5.0
SITE CHARACTERIZATION AND OTHER DATA REQUIREMENTS FOR MRBCA PROCESS

5.1 INTRODUCTION

This section presents:

- An explanation of the data necessary to implement the MRBCA process for petroleum underground and above ground storage tank (UST/AST) sites,
- A brief discussion of the techniques used to collect the data, and
- A description of the manner in which the data should be documented and reported to MDNR.

The data discussed herein will typically be collected subsequent to the confirmation of a release as part of the initial and comprehensive site characterization efforts. The objective of the data collection effort is to ensure that data of sufficient quality and quantity are available to:

- Develop a site conceptual model,
- Compare maximum site concentrations with the default target levels (DTLs, see Table 3-1),
- Compare representative concentrations or, for surficial soil under residential use, maximum concentrations, with Tier 1 risk-based target levels (RBTLs, see Tables 7-1through 7-6(c)),
- Develop Tier 2 and Tier 3 site-specific target levels (SSTLs), if necessary,
- Compare the SSTLs with representative (or maximum, as discussed above) chemical of concern (COC) concentrations, and
- Develop a Corrective Action Plan (CAP), if necessary.

The risk assessment should be completed only after all relevant data has been collected and a site conceptual model has been developed.

To accomplish the above objectives, the following information is required:

- Chronology of site events,
- Nature, magnitude, and location of spill or release (including identification of COCs),
- Site information (e.g., physical features, land use, etc.),
- Adjacent land use and receptor information,
- Vadose zone soil characteristics,
- Saturated zone and groundwater characteristics,
- Characteristics of nearby surface water bodies,
- Distribution of the COCs in soil,
- Distribution of the COCs in groundwater, and

- Information about corrective action measures ~~or risk management activities~~ that have been conducted and are planned.

Note: Additional data beyond that discussed herein might be required to develop a ~~RMP~~ Corrective Action Plan (CAP) or to complete a Tier 3 risk assessment. For instance, the collection of natural attenuation parameters or data from vapor extraction or pump and treat pilot tests might be required to design an active remediation system. Due to the variability in the type of data that might be needed, the collection of this type of data is not discussed here. Rather, requirements for and collection of such data will be determined on a site-specific basis.

5.2 CHRONOLOGY OF SITE EVENTS

~~At some UST/AST sites, numerous site investigations, monitoring events, system removal activities, and remediation activities might have been conducted. These activities would typically have occurred over an extended period of time, perhaps several years.~~ As part of the MRBCA evaluation, the person undertaking the evaluation must carefully review all existing data and identify any data gaps. ~~As appropriate, a work plan to fill in the data gaps shall be prepared and submitted to MDNR for approval prior to implementation.~~ Only after all the necessary data have been collected and full site characterization is complete should the person undertaking the evaluation proceed with the development of target levels.

The first step in the MRBCA evaluation is to develop a comprehensive chronology of events related to the aforementioned activities. A chronology of events will help create a comprehensive picture of the activities conducted at the site and identify gaps in those activities. The chronology shall include information regarding events such as:

- The date tanks were installed, removed and/or upgraded,
- Whether any contaminated soil was excavated and disposed of off-site,
- Date(s) when monitoring wells were drilled, sampled and gauged,
- Date(s) when soil samples were collected, and
- Dates when remedial activities were conducted.

Note that the intent of this exercise is to develop a clear understanding of historic site activities as they may impact current and potential future risk. Development of the chronology is not the "end in itself," but rather a means to understand site conditions.

5.3 NATURE, MAGNITUDE, AND LOCATION OF RELEASE

Knowledge about the nature, location, and magnitude of a release(s) is necessary to (i) identify the soil and/or the groundwater source(s) at the site, and (ii) identify the COCs. The person performing the work shall collect as much of the following information as is available for each release that has occurred at the site:

- Location and date of the release,

- Quantity of the release,
- Type of product released, and
- Any interim corrective action measures already performed with respect to each release.

Release-related information can be obtained by a variety of means, including (i) reviewing inventory records, (ii) interviewing past and current on-site employees, and (iii) reviewing historic spill incident reports filed with MDNR.

5.3.1 Location and Date of Release

Identifying the location of a release helps define the soil and groundwater source area(s). Likely release locations at petroleum UST sites include (i) corroded or damaged tanks, (ii) piping, especially at pipe bends and joints, (iii) dispenser islands, and (iv) accidental releases while filling the USTs/ASTs. A release may occur within the surficial soil (0-3 feet below the ground surface (bgs)), subsurface soil (from 3 feet bgs to the water table), or, if the groundwater is shallow (less than about 15 feet bgs), below the water table.

Identifying the date of a release is necessary to identify the COCs, as discussed in Section 5.3.3 (the COCs are listed in Table 5-1). Based on the chronology, the entity performing the work shall review the operational history of the site to determine the location and date of the release(s). Often the exact location and date of the release will not be known. In such cases, soil and groundwater sampling (including field screening using a photoionization detector (PID) and visual observations) shall be used to identify the likely location and extent (vertical and horizontal) of the soil and groundwater sources. The exact number and location of samples to be collected will be determined on a case-by-case basis using professional judgement. Sampling plans must be approved by MDNR prior to implementation.

5.3.2 Quantity of Release

The MRBCA process does not necessarily require knowledge of the exact quantity of the released petroleum. Often this information is not known. However, having a general idea of the amount released can assist in evaluating the severity of soil and groundwater contamination and the extent of the residual source. Information regarding the amount released is typically based on inventory records.

5.3.3 Product Released and Chemicals of Concern

MDNR's Tanks Section regulates releases of "regulated substances" from USTs and ASTs used for the sale of petroleum products. "Regulated substances" are defined as "petroleum, including crude oil or any fraction thereof, which is liquid at standard conditions of temperature and pressure, sixty degrees Fahrenheit and fourteen and seven-tenths pounds per square inch absolute, respective." (Section 319.00 RSMo). This may include:

- Gasoline,
- Diesel/Light Fuel Oils,
- Jet Fuel,
- Kerosene, or
- Used Oil.

Knowing what was released can simplify the process of identifying relevant COCs.

Each of the products listed above is a mixture of numerous hydrocarbon compounds and additives whose physical and chemical properties and percent composition vary. The environmental behavior (mobility, persistence, and inter-media transport) of these products and any adverse environmental and human health effects depend on (i) the properties of the individual compounds, (ii) their concentration in the product, and (iii) their degradation by-products and analogous compounds. Table 5-2 presents the range and average weight percent of a few of the constituents of different products.

