

# **New Jersey Department of Environmental Protection Draft Guidance - The Triad Approach**

## **POLICY STATEMENT IN SUPPORT OF THE TRIAD APPROACH**

The New Jersey Department of Environmental Protection is committed to streamlining the site investigation and remediation process at contaminated sites without compromising data quality and reliability. This goal can sometimes be better achieved by implementing the Triad approach, a process that integrates systematic planning, dynamic work plans, and real-time measurements to achieve more timely and cost-effective site characterization and cleanup. The Triad approach seeks to recognize and manage the uncertainties involved in generating representative data from heterogeneous environmental matrices.

The Department supports and encourages the use of Triad approach for sites undergoing investigation and remediation within the Site Remediation and Waste Management Program where feasible. The Department has evaluated the Technical Requirements for Site Remediation, N.J.A.C. 7:26E, in the context of Triad approach, and has determined that the concepts embodied in Triad approach can be implemented within the framework of the rules. The Department encourages persons interested in using the Triad approach to enter into Memoranda of Agreement, as described in N.J.A.C. 7:26C, because successful implementation of the Triad approach requires close interaction with the Department to ensure that appropriate considerations have been addressed. The Department will continue to consider whether modification of applicable rules would facilitate or further encourage use of the Triad approach.

## **OVERVIEW OF THE TRIAD APPROACH**

The Triad approach integrates systematic planning, dynamic work plans, and field analysis to achieve site characterization and cleanup. A key output of the Triad approach is the development of an accurate conceptual site model that can support correct decisions about the magnitude of risk and the design of effective risk reduction strategies. A conceptual site model identifies what is already known and what more must be known in order to remediate contamination at a site and thus reduce risk to acceptable levels.

In the first component of the Triad approach, systematic planning, the person responsible for conducting the remediation defines project goals and develops cost-effective strategy to achieve these goals. Systematic planning for the Triad approach focuses on explicitly identifying the uncertainties (i.e., the unknowns) that could lead to decision errors, and finding efficient mechanisms to manage these uncertainties. Note that "managing" uncertainty does not always mean that all uncertainties will be minimized or eliminated. The Triad approach distinguishes between outcome uncertainty (which applies to the confidence that final large-scale decisions, such as "redevelopment of a Brownfields site as a school will not endanger children," are correct) and input uncertainty (which applies to the confidence that data and other information used as the basis for decisions are accurate in an absolute sense). Uncertainty in the accuracy of inputs may be tolerated as long as the nature and impact of the uncertainty on the decision-making process is clearly identified and described.

Dynamic work plans are designed based on the systematic planning so that on-site decisions can be made in real-time, most often through the application of field analytics. The Triad approach reduces the overall uncertainty often associated with site information and data through systematic planning which identifies appropriate sampling locations and increases sampling density. This dynamic process should result in faster, better and more cost effective site characterization and cleanup. A critical uncertainty addressed by the Triad approach is the sampling representativeness of data. Employing the Triad approach requires consideration of how all aspects of sample collection may impact data quality when heterogeneous environmental matrices are being sampled. The Triad approach recognizes that concepts of decision support (the physical dimensions of the decision unit) and sample support (the physical dimensions of sample collection) are critical to data representativeness. The new sampling and analytical technologies coming into the environmental marketplace allow cost-effective detection and management of heterogeneity so that resulting conceptual site models are fully representative of actual site conditions in the context of the intended site decisions (see Field Methods chapter of the Field Sampling Procedures Manual).

Conceptual site models involve the assembly, organization and interpretation of site data into a form that facilitates understanding and decision-making by multi-disciplinary project teams. As applied to remediation, conceptual site models have been defined as written or pictorial representations of environmental systems to include the chemical, physical and biological processes affecting contaminant transport to receptors. Such a definition hints at the tremendous complexity that potentially exists as a part of site clean up activities. Constructing a conceptual site model involves making hypotheses about how the contamination got there, where it might be going, whether degradation into other toxic or non-toxic compounds could be occurring, and how receptors might be exposed. Using conceptual site models avoids inefficient use of resources by focusing attention on only those site uncertainties that directly influence project decision-making.

#### TECHNICAL REQUIREMENTS FOR SITE REMEDIATION COMPATIBILITY WITH THE TRIAD APPROACH

The Triad approach can be implemented within the framework of the Technical Requirements for Site Remediation, N.J.A.C. 7:26E (Technical rules). For example, N.J.A.C. 7:26E-2.1(b) provides for liberal use of field analytical methods (herein referred to as “real-time measurement technologies”) when conducting investigation and remediation, and 3.3(d) provides that “It is often appropriate to phase the site investigation so that the areas of concern most likely to be contaminated above the applicable remediation standards are sampled first. If at any time during the site investigation, any contamination is found above the applicable remediation standards, then the site investigation may be discontinued and the remediation continued at either the remedial investigation or remedial action phase.” There are certain provisions in the Technical rules that require Departmental oversight or notification, and other provisions that the Department has determined are often associated with complex aspects of investigation and remediation. It is critical that these provisions be considered during the strategic planning phase of the Triad process. These provisions from N.J.A.C. 7:26E are as follows:

##### 1. Department Oversight Required

- 1.12 Requirement for Department Oversight of Remediation (for sites suspected or known to be contaminated with anthropogenic radionuclide contamination of

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any media; and sites with immediate environmental concern (IEC) conditions.

- 5.2 Remedial action selection report (oversight required for certain types of remedies).
- 6.1(d) Free and/or residual product (oversight required for containment remedies).
- 6.2(b) Soil reuse (oversight required)
- 6.7 Remedial action report (oversight required)
- 7 Permit Identification and Application Schedule (oversight required)
- 8 Engineering and Institutional Controls (oversight required; note: if the need for a deed notice is reasonably anticipated, and the person responsible for conducting the remediation is not the property owner, plan for time delays in obtaining property owner approval).

### 2. Department Notification

- 1.4
  - prior to the initiation of any sampling activities at a contaminated site which is not already known to the Department;
  - if immediate environmental concern conditions are identified,
  - if an interim response action in response to an immediate environmental concern is to be conducted.

3.7(e)3.ii Potable well search (plan for possible time delays at this stage)

3.7(g)5 Upgradient ground water contamination

### 3. Potentially Complex Aspects of Investigation and Remediation

2.1(a)5 Proposing an alternative analytical method

3.7(g) Background groundwater investigation

3.8 Surface Water and Sediment

3.10 Background investigation in soil

3.11 Ecological evaluation

3.12 Investigation of historic fill material

4.1 If offsite contamination of soil, groundwater or other media is reasonably anticipated, plan for time delays in obtaining offsite access.

