Capillary zone effective diffusion coefficient, D^{eff}_{cz} (cm^2/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm^2/s)	Diffusion path length, L_d (cm)
1.90E+08	1.88E+09	9.35E-06	30	8,557	4.78E-03	2.06E-01	1.75E-04	1.28E-02	0.00E+00	0.00E+00	5.09E-04	7.31E-03	550

Convection path length, L_p (cm)	Source vapor conc., C_{source} (μg/m^3)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm^3/s)	Crack effective diffusion coefficient, D^{crack} (cm^2/s)	Area of crack, A_{crack} (cm^2)	Exponent of equivalent foundation Peclet number, exp(Pe^f) (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc., $C_{building}$ (μg/m^3)	Unit risk factor, URF (μg/m^3)$^{-1}$	Reference conc., RfC (mg/m^3)
30	3.70E+05	0.10	3.93E+02	1.28E-02	1.76E+04	4.14E+07	2.03E-06	7.53E-01	1.1E-04	4.0E-02

END

Industrial Risks Associated with Maximum Detected Concentrations of VOCs in Surface Soil

VOC	Soil (0 to 4 ft) Maximum (ug/Kg)	J-E Model Indoor Air (ug/m^3)	IND EC (ug/m^3) CARC[1]	IND EC (ug/m^3) NONCARC[2]	IND RSLS (ug/m^3) CARC	IND RSLS (ug/m^3) NONCARC	IND RISKS CARC[3]	IND RISKS NONCARC[4]
1,1,1-Trichloroethane	28	1.18E-01	9.62E-03	2.69E-02	NA	22000	NA	1.2E-06
1,1,2-Trichloroethane	NA	NA	NA	NA	0.77	0.88	NA	NA
1,1-Dichloroethane	5.5	2.32E-02	1.89E-03	5.30E-03	7.7	NA	2.5E-10	NA
1,2-Dichloroethene (Total)	15	6.33E-02	5.16E-03	1.45E-02	NA	260	NA	5.6E-05
2-Butanone	210	1.28E-01	1.04E-02	2.92E-02	NA	22000	NA	1.3E-06
4-Methyl-2-Pentanone	120	1.15E-01	9.38E-03	2.63E-02	NA	13000	NA	2.0E-06
Acetone	NA	NA	NA	NA	NA	140000	NA	NA
Benzene	NA	NA	NA	NA	1.6	130	NA	NA
Bromomethane	2	8.45E-03	6.89E-04	1.93E-03	NA	220	NA	8.8E-06
Carbon Disulfide	13	5.49E-02	4.48E-03	1.25E-02	NA	3100	NA	4.0E-06
Ethylbenzene	19	6.54E-02	5.33E-03	1.49E-02	4.9	4400	1.1E-09	3.4E-06
Styrene	54	3.15E-02	2.57E-03	7.19E-03	NA	4400	NA	1.6E-06
Tetrachloroethene	90	3.80E-01	3.10E-02	8.68E-02	47	180	6.6E-10	4.8E-04
Toluene	14	5.91E-02	4.82E-03	1.35E-02	NA	22000	NA	6.1E-07
Trichloroethene	640	2.70E+00	2.20E-01	6.16E-01	3	8.8	7.3E-08	7.0E-02
Xylene	71	2.20E-01	1.79E-02	5.02E-02	NA	440	NA	1.1E-04
						TOTAL	**7.5E-08**	**7.1E-02**

NA - Not Available
VOC - Volatile Organic Compound
IND - Industrial
RSL - EPA Regional Scrreening Level (May 2013)
EC - Exposure Concentration
CARC - Carcinogenic
NONCARC - Noncarcinogenic

[1]CARC IND EC = Indoor Air Concentration * (8 hr/24 hr) * (250 days/365 days) * (25 yr/70 yr)

[2]NONCARC IND EC = Indoor Air Concentration * (8 hr/24 hr) * (250 days/365 days) * (25 yr/25 yr)

[3]CAR IND RISK = IND EC * 1 x 10^{-6} / IND CARC RSL (Incremental Lifetime Cancer Risk)

[4]NONCARC IND RISK = IND EC / IND NONCARC RSL (Hazard Quotient)

Industrial Risks Associated with Maximum Detected Concentrations of VOCs in Subsurface Soil (4 to 8 ft)

VOC	Soil (4 to 8 ft)	J-E Model	IND EC (ug/m^3)		IND RSLS (ug/m^3)		IND RISKS	
	Maximum (ug/Kg)	Indoor Air (ug/m3)	CARC[1]	NONCARC[2]	CARC	NONCARC	CARC[3]	NONCARC[4]
1,1,1-Trichloroethane	2	0.00422	3.44E-04	9.63E-04	NA	22000	NA	4.4E-08
1,1,2-Trichloroethane	9	0.019	1.55E-03	4.34E-03	0.77	0.88	2.0E-09	4.9E-03
1,1-Dichloroethane	NA	NA	NA	NA	7.7	NA	NA	NA
1,2-Dichloroethene (Total)	26	0.0549	4.48E-03	1.25E-02	NA	260	NA	4.8E-05
2-Butanone	87	0.052	4.24E-03	1.19E-02	NA	22000	NA	5.4E-07
4-Methyl-2-Pentanone	150	0.141	1.15E-02	3.22E-02	NA	13000	NA	2.5E-06
Acetone	460	0.23	1.88E-02	5.25E-02	NA	140000	NA	3.8E-07
Benzene	1	0.00211	1.72E-04	4.82E-04	1.6	130	1.1E-10	3.7E-06
Bromomethane	1	0.00211	1.72E-04	4.82E-04	NA	220	NA	2.2E-06
Carbon Disulfide	14	0.0296	2.41E-03	6.76E-03	NA	3100	NA	2.2E-06
Ethylbenzene	8	0.0169	1.38E-03	3.86E-03	4.9	4400	2.8E-10	8.8E-07
Styrene	1	0.000572	4.66E-05	1.31E-04	NA	4400	NA	3.0E-08
Tetrachloroethene	760	1.6	1.30E-01	3.65E-01	47	180	2.8E-09	2.0E-03
Toluene	13	0.0274	2.23E-03	6.26E-03	NA	22000	NA	2.8E-07
Trichloroethene	770	1.63	1.33E-01	3.72E-01	3	8.8	4.4E-08	4.2E-02
Xylene	54	0.114	9.30E-03	2.60E-02	NA	440	NA	5.9E-05

TOTAL	**4.9E-08**	**4.9E-02**

NA - Not Available
VOC - Volatile Organic Compound
IND - Industrial
EC - Exposure Concentration
CARC - Carcinogenic
NONCARC - Noncarcinogenic

[1]CARC IND EC = Indoor Air Concentration * (8 hr/24 hr) * (250 days/365 days) * (25 yr/70 yr)
[2]NONCARC IND EC = Indoor Air Concentration * (8 hr/24 hr) * (250 days/365 days) * (25 yr/25 yr)
[3]CAR IND RISK = IND EC * 1 x 10^{-6} / IND CARC RSL (Incremental Lifetime Cancer Risk)
[4]NONCARC IND RISK = IND EC / IND NONCARC RSL (Hazard Quotient)

Industrial Risks Associated with Maximum Detected Concentrations of VOCs in Subsurface Soil (8 to 12 ft)

COPC	Soil (0 to 4') Maximum (ug/Kg)	J-E Model Indoor Air (ug/m3)	IND EC (ug/m^3) CARC[1]	NONCARC[2]	IND RSLS (ug/m^3) CARC	NONCARC	IND RISKS CARC[3]	NONCARC[4]
1,1,1-Trichloroethane	1	0.00156	1.27E-04	3.56E-04	NA	22000	NA	1.6E-08
1,1,2-Trichloroethane	NA	NA	NA	NA	0.77	0.88	NA	NA
1,1-Dichloroethane	11	0.0171	1.39E-03	3.90E-03	7.7	NA	1.8E-10	NA
1,2-Dichloroethene (Total)	15000	23.4	1.91E+00	5.34E+00	NA	260	NA	2.1E-02
2-Butanone	41	0.024	1.96E-03	5.48E-03	NA	22000	NA	2.5E-07
4-Methyl-2-Pentanone	84	0.0776	6.33E-03	1.77E-02	NA	13000	NA	1.4E-06
Acetone	1700	0.84	6.85E-02	1.92E-01	NA	140000	NA	1.4E-06
Benzene	24	0.0374	3.05E-03	8.54E-03	1.6	130	1.9E-09	6.6E-05
Bromomethane	2	0.0312	2.54E-03	7.12E-03	NA	220	NA	3.2E-05
Carbon Disulfide	11	0.0171	1.39E-03	3.90E-03	NA	3100	NA	1.3E-06
Ethylbenzene	720	1.12	9.13E-02	2.56E-01	4.9	4400	1.9E-08	5.8E-05
Styrene	NA	NA	NA	NA	NA	4400	NA	NA
Tetrachloroethene	390	0.607	4.95E-02	1.39E-01	47	180	1.1E-09	7.7E-04
Toluene	1000	1.56	1.27E-01	3.56E-01	NA	22000	NA	1.6E-05
Trichloroethene	1100	1.71	1.39E-01	3.90E-01	3	8.8	4.6E-08	4.4E-02
Xylene	7300	11.4	9.30E-01	2.60E+00	NA	440	NA	5.9E-03
						TOTAL	**6.8E-08**	**7.2E-02**

NA - Not Available
VOC - Volatile Organic Compound
IND - Industrial
EC - Exposure Concentration
CARC - Carcinogenic
NONCARC - Noncarcinogenic

[1]CARC IND EC = Indoor Air Concentration * (8 hr/24 hr) * (250 days/365 days) * (25 yr/70 yr)
[2]NONCARC IND EC = Indoor Air Concentration * (8 hr/24 hr) * (250 days/365 days) * (25 yr/25 yr)
[3]CAR IND RISK = IND EC * 1 x 10^{-6} / IND CARC RSL (Incremental Lifetime Cancer Risk)
[4]NONCARC IND RISK = IND EC / IND NONCARC RSL (Hazard Quotient)

Summary of Vapor Intrusion Risks (Industrial Exposure) - Maximum Risks

VOC	SURFACE SOIL		4 TO 8 FT		8 TO 12 FT		MAXIMUM RISKS[1]	
	CANCER	NONCANCER	CANCER	NONCANCER	CANCER	NONCANCER	CANCER	NONCANCER
1,1,1-Trichloroethane	NA	1.2E-06	NA	4.4E-08	NA	1.6E-08	NA	1.2E-06
1,1,2-Trichloroethane	NA	NA	2.0E-09	4.9E-03	NA	NA	2.0E-09	4.9E-03
1,1-Dichloroethane	2.5E-10	NA	NA	NA	1.8E-10	NA	2.5E-10	NA
1,2-Dichloroethene (Total)	NA	5.6E-05	NA	4.8E-05	NA	2.1E-02	NA	2.1E-02
2-Butanone	NA	1.3E-06	NA	5.4E-07	NA	2.5E-07	NA	1.3E-06
2-Hexanone	NA	NA	NA	NA	NA	NA	NA	NA
4-Methyl-2-Pentanone	NA	2.0E-06	NA	2.5E-06	NA	1.4E-06	NA	2.5E-06
Acetone	NA	NA	NA	3.8E-07	NA	1.4E-06	NA	1.4E-06
Benzene	NA	NA	1.1E-10	3.7E-06	1.9E-09	6.6E-05	1.9E-09	6.6E-05
Bromomethane	NA	8.8E-06	NA	2.2E-06	NA	3.2E-05	NA	3.2E-05
Carbon Disulfide	NA	4.0E-06	NA	2.2E-06	NA	1.3E-06	NA	4.0E-06
Chorobenzene	NA	NA	NA	NA	NA	NA	NA	0.0E+00
Chloromethane	NA	NA	NA	NA	NA	NA	NA	0.0E+00
Ethylbenzene	1.1E-09	3.4E-06	2.8E-10	8.8E-07	1.9E-08	5.8E-05	1.9E-08	5.8E-05
Styrene	NA	1.6E-06	NA	3.0E-08	NA	NA	NA	1.6E-06
Tetrachloroethene	6.6E-10	4.8E-04	2.8E-09	2.0E-03	1.1E-09	7.7E-04	2.8E-09	2.0E-03
Toluene	NA	6.1E-07	NA	2.8E-07	NA	1.6E-05	NA	1.6E-05
Trichloroethene	7.3E-08	7.0E-02	4.4E-08	4.2E-02	4.6E-08	4.4E-02	7.3E-08	7.0E-02
Xylene	NA	1.1E-04	NA	5.9E-05	NA	5.9E-03	NA	5.9E-03

TOTAL	**9.9E-08**	**1.0E-01**

NA - Not Available
VOC - Volatile Organic Compound

[1]Maximum Risk of each depth interval for each VOC

DATA ENTRY SHEET

SL-ADV
Version 3.1; 02/04

Reset to

CALCULATE RISK-BASED SOIL CONCENTRATION (enter "X" in "YES" box)

1,1,1-TRICHLOROETHANE SURFACE (0 TO 4 FT) MAXIMUM AND EPC

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL SOIL CONCENTRATION (enter "X" in "YES" box and initial soil conc. below)

YES [x]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial soil conc., C_R (μg/kg)	Chemical
71556	2.80E+01	1,1,1-Trichloroethane

MORE ↓

ENTER Average soil temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to top of contamination, L_t (cm)	ENTER Depth below grade to bottom of contamination, (enter value of 0 if value is unknown) L_b (cm)	ENTER (Totals must add up to value of L_t (cell G28)) Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm²)
10	30	122	366	122	0	0	S		

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm³)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm³/cm³)	ENTER Stratum A soil organic carbon fraction, f_{oc}^A (unitless)	ENTER Stratum B SCS soil type (Lookup Soil)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm³)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm³/cm³)	ENTER Stratum B soil organic carbon fraction, f_{oc}^B (unitless)	ENTER Stratum C SCS soil type (Lookup Soil)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm³)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm³/cm³)	ENTER Stratum C soil organic carbon fraction, f_{oc}^C (unitless)
S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s²)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	36576	51206	366	0.1	1	

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	30	30	350	1.0E-06	1

Used to calculate risk-based soil concentration.

END

INTERMEDIATE CALCULATIONS SHEET

1,1,1-TRICHLOROETHANE SURFACE (0 TO 4 FT) MAXIMUM AND EPC

Exposure duration, τ (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, θ_a^A (cm^3/cm^3)	Stratum B soil air-filled porosity, θ_a^B (cm^3/cm^3)	Stratum C soil air-filled porosity, θ_a^C (cm^3/cm^3)	Stratum A effective total fluid saturation, S_{te} (cm^3/cm^3)	Stratum A soil intrinsic permeability, k_i (cm^2)	Stratum A soil relative air permeability, k_{rg} (cm^2)	Stratum A soil effective vapor permeability, k_v (cm^2)	Floor-wall seam perimeter, X_{crack} (cm)	Initial soil concentration used, C_R (µg/kg)	Bldg. ventilation rate, $Q_{building}$ (cm^3/s)
9.46E+08	92	0.321	0.321	0.321	0.003	9.92E-08	0.998	9.91E-08	175,564	2.80E+01	1.90E+08

Area of enclosed space below grade, A_B (cm^2)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. soil temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. soil temperature, H_{TS} (atm-m^3/mol)	Henry's law constant at ave. soil temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm^2/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm^2/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm^2/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm^2/s)	Diffusion path length, L_d (cm)	Convection path length, L_p (cm)
1.88E+09	9.35E-06	30	7,885	8.48E-03	3.65E-01	1.75E-04	1.26E-02	0.00E+00	0.00E+00	1.26E-02	92	30

Soil-water partition coefficient, K_d (cm^3/g)	Source vapor conc., C_{source} (µg/m^3)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm^3/s)	Crack effective diffusion coefficient, D^{crack} (cm^2/s)	Area of crack, A_{crack} (cm^2)	Exponent of equivalent foundation Peclet number, $\exp(Pe^f)$ (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc., $C_{building}$ (µg/m^3)	Finite source β term (unitless)	Finite source ψ term $(sec)^{-1}$	Time for source depletion, τ_D (sec)	Exposure duration > time for source depletion (YES/NO)
2.20E-01	3.16E+04	0.10	3.90E+03	1.26E-02	1.76E+04	2.61E+76	NA	NA	6.71E+01	1.01E-06	1.79E+08	YES

Finite source indoor attenuation coefficient, <α> (unitless)	Mass limit bldg. conc., $C_{building}$ (µg/m^3)	Finite source bldg. conc., $C_{building}$ (µg/m^3)	Final finite source bldg. conc., $C_{building}$ (µg/m^3)	Unit risk factor, URF $(\mu g/m^3)^{-1}$	Reference conc., RfC (mg/m^3)
NA	1.18E-01	NA	1.18E-01	NA	2.2E+00

END

DATA ENTRY SHEET

SL-ADV
Version 3.1; 02/04

Reset to

CALCULATE RISK-BASED SOIL CONCENTRATION (enter "X" in "YES" box)

1,1-DICHLOROETHANE SURFACE (0 TO 4 FT) MAXIMUM AND EPC

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL SOIL CONCENTRATION (enter "X" in "YES" box and initial soil conc. below)

YES [X]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial soil conc., C_R (μg/kg)	Chemical
75343	5.50E+00	1,1-Dichloroethane

MORE ↓

ENTER Average soil temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to top of contamination, L_t (cm)	ENTER Depth below grade to bottom of contamination, (enter value of 0 if value is unknown) L_b (cm)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
10	30	122	366	122	0	0	S		

Totals must add up to value of L_t (cell G28) (applies to thickness of soil strata A, B and C)

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm^3)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm^3/cm^3)	ENTER Stratum A soil organic carbon fraction, f_{oc}^A (unitless)	ENTER Stratum B SCS soil type (Lookup Soil)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm^3)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm^3/cm^3)	ENTER Stratum B soil organic carbon fraction, f_{oc}^B (unitless)	ENTER Stratum C SCS soil type (Lookup Soil)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm^3)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm^3/cm^3)	ENTER Stratum C soil organic carbon fraction, f_{oc}^C (unitless)
S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s^2)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	36576	51206	366	0.1	1	

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	30	30	350	1.0E-06	1

Used to calculate risk-based soil concentration. (applies to TR and THQ)

END

1,1-DICHLOROETHANE SURFACE (0 TO 4 FT) MAXIMUM AND EPC

Exposure duration, τ (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, θ_a^A (cm³/cm³)	Stratum B soil air-filled porosity, θ_a^B (cm³/cm³)	Stratum C soil air-filled porosity, θ_a^C (cm³/cm³)	Stratum A effective total fluid saturation, S_{te} (cm³/cm³)	Stratum A soil intrinsic permeability, k_i (cm²)	Stratum A soil relative air permeability, k_{rg} (cm²)	Stratum A soil effective vapor permeability, k_v (cm²)	Floor-wall seam perimeter, X_{crack} (cm)	Initial soil concentration used, C_R (μg/kg)	Bldg. ventilation rate, $Q_{building}$ (cm³/s)
9.46E+08	92	0.321	0.321	0.321	0.003	9.92E-08	0.998	9.91E-08	175,564	5.50E+00	1.90E+08

Area of enclosed space below grade, A_B (cm²)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. soil temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. soil temperature, H_{TS} (atm-m³/mol)	Henry's law constant at ave. soil temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm²/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm²/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm²/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm²/s)	Diffusion path length, L_d (cm)	Convection path length, L_p (cm)
1.88E+09	9.35E-06	30	7,450	2.88E-03	1.24E-01	1.75E-04	1.20E-02	0.00E+00	0.00E+00	1.20E-02	92	30

Soil-water partition coefficient, K_d (cm³/g)	Source vapor conc., C_{source} (μg/m³)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm³/s)	Crack effective diffusion coefficient, D^{crack} (cm²/s)	Area of crack, A_{crack} (cm²)	Exponent of equivalent foundation Peclet number, $\exp(Pe^f)$ (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc., $C_{building}$ (μg/m³)	Finite source β term (unitless)	Finite source ψ term (sec)⁻¹	Time for source depletion, τ_D (sec)	Exposure duration > time for source depletion (YES/NO)
6.32E-02	5.69E+03	0.10	3.90E+03	1.20E-02	1.76E+04	2.14E+80	NA	NA	6.39E+01	8.84E-07	1.96E+08	YES

Finite source indoor attenuation coefficient, <α> (unitless)	Mass limit bldg. conc., $C_{building}$ (μg/m³)	Finite source bldg. conc., $C_{building}$ (μg/m³)	Final finite source bldg. conc., $C_{building}$ (μg/m³)	Unit risk factor, URF (μg/m³)⁻¹	Reference conc., RfC (mg/m³)
NA	2.32E-02	NA	2.32E-02	NA	5.0E-01

END

SL-ADV
Version 3.1; 02/04

Reset to

CALCULATE RISK-BASED SOIL CONCENTRATION (enter "X" in "YES" box)

1,2-DICHLOROETHENE SURFACE (0 TO 4 FT) MAXIMUM AND EPC

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL SOIL CONCENTRATION (enter "X" in "YES" box and initial soil conc. below)

YES [x]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial soil conc., C_R (µg/kg)	Chemical
156605	1.50E+01	trans-1,2-Dichloroethylene

MORE ↓

ENTER Average soil temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to top of contamination, L_t (cm)	ENTER Depth below grade to bottom of contamination, (enter value of 0 if value is unknown) L_b (cm)	ENTER Totals must add up to value of L_t (cell G28) Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm²)
10	30	122	366	122	0	0	S		

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm³)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm³/cm³)	ENTER Stratum A soil organic carbon fraction, f_{oc}^A (unitless)	ENTER Stratum B SCS soil type (Lookup Soil)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm³)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm³/cm³)	ENTER Stratum B soil organic carbon fraction, f_{oc}^B (unitless)	ENTER Stratum C SCS soil type (Lookup Soil)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm³)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm³/cm³)	ENTER Stratum C soil organic carbon fraction, f_{oc}^C (unitless)
S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s²)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	36576	51206	366	0.1	1	

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	30	30	350	1.0E-06	1

Used to calculate risk-based soil concentration.

END

INTERMEDIATE CALCULATIONS SHEET

1,2-DICHLOROETHENE SURFACE (0 TO 4 FT) MAXIMUM AND EPC

Exposure duration, τ (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, θ_a^A (cm^3/cm^3)	Stratum B soil air-filled porosity, θ_a^B (cm^3/cm^3)	Stratum C soil air-filled porosity, θ_a^C (cm^3/cm^3)	Stratum A effective total fluid saturation, S_{te} (cm^3/cm^3)	Stratum A soil intrinsic permeability, k_i (cm^2)	Stratum A soil relative air permeability, k_{rg} (cm^2)	Stratum A soil effective vapor permeability, k_v (cm^2)	Floor-wall seam perimeter, X_{crack} (cm)	Initial soil concentration used, C_R ($\mu g/kg$)	Bldg. ventilation rate, $Q_{building}$ (cm^3/s)
9.46E+08	92	0.321	0.321	0.321	0.003	9.92E-08	0.998	9.91E-08	175,564	1.50E+01	1.90E+08

Area of enclosed space below grade, A_B (cm^2)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. soil temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. soil temperature, H_{TS} ($atm\text{-}m^3/mol$)	Henry's law constant at ave. soil temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm^2/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm^2/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm^2/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm^2/s)	Diffusion path length, L_d (cm)	Convection path length, L_p (cm)
1.88E+09	9.35E-06	30	7,136	4.94E-03	2.13E-01	1.75E-04	1.14E-02	0.00E+00	0.00E+00	1.14E-02	92	30

Soil-water partition coefficient, K_d (cm^3/g)	Source vapor conc., C_{source} ($\mu g/m^3$)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm^3/s)	Crack effective diffusion coefficient, D^{crack} (cm^2/s)	Area of crack, A_{crack} (cm^2)	Exponent of equivalent foundation Peclet number, $exp(Pe^f)$ (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc., $C_{building}$ ($\mu g/m^3$)	Finite source β term (unitless)	Finite source ψ term $(sec)^{-1}$	Time for source depletion, τ_D (sec)	Exposure duration > time for source depletion (YES/NO)
1.05E-01	1.79E+04	0.10	3.90E+03	1.14E-02	1.76E+04	2.03E+84	NA	NA	6.09E+01	9.69E-07	1.70E+08	YES

Finite source indoor attenuation coefficient, <α> (unitless)	Mass limit bldg. conc., $C_{building}$ ($\mu g/m^3$)	Finite source bldg. conc., $C_{building}$ ($\mu g/m^3$)	Final finite source bldg. conc., $C_{building}$ ($\mu g/m^3$)	Unit risk factor, URF $(\mu g/m^3)^{-1}$	Reference conc., RfC (mg/m^3)
NA	6.33E-02	NA	6.33E-02	NA	7.0E-02

END

SL-ADV
Version 3.1; 02/04

Reset to

CALCULATE RISK-BASED SOIL CONCENTRATION (enter "X" in "YES" box)

2-BUTANONE SURFACE (0 TO 4 FT) MAXIMUM

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL SOIL CONCENTRATION (enter "X" in "YES" box and initial soil conc. below)

YES [X]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial soil conc., C_R (μg/kg)	Chemical
78933	2.10E+02	Methylethylketone (2-butanone)

MORE ↓

ENTER Average soil temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to top of contamination, L_t (cm)	ENTER Depth below grade to bottom of contamination, (enter value of 0 if value is unknown) L_b (cm)	ENTER Totals must add up to value of L_t (cell G28) Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm²)
10	30	122	366	122	0	0	S		

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm³)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm³/cm³)	ENTER Stratum A soil organic carbon fraction, f_{oc}^A (unitless)	ENTER Stratum B SCS soil type (Lookup Soil)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm³)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm³/cm³)	ENTER Stratum B soil organic carbon fraction, f_{oc}^B (unitless)	ENTER Stratum C SCS soil type (Lookup Soil)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm³)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm³/cm³)	ENTER Stratum C soil organic carbon fraction, f_{oc}^C (unitless)
S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s²)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	36576	51206	366	0.1	1	

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	30	30	350	1.0E-06	1

Used to calculate risk-based soil concentration.