The MRBCA process focuses on a limited set of chemicals specific to various petroleum products that pose the greatest risks to human health and the environment. These are known as the **chemicals of concern (COCs)**. Table 5-1 lists the major products and the corresponding COCs for which the impacted soil and groundwater shall be sampled and for which target levels shall be developed. Figure 5-1 is a flowchart that can be used to identify COCs. Depending on the petroleum product released, soil and groundwater samples at a site must be sampled for the COCs indicated in Figure 5-1 using the analytical methods listed in Table 5-1. Excluding COCs or using analytical methods other than those specified in Table 5-1 is allowed only with prior approval of MDNR. For releases other than gasoline, samples with detectable levels of total petroleum hydrocarbon-diesel range organic (TPH-DRO) or total petroleum hydrocarbon-oil range organic (TPH-ORO) shall also be analyzed for the polynuclear aromatic hydrocarbons (PAHs) listed on Table 5-1. The intent here is to identify site-related PAHs, hence additional sampling may be necessary to distinguish between site-related and background PAHs.

If the release at a site can be identified as consisting of a single product based on release reports, free product analysis, or location of impacts (e.g. the bottom of a particular product tank), COCs for that product only need be analyzed. If the product spilled or released cannot be conclusively identified based on these methods, then COCs corresponding to all products known or suspected to have been stored at the site shall be included in the initial analysis. Once the product or the COCs have been identified, the list of parameters for which samples are analyzed may be modified accordingly.

If data collected in the past does not include all the suspected COCs at a site, additional sampling might be necessary to quantitatively evaluate the missing COCs. The need to do so will be determined on a case-by-case basis.

5.3.4 Interim Corrective Actions

Typical interim corrective actions include the excavation and off-site disposal of contaminated soil, removal of free product, soil vapor extraction, and pump and treat. Interim corrective actions performed at a site could have removed all or part of the product spilled or released. Therefore, soil and groundwater data collected prior to the completion of such activities might not be representative of current conditions and shall not be used in the site risk assessment. At such sites, additional soil and groundwater concentration data representative of current conditions shall be collected after the completion of the interim corrective action. Data collected prior to the completion of interim corrective action may be used to determine where additional data shall be collected.

5.4 SITE INFORMATION

The following information is necessary to complete the MRBCA evaluation:

- An area map
- A land use map
- A site map,
- An understanding of ground surface conditions,
- Location of utilities on and adjacent to the site,
- On-site and nearby off-site groundwater use, and
- Regional hydrogeology and aquifer characteristics.

A brief discussion of each of the above items is presented below. Note that relevant site information can be obtained by various means, including (i) a site visit, (ii) review of engineering drawings showing the layout of the site, (iii) review of regional information, and (iv) review of files at MDNR related to the site or adjacent sites.

5.4.1 Required Maps

An area map shall be prepared using a United States Geological Survey (USGS) 7 ½ minute scale topographic map as a base. The site location should be centered on the topographic map and clearly marked.

A land use map shall be prepared documenting the results of the Land Use Survey. The map shall identify all structures and roads within a 500 foot radius from the tank system (refer to Subsection 6.1.1.1 for information on how to identify and describe land uses on the map).

A detailed map of the tank site showing property boundaries and the layout of past and current site features such as USTs, ASTs, piping, dispenser islands, paved and unpaved areas, canopy, station building, etc. shall be prepared. The map shall also show the locations of (i) on-site monitoring wells (including those that have been abandoned, lost or destroyed), (ii) water wells (public and private), (iii) soil borings, (iv) soil vapor extraction wells, (v) soil excavation areas, and (vi) area of release (refer to Section 5.8). As appropriate, multiple maps showing these features may be prepared. Site maps shall be made to scale, with a bar scale and a north arrow. MDNR will reject maps that are not to scale or without a north arrow.

5.4.2 Ground Surface Conditions

Determine the portion of the site that is paved, unpaved, or landscaped. Note the type, extent, and general condition of the pavement, and describe the unpaved areas (e.g., vegetated, gravel, bare soil, etc.). Determine the direction in which the surface is sloping and note relevant topographic site features (e.g., swales, drainage ditches, etc.).

5.4.3 Location of Utilities On and Adjacent to the Site

Due to the potential for preferential flow of impacted groundwater and vapors into underground utility lines/conduits, a thorough assessment of potential and actual migration and impact of COCs to underground utilities must be performed. Utilities include, but are not limited to, phone lines, water lines, sanitary sewers, storm sewers, and natural gas lines. A combination of site observations, knowledge of buried utilities, and discussions with utility representatives and the site owner shall be used to determine the locations of site utilities. At a minimum, perform the following:

- Locate all underground utility lines and conduits within the area of known or likely soil and groundwater impact, both on-site and off-site, where the release may have migrated or may migrate in the future.
- Determine the direction of flow in the utilities (water, storm water, and sewage).
- Identify the utility lines/conduits on a base map that also shows the extent and thickness of free product, if any, and soil and groundwater contamination.
- Determine depth of the utility lines/conduits relative to the depth of groundwater. Seasonal fluctuations of the groundwater levels (relative to the depth of utilities) shall be carefully evaluated. Where such would assist in the evaluation and understanding of site conditions, a cross-sectional diagram shall be provided illustrating the depth to groundwater and the locations and depths of the utility lines/conduits. At a minimum, a cross-section diagram would be required at sites where deeper water bearing zones are used for drinking water and where utilities may be preferential pathways.
- Determine the types of materials used for lines/conduits (i.e., PVC, terra-cotta, concrete, steel, etc.) and backfill around the utilities.
- Determine any past impacts to utilities and whether any complaints have been previously filed with MDNR or the property owner.
- As appropriate, sample the utilities and vaults using either an explosimeter, PID, or organic vapor monitor (OVM) or by taking air samples. If explosive conditions are encountered, immediately inform the local fire department and MDNR (contact MDNR at (573) 634-2436).

- Where a utility is threatened, or where the possibility of an explosion exists, appropriate measures to eliminate fire, explosive, and vapor hazards must be undertaken immediately.