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- 4.8 (c)3i Sampling Results Summary Table and averaging requirements. Using real-time measurement technology data to calculate average contaminant concentrations for contaminated areas should only be conducted in consultation with the NJDEP.

## **DRAFT CHAPTER 7 – FIELD SAMPLING PROCEDURES MANUAL**

### **FIELD ANALYSIS**

#### **A. INTRODUCTION**

The New Jersey Department of Environmental Protection (NJDEP) is committed to streamlining the site investigation and remediation process at contaminated sites. This chapter of the Field Sampling Procedures Manual was developed primarily in an effort to expedite site investigation and remediation by providing a means for improving the quality of real-time measurement technology data. This goal can be better achieved by implementing the Triad approach, which seeks to recognize and manage the uncertainties involved in generating representative data from heterogeneous environmental matrices. The basis and tenets of the Triad approach are discussed in detail in the introduction to this Manual, and the reader is encouraged to review that material when using this Chapter. Persons wishing to use the Triad approach are encouraged to conduct the strategic planning critical to a successful project in conjunction with NJDEP.

All site investigation and remediation activities must comply with the Technical Requirements for Site Remediation, N.J.A.C. 7:26E, including requirements for standard analytical methods. However, this does not preclude liberal use of real-time measurement technologies. Although there is greater flexibility to use real-time measurement technologies during earlier stages of the remediation process, they may be employed during all phases of site characterization and cleanup, following the requirements of N.J.A.C. 7:26E and using the variance process, where applicable.

With incorporation of the NJDEP Field Analysis Manual (1994) into the Field Sampling Procedures Manual, real-time measurement technologies are no longer included in this Chapter. However, this Chapter now incorporates by reference several resources for identifying appropriate real-time measurement technologies.

#### **B. APPLICATION OF REAL-TIME MEASUREMENT TECHNOLOGIES**

Field-portable instrumentation provides useful information for critical decisions in the field. Typical application of real-time measurement technologies include the following:

- Emergency response, Health, Safety and Industrial Hygiene, and Fence Line Monitoring to determine possible exposure of the community and of personnel
- Source/Process Monitoring- determines regulatory compliance-related monitoring of stack emissions or effluent discharge
- Odor Investigation- a portable GC/MS will permit a full analysis for unknowns and leak detection (source detection)
- Site Characterization and Remediation- Field portable instrumentation/method is well suited to implement dynamic sampling plans in which the goal is to perform a rapid characterization with limited mobilizations.

Almost all projects require screening or semi-quantitative techniques during the initial field

investigation. When combined with historical site information, this supports the development of an initial conceptual site model that predicts or determines the range of contaminant concentrations, the degree of heterogeneity, and spatial correlation for contaminant distributions. In order to demonstrate regulatory compliance with action levels, a conceptual site model that is representative of actual site conditions is necessary to guide 1) the selection and use of statistical tools, including statistical estimates of contaminant means across an exposure unit, using classical statistical hypothesis testing, and using emerging geostatistical and Bayesian statistical algorithms; 2) the design of sampling systems, including groundwater monitoring well installation, and soil and waste sampling designs; and 3) the choice of analytical methods used to produce the rigorous (i.e., low detection limit, analyte-specific) data needed for risk assessment and regulatory compliance. Measurement tools that quickly and inexpensively supply information about contaminant distributions and concentrations at short-range scales provide valuable information to the conceptual site model. For example, headspace gas chromatography can be simple and fast for the analysis of volatile organic compounds in soil and water samples during underground storage tank removal or well installation and monitoring. Enzyme kits can provide rapid detection of polychlorinated biphenyls or explosives during site characterization.

Many advances have been made in the development of field-portable instrumentation. Many of these instruments are hand-held, rugged, and offer very rapid results in the field. Field portable instruments include GCs, micro-GCs, GC/mass spectrometers (GC/MS), extractive Fourier transform infrared (FTIR) spectrometers, filter-based and other infrared (IR) spectrometers, X-ray fluorescence (XRF) spectrometers, and selective monitors in addition to continuous flame ionization detectors (FIDs) and photoionization detectors (PIDs).

### C. REAL-TIME MEASUREMENT TECHNOLOGIES

Within the Triad approach itself, “real-time” measurements are defined in terms of those sampling, analytical, and data review, interpretation, and management tools that are capable of meeting the needs of real-time decision-making. In other words, if the all steps of the data generation process can be accomplished rapidly enough to support “real-time decision-making” (generally understood to mean that field teams are not demobilized from the field while waiting for data before subsequent field work is performed), then those techniques are considered “real-time” under the Triad approach. However, for NJDEP purposes, it is useful to divide field analyses into two categories: real time and “near” real-time measurements. Real-time measurements provide instantaneous analysis without the need for sample pre-treatment. Examples include ion-selective electrodes, fiber optic sensors, hand-held gas monitors, direct measuring GCs and portable in-situ XRF instruments.

Near real-time measurements typically include some sample pretreatment prior to analysis of samples. These techniques include wet chemical and enzyme immunoassay kits; GC with a variety of detectors such as PID, FID, ECD and GC/MS. Total petroleum hydrocarbon (TPH) analyzers; inductively coupled plasma/optical emission spectroscopy (ICP/OES); ex-situ XRF; and anodic stripping voltammetry for metals analysis round out examples of these instruments/techniques. The size and experimental operating features determine whether they are classified as field portable or transportable (laboratory-grade) instruments. For example, portable GCs are typically small in size, can use batteries but may not have temperature programming (therefore, operates isothermally) or have slow temperature program ramps from ambient to 200 degree centigrade. In either case, these GCs are best suited to qualitative analysis of VOCs. In contrast, laboratory-grade field GC/MS instruments may require a generator or a line voltage power source but can produce quantitative analysis of VOCs and semi-VOCs in the field. However, note that with respect to such limitations, field-portable

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technologies are rapidly undergoing change, and statements that were true about a given technology a year ago may not be accurate today, and statements true today may not be accurate in the future. Field GC/MS can provide the necessary measurement sensitivity, precision, and accuracy to meet most site-specific data quality objectives). However, in many instances, rapid screening GC with ECD/FID or with MS is sufficient for VOC analyses of soil and water to determine vadose zone and ground water contamination profiles.

Some certified laboratories now also offer “quick turn-around” or near real-time analyses, which are conducted in the lab using procedures that may be modified from the standard methods. Guidelines herein for generation and use of data from real-time measurement technologies may also be applied to laboratory-generated near real-time data. Note also that NJDEP now offers certification for “analyze-immediately” parameters, including some real-time measurement technologies such as immunoassay test kits.

### D. SPECIFIC ADVANTAGES OF FIELD ANALYSIS

The main advantage of field analysis is that it allows for the performance of rapid characterization to achieve an accurate conceptual site model with only a few mobilizations via a dynamic sampling plan.