END

INTERMEDIATE CALCULATIONS SHEET

2-BUTANONE SURFACE (0 TO 4 FT) MAXIMUM

Exposure duration, τ (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, θ_a^A (cm³/cm³)	Stratum B soil air-filled porosity, θ_a^B (cm³/cm³)	Stratum C soil air-filled porosity, θ_a^C (cm³/cm³)	Stratum A effective total fluid saturation, S_{te} (cm³/cm³)	Stratum A soil intrinsic permeability, k_i (cm²)	Stratum A soil relative air permeability, k_{rg} (cm²)	Stratum A soil effective vapor permeability, k_v (cm²)	Floor-wall seam perimeter, X_{crack} (cm)	Initial soil concentration used, C_R (µg/kg)	Bldg. ventilation rate, $Q_{building}$ (cm³/s)
9.46E+08	92	0.321	0.321	0.321	0.003	9.92E-08	0.998	9.91E-08	175,564	2.10E+02	1.90E+08

Area of enclosed space below grade, A_B (cm²)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. soil temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. soil temperature, H_{TS} (atm-m³/mol)	Henry's law constant at ave. soil temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm²/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm²/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm²/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm²/s)	Diffusion path length, L_d (cm)	Convection path length, L_p (cm)
1.88E+09	9.35E-06	30	8,419	2.63E-05	1.13E-03	1.75E-04	1.31E-02	0.00E+00	0.00E+00	1.31E-02	92	30

Soil-water partition coefficient, K_d (cm³/g)	Source vapor conc., C_{source} (µg/m³)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm³/s)	Crack effective diffusion coefficient, D^{crack} (cm²/s)	Area of crack, A_{crack} (cm²)	Exponent of equivalent foundation Peclet number, $\exp(Pe^f)$ (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc., $C_{building}$ (µg/m³)	Finite source β term (unitless)	Finite source ψ term (sec)⁻¹	Time for source depletion, τ_D (sec)	Exposure duration > time for source depletion (YES/NO)
4.60E-03	6.36E+03	0.10	3.90E+03	1.31E-02	1.76E+04	5.59E+73	NA	NA	6.95E+01	2.81E-08	6.67E+09	NO

Finite source indoor attenuation coefficient, <α> (unitless)	Mass limit bldg. conc., $C_{building}$ (µg/m³)	Finite source bldg. conc., $C_{building}$ (µg/m³)	Final finite source bldg. conc., $C_{building}$ (µg/m³)	Unit risk factor, URF (µg/m³)⁻¹	Reference conc., RfC (mg/m³)
2.01E-05	NA	1.28E-01	1.28E-01	NA	5.0E+00

END

DATA ENTRY SHEET

SL-ADV
Version 3.1; 02/04

Reset to

CALCULATE RISK-BASED SOIL CONCENTRATION (enter "X" in "YES" box)

2-BUTANONE SURFACE (0 TO 4 FT) EPC

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL SOIL CONCENTRATION (enter "X" in "YES" box and initial soil conc. below)

YES [x]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial soil conc., C_R (µg/kg)	Chemical
78933	7.09E+01	Methylethylketone (2-butanone)

MORE ↓

ENTER Average soil temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to top of contamination, L_t (cm)	ENTER Depth below grade to bottom of contamination, (enter value of 0 if value is unknown) L_b (cm)	ENTER Totals must add up to value of L_t (cell G28) Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm²)
10	30	122	366	122	0	0	S		

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm³)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm³/cm³)	ENTER Stratum A soil organic carbon fraction, f_{oc}^A (unitless)	ENTER Stratum B SCS soil type (Lookup Soil)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm³)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm³/cm³)	ENTER Stratum B soil organic carbon fraction, f_{oc}^B (unitless)	ENTER Stratum C SCS soil type (Lookup Soil)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm³)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm³/cm³)	ENTER Stratum C soil organic carbon fraction, f_{oc}^C (unitless)
S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s²)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	36576	51206	366	0.1	1	

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	30	30	350	1.0E-06	1

Used to calculate risk-based soil concentration.

END

2-BUTANONE SURFACE (0 TO 4 FT) EPC

Exposure duration, τ (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, θ_a^A (cm^3/cm^3)	Stratum B soil air-filled porosity, θ_a^B (cm^3/cm^3)	Stratum C soil air-filled porosity, θ_a^C (cm^3/cm^3)	Stratum A effective total fluid saturation, S_{te} (cm^3/cm^3)	Stratum A soil intrinsic permeability, k_i (cm^2)	Stratum A soil relative air permeability, k_{rg} (cm^2)	Stratum A soil effective vapor permeability, k_v (cm^2)	Floor-wall seam perimeter, X_{crack} (cm)	Initial soil concentration used, C_R (µg/kg)	Bldg. ventilation rate, $Q_{building}$ (cm^3/s)
9.46E+08	92	0.321	0.321	0.321	0.003	9.92E-08	0.998	9.91E-08	175,564	7.09E+01	1.90E+08

Area of enclosed space below grade, A_B (cm^2)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. soil temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. soil temperature, H_{TS} (atm-m^3/mol)	Henry's law constant at ave. soil temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm^2/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm^2/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm^2/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm^2/s)	Diffusion path length, L_d (cm)	Convection path length, L_p (cm)
1.88E+09	9.35E-06	30	8,419	2.63E-05	1.13E-03	1.75E-04	1.31E-02	0.00E+00	0.00E+00	1.31E-02	92	30

Soil-water partition coefficient, K_d (cm^3/g)	Source vapor conc., C_{source} (µg/m^3)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm^3/s)	Crack effective diffusion coefficient, D^{crack} (cm^2/s)	Area of crack, A_{crack} (cm^2)	Exponent of equivalent foundation Peclet number, $\exp(Pe^f)$ (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc., $C_{building}$ (µg/m^3)	Finite source β term (unitless)	Finite source ψ term $(sec)^{-1}$	Time for source depletion, τ_D (sec)	Exposure duration > time for source depletion (YES/NO)
4.60E-03	2.15E+03	0.10	3.90E+03	1.31E-02	1.76E+04	5.59E+73	NA	NA	6.95E+01	2.81E-08	6.67E+09	NO

Finite source indoor attenuation coefficient, $\langle\alpha\rangle$ (unitless)	Mass limit bldg. conc., $C_{building}$ (µg/m^3)	Finite source bldg. conc., $C_{building}$ (µg/m^3)	Final finite source bldg. conc., $C_{building}$ (µg/m^3)	Unit risk factor, URF $(\mu g/m^3)^{-1}$	Reference conc., RfC (mg/m^3)
2.01E-05	NA	4.31E-02	4.31E-02	NA	5.0E+00

END

SL-ADV Version 3.1; 02/04

Reset to

CALCULATE RISK-BASED SOIL CONCENTRATION (enter "X" in "YES" box)

4-METHYL-2-PENTANONE SURFACE (0 TO 4 FT) MAXIMUM

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL SOIL CONCENTRATION (enter "X" in "YES" box and initial soil conc. below)

YES [X]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial soil conc., C_R (μg/kg)	Chemical
108101	1.20E+02	Methylisobutylketone (4-methyl-2-pentanone)

MORE ↓

ENTER Average soil temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to top of contamination, L_t (cm)	ENTER Depth below grade to bottom of contamination, (enter value of 0 if value is unknown) L_b (cm)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm²)
				Totals must add up to value of L_t (cell G28)					
10	30	122	366	122	0	0	S		

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm³)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm³/cm³)	ENTER Stratum A soil organic carbon fraction, f_{oc}^A (unitless)	ENTER Stratum B SCS soil type (Lookup Soil)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm³)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm³/cm³)	ENTER Stratum B soil organic carbon fraction, f_{oc}^B (unitless)	ENTER Stratum C SCS soil type (Lookup Soil)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm³)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm³/cm³)	ENTER Stratum C soil organic carbon fraction, f_{oc}^C (unitless)
S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s²)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	36576	51206	366	0.1	1	

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	30	30	350	1.0E-06	1
				Used to calculate risk-based soil concentration.	

END

INTERMEDIATE CALCULATIONS SHEET

4-METHYL-2-PENTANONE SURFACE (0 TO 4 FT) MAXIMUM

Exposure duration, τ (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, θ_a^A (cm^3/cm^3)	Stratum B soil air-filled porosity, θ_a^B (cm^3/cm^3)	Stratum C soil air-filled porosity, θ_a^C (cm^3/cm^3)	Stratum A effective total fluid saturation, S_{te} (cm^3/cm^3)	Stratum A soil intrinsic permeability, k_i (cm^2)	Stratum A soil relative air permeability, k_{rg} (cm^2)	Stratum A soil effective vapor permeability, k_v (cm^2)	Floor-wall seam perimeter, X_{crack} (cm)	Initial soil concentration used, C_R (µg/kg)	Bldg. ventilation rate, $Q_{building}$ (cm^3/s)
9.46E+08	92	0.321	0.321	0.321	0.003	9.92E-08	0.998	9.91E-08	175,564	1.20E+02	1.90E+08

Area of enclosed space below grade, A_B (cm^2)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. soil temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. soil temperature, H_{TS} (atm-m^3/mol)	Henry's law constant at ave. soil temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm^2/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm^2/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm^2/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm^2/s)	Diffusion path length, L_d (cm)	Convection path length, L_p (cm)
1.88E+09	9.35E-06	30	9,862	5.70E-05	2.45E-03	1.75E-04	1.21E-02	0.00E+00	0.00E+00	1.21E-02	92	30

Soil-water partition coefficient, K_d (cm^3/g)	Source vapor conc., C_{source} (µg/m^3)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm^3/s)	Crack effective diffusion coefficient, D^{crack} (cm^2/s)	Area of crack, A_{crack} (cm^2)	Exponent of equivalent foundation Peclet number, exp(Pe^f) (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc., $C_{building}$ (µg/m^3)	Finite source β term (unitless)	Finite source ψ term $(sec)^{-1}$	Time for source depletion, τ_D (sec)	Exposure duration > time for source depletion (YES/NO)
1.81E-02	5.76E+03	0.10	3.90E+03	1.21E-02	1.76E+04	2.91E+79	NA	NA	6.46E+01	4.14E-08	4.22E+09	NO

Finite source indoor attenuation coefficient, <α> (unitless)	Mass limit bldg. conc., $C_{building}$ (µg/m^3)	Finite source bldg. conc., $C_{building}$ (µg/m^3)	Final finite source bldg. conc., $C_{building}$ (µg/m^3)	Unit risk factor, URF $(µg/m^3)^{-1}$	Reference conc., RfC (mg/m^3)
2.00E-05	NA	1.15E-01	1.15E-01	NA	3.0E+00

END

DATA ENTRY SHEET

SL-ADV
Version 3.1; 02/04

Reset to

CALCULATE RISK-BASED SOIL CONCENTRATION (enter "X" in "YES" box)

4-METHYL-2-PENTANONE SURFACE (0 TO 4 FT) EPC

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL SOIL CONCENTRATION (enter "X" in "YES" box and initial soil conc. below)

YES [X]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial soil conc., C_R (μg/kg)	Chemical
108101	5.42E+01	Methylisobutylketone (4-methyl-2-pentanone)

MORE ↓

ENTER Average soil temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to top of contamination, L_t (cm)	ENTER Depth below grade to bottom of contamination, (enter value of 0 if value is unknown) L_b (cm)	ENTER Totals must add up to value of L_t (cell G28) Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm²)
10	30	122	366	122	0	0	S		

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm³)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm³/cm³)	ENTER Stratum A soil organic carbon fraction, f_{oc}^A (unitless)	ENTER Stratum B SCS soil type (Lookup Soil)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm³)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm³/cm³)	ENTER Stratum B soil organic carbon fraction, f_{oc}^B (unitless)	ENTER Stratum C SCS soil type (Lookup Soil)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm³)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm³/cm³)	ENTER Stratum C soil organic carbon fraction, f_{oc}^C (unitless)
S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s²)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	36576	51206	366	0.1	1	

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	30	30	350	1.0E-06	1

Used to calculate risk-based soil concentration.

END

4-METHYL-2-PENTANONE SURFACE (0 TO 4 FT) EPC

Exposure duration, τ (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, θ_a^A (cm^3/cm^3)	Stratum B soil air-filled porosity, θ_a^B (cm^3/cm^3)	Stratum C soil air-filled porosity, θ_a^C (cm^3/cm^3)	Stratum A effective total fluid saturation, S_{te} (cm^3/cm^3)	Stratum A soil intrinsic permeability, k_i (cm^2)	Stratum A soil relative air permeability, k_{rg} (cm^2)	Stratum A soil effective vapor permeability, k_v (cm^2)	Floor-wall seam perimeter, X_{crack} (cm)	Initial soil concentration used, C_R (µg/kg)	Bldg. ventilation rate, $Q_{building}$ (cm^3/s)
9.46E+08	92	0.321	0.321	0.321	0.003	9.92E-08	0.998	9.91E-08	175,564	5.42E+01	1.90E+08

Area of enclosed space below grade, A_B (cm^2)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. soil temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. soil temperature, H_{TS} (atm-m^3/mol)	Henry's law constant at ave. soil temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm^2/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm^2/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm^2/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm^2/s)	Diffusion path length, L_d (cm)	Convection path length, L_p (cm)
1.88E+09	9.35E-06	30	9,862	5.70E-05	2.45E-03	1.75E-04	1.21E-02	0.00E+00	0.00E+00	1.21E-02	92	30

Soil-water partition coefficient, K_d (cm^3/g)	Source vapor conc., C_{source} (µg/m^3)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm^3/s)	Crack effective diffusion coefficient, D^{crack} (cm^2/s)	Area of crack, A_{crack} (cm^2)	Exponent of equivalent foundation Peclet number, exp(Pe^f) (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc., $C_{building}$ (µg/m^3)	Finite source β term (unitless)	Finite source ψ term $(sec)^{-1}$	Time for source depletion, τ_D (sec)	Exposure duration > time for source depletion (YES/NO)
1.81E-02	2.60E+03	0.10	3.90E+03	1.21E-02	1.76E+04	2.91E+79	NA	NA	6.46E+01	4.14E-08	4.22E+09	NO

Finite source indoor attenuation coefficient, $<\alpha>$ (unitless)	Mass limit bldg. conc., $C_{building}$ (µg/m^3)	Finite source bldg. conc., $C_{building}$ (µg/m^3)	Final finite source bldg. conc., $C_{building}$ (µg/m^3)	Unit risk factor, URF $(\mu g/m^3)^{-1}$	Reference conc., RfC (mg/m^3)
2.00E-05	NA	5.21E-02	5.21E-02	NA	3.0E+00

END

SL-ADV
Version 3.1; 02/04

Reset to

BROMOMETHANE SURFACE (0 TO 4 FT) MAXIMUM AND EPC

CALCULATE RISK-BASED SOIL CONCENTRATION (enter "X" in "YES" box)

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL SOIL CONCENTRATION (enter "X" in "YES" box and initial soil conc. below)

YES [X]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial soil conc., C_R (μg/kg)	Chemical
74839	2.00E+00	Methyl bromide

MORE ↓

ENTER Average soil temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to top of contamination, L_t (cm)	ENTER Depth below grade to bottom of contamination, (enter value of 0 if value is unknown) L_b (cm)	ENTER Totals must add up to value of L_t (cell G28) Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm²)
10	30	122	366	122	0	0	S		

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm³)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm³/cm³)	ENTER Stratum A soil organic carbon fraction, f_{oc}^A (unitless)	ENTER Stratum B SCS soil type (Lookup Soil)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm³)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm³/cm³)	ENTER Stratum B soil organic carbon fraction, f_{oc}^B (unitless)	ENTER Stratum C SCS soil type (Lookup Soil)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm³)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm³/cm³)	ENTER Stratum C soil organic carbon fraction, f_{oc}^C (unitless)
S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s²)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	36576	51206	366	0.1	1	

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	30	30	350	1.0E-06	1

Used to calculate risk-based soil concentration.

END

INTERMEDIATE CALCULATIONS SHEET

BROMOMETHANE SURFACE (0 TO 4 FT) MAXIMUM AND EPC

Exposure duration, τ (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, θ_a^A (cm³/cm³)	Stratum B soil air-filled porosity, θ_a^B (cm³/cm³)	Stratum C soil air-filled porosity, θ_a^C (cm³/cm³)	Stratum A effective total fluid saturation, S_{te} (cm³/cm³)	Stratum A soil intrinsic permeability, k_i (cm²)	Stratum A soil relative air permeability, k_{rg} (cm²)	Stratum A soil effective vapor permeability, k_v (cm²)	Floor-wall seam perimeter, X_{crack} (cm)	Initial soil concentration used, C_R (µg/kg)	Bldg. ventilation rate, $Q_{building}$ (cm³/s)
9.46E+08	92	0.321	0.321	0.321	0.003	9.92E-08	0.998	9.91E-08	175,564	2.00E+00	1.90E+08

Area of enclosed space below grade, A_B (cm²)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. soil temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. soil temperature, H_{TS} (atm-m³/mol)	Henry's law constant at ave. soil temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm²/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm²/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm²/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm²/s)	Diffusion path length, L_d (cm)	Convection path length, L_p (cm)
1.88E+09	9.35E-06	30	5,651	3.76E-03	1.62E-01	1.75E-04	1.18E-02	0.00E+00	0.00E+00	1.18E-02	92	30

Soil-water partition coefficient, K_d (cm³/g)	Source vapor conc., C_{source} (µg/m³)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm³/s)	Crack effective diffusion coefficient, D^{crack} (cm²/s)	Area of crack, A_{crack} (cm²)	Exponent of equivalent foundation Peclet number, $\exp(Pe^f)$ (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc., $C_{building}$ (µg/m³)	Finite source β term (unitless)	Finite source ψ term (sec)$^{-1}$	Time for source depletion, τ_D (sec)	Exposure duration > time for source depletion (YES/NO)
2.10E-02	3.81E+03	0.10	3.90E+03	1.18E-02	1.76E+04	7.49E+81	NA	NA	6.27E+01	1.60E-06	1.06E+08	YES

Finite source indoor attenuation coefficient, $<\alpha>$ (unitless)	Mass limit bldg. conc., $C_{building}$ (µg/m³)	Finite source bldg. conc., $C_{building}$ (µg/m³)	Final finite source bldg. conc., $C_{building}$ (µg/m³)	Unit risk factor, URF (µg/m³)$^{-1}$	Reference conc., RfC (mg/m³)
NA	8.45E-03	NA	8.45E-03	NA	5.0E-03

END

DATA ENTRY SHEET

SL-ADV
Version 3.1; 02/04

Reset to

CALCULATE RISK-BASED SOIL CONCENTRATION (enter "X" in "YES" box)

CARBON DISULFIDE SURFACE (0 TO 4 FT) MAXIMUM AND EPC

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL SOIL CONCENTRATION (enter "X" in "YES" box and initial soil conc. below)

YES [X]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial soil conc., C_R (µg/kg)	Chemical
75150	1.30E+01	Carbon disulfide

MORE ↓

ENTER Average soil temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to top of contamination, L_t (cm)	ENTER Depth below grade to bottom of contamination, (enter value of 0 if value is unknown) L_b (cm)	ENTER (Totals must add up to value of L_t (cell G28)) Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm²)
10	30	122	366	122	0	0	S		

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm³)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm³/cm³)	ENTER Stratum A soil organic carbon fraction, f_{oc}^A (unitless)	ENTER Stratum B SCS soil type (Lookup Soil)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm³)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm³/cm³)	ENTER Stratum B soil organic carbon fraction, f_{oc}^B (unitless)	ENTER Stratum C SCS soil type (Lookup Soil)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm³)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm³/cm³)	ENTER Stratum C soil organic carbon fraction, f_{oc}^C (unitless)
S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s²)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	36576	51206	366	0.1	1	

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	30	30	350	1.0E-06	1
				Used to calculate risk-based soil concentration.	

END

INTERMEDIATE CALCULATIONS SHEET

CARBON DISULFIDE SURFACE (0 TO 4 FT) MAXIMUM AND EPC

Exposure duration, τ (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, θ_a^A (cm³/cm³)	Stratum B soil air-filled porosity, θ_a^B (cm³/cm³)	Stratum C soil air-filled porosity, θ_a^C (cm³/cm³)	Stratum A effective total fluid saturation, S_{te} (cm³/cm³)	Stratum A soil intrinsic permeability, k_i (cm²)	Stratum A soil relative air permeability, k_{rg} (cm²)	Stratum A soil effective vapor permeability, k_v (cm²)	Floor-wall seam perimeter, X_{crack} (cm)	Initial soil concentration used, C_R (µg/kg)	Bldg. ventilation rate, $Q_{building}$ (cm³/s)
9.46E+08	92	0.321	0.321	0.321	0.003	9.92E-08	0.998	9.91E-08	175,564	1.30E+01	1.90E+08

Area of enclosed space below grade, A_B (cm²)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. soil temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. soil temperature, H_{TS} (atm-m³/mol)	Henry's law constant at ave. soil temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm²/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm²/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm²/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm²/s)	Diffusion path length, L_d (cm)	Convection path length, L_p (cm)
1.88E+09	9.35E-06	30	6,682	1.66E-02	7.16E-01	1.75E-04	1.68E-02	0.00E+00	0.00E+00	1.68E-02	92	30

Soil-water partition coefficient, K_d (cm³/g)	Source vapor conc., C_{source} (µg/m³)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm³/s)	Crack effective diffusion coefficient, D^{crack} (cm²/s)	Area of crack, A_{crack} (cm²)	Exponent of equivalent foundation Peclet number, $\exp(Pe^f)$ (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc., $C_{building}$ (µg/m³)	Finite source β term (unitless)	Finite source ψ term (sec)$^{-1}$	Time for source depletion, τ_D (sec)	Exposure duration > time for source depletion (YES/NO)
9.14E-02	3.55E+04	0.10	3.90E+03	1.68E-02	1.76E+04	2.05E+57	NA	NA	8.91E+01	3.26E-06	7.35E+07	YES

Finite source indoor attenuation coefficient, <α> (unitless)	Mass limit bldg. conc., $C_{building}$ (µg/m³)	Finite source bldg. conc., $C_{building}$ (µg/m³)	Final finite source bldg. conc., $C_{building}$ (µg/m³)	Unit risk factor, URF (µg/m³)$^{-1}$	Reference conc., RfC (mg/m³)
NA	5.49E-02	NA	5.49E-02	NA	7.0E-01

END

DATA ENTRY SHEET

SL-ADV
Version 3.1; 02/04

Reset to

CALCULATE RISK-BASED SOIL CONCENTRATION (enter "X" in "YES" box)

ETHYLBENZENE SURFACE (0 TO 4 FT) MAXIMUM AND EPC

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL SOIL CONCENTRATION (enter "X" in "YES" box and initial soil conc. below)

YES [X]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial soil conc., C_R (μg/kg)	Chemical
100414	1.90E+01	Ethylbenzene

MORE ↓

ENTER Average soil temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to top of contamination, L_t (cm)	ENTER Depth below grade to bottom of contamination, (enter value of 0 if value is unknown) L_b (cm)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm²)
				Totals must add up to value of L_t (cell G28)					
10	30	122	366	122	0	0	S		

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm³)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm³/cm³)	ENTER Stratum A soil organic carbon fraction, f_{oc}^A (unitless)	ENTER Stratum B SCS soil type (Lookup Soil)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm³)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm³/cm³)	ENTER Stratum B soil organic carbon fraction, f_{oc}^B (unitless)	ENTER Stratum C SCS soil type (Lookup Soil)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm³)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm³/cm³)	ENTER Stratum C soil organic carbon fraction, f_{oc}^C (unitless)
S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s²)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	36576	51206	366	0.1	1	

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	30	30	350	1.0E-06	1
				Used to calculate risk-based soil concentration.	

END

INTERMEDIATE CALCULATIONS SHEET

ETHYLBENZENE SURFACE (0 TO 4 FT) MAXIMUM AND EPC

Exposure duration, τ (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, θ_a^A (cm³/cm³)	Stratum B soil air-filled porosity, θ_a^B (cm³/cm³)	Stratum C soil air-filled porosity, θ_a^C (cm³/cm³)	Stratum A effective total fluid saturation, S_{te} (cm³/cm³)	Stratum A soil intrinsic permeability, k_i (cm²)	Stratum A soil relative air permeability, k_{rg} (cm²)	Stratum A soil effective vapor permeability, k_v (cm²)	Floor-wall seam perimeter, X_{crack} (cm)	Initial soil concentration used, C_R (µg/kg)	Bldg. ventilation rate, $Q_{building}$ (cm³/s)
9.46E+08	92	0.321	0.321	0.321	0.003	9.92E-08	0.998	9.91E-08	175,564	1.90E+01	1.90E+08

Area of enclosed space below grade, A_B (cm²)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. soil temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. soil temperature, H_{TS} (atm-m³/mol)	Henry's law constant at ave. soil temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm²/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm²/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm²/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm²/s)	Diffusion path length, L_d (cm)	Convection path length, L_p (cm)
1.88E+09	9.35E-06	30	10,155	3.17E-03	1.36E-01	1.75E-04	1.21E-02	0.00E+00	0.00E+00	1.21E-02	92	30

Soil-water partition coefficient, K_d (cm³/g)	Source vapor conc., C_{source} (µg/m³)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm³/s)	Crack effective diffusion coefficient, D^{crack} (cm²/s)	Area of crack, A_{crack} (cm²)	Exponent of equivalent foundation Peclet number, $\exp(Pe^f)$ (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc., $C_{building}$ (µg/m³)	Finite source β term (unitless)	Finite source ψ term (sec)$^{-1}$	Time for source depletion, τ_D (sec)	Exposure duration > time for source depletion (YES/NO)
7.26E-01	3.30E+03	0.10	3.90E+03	1.21E-02	1.76E+04	2.97E+79	NA	NA	6.45E+01	1.50E-07	1.16E+09	NO

Finite source indoor attenuation coefficient, $<\alpha>$ (unitless)	Mass limit bldg. conc., $C_{building}$ (µg/m³)	Finite source bldg. conc., $C_{building}$ (µg/m³)	Final finite source bldg. conc., $C_{building}$ (µg/m³)	Unit risk factor, URF (µg/m³)$^{-1}$	Reference conc., RfC (mg/m³)
1.98E-05	NA	6.54E-02	6.54E-02	NA	1.0E+00

END

DATA ENTRY SHEET

SL-ADV
Version 3.1; 02/04

Reset to

CALCULATE RISK-BASED SOIL CONCENTRATION (enter "X" in "YES" box)

STYRENE SURFACE (0 TO 4 FT) MAXIMUM

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL SOIL CONCENTRATION (enter "X" in "YES" box and initial soil conc. below)

YES [X]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial soil conc., C_R (μg/kg)	Chemical
100425	5.40E+01	Styrene

MORE ↓

ENTER Average soil temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to top of contamination, L_t (cm)	ENTER Depth below grade to bottom of contamination, (enter value of 0 if value is unknown) L_b (cm)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm²)
				Totals must add up to value of L_t (cell G28)					
10	30	122	366	122	0	0	S		

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm³)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm³/cm³)	ENTER Stratum A soil organic carbon fraction, f_{oc}^A (unitless)	ENTER Stratum B SCS soil type (Lookup Soil)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm³)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm³/cm³)	ENTER Stratum B soil organic carbon fraction, f_{oc}^B (unitless)	ENTER Stratum C SCS soil type (Lookup Soil)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm³)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm³/cm³)	ENTER Stratum C soil organic carbon fraction, f_{oc}^C (unitless)
S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s²)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	36576	51206	366	0.1	1	

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	30	30	350	1.0E-06	1
				Used to calculate risk-based soil concentration.	