5.4.4 On-site Groundwater Use

The current and former site owners and operators should be interviewed to determine whether a water well is/was located on site. If a water well is identified, construction details of the well shall be obtained to the extent such are available. At a minimum, the total depth of the well, screen (if present) interval, and the use of water from the well shall be determined. If such a well is identified and is not currently in use or likely to be used in the future, it shall be properly abandoned in accordance with MDNR requirements, unless it is to be used for future sampling as part of a corrective action plan for the site. In addition to water wells, dewatering wells on or adjacent to the facility shall also be identified.

5.4.5 Regional Hydrogeology and Aquifer Characteristics

Published literature, especially USGS publications and United States Department of Agriculture (USDA) soil surveys, and reports for any investigations conducted at adjacent or nearby release sites, shall be reviewed to determine regional hydrogeology, soil types, and aquifer characteristics. This evaluation shall be used to determine the type and depth of aquifers in the area and whether they are confined, semi-confined, or unconfined. General aquifer characteristics such as yield and total dissolved solids will help determine whether the groundwater ingestion exposure pathway is a concern. Regional information will assist the entity conducting the work to better understand site-specific soil and groundwater conditions.

Two valuable ~~A valuable~~ sources of regional hydrogeology and aquifer characteristic information are the Well Information System, which contains all records of known wells in Missouri and is available at http://dnr.mo.gov/mowells/publicLanding.do, and “CARES” maps, available at http://ims.missouri.edu/moims/step1.aoi/countylist.asp. ~~is the Missouri Environmental Geology Atlas (MEGA) developed by MDNR in association with the Missouri Petroleum Storage Tank Insurance Fund (PSTIF). Data can be obtained from MDNR’s Geological Survey & Resource Assessment Division at (573) 368-2101;~~.

The review discussed above shall also locate surface water bodies (e.g., creeks, lakes, rivers, etc.), seeps, and springs within 500 feet of the site (unless MDNR requires a different distance based on site conditions) that could be or are affected by the site release. If a surface water body is identified and it is determined that it may be impacted by site-specific COCs, collect information regarding the type (perennial vs. intermittent), flow rate, flow direction, depth, width, and use of the surface water body. The water body must be identified on the area map discussed at 5.4.1. In karst areas, MDNR may require that the minimum search area radius be increased and the identification of springs, seeps, sink holes, and other karst features be included.

5.5 ON-SITE AND OFF-SITE LAND USE AND RECEPTOR INFORMATION

Land use information is used to identify the (i) location and type of receptors, (ii) routes of exposure by which the receptors might be exposed to the COCs, and (iii) presence of any activity and use limitations (AULs) pertaining to the site. This information is critical in developing a site exposure model as discussed in Section 6.1. The following information shall be collected:

- Current land use,
- Potential future land use,
- Local ordinances and restrictions that affect land use and/or groundwater use,
- Water well survey, and
- Ecological receptor survey.

A land use and receptor survey covering a radius of 500 feet from the area of release will generally be adequate. At sites where the plume might be much longer due to the magnitude of the spill or other site-specific conditions, MDNR may require that the minimum survey radius be increased and will require submittal of a land use map covering the entire impacted and potentially impacted area.

5.5.1 Water Well Survey

A water well survey shall be conducted to locate all public water supply wells within an approximately one-mile radius of the site and all private water wells within an approximately quarter-mile radius of the site. Information sources include the USGS, the Missouri Environmental Geology Atlas (available from GSRADMDNR's Missouri Geological Survey), water system operators, and interviews with local residents. In areas where private water use wells are likely, MDNR may require that a door-to-door survey of businesses and residents within a quarter-mile radius of the site be conducted. To the extent such information is available, well characteristics including age, depth to water and total well depth, water use, screen (if present) interval, construction, depth of casing(s), and mode of operation (continuous vs. intermittent) shall be documented.

5.5.2 Ecological Receptor Survey

Ecological receptors include both specific species and general populations of flora and fauna and their habitats, including, but not limited to, wetlands, surface water bodies, sensitive habitats, and endangered species. The checklist included as Attachment A to this section must be completed for each site, except those where initial sampling indicates concentrations of COCs are below the DTLs and the site poses no obvious threat to ecological receptors. If the answer to any of the questions on the checklist at Attachment A is yes, then the Attachment B checklist must also be completed. These checklists are located at the end of this chapter. Completion of either checklist might require that the area within an approximately 500-foot radius of the site be visually surveyed for specific ecological receptor criteria as identified on the checklists. MDNR will require that such a survey be conducted if the checklists cannot be completed based on existing information.

For any site where ecological receptors might be affected by contamination from a site being evaluated under this guidance, as determined by completion of the checklists in Attachments A and B, consultation with MDNR will be required. Refer to Section 6.6 for further information regarding ecological receptor evaluations.

5.6 VADOSE ZONE SOIL CHARACTERISTICS

Vadose zone soil is the media through which COCs migrate to groundwater and vapors move upward to the ambient air or into an enclosed space. The following vadose zone parameters and their variability across the impacted area significantly affect the movement of chemicals through vadose zone soil:

- Thickness of vadose zone and depth to groundwater,
- Porosity,
- Water content,
- Fractional organic carbon content, and
- Bulk density.

In developing the DTLs and Tier 1 RBTLs, MDNR assigned conservative values to these parameters as shown in Table B-4. For Tier 2 and Tier 3 risk assessments, these parameters may be assigned site-specific values based on data collected from the site.

Please note: When collecting site-specific geotechnical data (i.e., volumetric water content, fractional organic carbon, bulk density, and porosity), careful consideration must be given to the location of contaminants relative to receptors and the effect of the specific geotechnical parameter on transport of the contaminant to a receptor. For instance, to develop SSTLs for the vapor intrusion pathway, geotechnical data from the soil zone between the area of impact and the receptor (e.g., building foundation) is needed to properly assess the degree to which volumetric water content and fractional organic carbon impede the upward transport of vapors. However, to develop SSTLs for the leaching pathways, the geotechnical data of most relevance are from the zone below the area of soil impact. These types of considerations must be kept in mind when collecting and using geotechnical soil data.

In the event that circumstances at a site are such that the geotechnical properties discussed below cannot be determined because of sampling limitations, the evaluator shall use appropriate, justifiable literature values. Where such literature values cannot be found or do not exist, the evaluator shall contact MDNR's Tanks Section.

5.6.1 Thickness of Vadose Zone and Depth to Groundwater

The thickness of the vadose zone can be determined from boring logs and is representative of the distance from the ground surface to the top of the water table, not including the thickness of the capillary fringe. Depth to groundwater is used in estimating the vapor emissions from groundwater and to determine the vadose zone dilution attenuation factor.

