

DRAFT-Hydrogeologic Investigation Checklist

Check Below if Included

___ Project information

Facility ID: _____
Facility Project #: _____
Facility Name: _____
Facility Address: _____
Tax Parcel ID: _____

File Code: 34

___ Responsible Party information

Responsible Party: _____
Address: _____
Contact: _____

Data Collection and Reporting

Page in Guide

___ Release Information (cause, amount, etc.)	8
___ QA/QC procedures	8
___ Investigative work conducted	8
___ Vertical and Horizontal extent of Soil contamination	9
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___ Points of Exposure	14

Data Interpretation

___ Risk and Risk-Based Screening Levels	16
___ Conceptual Site Model	18
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Which best fits your recommendations (check all that apply):

- ___ No Further Action
- ___ One year of monitoring
- ___ Remedial Action
- ___ Further investigation
- ___ Tier 2 evaluation
- ___ Other

Appendices

- ___ Laboratory reports with chain of custody documentation
- ___ Regional figure
- ___ Facility scale figure
- ___ Groundwater flow figure
- ___ Contaminant distribution figures
 - ___ soil
 - ___ groundwater
- ___ Boring logs/well logs
- ___ Well Permits
- ___ Point of exposure figure
- ___ Cross sections
- ___ Analytical results tables
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- ___ Financial Responsibility Survey (if received)

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List of Acronyms

AST	Aboveground Storage Tank
ASTM	American Society for Testing and Materials
CMP	Contaminant Migration Pathway
COC	Chemical of Concern
CSM	Conceptual Site Model
DERBCAP	Delaware Risk-Based Corrective Action Program
DNREC	Department of Natural Resources and Environmental Control
HI	Hydrogeologic Investigation
HIR	Hydrogeologic Investigation Report
ID	Identification
LIF	Laser-Induced Fluorescence
LCSM	LNAPL Conceptual Site Model
LNAPL	Light non-Aqueous Phase Liquid
LUST	Leaking Underground Storage Tank
MIP	Membrane Interface Probe
MTBE	Methyl tert-butyl Ether
NFA	No Further Action
PE	Professional Engineer
PG	Professional Geologist
POC	Point of Compliance
POE	Point of Exposure
QA	Quality Assurance
QC	Quality Control
RAWP	Remedial Action Work Plan
RBCA	Risk-Based Corrective Action
RBSL	Risk-Based Screening Level
RP	Responsible Party
TMB	Tank Management Branch
UST	Underground Storage Tank

Hydrogeologic Investigation Guide

PART I - INTRODUCTION

1.0 Introduction

- 1.1 The Hydrogeologic Investigation Guide (referenced as “this guide”) is one document in a series of guidance documents that the Department of Natural Resources and Environmental Control, Tank Management Branch (DNREC-TMB) has created (or will create) in assisting consultants, responsible parties and the public with following the requirements of Part E of DE Admin. Code 1351, State of Delaware *Regulations Governing Underground Storage Tank Systems* (the UST Regulations).
- 1.2 The focus of *this* guide will be how to successfully complete the Hydrogeologic Investigation (HI) requirements as required in Part E §4.2 of the UST Regulations.
- 1.3 This guide is to be used in conjunction with the Delaware Risk-Based Corrective Action Program (DERBCAP).
- 1.4 The HI is perhaps the most important part of the corrective action process (Corrective Action Process Flow Chart in appendix) because it defines the extent of the confirmed release.
- 1.5 It is the goal of the DNREC-TMB that by creating this document more complete HIs will be conducted, thus, allowing for better protection of human health, safety, and the environment. In addition, Leaking Underground Storage Tank (LUST) projects will progress more quickly towards a no further action (NFA) determination by the DNREC-TMB.
- 1.6 Since all projects are driven by risk, the completion of every task covered in this document is not necessary for all situations.

2.0 Responsibility

- 2.1 It is the responsibility of the Responsible Party (RP) to successfully complete the HI requirements as stated in the UST Regulations, the *Hydrogeologic Investigation Required* letter and all subsequent correspondence concerning a confirmed release.
- 2.2 Part E § 4.2.2 of the UST Regulations requires the RP to submit the **complete** *Hydrogeologic Investigation Report (HIR)* to the DNREC-TMB within 120 days following receipt of the *Hydrogeologic Investigation Required* letter. Incomplete HIRs will not be accepted and will not be considered for meeting the 120 day deadline
- 2.3 Two copies of the HIR should be submitted to the DNREC-TMB project officer for review. One of the copies may be an electronic copy.
- 2.4 In general, the RP hires a qualified environmental professional, or consultant, to assist them in meeting the investigation and reporting requirements of the HI and HIR.
- 2.5 ***It is important to realize that although the RP hires a consultant, it is ultimately the responsibility of the RP (not the consultant) to meet the requirements and deadlines set in the UST Regulations and by the DNREC-TMB; therefore, it is important for the RP to make sure the consultant is meeting deadlines on their behalf.***
- 2.6 Unless the RP is well-versed in conducting a HI, it is recommended that the RP requests proposals from multiple consultants. To address the same LUST project, different consultants will have different approaches that come with varying time frames and costs.
- 2.7 The RP should hire a consultant based on, but not limited to, weighing the following factors:
 - Experience
 - Professionalism

- PG and/or PE licenses as necessary
 - References
 - Cost
 - Approach
 - Reliability
- 2.8 The hydrologists at the DNREC-TMB are always available to discuss different approaches and technologies.
- 2.9 During the process of the HI, the DNREC-TMB must be notified **immediately** if any of the following observations are made:
- Any private or public well impact
 - The appearance of mobile or free light non-aqueous phase liquid (LNAPL)
 - Any surface water impact resulting in a sheen
 - Anytime there is an immediate threat to human health and safety or the environment.

3.0 Work Plans

- 3.1 The DNREC-TMB recently reviewed its corrective action process to more efficiently move projects toward NFA determinations and to lessen the burden of administrative work (report and work plan reviewing, letter writing, etc.).
- 3.2 The first step in streamlining the DNREC-TMB's corrective action process was the elimination of the requirement to submit a HI work plan for the initial investigations. Work required after the submittal of the initial HIR will still require a work plan.
- 3.3 In the past, the scopes of *approved* work plans were sometimes insufficient in delineating the full extent of the contamination. In these cases decisions to expand the investigations could have been made in the field to more quickly delineate the plume and provide useful information for the project. However, these "expanded" investigations were not performed because they were not pre-approved by the DNREC-TMB. As a result, several weeks were added to the project life and additional costs were incurred by the RP through the development of additional work plans, field mobilizations etc.
- 3.4 The DNREC-TMB expects that by eliminating the work plan step in the corrective action process a more flexible, field-driven investigation will be performed. Decisions made in real time will allow for an additional field mobilization, if necessary, within the 120 day deadline. Better field time management will permit time for more complete data collection, allowing for more constructive recommendations for a path forward or a warranted request for a NFA determination.
- 3.5 ***While a work plan will no longer be required for a HI, the DNREC-TMB welcomes and encourages meetings or teleconferences to discuss your planned investigation in advance of any field mobilizations.***

4.0 Content of the Hydrogeologic Investigation Guide

- 4.1 The purpose of the HI checklist is to act as a quick visual guide to ensure that the HI is complete and contains the appropriate sections and report appendices.
- 4.2 The HI checklist **must** be filled out and included as the cover of the HIR. It is acceptable to place the HI checklist behind your hired consultant's coversheet.
- 4.3 This guidance document is intended to help the RP and their hired consultant understand what the DNREC-TMB expects in terms of a complete HI for a range of projects.
- 4.4 Although this guide covers a topic of a technical nature, it is written in such a way that a non-technical reader can form a general understanding of the concepts and use the information in either reviewing a consultant's report and recommendations. However, the majority of the material in this guidance document assumes the reader has a basic technical background and is geared toward the professionals that will be conducting the HI.

