# Section 10: Environmental Monitoring

## 10.1 Introduction

**Purpose**

Environmental monitoring is required to evaluate the performance of engineered environmental control systems (e.g., liners, leachate and gas control systems) and to assess potential environmental impacts and public health and safety risks from any contaminant releases.

**How to respond**

Prepare and submit an Environmental Monitoring Plan (EMP) report to the Department for review and approval. Upon approval, all environmental monitoring must be conducted in accordance with the EMP, including any conditions of the approval.

The plan should be stamped by an Oregon Registered Geologist with experience in environmental monitoring.

**Regulatory framework**

The following regulations govern environmental monitoring:

- 40 CFR Part 258, Solid Waste Disposal Facility Criteria
- OAR 340 Division 94, Solid Waste Management
- OAR 340 Division 40, Groundwater Quality Protection.

**Monitoring overview**

The progression of activities and submittals related to the environmental monitoring include the following:

| Stage | Activity | Guidance section |
|---|---|---|
| 1 | Site characterization | 2 and 3 |
| 2 | Engineering design | 7 |
| 3 | Interim monitoring | 10.1 |
| 4 | Environmental monitoring plan monitoring | 10 |
| 5 | Establishing permit specific concentration limits | 10.15 |
| 6 | Long-term monitoring | 10.15 |

Complete the site characterization and engineering design stages prior to development of the EMP. Use the information on facility hydrology, geology, and hydrogeology in preparing the plan.

**Interim monitoring**

Interim monitoring may be required by the permit. Interim monitoring is conducted after site characterization until an approved EMP is implemented. Any interim monitoring requirements will be specified in the permit.

**Plan updates**

The monitoring program extends through the post-closure period of the landfill. Updates to the monitoring plan may be required for:

- facility development
- landfill expansion
- the addition of a new cell
- changes in the groundwater flow
- major changes in operations
- additional sampled media, or
- anytime the Department requires changes or additions to the program, such as installation of new wells or changes in sampling parameters

**In this section**

This section describes the elements that should be addressed in the Environmental Monitoring Plan, including:

- Environmental Monitoring Network Design
  - Groundwater
  - Surface Water
  - Leachate
  - Vadose Zone
  - Landfill Gas
  - Air Quality
- Groundwater Monitoring Network Construction
- Sampling and Analysis
- Data Analysis and Evaluation
  - Setting Permit Specific Concentration Limits
- Reporting
- Action Requirements, Assessment and Corrective Action

## 10.2 Environmental Monitoring Network Design

**Monitoring network**

The environmental monitoring network consists of several components designed to detect and characterize facility impacts through groundwater, surface water, vadose zone, leachate, and gas monitoring. The network's individual monitoring components should be compatible with each other and with site characteristics, the landfill design, and other facility operations.

**Design considerations**

Site characterization, engineering design, and the environmental monitoring network are interdependent elements of landfill development. Conceptual models of site hydrology, geology, and groundwater should be developed to define the physical and environmental criteria needed for designing the monitoring system.

**EMP contents**

The network system design section of the EMP should:

- describe how the monitoring network will characterize facility impacts through the monitoring of:
  - groundwater
  - surface water
  - leachate
  - vadose zone
  - landfill gas
  - private wells, and
  - any other appropriate environmental monitoring
- Identify new and existing wells and piezometers intended for the monitoring network. Justify the number of wells and well location, depths, and horizontal and vertical spacing
- Identify all sampling locations on a location map that shows:
  - the unique identification number of all sample locations
  - surrounding features, including manmade, natural features, and contours
  - the location and boundary of the facility
  - all landowners within one-half mile radius of the solid waste boundary
  - a North arrow
  - any USGS benchmarks

Map size: The location map should be at a scale of not more than 1" = 200' and contour intervals not to exceed 5'.