Where the water table fluctuates considerably, available data shall be evaluated to determine whether the fluctuations are seasonal or represent a consistent upward or downward regional trend. For sites with seasonal fluctuations, average thickness of the vadose zone (as determined by groundwater elevation measurements) must be used in developing Tier 2 SSTLs. At sites with a consistent upward or downward water level trend, the most recent data will be used to estimate the depth to groundwater.

Generally, collection of samples for the four parameters discussed below will require the advancement of more than one boring or probe, depending on site conditions and recovery volumes. Ultimately the number of borings or probes advanced to obtain adequate samples for these parameters will be a site-specific decision of the driller and environmental consultant based on professional experience and judgment. Boring logs must be detailed, accurate, and carefully reviewed. Each soil type must be identified and geotechnical characteristics for that soil type must be determined.

Note that in situations where undisturbed samples cannot practically be collected but disturbed samples can be, samples should be collected for those parameters not requiring an undisturbed sample (i.e., fractional organic carbon, gravimetric water content, and particle density [a value required for determining porosity]).

5.6.2 Dry Bulk Density (g/cc)

Dry bulk density is the dry weight of a soil sample divided by its field volume. An accurate measurement of bulk density requires determining the dry weight and volume of an undisturbed sample. An undisturbed soil core sample may be collected using a Shelby tube, a thin-walled sampler, or an equivalent method. The sample must not be disturbed prior to laboratory analysis.

Dry bulk density is estimated using the American Society for Testing and Materials (ASTM) Method D2937-94, "Standard Test Method for Density of Soil in Place by the Drive-Cylinder Method."

5.6.3 Porosity (cc/cc-soil)

Porosity is the ratio of the volume of voids to the volume of the soil sample. Many laboratories use dry bulk density and specific gravity to calculate porosity using the following:

$$n = 1 - \rho_b/\rho_s \qquad (5\text{-}1)$$

where,

n = porosity (cc/cc)

ρ_b = dry bulk density (g/cc)

ρ_s = specific gravity or particle density (g/cc).

Thus, specific gravity and dry soil bulk density are needed to estimate porosity.

The “Standard Test Method for Specific Gravity of Soil,” ASTM Method D854, may be used to determine specific gravity. If specific gravity or particle density is not available, then 2.65 g/cc can be assumed for most mineral soils. Note, however, that use of this value must be justified.

If a site-specific porosity value cannot be determined, literature values consistent with the site lithology may be used, provided the source(s) of the value(s) is cited and appropriately justified. Where the total and effective porosities differ, the effective porosity value must be used.

5.6.4 Volumetric Water Content/Moisture Content (cc/cc)

Volumetric water content is the ratio of the volume of water to the volume of soil. ASTM Method D2216-92, “Standard Test Method for Laboratory Determination of Water [Moisture] Content of Soil and Rock,” is a gravimetric oven drying method that may be used to measure the water content of vadose zone soils. However, the water content value used in most models is the volumetric water content. Hence, if a gravimetric method is used to measure water content, the following conversion equation should be used to obtain the volumetric value:

$$\theta_{wv} = \theta_{wg} \times \frac{\rho_b}{\rho_l} \qquad (5\text{-}2)$$

where,

θ_{wv} = volumetric water content (cc water / cc soil)
θ_{wg} = gravimetric water content, typically reported by the laboratory (g of water / g of soil)
ρ_b = dry bulk density (g of dry soil/cc of soil)
ρ_l = density of water (g/cc).

Multiple samples from across the site and at varying depths must be analyzed for water content to estimate a representative water content value for the vadose zone. To accomplish this, each soil sample analyzed for one or more COCs must be analyzed for water content; since the lab must provide COC concentrations on a dry weight basis, water content data are readily available for these samples. In addition, water content values representative of each of the lithologic units that comprise the vadose zone must be determined.

Water content data should be carefully reviewed prior to being used to calculate Tier 2 SSTLs. The VWC of a sample cannot exceed the porosity of that same sample or another sample collected from the same soil. If the laboratory report indicates this to be the case, the consultant should make inquiry of the lab to determine which value is in error.

Refer to Subsection 5.8 for developing a sampling plan ~~for VWC~~. Because VWC varies over time most significantly in surficial soil, VWC data should not be collected from surficial soil (i.e., 0 – 3’) except when the foundation of an existing building is less than 3’ deep.

5.6.5 Fractional Organic Carbon Content in Soil (g-C/g-soil)

Fractional organic carbon (FOC) content is the weight of organic carbon in the soil divided by the weight of the soil and is expressed either as a ratio or as a percent. FOC must be determined using soil samples not impacted by petroleum or other anthropogenic chemicals. Therefore, FOC samples must be collected from soil borings or probe holes away from areas of contamination. Prior to collecting samples for FOC analysis, a PID reading should be taken to confirm that the sample has not been impacted by petroleum products or other anthropogenic contaminants. As an alternative, lab data from the same boring or a nearby boring may be used to confirm that contamination is not present.

Unless drinking water or vapor intrusion risks are being evaluated at a point of exposure outside the area of impact and the saturated zone has a different type of soil than the vadose zone, no soil samples from the saturated zone need be collected for FOC analysis.

Data from multiple borings or probe holes from non-impacted locations are required to accurately determine FOC for the site. In addition, multiple samples from each boring or probe hole may be required if there are different types of soils in the vadose zone.

Prior to shipping samples to the lab for analysis, subsamples of the same soil type collected from different borings or probes may be combined into a single composite sample for laboratory analysis. For instance, if three different soil types underlie a site and a sample of each is collected from four different borings, the samples from each soil type may be combined into a single composite sample for that soil type. This would result in three samples for FOC analysis rather than twelve.

Fractional organic carbon content may be estimated using the Walkley Black Method (Page et al., 1982) or the method outlined in *Determination of Total Organic Carbon in Sediment (Lloyd Kahn Method)*, July 27, 1988, a copy of which is found at the end of this section of the guidance, or a similar method. However, some labs may not be familiar with these methods. If the lab is not equipped to conduct either of these methods, an alternative, though less preferred, method is ASTM Method 2974 (*Standard Test Method for Moisture, Ash, and Organic Matter of Peat and Other Organic Soils*). Method 2974 measures the organic matter content of a sample. When using the method, the result must be divided by 1.724 to get fractional organic carbon content. If the laboratory results are reported as a percent, fractional organic carbon content may be obtained by dividing by 100. The FOC analytical method must be identified in the site characterization report submitted to MDNR.