- 4.5 The content of this guide is intended to ensure that good quality data is collected and allow for good, sound, professional decision making to allow a wide variety of LUST projects and situations to be addressed.
- 4.6 The sections of this guidance document beginning in Part II are organized as follows:
- The section title will begin a new section (i.e. 1.0) and will be printed in bold. The section title will correspond to the table of contents and loosely to the HI checklist.
 - The first subsection (i.e. 1.1) will have the title of *Report Appendices required to be submitted*, and will be a bulleted list of appendices (i.e. figures, tables, lab reports, etc.) that should accompany the HIR. The appendices will be relevant to the section.
 - The second subsection (i.e. 1.2) will have the title of *Topics of discussion*, and will be a bulleted list of topics which will make up the body of the report for that section.
 - The third subsection (i.e. 1.3) will be the guidance on how to create and submit required Report Appendices and how to sufficiently investigate and report on topics which are integral to the report.
- 4.9 Some requirements are repeated in several sections. Double submittal is not expected and combining requirements is recommended. For example, in Part II Sections 3.0 and 4.0, figures are required to be submitted detailing the locations of borings and sample points. If the data required in said parts can be clearly depicted with one figure, one figure is all that is needed.
- 4.10 Due to the risk-based nature of the DNREC-TMB Program, written justification explaining why completing a requirement as prescribed in this guide is not applicable due to the risk posed by a facility is as sufficient as completing the requirement as outlined in this guide when the risk warrants its completion. For example, door-to-door well surveys may not be necessary if the exposure pathway can be eliminated.

5.0 Summary of Intent

- 5.1 The DNREC-TMB recognizes that each LUST project presents its own unknowns and complications and that some methods for completing a HI are more beneficial than others for different sites and at different times (e.g. temporary direct push sampling versus permanent monitoring wells and vice versa).
- 5.2 The DNREC-TMB would like to see all projects move as efficiently towards a NFA determination as possible while providing for the protection of human health and safety, and the environment. The DNREC-TMB understands that achieving every task in this document is not necessary for completing that goal and does not expect extra, non-value added work to be conducted.
- 5.3 The DNREC-TMB is always available for guidance.

6.0 Professional Geologist (PG), Professional Engineer (PE) Signature Requirement

- 6.1 According to Part E §4.2.3 of the UST Regulations, a HIR is required to be signed by a Delaware-licensed PG or PE. This requirement is in place to ensure the quality of the investigation and accuracy of data interpretation because it has a direct impact on the well being of the environment and individuals.
- 6.2 In some cases, when a release is limited and an investigation can be completed through Tier 0 soil sampling only, PG or PE signature may not be necessary. However, prior **DNREC-TMB approval will be required.**

Here is an example of 6.2:

A 550-gallon heating oil UST is removed with composite and grab soil samples collected and groundwater is not encountered. The samples are analyzed for DRO with the results of the grab sample being reported at 1,800 mg/Kg, which is over the action level of 1,000 mg/Kg. A HI is then required. The RP hires a consultant who plans to collect a soil sample from a deeper depth and from four locations around the former UST with all samples being analyzed for DRO. The results of this investigation do not need to be signed by a PE or PG.

7.0 Aboveground Storage Tanks (ASTs)

- 7.1 While this guide was created to aid in completing a HI for a UST facility, the general principals are applicable for AST facilities and this guidance should be followed to complete the investigation required in Part E, § 1.0 in the DE Admin. Code 1352, State of Delaware *Regulations Governing Aboveground Storage Tanks* (the AST Regulations).
- 7.2 When following this guide to complete an investigation at an AST facility some regulatory differences are to be implied:
 - Release is defined differently
 - Owners and Operators are responsible for AST facilities, RP is not defined in the AST Regulations
- 7.3 Just as in UST projects, the DNREC-TMB project officer is available for teleconferences or meetings.
- 7.4 For additional guidance, please review the Aboveground Storage Tank Site Assessment Guidance document found at:
http://www.dnrec.state.de.us/dnrec2000/Divisions/AWM/ust/pdf%5CFinal_AST_Sampling_Guidance.pdf

PART II – Data Collection and Reporting

1.0 Release Information

1.1 Report Appendices required to be submitted:

- Documentation supporting release volume calculation, including inventory records
- Repair documentation
- Photos
- Field Orders and/or Secretary Orders from DNREC emergency personnel
- General Site Figure
- Regional Figure
- Other applicable documentation

1.2 Topics of discussion:

- Identify how the leak was caused, when the leak began, and how the leak was identified.
- Report the estimated volume of the release and what was released.
- Report any actions conducted as an emergency effort, by any party, to minimize the release (e.g. trenching, pumping, etc.).

1.3 Guidance:

- 1.3.1 The cause of a release is sometimes very difficult to pinpoint but professional judgment based on how the release was identified can provide assistance. A release is commonly identified during UST removal activities, retrofit activities, or during a Phase II assessment. The location of contamination will aid in producing an approximate cause of the release. In addition, this data is now required to be collected under the Energy Policy Act of 2005 (Pub.L. 109-58) and is important in the development of a conceptual site model (CSM) (Part III Section 5).
- 1.3.2 Carefully review all data available for the specific site. Review UST removal or closure-in-place reports, data on previous LUST projects at the facility, and review basic information on nearby LUST facilities (especially if a second source is a potential).
- 1.3.3 Speak to the DNREC-TMB compliance officer if one is assigned. The project officer can and will provide you with this information.
- 1.3.4 Other than in emergency situations, determining the exact time that a leak began may be impossible. Estimates of when the release began may be aided by reviewing inventory records, product delivery receipts and looking for continuous net losses or receiving excessive deliveries. This documentation may be obtained from the UST operator, DNREC-TMB files and/or the UST owner.
- 1.3.5 Inventory records and product delivery receipts can also aid in approximating the volume of product released. In addition, by defining the extent of soil contamination a loose estimate of volume released can be obtained.
- 1.3.6 If remedial actions were taken before receipt of the letter informing the RP that a HI is required, details of those actions and backup documentation must be gathered and submitted.
- 1.3.7 A general figure of the facility must be prepared and submitted with the HIR. The figure must be set to an appropriate scale, have a north arrow, and legend, and include the locations of present and former USTs, present and former dispensers, present and former piping runs, utilities and all structures.
- 1.3.8 A figure of the region must be prepared and submitted with the HIR. The figure must be scaled appropriately to allow someone who is not familiar with the area to find the facility.

2.0 Quality Assurance and Quality Control (QA/QC)

2.1 Report Appendices required to be submitted:

- Chain of Custody forms with appropriate information

2.2 Topics of discussion:

- Briefly discuss the QA/QC that was performed during this LUST project.
- Discuss any potential problems that have been identified through your QA/QC efforts.

2.3 Guidance:

- 2.3.1 QA/QC is crucial for ensuring that the data reported and decisions made from that data are sound. Part E § 4.3 of the UST Regulations requires the development and implementation of a QA/QC plan.
- 2.3.2 Analytical reports must always include a chain of custody.
- 2.3.3 When relinquishing the chain of custody signatures, times and dates must be documented. In addition, the temperature of the samples when received by the lab must be noted on the chain of custody or documented in a laboratory summary report. If your lab does not currently provide this service, it should be requested.
- 2.3.4 All groundwater sampling events and soil sampling events where volatile compounds are being analyzed for must include one trip blank per cooler.
- 2.3.5 One equipment blank sample must be collected per day when non-dedicated equipment is used.
- 2.3.6 All samples must be collected and placed in the appropriate, sterile containers.
- 2.3.7 Samples should be kept at ≤ 6 °C until delivered to the laboratory.
- 2.3.8 Contaminant and analytical method specific holding times must be met.
- 2.3.9 If sample results are reported with expired holding times and/or excessive temperatures, the DNREC-TMB will not accept the results and will require the samples be recollected.
- 2.3.10 Field blanks, duplicate samples and split sampling may be necessary.
- 2.3.11 Having the lab run matrix spikes and matrix spike duplicates is recommended.
- 2.3.12 Lab reports must include the results of matrix spikes, matrix spike duplicates, and instrument calibration results.
- 2.3.13 All sampling equipment that is not dedicated or disposable must go through proper decontamination procedures to protect against cross contamination. ASTM practice D5088 provides procedures for decontamination.
- 2.3.14 Instruments used for collecting field measurements should be properly calibrated according to the manufacturer's standards. Calibration dates and times must be recorded in field books, field logs, or equipment logs.
- 2.3.15 Further guidance and explanation is available in the appendix.

3.0 Defining the Vertical and Horizontal Extent of Soil Contamination

3.1 Report Appendices required to be submitted:

- Figure with soil sample and boring locations
- Figure with interpreted extent and concentrations of soil contamination
- Lab analytical reports
- Table of soil sample analytical results
- Boring log(s)
- Cross section(s)

3.2 Topics of discussion:

- Interpret analytical and screening data collected to date to determine the volume of soil contamination.
- Discuss sampling methods.
- Discuss screening methods.
- Discuss how source mass is contributing to daughter plumes.
- Report any identified data gaps and propose how they will be filled.

