MARYLAND ENVIRONMENTAL ASSESSMENT TECHNOLOGY
for
LEAKING UNDERGROUND STORAGE TANKS

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INTRODUCTION

The Maryland Department of the Environment (MDE), Oil Control Program (OCP), is mandated to protect the public's health and safety, and to ensure environmental protection at sites that have been impacted by a release of petroleum product. This mandate covers all petroleum sites regardless of the source of the release. OCP also regulates the release of hazardous substances from regulated underground storage tank (UST) systems.

A substantial threat from released product is the impact to groundwater, surface water, and potable water supplies. The Comprehensive Groundwater Protection Strategy adopted by the State of Maryland in July 1986 states:

> "The State of Maryland is committed to protecting the physical, chemical, and biological integrity of the groundwater resources in order to protect human health and the environment, to ensure that in the future an adequate supply of the resource is available, and in all situations, to manage that resource for the greatest beneficial use of the citizens of the State."

Note: Groundwater is a State of Maryland resource solely controlled by the State. Its use is permitted by the State whether on State, federal, or private land.

With this strategy in mind, OCP has adopted the procedures and goals as outlined in this document. This document is designed to assist Maryland regulators, responsible parties, and environmental response companies in the investigation of suspected and known releases and the remediation of sites with confirmed releases. The document is to be used as initial guidance. All sites have unique characteristics and, as required by Maryland law, must be addressed under the direction of OCP.

The information contained in this document is intended solely for guidance. Notwithstanding the information conveyed, persons must also adhere to all applicable State and federal environmental laws and regulations. Persons using this guidance should be aware that there are acceptable alternatives to this guidance for achieving compliance with regulatory requirements. Reporting requirements, however, are mandatory.

Furthermore, a responsible party should not mistake the willingness of MDE to provide guidance and oversight of a remediation action as an approval of the discharge that has occurred. The release of petroleum products is a violation of Maryland law and regulations. The responsible party may face enforcement sanctions from MDE or other regulatory agencies. The responsible party may also face third-party litigation associated with the release.

LIMITATIONS

Hazardous Substance

Hazardous substance remediation is not discussed in this document.

Regulations

This guidance document is not intended, nor should it be interpreted, to be a regulation as defined in Section 10-101, State Government Article. This guidance document sets forth criteria and guidelines to assist MDE, responsible parties, and their consultants in determining the nature of a possible release of petroleum product. If at anytime MDE determines that a site represents a significant threat that is unresolved or unaddressed by the responsible party, MDE may assume control of the site and initiate steps to abate the threat. All costs incurred by MDE while undertaking such actions are recoverable from the responsible party.

Third Party Financial Impacts

Maryland law does not allow OCP to take into consideration the financial impact to affected parties, such as the reduction of property values. The recovery of third-party cost and making an impacted party whole is between the responsible party and the third party. These issues are best resolved through direct negotiation or through the Maryland court system.

Purchase of Contaminated Property

Although Maryland law gives some protection to new owners of petroleum-contaminated property, the new owner accepts certain liabilities associated with previously contaminated sites. A thorough Phase I and II assessment should be performed in order for a potential buyer to be well informed of the degree of contamination and the impact it may have on future construction and property use.

MDE SITE-SPECIFIC APPROACH

MDE has adopted a strategy that relies on site-specific decision making. We have found that this strategy best fits the needs of MDE and Maryland citizens. We believe this approach is protective of public health, safety, and the environment. The support for this strategy is discussed in this section.

Maryland Regulations

Regulations requiring the reporting of petroleum releases to MDE are found in Code of Maryland Regulations (COMAR) 26.10.01.03 and 26.10.08. The authors of these regulations required a timely and detailed report to place MDE on notice and to activate MDE oversight of the release site. COMAR 26.10.09 further requires that MDE direct and approve all initial abatement measures, site characterization, and corrective action plans.

Geologic Complexity

Maryland geology is diverse. The eastern part of the state has numerous terraces due to sea level and orographic upland changes, causing the subsurface to vary from clay to gravel over short distances. The surface system is underlain by complex regional aquifers and aquitards with surface outcrops. The Piedmont has complex bedrock structures including domes, nappes, and fault systems. Much of the surface material in the Piedmont is underlain by saprolite and weathered and fractured bedrock, which is more complex than unconsolidated materials. In the Blue Ridge Valley and Ridge and Allegheny Plateau Regions in the western portion of the state, much of the groundwater is contained in fractured bedrock, including karst limestone.

Contaminant transport characteristics are a function of hydraulic conductivity, gradient, effective porosity, soil organic matter, and soil bulk density. The range of field values for these properties is quite large in Maryland. Hydraulic conductivity ranges from 10-9 cm/sec for marine clays to 100 cm/sec in limestone and karst in Western Maryland. Gradient ranges from 0.0001 on the Eastern Shore to 0.2 in Western Maryland, and effective porosity ranges 0.02 to 0.4 depending on material type. Soil organic matter in the state ranges from 0.0001 percent in bedrock to 40 percent in wetland muck, and soil bulk density ranges from 1.2 gm/cm to 2.3 gm/cm (Fetter, 1988, 1993; Dragun, 1998). Heterogeneous transport properties over short distances are common in Maryland, but difficult to incorporate into fate and transport models and are better handled with a detailed site investigation.

Some states are able to predict cleanup levels with simple porous media groundwater flow and contaminant transport models with first order adsorption and decay terms using the ASTM and other RBCA approaches. In Maryland much of the state is not simple porous media. Models and aquifer test methods for non-porous media are currently in the research stage and are not applicable to sites at this point in time.

Complex Land Use and Demographics

Cleanup requirements need to be appropriate for current and future land use and area demographics. Due to the complex land use and demographics in some portions of the state, site-specific cleanup requirements are necessary rather than applying uniform standards across all sites. For example, Baltimore has been a major international port since 1706. Portions of the city have been used for heavy industry, such as steel making, petroleum refining, and chemical manufacturing, for many decades. In some cases protecting the Baltimore Harbor may be a more important concern than local groundwater, which is not predicted for future residential drinking purposes in an area of heavy industry and ample municipal water resources.

For these reasons, OCP uses empirical measurements to show that the contaminants will never reach a Point of Exposure (POE). Time series groundwater monitoring data are used to demonstrate that the affected groundwater plume is in a stable or shrinking condition; in which case, POEs outside the current plume area will not be impacted. Such time series data regarding plume stability are considered more reliable than fate and transport modeling. The quality of the field investigation (site assessment) is essential to producing dependable time series data. Unrepresentative data will result in an unreliable demonstration of the state of affected water resources. The requirements for developing high-quality time series groundwater monitoring data are detailed in this document.

Furthermore, OCP is actively involved in site management and field activities during all aspects of site investigation and data collection to ensure the quality of assessments and remediation activities. It is through this active field involvement that OCP has achieved a high level of site compliance, reliable information, and the ability to resolve cases in a cost effective manner.

REMEDIAL GOALS

Remedial goals must be understood in order to formulate a proper corrective action plan. The OCP recognizes that each site needs to be evaluated individually, yet assessed fairly and consistently. The intent of the program since its inception in 1974 has been to evaluate each site individually to determine the risk posed by the site. Not every site will have the same risk or the same physical characteristics. OCP recognizes that every site can reach the appropriate remediation goal if suitable and well-documented remedial procedures are used. Achievement of these goals will result in case closure. OCP also recognizes that monetary and technological barriers may limit the ability of the responsible party to reach zero contamination. This section describes the goals of OCP for the two physical phases of hydrocarbon releases that impact groundwater and soil.

Hazardous substance remediation is not discussed in this document. The remediation of a hazardous substance must be designed for the specific substance and its byproducts involved in the release.

Liquid Phase Hydrocarbons (LPH)

Each site demonstrating the presence of liquid phase hydrocarbons (LPH) must remove the LPH to the maximum extent possible. The maximum extent is generally indicated when measurable product can no longer be detected over an extended period of time in site monitoring points used to observe the subsurface and/or groundwater beneath the site. In most cases, if the site goal is the removal of LPH, a remaining sheen of product may be acceptable. The removal of LPH is <u>not</u> negotiable with MDE.

Dissolved-Phase Contamination

The decision to remediate dissolved-phase contamination is based on the risk the contamination may pose to public health and the environment. This approach is considered Risk Based Corrective Action (RBCA) and is discussed in detail later in this document.

Once it is determined that dissolved-phase hydrocarbon remediation is a site goal, either the use of the document "State of Maryland, Department of Environment, Cleanup Standards for Soil and Groundwater," as developed pursuant to Maryland Environment Article 7-508, or the achievement of the three OCP specific objectives listed below, must be satisfied. They are:

1. Remove all risks posed by the release (see Seven Risk Factors);
2. Prevent contamination migration; and
3. Demonstrate that an asymptotic trend in dissolved-phase contamination has been established.

The asymptotic trend in item 3 must be accomplished through the use and documentation of the best technology available, as approved by OCP in a corrective action plan, and assumes that a sufficient site assessment has been completed. The asymptotic trend must also be low enough to be meaningful and take into account seasonal groundwater fluctuation. When the "three objective approach" is chosen, OCP endeavors to establish effective corrective action goals reflecting achievable and realistic groundwater cleanup levels. We recognize that not all sites require the same cleanup level and should be considered on an individual basis depending on the risk scenario type.