FOC analytical data should be carefully reviewed prior to being used to calculate Tier 2 SSTLs and prior to submission to MDNR. Data indicating unexpectedly high FOC should be verified through discussion with the analytical laboratory and, if warranted, via collection and analysis of additional samples.

5.7 SATURATED ZONE CHARACTERISTICS

COCs that reach the water table primarily travel horizontally in the saturated zone. Vertical transport is also possible when a vertical gradient exists between shallow and deeper saturated zones. Saturated zone characteristics that determine the travel time for the COCs as well as the travel direction include:

- Horizontal hydraulic conductivity,
- Hydraulic gradients (magnitude and direction),
- Saturated zone soil characteristics (fractional organic carbon content, porosity, and bulk density), and
- Occurrence and rate of biodegradation.

Of the four characteristics mentioned above, the most important aquifer properties are horizontal hydraulic conductivity and hydraulic gradient. Each of these is discussed below, along with a brief discussion regarding the capillary fringe.

Note that quantification of the above characteristics will be required only at sites where it is necessary to quantify the movement of water or the COCs by using a model. If a quantitative evaluation is not necessary, a qualitative understanding of these parameters is sufficient.

5.7.1 Hydraulic Conductivity (cm/sec)

Hydraulic conductivity is the discharge of water per unit area per unit hydraulic gradient in a subsurface formation. Reliable estimates of site-specific hydraulic conductivity can be obtained by pump tests or slug tests. In the absence of these tests, literature values corresponding to the type of soil in the saturated zone may be used. When a literature value is used, adequate reference and justification for the value chosen must be provided. When using literature values, all predominant soil types composing the saturated zone must be considered. Hydraulic conductivity may also be estimated based on the grain size distribution of the porous formation.

5.7.2 Hydraulic Gradient (cm/cm)

The magnitude and direction of the hydraulic gradient is estimated by comparing water levels measured in monitoring wells across a site. A contour map shall be prepared, either manually or using a computer program, using field measured water level data. These contour maps can be used to estimate both the direction and magnitude of the hydraulic gradient. When drawing the contour maps, care shall be taken to ensure that measurements from monitoring wells screened in the same interval or hydrologic unit are used. For sites where wells are screened in multiple zones, a contour map for each zone shall be developed. For sites that have seasonal variation in hydraulic gradient and/or predominant flow direction, estimate the average hydraulic gradient for each season and each flow direction.

At sites where a "deeper" groundwater zone is used as a water supply, vertical gradients must also be determined via a comparison of water levels in adjacent wells screened in different intervals. MDNR will consider exceptions to this requirement on a site-specific basis.

5.7.3 Thickness of Capillary Fringe (cm)

The capillary fringe is the zone immediately above the saturated zone where capillary attraction causes upward movement of water molecules from the saturated zone into the soil above. This zone is distinct in that it has characteristics of both the vadose and saturated zones. For purposes of the MRBCA process, the thickness or height of the capillary fringe must be measured or a default value used. Because accurate field measurement of the thickness of the capillary fringe can be difficult, literature values based on the soil type immediately above the water table may be used to assign a site-specific value for the capillary fringe thickness.

5.7.4 Saturated Zone Soil Characteristics

The saturated zone soil characteristics include fractional organic carbon content, porosity, and bulk density. These parameters are required to estimate the retardation factor that "slows" the movement of chemicals within the saturated zone and are also useful when estimating future concentrations using models that include a finite source and/or biodecay. The laboratory methods to measure these parameters have been discussed in Section 5.6.

5.7.5 Occurrence and Rate of Biodegradation

By measuring several indicators (chemical concentrations, geo-chemical indicators, electron acceptors, microorganisms, carbon dioxide, etc.), the occurrence of natural attenuation can be measured at a site. These indicators can be broadly classified into three groups: (i) primary, (ii) secondary, and (iii) tertiary lines of evidence. The collection of biodegradation data need not occur at every site. Generally, this data will be required only when biodegradation is a principal element of the RMP. Data collected under each line of evidence is used to qualitatively evaluate the occurrence of biodegradation.

- The primary line of evidence is developed by demonstrating that reductions in chemical concentrations are occurring at a site via the evaluation of COC concentrations in groundwater. The primary line of evidence is best determined by (i) plotting concentrations of COCs as a function of distance along the plume center line, (ii) plotting concentrations of COCs in each well as a function of time, and (iii) comparing COC concentration contour maps at various times.

- The secondary line of evidence involves measuring geo-chemical indicators including (i) dissolved oxygen, (ii) dissolved nitrates, (iii) manganese, (iv) ferrous iron, (v) sulfate, and (vi) methane. These indicators shall be measured in at least three wells located along the plume flow line. The wells must be located to represent conditions at (i) a background or upgradient location, (ii) an area within the plume near the source, and (iii) an area within the plume downgradient of the source. Developing a secondary line of evidence is necessary when the primary line of evidence is inconclusive, or when such information is necessary to design a remedial system (e.g., the addition of oxygen).

- Developing a tertiary line of evidence involves identifying and quantifying microorganisms within and near the plume via the performance of microbiological studies. A tertiary line of evidence is seldom developed at petroleum hydrocarbon impacted sites. MDNR has found that, in most cases, microbial populations at sites having petroleum contamination are adequate.

The commonly used methods to estimate biodegradation include (i) mass balance analysis for expanding, stable, or shrinking plumes and (ii) plume concentration vs. distance plots.

At most UST/AST sites, the development of secondary and tertiary lines of evidence is usually not necessary. However, at most sites, groundwater sampling data should be plotted to evaluate temporal trends. These trends can be used to determine whether the plume is expanding, stable, or decreasing. MDNR will require that the groundwater plume be stable or decreasing prior to issuing a No Further Action (NFA).

5.8 DISTRIBUTION OF COCs IN SOIL

The objective of soil characterization is to (i) delineate the extent of site-related COCs, (ii) compare representative concentrations, or, for surficial soil at a residential site, maximum concentrations, for each complete pathway to the target levels, and (iii) define the area of release in the event that fate and transport modeling is necessary.