A key advantage that is offered by field analysis is dedicated analysis of the samples and the associated QC samples. The samples are not analyzed as a part of a batch (as often is the case in an off-site laboratory for a small number of samples). Often in a 20-sample batch in a laboratory, a small number of samples (e.g., three samples) from the site of interest are processed with other unrelated samples and the QC samples (e.g., matrix spike samples) may not be one of the site samples. Therefore, the site specific objectives that require the Quality Assurance Project Plan (QAPP) to be based on the very specific needs of each site is served well or often better by dedicated field analysis. Also the field analysis quality may be as good as or better than that of a fixed laboratory in terms of sample integrity/preservation. Due to a rapid turn-around time, the sample integrity of a properly collected and stored one-hour-old sample is often better than that of a sample held for 14-days.

### E. SELECTION OF A REAL-TIME MEASUREMENT TECHNOLOGY

If the purpose of the field data is limited to building the conceptual site model by establishing spatial or temporal contaminant distributions and the degree of concentration variability (a task usually referred to as “site screening”), then it may not be absolutely necessary for the field method to detect below the action level. However, if decisions about compliance with an action level will be made based on field analysis, then the selected field analysis method must demonstrate method detection limits below the action level or levels of concern (e.g. EPA’s soil screening level or NJDEP’s soil cleanup criteria) for the medium. To ensure that the real-time measurement technologies selected are amenable to a given site, site-specific method detection limit studies using soil or other media of concern from the site are recommended. This will help to determine whether matrix interference or target compounds mask (e.g. portable GC) or cross-react (e.g., immunoassay kits) with targeted organics. For further information, please refer to Section I, “Choosing Appropriate Real-time Measurements for Contaminant Investigation.”

### F. FACTORS TO BE CONSIDERED FOR FIELD ANALYSES

To be “effective for decision-making,” any data must be of known quality with both the sampling and

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analytical uncertainties managed to the degree necessary to support the specified decisions. Unless the decision is clearly specified, it is not possible to ascertain whether data are “effective” or not. This applies equally to fixed laboratory data as well as to field data. This is part of the systematic planning process. Data are of known quality when the sample representativeness is known, and measurement precision or reproducibility, accuracy, and sensitivity are documented. Correlation of data generated by real-time measurement technologies with standard laboratory methods is sometimes needed in order to document any bias in the real-time measurement technology and to aid interpretation of data that are not analyte-specific. This correlation needs to be documented if the real-time measurement data are to be used to support the objective of the site investigation or cleanup. Several factors to be considered before mobilization include the following (the factors are not intended to be all inclusive):

- Sample support, such as volume, orientation, and particle size of specimens as they are collected and subsampled for analysis;
- Sampling strategies, such as grab sampling vs. composting, if applicable;
- Pre-analysis sample processing, especially homogenization of samples (if applicable), prior to splitting for analysis by different analytical methods;
- The action levels for field decisions;
- The project objective specified to allow the use of screening and semi-quantitative techniques in addition to quantitative techniques to meet site specific objectives;
- The percentage of samples to be analyzed in the field as well as sent off-site for laboratory confirmation, along with the strategy for selecting samples for confirmation analysis. Both are determined based on an understanding of the uncertainties that the confirmation analysis is intended to manage;
- The methodology to compare field and laboratory data, for example using duplicate (field duplicate samples) and/or performance evaluation samples in addition to initial and daily calibrations;
- Instrument and method selectivity, sensitivity, precision, accuracy;
- Standard operating procedures and method detection limit studies before mobilization, in order to evaluate matrix interference that might be associated with a particular field analytics;
- Qualification of field technicians or chemists performing the analyses, if applicable; and
- Sample preservation method, if required, etc.

### G. ROLE OF FIELD SCREENING/ANALYTICAL METHODS ACCORDING TO THE NJDEP TECHNICAL REQUIREMENTS FOR SITE REMEDIATION, N.J.A.C. 7:26E

A site investigation must follow the Technical Requirements for Site Remediation, N.J.A.C. 7:26E. The role of field methods (real-time measurement technologies) as defined by N.J.A.C. 7:26E-2.1(b) is as follows:

- For delineation when the contaminant identity is known or if there is reasonable certainty that a specific contaminant may be present (for example, benzene, toluene, ethylbenzene, xylene in the case of sampling for a gasoline release); or
- To bias sample location to the location of greatest suspected contamination.

Although standard analytical methods are not one hundred percent accurate, data generated with these methods currently represent the best estimate of the true concentration of a contaminant in an environmental sample, when sampling variables have been controlled. Therefore, a comparison of

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real-time measurement data with standard analytical method data may be appropriate to provide some guidance on the validity of the real-time data.

In accordance with N.J.A.C. 7:26E-2.1(b)2, “Field screening methods shall not be used to verify contaminant identity or clean zones. However, where 10 or more samples are required for initial characterization sampling at an area of concern, field screening methods listed in (b)3 and 4 below may be used to document that up to 50 percent of sampling points within the area of concern are not contaminated.” Pursuant to N.J.A.C. 7:26E-2.1(b), delineation of a known contaminant may be conducted using real-time measurement technologies without a variance. The location and percentage of samples selected to be confirmed by standard analytical methods should be selected to specifically reduce uncertainty in the data being used for site specific decisions. The project technical team, including NJDEP representatives, should identify in advance a decision logic for how split samples will be incorporated into a site specific QC protocol to build confidence that relevant variables that influence the reliability of the data have been controlled.

The Technical Requirements for Site Remediation, N.J.A.C. 7:26E requires that all clean zone samples be confirmed by certified laboratories. However, the number of certified laboratory confirmation samples for clean zone determination during any remedial phase may be reduced, with an approved variance. Any person responsible for conducting site investigation or remediation may petition the NJDEP for a variance from sampling frequency requirements in accordance with N.J.A.C. 7:26E-1.6(d). These variance petitions must provide technical justification and will be evaluated by the NJDEP on case by case basis.

Technical justification for a variance application may include:

- the contaminant is known,
- lack of or minimal matrix effect,
- lack of or minimal interfering constituents,
- capability to produce qualitative and quantitative data using standard calibration and QA/QC practices, and appropriate deliverables,
- high confidence in the ability of a “negative” (non-detect or low) field result to predict “clean” (i.e., below the relevant criteria or standard).
- project-specific audits where a NJDEP staff visits the site during the field sampling/analyses to verify that the standard operating procedure (SOP) and QAPP is followed,
- the field strategy has been accepted as an ASTM Standard Practice or the technology has been independently verified,
- demonstration of the applicability of the method by a pilot study using soils from the site.