**Professional surveying**

The map should be prepared and stamped by a registered land surveyor or civil engineer. Surveyed well locations should:

- provide a horizontal accuracy of 0.2 feet (0.06 meters)
- provide the elevation of the land surface with a vertical accuracy of 0.1 feet (0.03 meters)
- provide the marked level at the top of the well casing with a vertical accuracy of 0.01 feet (0.003 meters)
- use National Geodetic Vertical Datum of 1929 as the vertical elevation control, and the Oregon State Plane Coordinate System (ORS 93.330) as the horizontal control, and
- describe the location in latitude and longitude coordinates accurate to 0.1 seconds of latitude and longitude

## 10.3 Monitoring Network Design -- Groundwater

**Objective of groundwater monitoring**

Monitor groundwater to provide reliable and representative information on:

- aquifer characteristics
- groundwater flow directions, and
- chemical and physical characteristics of groundwater being monitored

**Network design**

Describe the groundwater monitoring network, including:

- the number, location, spacing, depth, and screen interval of monitoring wells for each potentially impacted aquifer
- methods to provide background data and/or to intercept potential contaminant flow paths
- site-specific geology/hydrogeology as defined by site characterization
- the lateral and vertical extent of any existing contaminant plumes and their expected transport
- landfill configuration and size
- purpose of each well (detection, background, characterization)
- aquifer(s) monitored
- relationship to facility operations and other monitoring components (i.e., potential for landfill gas migration)

**Well network**

The network should adequately characterize each monitored aquifer or water bearing zone. The groundwater monitoring network should include a sufficient number of the following types of wells:

- background wells
- detection wells
- compliance wells, and
- piezometers (as appropriate)

**Types of wells** The table below discusses the types of groundwater monitoring wells that may be part of the monitoring program.

| Well type | Description |
|---|---|
| Characterization wells | Designed to collect information to characterize the geology, hydrogeology and groundwater chemistry used for designing the facility and a long term monitoring program. Usually installed during the site characterization phases of the project. If located in desirable locations, may later be proposed for the long term monitoring program. |
| Background wells | Designed to characterize background water quality at the facility. Typically located upgradient from the waste disposal facility, but other configurations (i.e., cross gradient) may be approved by the Department if geologic, hydrogeologic or other conditions do not allow for a satisfactory upgradient location. Should be screened in the same water bearing zone(s) as the downgradient detection and compliance wells. |
| Detection wells | Designed to intercept pathways of contaminant migration from the facility. Usually installed at the downgradient edge of the solid waste disposal boundary to immediate detect any releases of contamination. Always located inside the compliance boundary. May coincide with the point of compliance. |
| Compliance wells | Designed to monitor the quality of groundwater downgradient from the landfill passing through the facility's compliance boundary. The compliance boundary is the point where groundwater must be at or below the permit specific concentration limits established for that facility. The default compliance boundary is the waste management boundary unless otherwise approved by the Department. |
| Piezometers | Used to measure groundwater elevations for determining hydraulic gradients and/or flow directions across the facility. Should be screened in the appropriate intervals to determine the vertical and horizontal groundwater gradients in the monitored aquifers. |

Note: At new facilities, characterization of background water quality may be required before waste is accepted at the facility or new unit of landfill cell. Groundwater collected at both background and downgradient prior to accepting waste may be used to establish pre-operation background groundwater quality.

## 10.4 Monitoring Network Design -- Surface Water

**Objective of surface water monitoring**

Monitor surface water potentially impacted by leachate releases, contaminated groundwater seepage, or surface water run-off.

**Related requirements**

Surface water monitoring may be required by the Department's Water Quality program through National Pollutant Discharge Elimination System (NPDES) or Water Pollution Control Facility (WPCF) permits and/or through the solid waste permit.