3.3 Guidance:

- 3.3.1 Part E §4.2.1.2 and §4.2.1.3 of the UST Regulations require that the horizontal and vertical extent and distribution of the Release be determined. This requirement includes *soil contamination*. Defining the extent of soil contamination is a critical part of a HI. Note that the data gathered may come from many phases of work at a tank site, from tank removal or closure in place through HI and remediation.
- 3.3.2 Soil samples must be collected in the proper laboratory provided bottleware according to the method of analysis.
- 3.3.3 Defining the extent of soil contamination is integral to the following:
- Estimating the amount of source mass contributing to dissolved and vapor contamination;
 - Aiding in selection of locations for groundwater sampling or monitor well installation;
 - Aiding in remedial design or modeling;
 - Estimating the potential extent of soil overexcavation; either during underground storage tank removal, or as a remedial strategy;
 - Determining risks, such as potential for exposure to contaminated soil during excavation. This includes long term stewardship of a property following a risk-based NFA determination, through which residual contamination is left in soil.
- 3.3.4 Collection of data can occur in every phase of corrective action, but early determination of the extent of soil contamination will serve to guide further corrective actions. Techniques such as membrane interface probe (MIP) or laser-induced fluorescence (LIF) are quick ways to develop a 3-dimensional picture of contamination at the site. These investigative tools may cost more initially but can lower costs in the future with the collection of fewer soil samples, less staff time associated with field mobilizations and sample collection, and providing the ability to target well locations.
- 3.3.5 Ensure that soil data collection is integrated with groundwater data collection.
- 3.3.6 All opportunities for collecting soil data, such as during monitor well installation, excavation, installation of remediation systems, etc., should be exploited.
- 3.3.7 It is beneficial to review soil analytical data from tank system removal, closure-in-place, and/or retrofit reports to aid in defining extent of soil contamination. You may need to check the DNREC-TMB facility file for the information.
- 3.3.8 Field screening information is a part of delineating soil contamination. Ensure that QC is employed in screening data collection, data is recorded accurately, and equipment is properly calibrated.
- 3.3.9 Field screening techniques must be used in selecting representative soil samples for laboratory analyses. Grab soil samples must be collected from the points of highest screening readings or areas of staining and at the interval directly above the water table. If screening readings are non-detect, a grab sample can be collected from the interval above the water table. However, if detections are uniform, a grab sample from above the water table and a composite sample of the boring must be collected. Samples collected, bagged and used for headspace readings must **not** be submitted to the lab for analysis.
- 3.3.10 Screening of borings must continue until readings return to non-detect or staining is no longer present. Soil borings that stop at the water table and still exhibit signs of contamination do not vertically delineate contamination.
- 3.3.11 Soil samples must be collected below the water table from a representative number of locations if staining is observed.

- 3.3.12 You must clearly describe in the HIR how the extent of contamination was determined. That is, describe what laboratory and/or field screening data was used in determining the lateral and vertical extent of soil contamination.
- 3.3.13 A figure must be included displaying the horizontal extent of soil contamination and defining areas of varying concentrations. The figure must be to scale with a north arrow and legend. Within reason, historic soil borings/sample locations should be included on the figure.
- 3.3.14 A table must be prepared summarizing analytical results. The table must include local identification (SB-1), DNREC well permit number, proposed RBSLs, and laboratory detection limit if result is not detected. An example is included in the appendix.
- 3.3.15 A cross-section displaying the extent of soil contamination (soil sample locations, screening results, observed staining, lithology, etc.) as well as groundwater sampling data (lithology, sample locations, well screens, screening results, water elevations, etc.) must be prepared to support the discussion on the vertical extent of soil contamination.
- 3.3.16 Boring/well logs must include field screening information, including notation of intervals from which screening information and soil samples were collected. Boring logs must also include drilling method, local identification (SB-1) and the DNREC well permit number (if applicable). In addition, lithology must be described by using common nomenclature such as the Unified Soil Classification System (ASTM D2488). An example is included in the appendix.
- 3.3.17 For releases near subsurface structures, consider where released product may have migrated, such as into drains, trenches, along walls, pipes, etc. Soil contamination may “hide” in such areas.

4.0 Groundwater Flow Direction

4.1 Report Appendices required to be submitted:

- Figure with sample and groundwater gauging locations
- Figure(s) with inferred groundwater elevation and flow direction
- A figure with preferential pathways identified
- Well Permits
- A table with gauging or groundwater elevation data

4.2 Topics of discussion:

- Discuss how the groundwater flow direction was determined.
- Interpret data collected to date to determine the migration of a groundwater contamination plume.
- Starting with the larger conduits or preferential pathways consider the potential for them to influence groundwater flow and the overall CSM (Part III Section 5.0).
- Discuss the ultimate discharge location of groundwater
- Report any identified data gaps and propose how they will be filled.

4.3 Guidance:

- 4.3.1 If groundwater contamination is confirmed, the RP will need to determine in what direction groundwater flows to determine if any POEs are at risk.
- 4.3.2 In early stages of an investigation, or perhaps as the only means in a limited investigation, topographic maps, information on nearby sites, published works or information on drainage basins can be used.
- 4.3.3 The best way to determine groundwater flow direction is through an installed monitoring well network. For the outcome of the gauging data to be acceptable the following principles must be followed:

- 4.3.3.1 A minimum of three wells must be used and the wells must be installed in a 'wide triangle'. In other words, the wells must be well distributed over the area of interest. Wells installed in a straight line or near straight line will not provide useful data in determining groundwater flow.
- 4.3.3.2 Wells used in determining groundwater flow must be screened at the same interval. Deep well data should not be used for determining shallow groundwater flow or vice versa.
- 4.3.3.3 Wells to be used for determining groundwater flow should not be installed in former tank pits or other areas of non-native fill. Groundwater elevations tend to be higher in these areas and will affect results. However, wells installed in these areas can provide useful contamination data.
- 4.3.3.4 Groundwater monitoring wells must be adequately developed to provide good communication with the aquifer. ASTM guide D5521 provides a framework for well development.
- 4.3.3.5 While a professional survey of wells is not required, a survey must be conducted by skilled individuals to obtain top of casing elevations.
- 4.3.3.6 Well elevations must be in reference to an immobile and permanent benchmark. This benchmark should be noted in the discussion of how groundwater flow direction was determined to allow for the replication of the survey data if necessary.
- 4.3.3.7 Groundwater elevations can be collected from temporary wells or from screen points. However, that data should not be used as the only means of determining groundwater flow direction due to the variability and inaccuracies associated with those installation methods.
- 4.3.4 When groundwater elevations are collected, a scaled figure must be prepared with groundwater elevations, contours and groundwater flow direction indicated.
- 4.3.5 Groundwater gauging data must be tabulated. The table must include the well ID, depth to water, top of screening height, groundwater elevation, depth to product, and product thickness.
- 4.3.6 Preferential pathways in the form of man-made conduits (former UST system trenches, sewer lines, electric lines, etc.) affect the flow of groundwater and/or vapors and the overall distribution of contamination. Possible effects of man-made conduits must be considered.
- 4.3.7 RBSLs established in the DERBCAP Guide are established using generic parameters (hydraulic conductivity, seepage velocity, gradient). You are required to establish estimates of hydraulic conductivity and gradient based on the information available.

5.0 Defining the Vertical and Horizontal Extent of *Groundwater Contamination*

5.1 Report Appendices required to be submitted:

- Figure with sample locations
- Figure(s) with interpreted extent and inferred concentration isopleths of groundwater contamination
- Lab analytical reports
- Table of groundwater analytical results
- Boring and well logs
- Well Permits
- Cross-section(s)

5.2 Topics of discussion:

- Interpret data collected to date to determine the vertical and horizontal extent of groundwater contamination.
- Discuss any impacted or potentially impacted off site properties.
- Discuss the potential for plume diving to occur.
- Report any identified data gaps and propose how they will be filled.