Soil

The impact to soil from a release of petroleum product presents its own series of issues. The goal established by OCP is to ensure that the product or contaminants in the soil cannot migrate to water resources of the State. Further clean-up goals are established for soil if it is determined that the soil may release vapors or otherwise cause impacts to human health or the environment. Pathways of exposure include dermal contact, ingestion, and inhalation. It may not be mandatory to remove soil simply based on an across-the-board action level. The decision to remove and treat soil is site specific. However, OCP recognizes that soil removal is generally the most reliable procedure to prevent future contamination migration and reduce risk.

MDE has determined that soil contamination at a release site with Total Petroleum Hydrocarbons (TPH) levels below 230 parts per million (ppm), as determine by EPA method 8015B DRO/GRO, does not pose a risk or a threat of adverse effects <u>if left in place</u>. However, soil that is treated at an "oil-contaminated soil facility" must be treated to the regulatory level of 10 ppm TPH or treated as established by the facility's permit. Soil treated on site must be treated to the point that the "three objective approach" is accomplished.

Soil showing a contaminant level over 10 ppm, <u>removed</u> from a site or otherwise handled, is considered "oil-contaminated." This level is established by default due to the fact that this level is required for "post-treatment soil" from a permitted oil treatment facility as mentioned above. This regulation can be found in COMAR 26.10.13.11. If oil-contaminated soil is to be treated on site, the activity must be conducted under an OCP approved corrective action plan for the site.

RISK DETERMINATION

Risk is defined as the possibility of suffering harm or loss. The OCP requires the potential risk be measured at every site that has a reported release. Taking the measure of risk into account to establish cleanup goals and to determine if remediation is necessary is known as Risk Based Corrective Action (RBCA). Many states have adopted a tiered approach to RBCA such as the ASTM standard PS104-98. OCP continues to assess risk by a "Seven Risk Factor" process. This process examines certain factors that are described in detail within this document. OCP has chosen this process because of simplicity, ability to comprehend, ease of review, and the level of protection it allows for human health and the environment. If a site is positive for one or more of the factors, a site assessment and a corrective action plan will be required. A key element of a successful corrective action plan is a thorough site assessment.

The "Seven Risk Factor" approach works as simple as this: If a site does not show any of the factors, a corrective action plan is not warranted. However, OCP may choose to monitor the site that does not require corrective action for a period of time to verify that decision. If a site is positive for one or more of the factors, a corrective action plan will be required.

Seven Risk Factors

The Seven Risk Factors considered for each site by OCP are:

(1) Liquid Phase Hydrocarbons. LPH refers to a regulated substance that is present as a non-aqueous phase liquid. When LPH is found on site, the liquid product must be removed to the maximum extent possible. OCP has determined this to be a sheen.

(2) Current and Future Use of Impacted Groundwater. If the groundwater impacted by the release is used for direct consumption within a half mile of the site or the site is located within an approved wellhead protection zone, a site assessment and corrective action plan must be designed. Other uses of groundwater that would warrant remediation include industrial, agricultural, and surface water augmentation. If known, future use of the groundwater must be taken into consideration. If site-specific future use is unsure, regional trends must be considered. Generally, if future use is not clear a more conservative approach to cleanup is applied.

(3) Migration of Contamination. The ability of contamination to migrate off site or to migrate to a receptor is a critical measure. If it can be demonstrated that the contamination is stationary and site conditions restrict the potential for migration, the need for cleanup may be reduced.

(4) Human Exposure. Any exposure to the public warrants site corrective action. There are several exposure pathways that must be considered. These pathways include but are not limited to inhalation, ingestion, and dermal contact.

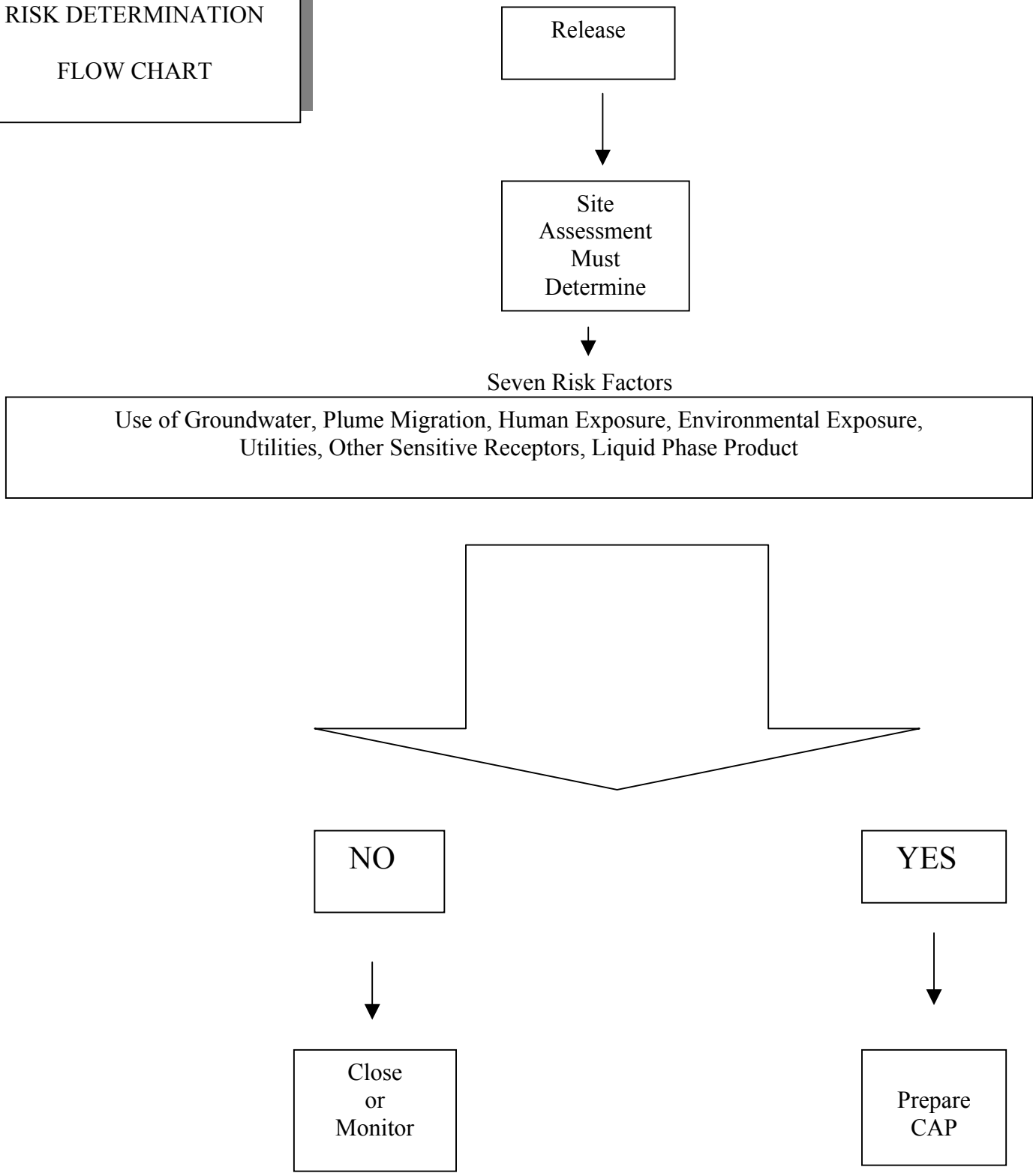
(5) Environmental Ecological Exposure. The need to protect the natural resources of the State is mandated by Maryland law. If there is exposure to animal or plant life from the petroleum release or the degradation of a natural resource, corrective action is warranted.

(6) Impact to Utilities and Other Buried Services. The responsible party must correct adverse affects to utilities. Utility materials have been known to degrade from contact with petroleum products. Utilities may also act as conduits that lead to the migration of contamination. Migration along utilities may cause vapor impacts or other issues at nearby structures.

(7) Other Sensitive Receptors. Sensitive receptors such as surface water, historic structures, and subways are an indication that a site may warrant further corrective action.

RISK DETERMINATION

FLOW CHART



Examples of Risk Scenarios and Possible Remediation

Risk Factor	Remediation
Liquid Phase Hydrocarbons	Bail/Wick Pump and Treat EFR
Impact to Groundwater	Monitor Pump and Treat Other automatic type system
Migration of Contamination	Pump and Treat Automatic system
Human Exposure	Filter well water SVE foundation Automatic system
Environmental Exposure	Remove impacted soil
Impact to Utilities	Vent utility system
Other Sensitive Receptors	Contain spill Install SVE

EFR: Enhanced Fluid Recovery
SVE: Soil Vapor Extraction

FINAL DECISION MAKING

Based on our legislative mandate, the final decision to perform remedial activity is made by MDE. This is the realization that MDE is in the best position to address the concerns of all parties interested in any given site. Besides the State and owners of the property, these parties include impacted neighbors and concerned citizens.

In order for MDE to make site decisions, each suspected release and/or release site is assessed by the assigned MDE personnel. MDE personnel are environmental compliance specialists, geologists, engineers, chemists, and management reviewers. The final decision to require remediation is based on a consensus of technical staff assigned to the case. In all cases, this decision is reviewed for approval by the regional section head. If the OCP finds any factors of concern, the responsible party is required to perform a site assessment and submit a corrective action plan to OCP. Each corrective action plan must comply with COMAR 26.10.09, must be tailored to the individual site, and must take into consideration the program's "Seven Risk Factors" and the site's geology and hydrology.

COMAR 26.10.09.08 requires public participation on sites that require a corrective action plan. Notice must be given to the public directly affected by the release and the corrective action plan. In certain cases, MDE will require the responsible party to hold a public meeting to consider comments on the plan.