END

INTERMEDIATE CALCULATIONS SHEET

STYRENE SURFACE (0 TO 4 FT) MAXIMUM

Exposure duration, τ (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, θ_a^A (cm^3/cm^3)	Stratum B soil air-filled porosity, θ_a^B (cm^3/cm^3)	Stratum C soil air-filled porosity, θ_a^C (cm^3/cm^3)	Stratum A effective total fluid saturation, S_{te} (cm^3/cm^3)	Stratum A soil intrinsic permeability, k_i (cm^2)	Stratum A soil relative air permeability, k_{rg} (cm^2)	Stratum A soil effective vapor permeability, k_v (cm^2)	Floor-wall seam perimeter, X_{crack} (cm)	Initial soil concentration used, C_R (μg/kg)	Bldg. ventilation rate, $Q_{building}$ (cm^3/s)
9.46E+08	92	0.321	0.321	0.321	0.003	9.92E-08	0.998	9.91E-08	175,564	5.40E+01	1.90E+08

Area of enclosed space below grade, A_B (cm^2)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. soil temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. soil temperature, H_{TS} (atm-m^3/mol)	Henry's law constant at ave. soil temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm^2/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm^2/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm^2/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm^2/s)	Diffusion path length, L_d (cm)	Convection path length, L_p (cm)
1.88E+09	9.35E-06	30	10,450	1.08E-03	4.64E-02	1.75E-04	1.15E-02	0.00E+00	0.00E+00	1.15E-02	92	30

Soil-water partition coefficient, K_d (cm^3/g)	Source vapor conc., C_{source} ($\mu g/m^3$)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm^3/s)	Crack effective diffusion coefficient, D^{crack} (cm^2/s)	Area of crack, A_{crack} (cm^2)	Exponent of equivalent foundation Peclet number, $\exp(Pe^f)$ (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc., $C_{building}$ ($\mu g/m^3$)	Finite source β term (unitless)	Finite source ψ term $(sec)^{-1}$	Time for source depletion, τ_D (sec)	Exposure duration > time for source depletion (YES/NO)
1.55E+00	1.57E+03	0.10	3.90E+03	1.15E-02	1.76E+04	8.91E+83	NA	NA	6.12E+01	2.38E-08	6.97E+09	NO

Finite source indoor attenuation coefficient, <α> (unitless)	Mass limit bldg. conc., $C_{building}$ ($\mu g/m^3$)	Finite source bldg. conc., $C_{building}$ ($\mu g/m^3$)	Final finite source bldg. conc., $C_{building}$ ($\mu g/m^3$)	Unit risk factor, URF $(\mu g/m^3)^{-1}$	Reference conc., RfC (mg/m^3)
2.01E-05	NA	3.15E-02	3.15E-02	NA	1.0E+00

END

DATA ENTRY SHEET

SL-ADV
Version 3.1; 02/04

Reset to

CALCULATE RISK-BASED SOIL CONCENTRATION (enter "X" in "YES" box)

STYRENE SURFACE (0 TO 4 FT) EPC

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL SOIL CONCENTRATION (enter "X" in "YES" box and initial soil conc. below)

YES [X]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial soil conc., C_R (µg/kg)	Chemical
100425	3.92E+01	Styrene

MORE

ENTER Average soil temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to top of contamination, L_t (cm)	ENTER Depth below grade to bottom of contamination, (enter value of 0 if value is unknown) L_b (cm)	ENTER Totals must add up to value of L_t (cell G28): Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm²)
10	30	122	366	122	0	0	S		

MORE

ENTER Stratum A SCS soil type (Lookup Soil)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm³)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm³/cm³)	ENTER Stratum A soil organic carbon fraction, f_{oc}^A (unitless)	ENTER Stratum B SCS soil type (Lookup Soil)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm³)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm³/cm³)	ENTER Stratum B soil organic carbon fraction, f_{oc}^B (unitless)	ENTER Stratum C SCS soil type (Lookup Soil)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm³)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm³/cm³)	ENTER Stratum C soil organic carbon fraction, f_{oc}^C (unitless)
S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002

MORE

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s²)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	36576	51206	366	0.1	1	

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	30	30	350	1.0E-06	1

Used to calculate risk-based soil concentration.

END

INTERMEDIATE CALCULATIONS SHEET

STYRENE SURFACE (0 TO 4 FT) EPC

Exposure duration, τ (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, θ_a^A (cm^3/cm^3)	Stratum B soil air-filled porosity, θ_a^B (cm^3/cm^3)	Stratum C soil air-filled porosity, θ_a^C (cm^3/cm^3)	Stratum A effective total fluid saturation, S_{te} (cm^3/cm^3)	Stratum A soil intrinsic permeability, k_i (cm^2)	Stratum A soil relative air permeability, k_{rg} (cm^2)	Stratum A soil effective vapor permeability, k_v (cm^2)	Floor-wall seam perimeter, X_{crack} (cm)	Initial soil concentration used, C_R (µg/kg)	Bldg. ventilation rate, $Q_{building}$ (cm^3/s)
9.46E+08	92	0.321	0.321	0.321	0.003	9.92E-08	0.998	9.91E-08	175,564	3.92E+01	1.90E+08

Area of enclosed space below grade, A_B (cm^2)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. soil temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. soil temperature, H_{TS} ($atm\text{-}m^3/mol$)	Henry's law constant at ave. soil temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm^2/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm^2/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm^2/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm^2/s)	Diffusion path length, L_d (cm)	Convection path length, L_p (cm)
1.88E+09	9.35E-06	30	10,450	1.08E-03	4.64E-02	1.75E-04	1.15E-02	0.00E+00	0.00E+00	1.15E-02	92	30

Soil-water partition coefficient, K_d (cm^3/g)	Source vapor conc., C_{source} ($\mu g/m^3$)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm^3/s)	Crack effective diffusion coefficient, D^{crack} (cm^2/s)	Area of crack, A_{crack} (cm^2)	Exponent of equivalent foundation Peclet number, $\exp(Pe^f)$ (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc., $C_{building}$ ($\mu g/m^3$)	Finite source β term (unitless)	Finite source ψ term $(sec)^{-1}$	Time for source depletion, τ_D (sec)	Exposure duration > time for source depletion (YES/NO)
1.55E+00	1.14E+03	0.10	3.90E+03	1.15E-02	1.76E+04	8.91E+83	NA	NA	6.12E+01	2.38E-08	6.97E+09	NO

Finite source indoor attenuation coefficient, $\langle\alpha\rangle$ (unitless)	Mass limit bldg. conc., $C_{building}$ ($\mu g/m^3$)	Finite source bldg. conc., $C_{building}$ ($\mu g/m^3$)	Final finite source bldg. conc., $C_{building}$ ($\mu g/m^3$)	Unit risk factor, URF $(\mu g/m^3)^{-1}$	Reference conc., RfC (mg/m^3)
2.01E-05	NA	2.29E-02	2.29E-02	NA	1.0E+00

END

DATA ENTRY SHEET

SL-ADV
Version 3.1; 02/04

Reset to

CALCULATE RISK-BASED SOIL CONCENTRATION (enter "X" in "YES" box)

TETRACHLOROETHENE SURFACE (0 TO 4 FT) MAXIMUM

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL SOIL CONCENTRATION (enter "X" in "YES" box and initial soil conc. below)

YES [X]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial soil conc., C_R (µg/kg)	Chemical
127184	9.00E+01	Tetrachloroethylene

MORE ↓

ENTER Average soil temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to top of contamination, L_t (cm)	ENTER Depth below grade to bottom of contamination, (enter value of 0 if value is unknown) L_b (cm)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm²)
				Totals must add up to value of L_t (cell G28)					
10	30	122	366	122	0	0	S		

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm³)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm³/cm³)	ENTER Stratum A soil organic carbon fraction, f_{oc}^A (unitless)	ENTER Stratum B SCS soil type (Lookup Soil)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm³)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm³/cm³)	ENTER Stratum B soil organic carbon fraction, f_{oc}^B (unitless)	ENTER Stratum C SCS soil type (Lookup Soil)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm³)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm³/cm³)	ENTER Stratum C soil organic carbon fraction, f_{oc}^C (unitless)
S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s²)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	36576	51206	366	0.1	1	

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	30	30	350	1.0E-06	1

Used to calculate risk-based soil concentration.

END

INTERMEDIATE CALCULATIONS SHEET

TETRACHLOROETHENE SURFACE (0 TO 4 FT) MAXIMUM

Exposure duration, τ (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, θ_a^A (cm^3/cm^3)	Stratum B soil air-filled porosity, θ_a^B (cm^3/cm^3)	Stratum C soil air-filled porosity, θ_a^C (cm^3/cm^3)	Stratum A effective total fluid saturation, S_{te} (cm^3/cm^3)	Stratum A soil intrinsic permeability, k_i (cm^2)	Stratum A soil relative air permeability, k_{rg} (cm^2)	Stratum A soil effective vapor permeability, k_v (cm^2)	Floor-wall seam perimeter, X_{crack} (cm)	Initial soil concentration used, C_R (µg/kg)	Bldg. ventilation rate, $Q_{building}$ (cm^3/s)
9.46E+08	92	0.321	0.321	0.321	0.003	9.92E-08	0.998	9.91E-08	175,564	9.00E+01	1.90E+08

Area of enclosed space below grade, A_B (cm^2)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. soil temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. soil temperature, H_{TS} ($atm\text{-}m^3/mol$)	Henry's law constant at ave. soil temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm^2/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm^2/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm^2/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm^2/s)	Diffusion path length, L_d (cm)	Convection path length, L_p (cm)
1.88E+09	9.35E-06	30	9,553	7.81E-03	3.36E-01	1.75E-04	1.16E-02	0.00E+00	0.00E+00	1.16E-02	92	30

Soil-water partition coefficient, K_d (cm^3/g)	Source vapor conc., C_{source} ($\mu g/m^3$)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm^3/s)	Crack effective diffusion coefficient, D^{crack} (cm^2/s)	Area of crack, A_{crack} (cm^2)	Exponent of equivalent foundation Peclet number, $\exp(Pe^f)$ (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc., $C_{building}$ ($\mu g/m^3$)	Finite source β term (unitless)	Finite source ψ term $(sec)^{-1}$	Time for source depletion, τ_D (sec)	Exposure duration > time for source depletion (YES/NO)
3.10E-01	7.42E+04	0.10	3.90E+03	1.16E-02	1.76E+04	6.09E+82	NA	NA	6.20E+01	6.83E-07	2.46E+08	YES

Finite source indoor attenuation coefficient, $<\alpha>$ (unitless)	Mass limit bldg. conc., $C_{building}$ ($\mu g/m^3$)	Finite source bldg. conc., $C_{building}$ ($\mu g/m^3$)	Final finite source bldg. conc., $C_{building}$ ($\mu g/m^3$)	Unit risk factor, URF $(\mu g/m^3)^{-1}$	Reference conc., RfC (mg/m^3)
NA	3.80E-01	NA	3.80E-01	5.9E-06	6.0E-01

END

DATA ENTRY SHEET

SL-ADV
Version 3.1; 02/04

Reset to

CALCULATE RISK-BASED SOIL CONCENTRATION (enter "X" in "YES" box)

TETRACHLOROETHENE SURFACE (0 TO 4 FT) EPC

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL SOIL CONCENTRATION (enter "X" in "YES" box and initial soil conc. below)

YES [X]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial soil conc., C_R (µg/kg)	Chemical
127184	5.16E+01	Tetrachloroethylene

MORE ↓

ENTER Average soil temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to top of contamination, L_t (cm)	ENTER Depth below grade to bottom of contamination, (enter value of 0 if value is unknown) L_b (cm)	ENTER Totals must add up to value of L_t (cell G28) Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm²)
10	30	122	366	122	0	0	S		

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm³)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm³/cm³)	ENTER Stratum A soil organic carbon fraction, f_{oc}^A (unitless)	ENTER Stratum B SCS soil type (Lookup Soil)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm³)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm³/cm³)	ENTER Stratum B soil organic carbon fraction, f_{oc}^B (unitless)	ENTER Stratum C SCS soil type (Lookup Soil)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm³)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm³/cm³)	ENTER Stratum C soil organic carbon fraction, f_{oc}^C (unitless)
S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s²)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	36576	51206	366	0.1	1	

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	30	30	350	1.0E-06	1

Used to calculate risk-based soil concentration.

END

INTERMEDIATE CALCULATIONS SHEET

TETRACHLOROETHENE SURFACE (0 TO 4 FT) EPC

Exposure duration, τ (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, θ_a^A (cm³/cm³)	Stratum B soil air-filled porosity, θ_a^B (cm³/cm³)	Stratum C soil air-filled porosity, θ_a^C (cm³/cm³)	Stratum A effective total fluid saturation, S_{te} (cm³/cm³)	Stratum A soil intrinsic permeability, k_i (cm²)	Stratum A soil relative air permeability, k_{rg} (cm²)	Stratum A soil effective vapor permeability, k_v (cm²)	Floor-wall seam perimeter, X_{crack} (cm)	Initial soil concentration used, C_R (µg/kg)	Bldg. ventilation rate, $Q_{building}$ (cm³/s)
9.46E+08	92	0.321	0.321	0.321	0.003	9.92E-08	0.998	9.91E-08	175,564	5.16E+01	1.90E+08

Area of enclosed space below grade, A_B (cm²)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. soil temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. soil temperature, H_{TS} (atm-m³/mol)	Henry's law constant at ave. soil temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm²/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm²/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm²/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm²/s)	Diffusion path length, L_d (cm)	Convection path length, L_p (cm)
1.88E+09	9.35E-06	30	9,553	7.81E-03	3.36E-01	1.75E-04	1.16E-02	0.00E+00	0.00E+00	1.16E-02	92	30

Soil-water partition coefficient, K_d (cm³/g)	Source vapor conc., C_{source} (µg/m³)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm³/s)	Crack effective diffusion coefficient, D^{crack} (cm²/s)	Area of crack, A_{crack} (cm²)	Exponent of equivalent foundation Peclet number, $\exp(Pe^f)$ (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc., $C_{building}$ (µg/m³)	Finite source β term (unitless)	Finite source ψ term (sec)$^{-1}$	Time for source depletion, τ_D (sec)	Exposure duration > time for source depletion (YES/NO)
3.10E-01	4.26E+04	0.10	3.90E+03	1.16E-02	1.76E+04	6.09E+82	NA	NA	6.20E+01	6.83E-07	2.46E+08	YES

Finite source indoor attenuation coefficient, <α> (unitless)	Mass limit bldg. conc., $C_{building}$ (µg/m³)	Finite source bldg. conc., $C_{building}$ (µg/m³)	Final finite source bldg. conc., $C_{building}$ (µg/m³)	Unit risk factor, URF (µg/m³)$^{-1}$	Reference conc., RfC (mg/m³)
NA	2.18E-01	NA	2.18E-01	5.9E-06	6.0E-01

END

DATA ENTRY SHEET

SL-ADV
Version 3.1; 02/04

Reset to

CALCULATE RISK-BASED SOIL CONCENTRATION (enter "X" in "YES" box)

TOLUENE SURFACE (0 TO 4 FT) MAXIMUM AND EPC

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL SOIL CONCENTRATION (enter "X" in "YES" box and initial soil conc. below)

YES [X]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial soil conc., C_R (μg/kg)	Chemical
108883	1.40E+01	Toluene

MORE ↓

ENTER Average soil temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to top of contamination, L_t (cm)	ENTER Depth below grade to bottom of contamination, (enter value of 0 if value is unknown) L_b (cm)	ENTER (Totals must add up to value of L_t (cell G28)) Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm²)
10	30	122	366	122	0	0	S		

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm³)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm³/cm³)	ENTER Stratum A soil organic carbon fraction, f_{oc}^A (unitless)	ENTER Stratum B SCS soil type (Lookup Soil)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm³)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm³/cm³)	ENTER Stratum B soil organic carbon fraction, f_{oc}^B (unitless)	ENTER Stratum C SCS soil type (Lookup Soil)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm³)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm³/cm³)	ENTER Stratum C soil organic carbon fraction, f_{oc}^C (unitless)
S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s²)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	36576	51206	366	0.1	1	

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	30	30	350	1.0E-06	1
				Used to calculate risk-based soil concentration.	

END

INTERMEDIATE CALCULATIONS SHEET

TETRACHLOROETHENE SURFACE (0 TO 4 FT) EPC

Exposure duration, τ (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, θ_a^A (cm^3/cm^3)	Stratum B soil air-filled porosity, θ_a^B (cm^3/cm^3)	Stratum C soil air-filled porosity, θ_a^C (cm^3/cm^3)	Stratum A effective total fluid saturation, S_{te} (cm^3/cm^3)	Stratum A soil intrinsic permeability, k_i (cm^2)	Stratum A soil relative air permeability, k_{rg} (cm^2)	Stratum A soil effective vapor permeability, k_v (cm^2)	Floor-wall seam perimeter, X_{crack} (cm)	Initial soil concentration used, C_R (µg/kg)	Bldg. ventilation rate, $Q_{building}$ (cm^3/s)
9.46E+08	92	0.321	0.321	0.321	0.003	9.92E-08	0.998	9.91E-08	175,564	1.40E+01	1.90E+08

Area of enclosed space below grade, A_B (cm^2)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. soil temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. soil temperature, H_{TS} (atm-m^3/mol)	Henry's law constant at ave. soil temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm^2/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm^2/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm^2/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm^2/s)	Diffusion path length, L_d (cm)	Convection path length, L_p (cm)
1.88E+09	9.35E-06	30	9,154	2.92E-03	1.26E-01	1.75E-04	1.41E-02	0.00E+00	0.00E+00	1.41E-02	92	30

Soil-water partition coefficient, K_d (cm^3/g)	Source vapor conc., C_{source} (µg/m^3)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm^3/s)	Crack effective diffusion coefficient, D^{crack} (cm^2/s)	Area of crack, A_{crack} (cm^2)	Exponent of equivalent foundation Peclet number, exp(Pe^f) (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc., $C_{building}$ (µg/m^3)	Finite source β term (unitless)	Finite source ψ term $(sec)^{-1}$	Time for source depletion, τ_D (sec)	Exposure duration > time for source depletion (YES/NO)
3.64E-01	4.18E+03	0.10	3.90E+03	1.41E-02	1.76E+04	3.25E+68	NA	NA	7.47E+01	2.99E-07	6.74E+08	YES

Finite source indoor attenuation coefficient, <α> (unitless)	Mass limit bldg. conc., $C_{building}$ (µg/m^3)	Finite source bldg. conc., $C_{building}$ (µg/m^3)	Final finite source bldg. conc., $C_{building}$ (µg/m^3)	Unit risk factor, URF $(\mu g/m^3)^{-1}$	Reference conc., RfC (mg/m^3)
NA	5.91E-02	NA	5.91E-02	NA	4.0E-01

END

DATA ENTRY SHEET

SL-ADV
Version 3.1; 02/04

Reset to

CALCULATE RISK-BASED SOIL CONCENTRATION (enter "X" in "YES" box)

TRICHLOROETHENE SURFACE (0 TO 4 FT) MAXIMUM

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL SOIL CONCENTRATION (enter "X" in "YES" box and initial soil conc. below)

YES [x]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial soil conc., C_R (μg/kg)	Chemical
79016	6.40E+02	Trichloroethylene

MORE ↓

ENTER Average soil temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to top of contamination, L_t (cm)	ENTER Depth below grade to bottom of contamination, (enter value of 0 if value is unknown) L_b (cm)	ENTER (Totals must add up to value of L_t (cell G28)) Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm²)
10	30	122	366	122	0	0	S		

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm³)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm³/cm³)	ENTER Stratum A soil organic carbon fraction, f_{oc}^A (unitless)	ENTER Stratum B SCS soil type (Lookup Soil)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm³)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm³/cm³)	ENTER Stratum B soil organic carbon fraction, f_{oc}^B (unitless)	ENTER Stratum C SCS soil type (Lookup Soil)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm³)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm³/cm³)	ENTER Stratum C soil organic carbon fraction, f_{oc}^C (unitless)
S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s²)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	36576	51206	366	0.1	1	

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	30	30	350	1.0E-06	1

Used to calculate risk-based soil concentration.

END

TRICHLOROETHENE SURFACE (0 TO 4 FT) MAXIMUM

Exposure duration, τ (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, θ_a^A (cm³/cm³)	Stratum B soil air-filled porosity, θ_a^B (cm³/cm³)	Stratum C soil air-filled porosity, θ_a^C (cm³/cm³)	Stratum A effective total fluid saturation, S_{te} (cm³/cm³)	Stratum A soil intrinsic permeability, k_i (cm²)	Stratum A soil relative air permeability, k_{rg} (cm²)	Stratum A soil effective vapor permeability, k_v (cm²)	Floor-wall seam perimeter, X_{crack} (cm)	Initial soil concentration used, C_R (µg/kg)	Bldg. ventilation rate, $Q_{building}$ (cm³/s)
9.46E+08	92	0.321	0.321	0.321	0.003	9.92E-08	0.998	9.91E-08	175,564	6.40E+02	1.90E+08

Area of enclosed space below grade, A_B (cm²)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. soil temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. soil temperature, H_{TS} (atm-m³/mol)	Henry's law constant at ave. soil temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm²/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm²/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm²/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm²/s)	Diffusion path length, L_d (cm)	Convection path length, L_p (cm)
1.88E+09	9.35E-06	30	8,557	4.78E-03	2.06E-01	1.75E-04	1.28E-02	0.00E+00	0.00E+00	1.28E-02	92	30

Soil-water partition coefficient, K_d (cm³/g)	Source vapor conc., C_{source} (µg/m³)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm³/s)	Crack effective diffusion coefficient, D^{crack} (cm²/s)	Area of crack, A_{crack} (cm²)	Exponent of equivalent foundation Peclet number, $\exp(Pe^f)$ (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc., $C_{building}$ (µg/m³)	Finite source β term (unitless)	Finite source ψ term (sec)⁻¹	Time for source depletion, τ_D (sec)	Exposure duration > time for source depletion (YES/NO)
3.32E-01	3.26E+05	0.10	3.90E+03	1.28E-02	1.76E+04	2.81E+75	NA	NA	6.79E+01	4.63E-07	3.97E+08	YES

Finite source indoor attenuation coefficient, <α> (unitless)	Mass limit bldg. conc., $C_{building}$ (µg/m³)	Finite source bldg. conc., $C_{building}$ (µg/m³)	Final finite source bldg. conc., $C_{building}$ (µg/m³)	Unit risk factor, URF (µg/m³)⁻¹	Reference conc., RfC (mg/m³)
NA	2.70E+00	NA	2.70E+00	1.1E-04	4.0E-02

END

DATA ENTRY SHEET

SL-ADV
Version 3.1; 02/04

Reset to

CALCULATE RISK-BASED SOIL CONCENTRATION (enter "X" in "YES" box)

TRICHLOROETHENE SURFACE (0 TO 4 FT) EPC

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL SOIL CONCENTRATION (enter "X" in "YES" box and initial soil conc. below)

YES [X]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial soil conc., C_R (µg/kg)	Chemical
79016	8.24E+01	Trichloroethylene

MORE ↓

ENTER Average soil temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to top of contamination, L_t (cm)	ENTER Depth below grade to bottom of contamination, (enter value of 0 if value is unknown) L_b (cm)	ENTER Thickness of soil stratum A, h_A (cm) (Totals must add up to value of L_t (cell G28))	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm²)
10	30	122	366	122	0	0	S		

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm³)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm³/cm³)	ENTER Stratum A soil organic carbon fraction, f_{oc}^A (unitless)	ENTER Stratum B SCS soil type (Lookup Soil)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm³)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm³/cm³)	ENTER Stratum B soil organic carbon fraction, f_{oc}^B (unitless)	ENTER Stratum C SCS soil type (Lookup Soil)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm³)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm³/cm³)	ENTER Stratum C soil organic carbon fraction, f_{oc}^C (unitless)
S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s²)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	36576	51206	366	0.1	1	

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	30	30	350	1.0E-06	1

Used to calculate risk-based soil concentration.