## H. POLICY INITIATIVES FOR DEVELOPMENT OF FIELD ANALYSES

New third party technology verification programs are involved in evaluating, reviewing, or endorsing new and innovative field testing technologies. One such technology verification program is the EPA’s Environmental Technology Verification (ETV) program. Interstate initiatives such as the Interstate Technology & Regulatory Council (ITRC), which currently has 40 member states, are in place to review and promote innovative technologies (see [www.itrcweb.org](http://www.itrcweb.org) for details). The ITRC publishes guidance documents on new technologies for environmental applications, and now has a Sampling, Characterization and Monitoring Team. The ITRC/ASTM partnership for accelerated site

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characterization, in Appendix G of their FY-97 summary report, delineated detailed guidelines on “*Practice for Expedited Site Characterization of Vadose Zone and Ground Water Contamination at Hazardous Waste Contamination Sites*”.

A variety of innovative characterization and assessment strategies described over the years by various organizations and agencies were tabulated in an EPA review paper: “Summary of Recent Improvements in Methods for the Study of Contaminated and Potentially Contaminated Sites”, funded by the EPA Technology Innovation Office (TIO). A common feature of these strategies is endorsing the use of field methods for quick turnaround information for on-site decision making.”

Individual training programs such as EPA Internet training on the Triad approach (through [www.clu-in.org](http://www.clu-in.org)), DOE’s ESC Training Course, Argonne National Laboratory’s Quick Site™ Course and EPA’s Field-Based Site Characterization Technologies and Strategies for Field-Based Analytical and Sampling Technologies Courses are available. These as well as vendor-provided courses offer information to keep abreast of new developments in the expedited site characterization area.

Currently, the following two strategies have been accepted as ASTM Standard Practices: Accelerated Site Characterization for Confirmed or Suspected Petroleum Releases (PS3-95) and Expedited Site Characterization of Hazardous Waste Contaminated Sites (D6235-98). In the future, as sophisticated analytical instruments are being miniaturized, more field-based technologies are likely to become standard practices.

### I. CHOOSING APPROPRIATE REAL-TIME MEASUREMENTS FOR CONTAMINANT INVESTIGATION

The universe of real-time measurement technologies has grown significantly and the accuracy of the methods has increased dramatically since the NJDEP initially developed the “Field Analysis Manual” in 1994. The NJDEP determined that inclusion of individual real-time measurements in this chapter of the Field Sampling Procedures Manual is not practical and not necessary considering the number of useful web sites dedicated to real-time measurements. Therefore, this section provides a guide to using web sites to identify appropriate real-time measurements, gather information regarding these methods and present this information to the NJDEP in an acceptable format.

#### 1. Considerations prior to Researching Real-time Measurement Technologies

Real-time measurements can provide accurate results instantaneously or within a short period of time; however, the method chosen must be appropriate for the analytes of concern and site conditions, and must be conducted by trained, experienced and qualified personnel. When choosing a real-time measurement technology, the first consideration should be to determine what analytes of concern are present on the site (i.e. polynuclear aromatic hydrocarbons (PAHs), PCBs, metals, etc.) and what level of detection (i.e. low ppb, mid ppm, etc.) must be achieved in order to reach the goals established in the QAPP. Most web sites will provide a search engine allowing for a search of methods specific to an analyte or group of analytes or will provide information indicating which methods are appropriate for an analyte or set of analytes. These web sites will generally also provide typical detection limits for each method.

a. Matrix Effects: The matrix or matrices (i.e. soil type, sediment, water, etc.) may cause one field

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analytical method to be preferable to another, or may cause interference in an analytical method. An example of matrix effects is extremely fine clays, which may cause an immunoassay test to be biased low. Another example of matrix effects is the presence of large pebbles, which may render it difficult to use an XRF efficiently, because a flat and relatively uniform surface is required for analysis (this problem may be solved by sieving the soil prior to analysis). Some real-time measurements require extraction or other sample preparation methods and therefore, are not amenable to using with certain matrices. Knowledge of the unique characteristics of the site matrices will permit identification of potential interference due to matrix effects. Concentrations of elements in different types of soil or matrices might change, causing interference (i.e. between arsenic and lead). However, site-specific calibration can compensate for some of those effects.

- b. Analyte(s) of Concern: The real-time measurement technology chosen must be capable of detecting the analyte or analytes of concern at the site. Unlike most laboratory methods, which detect suites of analytes providing approximate quantitation for each of the individual analytes, many real-time measurement technologies selectively detect only an individual analyte or an analyte group without providing quantitation for each of the individual analytes in the group. Several real-time measurement technologies (i.e. XRF, Field GC, etc.) can analyze a suite of analytes and provide quantitation for each individual analyte; however, just as with standard analytical methods, these methods must be calibrated for each analyte of concern. Several real-time measurement technologies can be used in conjunction to determine an array of analytes or cross-reference a common analyte. The objectives in the QAPP will determine which real-time measurement technologies will be employed at the site. If a number of similar analytes are present at a site, it may be difficult to quantify certain analytes accurately because interference may create false positive results. Results obtained by some real-time measurement technologies (i.e. indicator tubes) are qualitative to semi-quantitative at best. In addition, the minimum detection limits for some real-time measurement technologies are influenced by factors such as water vapor and chemical interference.
- c. Interfering Constituents: Another item to consider when researching real-time measurement technologies is whether other interfering constituents or contamination are present on the site. Other constituents, even those not regulated or below regulatory limits, may cause interference with the chosen real-time measurement technology. Interference may occur, for example, when high iron levels are present in a soil sample, but the levels are below regulatory levels. These high iron concentrations can cause an increase in detection limits in XRF analysis for other metals with lower regulatory limits. Familiarity with other site constituents prior to researching a real-time measurement technology will permit quick identification of possible interference. Some real-time measurement technologies (i.e. field GC) may experience co-elution of analytes which may cause biased high results, false positives or make quantification difficult or impossible.
- d. Limitations: All analytical methods (fixed laboratory methods, real-time measurement technologies, etc.) have limitations. Understanding these limitations will help to apply the technology properly to generate data that meets the needs of the project. Some methods may not perform well for certain groups of analytes (i.e. petroleum hydrocarbon [immunoassay] methods may not perform well for motor oil or grease, or for highly degraded petroleum fuels) and therefore, these methods may have a potential for false negative results. Some reagents may require refrigeration and, therefore, it may be necessary to have a cooler or refrigerator on site. While analysis with some real-time measurement technologies can be accomplished quickly, it can be time-consuming to perform analyses with other real-time measurement technologies. Certain

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instrumentation operation (i.e. field GC) requires a higher degree of expertise than most other real-time measurement technologies. Some real-time measurement technologies may require judgement made by the operator (i.e. color comparison to a chart) that can lead to inaccurate results. Some real-time measurement technologies may require that the specific analyte to be tested must be known, so that the method can be calibrated correctly. Some real-time measurement technologies may have no true field-portability, with a mobile laboratory setup required or an electrical power source required. Some real-time measurement technologies may be cost prohibitive on small-scale projects, or a specific license may be required to operate certain instruments (i.e. XRF with a radioactive source).