5.3 Guidance:

- 5.3.1 The goal of this section is to determine the distribution of groundwater contamination. Part E §4.2.1.1 of the UST Regulations requires that the horizontal and vertical extent and distribution of the Release be determined. While this requirement is straightforward, it is also time consuming, costly, and difficult to accomplish.
- 5.3.2 Groundwater samples must be collected in the proper laboratory provided bottlenecks according to the method of analysis. ASTM standards D6452, D6634, and D6771 provide methods for sampling monitoring wells as well as information on sampling devices.
- 5.3.3 Wells installed for the purpose of collecting groundwater samples must not have well screen lengths greater than 20 feet without first getting approval from the TMB project officer.
- 5.3.4 Groundwater samples must be collected from the source zone or expected area of worst contamination.
- 5.3.5 Groundwater samples must be collected up-gradient of the area of contamination. This data may confirm an off-site source, another previously unknown area of contamination, show fluctuation in groundwater flow direction, or provide background data.
- 5.3.6 Groundwater samples must be collected from the downgradient property boundary to establish a point of compliance (POC).
- 5.3.6.1 LUST projects which require a HI and have concentrations of chemicals of concern (COCs) in excess of the DERBCAP <50 foot RBSLs are typically fueling stations. Generally, fueling stations are relatively small and POC wells are easily impacted. **This requires an off-site investigation and may warrant some type of interim remedial action.**
- 5.3.6.2 LUST projects located on a large parcel of land are likely to have a clean POC well. However, the extent of the plume will not necessarily be defined, in which case samples will need to be collected between the source zone and the POC well to aid in determining distribution, plume stability and fluctuations in groundwater flow.
- 5.3.7 As long as screened intervals are appropriate, samples can be collected and lateral distribution and extent can be determined from both permanent and temporary wells.
- 5.3.8 If groundwater contamination exists at a deeper interval or aquifer, lateral extent and distribution at that depth is required to be determined.
- 5.3.9 A figure must be prepared showing a graphical representation of lateral contamination distribution. Several figures may be necessary if multiple COCs are “driving” the project. For example, if benzene and MTBE concentrations exceed RBSL, two figures will need to be drafted if the data is too jumbled or confusing when represented on one figure.
- 5.3.10 Groundwater contamination can migrate to deeper depths when influenced by geology, drawdown from a well, surface water infiltration, and contaminant density.
- 5.3.11 Groundwater samples should be collected from varying depths to determine the vertical extent of contamination. This can be accomplished by installing nesting well units or collecting temporary samples from multiple depths.

- 5.3.12 A cross-section displaying the well network and/or locations of temporary wells (lithology, well screens, screening results, water elevations, etc.) as well as soil contamination data (soil sample locations, screening results, lithology, observed staining, etc.) must be prepared to backup the discussion on the vertical extent and potential for diving plumes.
- 5.3.13 A table must be prepared summarizing analytical results. The table must include local identification (SB-1), DNREC well permit number, proposed RBSLs, and laboratory limits of quantitation if analyte is not detected. An example is included in the appendix.
- 5.3.14 Boring/well logs must include field screening information, including notation of intervals from which screening information and soil samples were collected. Boring logs must also include drilling method, local identification (SB-1) and the DNREC permit number. In addition, lithology must be described by using common nomenclature such as the Unified Soil Classification System (ASTM D2488). Well logs must include construction details of the well. An example is included in the appendix.

Note: Ideally a permanent well network or network of temporary well samples will include samples collected from the fringe and the core of the plume with concentrations of COCs above laboratory detection limits but below the <50' RBSLs. Wells significantly outside the footprint of the plume provide little information.

6.0 Points of Exposure (POEs)

6.1 Report Appendices required to be submitted:

- Figure identifying POEs
- DNREC Water Resource well records
- Table of all identified POEs
- Results of a neighborhood receptor search
- Drilling records and logs for nearby wells

6.2 Topics of discussion:

- Discuss methods used to identify POEs.
- Discuss identified POEs.
- Report any identified data gaps and propose how they will be filled.

6.3 Guidance:

6.3.1 POEs are sensitive receptors where a person, population or wildlife may come in contact with contamination and include, but are not limited to:

- Private and public wells,
- Wellhead protection areas,
- Surface water bodies,
- Building basements,
- Underground utility vaults, and
- Areas considered to be environmentally sensitive (see Section 6.3.2 of this Part)

6.3.2 Areas that are considered environmentally sensitive include but are not limited to:

- Recharge Water Resource Protection Areas (WRPAs) located in New Castle County,
- Areas in Kent and Sussex Counties that are identified as areas of excellent recharge, and
- Wellhead protection areas.

- 6.3.3 Protecting human health and safety and the environment, is the ultimate mission of the DNREC-TMB. The first step in protecting them from a release is accurately indentifying POEs.
- 6.3.4 With the HI being the initial step in the corrective action process, POEs with the greatest potential to become impacted must be considered first. Initially, the DNREC-TMB requires that all POEs within at least 500 feet of the contaminant plume be considered at risk of becoming impacted.
- 6.3.5 When identifying POEs, the DNREC-TMB requires that DNREC's Division of Water Resources, Water Supply Section be contacted at (302) 739-9945. They keep a database of permitted water wells throughout Delaware and can provide a list of permitted wells within 500 feet of the facility. Copies of records received from the Division of Water Resources must be submitted as supporting documentation.
- 6.3.6 DNREC-Water Supply's database only tracks wells that have gone through the permitting process since 1969. If a well was installed before 1969 or never received a permit, it will not be identified in the search. In addition, records for relatively old wells may not be reliable.
- 6.3.7 Due to the shortcomings of the database used to track well permits, it is necessary to conduct a neighborhood receptor search to verify locations of identified wells and located previously unknown wells. The neighborhood receptor search may be conducted in a phased approach as more is learned about the risk posed by the LUST. In addition to gathering information on wells, information on buildings with basements should also be collected.
- 6.3.8 Local water companies can also be contacted to learn who is not served by public water within the 500 foot radius.
- 6.3.9 The required figure must be drawn to scale with a clear legend and north arrow. All POEs identified within 500 feet of the plume boundaries must be represented on the figure.
- 6.3.10 All identified POEs must be compiled in tabular form, which must include each POE's distance from the plume boundary. If wells are identified the table must include each well's location, the property owner, and if available well construction details including depth, screened interval and date installed.

PART III– Data Interpretation

1.0 Contaminant Migration Pathways (CMPs)

1.1 Report Appendices required to be submitted

- Figures with utility corridors/conduits/other preferential pathways

1.2 Topics of discussion:

- Discuss how contamination may travel through each of the contaminant migration pathways and impact potential POEs.
- Discussion and representation of any calculations used.
- Report any identified data gaps and propose how they will be filled.

1.3 Guidance:

- 1.3.1 CMPs are the routes that COCs take from a contaminant source to a sensitive receptor or POE through soils, groundwater, and air. There are three (3) exposure routes that DNREC-TMB is concerned with:
- dermal or physical contact with the contamination
 - inhalation or vapor issues, refer to section 2.3.9 of this part for a link to additional guidance
 - ingestion, primarily through drinking impact water
- 1.3.2 The RP is responsible for determining how far contaminants have migrated through each pathway and to determine if any POEs are either impacted or in danger of being impacted by the release of regulated substances.

2.0 Risk Assessments

2.1 Report Appendices required to be submitted:

- Any backup documentation or supporting documentation

2.2 Topics of discussion:

- Discuss what RBSLs are recommended to be implemented
- Indicate whether or not concentrations discovered are above applicable RBSLs
- Based on concentrations discovered and POEs identified, determine if CMPs are or may potentially become complete.
- Report any identified data gaps and propose how they will be filled.

2.3 Guidance:

- 2.3.1 The DERBCAP Guidance Manual should be referred to for more background and details on RBSLs, risks, and risk assessments.
- 2.3.2 Based on the distance to POEs and property boundaries determine what scenario in the [DERBCAP](#) Guidance Manual (pages 27-35) is appropriate for this LUST project.
- 2.3.3 Property boundaries are considered POCs and cannot be ignored in the determination of RBSLs.
- 2.3.4 A request for NFA may be appropriate when concentrations of all COCs are below applicable RBSLs, POEs are not impacted, and LNAPL is not present or has been addressed in accordance with Part E, Section 3 of the UST Regulations.
- 2.3.5 If contamination can be shown to exist only in the subsurface soil on-site and groundwater is not impacted, the ingestion migration pathway can generally be assumed to be incomplete and not pose a risk.
- 2.3.6 If the chemicals detected are not volatile and/or no structures are located on or near the contaminant plume, the inhalation pathway can generally be assumed to be incomplete and not pose a risk.
- 2.3.7 As the degree of contamination increases and/or LNAPL is present, the amount of details and sampling required for the risk assessment increases.