SITE ASSESSMENT

The site assessment is used to characterize the location and extent of the release and is, therefore, a very critical step in the process to maximize the use of resources. The site assessment will include all information later used to determine appropriate remedial action and, as an interactive process, continues until closure.

Essential Determinations

The type of petroleum product involved in the release must be determined. The level of dissolved constituents and the migration possibilities differ between products. The level of contamination is required to compare it to any known State or federal standards. The initial level of contamination is also used as one of several benchmarks to gauge the success of future remedial activities on the site. Since petroleum products consist of 200 to 400 chemicals, the initial chemical testing should be comprehensive and may change over the life of the project.

OCP recognizes two general types of site assessments: (1) those performed by OCP and (2) those performed by a responsible party under OCP supervision. The table below depicts some general investigation scenarios and further requirements.

Investigation Scenario by OCP	**Requirements**
Tank excavation clean	No further action. Submit report.
Tank excavation over 230 ppm TPH	Excavate soil to achieve < 230 ppm TPH. Submit report.
Tank excavation over 230 ppm TPH and unable to excavate.	RP complete work plan and site assessment. Submit report.
Investigation Scenario by RP	**Requirements**
Subsurface investigation satisfies "Seven Risk Factors"	No further action. Submit report.
Subsurface investigation fails "Seven Risk Factors"	Expand assessment, e.g., install additional monitoring wells, define groundwater flow and dissolved levels. Submit report.
Monitoring wells indicate plume, which fails "Seven Risk Factors"	Delineate plume. Submit CAP.

OCP Performed Investigation

The field staff of OCP has the authority to determine whether further investigation is warranted. This determination is usually made on sites where a tank removal operation is occurring or during the initial response to a reported release. At tank removals, OCP field staff examine the tank vessel and all associated product lines for perforations and signs of release. Soil is screened with portable field instruments and inspected for the presence of a release. Any groundwater encountered during the removal is also inspected for signs of a release. The OCP may, and often requires, the collection of confirmation samples, which are tested by an approved laboratory.

The OCP requires sampling of all water supply wells located at release sites. Based on construction and proximity to the release site, OCP will determine if neighboring wells are required to be sampled.

If OCP staff determine further investigation is warranted, the site must undergo a site assessment by the responsible party. OCP will assist the responsible party in determining the nature and extent of the assessment and must approve the activity. However, the sole responsibility for the activity lies with the responsible party.

Private residential sites with a suspected heating oil release may perform a tank closure assessment in accordance with the guidance set forth in OCP's "Residential Underground Heating Oil Tank Failure Assessment" document.

Responsible Party Site Assessment

The responsible party site assessment will be reviewed by OCP. It must be accurate, thorough, and should, in most cases, be a stand-alone document. OCP will dictate to the responsible party the time frame by which the assessment must be performed. Normally OCP requires the assessment be performed within a 60-day window. The site assessment process is a cumulative effort. Each component of the site assessment builds upon the previous work. The site assessment may also roll into the remediation phase, particularly if the site is complex. It is critical that the site assessment address the "Seven Risk Factors" and further determine the extent of contamination to zero points or area background levels.

The site assessment has three phases: (1) the work plan; (2) field activity; and (3) the site assessment report.

(1) Work Plan

All work must be approved by OCP prior to its performance. Approvals are normally in writing. Written approvals are important in preventing miscommunication and unnecessary and unapproved activities. However, during emergency situations approvals are granted verbally by the OCP.
The work plan must include:

- A complete, concise description of all proposed methods of investigation;
- A to-scale site map with locations of proposed sampling points and all historical sampling points with identifiers;
- Name and contacts of parties performing the work; and
- Proposed work schedules.

(2) Field Activity and Data Quality

When the work plan is approved, the responsible party or their representative must notify OCP at least five (5) working days prior to the work performance. In selected cases, the OCP may require to be present on site for field activities. The RP must accommodate OCP's schedule in these cases. Work accomplished without approval by the OCP and/or accomplished without the presence of OCP personnel, when required, may result in nullification of the work. The work may then have to be redone.

It is important that high quality and supported data are collected for time series data used during site investigation. Time series data falls into three categories: water; air; and soil. Laboratories with established QA/QC procedures must be used. Trip, field, and laboratory test blanks must be provided at appropriate intervals to determine that cross-contamination is not occurring during sampling, handling, and laboratory analysis.

Monitoring well water data are the most common type of time series data. Gauging data for free product and potentiometric surface determination should be obtained by using a clean, clear bailer for product levels below 0.1 feet and a proper factory-calibrated interface probe capable of measuring to 0.01 feet for larger thickness. Potentiometric surface measurements should be conducted with instruments capable of measuring to 0.01 feet. When product is present, the data must be corrected for differences in density.

(3) Site Assessment Report

The site assessment report is developed when the site investigation has been completed. The report must include: a to-scale site map with the final well, direct-push, and/or sampling locations; and a map or layout of site buildings, utilities and other pertinent features. All well logs, soil-boring logs, sampling analyses, and aquifer tests must be included in the report. The assessment report must also include the following sections:

- An introduction
- Synopsis of the investigation methods
- Local and regional geology and hydrology
- Results of work performed
- Conclusions
- Recommendations

THE SITE ASSESSMENT REPORT

Introduction

The introduction is designed to inform the reader of the pertinent details of the site such as location, history, MDE's case number, type of product released, estimated amount of the release, the circumstances of release discovery, and initial abatement actions. A comprehensive report will shorten review time.

Investigation Methods

This section should include a concise summary of each method used for investigation. For example, a sampling procedure may be described as follows: "On January 10, 2001 each monitoring well was sampled. Three well volumes were removed from each well prior to using a clean bailer to extract a sample. The sample was preserved with hydrochloric acid and packed in ice. It was delivered to the laboratory within 24 hours. The water purged from the wells was treated with activated carbon before release."

A description of the investigation method should be detailed. Methods recognized by MDE include: the installation of observation wells; direct-push; soil boring; soil sampling; soil gas survey; etc. Depending on site conditions, non-laboratory screening methods such as Immunoassay, spectrometric tests, and Geoprobe-MIP probe or Cone penetrometer investigations may also be acceptable and should be approved beforehand by MDE. For newly installed monitoring wells, a two-week waiting period before sampling is desirable. Sampling procedures can be mentioned here but should be detailed in the "Description and Results of Work" section. Information concerning well permits and well development should be described in this section.

Local/Regional Geology and Hydrology This section should contain:

1. Topographic map of the release site and its surroundings.
2. Description of site and regional geology including:
   - A. Lithology descriptions of the unconsolidated and consolidated sediments. The lithology should include composition of unconsolidated deposits or rocks. Keep in mind that the section above and below the water table (including seasonal fluctuation) is the most important in remediating the site.
   - B. Mineralogy, grain size, grain shape, packing.
   - C. Stratigraphy, formation, composition sequence, and correlation of stratified rocks and unconsolidated surficial materials (clay, silt, sand, and gravel) series and formation names of the sediments, dip.
   - D. Other Geologic Structures, any identifying characteristics, any characteristics that may affect the site such as fractures or high iron content, any known faults, and thickness of the formations. Structural orientation of features produced by movement, deposition, folds or fractures that may provide preferential pathways for contaminants to move and require special attention during remediation. This is important where surficial deposits are thin or very permeable.
3. Description of the site's proximity to surface water bodies.

4. Hydrology should include regional groundwater flow, site groundwater flow, recharge and discharge areas, relationship of movement of subsurface water to geology, and direction and rate of groundwater flow.

This section is also the appropriate place to include a map depicting wells within a half-mile radius of the site.

Results of the Work Performed

Describe and include a site map depicting where the sampling points were located. For soil borings and observation wells, a description (boring log) must be included. This section of the report should include the results of all well gauging data, chemical sampling, and laboratory methods and chain-of-custody forms. If a large number of samples were collected, they can be reported in a tabular form. When several rounds of well gauging and sampling have occurred, they must be reported in tabular format (see appendix H). Backup documentation in the form of actual laboratory reports must be included the first time the data set is reported. The results of sampling must be placed on a site map showing sampling location and levels. A plume isocontour map with data and identifiers posted, as well as a groundwater flow map, should be included.

Conclusions:

It is imperative that the professional environmental company performing the investigation interpret the results of the data collected. The conclusion should evaluate the site for the "Seven Risk Factors" mentioned under the Risk Determination chapter. This section should include a discussion on whether domestic or municipal supply wells are located within half a mile of the site or within an established wellhead protection area and if these wells have been impacted. A discussion on the closest surface water body and its risk of impact is also appropriate for this section.

Recommendations:

Based on the data collected and the investigation performed, the company that performed the study should make the recommendations they believe warranted. These recommendations could include additional study, the need for cleanup, a period of monitoring, or a request to close the case.

Other Report Contents:

All maps required under this chapter must contain a scale bar. When possible, the maps should be drawn to the same scale, with an accurate north indicator. The maps should be clearly identified with the site name; date drafted; consultant/contractor's name, address, and telephone number; and a scale and legend defining all symbols on the map.

Remember: All data collected at the site must be used for the report. If all data are not considered, a justification for the elimination must be given. If the report has insufficiencies due to a lack of inclusion of existing knowledge and/or data, the report will be considered not responsive and returned prior to full review. The site investigation report will be the basis to determine if further site action is warranted. MDE will review the site using the "Seven Risk Factors" as outlined and other site-specific concerns. As stated, MDE has the authority and will make the final decision on additional site requirements.