- e. **Physical Conditions:** Physical conditions on site may cause logistical problem with certain real-time measurement technologies (i.e. space limitations, flat surfaces, dry surfaces, etc.) or may cause interference with the real-time measurement technologies (i.e. heat, cold, excessive sunlight, etc.). An example of logistical problem would be providing enough room with a relatively flat surface in an up wind location for a field GC. In addition, extreme temperatures will affect most real-time measurement technologies and excessive sunlight may cause some reagents to break down. Familiarity with the site conditions will permit a determination of whether a given real-time measurement technology is viable at a particular site at a particular season.

### 2. Searching the Websites

Once the analyte(s) of concern are determined, other constituents present at the site have been ascertained and the site matrix (matrices) and physical conditions are known, an Internet search to determine if an appropriate real-time measurement technology can be performed. Several Internet sites including <http://fate.clu-in.org/index.htm>, <http://www.epareachit.org/index3.html>, <http://www.frtr.gov/cost/>, [www.clu-in.org](http://www.clu-in.org), [www.itrcweb.org](http://www.itrcweb.org), and <http://www.brownfieldstsc.org> are good references to begin determination of which real-time measurement technologies will be appropriate. In addition, many vendors provide web sites for their products. Whereas vendor web sites are good sources of information, research from an independent review of the real-time measurement technologies is advisable. Each Internet site has a unique way to begin a search.

- a. **FATE:** The Field Analytical Technologies Encyclopedia (FATE) site lists real-time measurement technologies by method. The web site then details under each method the list of appropriate analytes and matrices, what interferences and limitations are associated with the method, typical detection limits, and physical limitations of the field analytical method as well as links to other related web sites.
- b. **EPAREACHIT:** The **EPA RE**mediation And **CH**aracterization Innovation Technologies (EPAREACHIT) site provides a search engine to select analytes or groups of analytes, matrices and whether the technology has previously been used at a pilot scale, full scale or bench scale. The site then provides detailed information about the technology and links to other related sites.
- c. **FRTR:** The Federal Remediation Technologies Roundtable (FRTR) site provides case studies where site characterization technologies were used. The site lists advantages of the methods employed as well as a section on lessons learned during the case study. The site includes the “Field Sampling and Analysis Technologies Matrix and Reference Guide.”
- d. **CLU-IN:** The Clu-in site includes links to many Triad approach resources under the

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‘Characterization and Monitoring’ module, and also includes the Vendor Field Analytical and Characterization Technologies System (Vendor FACTS). This website has links to relevant “performance based” site characterization and clean up information. Vendor FACTS is a Windows™ based database of innovative technologies for site characterization available for registered users.

- e. ITRC: This site includes a link to the ITRC Sampling, Characterization and Monitoring Team that develops technical and regulatory guidance for new technologies. The ITRC is also developing guidance for Triad approach implementation.
- f. The Brownfields Technology Support Center: This site provides several resources for expedited site assessment including “Assessing Contractor Capabilities for Streamlined Site Investigations”(EPA 542-R-00-001)”.

When utilizing one of these web sites or any other web site, it is important to identify as many different real-time measurement technologies applicable to the site as possible along with the advantages and disadvantages of each in order to determine which method will best meet the objectives identified in the QAPP. Links to vender sites are useful, but while providing worthwhile information, may impart a bias to a particular method or instrument. When considering the advantages of a real-time measurement technology, it is always important to consider the site matrices, analytes of concern, potential interferences and limitations of the method.

### 3. Listing Limitations and Interference for Selected Real-time Measurement Technologies

All analytical techniques have limitations and interference, including methods used at a fixed laboratory; however, limitations and interference do not preclude these methods from providing useful information. A thorough understanding of the real-time measurement technology’s limitations and interference as related to the site can define the usefulness of the method and data produced by that method. The limitations and interference, as discussed in 1.a-e above should be addressed and presented to NJDEP when initially requesting approval for the use of a real-time measurement technology. In addition to listing the limitations and interference, ways of compensating for these limitations and interference or reasons why they will not interfere with the objectives of the QAPP for a given phase of the investigation of the site should be listed.

## J. QUALITY ASSURANCE PROJECT PLAN (QAPP) FOR IMPLEMENTATION OF REAL-TIME MEASUREMENT TECHNOLOGIES

This section defines the NJDEP Site Remediation and Waste Management Program's Data Quality Levels for contaminant investigation and provides guidance on deliverables for real-time measurement technologies.

### 1. Data Quality Levels

There are four types of data that can be used to support different types of decisions: “Screening Analyses”, “Supportive Analyses”, “Confirmatory Analyses” and “State-of-the-Art” Analyses. The type of data required depends on the decision to be made. More detail on each of these is provided below and a summary of this information is provided in Table 7-1 “Overview of Sample Analyses”. To guide in the selection of real-time measurement technologies, a contaminant investigation plan should meet the minimum data quality standards prior to receiving approval. The project team is

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responsible for the review and revision of all real-time measurement technology proposals.

- a. Screening Analyses - These analyses use field portable instruments. Results often are not compound specific or quantitative, but results are available real time. The key feature is that additional confirmatory analysis of the same samples is usually required with respect to the decision to be made.
- b. Supportive Analyses - These analyses use portable analytical instruments with quantitative capability. Depending on the objective of the analyses, the data generated by Supportive Analyses may or may not be adequate for decision-making. The quality of the data depends on the use of suitable calibration standards, reference material, sample preparation equipment, the training of the operator and sample size, location and depth. Results are available real time or within several hours.

The analytical uncertainty of the data generated by Supportive Analyses is reduced if a portion of the results are substantiated or verified by certified laboratory analysis using approved methods. Whether Supportive Analyses are adequate for decision-making depends on the intended use of the data. For example, suppose that a site has been characterized well enough that the identities of the contaminants are known, and “yes or no” decisions about categorizing waste piles must be made. The analytical tool selected may be known to cross-react with a range of analytes, but, because it is known (from previous confirmatory investigation) that those interferences are not present, the tool is acceptable for support of the “yes or no” decision without a confirmatory analysis by another method.

As previously stated, according to N.J.A.C. 7:26E-2.1(b), real-time measurement technologies are generally not to be used to determine contaminant identity or clean zones. However, when appropriate and applicable a variance may be approved by the NJDEP. Please refer to Section G of this Chapter for further guidance.