Within the MRBCA program, distinction is made between surficial soil and subsurface soil. Surficial soil is defined as soil extending from the surface to 3 feet below the ground surface (bgs). Subsurface soil is defined as soil that extends from 3 ft bgs to the top of the water table. A key difference between surface and subsurface soil is that, for surficial soil, the direct contact pathway (ingestion, dermal contact, and inhalation of vapors and particulates) is considered complete for both the residential and non-residential receptors. For the subsurface soil, this pathway is considered incomplete for the subsurface soil except for the construction worker who may be involved in excavation activities below the surficial zone and hence come in direct contact with subsurface soil. In fact, for the construction worker, no distinction is made between the surface and subsurface soil.

Because of the differences in exposure pathways for surface and subsurface soils, an adequate number of soil samples from each zone has to be collected to meet the soil characterization objectives listed above. Surficial soil (as well as subsurface soil) may include fill material - the distinction between surface and subsurface soil is one of depth rather than composition.

Note that, when volatile organic compounds (VOCs) are COCs at a site, soil samples for VOC analysis must be collected and analyzed in accordance with SW-846 Method 5035.

The following discussion is intended to assist the person conducting the work in determining where soil samples shall be collected.

5.8.1 Delineation Criteria, Area of Release, and Point of Release

The underlying basis of delineation is that chemical impacts at a site should be delineated to levels that are protective of human health and the environment. To the extent that COC concentrations protective of human health and the environment depend on the complete routes of exposure, the delineation criteria depend on land use. Because delineation is necessary to develop risk-based target levels, some iteration in delineation sampling may be necessary.

The delineation criteria are the lowest MRBCA Tier 1 RBTLs for each media. For soils these levels depend on the land use (residential vs. non-residential). Note that target levels for surface soils (0-3 ft bgs) are different than target levels for subsurface soils (>3 ft bgs). Note also that, when delineation criteria are lower than the Required Reporting Limits (RRLs) listed in Table 5-3, the RRLs or, if lower, the detection limits of the laboratory conducting the analysis, shall be considered as the delineation criteria.

As applicable, the Tier 1 values in Table 7-1, 7-2, 7-4(a), 7-4(b), 7-4(c), or 3-1 may be used as delineation criteria. If the Tier 1 target levels change, MDNR may adjust the delineation criteria.

To determine the applicable delineation criteria at a site the following three steps are necessary:

Step 1: Develop a land use map and determine what land uses (residential or non-residential) apply to on and off-site properties (refer to Sections 5.5.1 and 5.5.2, and Figure 5-2).

Step 2: Determine whether the groundwater ingestion pathway is complete (under both current and reasonably anticipated future use of the property) for the zones where groundwater is or will be impacted (refer to Section 6.3).

Step 3: Based on the above steps, select soil delineation levels for the COCs listed in Table 5-1 that are applicable to the site.

As discussed in Section 5.3.3, COCs depend on the product released. While, typically benzene, methyl tert-butyl ether (MTBE), and total petroleum hydrocarbon-gasoline range organic (TPH-GRO) will be the primary drivers, delineation is required for all applicable COCs.

A few examples for determining delineation criteria are presented below:

- If the land use both on-site and off-site is non-residential, use non-residential delineation criteria.
- If the land use both on-site and off-site is residential, use residential delineation.
- If either the on-site or the adjacent off-site land use is residential, use residential delineation criteria.

Once the delineation criteria have been established, the number of samples to be collected horizontally and vertically depends on the area of release and the point of release. These terms are defined below:

Area of Release: The vadose zone area through which petroleum product migrated from the point of release to the capillary fringe and the water table below. In the area of release, COC concentrations are elevated in the vadose zone below the point of release and laterally where the petroleum migrated through the soil.

Point of Release: This is the specific location within the area of release at which petroleum product was released to the environment. Typical points of release include holes in USTs, pipe joints or connections, pump island connections, AST spill drains, and fill ports.

Professional judgment is frequently required in determining the point of release.

5.8.2 Determining Area of Release

Step 1: Initially, review site information and site history to make reasonable judgments about the area(s) of release. Within each area of release, identify the point of release and locate a boring at this point. If the point of release within an area cannot be determined, locate the boring near the center of the release area. If the point of release is an active tank or piping run, locating a boring immediately adjacent to the tank or piping might not be practical for safety reasons. In such cases, locate the point of release boring as close to the tank or piping run as is safely possible[1].

Step 2: From the point of release identified in Step 1, step out 25 feet in four opposing directions (e.g., south, north, east, west or southeast, northwest, northeast, southwest, etc.) and install 4 more borings. While installing each boring, screen soil samples continuously with a PID to determine whether or not the boring is within the area of release. This step will require professional judgment of field screening results (e.g., PID readings, evidence of soil staining, perception of odors, etc). If the results of field screening indicate that one or more of the borings are still within the area of release, step out in the same direction another 25 feet from the point of release boring (i.e. it will not be necessary to step out in all directions) and install another boring, screening the core samples as the boring is advanced. Continue to step out in this manner until borings are

[1] All borings and probe holes 10 feet deep or deeper must be properly plugged in accordance with 10 CSR 23-4.

outside the release area in all directions. Using this protocol, some borings will be within the area of release and some will not. Note that, depending on the distance from the point of release to the edge of the area of release, additional borings might be needed to provide data for the areas between the step-out borings. The number of soil samples collected in each boring shall be determined as follows.

Soil Sampling at the Point of Release

To determine the vertical extent of COCs at each boring or probe advanced at a point of release, four soil samples shall be collected for laboratory analysis as follows:

- In each boring or probe, continuously conduct field screening (using a PID for releases of gasoline and PID and sight and smell for heavier petroleum products). Continue field screening, below the water table if necessary, until PID readings at two consecutive intervals are at or below background levels.
- Collect one soil sample from the 0 to 3' interval (at the point of release, this sample is collected regardless of field screening results).
- Collect one sample from the interval between 3' and the top of the water table, choosing the sample from the interval where field screening indicates COC levels are at their maximum.
- Collect one sample at the interface of the vadose and saturated zones i.e., within the capillary fringe.
- Collect one sample below the water table from the interval where field screening indicates COC levels are at their maximum.

At sites where bedrock is encountered before reaching the water table, collect a sample at the soil/bedrock interface.

Borings Away from Point of Release but within Area of Release

Borings or probes advanced away from the point of release but within the area of release should be sampled as discussed above for the point of release, except that a sample need not be collected from the 0 to 3' interval unless field screening indicates COC levels are elevated in the interval.