CORRECTIVE ACTION PLAN

A corrective action plan (CAP) is required once the determination has been made to remediate or monitor a release site. The degree of cleanup and plan detail will depend on complexity of the site and the risk associated by the site. The CAP must comply with COMAR 26.10.09. The author of the CAP should aim for a brief concise presentation of the requested information. Maps, tables, and graphs should be used whenever possible to present large quantities of information. A clear and simple presentation of the work plan will allow for rapid review and approval. The plan should be set out with the following sections:

Introduction:

The introduction is designed to inform the reader of the pertinent details of the site and recommended remediation. As in the assessment report, the introduction should describe the site location, site history, and state MDE's case number. Items such as the type of product and the estimated amount of the release, release discovery, and initial abatement actions should be included.

Synopsis of the previous work performed:

This section should briefly describe the assessment activities and other remediation activities, which may have taken place on the site to this point in time. Inclusion and/or reference to previous site assessment document(s) should be made.

Basic Site Maps:

This section must contain to-scale (with a scale bar) site maps with the final well, direct-push, and/or sampling locations; and a map or layout of site buildings, utilities, remediation system, and other pertinent features.

Planned Remediation Activities:

This section should be very detailed in describing corrective action for the site. If pilot testing is still needed, it should be described in this section.

System Design:

When mechanical systems are to be used, the design and site layout of the system must be presented. A full schematic of the system, as planned to be installed, must be included. This section does not need to be in great detail. However, specifics should be available if requested from OCP.

Sampling and Maintenance: This section commits to sampling schedules and estimates maintenance schedules.

Permits:

All local and State permits to construct and run the remediation system are to be discussed here. Discharge sampling requirements will be specified in the discharge permits. However, OCP has the authority to require additional sampling on a site-specific basis. A receipt of a discharge permit does not convey the authority to start up and run a system. Specific OCP final approval must be given for operation of the system.

CAP Review. The CAP will be reviewed by OCP for the following:

1. Sufficient information from the site assessment and pilot testing is presented to determine the appropriateness of the remediation technology proposed.
2. Remediation technology selected has the potential to achieve remediation goals and reduce risk. Specifically, does the remediation technology selected have a history of successful site cleanups in Maryland or verifiable case histories elsewhere? Will the site geology and groundwater chemistry (particularly iron) affect the operation of the technology selected?
3. Is their compliance with OCP enforcement requirements?
4. Community safety: Does the remediation design provide adequate fail-safe and cut off devices to prevent additional product releases, migration, or adverse impacts?
5. Are the "Seven Risk Factors" addressed?
6. Any site-specific concerns?

Approval of work plans. Site assessments and corrective action plans by OCP do not imply adequacy to fully characterize and/or remediate a site. It is incumbent on the RP to assure adequacy of the work performed during the project. The OCP may decide additional work must be performed to assess or remediate a site.

PERIODIC REPORTING ON
REMEDIATION OPERATION, MAINTENANCE, AND MONITORING

The (monthly, quarterly, or semiannual) reports should be a concise summary of activities at the site during the previous time period. An ideal report will consist of an activity summary and the required tables and text. Depending on the type of system (Pump and Treat, SVE, etc.), the contents of the tables may differ. The data required for each type of system is specified below.

The activity summary should include a title page or banner with site name, location, MDE case number, and RP contact. Contents are to include the following:

1. Synopsis of site/release activities. This can be copied from previous site reports.
2. System configuration.
3. Work authorized during the period of report.
4. Work performed.
5. Portion of the period the system was operational: e.g., system was pumping 28 out of 31 days. MDE must be contacted if the system is down for more than 48 hours.
6. Problems or routine maintenance to the system, i.e., system down 10/02/00 to change carbon; SVE system down on 10/7/00 due to problem with blower motor. Motor replaced and system back in operation 10/09/00. Amount of water pumped through the recovery system (include flow meter readings), pounds of vapors recovered (include flow rate in cfm), volume of free product recovered this period, and cumulative total. For free product recovery, describe how much was recovered by an automatic system and how much was recovered via hand bailing and wicking. For sites with multiple recovery wells, a table showing amount of product (as vapor, dissolved, and/or LPH) removed from each well is required. The conversion factors and equations used to determine amounts must be stated. Describe which wells are being pumped or vented, and outline any additions or subtractions to the system originally proposed in the CAP.
7. Status of outstanding permits including permit numbers, which affect installation or operation of the system. (See Appendix J)
8. Sample results of influent and effluent concentrations to demonstrate the treatment system is properly functioning.
9. Maximum BTEX and MTBE concentrations in monitoring wells.

The Operation and Maintenance Reports should also include detailed tables covering the information described above, which provides documentation for the activity summary.

Groundwater Extraction Data Tables. This table should include:

1. Groundwater extracted for the period in gallons;
2. Average extraction rate per well and system in gpm;
3. Average influent BTEX concentrations (ppb);
4. Average effluent BTEX concentrations (ppb);
5. Average treatment efficiency (%);
6. Dissolved phase hydrocarbons recovered for the reporting period in gallons; and
7. Cumulative hydrocarbons recovered for the reporting period and historically in gallons, per operational extraction point.

Vapor Extraction Data Tables. This table should include:

1. Vapors extracted for the period in lbs./day;
2. Manifold lbs./day, manifold extraction rate in/cfm;
3. Manifold cfm, manifold vacuum in inches of water;
4. Average influent vapor concentrations (ppm);
5. Average effluent concentrations (ppm);
6. Average treatment efficiency(%);
7. Hydrocarbons recovered for the reporting period in lbs./day;
8. Cumulative hydrocarbons recovered for the reporting period and historically in lbs./day; and
9. Operational period in lbs./day.

Water Quality Tables must include the following:

1. Well or sample point identification;
2. Date sampled;
3. Constituent name; and
4. Units for each constituent.

Gauging and Liquid Level Data must include the following:

1. Well identification;
2. Date gauged;
3. Top of casing elevation;
4. LPH depth in feet from top of casing;
5. Water depth in feet from top of casing;
6. LPH thickness in feet;
7. Groundwater elevation in feet; and
8. Corrected groundwater elevation in feet (include product density value used).

Maps:

Must be to-scale with the final well, direct-push, and/or sampling locations; a layout of site buildings and utilities; a layout of the remediation system; and other pertinent features. The measured value for groundwater elevation or constituent of concern (such as LPH, BTEX, MTBE, etc.) should be posted by the appropriate well. Contours summarizing this point data will also be presented, i.e,. groundwater contour map, LPH thickness map, and dissolved total BTEX and MTBE contour maps.

Managing Future Environmental and Health Impacts:

Future changes to land use may alter the risk based assumptions and corresponding cleanup level under which the site was originally closed. Reassessment of cleanup levels may be required when land use changes. This will be addressed on a site-specific basis. Institutional controls, such as deed restrictions/deed notices, groundwater management zones, and well permit limitations, may be considered as part of the corrective action plan for a particular site. This decision is made on a site-specific basis.

CLOSING

This document was designed to assist you in understanding the decision-making process regarding corrective action on oil-contaminated sites in Maryland. We encourage you to comment so we can continue to refine this and other documents to meet the State's and your needs. OCP takes pride in its ability to ensure site remediation and the protection of impacted parties and the environment. We have found that communication is the key to success in our projects.

Please forward your comments or questions to the:

Oil Control Program
Suite 620
1800 Washington Boulevard
Baltimore MD 21230-1719

or E-mail us at:

mbutler@mde.state.md.us

GLOSSARY

ASTM: American Society for Testing and Materials. This is the body that has published a standardized risk based corrective action standard PS104-98.

Asymptotic Trend: In regards to contamination, the trend is approaching a finite value but has leveled off. Depending on the finite value and site specifics, an asymptotic trend may be used to determine if case closure is warranted.

EFR: Enhanced fluid recovery. The use of a vacuum truck or other mechanical means to provide a short-term aggressive event to recover contamination.

CAP: Corrective Action Plan. The plan submitted by a responsible party or their consultant to address remediation of a petroleum release.

COV: Complaint, Order, and Civil Penalty

Dissolved Phase Hydrocarbons: Hydrocarbon contamination that has partitioned into water.

LNAPL: Light, non-aqueous phase liquid. LNAPL will float on the surface of surface and/or groundwater.

LPH: Liquid Phase Hydrocarbons. As used in this document, LPH refers to LNAPL that is not tenaciously adsorbed or absorbed to subsurface material and is extractable (removable) from the site by natural and/or manmade conditions. LPH is petroleum product in a non-aqueous phase normally found floating on the groundwater. The removal of LPH is always a goal for remediation.

Maryland Licensed Well Driller: A licensed driller must hold one of three drilling licenses, which are administered by MDE's Water Management Administration (WMA). The three licenses are: 1. Apprentice; 2. Journeyman; and 3. Master. The individual operating the drilling equipment (hand auger, direct push, rotary rig, etc.) used to sample or explore for groundwater must be licensed. Each license has specific requirements, which may be obtained from WMA.

MDE: Maryland Department of the Environment

Monitoring Well: In this document, a well constructed to OCP specifications. Generally, a monitoring well is used to monitor groundwater conditions. Monitoring wells are also known as observation wells.

NOV: Notice of Violation

OCP: Oil Control Program

Plume: The area of groundwater impacted by a release, either in a dissolved or liquid phase.

POE: Point of Exposure is the point at which an individual, population, or any environmentally sensitive area may come in contact with a contaminant.