- c. Confirmatory Analyses - These analyses are performed by applying methods that determine the identity and concentration of analytes with “reasonable” certainty. These data can stand on their own with respect to the vast majority of possible decisions. These analyses are performed by fixed-base or mobile certified laboratories using an approved method and contain QA/QC deliverables as required in N.J.A.C. 7:26E, Appendix A. The data generated by these analyses can be used for clean zone confirmation during any remedial phase.
- d. “State-of-the-Art” Analyses: Special “state-of-the-art” methods may be developed specifically for a particular site, and would be approved on a case by case basis.

### 2. Deliverables for Real-time measurement technologies

The Technical rules require that reports submitted to NJDEP include results of all analyses, copies of all laboratory data sheets and the required laboratory data deliverables. Therefore, it is appropriate that all real-time measurement technologies method data be submitted to the Department. Note however that, pursuant to N.J.A.C. 7:26E -2.1(a)13iii, “Analytical results without all quality control and raw data as required in full and reduced laboratory data deliverables, may be provided for all delineation samples which necessitate additional delineation sampling...” The deliverables guidelines in Section L below are applicable as support for variance petitions to

use real-time measurement technologies in place of standard analytical methods for initial characterization sampling or clean zone determination.

## K. QUALITY ASSURANCE REQUIREMENTS

### 1. Screening Analyses

- a. Screening Analyses are intended to be used for health & safety, initial contaminant screening and/or contaminant delineation.
- b. Instruments used for Screening Analyses include PID survey instruments and FID survey instruments. Methods used for Screening Analyses include hydrophobic dye test, colorimetric analysis and headspace analysis.
- c. Data generated by Screening Analyses should only be considered an indicator of contamination.
- d. Screening Analyses are real-time, but are semi-qualitative and semi-quantitative, and measurements may be erratic. Therefore, data should only be used for health and safety and to guide sample placement for analysis by higher level methods.
- e. Since relatively few quality control procedures are employed compared to higher-level field methods, data quality is very much a function of sample handling techniques and analyst skill.

### 2. Supportive Analyses

- a. Supportive Analyses are intended to be effective for the end use and to provide reliable, rapid, contaminant delineation.
- b. Supportive Analyses can achieve a high degree of reproducibility when required QA/QC procedures are employed.
- c. Field analysis methods are typically laboratory methods, which have been adapted for field use (i.e. field GC, portable XRF, field IR).
- d. Field analysis data may be semi-quantitative (i.e. providing an estimated value) and semi-qualitative or class specific (individual contaminant identification is not provided).
- e. A comparison of real-time measurement data with standard analytical method data can help to provide some guidance on the validity of the field data. Although this comparison may not be applicable in all cases, guidance may be found in Section G of this chapter.

A correlation of real-time measurement data with standard analytical method data has two components and can be calculated by the following regression analysis equation. Non-parametric statistical methods can also be used to compare data:

$$L = xF + y$$

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where:

L = the reported standard analytical method concentration of a contaminant

F = the reported real-time measurement concentration of the same contaminant

x = the slope of the correlation of the data sets

y = the intercept of the data sets (constant)

R squared = fit of equation

The two components of the data correlation are: 1) the fit (R squared) and 2) the intercept (y). Given the lack of homogeneity of environmental samples, variation in sample handling and variations inherent in both data sets, the fit of the equation is not expected to be perfect (i.e. in most cases, R squared  $\neq$  100 percent); however, R squared and a plot of the scatter graph should be developed by the data reviewer and submitted to the NJDEP. An examination of the R squared and scatter graph should be made to determine the usefulness of the real-time measurement data. Professional judgment should be used when determining whether real-time measurement data should be used for delineation and/or clean zone determination.

The intercept (y) is important due to differences in concentrations determined in the data sets. During the remedial investigation (RI), field based target concentrations for delineation of the contaminated zone may be adjusted per the following equation:

$$C = xC_f + y$$

where:

$C_f$  = contamination zone delineation criteria for real-time data

C = cleanup criteria for standard analytical method data

x = the slope of the correlation of the data sets

y = the intercept of the data sets

- f. Real-time measurement technologies also include published laboratory methods such as USEPA SW-846 laboratory methods, which are highly reproducible; however, real-time measurement technology data are generally documented using only limited quality assurance deliverables.
- g. The quality of real-time measurement data generated using published methods with limited deliverables is a function of sample handling, storage and preservation procedures, and analytical instrument maintenance. These data should be reliable if proper sampling, analytical, and QC procedures are followed.

### **3. Confirmatory Analyses**

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- a. Final remediation should be based on the site-specific cleanup criteria using Confirmatory Analyses because this type of analyses is intended to generate the most reliable data practicable.
- b. Confirmatory Analyses are highly reproducible and can provide the end user with complete QA/QC documentation in accordance with N.J.A.C. 7:26E, Appendix A.
- c. Methods used for Confirmatory Analyses are sometimes the same published laboratory methods as those for real-time measurement technologies but are supported with full laboratory data deliverables or reduced laboratory data deliverables in accordance with subchapter 2 and Appendix A of N.J.A.C. 7:26E.
- d. Confirmatory Analyses can be performed by a certified or otherwise approved fixed or mobile laboratory pursuant to N.J.A.C. 7:26E section 2.1.

#### **4. “State-of-the-Art” Data:**

- a. Generally "State-of-the-Art" methods are developed specifically for a particular site or contaminant.
- b. “State-of-the-Art” methods are used when standard laboratory methods are either unavailable or impractical.
- c. “State-of-the-Art” methods may be accepted to delineate a contaminant, define a "clean zone" or confirm field data.
- d. Generation of “State-of-the-Art” data may necessitate use of a laboratory which specializes in methods development.