END

INTERMEDIATE CALCULATIONS SHEET

TRICHLOROETHENE SURFACE (0 TO 4 FT) EPC

Exposure duration, τ (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, θ_a^A (cm^3/cm^3)	Stratum B soil air-filled porosity, θ_a^B (cm^3/cm^3)	Stratum C soil air-filled porosity, θ_a^C (cm^3/cm^3)	Stratum A effective total fluid saturation, S_{te} (cm^3/cm^3)	Stratum A soil intrinsic permeability, k_i (cm^2)	Stratum A soil relative air permeability, k_{rg} (cm^2)	Stratum A soil effective vapor permeability, k_v (cm^2)	Floor-wall seam perimeter, X_{crack} (cm)	Initial soil concentration used, C_R (µg/kg)	Bldg. ventilation rate, $Q_{building}$ (cm^3/s)
9.46E+08	92	0.321	0.321	0.321	0.003	9.92E-08	0.998	9.91E-08	175,564	8.24E+01	1.90E+08

Area of enclosed space below grade, A_B (cm^2)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. soil temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. soil temperature, H_{TS} ($atm\text{-}m^3/mol$)	Henry's law constant at ave. soil temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm^2/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm^2/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm^2/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm^2/s)	Diffusion path length, L_d (cm)	Convection path length, L_p (cm)
1.88E+09	9.35E-06	30	8,557	4.78E-03	2.06E-01	1.75E-04	1.28E-02	0.00E+00	0.00E+00	1.28E-02	92	30

Soil-water partition coefficient, K_d (cm^3/g)	Source vapor conc., C_{source} ($\mu g/m^3$)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm^3/s)	Crack effective diffusion coefficient, D^{crack} (cm^2/s)	Area of crack, A_{crack} (cm^2)	Exponent of equivalent foundation Peclet number, $\exp(Pe^f)$ (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc., $C_{building}$ ($\mu g/m^3$)	Finite source β term (unitless)	Finite source ψ term $(sec)^{-1}$	Time for source depletion, τ_D (sec)	Exposure duration > time for source depletion (YES/NO)
3.32E-01	4.19E+04	0.10	3.90E+03	1.28E-02	1.76E+04	2.81E+75	NA	NA	6.79E+01	4.63E-07	3.97E+08	YES

Finite source indoor attenuation coefficient, $\langle\alpha\rangle$ (unitless)	Mass limit bldg. conc., $C_{building}$ ($\mu g/m^3$)	Finite source bldg. conc., $C_{building}$ ($\mu g/m^3$)	Final finite source bldg. conc., $C_{building}$ ($\mu g/m^3$)	Unit risk factor, URF $(\mu g/m^3)^{-1}$	Reference conc., RfC (mg/m^3)
NA	3.48E-01	NA	3.48E-01	1.1E-04	4.0E-02

END

DATA ENTRY SHEET

SL-ADV
Version 3.1; 02/04

Reset to

CALCULATE RISK-BASED SOIL CONCENTRATION (enter "X" in "YES" box)

XYLENE SURFACE (0 TO 4 FT) MAXIMUM

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL SOIL CONCENTRATION (enter "X" in "YES" box and initial soil conc. below)

YES [X]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial soil conc., C_R (μg/kg)	Chemical
106423	7.10E+01	p-Xylene

MORE ↓

ENTER Average soil temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to top of contamination, L_t (cm)	ENTER Depth below grade to bottom of contamination, (enter value of 0 if value is unknown) L_b (cm)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm²)
				Totals must add up to value of L_t (cell G28)					
10	30	122	366	122	0	0	S		

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm³)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm³/cm³)	ENTER Stratum A soil organic carbon fraction, f_{oc}^A (unitless)	ENTER Stratum B SCS soil type (Lookup Soil)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm³)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm³/cm³)	ENTER Stratum B soil organic carbon fraction, f_{oc}^B (unitless)	ENTER Stratum C SCS soil type (Lookup Soil)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm³)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm³/cm³)	ENTER Stratum C soil organic carbon fraction, f_{oc}^C (unitless)
S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s²)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	36576	51206	366	0.1	1	

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	30	30	350	1.0E-06	1
				Used to calculate risk-based soil concentration.	

END

XYLENE SURFACE (0 TO 4 FT) MAXIMUM

Exposure duration, τ (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, θ_a^A (cm^3/cm^3)	Stratum B soil air-filled porosity, θ_a^B (cm^3/cm^3)	Stratum C soil air-filled porosity, θ_a^C (cm^3/cm^3)	Stratum A effective total fluid saturation, S_{te} (cm^3/cm^3)	Stratum A soil intrinsic permeability, k_i (cm^2)	Stratum A soil relative air permeability, k_{rg} (cm^2)	Stratum A soil effective vapor permeability, k_v (cm^2)	Floor-wall seam perimeter, X_{crack} (cm)	Initial soil concentration used, C_R (µg/kg)	Bldg. ventilation rate, $Q_{building}$ (cm^3/s)
9.46E+08	92	0.321	0.321	0.321	0.003	9.92E-08	0.998	9.91E-08	175,564	7.10E+01	1.90E+08

Area of enclosed space below grade, A_B (cm^2)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. soil temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. soil temperature, H_{TS} (atm-m^3/mol)	Henry's law constant at ave. soil temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm^2/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm^2/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm^2/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm^2/s)	Diffusion path length, L_d (cm)	Convection path length, L_p (cm)
1.88E+09	9.35E-06	30	10,248	3.06E-03	1.32E-01	1.75E-04	1.24E-02	0.00E+00	0.00E+00	1.24E-02	92	30

Soil-water partition coefficient, K_d (cm^3/g)	Source vapor conc., C_{source} (µg/m^3)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm^3/s)	Crack effective diffusion coefficient, D^{crack} (cm^2/s)	Area of crack, A_{crack} (cm^2)	Exponent of equivalent foundation Peclet number, $\exp(Pe^f)$ (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc., $C_{building}$ (µg/m^3)	Finite source β term (unitless)	Finite source ψ term (sec)$^{-1}$	Time for source depletion, τ_D (sec)	Exposure duration > time for source depletion (YES/NO)
7.78E-01	1.12E+04	0.10	3.90E+03	1.24E-02	1.76E+04	3.23E+77	NA	NA	6.62E+01	1.39E-07	1.29E+09	NO

Finite source indoor attenuation coefficient, <α> (unitless)	Mass limit bldg. conc., $C_{building}$ (µg/m^3)	Finite source bldg. conc., $C_{building}$ (µg/m^3)	Final finite source bldg. conc., $C_{building}$ (µg/m^3)	Unit risk factor, URF (µg/m^3)$^{-1}$	Reference conc., RfC (mg/m^3)
1.99E-05	NA	2.22E-01	2.22E-01	NA	1.0E-01

END

DATA ENTRY SHEET

SL-ADV
Version 3.1; 02/04

Reset to

CALCULATE RISK-BASED SOIL CONCENTRATION (enter "X" in "YES" box)

XYLENE SURFACE (0 TO 4 FT) EPC

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL SOIL CONCENTRATION (enter "X" in "YES" box and initial soil conc. below)

YES [X]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial soil conc., C_R (µg/kg)	Chemical
106423	3.80E+01	p-Xylene

MORE ↓

ENTER Average soil temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to top of contamination, L_t (cm)	ENTER Depth below grade to bottom of contamination, (enter value of 0 if value is unknown) L_b (cm)	ENTER Totals must add up to value of L_t (cell G28) Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm²)
10	30	122	366	122	0	0	S		

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm³)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm³/cm³)	ENTER Stratum A soil organic carbon fraction, f_{oc}^A (unitless)	ENTER Stratum B SCS soil type (Lookup Soil)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm³)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm³/cm³)	ENTER Stratum B soil organic carbon fraction, f_{oc}^B (unitless)	ENTER Stratum C SCS soil type (Lookup Soil)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm³)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm³/cm³)	ENTER Stratum C soil organic carbon fraction, f_{oc}^C (unitless)
S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s²)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	36576	51206	366	0.1	1	

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	30	30	350	1.0E-06	1

Used to calculate risk-based soil concentration.

END

INTERMEDIATE CALCULATIONS SHEET

XYLENE SURFACE (0 TO 4 FT) EPC

Exposure duration, τ (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, θ_a^A (cm^3/cm^3)	Stratum B soil air-filled porosity, θ_a^B (cm^3/cm^3)	Stratum C soil air-filled porosity, θ_a^C (cm^3/cm^3)	Stratum A effective total fluid saturation, S_{te} (cm^3/cm^3)	Stratum A soil intrinsic permeability, k_i (cm^2)	Stratum A soil relative air permeability, k_{rg} (cm^2)	Stratum A soil effective vapor permeability, k_v (cm^2)	Floor-wall seam perimeter, X_{crack} (cm)	Initial soil concentration used, C_R (µg/kg)	Bldg. ventilation rate, $Q_{building}$ (cm^3/s)
9.46E+08	92	0.321	0.321	0.321	0.003	9.92E-08	0.998	9.91E-08	175,564	3.80E+01	1.90E+08

Area of enclosed space below grade, A_B (cm^2)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. soil temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. soil temperature, H_{TS} ($atm\text{-}m^3/mol$)	Henry's law constant at ave. soil temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm^2/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm^2/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm^2/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm^2/s)	Diffusion path length, L_d (cm)	Convection path length, L_p (cm)
1.88E+09	9.35E-06	30	10,248	3.06E-03	1.32E-01	1.75E-04	1.24E-02	0.00E+00	0.00E+00	1.24E-02	92	30

Soil-water partition coefficient, K_d (cm^3/g)	Source vapor conc., C_{source} (µg/m^3)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm^3/s)	Crack effective diffusion coefficient, D^{crack} (cm^2/s)	Area of crack, A_{crack} (cm^2)	Exponent of equivalent foundation Peclet number, $exp(Pe^f)$ (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc., $C_{building}$ (µg/m^3)	Finite source β term (unitless)	Finite source ψ term $(sec)^{-1}$	Time for source depletion, τ_D (sec)	Exposure duration > time for source depletion (YES/NO)
7.78E-01	5.98E+03	0.10	3.90E+03	1.24E-02	1.76E+04	3.23E+77	NA	NA	6.62E+01	1.39E-07	1.29E+09	NO

Finite source indoor attenuation coefficient, <α> (unitless)	Mass limit bldg. conc., $C_{building}$ (µg/m^3)	Finite source bldg. conc., $C_{building}$ (µg/m^3)	Final finite source bldg. conc., $C_{building}$ (µg/m^3)	Unit risk factor, URF $(\mu g/m^3)^{-1}$	Reference conc., RfC (mg/m^3)
1.99E-05	NA	1.19E-01	1.19E-01	NA	1.0E-01

END

DATA ENTRY SHEET

SL-ADV Version 3.1; 02/04

Reset to

CALCULATE RISK-BASED SOIL CONCENTRATION (enter "X" in "YES" box)

1,1,1-TRICHLOROETHANE (4 TO 8 FT) MAXIMUM

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL SOIL CONCENTRATION (enter "X" in "YES" box and initial soil conc. below)

YES [X]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial soil conc., C_R (µg/kg)	Chemical
71556	2.00E+00	1,1,1-Trichloroethane

MORE ↓

ENTER Average soil temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to top of contamination, L_t (cm)	ENTER Depth below grade to bottom of contamination, (enter value of 0 if value is unknown) L_b (cm)	ENTER (Totals must add up to value of L_t (cell G28)) Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm²)
10	30	244	366	244	0	0	S		

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm³)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm³/cm³)	ENTER Stratum A soil organic carbon fraction, f_{oc}^A (unitless)	ENTER Stratum B SCS soil type (Lookup Soil)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm³)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm³/cm³)	ENTER Stratum B soil organic carbon fraction, f_{oc}^B (unitless)	ENTER Stratum C SCS soil type (Lookup Soil)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm³)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm³/cm³)	ENTER Stratum C soil organic carbon fraction, f_{oc}^C (unitless)
S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s²)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	36576	51206	366	0.1	1	

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	30	30	350	1.0E-06	1

Used to calculate risk-based soil concentration.

END

INTERMEDIATE CALCULATIONS SHEET

1,1,1-TRICHLOROETHANE (4 TO 8 FT) MAXIMUM

Exposure duration, τ (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, θ_a^A (cm^3/cm^3)	Stratum B soil air-filled porosity, θ_a^B (cm^3/cm^3)	Stratum C soil air-filled porosity, θ_a^C (cm^3/cm^3)	Stratum A effective total fluid saturation, S_{te} (cm^3/cm^3)	Stratum A soil intrinsic permeability, k_i (cm^2)	Stratum A soil relative air permeability, k_{rg} (cm^2)	Stratum A soil effective vapor permeability, k_v (cm^2)	Floor-wall seam perimeter, X_{crack} (cm)	Initial soil concentration used, C_R (μg/kg)	Bldg. ventilation rate, $Q_{building}$ (cm^3/s)
9.46E+08	214	0.321	0.321	0.321	0.003	9.92E-08	0.998	9.91E-08	175,564	2.00E+00	1.90E+08

Area of enclosed space below grade, A_B (cm^2)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. soil temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. soil temperature, H_{TS} (atm-m^3/mol)	Henry's law constant at ave. soil temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm^2/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm^2/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm^2/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm^2/s)	Diffusion path length, L_d (cm)	Convection path length, L_p (cm)
1.88E+09	9.35E-06	30	7,885	8.48E-03	3.65E-01	1.75E-04	1.26E-02	0.00E+00	0.00E+00	1.26E-02	214	30

Soil-water partition coefficient, K_d (cm^3/g)	Source vapor conc., C_{source} (μg/m^3)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm^3/s)	Crack effective diffusion coefficient, D^{crack} (cm^2/s)	Area of crack, A_{crack} (cm^2)	Exponent of equivalent foundation Peclet number, $exp(Pe^f)$ (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc., $C_{building}$ (μg/m^3)	Finite source β term (unitless)	Finite source ψ term $(sec)^{-1}$	Time for source depletion, τ_D (sec)	Exposure duration > time for source depletion (YES/NO)
2.20E-01	2.26E+03	0.10	3.90E+03	1.26E-02	1.76E+04	2.61E+76	NA	NA	2.94E+01	1.87E-07	9.04E+07	YES

Finite source indoor attenuation coefficient, <α> (unitless)	Mass limit bldg. conc., $C_{building}$ (μg/m^3)	Finite source bldg. conc., $C_{building}$ (μg/m^3)	Final finite source bldg. conc., $C_{building}$ (μg/m^3)	Unit risk factor, URF $(\mu g/m^3)^{-1}$	Reference conc., RfC (mg/m^3)
NA	4.22E-03	NA	4.22E-03	NA	2.2E+00

END

DATA ENTRY SHEET

SL-ADV
Version 3.1; 02/04

Reset to

CALCULATE RISK-BASED SOIL CONCENTRATION (enter "X" in "YES" box)

1,1,2-TRICHLOROETHANE (4 TO 8 FT) MAXIMUM

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL SOIL CONCENTRATION (enter "X" in "YES" box and initial soil conc. below)

YES [x]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial soil conc., C_R (μg/kg)	Chemical
79005	9.00E+00	1,1,2-Trichloroethane

MORE ↓

ENTER Average soil temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to top of contamination, L_t (cm)	ENTER Depth below grade to bottom of contamination, (enter value of 0 if value is unknown) L_b (cm)	ENTER Totals must add up to value of L_t (cell G28) Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm²)
10	30	244	366	244	0	0	S		

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm³)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm³/cm³)	ENTER Stratum A soil organic carbon fraction, f_{oc}^A (unitless)	ENTER Stratum B SCS soil type (Lookup Soil)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm³)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm³/cm³)	ENTER Stratum B soil organic carbon fraction, f_{oc}^B (unitless)	ENTER Stratum C SCS soil type (Lookup Soil)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm³)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm³/cm³)	ENTER Stratum C soil organic carbon fraction, f_{oc}^C (unitless)
S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s²)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	36576	51206	366	0.1	1	

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	30	30	350	1.0E-06	1

Used to calculate risk-based soil concentration.

END

INTERMEDIATE CALCULATIONS SHEET

1,1,2-TRICHLOROETHANE (4 TO 8 FT) MAXIMUM

Exposure duration, τ (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, θ_a^A (cm^3/cm^3)	Stratum B soil air-filled porosity, θ_a^B (cm^3/cm^3)	Stratum C soil air-filled porosity, θ_a^C (cm^3/cm^3)	Stratum A effective total fluid saturation, S_{te} (cm^3/cm^3)	Stratum A soil intrinsic permeability, k_i (cm^2)	Stratum A soil relative air permeability, k_{rg} (cm^2)	Stratum A soil effective vapor permeability, k_v (cm^2)	Floor-wall seam perimeter, X_{crack} (cm)	Initial soil concentration used, C_R (µg/kg)	Bldg. ventilation rate, $Q_{building}$ (cm^3/s)
9.46E+08	214	0.321	0.321	0.321	0.003	9.92E-08	0.998	9.91E-08	175,564	9.00E+00	1.90E+08

Area of enclosed space below grade, A_B (cm^2)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. soil temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. soil temperature, H_{TS} (atm-m^3/mol)	Henry's law constant at ave. soil temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm^2/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm^2/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm^2/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm^2/s)	Diffusion path length, L_d (cm)	Convection path length, L_p (cm)
1.88E+09	9.35E-06	30	9,572	3.87E-04	1.67E-02	1.75E-04	1.26E-02	0.00E+00	0.00E+00	1.26E-02	214	30

Soil-water partition coefficient, K_d (cm^3/g)	Source vapor conc., C_{source} (µg/m^3)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm^3/s)	Crack effective diffusion coefficient, D^{crack} (cm^2/s)	Area of crack, A_{crack} (cm^2)	Exponent of equivalent foundation Peclet number, exp(Pe^f) (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc., $C_{building}$ (µg/m^3)	Finite source β term (unitless)	Finite source ψ term $(sec)^{-1}$	Time for source depletion, τ_D (sec)	Exposure duration > time for source depletion (YES/NO)
1.00E-01	1.10E+03	0.10	3.90E+03	1.26E-02	1.76E+04	2.60E+76	NA	NA	2.94E+01	2.03E-08	8.33E+08	YES

Finite source indoor attenuation coefficient, <α> (unitless)	Mass limit bldg. conc., $C_{building}$ (µg/m^3)	Finite source bldg. conc., $C_{building}$ (µg/m^3)	Final finite source bldg. conc., $C_{building}$ (µg/m^3)	Unit risk factor, URF $(µg/m^3)^{-1}$	Reference conc., RfC (mg/m^3)
NA	1.90E-02	NA	1.90E-02	1.6E-05	1.4E-02

END

DATA ENTRY SHEET

SL-ADV
Version 3.1; 02/04

Reset to

CALCULATE RISK-BASED SOIL CONCENTRATION (enter "X" in "YES" box)

1,2-DICHLOROETHENE (4 TO 8 FT) MAXIMUM

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL SOIL CONCENTRATION (enter "X" in "YES" box and initial soil conc. below)

YES [X]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial soil conc., C_R (μg/kg)	Chemical
156605	2.60E+01	trans-1,2-Dichloroethylene

MORE ↓

ENTER Average soil temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to top of contamination, L_t (cm)	ENTER Depth below grade to bottom of contamination, (enter value of 0 if value is unknown) L_b (cm)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm²)
				Totals must add up to value of L_t (cell G28)					
10	30	244	366	244	0	0	S		

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm³)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm³/cm³)	ENTER Stratum A soil organic carbon fraction, f_{oc}^A (unitless)	ENTER Stratum B SCS soil type (Lookup Soil)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm³)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm³/cm³)	ENTER Stratum B soil organic carbon fraction, f_{oc}^B (unitless)	ENTER Stratum C SCS soil type (Lookup Soil)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm³)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm³/cm³)	ENTER Stratum C soil organic carbon fraction, f_{oc}^C (unitless)
S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s²)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	36576	51206	366	0.1	1	

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	30	30	350	1.0E-06	1

Used to calculate risk-based soil concentration.

END

INTERMEDIATE CALCULATIONS SHEET

1,2-DICHLOROETHENE (4 TO 8 FT) MAXIMUM

Exposure duration, τ (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, θ_a^A (cm^3/cm^3)	Stratum B soil air-filled porosity, θ_a^B (cm^3/cm^3)	Stratum C soil air-filled porosity, θ_a^C (cm^3/cm^3)	Stratum A effective total fluid saturation, S_{te} (cm^3/cm^3)	Stratum A soil intrinsic permeability, k_i (cm^2)	Stratum A soil relative air permeability, k_{rg} (cm^2)	Stratum A soil effective vapor permeability, k_v (cm^2)	Floor-wall seam perimeter, X_{crack} (cm)	Initial soil concentration used, C_R ($\mu g/kg$)	Bldg. ventilation rate, $Q_{building}$ (cm^3/s)
9.46E+08	214	0.321	0.321	0.321	0.003	9.92E-08	0.998	9.91E-08	175,564	2.60E+01	1.90E+08

Area of enclosed space below grade, A_B (cm^2)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. soil temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. soil temperature, H_{TS} ($atm\text{-}m^3/mol$)	Henry's law constant at ave. soil temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm^2/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm^2/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm^2/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm^2/s)	Diffusion path length, L_d (cm)	Convection path length, L_p (cm)
1.88E+09	9.35E-06	30	7,136	4.94E-03	2.13E-01	1.75E-04	1.14E-02	0.00E+00	0.00E+00	1.14E-02	214	30

Soil-water partition coefficient, K_d (cm^3/g)	Source vapor conc., C_{source} ($\mu g/m^3$)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm^3/s)	Crack effective diffusion coefficient, D^{crack} (cm^2/s)	Area of crack, A_{crack} (cm^2)	Exponent of equivalent foundation Peclet number, $\exp(Pe^f)$ (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc., $C_{building}$ ($\mu g/m^3$)	Finite source β term (unitless)	Finite source ψ term $(sec)^{-1}$	Time for source depletion, τ_D (sec)	Exposure duration > time for source depletion (YES/NO)
1.05E-01	3.10E+04	0.10	3.90E+03	1.14E-02	1.76E+04	2.03E+84	NA	NA	2.68E+01	1.79E-07	8.61E+07	YES

Finite source indoor attenuation coefficient, <α> (unitless)	Mass limit bldg. conc., $C_{building}$ ($\mu g/m^3$)	Finite source bldg. conc., $C_{building}$ ($\mu g/m^3$)	Final finite source bldg. conc., $C_{building}$ ($\mu g/m^3$)	Unit risk factor, URF $(\mu g/m^3)^{-1}$	Reference conc., RfC (mg/m^3)
NA	5.49E-02	NA	5.49E-02	NA	7.0E-02

END

DATA ENTRY SHEET

SL-ADV
Version 3.1; 02/04

Reset to

CALCULATE RISK-BASED SOIL CONCENTRATION (enter "X" in "YES" box) — **2-BUTANONE (4 TO 8 FT) MAXIMUM**

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL SOIL CONCENTRATION (enter "X" in "YES" box and initial soil conc. below)

YES [X]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial soil conc., C_R (μg/kg)	Chemical
78933	8.70E+01	Methylethylketone (2-butanone)

MORE ↓

ENTER Average soil temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to top of contamination, L_t (cm)	ENTER Depth below grade to bottom of contamination, (enter value of 0 if value is unknown) L_b (cm)	ENTER Totals must add up to value of L_t (cell G28) Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm²)
10	30	244	366	244	0	0	S		

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm³)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm³/cm³)	ENTER Stratum A soil organic carbon fraction, f_{oc}^A (unitless)	ENTER Stratum B SCS soil type (Lookup Soil)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm³)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm³/cm³)	ENTER Stratum B soil organic carbon fraction, f_{oc}^B (unitless)	ENTER Stratum C SCS soil type (Lookup Soil)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm³)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm³/cm³)	ENTER Stratum C soil organic carbon fraction, f_{oc}^C (unitless)
S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s²)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	36576	51206	366	0.1	1	

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	30	30	350	1.0E-06	1

Used to calculate risk-based soil concentration.

END

2-BUTANONE (4 TO 8 FT) MAXIMUM

Exposure duration, τ (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, θ_a^A (cm³/cm³)	Stratum B soil air-filled porosity, θ_a^B (cm³/cm³)	Stratum C soil air-filled porosity, θ_a^C (cm³/cm³)	Stratum A effective total fluid saturation, S_{te} (cm³/cm³)	Stratum A soil intrinsic permeability, k_i (cm²)	Stratum A soil relative air permeability, k_{rg} (cm²)	Stratum A soil effective vapor permeability, k_v (cm²)	Floor-wall seam perimeter, X_{crack} (cm)	Initial soil concentration used, C_R (µg/kg)	Bldg. ventilation rate, $Q_{building}$ (cm³/s)
9.46E+08	214	0.321	0.321	0.321	0.003	9.92E-08	0.998	9.91E-08	175,564	8.70E+01	1.90E+08

Area of enclosed space below grade, A_B (cm²)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. soil temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. soil temperature, H_{TS} (atm-m³/mol)	Henry's law constant at ave. soil temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm²/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm²/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm²/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm²/s)	Diffusion path length, L_d (cm)	Convection path length, L_p (cm)
1.88E+09	9.35E-06	30	8,419	2.63E-05	1.13E-03	1.75E-04	1.31E-02	0.00E+00	0.00E+00	1.31E-02	214	30

Soil-water partition coefficient, K_d (cm³/g)	Source vapor conc., C_{source} (µg/m³)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm³/s)	Crack effective diffusion coefficient, D^{crack} (cm²/s)	Area of crack, A_{crack} (cm²)	Exponent of equivalent foundation Peclet number, $\exp(Pe^f)$ (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc., $C_{building}$ (µg/m³)	Finite source β term (unitless)	Finite source ψ term $(sec)^{-1}$	Time for source depletion, τ_D (sec)	Exposure duration > time for source depletion (YES/NO)
4.60E-03	2.63E+03	0.10	3.90E+03	1.31E-02	1.76E+04	5.59E+73	NA	NA	3.04E+01	5.20E-09	3.37E+09	NO

Finite source indoor attenuation coefficient, <α> (unitless)	Mass limit bldg. conc., $C_{building}$ (µg/m³)	Finite source bldg. conc., $C_{building}$ (µg/m³)	Final finite source bldg. conc., $C_{building}$ (µg/m³)	Unit risk factor, URF $(\mu g/m^3)^{-1}$	Reference conc., RfC (mg/m³)
1.97E-05	NA	5.20E-02	5.20E-02	NA	5.0E+00

END

DATA ENTRY SHEET

SL-ADV
Version 3.1; 02/04

Reset to

CALCULATE RISK-BASED SOIL CONCENTRATION (enter "X" in "YES" box)

4-METHYL-2-PENTANONE (4 TO 8 FT) MAXIMUM

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL SOIL CONCENTRATION (enter "X" in "YES" box and initial soil conc. below)

YES [X]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial soil conc., C_R (µg/kg)	Chemical
108101	1.50E+02	Methylisobutylketone (4-methyl-2-pentanone)

MORE ↓

ENTER Average soil temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to top of contamination, L_t (cm)	ENTER Depth below grade to bottom of contamination, (enter value of 0 if value is unknown) L_b (cm)	ENTER Totals must add up to value of L_t (cell G28) Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm²)
10	30	244	366	244	0	0	S		

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm³)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm³/cm³)	ENTER Stratum A soil organic carbon fraction, f_{oc}^A (unitless)	ENTER Stratum B SCS soil type (Lookup Soil)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm³)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm³/cm³)	ENTER Stratum B soil organic carbon fraction, f_{oc}^B (unitless)	ENTER Stratum C SCS soil type (Lookup Soil)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm³)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm³/cm³)	ENTER Stratum C soil organic carbon fraction, f_{oc}^C (unitless)
S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s²)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	36576	51206	366	0.1	1	

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	30	30	350	1.0E-06	1

Used to calculate risk-based soil concentration.