Pump and Treat: Refers to the mechanical (often performed by automatic systems) removal of liquid and vapor phases from the surface and subsurface with various treatments applied at the surface. Pump and treat includes skimming, SVE, sparge, slurping, total fluids, dual-phase extraction, etc., and the depression of groundwater to facilitate the above and the control of LPH and dissolved plumes. This broad definition is adapted to alert responsible parties to the fact that "pump and treat" in NOVs and COVs is all-inclusive.

Risk is defined as the possibility of suffering harm or loss. OCP requires that the potential risk be evaluated at every site that has a reported release.

Recovery Well: In this document, a well constructed to OCP specifications and/or by approval for the purpose of recovering groundwater and contamination from the site. If an existing monitoring well is used for augmented recovery (recovery other than bailing/wicking), in most cases it may no longer be suitable as a monitoring well.

Site Assessment: A site assessment is a study comprised of records review, interviews, and surface and subsurface investigation handled in a well-documented and scientific manner with the goal of determining the total extent of contamination from a release or suspected release. If the site assessment does not determine the full extent of contamination, remediation efforts are likely to take much longer than necessary as new information comes to light over time. This increases the level of effort of the corrective action.

Soil Vapor Extraction (SVE): means the use of a mechanical device to remove and treat soil vapor, which contains contamination.

Time Series Data: The collection of site information for a specific period of time. Time series data normally involves groundwater sampling.

Well: According to the Water Management Administration, a well is any hole in the ground to sample or extract groundwater.

Appendix (A): Groundwater Monitoring Well Sampling Procedures

The following is a groundwater purging/sampling guideline for monitoring wells at oil pollution sites. No-purge sampling or low flow purging using EPA standard protocols may be allowed on a site-specific basis. However, no-purge is only approved if site data and history supports the technique.

Extreme care must be taken to minimize cross-contamination of groundwater samples during collection. Sampling equipment should be stored in clean, plastic bags and should not come into direct contact with any surface (ground, truck tailgate, etc.) or any petroleum products. Clean plastic gloves should be used and changed frequently. Clean dedicated bailers must be used to collect groundwater samples at each monitoring well. If an undesignated bailer is used for purging, it should be thoroughly washed using a warm soapy water solution between wells.

Before sampling, monitoring wells must be inspected. The condition of the wells should be noted on the sampling log. Missing caps, locks, or damaged well casings should be recorded and arrangement made for repairs. Monitoring wells must also be gauged prior to purging and sampling. Depth-to-product (if present) and depth-to-groundwater (measured from the top of the well casing) should be recorded on the sampling log. Odors, color of product (if present), and other visual observations should be recorded. In most cases, if measurable product is present (greater than a sheen), purging and sampling should not be performed.

Unless approved by OCP, groundwater must be purged from the well prior to sampling. Purging is the removal of water in the well. This is done to remove stagnant water from the well and to obtain a representative sample from the surrounding formation. Purging is conducted by removing 3 well volumes using a hand bailer or pump or by using a low flow method. A well volume is calculated by subtracting depth-to-water (water level) from the well depth. The result is the linear feet of water in the well. The amount of water in the well casing is obtained by multiplying the linear feet of water by the volume per foot for the diameter well casing. For a 4-inch well casing, the volume per foot is 0.65 gallons. For a 2-inch well casing, the volume per foot is 0.16 gallons. Standing water in the well casing is then multiplied by the number of volumes to be removed (i.e., 3 well volumes). Example (for a 4-inch well):

Depth to water:	20 feet
Depth to bottom of well:	30 feet
Linear feet of water:	30 feet – 20 feet = 10 feet
Well volume in 4-inch well casing:	10 feet x 0.65 gallons = 6.5 gallons
Purge volume:	6.5 gallons x 3 well volumes = 19.5 gallons

Therefore, 20 gallons of water is the volume of water to be removed from the well prior to collecting a groundwater sample. Purging should cease if the well is bailed dry or nearly dry prior to removing 3 well volumes. After the well recharges, a groundwater sample can be collected. This should be noted on the sampling log.

No-purge sampling <u>may</u> be allowed on a site-specific basis. However, no-purge sampling is only approved if site data and history supports the technique.

Purge water must either be contained for proper disposal or treated on site. Treatment requirements are the same for those required in a general discharge permit.

Once purging is accomplished, a groundwater sample is collected by slowly lowering a bailer into the well until it is submerged. Care should be taken to avoid excessive agitation and aeration. The bailer is retrieved and a sample is carefully transferred into a clean, laboratory-ready volatile organic analysis (VOA) bottle preserved with hydrochloric acid (HCL). Most laboratories will provide their client with the proper container. The VOA bottle should be filled entirely with the groundwater sample and must be free of bubbles and air space. Turning the VOA bottle upside down and gently tapping the bottle can assess air bubbles in a sample. Air bubbles present in the sample will rise to and will be visible through the glass top of the bottle. Other container sizes are needed for samples such as TPH or semi-volatiles.

When a sample is collected, it must be placed in a cooler with ice. Samples must be kept below 4 degrees C from the time collected until arrival at the laboratory. The samples should be submitted to a laboratory within 24 hours and adhering to the chain-of-custody procedures established by the laboratory. Sample labels should include site name, site number, time of sample collection, sample or well number, analyses to be performed, and the sampler's initials. Groundwater sampling logs should be filled out for each well sampled. Upon receipt of the sampling analyses from the lab, the sampling results, sampling log, and chain-of-custody form signed by the sampler and lab, the data must be submitted to OCP for review in the proper report and at a schedule determined by OCP for the site.

Sample Event Log

Groundwater Monitoring Well Sampling

Date:_____ Initials:_____

Site Name/Location:
_____
_____
_____

Well No.:_____ Well Condition:_____

Well Diameter:_____ Stickup or flush-mount:_____

Well depth (ft):_____

Depth-to-product (ft):_____

Time purging begins:_____

Before purging and at time of sampling
Depth-to-water (ft):_____

Before purging and at time of sampling
Linear feet of water :_____

Volume of water in well [(4) x F]:_____
F = 0.16 for a 2-inch well
F = 0.65 for a 4-inch well

Purge volume [(5) x 3 =]:_____

Did well bail dry? ___Yes ___No

If so, how many gallons removed?_____

Groundwater sampling analysis to be performed (Circle):

BTEX MTBE TPH-DRO TPH-GRO OTHER

Time of groundwater sample collection:_____

Comments and Observations:
_____
_____

Appendix (B): **Laboratory Analytical Methods**

Product	EPA Method
Home Heating Oil, Diesel Fuel, and Kerosene	Water: 8260, 524.2 8015B GRO/DRO Soil: 8015B GRO/DRO
Gasoline	Water: 8260, or 524.2 Soil: 8015B GRO/DRO and 8021 for BTEX, MTBE
Aviation Gasoline	Water: 8260, or 524.2 Soil: 8015B GRO/DRO
Jet Fuel	Water: 8260, 524.2 8015B GRO/DRO Soil: 8015B GRO/DRO
Heavy Fuel (#4, #5 and #6)	Water: 8260, 524.2 8015B GRO/DRO and PAHs 8270 or 8310 Soil: 1664, 8015B GRO/DRO
Used Oil	Water: 8260, 524.2 8015B GRO/DRO and PAHs 8270 or 8310 Soil: 8015B GRO/DRO, PAHs 8270 or 8310 and 1311 TCLP metals
Hydraulic Oil	Water: 8015B GRO/DRO Soil: 8015B GRO/DRO
Liquid Asphalt	Water: 8015B GRO/DRO and PAHs 8270 or 8310 Soil: 8015B GRO/DRO and PAHs 8270 or 8310

Appendix (C)

Oil Control Program
Summary of Specifications for the Design and Installation of Groundwater Monitoring Wells

- A Maryland-licensed well driller, in accordance with pertinent State and local laws and regulations, must install all wells. The Land Management Administration's Oil Control Program (OCP) has final approval of the proposed location and design of each well.

- All monitoring well casings and screens must be constructed of 4-inch, inner-diameter pipe composed of Schedule 40 Polyvinyl chloride (PVC), Teflon (PFE), or stainless steel joined using threaded couplings. NO SOLVENTS, GLUES, OR LUBRICANTS SHALL BE USED IN THE CONSTRUCTION OF THE WELL.

- The monitoring well must be constructed with screen with a minimum slot size of 0.02 inch and a maximum slot size of 0.025 inch. The screen must be placed at least 10 feet below the detected water table, and 10 feet above the water table, at a minimum. In some cases, for shallow water table conditions, the (10 feet above the water table) requirement cannot be met. In this instance, the screen may be extended to within 2 feet of the ground surface to allow for a proper surface seal. For deeper wells and/or when the exact water table is not certain, additional screen lengths may be necessary. Drilling contractors should be prepared with appropriate amounts of screen and materials at the job site to deal with unforeseen requirements.

- The diameter of the boring must exceed the diameter of the well by at least 4 inches (e.g., a 4-inch well must be installed in a hole at least 8 inches in diameter).

- The annular space of all wells shall be packed with #2 Moiré Sand to at least 2 feet above the well screen. At least 2 feet of bentonite pellets must be placed above the sand. In cases where the groundwater is shallow (0 to 3 feet below grade), it is not possible to place 2 feet of the sand above the screen, and 2 feet of bentonite. In these situations, and <u>only</u> these, no less than 6 inches of each must be placed in the well.

- The annular space above the bentonite must be grouted with Portland cement or Portland cement/bentonite slurry to the top of the well, or the bottom of the vault.