**Table 7-1 Overview of Sample Analyses**

<b>Types of Analyses</b>	<b>Purpose of Sample</b>	<b>Example Methods or Instruments</b>
Screening Analyses	<ul style="list-style-type: none"> <li>• Health &amp; Safety</li> <li>• Field use when excavating</li> <li>• Contaminant Screening &amp; Delineation</li> </ul>	<ul style="list-style-type: none"> <li>• Portable PID, Portable FID</li> <li>• Colorimetric Analysis</li> <li>• TPH analyzers</li> <li>• Headspace Analysis</li> <li>• Hydrophobic Dye Test</li> </ul>
Supportive Analyses	<ul style="list-style-type: none"> <li>• Clean Sample Confirmation during SI if more than 10 Samples are Collected</li> <li>• Clean Sample Confirmation during SI with a Variance if less than 10 Samples are Collected</li> <li>• Contaminant Delineation</li> <li>• Clean Zone Confirmation with a Variance</li> </ul>	<ul style="list-style-type: none"> <li>• Portable Instruments including: GC, GC/MS, ICP/OES, IR, XRF, AA</li> <li>• Immunoassay</li> <li>• USEPA SW-846 Field Screening Methods</li> <li>• USEPA SW-846 Laboratory Methods with Limited QA/QC requirements.</li> </ul>
Confirmatory Analyses	<ul style="list-style-type: none"> <li>• Contaminant Identification</li> <li>• Clean Zone Confirmation</li> </ul>	<ul style="list-style-type: none"> <li>• Fixed or Mobile Certified Laboratory Analyses</li> </ul>
State-of-the-art Analyses	Non-standard method analysis	Laboratory Special Services, Mobile Laboratory

**L. FIELD DATA DELIVERABLES FORMAT**

The following requirements can be incorporated into a dynamic workplan and to establish standard operating procedures (SOPs) and the QAPP. SOPs for sample collection and analysis should always be developed with other SOPs required to answer site-specific questions (e.g., geophysical and hydrogeological surveys, etc.). As stated earlier, the deliverables guidelines below are applicable as support for variance petitions to use real-time measurement technologies in place of standard analytical methods for initial characterization sampling or clean zone determination.

**1. Screening Analyses**

The following represents suggested deliverables for field screening data. The "Data Deliverables" section of each method will provide specific requirements:

- a. A brief method review.
- b. A single point calibration should always be conducted prior to any field activities using site-

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specific standards.

- c. Calibration checks should always be performed at a minimum of twice daily bracketing the sample analyses. If a calibration check falls outside the manufacturer's suggested range, then a complete multi-point calibration is required.
- d. A baseline or blank scan (i.e. "clean air", "clean water" or "clean soil" as appropriate) should always be run each day prior to analyzing any site samples.
- e. An instrument log should be maintained and submitted (where appropriate). This log should include instrument maintenance, blank, and calibration information, *including date, time*, analyst's name, calibration standard compounds, the concentrations and readings of the calibration standards.
- f. Field logs should always document sample ID#, date, time, location, depth, matrix (i.e. soil type, water, air), soil moisture (qualitative estimate where appropriate), and the reading and concentration/result of the analysis.
- g. A non-conformance summary should state all data inconsistencies and all divergences from the approved sampling/analysis program. The implication of all non-conformances should be clearly explained and quantified (if possible).

### 2. Supportive Analyses

In addition to the deliverables listed for the field screening data, the following represents suggested data deliverables for real-time measurement technology data. The "Data Deliverables" section of each method will provide specific requirements:

- a. Each project team that uses a field analysis method is required to operate a formal quality control program. The minimum requirements of this program consist of an initial demonstration of capability and an ongoing analysis of calibration standards. To establish the ability to generate acceptable accuracy and precision, the analyst should perform the following operations:
  - i. A soil quality control (QC) check sample. The QC check sample should be prepared by the laboratory using stock standards prepared independently from those used for calibration.
  - ii. An aqueous QC sample, prepared in the same fashion as the soil QC sample, is also required.
  - iii. Analyze four aliquots of each of the well-mixed QC check samples according to standard procedures.
  - iv. Calculate the average recovery mean ( $\bar{X}$ ) and the standard deviation of the recovery ( $s$ ) for each parameter of interest in each matrix using the four results.
  - v. For each compound,  $\bar{X}$  should be between 60 percent and 140 percent of the true value. Additionally,  $s$  should be + 40 percent of  $\bar{X}$ .
- b. Method blanks (i.e. syringe blanks, equipment blanks, and instrument blanks) should be run at the

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beginning and during each workday or after a sample when carry-over is anticipated. A higher frequency of blank analyses may be required depending upon equipment use and results.

- c. Instruments should be calibrated each month with 3-point or 3- level (minimum) laboratory certified standards and should also be calibrated daily with 1- mid point or 1-mid level laboratory certified standards. The standard analytes and concentrations should be chosen based on known site contamination and encompass the range of expected concentrations. Surrogate compounds should also be included. Matrix-specific minimum detection limits should always be determined and reported for all site-specific compounds.
- d. If standard curves remain linear over the entire analysis range, only one midpoint standard should be analyzed at a frequency of 1 per 10 samples. If standard curves are not linear over the entire analysis range, a minimum of two (2) calibration standards, one low level and one high level standard should be analyzed at a frequency of 1 per every 10 samples.
- e. Matrix Spike and Matrix Spike Duplicate samples may be required at a rate of one per every 20 samples. The project team should determine if MS/MSD samples are required on a case-by-case basis.
- f. Chain of custody or sample tracking documentation should always be generated for all samples collected and analyzed. This documentation should include a statement certifying that all data were generated following proper procedures.
- g. Proof of training for the technician performing the analyses is required.

### 3. Confirmatory Analyses

Methods used for Confirmatory Analyses are sometimes the same published laboratory methods as those for real-time measurement technologies but are supported with full laboratory data deliverables or reduced laboratory data deliverables in accordance with subchapter 2 and Appendix A of N.J.A.C. 7:26E.

### 4. "State-of-the-Art" Data:

Data generated using a "State-of-the-Art" method may have variable deliverable requirements. These requirements will be proposed by the laboratory or person performing the analysis and evaluated by the Department for each method proposed. If the method and the deliverables requirements are approved, the data produced by methods conforming to these requirements will be acceptable for their intended use.

## M. DATA MANAGEMENT PLAN

Field teams will need tools for the management and evaluation of the increased amount of data generated during Triad approach investigations. These software tools usually include some form of database to track samples and sample results, a geographical information system (GIS), and data visualization applications (similar to Surfer, RockWorks and EarthVision). A variety of packages are available commercially, and a few are publicly available (free). Vendors of real-time measurement technology services, especially those practiced in using the Triad approach may provide data

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management as part of their services. Larger organizations, such as the Army Corps of Engineers and EPA, may have software tools developed to support their organization.

Software packages developed with EPA support and are available free include *FORMS II Lite* (a sample labeling and tracking tool), *Field Environmental Decision Support* (FIELDS, includes data manipulation and mapping/geostatistical modules that require the commercial package ArcView to run), and *Spatial Analysis and Decision Assistance* (SADA, a stand-alone, free, geostatistically-based package). Visual Sampling Plan (VSP) is also a freely available software package. It consists of a number of modules that support design of a sampling plan, most of which are based on classical statistical algorithms. All of these free packages continue to be further developed, with additional functionality being added on a yearly basis.