- 2.3.8 The results of the RP's consultant's risk assessment are used by DNREC-TMB to determine if active remediation will be required for each LUST site project and to assess if an appropriate RBSL has been proposed. For guidance on vapor intrusion, risks, and investigation, refer to the guidance document prepared by the DNREC-Site Investigation and Restoration Branch which can be found at: <http://www.dnrec.state.de.us/dnrec2000/Divisions/AWM/sirb/policy%20concern07008.pdf>
- 2.3.9 Please contact TMB prior to proceeding with VI investigation activities.

3.0 Human Risk Assessment and Management

3.1 Report Appendices required to be submitted:

- Copies of letters issued to property owners regarding well sampling
- Figure with locations of sampled private/public wells
- Well logs/records for potable wells
- Lab analytical reports

3.2 Topics of discussion:

- Report all private/public wells that have been sampled and discuss results.
- Discuss interim remedial actions that have been performed to eliminate, temporarily or permanently, human risk. Examples include water filtration, well replacement, vapor recovery (passive or active) etc.
- Describe all points of exposure (i.e. potable wells, basements, conduits etc.) as identified in Part II Section 6 of this guide that have the potential to be, or were, impacted by the release. The description should include, but is not limited to, the location, well ID, depth of wells, construction detail of wells and building foundations, sampling results etc.
- Describe potential human health risks due to contaminant migration, future well installation, future construction and/or utility work. All exposure pathways should be discussed in detail including dissolved, soil and vapor phases.
- Report any identified data gaps and propose how they will be filled.

3.3 Guidance:

- 3.3.1 Prior to assessing human health risks, all immediate risks to human health and safety must be addressed and resolved. According to Part E § 4.2.1.4 of the UST Regulations, the RP must "*Evaluate, in accordance with DERBCAP or other Department approved procedures, the potential risks posed by the Release including identification of environmentally sensitive receptors, and an estimate of the impacts to human health and the environment that may occur as a result of the release*".
- 3.3.2 If groundwater contamination is discovered, regardless of concentration, an onsite potable well must be sampled if one is present. However, if the ingestion contamination migration pathway for a specific drinking well can be shown to be nonexistent due to the well's construction the well does not need to be sampled with the initial investigation. However, exception from sampling a well must be clearly justified in the report.
- 3.3.3 The RP must send the sampling results for potable wells to the property owner and tenant. The RP is not responsible for discussing health issues and may refer them to the DNREC-TMB.
- 3.3.4 If contamination is discovered in a potable well, the DNREC-TMB must be notified immediately by phone or email.
- 3.3.5 If contamination is discovered in a potable well in concentrations above the maximum contaminant levels recommended by the Environmental Protection Agency or above Delaware drinking water standards, the RP must provide an immediate response to insure the well's users have access to clean water.

- 3.3.6 At this initial phase of the corrective action process, all private/public wells within the maximum RBSL distance that was exceeded must be sampled. For example: if benzene is reported at a concentration of 120 µg/L, which exceeds the 51-100 foot RBSL, all wells located within 100 feet of the sample location must be sampled. However, if the ingestion contamination migration pathway for a specific drinking well can be shown to be nonexistent due to the well's construction the well does not need to be sampled with the initial investigation. However, exception from sampling a well must be clearly justified in the report.

4.0 Environmental Risk Assessment and Management

4.1 Report Appendices required to be submitted:

- Lab analytical reports

4.2 Topics of discussion:

- Describe the potential environmental receptors that are impacted or in danger of being impacted (i.e. surface water body, wetlands, wildlife habitat, etc.).
- Describe the pathways by which the contamination is taking, or could potentially take, to cause an environmental risk.
- Report any identified data gaps and propose how they will be filled.

4.3 Guidance :

- 4.3.1 Prior to assessing environmental risks, all immediate risks to human health, safety and the environment must be addressed and resolved. According to Part E § 4.2.1.4 of the UST Regulations, the Responsible Party must “Evaluate, in accordance with DERBCAP or other Department approved procedures, the potential risks posed by the Release *including identification of environmentally sensitive receptors*, and an estimate of the impacts to human health and the environment that may occur as a result of the release”.
- 4.3.2 It is not expected or required at this time that a full ecological survey be conducted. However, it is required that environmental receptors, POEs, be identified.
- 4.3.3 It should be noted that calculating risk, as is done for RBSLs, involves using mathematical equations relating to a variety of factors including, but not limited to, body weight, consumption rates, concentrations and ingestion rates. The DERBCAP assumptions may not be appropriate for Environmental Risks.

5.0 Conceptual Site Model (CSM)

5.1 Report Appendices required to be submitted:

- Figures or other graphically representations

5.2 Topics of discussion:

- Interpret all data collected to date and explain the CSM model that guides the project forward.
- Report any identified data gaps and propose how they will be filled.

5.3 Guidance:

- 5.3.1 A CSM must be designed based on all of the data collected to date. The CSM should attempt to explain why contamination is located where it is located and where it is going.
- 5.3.2 It is important to prepare a CSM because it will aid in determining what steps are needed next. The CSM should justify the recommendations.
- 5.3.3 The CSM should be updated as data comes in. New data can either confirm that the CSM is correct or that it is flawed.
- 5.3.4 The DNREC-TMB is not looking for lengthy or costly CSM, but the DNREC-TMB is requiring that the CSM be described in the HIR.

- 5.3.5 Included in the appendix is a list of web sites describing CSMs and how you may want to produce one.
- 5.3.6 When LNAPL is present, Part E § 3.3 of the UST Regulations require that a LNAPL Conceptual Site Model (LCSM) be prepared. The LCSM should explain the observance of LNAPL or lack of LNAPL and its distribution. The LCSM must be conducted in accordance with Part E § 3.3 of the UST Regulations. Additional information and guidance can be found at the Interstate Technology & Regulatory Council web site, www.itrcweb.org.

6.0 Recommendations

6.1 Report Appendices required to be submitted:

- Figures with locations of proposed future investigations
- Access agreements
- Design information

6.2 Topics of discussion:

- Clearly report recommended next steps.

6.3 Guidance:

6.3.1 According to Part E § 4.2.2 of the UST Regulations, "...The hydrogeologic investigation report shall include recommendations for further action". If such recommendations are not included in the HIR, the report will not be accepted by the DNREC-TMB as being complete. The HIR must include a recommendation for at least one of the following outcomes:

6.3.1.1 No Further Action Recommendation

- A NFA recommendation may be made if concentrations of all appropriate contaminants of concern are below DERBCAP Risk-Based Screening levels. This is assuming that the soil and groundwater samples adequately characterize the site.
- In some cases, it may be necessary to perform quarterly monitoring for a period of one year before a NFA may be granted.

6.3.1.2 **Remedial Action Work Plan (RAWP)** - If the site is adequately characterized according to Part II Sections 3 and 5 of this guide, and concentrations exceed DERBCAP RBSLs, the RP can recommend evaluating and implementing an active remedial action. This recommendation for remediation in the HI may come in several forms. The following are acceptable forms for the recommendation:

- A full scale RAWP that includes design information and everything that is required in a RAWP as per Part E §5 of the UST Regulations and appropriate guidance.
- A recommendation to perform pilot and feasibility testing in order to design an appropriate remedial action.
- A request to pursue evaluating remedial technologies with appropriate timeframes as to when a full RAWP will be submitted.
- A hybrid of any of the above with an interim remedial action to jump start the remedial process.

6.3.1.3 **Tier 2 Evaluation** – If the site is adequately characterized according to Part II Sections 3 and 5, the concentrations exceed DERBCAP RBSLs, the RP can recommend evaluating the site under Tier 2 of DERBCAP. This recommendation shall include, at a minimum, the following:

- A description of what additional data is needed in order to change the default parameters used to calculate the RBSLs in DERBCAP to create site specific target levels
- Justification for use of default or site-specific values for Site Specific Target Level calculation
- A timeframe as to when the data will be collected.
- A detailed work plan for how site specific target levels will be calculated, or, a timeframe for when such a work plan will be submitted if data is required to be collected prior to creating such a work plan.