- The well must be protected from damage by an outer vault, usually a 12-inch x 6-inch or 12-inch x 12-inch steel manhole.

- A locking, watertight cap must seal the well.

- All wells must be properly developed. Any water produced from a monitoring well must be properly treated prior to discharge.

- All wells must be properly tagged with the well permit number clearly visible.

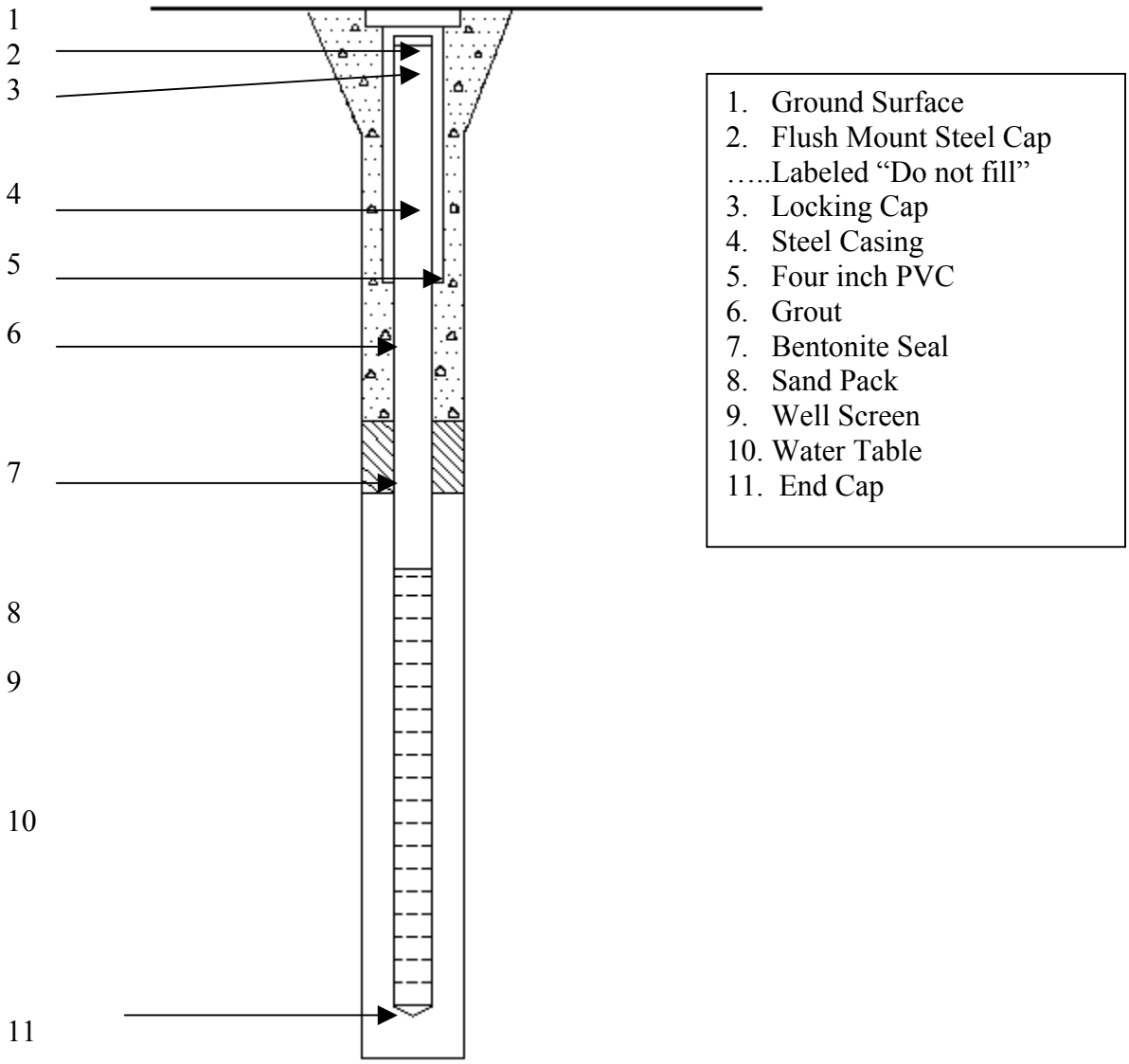
- Well completion reports must be fully completed for each well installed, and a copy of the well completion report forms must be submitted to the OCP within 30 days of the well installation.

- The OCP must be notified at least 3 working days prior to any drilling.

- Any changes to the construction of the wells must be approved in writing from the OCP prior to implementation of the changes in construction.

- Any wells that are to be abandoned must be abandoned in accordance to regulation COMAR 26.04.04.11. Casing must be removed if possible, and the entire well and gravel pack must be completely filled with Portland cement grout from the base of the former boring to the ground surface.

- The authority for the above is COMAR 26.04.04.07M(6), "Observations Wells." The Approving Authority may specify special construction standards for wells installed for the sole purpose of monitoring water quality or water levels.



Typical Monitoring Well Design

Appendix D

DIRECT PUSH INVESTIGATION TECHNOLOGIES

Direct Push ((DP) technology (also known as "direct drive," "drive point," "hydropunch," "geoprobe," or "push" technology) refers to a growing family of tools used for performing surface investigations by driving, pushing, and/or vibrating small diameter hollow steel rods into the ground. MDE approves this type of technology as an investigation technique.

By attaching sampling tools to the end of the steel rods they can be used to collect soil, soil-gas, and groundwater samples. DP rods can also be used with probes that provide continuous in-situ measurements of subsurface properties (e.g. stratigraphy, contaminant distribution). DP equipment can be advanced into the ground with various methods ranging from 30-pound manual hammers to truck mounted hydraulic units.

The Geoprobe is an example of a sampling system that is compact and allows for greatly reduced mobilization and setup time. Usually, the equipment is installed at the rear of a small truck or on mobile equipment such as a "Bobcat." This unit can drill through surface pavement and perform vertical soil profiling to approximately 25 feet deep. Groundwater can be sampled to depths exceeding 40 feet. Depending on the services, the contractor may have a mobile lab for immediate analyses of soil gas samples or can be transported to an off-site laboratory.

This technology was developed in response to a growing need to assess contaminated sites more completely and more quickly than is possible with conventional methods. With the development of DP technologies, large permanent monitoring wells are no longer the only method for collecting groundwater samples or characterizing a site. Multiple soil, soil-gas, and groundwater samples can now be collected rapidly, allowing high data quality analytical methods to be used on site, economically.

DP technologies are most applicable in unconsolidated sediments, typically to depths less than 100 feet and can be used to install small diameter (i.e,. less than 2 inches) temporary wells and piezometers (used for groundwater gradients). They have also been used in the installation of remediation equipment such as soil vapor extraction wells and air sparging injection points. Penetration is limited in semi-consolidated sediments and is generally not possible in consolidated formations, although highly weathered bedrock (i.e., saprolite) is an exception for some equipment.

DP equipment may also be limited in unconsolidated sediments with high percentages of gravel and cobbles. As a result, other drilling methods are necessary in site assessment and remediation activities where geological conditions are unfavorable for DP technologies or where larger diameter (i.e., greater than 2 inches) wells are needed.

OCP does not accept DP points as long term monitoring or recovery wells. These points must be replaced with an appropriately designed and constructed well. A list of direct push/geoprobe contractors is available to the public from the Department's Oil Control Program.

Appendix E

Investigation Derived Wastes, Treatment, and Disposal

During site investigation, monitoring and recovery waste water and soil are generated. It is important that these waste are handled in an environmentaly safe manner that complies with State, local, and federal regulations.

WATER

According to COMAR 26.08.04.01B(1), a specific permit is not required if the discharge water capcitiy is less than 10,000 gallons per day, as a monthly average. However, if the groundwater is known to be contamininated, it must be treated appropriately prior to discharge. Conservatively, contaminant levels in the groundwater to be discharged should not exceed the levels listed in COMAR 26.08.02.03-3, Table 1, "Toxic Substance Criteria for Ambient Surface Waters," or COMAR 26.04.01.07 (D) through (F), whichever is less. The water should be monitored prior to and after treatment. Basically, OCP is looking for discharge water at petroleum release sites to maintain a level below 100 ppb total BETX and 5 ppb Benzene.

Small Quantity

For a small quantity of water (20 gallons or less per well), the quantity can be bailed or pumped onto the ground surface. Visible liquid product or sheen must first be removed with an appropriate absorbent material. The water is then bailed/pumped through a filter bed of activated carbon. A filter bed is easily made with common materials. (See Attachment)

Large Quantity

For a large quantity of water (more than 20 gallons per well), the site owner has several options.

1. A professional company specializing in the handling of contaminated water and products can be hired to pump the water. This is usually performed with the use of a vacuum truck system. The professional company must properly handle the disposal of all fluids collected.

2. Site water can be collected and consolidated in one location to achieve the highest cost benefit from a professional company pickup. It is critical not to accumulate over 500 gallons of water at any one time.

3. The water may be sampled. If found to contain less than 100 ppb total BTEX and 5 ppb Benzene, the water, if quantity is under 10,000 gallons, may be pumped onto the ground as a one-time event.

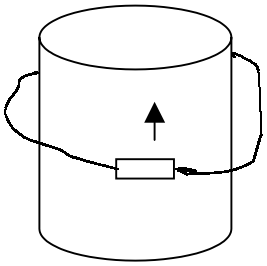
Water contaminated with any amount of petroleum product is considered "oil" by Maryland regulations. Therefore, the handling of water must be performed in a professional and environmentally safe manner.