END

INTERMEDIATE CALCULATIONS SHEET

4-METHYL-2-PENTANONE (4 TO 8 FT) MAXIMUM

Exposure duration, τ (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, θ_a^A (cm^3/cm^3)	Stratum B soil air-filled porosity, θ_a^B (cm^3/cm^3)	Stratum C soil air-filled porosity, θ_a^C (cm^3/cm^3)	Stratum A effective total fluid saturation, S_{te} (cm^3/cm^3)	Stratum A soil intrinsic permeability, k_i (cm^2)	Stratum A soil relative air permeability, k_{rg} (cm^2)	Stratum A soil effective vapor permeability, k_v (cm^2)	Floor-wall seam perimeter, X_{crack} (cm)	Initial soil concentration used, C_R (μg/kg)	Bldg. ventilation rate, $Q_{building}$ (cm^3/s)
9.46E+08	214	0.321	0.321	0.321	0.003	9.92E-08	0.998	9.91E-08	175,564	1.50E+02	1.90E+08

Area of enclosed space below grade, A_B (cm^2)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. soil temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. soil temperature, H_{TS} (atm-m^3/mol)	Henry's law constant at ave. soil temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm^2/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm^2/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm^2/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm^2/s)	Diffusion path length, L_d (cm)	Convection path length, L_p (cm)
1.88E+09	9.35E-06	30	9,862	5.70E-05	2.45E-03	1.75E-04	1.21E-02	0.00E+00	0.00E+00	1.21E-02	214	30

Soil-water partition coefficient, K_d (cm^3/g)	Source vapor conc., C_{source} (μg/m^3)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm^3/s)	Crack effective diffusion coefficient, D^{crack} (cm^2/s)	Area of crack, A_{crack} (cm^2)	Exponent of equivalent foundation Peclet number, exp(Pe^f) (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc., $C_{building}$ (μg/m^3)	Finite source β term (unitless)	Finite source ψ term $(sec)^{-1}$	Time for source depletion, τ_D (sec)	Exposure duration > time for source depletion (YES/NO)
1.81E-02	7.20E+03	0.10	3.90E+03	1.21E-02	1.76E+04	2.91E+79	NA	NA	2.83E+01	7.65E-09	2.13E+09	NO

Finite source indoor attenuation coefficient, <α> (unitless)	Mass limit bldg. conc., $C_{building}$ (μg/m^3)	Finite source bldg. conc., $C_{building}$ (μg/m^3)	Final finite source bldg. conc., $C_{building}$ (μg/m^3)	Unit risk factor, URF $(\mu g/m^3)^{-1}$	Reference conc., RfC (mg/m^3)
1.96E-05	NA	1.41E-01	1.41E-01	NA	3.0E+00

END

DATA ENTRY SHEET

SL-ADV
Version 3.1; 02/04

Reset to

CALCULATE RISK-BASED SOIL CONCENTRATION (enter "X" in "YES" box)

ACETONE (4 TO 8 FT) MAXIMUM

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL SOIL CONCENTRATION (enter "X" in "YES" box and initial soil conc. below)

YES [X]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial soil conc., C_R (µg/kg)	Chemical
67641	4.60E+02	Acetone

MORE ↓

ENTER Average soil temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to top of contamination, L_t (cm)	ENTER Depth below grade to bottom of contamination, (enter value of 0 if value is unknown) L_b (cm)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm²)
				Totals must add up to value of L_t (cell G28)					
10	30	244	366	244	0	0	S		

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm³)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm³/cm³)	ENTER Stratum A soil organic carbon fraction, f_{oc}^A (unitless)	ENTER Stratum B SCS soil type (Lookup Soil)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm³)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm³/cm³)	ENTER Stratum B soil organic carbon fraction, f_{oc}^B (unitless)	ENTER Stratum C SCS soil type (Lookup Soil)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm³)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm³/cm³)	ENTER Stratum C soil organic carbon fraction, f_{oc}^C (unitless)
S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s²)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	36576	51206	366	0.1	1	

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	30	30	350	1.0E-06	1
				Used to calculate risk-based soil concentration.	

END

INTERMEDIATE CALCULATIONS SHEET

ACETONE (4 TO 8 FT) MAXIMUM

Exposure duration, τ (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, θ_a^A (cm^3/cm^3)	Stratum B soil air-filled porosity, θ_a^B (cm^3/cm^3)	Stratum C soil air-filled porosity, θ_a^C (cm^3/cm^3)	Stratum A effective total fluid saturation, S_{te} (cm^3/cm^3)	Stratum A soil intrinsic permeability, k_i (cm^2)	Stratum A soil relative air permeability, k_{rg} (cm^2)	Stratum A soil effective vapor permeability, k_v (cm^2)	Floor-wall seam perimeter, X_{crack} (cm)	Initial soil concentration used, C_R (μg/kg)	Bldg. ventilation rate, $Q_{building}$ (cm^3/s)
9.46E+08	214	0.321	0.321	0.321	0.003	9.92E-08	0.998	9.91E-08	175,564	4.60E+02	1.90E+08

Area of enclosed space below grade, A_B (cm^2)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. soil temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. soil temperature, H_{TS} (atm-m^3/mol)	Henry's law constant at ave. soil temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm^2/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm^2/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm^2/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm^2/s)	Diffusion path length, L_d (cm)	Convection path length, L_p (cm)
1.88E+09	9.35E-06	30	7,559	1.97E-05	8.47E-04	1.75E-04	2.01E-02	0.00E+00	0.00E+00	2.01E-02	214	30

Soil-water partition coefficient, K_d (cm^3/g)	Source vapor conc., C_{source} ($\mu g/m^3$)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm^3/s)	Crack effective diffusion coefficient, D^{crack} (cm^2/s)	Area of crack, A_{crack} (cm^2)	Exponent of equivalent foundation Peclet number, exp(Pe^f) (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc., $C_{building}$ ($\mu g/m^3$)	Finite source β term (unitless)	Finite source ψ term $(sec)^{-1}$	Time for source depletion, τ_D (sec)	Exposure duration > time for source depletion (YES/NO)
1.15E-03	1.15E+04	0.10	3.90E+03	2.01E-02	1.76E+04	1.13E+48	NA	NA	4.62E+01	6.60E-09	4.01E+09	NO

Finite source indoor attenuation coefficient, $\langle\alpha\rangle$ (unitless)	Mass limit bldg. conc., $C_{building}$ ($\mu g/m^3$)	Finite source bldg. conc., $C_{building}$ ($\mu g/m^3$)	Final finite source bldg. conc., $C_{building}$ ($\mu g/m^3$)	Unit risk factor, URF $(\mu g/m^3)^{-1}$	Reference conc., RfC (mg/m^3)
2.00E-05	NA	2.30E-01	2.30E-01	NA	3.5E-01

END

DATA ENTRY SHEET

SL-ADV
Version 3.1; 02/04

Reset to

CALCULATE RISK-BASED SOIL CONCENTRATION (enter "X" in "YES" box)

BENZENE (4 TO 8 FT) MAXIMUM

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL SOIL CONCENTRATION (enter "X" in "YES" box and initial soil conc. below)

YES [X]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial soil conc., C_R (µg/kg)	Chemical
71432	1.00E+00	Benzene

MORE ↓

ENTER Average soil temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to top of contamination, L_t (cm)	ENTER Depth below grade to bottom of contamination, (enter value of 0 if value is unknown) L_b (cm)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm²)
				Totals must add up to value of L_t (cell G28)					
10	30	244	366	244	0	0	S		

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm³)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm³/cm³)	ENTER Stratum A soil organic carbon fraction, f_{oc}^A (unitless)	ENTER Stratum B SCS soil type (Lookup Soil)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm³)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm³/cm³)	ENTER Stratum B soil organic carbon fraction, f_{oc}^B (unitless)	ENTER Stratum C SCS soil type (Lookup Soil)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm³)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm³/cm³)	ENTER Stratum C soil organic carbon fraction, f_{oc}^C (unitless)
S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s²)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	36576	51206	366	0.1	1	

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	30	30	350	1.0E-06	1
				Used to calculate risk-based soil concentration.	

END

INTERMEDIATE CALCULATIONS SHEET

BENZENE (4 TO 8 FT) MAXIMUM

Exposure duration, τ (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, θ_a^A (cm³/cm³)	Stratum B soil air-filled porosity, θ_a^B (cm³/cm³)	Stratum C soil air-filled porosity, θ_a^C (cm³/cm³)	Stratum A effective total fluid saturation, S_{te} (cm³/cm³)	Stratum A soil intrinsic permeability, k_i (cm²)	Stratum A soil relative air permeability, k_{rg} (cm²)	Stratum A soil effective vapor permeability, k_v (cm²)	Floor-wall seam perimeter, X_{crack} (cm)	Initial soil concentration used, C_R (µg/kg)	Bldg. ventilation rate, $Q_{building}$ (cm³/s)
9.46E+08	214	0.321	0.321	0.321	0.003	9.92E-08	0.998	9.91E-08	175,564	1.00E+00	1.90E+08

Area of enclosed space below grade, A_B (cm²)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. soil temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. soil temperature, H_{TS} (atm-m³/mol)	Henry's law constant at ave. soil temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm²/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm²/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm²/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm²/s)	Diffusion path length, L_d (cm)	Convection path length, L_p (cm)
1.88E+09	9.35E-06	30	8,122	2.68E-03	1.15E-01	1.75E-04	1.42E-02	0.00E+00	0.00E+00	1.42E-02	214	30

Soil-water partition coefficient, K_d (cm³/g)	Source vapor conc., C_{source} (µg/m³)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm³/s)	Crack effective diffusion coefficient, D^{crack} (cm²/s)	Area of crack, A_{crack} (cm²)	Exponent of equivalent foundation Peclet number, $\exp(Pe^f)$ (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc., $C_{building}$ (µg/m³)	Finite source β term (unitless)	Finite source ψ term (sec)⁻¹	Time for source depletion, τ_D (sec)	Exposure duration > time for source depletion (YES/NO)
1.18E-01	6.68E+02	0.10	3.90E+03	1.42E-02	1.76E+04	5.40E+67	NA	NA	3.31E+01	1.25E-07	1.52E+08	YES

Finite source indoor attenuation coefficient, <α> (unitless)	Mass limit bldg. conc., $C_{building}$ (µg/m³)	Finite source bldg. conc., $C_{building}$ (µg/m³)	Final finite source bldg. conc., $C_{building}$ (µg/m³)	Unit risk factor, URF (µg/m³)⁻¹	Reference conc., RfC (mg/m³)
NA	2.11E-03	NA	2.11E-03	7.8E-06	3.0E-02

END

DATA ENTRY SHEET

SL-ADV
Version 3.1; 02/04

Reset to

CALCULATE RISK-BASED SOIL CONCENTRATION (enter "X" in "YES" box)

BROMOMETHANE (4 TO 8 FT) MAXIMUM

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL SOIL CONCENTRATION (enter "X" in "YES" box and initial soil conc. below)

YES [X]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial soil conc., C_R (µg/kg)	Chemical
74839	1.00E+00	Methyl bromide

MORE ↓

ENTER Average soil temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to top of contamination, L_t (cm)	ENTER Depth below grade to bottom of contamination, (enter value of 0 if value is unknown) L_b (cm)	ENTER Totals must add up to value of L_t (cell G28) Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm²)
10	30	244	366	244	0	0	S		

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm³)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm³/cm³)	ENTER Stratum A soil organic carbon fraction, f_{oc}^A (unitless)	ENTER Stratum B SCS soil type (Lookup Soil)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm³)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm³/cm³)	ENTER Stratum B soil organic carbon fraction, f_{oc}^B (unitless)	ENTER Stratum C SCS soil type (Lookup Soil)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm³)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm³/cm³)	ENTER Stratum C soil organic carbon fraction, f_{oc}^C (unitless)
S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s²)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	36576	51206	366	0.1	1	

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	30	30	350	1.0E-06	1

Used to calculate risk-based soil concentration.

END

BROMOMETHANE (4 TO 8 FT) MAXIMUM

Exposure duration, τ (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, θ_a^A (cm³/cm³)	Stratum B soil air-filled porosity, θ_a^B (cm³/cm³)	Stratum C soil air-filled porosity, θ_a^C (cm³/cm³)	Stratum A effective total fluid saturation, S_{te} (cm³/cm³)	Stratum A soil intrinsic permeability, k_i (cm²)	Stratum A soil relative air permeability, k_{rg} (cm²)	Stratum A soil effective vapor permeability, k_v (cm²)	Floor-wall seam perimeter, X_{crack} (cm)	Initial soil concentration used, C_R (µg/kg)	Bldg. ventilation rate, $Q_{building}$ (cm³/s)
9.46E+08	214	0.321	0.321	0.321	0.003	9.92E-08	0.998	9.91E-08	175,564	1.00E+00	1.90E+08

Area of enclosed space below grade, A_B (cm²)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. soil temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. soil temperature, H_{TS} (atm-m³/mol)	Henry's law constant at ave. soil temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm²/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm²/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm²/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm²/s)	Diffusion path length, L_d (cm)	Convection path length, L_p (cm)
1.88E+09	9.35E-06	30	5,651	3.76E-03	1.62E-01	1.75E-04	1.18E-02	0.00E+00	0.00E+00	1.18E-02	214	30

Soil-water partition coefficient, K_d (cm³/g)	Source vapor conc., C_{source} (µg/m³)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm³/s)	Crack effective diffusion coefficient, D^{crack} (cm²/s)	Area of crack, A_{crack} (cm²)	Exponent of equivalent foundation Peclet number, $\exp(Pe^f)$ (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc., $C_{building}$ (µg/m³)	Finite source β term (unitless)	Finite source ψ term (sec)$^{-1}$	Time for source depletion, τ_D (sec)	Exposure duration > time for source depletion (YES/NO)
2.10E-02	1.91E+03	0.10	3.90E+03	1.18E-02	1.76E+04	7.49E+81	NA	NA	2.75E+01	2.95E-07	5.37E+07	YES

Finite source indoor attenuation coefficient, <α> (unitless)	Mass limit bldg. conc., $C_{building}$ (µg/m³)	Finite source bldg. conc., $C_{building}$ (µg/m³)	Final finite source bldg. conc., $C_{building}$ (µg/m³)	Unit risk factor, URF (µg/m³)$^{-1}$	Reference conc., RfC (mg/m³)
NA	2.11E-03	NA	2.11E-03	NA	5.0E-03

END

DATA ENTRY SHEET

SL-ADV
Version 3.1; 02/04

Reset to

CALCULATE RISK-BASED SOIL CONCENTRATION (enter "X" in "YES" box)

CARBON DISULFIDE (4 TO 8 FT) MAXIMUM

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL SOIL CONCENTRATION (enter "X" in "YES" box and initial soil conc. below)

YES [X]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial soil conc., C_R (μg/kg)	Chemical
75150	1.40E+01	Carbon disulfide

MORE ↓

ENTER Average soil temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to top of contamination, L_t (cm)	ENTER Depth below grade to bottom of contamination, (enter value of 0 if value is unknown) L_b (cm)	ENTER Totals must add up to value of L_t (cell G28) Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm²)
10	30	244	366	244	0	0	S		

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm³)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm³/cm³)	ENTER Stratum A soil organic carbon fraction, f_{oc}^A (unitless)	ENTER Stratum B SCS soil type (Lookup Soil)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm³)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm³/cm³)	ENTER Stratum B soil organic carbon fraction, f_{oc}^B (unitless)	ENTER Stratum C SCS soil type (Lookup Soil)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm³)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm³/cm³)	ENTER Stratum C soil organic carbon fraction, f_{oc}^C (unitless)
S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s²)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	36576	51206	366	0.1	1	

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	30	30	350	1.0E-06	1

Used to calculate risk-based soil concentration.

END

CARBON DISULFIDE (4 TO 8 FT) MAXIMUM

Exposure duration, τ (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, θ_a^A (cm^3/cm^3)	Stratum B soil air-filled porosity, θ_a^B (cm^3/cm^3)	Stratum C soil air-filled porosity, θ_a^C (cm^3/cm^3)	Stratum A effective total fluid saturation, S_{te} (cm^3/cm^3)	Stratum A soil intrinsic permeability, k_i (cm^2)	Stratum A soil relative air permeability, k_{rg} (cm^2)	Stratum A soil effective vapor permeability, k_v (cm^2)	Floor-wall seam perimeter, X_{crack} (cm)	Initial soil concentration used, C_R (μg/kg)	Bldg. ventilation rate, $Q_{building}$ (cm^3/s)
9.46E+08	214	0.321	0.321	0.321	0.003	9.92E-08	0.998	9.91E-08	175,564	1.40E+01	1.90E+08

Area of enclosed space below grade, A_B (cm^2)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. soil temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. soil temperature, H_{TS} (atm-m^3/mol)	Henry's law constant at ave. soil temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm^2/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm^2/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm^2/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm^2/s)	Diffusion path length, L_d (cm)	Convection path length, L_p (cm)
1.88E+09	9.35E-06	30	6,682	1.66E-02	7.16E-01	1.75E-04	1.68E-02	0.00E+00	0.00E+00	1.68E-02	214	30

Soil-water partition coefficient, K_d (cm^3/g)	Source vapor conc., C_{source} (μg/m^3)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm^3/s)	Crack effective diffusion coefficient, D^{crack} (cm^2/s)	Area of crack, A_{crack} (cm^2)	Exponent of equivalent foundation Peclet number, exp(Pe^f) (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc., $C_{building}$ (μg/m^3)	Finite source β term (unitless)	Finite source ψ term $(sec)^{-1}$	Time for source depletion, τ_D (sec)	Exposure duration > time for source depletion (YES/NO)
9.14E-02	3.82E+04	0.10	3.90E+03	1.68E-02	1.76E+04	2.05E+57	NA	NA	3.89E+01	6.03E-07	3.70E+07	YES

Finite source indoor attenuation coefficient, <α> (unitless)	Mass limit bldg. conc., $C_{building}$ (μg/m^3)	Finite source bldg. conc., $C_{building}$ (μg/m^3)	Final finite source bldg. conc., $C_{building}$ (μg/m^3)	Unit risk factor, URF $(\mu g/m^3)^{-1}$	Reference conc., RfC (mg/m^3)
NA	2.96E-02	NA	2.96E-02	NA	7.0E-01

END

DATA ENTRY SHEET

SL-ADV
Version 3.1; 02/04

Reset to

CALCULATE RISK-BASED SOIL CONCENTRATION (enter "X" in "YES" box)

ETHYLBENZENE (4 TO 8 FT) MAXIMUM

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL SOIL CONCENTRATION (enter "X" in "YES" box and initial soil conc. below)

YES [X]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial soil conc., C_R (μg/kg)	Chemical
100414	8.00E+00	Ethylbenzene

MORE ↓

ENTER Average soil temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to top of contamination, L_t (cm)	ENTER Depth below grade to bottom of contamination, (enter value of 0 if value is unknown) L_b (cm)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm²)
10	30	244	366	244	0	0	S		

Totals must add up to value of L_t (cell G28)

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm³)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm³/cm³)	ENTER Stratum A soil organic carbon fraction, f_{oc}^A (unitless)	ENTER Stratum B SCS soil type (Lookup Soil)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm³)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm³/cm³)	ENTER Stratum B soil organic carbon fraction, f_{oc}^B (unitless)	ENTER Stratum C SCS soil type (Lookup Soil)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm³)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm³/cm³)	ENTER Stratum C soil organic carbon fraction, f_{oc}^C (unitless)
S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s²)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	36576	51206	366	0.1	1	

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	30	30	350	1.0E-06	1

Used to calculate risk-based soil concentration.

END

INTERMEDIATE CALCULATIONS SHEET

ETHYLBENZENE (4 TO 8 FT) MAXIMUM

Exposure duration, τ (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, θ_a^A (cm³/cm³)	Stratum B soil air-filled porosity, θ_a^B (cm³/cm³)	Stratum C soil air-filled porosity, θ_a^C (cm³/cm³)	Stratum A effective total fluid saturation, S_{te} (cm³/cm³)	Stratum A soil intrinsic permeability, k_i (cm²)	Stratum A soil relative air permeability, k_{rg} (cm²)	Stratum A soil effective vapor permeability, k_v (cm²)	Floor-wall seam perimeter, X_{crack} (cm)	Initial soil concentration used, C_R (µg/kg)	Bldg. ventilation rate, $Q_{building}$ (cm³/s)
9.46E+08	214	0.321	0.321	0.321	0.003	9.92E-08	0.998	9.91E-08	175,564	8.00E+00	1.90E+08

Area of enclosed space below grade, A_B (cm²)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. soil temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. soil temperature, H_{TS} (atm-m³/mol)	Henry's law constant at ave. soil temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm²/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm²/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm²/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm²/s)	Diffusion path length, L_d (cm)	Convection path length, L_p (cm)
1.88E+09	9.35E-06	30	10,155	3.17E-03	1.36E-01	1.75E-04	1.21E-02	0.00E+00	0.00E+00	1.21E-02	214	30

Soil-water partition coefficient, K_d (cm³/g)	Source vapor conc., C_{source} (µg/m³)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm³/s)	Crack effective diffusion coefficient, D^{crack} (cm²/s)	Area of crack, A_{crack} (cm²)	Exponent of equivalent foundation Peclet number, $\exp(Pe^f)$ (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc., $C_{building}$ (µg/m³)	Finite source β term (unitless)	Finite source ψ term (sec)⁻¹	Time for source depletion, τ_D (sec)	Exposure duration > time for source depletion (YES/NO)
7.26E-01	1.39E+03	0.10	3.90E+03	1.21E-02	1.76E+04	2.97E+79	NA	NA	2.83E+01	2.77E-08	5.88E+08	YES

Finite source indoor attenuation coefficient, <α> (unitless)	Mass limit bldg. conc., $C_{building}$ (µg/m³)	Finite source bldg. conc., $C_{building}$ (µg/m³)	Final finite source bldg. conc., $C_{building}$ (µg/m³)	Unit risk factor, URF (µg/m³)⁻¹	Reference conc., RfC (mg/m³)
NA	1.69E-02	NA	1.69E-02	NA	1.0E+00

END

DATA ENTRY SHEET

SL-ADV Version 3.1; 02/04

Reset to

CALCULATE RISK-BASED SOIL CONCENTRATION (enter "X" in "YES" box) | YES [ ]

STYRENE (4 TO 8 FT) MAXIMUM

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL SOIL CONCENTRATION (enter "X" in "YES" box and initial soil conc. below) | YES [X]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial soil conc., C_R (µg/kg)	Chemical
100425	1.00E+00	Styrene

MORE ↓

ENTER Average soil temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to top of contamination, L_t (cm)	ENTER Depth below grade to bottom of contamination, (enter value of 0 if value is unknown) L_b (cm)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm²)
10	30	244	366	244	0	0	S		

Totals must add up to value of L_t (cell G28)

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm³)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm³/cm³)	ENTER Stratum A soil organic carbon fraction, f_{oc}^A (unitless)	ENTER Stratum B SCS soil type (Lookup Soil)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm³)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm³/cm³)	ENTER Stratum B soil organic carbon fraction, f_{oc}^B (unitless)	ENTER Stratum C SCS soil type (Lookup Soil)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm³)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm³/cm³)	ENTER Stratum C soil organic carbon fraction, f_{oc}^C (unitless)
S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s²)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	36576	51206	366	0.1	1	

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	30	30	350	1.0E-06	1

Used to calculate risk-based soil concentration.