6.3.1.4 **Quarterly Monitoring and/or Further Investigation** - In some cases, the initial investigation will be unsuccessful in meeting the minimum requirements of a complete HI or, there is not enough data in order to make an appropriate recommendation. In such cases, the RP may recommend either performing additional quarterly monitoring (up to one year), or, may need to continue the HI to further delineate the contamination. Such recommendations must include, at a minimum, the following justifications:

- A detailed description as to why additional monitoring is necessary.
- An explanation of what the additional information collected during the monitoring period will provide.
- Details on the locations of additional sampling points including maps, figures and sampling methods.
- Reasons for sampling locations.
- Estimated timeframe for completion of additional investigation.
- Part E, § 4.2.4 of the UST Regulations requires that additional information must be submitted within 90 days of HIR approval.

6.3.1.5 **Other**

- Seeking evaluation under different programs such as Brownfields or Voluntary Clean Up.

List of Required Report Appendices

- **Checklist**

Figures

- General Site Figure
- Regional Figure
- Figure identifying POEs
- Figure with locations of sampled private/public wells
- Figure with preferential pathways identified.
- Figure with sample and boring locations
- Figure with inferred groundwater elevation and flow direction
- Figure with historic soil sample locations
- Figure with interpreted extent and concentrations of soil contamination
- Figure(s) with interpreted extent and inferred concentrations of groundwater contamination

Tables

- Table of all identified POEs
- Results of a neighborhood receptor search
- DNREC Water Resource well records
- Groundwater gauging table
- Tables of analytical results

Other

- All Supporting/Backup documentation
- Lab analytical reports
- Photos
- Field Orders and/or Secretary Orders from DNREC emergency personnel
- Copies of letters issued to property owners regarding well sampling
- Well logs/records
- Drilling records and logs for nearby wells
- Lab analytical reports
- Boring logs
- Cross sections
- Well logs

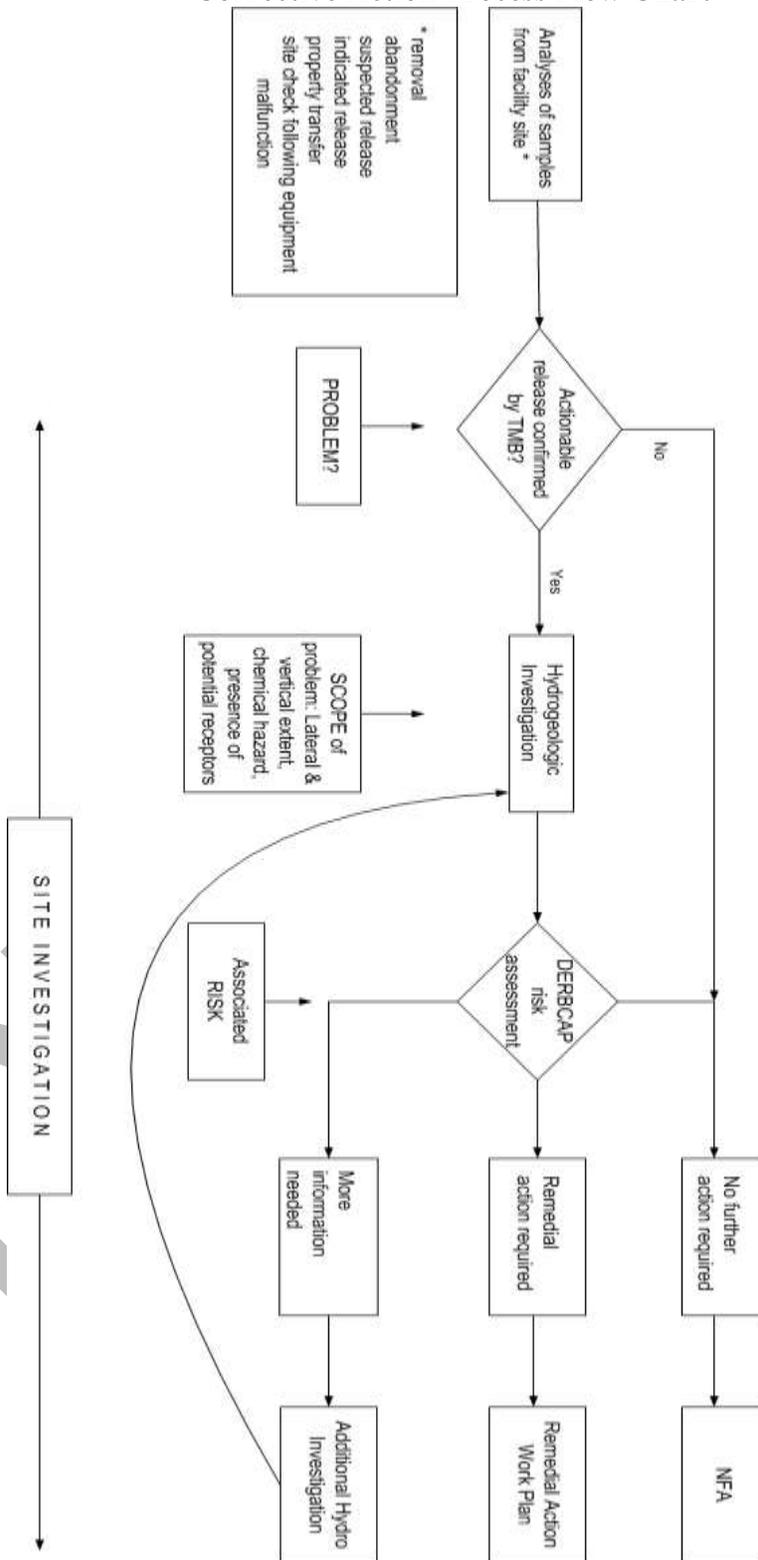
Appendices of the Hydrogeologic Investigation Guide

- Corrective Action Flow Chart
- QA/QC Guide
- Example boring/well log
- Soil classification guide
- Example Data Tables
- List of CSM weblinks
- Referenced ASTM Standards/Practices