Borings Outside the Area of Release

Soil samples for laboratory analysis will be collected from soil borings and borings advanced for monitoring wells outside of the area of release as follows:

- Collect one sample at the interface of the vadose and saturated zones.
- Collect one sample below the water table from the interval where field screening indicates COC levels are at their maximum.
- Collect one sample from the interval between 3' and the top of the water table only if field screening indicates that elevated COC levels exist in the interval (contamination detected in this zone generally means the boring remains within

an area of release).

At sites where bedrock is encountered before reaching the water table, collect a sample at the soil/bedrock interface.

5.8.3 Sampling for Polynuclear Aromatic Hydrocarbons (PAHs) in Soil

As indicated in Table 5-1, analysis of all soil samples for naphthalene is required for all petroleum types, including gasoline; however, analysis for other PAHs is only required when it is known that diesel fuel, jet fuel, kerosene, heavy fuel oils, or waste oil were released, or when the type of petroleum released is unknown.

The following are required for all PAHs except naphthalene:

- PAH analysis for all surficial soil samples in which TPH-DRO or TPH-ORO is detected at a concentration above the laboratory detection limit or the RRL, whichever is lower.

- PAH analysis for a minimum of 25%, or two samples, whichever is greater, of all subsurface soil samples in which TPH-DRO or TPH-ORO is detected at a concentration above the laboratory detection limit or the RRL, whichever is lower. The samples that contain the highest concentrations of TPH-DRO or TPH-ORO must be the ones selected for PAH analysis, except that two samples from the same boring shall not be used.

- PAH analysis for all samples containing TPH-DRO or TPH-ORO at a concentration above the detection limit or RRL, whichever is lower, and which will be used to assess construction worker exposures.

5.8.4 Ethylene Dibromide (EDB) and Ethylene Dichloride (EDC) in Soil

When the product released was or could have been racing fuel, aviation gas, or leaded gasoline, soil samples must be analyzed for EDB and EDC. To determine whether leaded gasoline could have been released, MDNR will assume gasoline sold after December 31, 1986 was unleaded.

In these cases, Method 8260B or Method 8260B-SIM (Selected Ion Monitoring) shall be used, unless another method having detection limits at or below applicable target levels is approved by MDNR.

5.8.5 Soil Sampling and Analytical Methods

All soil sampling must be performed in accordance with the following procedures:

- Soil borings must be extended to the water table or to a specified depth, not less than 20 ft bgs, if water is not encountered and impacts are not observed; this assumes one does not encounter refusal at a shallower depth.

- Field screening shall be conducted at intervals of 2 to no more than 5 feet.
- Soil borings shall be logged . The logs at Figures 5-3(a) and (b) or an equivalent shall be used.
- Samples must be collected, preserved, and analyzed within proper holding times in accordance with the methods presented in Table 5-1, except as follows:
  - Samples to be analyzed for volatile COCs must be collected in accordance with SW846 Method 5035 unless a comparable alternative method is approved by MDNR. When using Method 5035, if the analyzing laboratory purges samples at a temperature equal to or above 80 degrees Celsius, the sample must be preserved using either trisodium phosphate dodecahydrate (TSP) followed by refrigeration or deionized water followed by freezing. Preservation must not result in the loss of volatile COCs.
- Adequate quality assurance/quality control (QA/QC) procedures must be utilized to ensure sample quality and integrity.
- QA/QC samples shall include surrogate and spike recovery and trip blanks whenever possible. The samples must not be cross-contaminated by drilling fluid or by drilling or sampling procedures.
- For samples requiring preservation by refrigeration, the chain of custody form for the samples must indicate the temperature at which the samples were received by the laboratory. MDNR may reject data for samples received by the laboratory at temperatures above 6˚C.
- All sampling equipment must be decontaminated using EPA and standard industry protocols.
- A chain of custody form must accompany all samples. A copy of the completed chain of custody must be submitted with all laboratory analytical reports. MDNR will not accept laboratory data that is not accompanied by a corresponding chain of custody.

5.9 DISTRIBUTION OF COCs IN GROUNDWATER

An adequate number of groundwater samples shall be collected to definitively delineate the extent of dissolved contaminant plumes in all directions and to allow representative COC concentrations to be calculated based on the exposure model. Soil source delineation should serve as a guide in choosing the location of monitoring wells.

5.9.1 Delineation of Groundwater Contamination

The delineation criteria for groundwater depend on whether the groundwater pathway for ingestion is complete or incomplete based on consideration of current and potential future ingestion of the groundwater. Where the groundwater pathway for ingestion is complete, delineation criteria will be the lower of (i) the maximum contaminant levels (MCLs) (in the absence of MCLs, risk-based concentrations that assume ingestion of groundwater and inhalation of vapors due to indoor water use), and (ii) land use-dependent concentrations protective of indoor inhalation.

For groundwater where the groundwater ingestion pathway is incomplete, the delineation criteria are based on the protection of indoor inhalation. The indoor inhalation-protective values depend on whether the land use is residential or non-residential.

Delineation of groundwater contamination should be in accordance with the following:

- At sites where groundwater is, or is reasonably likely to be, used as a source of drinking water, investigations must delineate the extent of groundwater contamination to the applicable MCLs or other relevant standards protective of drinking water or the standards protective of indoor inhalation of vapors, whichever are lower

- If the groundwater ingestion pathway is incomplete, at both residential and non-residential sites, investigations must delineate groundwater contamination to the groundwater target levels protective of land use-specific indoor inhalation.

5.9.2 Groundwater Sampling and Analytical Methods

If groundwater has been contaminated by COCs, temporary sampling points may be used to screen for groundwater contamination and to assist in determining the optimal location of monitoring wells. A sufficient number of monitoring wells shall be installed to fully define the groundwater plume and allow the direction of groundwater flow to be determined. Monitoring wells 10 feet deep and deeper must be installed in accordance with 10 CSR 23-4, and the following procedures:

- An adequate number of monitoring wells must be installed to sufficiently delineate the horizontal and vertical extents of the groundwater plume and the direction of groundwater flow. At a minimum, one monitoring well must be installed in the source area, one upgradient of the source area, and another downgradient of the source area.

- Well placement and design shall consider the concentration of COCs in the source area and the occurrence of light non-aqueous phase liquids (LNAPLs) at the site.

- Well casing and screen materials must be properly selected. The top of the screened interval must be set at least 2-3 feet (preferably 5 feet) above the water table, unless the water table is within 3 feet of the ground surface.

- Wells must be properly developed and gauged after installation.

- A site survey must be conducted to establish well elevations and, by that, groundwater elevations. Based on the groundwater elevations, groundwater flow direction and gradient shall be determined and plotted on a map of the site.