END

INTERMEDIATE CALCULATIONS SHEET

STYRENE (4 TO 8 FT) MAXIMUM

Exposure duration, τ (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, θ_a^A (cm³/cm³)	Stratum B soil air-filled porosity, θ_a^B (cm³/cm³)	Stratum C soil air-filled porosity, θ_a^C (cm³/cm³)	Stratum A effective total fluid saturation, S_{te} (cm³/cm³)	Stratum A soil intrinsic permeability, k_i (cm²)	Stratum A soil relative air permeability, k_{rg} (cm²)	Stratum A soil effective vapor permeability, k_v (cm²)	Floor-wall seam perimeter, X_{crack} (cm)	Initial soil concentration used, C_R (µg/kg)	Bldg. ventilation rate, $Q_{building}$ (cm³/s)
9.46E+08	214	0.321	0.321	0.321	0.003	9.92E-08	0.998	9.91E-08	175,564	1.00E+00	1.90E+08

Area of enclosed space below grade, A_B (cm²)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. soil temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. soil temperature, H_{TS} (atm-m³/mol)	Henry's law constant at ave. soil temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm²/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm²/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm²/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm²/s)	Diffusion path length, L_d (cm)	Convection path length, L_p (cm)
1.88E+09	9.35E-06	30	10,450	1.08E-03	4.64E-02	1.75E-04	1.15E-02	0.00E+00	0.00E+00	1.15E-02	214	30

Soil-water partition coefficient, K_d (cm³/g)	Source vapor conc., C_{source} (µg/m³)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm³/s)	Crack effective diffusion coefficient, D^{crack} (cm²/s)	Area of crack, A_{crack} (cm²)	Exponent of equivalent foundation Peclet number, $\exp(Pe^f)$ (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc., $C_{building}$ (µg/m³)	Finite source β term (unitless)	Finite source ψ term (sec)$^{-1}$	Time for source depletion, τ_D (sec)	Exposure duration > time for source depletion (YES/NO)
1.55E+00	2.91E+01	0.10	3.90E+03	1.15E-02	1.76E+04	8.91E+83	NA	NA	2.69E+01	4.39E-09	3.52E+09	NO

Finite source indoor attenuation coefficient, $<\alpha>$ (unitless)	Mass limit bldg. conc., $C_{building}$ (µg/m³)	Finite source bldg. conc., $C_{building}$ (µg/m³)	Final finite source bldg. conc., $C_{building}$ (µg/m³)	Unit risk factor, URF (µg/m³)$^{-1}$	Reference conc., RfC (mg/m³)
1.96E-05	NA	5.72E-04	5.72E-04	NA	1.0E+00

END

DATA ENTRY SHEET

SL-ADV
Version 3.1; 02/04

Reset to

CALCULATE RISK-BASED SOIL CONCENTRATION (enter "X" in "YES" box)

TETRACHLOROETHENE (4 TO 8 FT) MAXIMUM

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL SOIL CONCENTRATION (enter "X" in "YES" box and initial soil conc. below)

YES [X]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial soil conc., C_R (μg/kg)	Chemical
127184	7.60E+02	Tetrachloroethylene

MORE ↓

ENTER Average soil temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to top of contamination, L_t (cm)	ENTER Depth below grade to bottom of contamination, (enter value of 0 if value is unknown) L_b (cm)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm²)
				Totals must add up to value of L_t (cell G28)					
10	30	244	366	244	0	0	S		

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm³)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm³/cm³)	ENTER Stratum A soil organic carbon fraction, f_{oc}^A (unitless)	ENTER Stratum B SCS soil type (Lookup Soil)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm³)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm³/cm³)	ENTER Stratum B soil organic carbon fraction, f_{oc}^B (unitless)	ENTER Stratum C SCS soil type (Lookup Soil)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm³)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm³/cm³)	ENTER Stratum C soil organic carbon fraction, f_{oc}^C (unitless)
S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s²)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	36576	51206	366	0.1	1	

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	30	30	350	1.0E-06	1
				Used to calculate risk-based soil concentration.	

END

INTERMEDIATE CALCULATIONS SHEET

TETRACHLOROETHENE (4 TO 8 FT) MAXIMUM

Exposure duration, τ (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, θ_a^A (cm^3/cm^3)	Stratum B soil air-filled porosity, θ_a^B (cm^3/cm^3)	Stratum C soil air-filled porosity, θ_a^C (cm^3/cm^3)	Stratum A effective total fluid saturation, S_{te} (cm^3/cm^3)	Stratum A soil intrinsic permeability, k_i (cm^2)	Stratum A soil relative air permeability, k_{rg} (cm^2)	Stratum A soil effective vapor permeability, k_v (cm^2)	Floor-wall seam perimeter, X_{crack} (cm)	Initial soil concentration used, C_R (μg/kg)	Bldg. ventilation rate, $Q_{building}$ (cm^3/s)
9.46E+08	214	0.321	0.321	0.321	0.003	9.92E-08	0.998	9.91E-08	175,564	7.60E+02	1.90E+08

Area of enclosed space below grade, A_B (cm^2)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. soil temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. soil temperature, H_{TS} (atm-m^3/mol)	Henry's law constant at ave. soil temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm^2/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm^2/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm^2/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm^2/s)	Diffusion path length, L_d (cm)	Convection path length, L_p (cm)
1.88E+09	9.35E-06	30	9,553	7.81E-03	3.36E-01	1.75E-04	1.16E-02	0.00E+00	0.00E+00	1.16E-02	214	30

Soil-water partition coefficient, K_d (cm^3/g)	Source vapor conc., C_{source} (μg/m^3)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm^3/s)	Crack effective diffusion coefficient, D^{crack} (cm^2/s)	Area of crack, A_{crack} (cm^2)	Exponent of equivalent foundation Peclet number, $exp(Pe^f)$ (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc., $C_{building}$ (μg/m^3)	Finite source β term (unitless)	Finite source ψ term $(sec)^{-1}$	Time for source depletion, τ_D (sec)	Exposure duration > time for source depletion (YES/NO)
3.10E-01	6.27E+05	0.10	3.90E+03	1.16E-02	1.76E+04	6.09E+82	NA	NA	2.72E+01	1.26E-07	1.24E+08	YES

Finite source indoor attenuation coefficient, <α> (unitless)	Mass limit bldg. conc., $C_{building}$ (μg/m^3)	Finite source bldg. conc., $C_{building}$ (μg/m^3)	Final finite source bldg. conc., $C_{building}$ (μg/m^3)	Unit risk factor, URF $(\mu g/m^3)^{-1}$	Reference conc., RfC (mg/m^3)
NA	1.60E+00	NA	1.60E+00	5.9E-06	6.0E-01

END

SL-ADV
Version 3.1; 02/04

Reset to

CALCULATE RISK-BASED SOIL CONCENTRATION (enter "X" in "YES" box)

TOLUENE (4 TO 8 FT) MAXIMUM

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL SOIL CONCENTRATION (enter "X" in "YES" box and initial soil conc. below)

YES [X]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial soil conc., C_R (μg/kg)	Chemical
108883	1.30E+01	Toluene

MORE ↓

ENTER Average soil temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to top of contamination, L_t (cm)	ENTER Depth below grade to bottom of contamination, (enter value of 0 if value is unknown) L_b (cm)	ENTER Totals must add up to value of L_t (cell G28) Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm²)
10	30	244	366	244	0	0	S		

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm³)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm³/cm³)	ENTER Stratum A soil organic carbon fraction, f_{oc}^A (unitless)	ENTER Stratum B SCS soil type (Lookup Soil)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm³)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm³/cm³)	ENTER Stratum B soil organic carbon fraction, f_{oc}^B (unitless)	ENTER Stratum C SCS soil type (Lookup Soil)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm³)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm³/cm³)	ENTER Stratum C soil organic carbon fraction, f_{oc}^C (unitless)
S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s²)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	36576	51206	366	0.1	1	

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	30	30	350	1.0E-06	1

Used to calculate risk-based soil concentration.

END

INTERMEDIATE CALCULATIONS SHEET

TOLUENE (4 TO 8 FT) MAXIMUM

Exposure duration, τ (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, θ_a^A (cm^3/cm^3)	Stratum B soil air-filled porosity, θ_a^B (cm^3/cm^3)	Stratum C soil air-filled porosity, θ_a^C (cm^3/cm^3)	Stratum A effective total fluid saturation, S_{te} (cm^3/cm^3)	Stratum A soil intrinsic permeability, k_i (cm^2)	Stratum A soil relative air permeability, k_{rg} (cm^2)	Stratum A soil effective vapor permeability, k_v (cm^2)	Floor-wall seam perimeter, X_{crack} (cm)	Initial soil concentration used, C_R (µg/kg)	Bldg. ventilation rate, $Q_{building}$ (cm^3/s)
9.46E+08	214	0.321	0.321	0.321	0.003	9.92E-08	0.998	9.91E-08	175,564	1.30E+01	1.90E+08

Area of enclosed space below grade, A_B (cm^2)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. soil temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. soil temperature, H_{TS} (atm-m^3/mol)	Henry's law constant at ave. soil temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm^2/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm^2/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm^2/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm^2/s)	Diffusion path length, L_d (cm)	Convection path length, L_p (cm)
1.88E+09	9.35E-06	30	9,154	2.92E-03	1.26E-01	1.75E-04	1.41E-02	0.00E+00	0.00E+00	1.41E-02	214	30

Soil-water partition coefficient, K_d (cm^3/g)	Source vapor conc., C_{source} (µg/m^3)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm^3/s)	Crack effective diffusion coefficient, D^{crack} (cm^2/s)	Area of crack, A_{crack} (cm^2)	Exponent of equivalent foundation Peclet number, $\exp(Pe^f)$ (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc., $C_{building}$ (µg/m^3)	Finite source β term (unitless)	Finite source ψ term (sec)$^{-1}$	Time for source depletion, τ_D (sec)	Exposure duration > time for source depletion (YES/NO)
3.64E-01	3.88E+03	0.10	3.90E+03	1.41E-02	1.76E+04	3.25E+68	NA	NA	3.27E+01	5.53E-08	3.40E+08	YES

Finite source indoor attenuation coefficient, $<\alpha>$ (unitless)	Mass limit bldg. conc., $C_{building}$ (µg/m^3)	Finite source bldg. conc., $C_{building}$ (µg/m^3)	Final finite source bldg. conc., $C_{building}$ (µg/m^3)	Unit risk factor, URF (µg/m^3)$^{-1}$	Reference conc., RfC (mg/m^3)
NA	2.74E-02	NA	2.74E-02	NA	4.0E-01

END

DATA ENTRY SHEET

SL-ADV
Version 3.1; 02/04

Reset to

CALCULATE RISK-BASED SOIL CONCENTRATION (enter "X" in "YES" box)

TRICHLOROETHENE (4 TO 8 FT) MAXIMUM

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL SOIL CONCENTRATION (enter "X" in "YES" box and initial soil conc. below)

YES [X]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial soil conc., C_R (µg/kg)	Chemical
79016	7.70E+02	Trichloroethylene

MORE ↓

ENTER Average soil temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to top of contamination, L_t (cm)	ENTER Depth below grade to bottom of contamination, (enter value of 0 if value is unknown) L_b (cm)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm²)
10	30	244	366	244	0	0	S		

Totals must add up to value of L_t (cell G28)

MORE ↓

ENTER Stratum A SCS soil type	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm³)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm³/cm³)	ENTER Stratum A soil organic carbon fraction, f_{oc}^A (unitless)	ENTER Stratum B SCS soil type	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm³)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm³/cm³)	ENTER Stratum B soil organic carbon fraction, f_{oc}^B (unitless)	ENTER Stratum C SCS soil type	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm³)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm³/cm³)	ENTER Stratum C soil organic carbon fraction, f_{oc}^C (unitless)
Lookup Soil					Lookup Soil					Lookup Soil				
S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s²)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	36576	51206	366	0.1	1	

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	30	30	350	1.0E-06	1

Used to calculate risk-based soil concentration.

END

INTERMEDIATE CALCULATIONS SHEET

TRICHLOROETHENE (4 TO 8 FT) MAXIMUM

Exposure duration, τ (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, θ_a^A (cm^3/cm^3)	Stratum B soil air-filled porosity, θ_a^B (cm^3/cm^3)	Stratum C soil air-filled porosity, θ_a^C (cm^3/cm^3)	Stratum A effective total fluid saturation, S_{te} (cm^3/cm^3)	Stratum A soil intrinsic permeability, k_i (cm^2)	Stratum A soil relative air permeability, k_{rg} (cm^2)	Stratum A soil effective vapor permeability, k_v (cm^2)	Floor-wall seam perimeter, X_{crack} (cm)	Initial soil concentration used, C_R (μg/kg)	Bldg. ventilation rate, $Q_{building}$ (cm^3/s)
9.46E+08	214	0.321	0.321	0.321	0.003	9.92E-08	0.998	9.91E-08	175,564	7.70E+02	1.90E+08

Area of enclosed space below grade, A_B (cm^2)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. soil temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. soil temperature, H_{TS} ($atm\text{-}m^3/mol$)	Henry's law constant at ave. soil temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm^2/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm^2/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm^2/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm^2/s)	Diffusion path length, L_d (cm)	Convection path length, L_p (cm)
1.88E+09	9.35E-06	30	8,557	4.78E-03	2.06E-01	1.75E-04	1.28E-02	0.00E+00	0.00E+00	1.28E-02	214	30

Soil-water partition coefficient, K_d (cm^3/g)	Source vapor conc., C_{source} ($\mu g/m^3$)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm^3/s)	Crack effective diffusion coefficient, D^{crack} (cm^2/s)	Area of crack, A_{crack} (cm^2)	Exponent of equivalent foundation Peclet number, $exp(Pe^f)$ (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc., $C_{building}$ ($\mu g/m^3$)	Finite source β term (unitless)	Finite source ψ term $(sec)^{-1}$	Time for source depletion, τ_D (sec)	Exposure duration > time for source depletion (YES/NO)
3.32E-01	3.92E+05	0.10	3.90E+03	1.28E-02	1.76E+04	2.81E+75	NA	NA	2.98E+01	8.55E-08	2.00E+08	YES

Finite source indoor attenuation coefficient, <α> (unitless)	Mass limit bldg. conc., $C_{building}$ ($\mu g/m^3$)	Finite source bldg. conc., $C_{building}$ ($\mu g/m^3$)	Final finite source bldg. conc., $C_{building}$ ($\mu g/m^3$)	Unit risk factor, URF $(\mu g/m^3)^{-1}$	Reference conc., RfC (mg/m^3)
NA	1.63E+00	NA	1.63E+00	1.1E-04	4.0E-02

END

SL-ADV
Version 3.1; 02/04

Reset to

CALCULATE RISK-BASED SOIL CONCENTRATION (enter "X" in "YES" box)

XYLENE (4 TO 8 FT) MAXIMUM

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL SOIL CONCENTRATION (enter "X" in "YES" box and initial soil conc. below)

YES [x]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial soil conc., C_R (μg/kg)	Chemical
106423	5.40E+01	p-Xylene

MORE ↓

ENTER Average soil temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to top of contamination, L_t (cm)	ENTER Depth below grade to bottom of contamination, (enter value of 0 if value is unknown) L_b (cm)	ENTER Totals must add up to value of L_t (cell G28) Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm²)
10	30	244	366	244	0	0	S		

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm³)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm³/cm³)	ENTER Stratum A soil organic carbon fraction, f_{oc}^A (unitless)	ENTER Stratum B SCS soil type (Lookup Soil)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm³)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm³/cm³)	ENTER Stratum B soil organic carbon fraction, f_{oc}^B (unitless)	ENTER Stratum C SCS soil type (Lookup Soil)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm³)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm³/cm³)	ENTER Stratum C soil organic carbon fraction, f_{oc}^C (unitless)
S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s²)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	36576	51206	366	0.1	1	

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	30	30	350	1.0E-06	1

Used to calculate risk-based soil concentration.

END

INTERMEDIATE CALCULATIONS SHEET

XYLENE (4 TO 8 FT) MAXIMUM

Exposure duration, τ (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, θ_a^A (cm^3/cm^3)	Stratum B soil air-filled porosity, θ_a^B (cm^3/cm^3)	Stratum C soil air-filled porosity, θ_a^C (cm^3/cm^3)	Stratum A effective total fluid saturation, S_{te} (cm^3/cm^3)	Stratum A soil intrinsic permeability, k_i (cm^2)	Stratum A soil relative air permeability, k_{rg} (cm^2)	Stratum A soil effective vapor permeability, k_v (cm^2)	Floor-wall seam perimeter, X_{crack} (cm)	Initial soil concentration used, C_R ($\mu g/kg$)	Bldg. ventilation rate, $Q_{building}$ (cm^3/s)
9.46E+08	214	0.321	0.321	0.321	0.003	9.92E-08	0.998	9.91E-08	175,564	5.40E+01	1.90E+08

Area of enclosed space below grade, A_B (cm^2)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. soil temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. soil temperature, H_{TS} ($atm\text{-}m^3/mol$)	Henry's law constant at ave. soil temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm^2/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm^2/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm^2/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm^2/s)	Diffusion path length, L_d (cm)	Convection path length, L_p (cm)
1.88E+09	9.35E-06	30	10,248	3.06E-03	1.32E-01	1.75E-04	1.24E-02	0.00E+00	0.00E+00	1.24E-02	214	30

Soil-water partition coefficient, K_d (cm^3/g)	Source vapor conc., C_{source} ($\mu g/m^3$)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm^3/s)	Crack effective diffusion coefficient, D^{crack} (cm^2/s)	Area of crack, A_{crack} (cm^2)	Exponent of equivalent foundation Peclet number, $\exp(Pe^f)$ (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc., $C_{building}$ ($\mu g/m^3$)	Finite source β term (unitless)	Finite source ψ term $(sec)^{-1}$	Time for source depletion, τ_D (sec)	Exposure duration > time for source depletion (YES/NO)
7.78E-01	8.50E+03	0.10	3.90E+03	1.24E-02	1.76E+04	3.23E+77	NA	NA	2.90E+01	2.57E-08	6.49E+08	YES

Finite source indoor attenuation coefficient, $<\alpha>$ (unitless)	Mass limit bldg. conc., $C_{building}$ ($\mu g/m^3$)	Finite source bldg. conc., $C_{building}$ ($\mu g/m^3$)	Final finite source bldg. conc., $C_{building}$ ($\mu g/m^3$)	Unit risk factor, URF $(\mu g/m^3)^{-1}$	Reference conc., RfC (mg/m^3)
NA	1.14E-01	NA	1.14E-01	NA	1.0E-01

END

DATA ENTRY SHEET

SL-ADV
Version 3.1; 02/04

Reset to

CALCULATE RISK-BASED SOIL CONCENTRATION (enter "X" in "YES" box)

1,1,1-TRICHLOROETHANE (8 TO 12 FT) MAXIMUM

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL SOIL CONCENTRATION (enter "X" in "YES" box and initial soil conc. below)

YES [X]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial soil conc., C_R (μg/kg)	Chemical
71556	1.00E+00	1,1,1-Trichloroethane

MORE ↓

ENTER Average soil temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to top of contamination, L_t (cm)	ENTER Depth below grade to bottom of contamination, (enter value of 0 if value is unknown) L_b (cm)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm²)
				Totals must add up to value of L_t (cell G28)					
10	30	366	456	366	0	0	S		

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm³)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm³/cm³)	ENTER Stratum A soil organic carbon fraction, f_{oc}^A (unitless)	ENTER Stratum B SCS soil type (Lookup Soil)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm³)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm³/cm³)	ENTER Stratum B soil organic carbon fraction, f_{oc}^B (unitless)	ENTER Stratum C SCS soil type (Lookup Soil)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm³)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm³/cm³)	ENTER Stratum C soil organic carbon fraction, f_{oc}^C (unitless)
S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s²)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	36576	51206	366	0.1	1	

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	30	30	350	1.0E-06	1
				Used to calculate risk-based soil concentration.	

END

1,1,1-TRICHLOROETHANE (8 TO 12 FT) MAXIMUM

Exposure duration, τ (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, θ_a^A (cm^3/cm^3)	Stratum B soil air-filled porosity, θ_a^B (cm^3/cm^3)	Stratum C soil air-filled porosity, θ_a^C (cm^3/cm^3)	Stratum A effective total fluid saturation, S_{te} (cm^3/cm^3)	Stratum A soil intrinsic permeability, k_i (cm^2)	Stratum A soil relative air permeability, k_{rg} (cm^2)	Stratum A soil effective vapor permeability, k_v (cm^2)	Floor-wall seam perimeter, X_{crack} (cm)	Initial soil concentration used, C_R (µg/kg)	Bldg. ventilation rate, $Q_{building}$ (cm^3/s)
9.46E+08	336	0.321	0.321	0.321	0.003	9.92E-08	0.998	9.91E-08	175,564	1.00E+00	1.90E+08

Area of enclosed space below grade, A_B (cm^2)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. soil temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. soil temperature, H_{TS} (atm-m^3/mol)	Henry's law constant at ave. soil temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm^2/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm^2/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm^2/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm^2/s)	Diffusion path length, L_d (cm)	Convection path length, L_p (cm)
1.88E+09	9.35E-06	30	7,885	8.48E-03	3.65E-01	1.75E-04	1.26E-02	0.00E+00	0.00E+00	1.26E-02	336	30

Soil-water partition coefficient, K_d (cm^3/g)	Source vapor conc., C_{source} (µg/m^3)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm^3/s)	Crack effective diffusion coefficient, D^{crack} (cm^2/s)	Area of crack, A_{crack} (cm^2)	Exponent of equivalent foundation Peclet number, $\exp(Pe^f)$ (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc., $C_{building}$ (µg/m^3)	Finite source β term (unitless)	Finite source ψ term $(sec)^{-1}$	Time for source depletion, τ_D (sec)	Exposure duration > time for source depletion (YES/NO)
2.20E-01	1.13E+03	0.10	3.90E+03	1.26E-02	1.76E+04	2.61E+76	NA	NA	1.91E+01	7.60E-08	6.78E+07	YES

Finite source indoor attenuation coefficient, $<\alpha>$ (unitless)	Mass limit bldg. conc., $C_{building}$ (µg/m^3)	Finite source bldg. conc., $C_{building}$ (µg/m^3)	Final finite source bldg. conc., $C_{building}$ (µg/m^3)	Unit risk factor, URF $(\mu g/m^3)^{-1}$	Reference conc., RfC (mg/m^3)
NA	1.56E-03	NA	1.56E-03	NA	2.2E+00

END

SL-ADV
Version 3.1; 02/04

Reset to

CALCULATE RISK-BASED SOIL CONCENTRATION (enter "X" in "YES" box)

1,1-DICHLOROETHANE (8 TO 12 FT) MAXIMUM

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL SOIL CONCENTRATION (enter "X" in "YES" box and initial soil conc. below)

YES [X]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial soil conc., C_R (µg/kg)	Chemical
75343	1.10E+01	1,1-Dichloroethane

MORE ↓

ENTER Average soil temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to top of contamination, L_t (cm)	ENTER Depth below grade to bottom of contamination, (enter value of 0 if value is unknown) L_b (cm)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm²)
				Totals must add up to value of L_t (cell G28)					
10	30	366	456	366	0	0	S		

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm³)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm³/cm³)	ENTER Stratum A soil organic carbon fraction, f_{oc}^A (unitless)	ENTER Stratum B SCS soil type (Lookup Soil)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm³)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm³/cm³)	ENTER Stratum B soil organic carbon fraction, f_{oc}^B (unitless)	ENTER Stratum C SCS soil type (Lookup Soil)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm³)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm³/cm³)	ENTER Stratum C soil organic carbon fraction, f_{oc}^C (unitless)
S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s²)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	36576	51206	366	0.1	1	

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	30	30	350	1.0E-06	1
				Used to calculate risk-based soil concentration.	

END

INTERMEDIATE CALCULATIONS SHEET

1,1-DICHLOROETHANE (8 TO 12 FT) MAXIMUM

Exposure duration, τ (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, θ_a^A (cm^3/cm^3)	Stratum B soil air-filled porosity, θ_a^B (cm^3/cm^3)	Stratum C soil air-filled porosity, θ_a^C (cm^3/cm^3)	Stratum A effective total fluid saturation, S_{te} (cm^3/cm^3)	Stratum A soil intrinsic permeability, k_i (cm^2)	Stratum A soil relative air permeability, k_{rg} (cm^2)	Stratum A soil effective vapor permeability, k_v (cm^2)	Floor-wall seam perimeter, X_{crack} (cm)	Initial soil concentration used, C_R (μg/kg)	Bldg. ventilation rate, $Q_{building}$ (cm^3/s)
9.46E+08	336	0.321	0.321	0.321	0.003	9.92E-08	0.998	9.91E-08	175,564	1.10E+01	1.90E+08

Area of enclosed space below grade, A_B (cm^2)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. soil temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. soil temperature, H_{TS} (atm-m^3/mol)	Henry's law constant at ave. soil temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm^2/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm^2/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm^2/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm^2/s)	Diffusion path length, L_d (cm)	Convection path length, L_p (cm)
1.88E+09	9.35E-06	30	7,450	2.88E-03	1.24E-01	1.75E-04	1.20E-02	0.00E+00	0.00E+00	1.20E-02	336	30

Soil-water partition coefficient, K_d (cm^3/g)	Source vapor conc., C_{source} (μg/m^3)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm^3/s)	Crack effective diffusion coefficient, D^{crack} (cm^2/s)	Area of crack, A_{crack} (cm^2)	Exponent of equivalent foundation Peclet number, exp(Pe^f) (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc., $C_{building}$ (μg/m^3)	Finite source β term (unitless)	Finite source ψ term $(sec)^{-1}$	Time for source depletion, τ_D (sec)	Exposure duration > time for source depletion (YES/NO)
6.32E-02	1.14E+04	0.10	3.90E+03	1.20E-02	1.76E+04	2.14E+80	NA	NA	1.82E+01	6.63E-08	7.42E+07	YES

Finite source indoor attenuation coefficient, <α> (unitless)	Mass limit bldg. conc., $C_{building}$ (μg/m^3)	Finite source bldg. conc., $C_{building}$ (μg/m^3)	Final finite source bldg. conc., $C_{building}$ (μg/m^3)	Unit risk factor, URF $(\mu g/m^3)^{-1}$	Reference conc., RfC (mg/m^3)
NA	1.71E-02	NA	1.71E-02	NA	5.0E-01

END

DATA ENTRY SHEET

SL-ADV Version 3.1; 02/04

Reset to

CALCULATE RISK-BASED SOIL CONCENTRATION (enter "X" in "YES" box)

DICHLOROETHENE (8 TO 12 FT) MAXIMUM

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL SOIL CONCENTRATION (enter "X" in "YES" box and initial soil conc. below)

YES [X]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial soil conc., C_R (μg/kg)	Chemical
156605	1.50E+04	trans-1,2-Dichloroethylene

MORE ↓

ENTER Average soil temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to top of contamination, L_t (cm)	ENTER Depth below grade to bottom of contamination, (enter value of 0 if value is unknown) L_b (cm)	ENTER Thickness of soil stratum A, h_A (cm) (Totals must add up to value of L_t (cell G28))	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm²)
10	30	366	456	366	0	0	S		

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm³)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm³/cm³)	ENTER Stratum A soil organic carbon fraction, f_{oc}^A (unitless)	ENTER Stratum B SCS soil type (Lookup Soil)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm³)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm³/cm³)	ENTER Stratum B soil organic carbon fraction, f_{oc}^B (unitless)	ENTER Stratum C SCS soil type (Lookup Soil)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm³)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm³/cm³)	ENTER Stratum C soil organic carbon fraction, f_{oc}^C (unitless)
S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s²)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	36576	51206	366	0.1	1	

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	30	30	350	1.0E-06	1
				Used to calculate risk-based soil concentration.	