DRAFT

STREAM-lined Hydrogeologic Investigations

Corrective Action Process Flow Chart

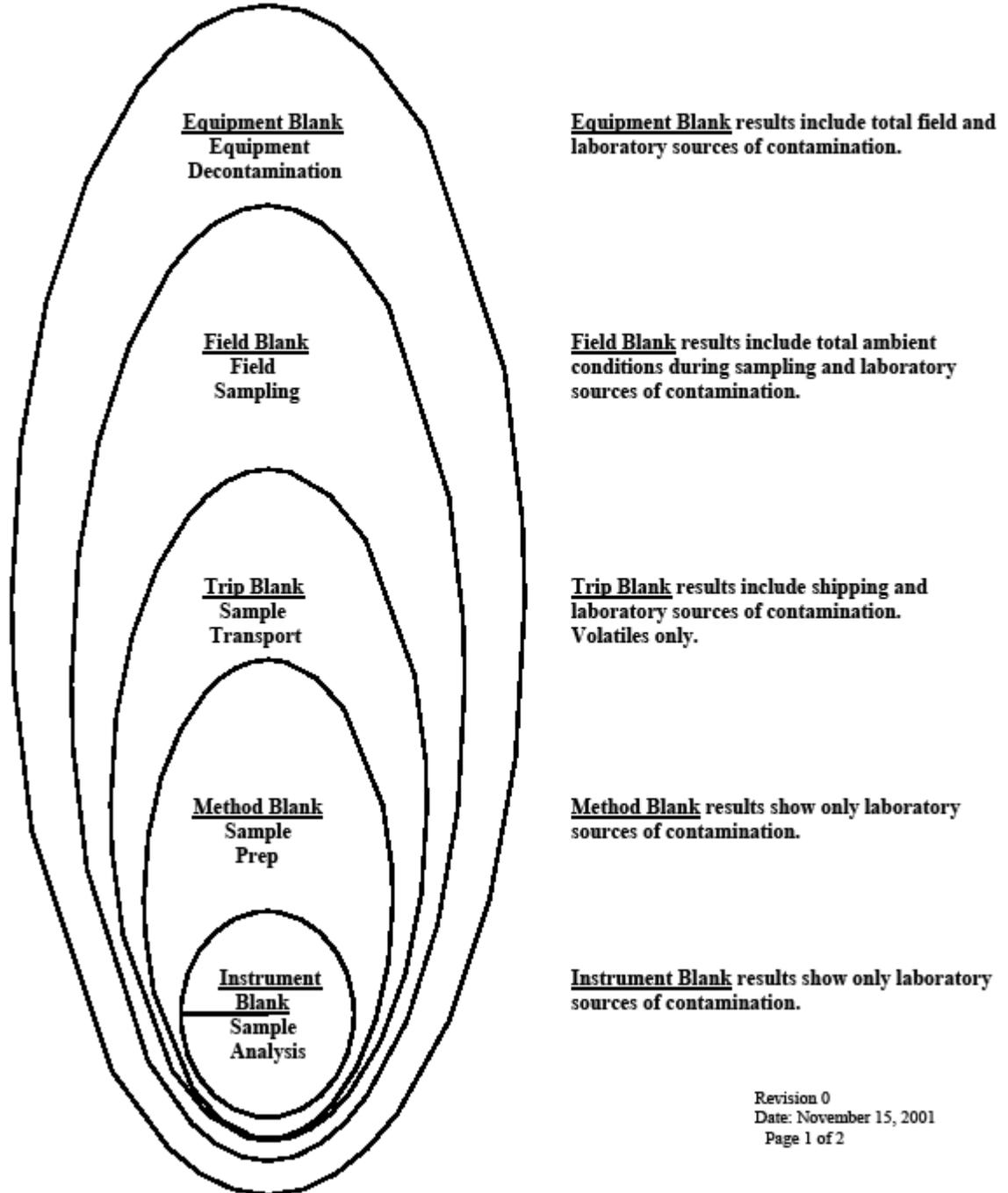


QA/QC Guide (page 1 of 2)

Region III Fact Sheet

Quality Control Tools: Blanks

The primary purpose of blanks is to trace sources of artificially introduced contamination. The diagram below shows how comparison of different blank sample results can be used to identify and isolate the source of contamination introduced in the field or the laboratory. See page 2 for a definition of each blank, its purpose and collection frequency.



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FIELD BLANKS

Rinsate/Equipment Blank - A sample of analyte-free water poured over or through decontaminated field sampling equipment prior to the collection of environmental samples.

Purpose: Assess the adequacy of the decontamination process. Assesses contamination from the total sampling, sample preparation and measurement process, when decontaminated sampling equipment is used to collect samples.

Frequency - 1 blank/day/matrix or 1 blank/20 samples/matrix, whichever is more frequent.

Field Blank - A sample of analyte free water poured into the container in the field, preserved and shipped to the laboratory with field samples.

Purpose: Assess contamination from field conditions during sampling.

Frequency - 1 blank/day/matrix or 1 blank/20 samples/matrix, whichever is more frequent.

Trip Blank - A clean sample of a matrix that is taken from the laboratory to the sampling site and transported back to the laboratory without having been exposed to sampling procedures. Typically, analyzed only for volatile compounds.

Purpose: Assess contamination introduced during shipping and field handling procedures.

Frequency - 1 blank/cooler containing volatiles.

LABORATORY BLANKS Method Blank - A blank prepared to represent the matrix as closely as possible. The method blank is prepared/extracted/digested and analyzed exactly like the field samples.

Purpose: Assess contamination introduced during sample preparation activities

Frequency - 1 blank/batch (samples prepared at one time.)

Instrument Blank - A blank analyzed with field samples.

Purpose: Assess the presence or absence of instrument contamination.

Frequency - defined by the analytical method or at the analyst's discretion (e.g., after high concentration samples.)

COMPARING BLANKS: The source of contamination introduced in the field or laboratory can be deduced by comparing blank results. An equipment blank could potentially be contaminated in the field, during transport to the lab or in the lab. The method blank, on the other hand, could only be contaminated in the lab. Using all blanks (appropriate for the project) described in this fact sheet will facilitate the identification of contamination sources.

Temperature Indicator (often called a Temperature Blank, but is not a blank) - A VOA vial or other small sample bottle filled with distilled water that is placed in each cooler. Upon arrival at the laboratory, the temperature of this vial is measured. The temperature indicator or blank is not analyzed and does not measure introduced contamination, therefore, is not a blank.

Purpose: To evaluate if samples were adequately cooled during sample shipment

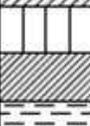
Frequency: 1 blank/cooler

Example Boring/Well Log

Well Log Header										
Sample Log					Borehole Log				Well Design Log	
Sample #	OVA/PID	Spl. results	Density	(blows/ft.)	Depth in ft.	Depth in feet	USCS Symbol	Graphic Log	Log	Geologic Description (soil type, color, grain, minor soil component, moisture, density, odor, etc.)

Soil Classification Guide (page 1 of 3)

UNIFIED SOIL CLASSIFICATION SYSTEM - ASTM D2488

MAJOR DIVISION		GROUP SYMBOL	LETTER SYMBOL	GROUP NAME	
COARSE GRAINED SOILS CONTAINS MORE THAN 50% FINES	GRAVEL AND GRAVELLY SOILS MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	GRAVEL WITH <u>*5% FINES</u>		GW	Well-graded GRAVEL
		GRAVEL WITH BETWEEN 5% AND 15% FINES		GP	Poorly graded GRAVEL
				GW-GM	Well-graded GRAVEL with silt
				GW-GC	Well-graded GRAVEL with clay
				GP-GM	Poorly graded GRAVEL with silt
			GP-GC	Poorly graded GRAVEL with clay	
	GRAVEL WITH <u>≥ 15% FINES</u>		GM	Silty GRAVEL	
			GC	Clayey GRAVEL	
	SAND AND SANDY SOILS MORE THAN 50% OF COARSE FRACTION PASSING ON NO. 4 SIEVE	SAND WITH <u>*5% FINES</u>		SW	Well-graded SAND
				SP	Poorly graded SAND
		SAND WITH BETWEEN 5% AND 15% FINES		SW-SM	Well-graded SAND with silt
				SW-SC	Well-graded SAND with clay
				SP-SM	Poorly graded SAND with silt
				SP-SC	Poorly graded SAND with clay
SAND WITH <u>≥ 15% FINES</u>			SM	Silty SAND	
			SC	Clayey SAND	
FINE GRAINED SOILS CONTAINS MORE THAN 50% FINES	SILT AND CLAY		ML	Inorganic SILT with low plasticity	
			CL	Lean inorganic CLAY with low plasticity	
			OL	Organic SILT with low plasticity	
	LIQUID LIMIT <u>GREATER THAN 50</u>		MH	Elastic inorganic SILT with moderate to high plasticity	
			CH	Fat inorganic CLAY with moderate to high plasticity	
			OH	Organic SILT or CLAY with moderate to high plasticity	
HIGHLY ORGANIC SOILS			PT	PEAT soils with high organic contents	

NOTES:

- 1) Sample descriptions are based on visual field and laboratory observations using classification methods of ASTM D2488. Where laboratory data are available, classifications are in accordance with ASTM D2487.
- 2) Solid lines between soil descriptions indicate change in interpreted geologic unit. Dashed lines indicate stratigraphic change within the unit.
- 3) Fines are material passing the U.S. Std. #200 Sieve.

Soil Classification Guide (page 2 of 3)



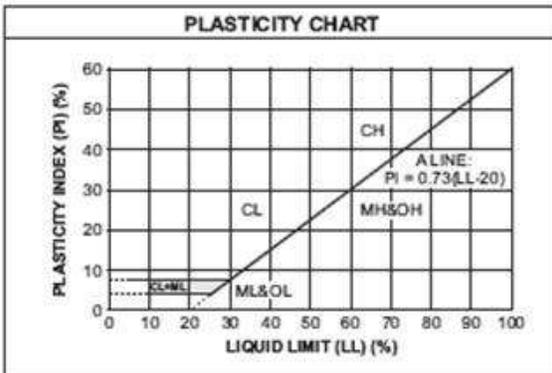
UNIFIED SOIL CLASSIFICATION SYSTEM

UNIFIED SOIL CLASSIFICATION AND SYMBOL CHART		
COARSE-GRAINED SOILS (more than 50% of material is larger than No. 200 sieve size.)		
Clean Gravels (Less than 5% fines)		
GRAVELS More than 50% of coarse fraction larger than No. 4 sieve size	GW	Well-graded gravels, gravel-sand mixtures, little or no fines
	GP	Poorly-graded gravels, gravel-sand mixtures, little or no fines
	Gravels with fines (More than 12% fines)	
	GM	Silty gravels, gravel-sand-silt mixtures
	GC	Clayey gravels, gravel-sand-clay mixtures
Clean Sands (Less than 5% fines)		
SANDS 50% or more of coarse fraction smaller than No. 4 sieve size	SW	Well-graded sands, gravelly sands, little or no fines
	SP	Poorly graded sands, gravelly sands, little or no fines
	Sands with fines (More than 12% fines)	
	SM	Silty sands, sand-silt mixtures
	SC	Clayey sands, sand-clay mixtures
FINE-GRAINED SOILS (50% or more of material is smaller than No. 200 sieve size.)		
SILTS AND CLAYS Liquid limit less than 50%	ML	Inorganic silts and very fine sands, rock flour, silty of clayey fine sands or clayey silts with slight plasticity
	CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
	OL	Organic silts and organic silty clays of low plasticity
SILTS AND CLAYS Liquid limit 50% or greater	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts
	CH	Inorganic clays of high plasticity, fat clays
	OH	Organic clays of medium to high plasticity, organic silts
HIGHLY ORGANIC SOILS	PT	Peat and other highly organic soils