SOIL

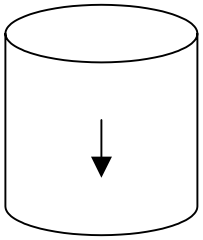
When soil is found to be "non-contaminated" (a TPH level of 10 ppm or less), the soil, if property conditions allow, may be left on site. The soil must be incorporated onto the site in a manner that prevents run off and is visualy pleasing.

If the soil is to be moved off site as non-contaminated, the TPH level must be at 10 ppm or less. If over 10 ppm, the soil must either be taken to a local landfill that accepts oil contaminated soil or to a soil treatment facility. OCP maintains a list of soil treatment facilities. Remember: COMAR 26.10.09.03A(5) requires: "Excavated contaminated soil shall be removed from the site within 50 days or treated in accordance with a corrective action plan approved by the Departmenmt."

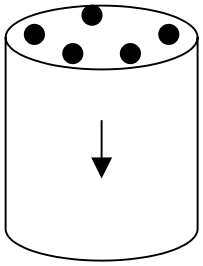
HOME MADE CARBON BED



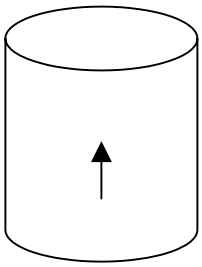
FIVE GALLON BUCKET



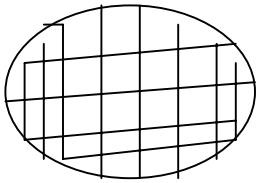
TURN BUCKET ON ITS TOP



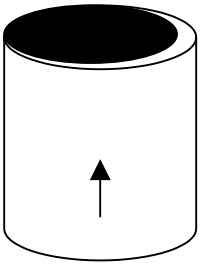
PUNCH 5-1/4 INCH HOLES IN BOTTOM



TURN BUCKET BACK OVER



CUT OUT WINDOW SCREEN TO FIT BUCKET BOTTOM



INSERT WINDOW SCREEN AND FILL BUCKET WITH CARBON

A second bucket should be used to carry the carbon bed in. This will assist in retaining residue water with the carbon bed and help with transport. The carbon in the bed should be replaced after five gallons of use. Water must be passed through the carbon at a lower flow to prevent overflowing the top of the bucket. Please note this item should only be used for water quantities under 20 gallons.

Appendix F

Generic Numeric Cleanup Standards for Groundwater and Soil

	Goundwater Standards	Soil Standards					
Analyte	***Type I and II Aquifers (ug/L)***	***Residential Clean-up Standard***		***Non-Residential Clean-up Standard***		***Protection of Groundwater***	
VOCs							
Acetone	61	782	mg/kg (ppm)	20440	mg/kg (ppm)	2.5	mg/kg (ppm)
Benzene	5.0	11.6	mg/kg (ppm)	104	mg/kg (ppm)	5.0	ug/kg (ppb)
Carbon Tetrachloride	5.0	4.9	mg/kg (ppm)	44.0	mg/kg (ppm)	5.0	ug/kg (ppb)
Chlorobenzene	11	156	mg/kg (ppm)	4088	mg/kg (ppm)	801	ug/kg (ppb)
Ethylbenzene	700	782	mg/kg (ppm)	20440	mg/kg (ppm)	15	mg/kg (ppm)
Isopropylbenzene	66	782	mg/kg (ppm)	20440	mg/kg (ppm)	64	mg/kg (ppm)
Methyl Tert Butyl Ether	20	653	mg/kg (ppm)	2728	mg/kg (ppm)	28	mg/kg (ppm)
Styrene	100	1564	mg/kg (ppm)	40880	mg/kg (ppm)	57	mg/kg (ppm)
Toluene	1000	1564	mg/kg (ppm)	40880	mg/kg (ppm)	8.8	mg/kg (ppm)
Xylenes	10000	15643	mg/kg (ppm)	408800	mg/kg (ppm)	170	mg/kg (ppm)
SVOCs							
Acenaphthene	37	469	mg/kg (ppm)	12264	mg/kg (ppm)	105	mg/kg (ppm)
Acenaphthylene	37	469	mg/kg (ppm)	12264	mg/kg (ppm)	105	mg/kg (ppm)
Anthracene	180	2346	mg/kg (ppm)	61320	mg/kg (ppm)	466	mg/kg (ppm)
Benz[a]anthracene	0.1	875	ug/kg (ppb)	7.8	mg/kg (ppm)	1.5	mg/kg (ppm)
Benzo[a]pyrene	0.2	87.5	ug/kg (ppb)	784	ug/kg (ppb)	374	ug/kg (ppb)
Benzo[b]fluoranthene	0.1	875	ug/kg (ppb)	7.8	mg/kg (ppm)	4.5	mg/kg (ppm)
Benzo[g,h,i]perylene	18.0	235	mg/kg (ppm)	6132	mg/kg (ppm)	682	mg/kg (ppm)
Benzo[k]fluoranthene	0.9	8.7	mg/kg (ppm)	78.4	mg/kg (ppm)	45	mg/kg (ppm)
Carbazole	3.3	31.9	mg/kg (ppm)	286	mg/kg (ppm)	467	ug/kg (ppb)
Chrysene	9.2	87.5	mg/kg (ppm)	784	mg/kg (ppm)	146	mg/kg (ppm)
Dibenz[a,h]anthracene	0.01	87.5	ug/kg (ppb)	784	ug/kg (ppb)	1.4	mg/kg (ppm)
1,2-Dichlorobenzene	600	704	mg/kg (ppm)	18396	mg/kg (ppm)	9.3	mg/kg (ppm)
1,3-Dichlorobenzene	18	235	mg/kg (ppm)	6132	mg/kg (ppm)	2.9	mg/kg (ppm)
1,4-Dichlorobenzene	75	26.6	mg/kg (ppm)	238	mg/kg (ppm)	330	ug/kg (ppb)
Fluoranthene	150	313	mg/kg (ppm)	8176	mg/kg (ppm)	6255	mg/kg (ppm)
Fluorene	24	313	mg/kg (ppm)	8176	mg/kg (ppm)	135	mg/kg (ppm)

	Goundwater Standards	Soil Standards					
Analyte	***Type I and II Aquifers (ug/L)***	***Residential Clean-up Standard***		***Non-Residential Clean-up Standard***		***Protection of Groundwater***	
Indeno[1,2,3-c,d]pyrene	0.1	875	ug/kg (ppb)	7.8	mg/kg (ppm)	13	mg/kg (ppm)
Isophorone	70	672	mg/kg (ppm)	6024	mg/kg (ppm)	415	ug/kg (ppb)
2-Methylnaphthalene	12	156	mg/kg (ppm)	4088	mg/kg (ppm)	22	mg/kg (ppm)
Naphthalene	0.7	156	mg/kg (ppm)	4088	mg/kg (ppm)	330	ug/kg (ppb)
Nitrobenzene	0.4	3.9	mg/kg (ppm)	102	mg/kg (ppm)	670	ug/kg (ppb)
Phenanthrene	180	2346	mg/kg (ppm)	61320	mg/kg (ppm)	466	mg/kg (ppm)
Pyrene	18	235	mg/kg (ppm)	6132	mg/kg (ppm)	682	mg/kg (ppm)
1,2,4-Trichlorobenzene	70	78.2	mg/kg (ppm)	2044	mg/kg (ppm)	7.5	mg/kg (ppm)

	Goundwater Standards	Soil Standards					
Analyte	***Type I and II Aquifers (ug/L)***	***Residential Clean-up Standard***		***Non-Residential Clean-up Standard***		***Protection of Groundwater [a]***	
Gasoline Range Organics (GRO)	47	230	mg/kg (ppm)	620	mg/kg (ppm)	--	--
Diesel Range Organics (DRO)	47	230	mg/kg (ppm)	620	mg/kg (ppm)	--	--

[a] Standard based on Region III SSLs for groundwater migration using a dilution attenuation factor (DAF) of 20.
[b] (shaded) the standard for this analyte is based upon the practical quantitation limit (PQL). Additional evaluation may be necessary if this analyte is detected on site.

Appedix G

Use of Chemical Oxidation

The use of in-situ chemical oxidation for remediation of soil and groundwater is increasingly requested as a corrective action method. It is claimed that chemical oxidation shows promise in destroying petroleum products. This remedition occurs by stimulating the in-situ biological process. OCP notes the following limitations associated with chemical oxidation:

1. Potential impacts from aggressive chemical reaction. Use may be inappropriate close to an underground storage tank field, utility corridor, or buildings.
2. May cause ground/pavement heaving or subsidence. This can adversely impact parking lots, roadways, and utility corridors.
3. May push vapors ahead of reaction front and cause their movement into buildings through preferential flow paths such as drains, gravel beds, sewer lines, etc.
4. Not appropriate for more than approximately 1/2 inch of free phase floating product.
5. Incomplete penetration in layered geology with clay lenses.
6. Requires separate injection points around wells of interest and adequate monitoring points to judge the remediation's effectiveness.
7. One time application of oxygen to stimulate microbial growth does not appear to be a long-term solution.
8. Hydrogen peroxide should be mixed with a chelated iron specific to site conditions to limit violence of the reaction and ensure penetration in the aquifer. <u>Pilot testing is absolutely necessary</u>.