Although extremely useful, care is required when using all classical and geostatistical packages to ensure that key assumptions of the statistical algorithms are not violated in a way that invalidates the output of the package. For example, many of the VSP modules are based on classical statistical algorithms. Because environmental contamination typically displays spatial patterning, classical statistics must be used cautiously (constrained by clear project goals and the conceptual site model) to ensure that the classical statistical assumption of no spatial relationship between data points in the population being sampled is not severely violated. The successful utilization of these applications will require understanding of the theory behind the tool. In addition, when very large data sets and sophisticated software are anticipated, it is often desirable for database and computer data evaluation team members to be involved in both planning and implementation of the fieldwork.

More information on each of the EPA-supported software packages is available from the following websites:

FIELDS <http://www.epa.gov/region5fields/>

SADA <http://www.tiem.utk.edu/~sada/>

FORMS II Lite <http://www.epa.gov/oerrpage/superfund/programs/clp/f2lite.htm>

VSP <http://dgo.pnl.gov/vsp/Index.htm>

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Technical Requirements for Site Remediation, N.J.A.C. 7:26E, Readoption with Amendments February 18, 1997, Latest Amendments, July 2, 1999.

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### **Glossary**

**Accuracy** - the ability of a technique to detect the true concentration of the analyte.

**Calibration** - the process by which data can be made to correlate with known standards.

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**Certified Laboratory** - a laboratory that is currently certified pursuant to N.J.A.C. 7:18, the Regulations Governing Laboratory Certification and Standards of Performance, to perform laboratory analysis for a specific certification category and a specific parameter within the certification categories.

**Clean Zone** - a series of contiguous samples collected at a frequency consistent with the requirements of the Technical Requirements for Site Remediation, N.J.A.C. 7:26E, which are analyzed and determined to be below the cleanup criteria (a single sample may constitute a clean zone for small contaminated areas).

**Conceptual Site Model** - any depiction or representation that conceptualizes or models contamination concerns to make predictions about nature, extent, risk, and risk reduction strategies. An accurate conceptual site model will delineate contaminant populations for which decisions about risk or remedial action or the project outcome will differ.

**Confirmatory Analyses** - analyses performed by applying methods that determine the identity and concentration of analytes with “reasonable” certainty. These data can stand on their own with respect to the vast majority of possible decisions. These analyses are performed by fixed-base or mobile certified laboratories using an approved method and contain QA/QC deliverables as required in N.J.A.C. 7:26E, Appendix A. The data generated by these analyses can be used for clean zone confirmation during any remedial phase.

**Contaminant** - as defined in N.J.A.C. 7:26E, currently: any hazardous substance, hazardous constituent, hazardous waste or pollutant discharged by any individual or entity.

**Contaminant Delineation** - the systematic collection and analysis of samples from a point of known contamination to determine the vertical and horizontal extent of contamination.

**Contaminant Screening** - the analysis of environmental media by non-selective instrumentation or methods to gain a preliminary estimate of contaminant extent.

**Corrected Results** - the results obtained when instrumental results are adjusted to account for laboratory confirmation values and/or other quality control criteria.

**Field Portable** - an instrument that is durable and relatively simple to move between facilities for on-site analysis.

**Full Laboratory Data Deliverables** - the data deliverables as required in N.J.A.C. 7:26E section 1.8 and Appendix A.

**Instrument Log** - a manual that documents all instruments outputs, calibration, and maintenance.

**Isoconcentration** - more than one sample point exhibiting the same analyte concentration.

**Isopleth** - the line or area represented by an isoconcentration.

**MDL (method detection limit)** - the minimum concentration of a substance that can be measured and reported with a 99 percent confidence that the analyte concentration is greater than zero and is determined from the analysis of a sample in a given matrix containing the analyte.

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**PQL (practical quantitation level)** - the lowest quantitation level of a given analyte that can be reliably achieved among laboratories within the specified limits of precision and accuracy of a given analytical method during routine operating conditions.

**Precision** - the ability of a method to provide reproducible results from sample to sample.

**Qualitative data** - results that provide (or are interpreted as) a “yes/no”; “present/not present” response.

**Quality Assurance** - documentation designed to assure that proper sampling and/or analysis protocol are being followed. Measures taken to independently check and verify that the quality control procedures specified in the QA/QC plan are being carried out.

**Quality Assurance Project Plan (QAPP)**– a document which presents in specific terms the policies, organization, objectives, functional activities and specific quality assurance/quality control activities designed to achieve the data quality goals or objectives of a specific project or operation.

**Quality control** - the implementation of protocols designed to assure that the final sampling or analytical results are reliable. QC is the process of ensuring the quality of data during their collection, measurement, integration, interpretation, and archiving, through the application of defined procedures.

**Quantitative data** - results provided as a continuous (in the numerical sense) numerical value as the “best estimate.” Uncertainty in the point estimate can be expressed as an associated confidence interval or by the number of significant figures provided in the value or by another device.

**Real-time measurement technologies** - any data generation and interpretation mechanisms that support real-time decision-making (i.e., a dynamic work plan strategy) including rapid turn around from a fixed lab (using screening, supportive or confirmatory methods), field-based measurements, and software or tools that facilitate rapid data management, mapping, interpretation, and decision support. The software could be used on-site, but doesn't have to be (e.g., data can be transmitted electronically to an office for processing, and then the output transmitted back to the field fast enough to support real-time decision-making).

**Reduced Laboratory Data Deliverables** - the data deliverables as required in N.J.A.C. 7:26E section 2.1 and Appendix A.

**Response Factor (Relative Response Factor)** - a measure of the relative response of the instrument detector to an analyte compared to an internal or external standard. Relative Response Factors are determined by the analysis of standards and are used to calculate the concentrations of analytes in samples.

**Screening Analyses** - these analyses use field portable instruments. Results often are not compound specific or quantitative, but results are available real time. The key feature is that additional confirmatory analysis of the same samples is usually required with respect to the decision to be made.

**Semi-Qualitative** - identification of a compound by class rather than identification of the specific compound (i.e. semi-qualitative would identify aromatic hydrocarbons whereas qualitative would

identify benzene).

**Semi-Quantitative** - numeric values which only approximate the true concentration of the analytes, or are expressed as a concentration range, such as “less than 10 mg/kg.”

**Site-similar material** (background contamination)- material containing the same chemical and physical characteristics of native material found on-site and should include actual site material used for the prescribed purpose.

**Supportive Analyses** - these analyses use portable analytical instruments with quantitative capability. Depending on the objective of the analyses, the data generated by Supportive Analyses may or may not be adequate for decision-making. The quality of the data depends on the use of suitable calibration standards, reference material, sample preparation equipment, the training of the operator and sample size, location and depth. Results are available real time or within several hours.

**Survey Instrument** - an instrument which detects compounds with little or no selectivity.

**Total Recoverable** - the amount of a contaminant that is extracted from the sample.