END

INTERMEDIATE CALCULATIONS SHEET

DICHLOROETHENE (8 TO 12 FT) MAXIMUM

Exposure duration, τ (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, θ_a^A (cm³/cm³)	Stratum B soil air-filled porosity, θ_a^B (cm³/cm³)	Stratum C soil air-filled porosity, θ_a^C (cm³/cm³)	Stratum A effective total fluid saturation, S_{te} (cm³/cm³)	Stratum A soil intrinsic permeability, k_i (cm²)	Stratum A soil relative air permeability, k_{rg} (cm²)	Stratum A soil effective vapor permeability, k_v (cm²)	Floor-wall seam perimeter, X_{crack} (cm)	Initial soil concentration used, C_R (µg/kg)	Bldg. ventilation rate, $Q_{building}$ (cm³/s)
9.46E+08	336	0.321	0.321	0.321	0.003	9.92E-08	0.998	9.91E-08	175,564	1.50E+04	1.90E+08

Area of enclosed space below grade, A_B (cm²)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. soil temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. soil temperature, H_{TS} (atm-m³/mol)	Henry's law constant at ave. soil temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm²/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm²/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm²/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm²/s)	Diffusion path length, L_d (cm)	Convection path length, L_p (cm)
1.88E+09	9.35E-06	30	7,136	4.94E-03	2.13E-01	1.75E-04	1.14E-02	0.00E+00	0.00E+00	1.14E-02	336	30

Soil-water partition coefficient, K_d (cm³/g)	Source vapor conc., C_{source} (µg/m³)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm³/s)	Crack effective diffusion coefficient, D^{crack} (cm²/s)	Area of crack, A_{crack} (cm²)	Exponent of equivalent foundation Peclet number, $\exp(Pe^f)$ (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc., $C_{building}$ (µg/m³)	Finite source β term (unitless)	Finite source ψ term (sec)$^{-1}$	Time for source depletion, τ_D (sec)	Exposure duration > time for source depletion (YES/NO)
1.05E-01	1.79E+07	0.10	3.90E+03	1.14E-02	1.76E+04	2.03E+84	NA	NA	1.74E+01	7.26E-08	6.47E+07	YES

Finite source indoor attenuation coefficient, <α> (unitless)	Mass limit bldg. conc., $C_{building}$ (µg/m³)	Finite source bldg. conc., $C_{building}$ (µg/m³)	Final finite source bldg. conc., $C_{building}$ (µg/m³)	Unit risk factor, URF (µg/m³)$^{-1}$	Reference conc., RfC (mg/m³)
NA	2.34E+01	NA	2.34E+01	NA	7.0E-02

END

DATA ENTRY SHEET

SL-ADV
Version 3.1; 02/04

Reset to

CALCULATE RISK-BASED SOIL CONCENTRATION (enter "X" in "YES" box)

2-BUTANONE (8 TO 12 FT) MAXIMUM

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL SOIL CONCENTRATION (enter "X" in "YES" box and initial soil conc. below)

YES [X]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial soil conc., C_R (μg/kg)	Chemical
78933	4.10E+01	Methylethylketone (2-butanone)

MORE ↓

ENTER Average soil temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to top of contamination, L_t (cm)	ENTER Depth below grade to bottom of contamination, (enter value of 0 if value is unknown) L_b (cm)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm²)
				Totals must add up to value of L_t (cell G28)					
10	30	366	456	366	0	0	S		

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm³)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm³/cm³)	ENTER Stratum A soil organic carbon fraction, f_{oc}^A (unitless)	ENTER Stratum B SCS soil type (Lookup Soil)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm³)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm³/cm³)	ENTER Stratum B soil organic carbon fraction, f_{oc}^B (unitless)	ENTER Stratum C SCS soil type (Lookup Soil)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm³)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm³/cm³)	ENTER Stratum C soil organic carbon fraction, f_{oc}^C (unitless)
S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s²)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	36576	51206	366	0.1	1	

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	30	30	350	1.0E-06	1
				Used to calculate risk-based soil concentration.	

END

INTERMEDIATE CALCULATIONS SHEET

2-BUTANONE (8 TO 12 FT) MAXIMUM

Exposure duration, τ (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, θ_a^A (cm^3/cm^3)	Stratum B soil air-filled porosity, θ_a^B (cm^3/cm^3)	Stratum C soil air-filled porosity, θ_a^C (cm^3/cm^3)	Stratum A effective total fluid saturation, S_{te} (cm^3/cm^3)	Stratum A soil intrinsic permeability, k_i (cm^2)	Stratum A soil relative air permeability, k_{rg} (cm^2)	Stratum A soil effective vapor permeability, k_v (cm^2)	Floor-wall seam perimeter, X_{crack} (cm)	Initial soil concentration used, C_R (µg/kg)	Bldg. ventilation rate, $Q_{building}$ (cm^3/s)
9.46E+08	336	0.321	0.321	0.321	0.003	9.92E-08	0.998	9.91E-08	175,564	4.10E+01	1.90E+08

Area of enclosed space below grade, A_B (cm^2)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. soil temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. soil temperature, H_{TS} (atm-m^3/mol)	Henry's law constant at ave. soil temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm^2/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm^2/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm^2/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm^2/s)	Diffusion path length, L_d (cm)	Convection path length, L_p (cm)
1.88E+09	9.35E-06	30	8,419	2.63E-05	1.13E-03	1.75E-04	1.31E-02	0.00E+00	0.00E+00	1.31E-02	336	30

Soil-water partition coefficient, K_d (cm^3/g)	Source vapor conc., C_{source} (µg/m^3)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm^3/s)	Crack effective diffusion coefficient, D^{crack} (cm^2/s)	Area of crack, A_{crack} (cm^2)	Exponent of equivalent foundation Peclet number, exp(Pe^f) (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc., $C_{building}$ (µg/m^3)	Finite source β term (unitless)	Finite source ψ term (sec)$^{-1}$	Time for source depletion, τ_D (sec)	Exposure duration > time for source depletion (YES/NO)
4.60E-03	1.24E+03	0.10	3.90E+03	1.31E-02	1.76E+04	5.59E+73	NA	NA	1.97E+01	2.11E-09	2.52E+09	NO

Finite source indoor attenuation coefficient, <α> (unitless)	Mass limit bldg. conc., $C_{building}$ (µg/m^3)	Finite source bldg. conc., $C_{building}$ (µg/m^3)	Final finite source bldg. conc., $C_{building}$ (µg/m^3)	Unit risk factor, URF (µg/m^3)$^{-1}$	Reference conc., RfC (mg/m^3)
1.94E-05	NA	2.40E-02	2.40E-02	NA	5.0E+00

END

DATA ENTRY SHEET

SL-ADV
Version 3.1; 02/04

Reset to

CALCULATE RISK-BASED SOIL CONCENTRATION (enter "X" in "YES" box)

4-METHYL-2-PENTANONE (8 TO 12 FT) MAXIMUM

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL SOIL CONCENTRATION (enter "X" in "YES" box and initial soil conc. below)

YES [X]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial soil conc., C_R (μg/kg)	Chemical
108101	8.40E+01	Methylisobutylketone (4-methyl-2-pentanone)

MORE ↓

ENTER Average soil temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to top of contamination, L_t (cm)	ENTER Depth below grade to bottom of contamination, (enter value of 0 if value is unknown) L_b (cm)	ENTER (Totals must add up to value of L_t (cell G28)) Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm²)
10	30	366	456	366	0	0	S		

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm³)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm³/cm³)	ENTER Stratum A soil organic carbon fraction, f_{oc}^A (unitless)	ENTER Stratum B SCS soil type (Lookup Soil)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm³)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm³/cm³)	ENTER Stratum B soil organic carbon fraction, f_{oc}^B (unitless)	ENTER Stratum C SCS soil type (Lookup Soil)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm³)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm³/cm³)	ENTER Stratum C soil organic carbon fraction, f_{oc}^C (unitless)
S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s²)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	36576	51206	366	0.1	1	

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	30	30	350	1.0E-06	1

Used to calculate risk-based soil concentration.

END

INTERMEDIATE CALCULATIONS SHEET

4-METHYL-2-PENTANONE (8 TO 12 FT) MAXIMUM

Exposure duration, τ (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, θ_a^A (cm³/cm³)	Stratum B soil air-filled porosity, θ_a^B (cm³/cm³)	Stratum C soil air-filled porosity, θ_a^C (cm³/cm³)	Stratum A effective total fluid saturation, S_{te} (cm³/cm³)	Stratum A soil intrinsic permeability, k_i (cm²)	Stratum A soil relative air permeability, k_{rg} (cm²)	Stratum A soil effective vapor permeability, k_v (cm²)	Floor-wall seam perimeter, X_{crack} (cm)	Initial soil concentration used, C_R (µg/kg)	Bldg. ventilation rate, $Q_{building}$ (cm³/s)
9.46E+08	336	0.321	0.321	0.321	0.003	9.92E-08	0.998	9.91E-08	175,564	8.40E+01	1.90E+08

Area of enclosed space below grade, A_B (cm²)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. soil temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. soil temperature, H_{TS} (atm-m³/mol)	Henry's law constant at ave. soil temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm²/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm²/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm²/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm²/s)	Diffusion path length, L_d (cm)	Convection path length, L_p (cm)
1.88E+09	9.35E-06	30	9,862	5.70E-05	2.45E-03	1.75E-04	1.21E-02	0.00E+00	0.00E+00	1.21E-02	336	30

Soil-water partition coefficient, K_d (cm³/g)	Source vapor conc., C_{source} (µg/m³)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm³/s)	Crack effective diffusion coefficient, D^{crack} (cm²/s)	Area of crack, A_{crack} (cm²)	Exponent of equivalent foundation Peclet number, $\exp(Pe^f)$ (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc., $C_{building}$ (µg/m³)	Finite source β term (unitless)	Finite source ψ term (sec)$^{-1}$	Time for source depletion, τ_D (sec)	Exposure duration > time for source depletion (YES/NO)
1.81E-02	4.03E+03	0.10	3.90E+03	1.21E-02	1.76E+04	2.91E+79	NA	NA	1.84E+01	3.10E-09	1.60E+09	NO

Finite source indoor attenuation coefficient, <α> (unitless)	Mass limit bldg. conc., $C_{building}$ (µg/m³)	Finite source bldg. conc., $C_{building}$ (µg/m³)	Final finite source bldg. conc., $C_{building}$ (µg/m³)	Unit risk factor, URF (µg/m³)$^{-1}$	Reference conc., RfC (mg/m³)
1.93E-05	NA	7.76E-02	7.76E-02	NA	3.0E+00

END

DATA ENTRY SHEET

SL-ADV Version 3.1; 02/04

Reset to

CALCULATE RISK-BASED SOIL CONCENTRATION (enter "X" in "YES" box)

ACETONE (8 TO 12 FT) MAXIMUM

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL SOIL CONCENTRATION (enter "X" in "YES" box and initial soil conc. below)

YES [X]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial soil conc., C_R (μg/kg)	Chemical
67641	1.70E+03	Acetone

MORE ↓

ENTER Average soil temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to top of contamination, L_t (cm)	ENTER Depth below grade to bottom of contamination, (enter value of 0 if value is unknown) L_b (cm)	ENTER Totals must add up to value of L_t (cell G28) Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm²)
10	30	366	456	366	0	0	S		

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm³)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm³/cm³)	ENTER Stratum A soil organic carbon fraction, f_{oc}^A (unitless)	ENTER Stratum B SCS soil type (Lookup Soil)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm³)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm³/cm³)	ENTER Stratum B soil organic carbon fraction, f_{oc}^B (unitless)	ENTER Stratum C SCS soil type (Lookup Soil)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm³)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm³/cm³)	ENTER Stratum C soil organic carbon fraction, f_{oc}^C (unitless)
S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s²)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	36576	51206	366	0.1	1	

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	30	30	350	1.0E-06	1
				Used to calculate risk-based soil concentration.	

END

INTERMEDIATE CALCULATIONS SHEET

ACETONE (6 TO 12 FT) MAXIMUM

Exposure duration, τ (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, θ_a^A (cm^3/cm^3)	Stratum B soil air-filled porosity, θ_a^B (cm^3/cm^3)	Stratum C soil air-filled porosity, θ_a^C (cm^3/cm^3)	Stratum A effective total fluid saturation, S_{te} (cm^3/cm^3)	Stratum A soil intrinsic permeability, k_i (cm^2)	Stratum A soil relative air permeability, k_{rg} (cm^2)	Stratum A soil effective vapor permeability, k_v (cm^2)	Floor-wall seam perimeter, X_{crack} (cm)	Initial soil concentration used, C_R (μg/kg)	Bldg. ventilation rate, $Q_{building}$ (cm^3/s)
9.46E+08	336	0.321	0.321	0.321	0.003	9.92E-08	0.998	9.91E-08	175,564	1.70E+03	1.90E+08

Area of enclosed space below grade, A_B (cm^2)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. soil temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. soil temperature, H_{TS} (atm-m^3/mol)	Henry's law constant at ave. soil temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm^2/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm^2/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm^2/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm^2/s)	Diffusion path length, L_d (cm)	Convection path length, L_p (cm)
1.88E+09	9.35E-06	30	7,559	1.97E-05	8.47E-04	1.75E-04	2.01E-02	0.00E+00	0.00E+00	2.01E-02	336	30

Soil-water partition coefficient, K_d (cm^3/g)	Source vapor conc., C_{source} (μg/m^3)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm^3/s)	Crack effective diffusion coefficient, D^{crack} (cm^2/s)	Area of crack, A_{crack} (cm^2)	Exponent of equivalent foundation Peclet number, exp(Pe^f) (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc., $C_{building}$ (μg/m^3)	Finite source β term (unitless)	Finite source ψ term $(sec)^{-1}$	Time for source depletion, τ_D (sec)	Exposure duration > time for source depletion (YES/NO)
1.15E-03	4.26E+04	0.10	3.90E+03	2.01E-02	1.76E+04	1.13E+48	NA	NA	2.98E+01	2.68E-09	2.99E+09	NO

Finite source indoor attenuation coefficient, <α> (unitless)	Mass limit bldg. conc., $C_{building}$ (μg/m^3)	Finite source bldg. conc., $C_{building}$ (μg/m^3)	Final finite source bldg. conc., $C_{building}$ (μg/m^3)	Unit risk factor, URF $(\mu g/m^3)^{-1}$	Reference conc., RfC (mg/m^3)
1.97E-05	NA	8.40E-01	8.40E-01	NA	3.5E-01

END

DATA ENTRY SHEET

SL-ADV
Version 3.1; 02/04

Reset to

CALCULATE RISK-BASED SOIL CONCENTRATION (enter "X" in "YES" box)

BENZENE (8 TO 12 FT) MAXIMUM

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL SOIL CONCENTRATION (enter "X" in "YES" box and initial soil conc. below)

YES [X]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial soil conc., C_R (μg/kg)	Chemical
71432	2.40E+01	Benzene

MORE ↓

ENTER Average soil temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to top of contamination, L_t (cm)	ENTER Depth below grade to bottom of contamination, (enter value of 0 if value is unknown) L_b (cm)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm²)
				Totals must add up to value of L_t (cell G28)					
10	30	366	456	366	0	0	S		

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm³)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm³/cm³)	ENTER Stratum A soil organic carbon fraction, f_{oc}^A (unitless)	ENTER Stratum B SCS soil type (Lookup Soil)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm³)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm³/cm³)	ENTER Stratum B soil organic carbon fraction, f_{oc}^B (unitless)	ENTER Stratum C SCS soil type (Lookup Soil)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm³)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm³/cm³)	ENTER Stratum C soil organic carbon fraction, f_{oc}^C (unitless)
S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s²)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	36576	51206	366	0.1	1	

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	30	30	350	1.0E-06	1
				Used to calculate risk-based soil concentration.	

END

INTERMEDIATE CALCULATIONS SHEET

BENZENE (8 TO 12 FT) MAXIMUM

Exposure duration, τ (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, θ_a^A (cm³/cm³)	Stratum B soil air-filled porosity, θ_a^B (cm³/cm³)	Stratum C soil air-filled porosity, θ_a^C (cm³/cm³)	Stratum A effective total fluid saturation, S_{te} (cm³/cm³)	Stratum A soil intrinsic permeability, k_i (cm²)	Stratum A soil relative air permeability, k_{rg} (cm²)	Stratum A soil effective vapor permeability, k_v (cm²)	Floor-wall seam perimeter, X_{crack} (cm)	Initial soil concentration used, C_R (µg/kg)	Bldg. ventilation rate, $Q_{building}$ (cm³/s)
9.46E+08	336	0.321	0.321	0.321	0.003	9.92E-08	0.998	9.91E-08	175,564	2.40E+01	1.90E+08

Area of enclosed space below grade, A_B (cm²)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. soil temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. soil temperature, H_{TS} (atm-m³/mol)	Henry's law constant at ave. soil temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm²/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm²/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm²/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm²/s)	Diffusion path length, L_d (cm)	Convection path length, L_p (cm)
1.88E+09	9.35E-06	30	8,122	2.68E-03	1.15E-01	1.75E-04	1.42E-02	0.00E+00	0.00E+00	1.42E-02	336	30

Soil-water partition coefficient, K_d (cm³/g)	Source vapor conc., C_{source} (µg/m³)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm³/s)	Crack effective diffusion coefficient, D^{crack} (cm²/s)	Area of crack, A_{crack} (cm²)	Exponent of equivalent foundation Peclet number, exp(Pe^f) (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc., $C_{building}$ (µg/m³)	Finite source β term (unitless)	Finite source ψ term (sec)$^{-1}$	Time for source depletion, τ_D (sec)	Exposure duration > time for source depletion (YES/NO)
1.18E-01	1.60E+04	0.10	3.90E+03	1.42E-02	1.76E+04	5.40E+67	NA	NA	2.14E+01	5.07E-08	1.14E+08	YES

Finite source indoor attenuation coefficient, <α> (unitless)	Mass limit bldg. conc., $C_{building}$ (µg/m³)	Finite source bldg. conc., $C_{building}$ (µg/m³)	Final finite source bldg. conc., $C_{building}$ (µg/m³)	Unit risk factor, URF (µg/m³)$^{-1}$	Reference conc., RfC (mg/m³)
NA	3.74E-02	NA	3.74E-02	7.8E-06	3.0E-02

END

DATA ENTRY SHEET

SL-ADV
Version 3.1; 02/04

Reset to

BROMOMETHANE (8 TO 12 FT) MAXIMUM

CALCULATE RISK-BASED SOIL CONCENTRATION (enter "X" in "YES" box)

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL SOIL CONCENTRATION (enter "X" in "YES" box and initial soil conc. below)

YES [X]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial soil conc., C_R (μg/kg)	Chemical
74839	2.00E+00	Methyl bromide

MORE ↓

ENTER Average soil temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to top of contamination, L_t (cm)	ENTER Depth below grade to bottom of contamination, (enter value of 0 if value is unknown) L_b (cm)	ENTER Totals must add up to value of L_t (cell G28) Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm²)
10	30	366	456	366	0	0	S		

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm³)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm³/cm³)	ENTER Stratum A soil organic carbon fraction, f_{oc}^A (unitless)	ENTER Stratum B SCS soil type (Lookup Soil)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm³)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm³/cm³)	ENTER Stratum B soil organic carbon fraction, f_{oc}^B (unitless)	ENTER Stratum C SCS soil type (Lookup Soil)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm³)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm³/cm³)	ENTER Stratum C soil organic carbon fraction, f_{oc}^C (unitless)
S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s²)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	36576	51206	366	0.1	1	

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	30	30	350	1.0E-06	1

Used to calculate risk-based soil concentration.

END

INTERMEDIATE CALCULATIONS SHEET

BROMOMETHANE (8 TO 12 FT) MAXIMUM

Exposure duration, τ (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, θ_a^A (cm^3/cm^3)	Stratum B soil air-filled porosity, θ_a^B (cm^3/cm^3)	Stratum C soil air-filled porosity, θ_a^C (cm^3/cm^3)	Stratum A effective total fluid saturation, S_{te} (cm^3/cm^3)	Stratum A soil intrinsic permeability, k_i (cm^2)	Stratum A soil relative air permeability, k_{rg} (cm^2)	Stratum A soil effective vapor permeability, k_v (cm^2)	Floor-wall seam perimeter, X_{crack} (cm)	Initial soil concentration used, C_R (µg/kg)	Bldg. ventilation rate, $Q_{building}$ (cm^3/s)
9.46E+08	336	0.321	0.321	0.321	0.003	9.92E-08	0.998	9.91E-08	175,564	2.00E+00	1.90E+08

Area of enclosed space below grade, A_B (cm^2)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. soil temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. soil temperature, H_{TS} ($atm\text{-}m^3/mol$)	Henry's law constant at ave. soil temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm^2/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm^2/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm^2/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm^2/s)	Diffusion path length, L_d (cm)	Convection path length, L_p (cm)
1.88E+09	9.35E-06	30	5,651	3.76E-03	1.62E-01	1.75E-04	1.18E-02	0.00E+00	0.00E+00	1.18E-02	336	30

Soil-water partition coefficient, K_d (cm^3/g)	Source vapor conc., C_{source} ($\mu g/m^3$)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm^3/s)	Crack effective diffusion coefficient, D^{crack} (cm^2/s)	Area of crack, A_{crack} (cm^2)	Exponent of equivalent foundation Peclet number, $\exp(Pe^f)$ (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc., $C_{building}$ ($\mu g/m^3$)	Finite source β term (unitless)	Finite source ψ term $(sec)^{-1}$	Time for source depletion, τ_D (sec)	Exposure duration > time for source depletion (YES/NO)
2.10E-02	3.81E+03	0.10	3.90E+03	1.18E-02	1.76E+04	7.49E+81	NA	NA	1.79E+01	1.20E-07	4.03E+07	YES

Finite source indoor attenuation coefficient, $<\alpha>$ (unitless)	Mass limit bldg. conc., $C_{building}$ ($\mu g/m^3$)	Finite source bldg. conc., $C_{building}$ ($\mu g/m^3$)	Final finite source bldg. conc., $C_{building}$ ($\mu g/m^3$)	Unit risk factor, URF $(\mu g/m^3)^{-1}$	Reference conc., RfC (mg/m^3)
NA	3.12E-03	NA	3.12E-03	NA	5.0E-03

END

SL-ADV
Version 3.1; 02/04

Reset to

CALCULATE RISK-BASED SOIL CONCENTRATION (enter "X" in "YES" box)

CARBON DISULFIDE (8 TO 12 FT) MAXIMUM

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL SOIL CONCENTRATION (enter "X" in "YES" box and initial soil conc. below)

YES [X]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial soil conc., C_R (µg/kg)	Chemical
75150	1.10E+01	Carbon disulfide

MORE ↓

ENTER Average soil temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to top of contamination, L_t (cm)	ENTER Depth below grade to bottom of contamination, (enter value of 0 if value is unknown) L_b (cm)	ENTER Totals must add up to value of L_t (cell G28): Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm²)
10	30	366	456	366	0	0	S		

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm³)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm³/cm³)	ENTER Stratum A soil organic carbon fraction, f_{oc}^A (unitless)	ENTER Stratum B SCS soil type (Lookup Soil)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm³)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm³/cm³)	ENTER Stratum B soil organic carbon fraction, f_{oc}^B (unitless)	ENTER Stratum C SCS soil type (Lookup Soil)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm³)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm³/cm³)	ENTER Stratum C soil organic carbon fraction, f_{oc}^C (unitless)
S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s²)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	36576	51206	366	0.1	1	

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	30	30	350	1.0E-06	1

Used to calculate risk-based soil concentration.

END

INTERMEDIATE CALCULATIONS SHEET

CARBON DISULFIDE (8 TO 12 FT) MAXIMUM

Exposure duration, τ (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, θ_a^A (cm³/cm³)	Stratum B soil air-filled porosity, θ_a^B (cm³/cm³)	Stratum C soil air-filled porosity, θ_a^C (cm³/cm³)	Stratum A effective total fluid saturation, S_{te} (cm³/cm³)	Stratum A soil intrinsic permeability, k_i (cm²)	Stratum A soil relative air permeability, k_{rg} (cm²)	Stratum A soil effective vapor permeability, k_v (cm²)	Floor-wall seam perimeter, X_{crack} (cm)	Initial soil concentration used, C_R (µg/kg)	Bldg. ventilation rate, $Q_{building}$ (cm³/s)
9.46E+08	336	0.321	0.321	0.321	0.003	9.92E-08	0.998	9.91E-08	175,564	1.10E+01	1.90E+08

Area of enclosed space below grade, A_B (cm²)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. soil temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. soil temperature, H_{TS} (atm-m³/mol)	Henry's law constant at ave. soil temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm²/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm²/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm²/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm²/s)	Diffusion path length, L_d (cm)	Convection path length, L_p (cm)
1.88E+09	9.35E-06	30	6,682	1.66E-02	7.16E-01	1.75E-04	1.68E-02	0.00E+00	0.00E+00	1.68E-02	336	30

Soil-water partition coefficient, K_d (cm³/g)	Source vapor conc., C_{source} (µg/m³)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm³/s)	Crack effective diffusion coefficient, D^{crack} (cm²/s)	Area of crack, A_{crack} (cm²)	Exponent of equivalent foundation Peclet number, exp(Pe^f) (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc., $C_{building}$ (µg/m³)	Finite source β term (unitless)	Finite source ψ term (sec)$^{-1}$	Time for source depletion, τ_D (sec)	Exposure duration > time for source depletion (YES/NO)
9.14E-02	3.00E+04	0.10	3.90E+03	1.68E-02	1.76E+04	2.05E+57	NA	NA	2.51E+01	2.45E-07	2.76E+07	YES

Finite source indoor attenuation coefficient, <α> (unitless)	Mass limit bldg. conc., $C_{building}$ (µg/m³)	Finite source bldg. conc., $C_{building}$ (µg/m³)	Final finite source bldg. conc., $C_{building}$ (µg/m³)	Unit risk factor, URF (µg/m³)$^{-1}$	Reference conc., RfC (mg/m³)
NA	1.71E-02	NA	1.71E-02	NA	7.0E-01

END

DATA ENTRY SHEET

SL-ADV Version 3.1; 02/04

Reset to

CALCULATE RISK-BASED SOIL CONCENTRATION (enter "X" in "YES" box)

ETHYL BENZENE (8 TO 12 FT) MAXIMUM

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL SOIL CONCENTRATION (enter "X" in "YES" box and initial soil conc. below)

YES [X]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial soil conc., C_R (μg/kg)	Chemical
100414	7.20E+02	Ethylbenzene

MORE ↓

ENTER Average soil temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to top of contamination, L_t (cm)	ENTER Depth below grade to bottom of contamination, (enter value of 0 if value is unknown) L_b (cm)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm²)
10	30	366	456	366	0	0	S		

Totals must add up to value of L_t (cell G28)

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm³)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm³/cm³)	ENTER Stratum A soil organic carbon fraction, f_{oc}^A (unitless)	ENTER Stratum B SCS soil type (Lookup Soil)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm³)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm³/cm³)	ENTER Stratum B soil organic carbon fraction, f_{oc}^B (unitless)	ENTER Stratum C SCS soil type (Lookup Soil)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm³)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm³/cm³)	ENTER Stratum C soil organic carbon fraction, f_{oc}^C (unitless)
S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s²)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	36576	51206	366	0.1	1	

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	30	30	350	1.0E-06	1

Used to calculate risk-based soil concentration.