The advantages OCP has noted with chemical oxidation are:

1. Relatively inexpensive and an unobtrusive way to clean up small pockets of high dissolved and low LPH in a few wells.
2. Reaction runs to completion and does not appear to generate adverse/harmful byproducts.
3. Can speed up time to closure after more conventional methods, such as pump and treat and SVE, have reached the point of diminishing returns.
4. Can be useful in selected locations where wells persistently show low LPH and/or high dissolved levels and have not responded to EFRs, surfactant treatments, wicking and hand bailing.
5. Relatively inexpensive pilot testing can be conducted to test remediation effectiveness.

Therefore, OCP conludes that chemical oxidation is a viable remediation technology for many sites in Maryland. Some sites have physical limitations, so applicability will be restricted. Chemical oxidation is not a solution for all groundwater problems. This is especially true at sites with large amounts of free phase petroleum product.

OCP requires that all requests for oxidation use be reviewed with careful attention to the monitoring well network. Requests must include a strong detailed proposal and pilot testing. OCP will consider requests on a case-by-case basis and will carefully consider the delivery method proposed.

Appendix H

Historical Groundwater Analytical Results

Well No.	Date	Benzene (µg/l)	Toluene (µg/l)	Ethylbenzene (µg/l)	Total Xylenes (µg/l)	Total BTEX (µg/l)	MTBE (µg/l)
MW-1	09/03/99	485	1560	1130	4360	7535	150
	11/02/99	650	2410	1720	6580	11360	<5
	03/24/00	167	2050	1440	6690	10347	18
	05/15/00	759	2630	1560	7360	12309	22
	08/15/00	1140	1600	2110	7160	21010	<5
	11/27/00	900	1610	1880	5240	9630	3
	03/06/01	3030	4630	3340	14000	25000	98
	06/19/01	2890	4860	3550	15400	26700	93
MW-2	09/03/99	11000	38000	2900	11000	62900	64000
	11/02/99	2400	4100	830	2700	10030	13000
	03/24/00	14000	53000	3500	11000	81500	22800
	05/15/00	6500	26000	1800	7500	41800	18050
	08/15/00	4600	27000	2100	9300	43500	983
	11/27/00	6140	40600	4720	17900	69360	1780
	03/06/01	1560	15700	1800	8780	27840	2900
	06/19/01	3000	24800	3120	14600	45520	5730
MW-3	09/03/99	23	360	2200	410	3000	220
	11/02/99	43	140	960	320	1500	180
	03/24/00	LPH	LPH	LPH	LPH	LPH	LPH
	05/15/00	<10	1300	7900	1100	10300	200
	08/15/00	300	4200	1900	5600	12000	400
	11/27/00	37	170	300	380	887	40
	03/06/01	8	30	45	100	183	9
	06/19/01	<5	1.9	<5	<5	1.9	<1
MW-4	09/03/99	<5	<5	<5	<5	BDL	<5
	11/02/99	NS	NS	NS	NS	NS	NS
	03/24/00	<5	<5	<5	<5	BDL	<5
	05/15/00	<5	<5	<5	<5	BDL	<5
	08/15/00	<1	<1	<1	<1	BDL	<1
	11/27/00	NS	NS	NS	NS	NS	NS
	03/06/01	<1	<1	<1	<3	BDL	<1
	06/19/01	<1	<1	<1	<3	BDL	<1
MW-5	09/03/99	<5	<5	<5	<5	BDL	<5
	11/02/99	<5	<5	<5	<5	BDL	<5
	03/24/00	<5	<5	<5	<5	BDL	<5
	05/15/00	NS	NS	NS	NS	NS	NS
	08/15/00	NS	NS	NS	NS	NS	NS
	11/27/00	<1	<1	<1	<3	BDL	<1
	03/06/01	<1	<1	<1	<3	BDL	<1
	06/19/01	<1	<1	<1	<3	BDL	<1

µg/l Micrograms per liter

Notes:

BTEX	benzene, toluene, ethylbenzene and total xylenes
MTBE	methl tertiary butyl ether
LPH	Liquid Phase Hydrocarbons
NS	Not sampled
<	Below Minimum Quanitation Level
NA	Not analyzed for parameter
BDL	Below Detection Level

Appendix I

Well Gauging Report

Well No.	Gauge Date	Depth to Product (ft) *	Depth to Water (ft) *	Apparent Thickness (ft)	TOC Elevation (ft)	Groundwater Elevation (ft)	Corrected Water Elevation (ft) **
MW-1	06/05/01		36.45		98.33	61.88	
	07/03/01		36.62		98.33	61.71	
	08/07/01		36.65		98.33	61.68	
MW-2	06/05/01		26.43		88.05	61.62	
	07/03/01		26.46		88.05	61.59	
	08/07/01		26.62		88.05	61.43	
MW-3	06/05/01		29.57		91.23	61.66	
	06/12/01		29.61		91.23	61.62	
	06/15/01		29.64		91.23	61.59	
	06/19/01		29.66	Sheen	91.23	61.57	61.57
	06/22/01		29.67		91.23	61.56	
	06/26/01		29.69		91.23	61.54	
	07/03/01		29.67		91.23	61.56	
	07/10/01		29.65	Sheen	91.23	61.58	61.58
	07/13/01		29.71		91.23	61.52	61.52
	07/17/01		29.67	Sheen	91.23	61.56	61.56
	07/20/01		29.77		91.23	61.46	
	07/24/01	29.66	29.66	Sheen	91.23	61.57	61.57
	07/31/01	29.76	29.76	Sheen	91.23	61.47	61.47
	08/07/01		29.77		91.23	61.46	
	08/14/01		29.87		91.23	61.36	
MW-4	06/05/01	28.98	29.86	0.88	84.16	54.30	54.96
	06/12/01	28.96	29.89	0.93	84.16	54.27	54.97
	06/26/01	29.14	29.62	0.48	84.16	54.54	54.90
	07/10/01	29.10	29.81	0.71	84.16	54.35	54.88
	07/24/01	29.18	29.61	0.43	84.16	54.55	54.87
	08/07/01	29.19	29.67	0.48	84.16	54.49	54.85
MW-5	06/05/01		31.45		93.44	61.99	
	07/03/01		31.48		93.44	61.96	
	08/07/01		31.69		93.44	61.75	
MW-6	06/05/01		28.49		89.11	60.62	
	07/03/01		28.52		89.11	60.59	

	08/07/01	28.69	89.11	60.42
MW-7	06/05/01	32.29	93.92	61.63
	07/03/01	32.29	93.92	61.63
	08/07/01	32.44	93.92	61.48
MW-8	06/05/01	28.50	86.79	58.29
	07/03/01	28.65	86.79	58.14
	08/07/01	28.94	86.79	57.85
MW-9	06/05/01	29.06	86.89	57.83
	07/03/01	29.12	86.89	57.77
	08/07/01	29.30	86.89	57.59
MW-10	06/05/01	27.13	83.71	56.58
	07/03/01	27.39	83.71	56.32
	08/07/01	27.37	83.71	56.34

Notes: * Depths measured from top of casing (TOC)

** Adjusted/Corrected Elevation = water elevation + product density x product thickness

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Appendix J

TO: Oil Control Program
FROM: Air Toxics Section
DATE: February 12, 2003
SUBJECT: Remediation, A Simple Primer

There are three primary regulations governing this:

1. The first is the requirement to obtain a permit under COMAR 26.11.02.09. A remediation unit requires a permit unless it meets all of the following conditions:

   A. The uncontrolled VOC emissions are less than one (1) ton per calendar year;
   B. The uncontrolled emissions of Class II toxic air pollutants are less than one (1) ton per calendar year; and
   C. The emissions of Class I toxic air pollutants are no more than one (1) pound per day.

2. The second is the requirement to control VOC emissions under COMAR 26.11.06.06. This requires remediation equipment emitting more than 20 pounds of VOC per day to reduce emissions by 85 percent or more overall. This only applies in the following areas: Baltimore City, and Anne Arundel, Baltimore, Calvert, Carroll, Cecil, Charles, Frederick, Harford, Howard, Montgomery, and Prince George's counties.

3. The third is the requirement to control air toxics emissions under COMAR 26.11.15. This is done through a T-BACT (toxics best available control technology) requirement, which for remediation units specifies that they have a control device with an efficiency of 85 percent or more overall. This applies statewide and is implemented through a permit.

Basically, if the remediaton equipment is going to emit less than one (1) ton of VOC per year, it probably doesn't need a permit. If it goes over this, it will require a permit.

If the remediation equipment is going to go over the 20-pounds-per-day of VOC, it will need a control device to get the 85 percent reduction. It does not need a permit, though, unless it exceeds the one-ton-per year. This is important as remediation sites often spike with high VOC emissions initially and greatly reduce after a few days or few weeks of operation.

Appendix J

Remediation: A Simple Primer

The Class I TAP limit of less than one (1) pound per day to qualify for exemption is important. Benzene is a common ingredient in gasoline and a Class I TAP. A quantification of Benzene, and any other Class I TAP, needs to be done to ensure remediation qualifies for the exemption.

If a permit is required, and it is for gasoline remediation, the General Permit to Construct for Groundwater Air Strippers and Soil Vapor Extration Systems should be used. If remediation is for something other than gasoline, a standard Permit to Construct will be required.

These permits can be terminated when remediation has sufficiently progressed. The details of this are best spelled out in the General Permit. Currently, we are not actively tracking the termination of these permits.

If a remediation project results in VOC emissions greater than the major source threshold, a Title V Permit would be required. This threshold is 25 tons per year for much of the State.

For answers to further questions, please call Nolan Penney, Air Toxics Section Head, Air Quality Permits, at 410-537-3219.