LABORATORY CLASSIFICATION CRITERIA	
GW	$C_u = \frac{D_{60}}{D_{10}}$ greater than 4; $C_c = \frac{D_{30}}{D_{10} \times D_{60}}$ between 1 and 3
GP	Not meeting all gradation requirements for GW
GM	Atterberg limits below "A" line or P.I. less than 4
GC	Atterberg limits above "A" line with P.I. greater than 7
Above "A" line with P.I. between 4 and 7 are borderline cases requiring use of dual symbols	
SW	$C_u = \frac{D_{60}}{D_{10}}$ greater than 4; $C_c = \frac{D_{30}}{D_{10} \times D_{60}}$ between 1 and 3
SP	Not meeting all gradation requirements for GW
SM	Atterberg limits below "A" line or P.I. less than 4
SC	Atterberg limits above "A" line with P.I. greater than 7
Limits plotting in shaded zone with P.I. between 4 and 7 are borderline cases requiring use of dual symbols.	

Determine percentages of sand and gravel from grain-size curve. Depending on percentage of fines (fraction smaller than No. 200 sieve size), coarse-grained soils are classified as follows:

Less than 5 percent GW, GP, SW, SP
 More than 12 percent GM, GC, SM, SC
 5 to 12 percent Borderline cases requiring dual symbols



Soil Classification Guide (page 3 of 3)

Soil Texture

Step 1 (Get and moisten sample)

Use the triangle to determine the soil texture of your horizon.

Place some soil from a horizon (about the size of a small egg) in your hand, and, using the spray mist bottle, moisten the soil. Let the water soak in and then work the soil between your fingers until it is the same moisture throughout. Once the soil is moist, try to form a ball. If the soil forms a ball, go on to Step 2. If the soil does not form a ball, go to Step 5.

Step 2 (Test for Clay)

A. If the soil:

- Is really sticky
- Hard to squeeze
- Stains your hands
- Has a shine when rubbed
- Forms a long ribbon (5+ cm) without breaking.

Call it a **clay** and go to Step 3.

Otherwise, go to B.

B. If the soil:

- Is somewhat sticky
- Is somewhat hard to squeeze
- Forms a medium ribbon (between 2-5 cm)

Call it a **clay loam** and go to Step 3.

Otherwise, go to C.

C. If the soil is:

- Soft
- Smooth
- Easy to squeeze.
- At most slightly sticky,
- Forms a short ribbon (less than 2 cm)

Call it a **loam** and go to Step 3.

Otherwise, go to D.

D. If the soil forms a ball but **no** ribbon, go to Step 4.



Step 3 (Refine initial soil texture classification from Step 2 for relative amounts of sand and silt)

Wet a small pinch of the soil in your palm and rub it with a forefinger.

If the soil:

- Feels very gritty, go to E
- Feels very smooth, with no gritty feeling, go to F
- Feels only a little gritty, go to G

E. Add the word **sandy** to the initial classification.

Soil texture is (check one): sandy clay,
 sandy clay loam, sandy loam
 Soil Texture is complete.



F. Add the word **silt** or **silty** to the initial classification

Soil texture is (check one): silty clay,
 silty clay loam, silt loam
 Soil Texture is complete.



G. Leave the original classification of (check one):

clay, clay loam, loam
 Soil Texture is complete.

Step 4 (Test for loamy sand or silt)

If the soil:

- Forms a ball
- Forms **no** ribbon
- And is
 - H. Very gritty**
 Soil texture is: loamy sand
 Soil Texture is complete.

Or

- I. Very soft and smooth with **no** gritty feeling.**
 Soil texture is: silt
 Soil Texture is complete.



Step 5 (Test for sand)

If the soil:

- Forms no ball and falls apart in your hand,
 Soil texture is: sand
 Soil Texture is complete.



Example Data Tables

Well Gauging Data
June 25, 2008

Local ID	Depth to GW	Depth to LNAPL		LNAPL Thickness	GW Elevation
MW-1	8.10	ND		N/A	9.54
MW-2	12.43	12.06		0.37	9.47
MW-3	9.92	ND		N/A	9.51

All distances in feet.

Groundwater Sample Analytical Results

Permit Number	Local ID	Screened Interval
123456	MW-1	10-15ft
123456	MW-2	11-16ft
654321	MW-3	10-15ft
654321	MW-4	9-14ft

Local ID Sample Date	RBSL <50 ft	RBSL 51-100 ft	RBSL 101-300 ft	MW-1 6/26/2008	MW-2 6/26/2008	MW-3 6/26/2008	MW-4 6/26/2008
Benzene	29	51	160				
Toluene	7300	>520,000	>520,000				
Ethylbenzene	3700	>630,000	>630,000				
Total Xylenes	73000	>200,000	>200,000				
MTBE	180	240	560				
TBA	N/A	N/A	N/A				
Other Analytes as Applicable							

All concentrations in µg/L

Soil Sample Analytical Results

Local ID Sample Date Sample Depth	RBSL <50 ft Soil GW	RBSL <50 ft Soil DC	SB-1 6/26/2008 10-11ft	SB-2 6/26/2008 11-12ft	SB-3 6/26/2008 6-7ft	SB-4 6/26/2008 7-8ft
Benzene	0.23	19				
Toluene	210	3800				
Ethylbenzene	350	2300				
Total Xylenes	>500	43,900				
MTBE	0.13	200				
TBA	N/A	N/A				
Other Analytes as Applicable						

All concentrations in mg/Kg

Groundwater Analytical Results

Local ID	Permit #	RBSLs			
MW-1	123456	<50'			
Analyte (RBSL)	Benzene (29)	Toluene (7,300)	Ethylbenzene (3,700)	Total Xylenes (73,000)	MTBE (180)
DATE					

List of CSM Websites

<http://www.ce.utexas.edu/prof/maidment/risk/lhwlect/scmv2/index.htm>

http://www.epa.gov/region8/r8risk/hh_scm.html

http://www.co.sanmateo.ca.us/vgn/images/portal/cit_609/21/40/651311576Site%20Conceptual%20Model.pdf

<http://www.newmoa.org/cleanup/cwm/csm/HuntWhatIsTheCSM.pdf>

http://www.emd.saccounty.net/Documents/presentations/Site%20Conceptual%20Model_files/frame.htm

<http://www.triadcentral.org/mgmt/splan/sitemodel/index.cfm>

<http://www.dnr.mo.gov/env/hwp/tanks/siteconceptualmodelsrbca.pdf>

www.co.san-diego.ca.us/deh/water/docs/sam_kkezer_scm.ppt

http://www.epa.gov/athens/learn2model/part-two/onsite/i210_onsite.htm

Referenced ASTM Standards

[D2488](#) Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)

[D5088](#) Practice for Decontamination of Field Equipment Used at Non-Radioactive Waste Sites

[D5521](#) Guide for Development of Ground-Water Monitoring Wells in Granular Aquifers

[D6452](#) Standard Guide for Purging Methods for Wells Used for Ground-Water Quality Investigations

[D6634](#) Guide for the Selection of Purging and Sampling Devices for Ground-Water Monitoring Wells

[D6771](#) Standard Practice for Low-Flow Purging and Sampling for Wells and Devices Used for Ground-Water Quality Investigations

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