END

INTERMEDIATE CALCULATIONS SHEET

ETHYL BENZENE (8 TO 12 FT) MAXIMUM

Exposure duration, τ (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, θ_a^A (cm³/cm³)	Stratum B soil air-filled porosity, θ_a^B (cm³/cm³)	Stratum C soil air-filled porosity, θ_a^C (cm³/cm³)	Stratum A effective total fluid saturation, S_{te} (cm³/cm³)	Stratum A soil intrinsic permeability, k_i (cm²)	Stratum A soil relative air permeability, k_{rg} (cm²)	Stratum A soil effective vapor permeability, k_v (cm²)	Floor-wall seam perimeter, X_{crack} (cm)	Initial soil concentration used, C_R (µg/kg)	Bldg. ventilation rate, $Q_{building}$ (cm³/s)
9.46E+08	336	0.321	0.321	0.321	0.003	9.92E-08	0.998	9.91E-08	175,564	7.20E+02	1.90E+08

Area of enclosed space below grade, A_B (cm²)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. soil temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. soil temperature, H_{TS} (atm-m³/mol)	Henry's law constant at ave. soil temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm²/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm²/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm²/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm²/s)	Diffusion path length, L_d (cm)	Convection path length, L_p (cm)
1.88E+09	9.35E-06	30	10,155	3.17E-03	1.36E-01	1.75E-04	1.21E-02	0.00E+00	0.00E+00	1.21E-02	336	30

Soil-water partition coefficient, K_d (cm³/g)	Source vapor conc., C_{source} (µg/m³)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm³/s)	Crack effective diffusion coefficient, D^{crack} (cm²/s)	Area of crack, A_{crack} (cm²)	Exponent of equivalent foundation Peclet number, $\exp(Pe^f)$ (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc., $C_{building}$ (µg/m³)	Finite source β term (unitless)	Finite source ψ term (sec)$^{-1}$	Time for source depletion, τ_D (sec)	Exposure duration > time for source depletion (YES/NO)
7.26E-01	1.25E+05	0.10	3.90E+03	1.21E-02	1.76E+04	2.97E+79	NA	NA	1.84E+01	1.12E-08	4.41E+08	YES

Finite source indoor attenuation coefficient, $<\alpha>$ (unitless)	Mass limit bldg. conc., $C_{building}$ (µg/m³)	Finite source bldg. conc., $C_{building}$ (µg/m³)	Final finite source bldg. conc., $C_{building}$ (µg/m³)	Unit risk factor, URF (µg/m³)$^{-1}$	Reference conc., RfC (mg/m³)
NA	1.12E+00	NA	1.12E+00	NA	1.0E+00

END

DATA ENTRY SHEET

SL-ADV Version 3.1; 02/04

Reset to

CALCULATE RISK-BASED SOIL CONCENTRATION (enter "X" in "YES" box) — **TETRACHLOROETHENE (8 TO 12 FT) MAXIMUM**

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL SOIL CONCENTRATION (enter "X" in "YES" box and initial soil conc. below)

YES [X]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial soil conc., C_R (μg/kg)	Chemical
127184	3.90E+02	Tetrachloroethylene

MORE ↓

ENTER Average soil temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to top of contamination, L_t (cm)	ENTER Depth below grade to bottom of contamination, (enter value of 0 if value is unknown) L_b (cm)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm²)
10	30	366	456	366	0	0	S		

Totals must add up to value of L_t (cell G28)

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm³)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm³/cm³)	ENTER Stratum A soil organic carbon fraction, f_{oc}^A (unitless)	ENTER Stratum B SCS soil type (Lookup Soil)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm³)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm³/cm³)	ENTER Stratum B soil organic carbon fraction, f_{oc}^B (unitless)	ENTER Stratum C SCS soil type (Lookup Soil)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm³)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm³/cm³)	ENTER Stratum C soil organic carbon fraction, f_{oc}^C (unitless)
S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s²)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	36576	51206	366	0.1	1	

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	30	30	350	1.0E-06	1

Used to calculate risk-based soil concentration.

END

TETRACHLOROETHENE (8 TO 12 FT) MAXIMUM

Exposure duration, τ (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, θ_a^A (cm^3/cm^3)	Stratum B soil air-filled porosity, θ_a^B (cm^3/cm^3)	Stratum C soil air-filled porosity, θ_a^C (cm^3/cm^3)	Stratum A effective total fluid saturation, S_{te} (cm^3/cm^3)	Stratum A soil intrinsic permeability, k_i (cm^2)	Stratum A soil relative air permeability, k_{rg} (cm^2)	Stratum A soil effective vapor permeability, k_v (cm^2)	Floor-wall seam perimeter, X_{crack} (cm)	Initial soil concentration used, C_R (µg/kg)	Bldg. ventilation rate, $Q_{building}$ (cm^3/s)
9.46E+08	336	0.321	0.321	0.321	0.003	9.92E-08	0.998	9.91E-08	175,564	3.90E+02	1.90E+08

Area of enclosed space below grade, A_B (cm^2)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. soil temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. soil temperature, H_{TS} ($atm\text{-}m^3/mol$)	Henry's law constant at ave. soil temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm^2/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm^2/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm^2/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm^2/s)	Diffusion path length, L_d (cm)	Convection path length, L_p (cm)
1.88E+09	9.35E-06	30	9,553	7.81E-03	3.36E-01	1.75E-04	1.16E-02	0.00E+00	0.00E+00	1.16E-02	336	30

Soil-water partition coefficient, K_d (cm^3/g)	Source vapor conc., C_{source} ($\mu g/m^3$)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm^3/s)	Crack effective diffusion coefficient, D^{crack} (cm^2/s)	Area of crack, A_{crack} (cm^2)	Exponent of equivalent foundation Peclet number, $\exp(Pe^f)$ (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc., $C_{building}$ ($\mu g/m^3$)	Finite source β term (unitless)	Finite source ψ term $(sec)^{-1}$	Time for source depletion, τ_D (sec)	Exposure duration > time for source depletion (YES/NO)
3.10E-01	3.22E+05	0.10	3.90E+03	1.16E-02	1.76E+04	6.09E+82	NA	NA	1.77E+01	5.12E-08	9.32E+07	YES

Finite source indoor attenuation coefficient, $<\alpha>$ (unitless)	Mass limit bldg. conc., $C_{building}$ ($\mu g/m^3$)	Finite source bldg. conc., $C_{building}$ ($\mu g/m^3$)	Final finite source bldg. conc., $C_{building}$ ($\mu g/m^3$)	Unit risk factor, URF $(\mu g/m^3)^{-1}$	Reference conc., RfC (mg/m^3)
NA	6.07E-01	NA	6.07E-01	5.9E-06	6.0E-01

END

DATA ENTRY SHEET

SL-ADV
Version 3.1; 02/04

Reset to

CALCULATE RISK-BASED SOIL CONCENTRATION (enter "X" in "YES" box)

TOLUENE (8 TO 12 FT) MAXIMUM

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL SOIL CONCENTRATION (enter "X" in "YES" box and initial soil conc. below)

YES [X]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial soil conc., C_R (µg/kg)	Chemical
108883	1.00E+03	Toluene

MORE ↓

ENTER Average soil temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to top of contamination, L_t (cm)	ENTER Depth below grade to bottom of contamination, (enter value of 0 if value is unknown) L_b (cm)	ENTER Totals must add up to value of L_t (cell G28) Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm²)
10	30	366	456	366	0	0	S		

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm³)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm³/cm³)	ENTER Stratum A soil organic carbon fraction, f_{oc}^A (unitless)	ENTER Stratum B SCS soil type (Lookup Soil)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm³)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm³/cm³)	ENTER Stratum B soil organic carbon fraction, f_{oc}^B (unitless)	ENTER Stratum C SCS soil type (Lookup Soil)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm³)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm³/cm³)	ENTER Stratum C soil organic carbon fraction, f_{oc}^C (unitless)
S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s²)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	36576	51206	366	0.1	1	

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	30	30	350	1.0E-06	1

Used to calculate risk-based soil concentration.

END

INTERMEDIATE CALCULATIONS SHEET

TOLUENE (8 TO 12 FT) MAXIMUM

Exposure duration, τ (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, θ_a^A (cm^3/cm^3)	Stratum B soil air-filled porosity, θ_a^B (cm^3/cm^3)	Stratum C soil air-filled porosity, θ_a^C (cm^3/cm^3)	Stratum A effective total fluid saturation, S_{te} (cm^3/cm^3)	Stratum A soil intrinsic permeability, k_i (cm^2)	Stratum A soil relative air permeability, k_{rg} (cm^2)	Stratum A soil effective vapor permeability, k_v (cm^2)	Floor-wall seam perimeter, X_{crack} (cm)	Initial soil concentration used, C_R (µg/kg)	Bldg. ventilation rate, $Q_{building}$ (cm^3/s)
9.46E+08	336	0.321	0.321	0.321	0.003	9.92E-08	0.998	9.91E-08	175,564	1.00E+03	1.90E+08

Area of enclosed space below grade, A_B (cm^2)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. soil temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. soil temperature, H_{TS} (atm-m^3/mol)	Henry's law constant at ave. soil temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm^2/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm^2/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm^2/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm^2/s)	Diffusion path length, L_d (cm)	Convection path length, L_p (cm)
1.88E+09	9.35E-06	30	9,154	2.92E-03	1.26E-01	1.75E-04	1.41E-02	0.00E+00	0.00E+00	1.41E-02	336	30

Soil-water partition coefficient, K_d (cm^3/g)	Source vapor conc., C_{source} (µg/m^3)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm^3/s)	Crack effective diffusion coefficient, D^{crack} (cm^2/s)	Area of crack, A_{crack} (cm^2)	Exponent of equivalent foundation Peclet number, exp(Pe^f) (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc., $C_{building}$ (µg/m^3)	Finite source β term (unitless)	Finite source ψ term (sec)$^{-1}$	Time for source depletion, τ_D (sec)	Exposure duration > time for source depletion (YES/NO)
3.64E-01	2.99E+05	0.10	3.90E+03	1.41E-02	1.76E+04	3.25E+68	NA	NA	2.12E+01	2.24E-08	2.55E+08	YES

Finite source indoor attenuation coefficient, <α> (unitless)	Mass limit bldg. conc., $C_{building}$ (µg/m^3)	Finite source bldg. conc., $C_{building}$ (µg/m^3)	Final finite source bldg. conc., $C_{building}$ (µg/m^3)	Unit risk factor, URF (µg/m^3)$^{-1}$	Reference conc., RfC (mg/m^3)
NA	1.56E+00	NA	1.56E+00	NA	4.0E-01

END

SL-ADV
Version 3.1; 02/04

Reset to

CALCULATE RISK-BASED SOIL CONCENTRATION (enter "X" in "YES" box)

TRICHLOROETHENE (6 TO 12 FT) MAXIMUM

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL SOIL CONCENTRATION (enter "X" in "YES" box and initial soil conc. below)

YES [x]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial soil conc., C_R (µg/kg)	Chemical
79016	1.10E+03	Trichloroethylene

MORE ↓

ENTER Average soil temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to top of contamination, L_t (cm)	ENTER Depth below grade to bottom of contamination, (enter value of 0 if value is unknown) L_b (cm)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)		ENTER User-defined stratum A soil vapor permeability, k_v (cm²)
				Totals must add up to value of L_t (cell G28)				OR	
10	30	366	456	366	0	0	S		

MORE ↓

ENTER Stratum A SCS soil type	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm³)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm³/cm³)	ENTER Stratum A soil organic carbon fraction, f_{oc}^A (unitless)	ENTER Stratum B SCS soil type	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm³)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm³/cm³)	ENTER Stratum B soil organic carbon fraction, f_{oc}^B (unitless)	ENTER Stratum C SCS soil type	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm³)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm³/cm³)	ENTER Stratum C soil organic carbon fraction, f_{oc}^C (unitless)
Lookup Soil					Lookup Soil					Lookup Soil				
S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s²)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	36576	51206	366	0.1	1	

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	30	30	350	1.0E-06	1
				Used to calculate risk-based soil concentration.	

END

INTERMEDIATE CALCULATIONS SHEET

TRICHLOROETHENE (8 TO 12 FT) MAXIMUM

Exposure duration, τ (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, θ_a^A (cm^3/cm^3)	Stratum B soil air-filled porosity, θ_a^B (cm^3/cm^3)	Stratum C soil air-filled porosity, θ_a^C (cm^3/cm^3)	Stratum A effective total fluid saturation, S_{te} (cm^3/cm^3)	Stratum A soil intrinsic permeability, k_i (cm^2)	Stratum A soil relative air permeability, k_{rg} (cm^2)	Stratum A soil effective vapor permeability, k_v (cm^2)	Floor-wall seam perimeter, X_{crack} (cm)	Initial soil concentration used, C_R (µg/kg)	Bldg. ventilation rate, $Q_{building}$ (cm^3/s)
9.46E+08	336	0.321	0.321	0.321	0.003	9.92E-08	0.998	9.91E-08	175,564	1.10E+03	1.90E+08

Area of enclosed space below grade, A_B (cm^2)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. soil temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. soil temperature, H_{TS} ($atm\text{-}m^3/mol$)	Henry's law constant at ave. soil temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm^2/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm^2/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm^2/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm^2/s)	Diffusion path length, L_d (cm)	Convection path length, L_p (cm)
1.88E+09	9.35E-06	30	8,557	4.78E-03	2.06E-01	1.75E-04	1.28E-02	0.00E+00	0.00E+00	1.28E-02	336	30

Soil-water partition coefficient, K_d (cm^3/g)	Source vapor conc., C_{source} (µg/m³)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm^3/s)	Crack effective diffusion coefficient, D^{crack} (cm^2/s)	Area of crack, A_{crack} (cm^2)	Exponent of equivalent foundation Peclet number, $\exp(Pe^f)$ (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc., $C_{building}$ (µg/m³)	Finite source β term (unitless)	Finite source ψ term $(sec)^{-1}$	Time for source depletion, τ_D (sec)	Exposure duration > time for source depletion (YES/NO)
3.32E-01	5.60E+05	0.10	3.90E+03	1.28E-02	1.76E+04	2.81E+75	NA	NA	1.93E+01	3.47E-08	1.50E+08	YES

Finite source indoor attenuation coefficient, <α> (unitless)	Mass limit bldg. conc., $C_{building}$ (µg/m³)	Finite source bldg. conc., $C_{building}$ (µg/m³)	Final finite source bldg. conc., $C_{building}$ (µg/m³)	Unit risk factor, URF $(\mu g/m^3)^{-1}$	Reference conc., RfC (mg/m³)
NA	1.71E+00	NA	1.71E+00	1.1E-04	4.0E-02

END

DATA ENTRY SHEET

SL-ADV
Version 3.1; 02/04

Reset to

CALCULATE RISK-BASED SOIL CONCENTRATION (enter "X" in "YES" box)

XYLENE (8 TO 12 FT) MAXIMUM

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL SOIL CONCENTRATION (enter "X" in "YES" box and initial soil conc. below)

YES [X]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial soil conc., C_R (µg/kg)	Chemical
106423	7.30E+03	p-Xylene

MORE ↓

ENTER Average soil temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to top of contamination, L_t (cm)	ENTER Depth below grade to bottom of contamination, (enter value of 0 if value is unknown) L_b (cm)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm²)
10	30	366	456	366	0	0	S		

Totals must add up to value of L_t (cell G28)

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm³)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm³/cm³)	ENTER Stratum A soil organic carbon fraction, f_{oc}^A (unitless)	ENTER Stratum B SCS soil type (Lookup Soil)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm³)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm³/cm³)	ENTER Stratum B soil organic carbon fraction, f_{oc}^B (unitless)	ENTER Stratum C SCS soil type (Lookup Soil)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm³)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm³/cm³)	ENTER Stratum C soil organic carbon fraction, f_{oc}^C (unitless)
S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002	S	1.66	0.375	0.054	0.002

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s²)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	36576	51206	366	0.1	1	

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	30	30	350	1.0E-06	1

Used to calculate risk-based soil concentration.

END

XYLENE (8 TO 12 FT) MAXIMUM

Exposure duration, τ (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, θ_a^A (cm^3/cm^3)	Stratum B soil air-filled porosity, θ_a^B (cm^3/cm^3)	Stratum C soil air-filled porosity, θ_a^C (cm^3/cm^3)	Stratum A effective total fluid saturation, S_{te} (cm^3/cm^3)	Stratum A soil intrinsic permeability, k_i (cm^2)	Stratum A soil relative air permeability, k_{rg} (cm^2)	Stratum A soil effective vapor permeability, k_v (cm^2)	Floor-wall seam perimeter, X_{crack} (cm)	Initial soil concentration used, C_R (µg/kg)	Bldg. ventilation rate, $Q_{building}$ (cm^3/s)
9.46E+08	336	0.321	0.321	0.321	0.003	9.92E-08	0.998	9.91E-08	175,564	7.30E+03	1.90E+08

Area of enclosed space below grade, A_B (cm^2)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. soil temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. soil temperature, H_{TS} (atm-m^3/mol)	Henry's law constant at ave. soil temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm^2/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm^2/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm^2/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm^2/s)	Diffusion path length, L_d (cm)	Convection path length, L_p (cm)
1.88E+09	9.35E-06	30	10,248	3.06E-03	1.32E-01	1.75E-04	1.24E-02	0.00E+00	0.00E+00	1.24E-02	336	30

Soil-water partition coefficient, K_d (cm^3/g)	Source vapor conc., C_{source} ($\mu g/m^3$)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm^3/s)	Crack effective diffusion coefficient, D^{crack} (cm^2/s)	Area of crack, A_{crack} (cm^2)	Exponent of equivalent foundation Peclet number, exp(Pe^f) (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc., $C_{building}$ ($\mu g/m^3$)	Finite source β term (unitless)	Finite source ψ term. $(sec)^{-1}$	Time for source depletion, τ_D (sec)	Exposure duration > time for source depletion (YES/NO)
7.78E-01	1.15E+06	0.10	3.90E+03	1.24E-02	1.76E+04	3.23E+77	NA	NA	1.88E+01	1.04E-08	4.87E+08	YES

Finite source indoor attenuation coefficient, <α> (unitless)	Mass limit bldg. conc., $C_{building}$ ($\mu g/m^3$)	Finite source bldg. conc., $C_{building}$ ($\mu g/m^3$)	Final finite source bldg. conc., $C_{building}$ ($\mu g/m^3$)	Unit risk factor, URF $(\mu g/m^3)^{-1}$	Reference conc., RfC (mg/m^3)
NA	1.14E+01	NA	1.14E+01	NA	1.0E-01

END

ATTACHMENT 5

DECEMBER 15, 2009 LETTER FROM MPCA

December 15, 2009

Mr. Howard M. Hickey
Regional Project Manager
NAVFAC Midwest
201 Decatur Avenue, Building 1A
Great Lakes, IL 60088-2801

Mr. Douglas Hildre, P.E.
Environmental Affairs Manager
BAE Systems Land and Armaments
4800 East River Road
Minneapolis, MN 55421-1498

Dear Mr. Hickey and Mr. Hildre:

This letter is to notify you the criteria that will be used by Minnesota Pollution Control Agency (MPCA) to determine compliance with Minnesota surface water requirements have been modified. As discussed previously over the telephone with you, the MPCA is modifying water quality standards that apply to both Navy Industrial Reserve Ordnance Plant (NIROP) and FMC Corporation Superfund sites.

The reach of the Mississippi River in question is classified both as Class 2Bd and Class 2B. The definitions of these classifications are as follows:

> **Class 2Bd waters.**
>
> The quality of Class 2Bd surface waters shall be such as to permit the propagation and maintenance of a healthy community of cool or warm water sport or commercial fish and associated aquatic life and their habitats. These waters shall be suitable for aquatic recreation of all kinds, including bathing, for which the waters may be usable. This class of surface waters is also protected as a source of drinking water. (Minn. R. 7050:0220 subp. 3 https://www.revisor.mn.gov/rules/?id=7050.0222)
>
> **Class 2B waters.**
>
> The quality of Class 2B surface waters shall be such as to permit the propagation and maintenance of a healthy community of cool or warm water sport or commercial fish and associated aquatic life, and their habitats. These waters shall be suitable for aquatic recreation of all kinds, including bathing, for which the waters may be usable. This class of surface water is not protected as a source of drinking water. (Minn. R. 7050:0220, subp. 4 https://www.revisor.mn.gov/rules/?id=7050.0222)

As a result of an informal inquiry by the U.S. Navy, the MPCA reviewed the compliance requirements for the contaminant plumes of both Superfund sites. Minneapolis Water Works (MWW), which supplies drinking water to more than 500,000 people, is the main receptor down-gradient from where the contaminant plumes of both sites enter the Mississippi River. Protection of this critical drinking water use is paramount to any regulatory decision made by the MPCA in regards to the two Superfund sites. As means of addressing the Navy's concerns and protecting a vital drinking water source, the MPCA has determined that, NIROP and FMC Corporation Superfund sites must:

1. Meet Class 2Bd surface water quality standards in river water up-gradient from the MWW.
2. Meet Class 2B surface water quality standards in the compliance wells along the river and any seeps along the riverbank in order to protect aquatic life, especially benthic organisms.

Table 1. Class 2Bd Chronic Standards and Class 2B (Aquatic Life) Chronic Standards for Contaminants of Concern at NIROP and FMC Corporation Superfund Sites.

Chemical	Class 2Bd Chronic Standard*	Aquatic Life Chronic Standard
tetrachloroethene (PCE)	3.8 µg/L	8.9 µg/L
trichloroethene (TCE)	25 µg/L	120 µg/L
cis 1,2-dichloroethene +	50 µg/L	none
trans 1,2-dichloroethene+	100 µg/L	none
vinyl chloride	0.18 µg/L	9.2 µg/L

*for definitions of this and other terms please check the Minnesota Office of the Revisor of Statutes web page: https://www.revisor.mn.gov/rules/?id=7050.0218
+ Minnesota Department of Health's Health Risk Limits (HRL). For more information check web page http://www.health.state.mn.us/divs/eh/risk/guidance/gw/table.html

The MPCA Water Quality staff determined that it is appropriate to apply water quality standards for the protection of aquatic life in the compliance wells to protect benthic aquatic organisms. Additionally, the MPCA expects meeting these concentrations will be protective of Class 2B(d) drinking water standards in the Mississippi River. Part of the basis for assigning these concentrations in the compliance wells as protective is due to the fact that no trichloroethene (TCE), the main contaminant in both NIROP and FMC sites or its metabolites, had been detected for the last ten (10) years at the water intake from the Mississippi River at MWW. Please note that a small, but significant tetrachloroethene (PCE) plume is also present in an area down-gradient of the FMC Corporation site, and appears to be entering the Mississippi River and must also be addressed.

As a condition of the modification of the monitoring well compliance concentrations, the MPCA will require that the Navy and BAE coordinate the preparation and implementation of a sampling plan to characterize PCE, TCE and vinyl chloride and in river water. This plan will serve to evaluate the presence of these compounds from river water samples collected in a location up gradient from the NIROP and FMC sites, and in river water samples collected in a location approximately mid-point between the MWW water intake and the NIROP and FMC monitoring wells.

The sampling plan will need to select sample sites and depths based on an understanding of the hydrological, fate and transport characteristics of TCE from inputs of the NIROP and FMC non point sources. The river water must be sampled for a minimum of three (3) years during historic low flow time, starting in 2010. During such sampling events, if any river water samples were found to contain any of the COCs above Class 2Bd Chronic Standards, the MPCA, with U.S. Environmental Protection Agency's concurrence, will determine the means of addressing the exceedences. The regulators will consult you prior to such determination(s).

Protection of surface water will be achieved through the following activities:

1) Existing monitoring wells and seeps will be monitored to record concentrations of those contaminants that have numeric standards for aquatic life: PCE, TCE, and vinyl chloride.

2) The chronic value of the class 2B surface water quality standard for PCE TCE and vinyl chloride will be used as the cleanup goal. Detection of any of these chemicals from any sample of any compliance well or seep must not exceed the class 2B chronic standard for at least one year in order for MPCA to determine that the respective site is in compliance.

Please note, that the sampling regime described above is in addition to the remediation and monitoring activities that are required by respective decision documents for each site. In the coming weeks, I will contact both of you to set up a conference call to discuss details of implementation of the new standards applied to surface water along the subject stretch of Mississippi River.

Please contact me if you have any further questions at 651-757-2572 or email me at deepa.dealwis@state.mn.us. I look forward to working both of you to remediate your respective sites.

Sincerely,

Deepa deAlwis
Project Manager
Superfund, RCRA & Voluntary Cleanup Section
Remediation Division

DA:csa

cc: Mary Tierney, U.S. EPA
Phillip Monson, Environmental Analysis & Outcomes Division, MPCA
John Estes, Delta Environmental