Groundwater samples must be collected in accordance with the following guidelines and procedures:

- Monitoring wells must be purged an adequate number of well volumes prior to collecting a sample, unless a no-purge or low purge sampling technique has been approved by MDNR.

- Samples must be collected utilizing US EPA approved methods and equipment.

- Samples must be adequately preserved according to the requirements of the laboratory analyses and extracted within holding times specified for each analytical method.

- Water samples to be analyzed for MTBE or the other oxygenates listed in Table 5-1 must be preserved with trisodium phosphate dodecahydrate (TSP), followed by refrigeration, or by deionized water followed by freezing, unless the analyzing laboratory purges samples at a temperature below 80 degrees Celsius.

- For samples requiring preservation by refrigeration, the chain of custody form for the samples must indicate the temperature at which the samples were received by the laboratory. MDNR may reject data for samples received by the laboratory at temperatures greater than 6˚C.

- Sample analyses must be conducted in accordance with current MDNR analytical requirements and US EPA Office of Solid Waste and Emergency Response SW846 Methods. Refer to Table 5-1 for a listing of the required analytical methods.

- Adequate QA/QC procedures must be utilized to ensure sample quality and integrity. QA/QC samples shall include surrogate, spike recovery, field blanks, and trip blanks.

- All sampling equipment must be decontaminated using US EPA and industry standard protocols.

- A chain of custody form must accompany all samples. A copy of the completed chain of custody must be submitted with all laboratory analytical reports. MDNR will not accept laboratory data that is not accompanied by a corresponding chain of custody.

- In most cases, for the first year after well installation, quarterly samples will be required. Subsequent monitoring schedules should be designed and proposed to MDNR as part of a site characterization or corrective action plan, with a defined objective and timeframe.

5.9.2.1 Sampling Groundwater for PAHs

As indicated in Table 5-1, analysis of all groundwater samples for naphthalene is required for all petroleum types, including gasoline; however, analysis for other PAHs is only required when it is known that diesel fuel, jet fuel, kerosene, heavy fuel oils, or waste oil were released, or when the type of petroleum released is unknown.

The following are required for all PAHs except naphthalene::

- Samples in which the concentration of TPH-DRO or TPH-ORO is below the laboratory detection limits or the RRLs in Table 5-3, whichever are lower, need not be analyzed for PAHs;

- A minimum of 25%, or two, whichever is greater, of groundwater samples having detectable TPH-DRO or TPH-ORO shall be analyzed for PAHs. Samples selected for PAH analysis shall be those that contain the highest concentrations of TPH-DRO or TPH-ORO; and

- All groundwater samples that will be used to assess construction worker exposure and which contain TPH-DRO or TPH-ORO at a concentration above the detection limit or RRL, whichever is lower, must be analyzed for PAHs.

In certain cases where the solubility of PAHs is or is expected to be increased due to the presence of other contaminants in soil and/or groundwater, a greater number of groundwater samples than specified above may need to be analyzed for PAHs.

5.9.2.2 Ethylene Dibromide (EDB) and Ethylene Dichloride (EDC) in Groundwater

When the product released was or could have been racing fuel, aviation gas, or leaded gasoline, and there is a complete exposure pathway for domestic use of groundwater, groundwater samples must be analyzed for EDB and EDC. To determine whether leaded gasoline could have been released, MDNR will assume gasoline sold after December 31, 1986 was unleaded.

In these cases, Method 8011 shall be used to analyze for EDB and Method 8260B or Method 8260B-SIM (Selective Ion Monitoring) shall be used to analyze for EDC, unless other methods having detection limits at or below applicable target levels are approved by MDNR.

5.9.3 Determination of Plume Stability

To assess plume stability, groundwater monitoring must be conducted for a period of time sufficient to show a reliably consistent trend in contaminant concentrations. For the MRBCA process, such trend must be apparent over a monitoring period of one to three years, with samples collected on at least a quarterly basis. The default assumption is that two years of data will be necessary to make a determination of plume stability, however, in cases where one year of monitoring is sufficient to demonstrate a clearly declining or stable plume, no further monitoring will be required. In some cases where two years of monitoring does not clearly show a stable or declining plume, additional data may be required. Greater than three years of monitoring without a conclusion of stability would indicate that the plume is not stable.

Groundwater monitoring for the purpose of evaluating plume stability must be conducted under a work plan approved by MDNR.

5.10 SURFACE WATER AND SEDIMENT SAMPLING

MDNR may request the collection of surface water samples when site investigation data shows or suggests that COCs have migrated to a surface water body. Such sampling must consider the representativeness of the samples with regard to the flow conditions. Water samples shall be collected both upstream and downstream of each groundwater discharge point. If one or more discrete discharge points cannot be identified even though the data indicates that contaminated groundwater is discharging to surface water, the point of discharge shall be determined based on data pertaining to groundwater flow direction and the horizontal, lateral, and vertical extent of the plume.

In addition, the collection of sediment samples may be required by MDNR if warranted by site conditions. If site investigation data shows or suggests that contaminated groundwater is discharging to a surface water body, sediment samples must be collected from the affected surface water body. The evaluator shall compare the sediment sample data with sediment standards protective of human health and ecological receptors that can be obtained from literature (refer Section 6.6) or develop site-specific levels. The latter would be considered a Tier 3 activity and would require a pre-approved work plan. Refer to Section 6.4 for further guidance regarding the evaluation of surface water.

5.11 SOIL VAPOR SAMPLING

For sites where soil and/or groundwater concentrations exceed the Tier 1 RBTLs for the vapor migration to indoor air pathway, soil vapor monitoring can be conducted at either Tier 1 or Tier 2 to quantify COC concentrations in the vapor phase in soil. See subsection 6.1.3.1 and Appendix C.

5.12 LABORATORY QA/QC

Laboratory analytical data must be accompanied by QA/QC sample results. The required QA/QC samples include a method blank, a laboratory control sample, a matrix spike, and a duplicate/spike duplicate. Instrument performance samples such as internal standard and surrogate recovery samples must be included in the data package. Laboratories having National Environmental Laboratory Accreditation Program (NELAP) accreditation need not submit full internal QA/QC data packages with their analytical data, however the above mentioned QA/QC sample data must be submitted.

The laboratory must ensure that the portions of the chain of custody form relevant to the laboratory are completed and that the completed chain of custody form accompanies all data packages.