**Network design**

Describe the surface water monitoring network, including:

- proposed upstream, downstream, and potential point of discharge locations for surface water monitoring
- provisions for minimum monitoring and reporting requirements of any facility NPDES or WPCF permit
- justification for the number and location of sampling points
- provisions to provide a permanent marker at each sampling station (i.e., survey marker) to establish re-usable sampling locations
- a description of any flow measuring devices, recording equipment, or staff gauges that may be installed at the sampling site

**Sample location considerations**

The proposed sampling locations should consider:

- potential or existing contaminant migration pathways
- overland flow paths defined by topographic maps and visual observation
- site drainage patterns and surface water management controls
- potential groundwater discharge points to surface water, and
- streamflow, contaminant dilution, and chemical behavior

**Potential discharge sources**

Landfills may produce the following surface water discharges:

- leachate seeps or other drainage
- contaminated groundwater, including springs, seeps, or underflow to surface water
- overflow of lagoons
- malfunction of leachate conveyance system

## 10.5 Monitoring Network Design -- Leachate

**Objective of leachate monitoring**

Monitor the landfill leachate's existing characteristics and changes in quality during landfill development. Monitor the primary leachate collection system's effectiveness (e.g., head level). Monitor the secondary leachate collection system for primary liner failure and the presence of liquid.

**Network design**

The EMP should describe the leachate monitoring network, including:

- a proposal and justification for the number, location, depths, spacing, and type(s) of leachate monitoring points to monitoring leachate quality, quantity, and the presence of liquid in the secondary leachate collection system
- proposed construction details, materials, and methods of installation for any new monitoring devices
- documentation/description of the construction and design of existing monitoring points
- scaled construction diagram of each device or typical device, and
- sampling or testing methods proposed during construction

**Sampling locations**

Leachate sampling locations could include:

- sumps, manholes, or other access points to the leachate collection system, if the site is equipped with such a system
- sampling points within the waste at locations that will yield representative samples, and account for the heterogeneities of the waste material and leachate
- sampling from landfill gas wells that penetrate leachate saturated waste zones, or
- vertical or horizontal wells specifically installed within the waste for sampling leachate

**Design precautions**

Consider the following precautions in the design of the leachate monitoring network:

- Leachate lagoons and holding ponds are not good monitoring points for characterizing raw leachate quality. The leachate can be diluted by rainfall and/or undergo chemical/quality changes during removal, exposure to the atmosphere, storage, and intentional treatment processes.
- Groundwater and surface water may infiltrate into the leachate collection system and dilute the leachate. These influences usually occur seasonally.
- Variations in the waste and leachate. Leachate quality can vary temporally and spatially due to differences in the composition, age, and disposal method.

## 10.6 Monitoring Network Design -- Vadose Zone

**Objective of vadose zone monitoring**

Detect leachate releases by monitoring the moisture content and quality of the pore water beneath the facility.

**Network design**

Describe the vadose zone monitoring network, including:

- the type of device, function, and site monitoring application
- the proposed number, location, depths, spacing, and type(s) of vadose zone monitoring devices
- proposed construction details, materials, and methods of installation
- scaled construction diagram of each device or typical device, and
- sampling or testing methods proposed during construction

**Basis for design**

Design the vadose zone monitoring network to reflect the following:

- landfill cell and leachate collection and conveyance system design
- site-specific unsaturated zone characteristics (soils, lithology, hydrology) as determined during the site characterization phases
- soil types, layers (stratigraphy), and characteristics including permeability, saturated and unsaturated hydraulic conductivity, particle size and distribution, and other chemical and physical characteristics, and
- water flow in the vadose zone beneath the landfill liner

**Location considerations**

Install monitoring devices beneath those areas where the liner is most likely to leak, such as sumps, collection laterals, or major liner seams. Other sensitive areas include low spots where water accumulates and locations where low permeable materials were removed during construction.

**Monitoring methods**

Example vadose zone monitoring methods are discussed in the table below.

| Method | Description |
|---|---|
| collection lysimeters | • Lined basin installed beneath the landfill liner similar to a localized leachate collection system<br>• Direct method of collecting soil water for chemical analysis<br>• Collection of quantity and quality data from a discrete area |

| | |
|---|---|
| suction lysimeters | • Perform poorly in arid regions<br>• Limited to extract samples from soils at tensions no greater than 1 or 2 atmospheres |
| other examples | • vapor probes - monitor/extract the soil gas for chemical analysis<br>• ion probes - measure the ion concentrations<br>• conductivity probes - measure the conductivity<br>• tensiometers - measure the moisture content in the unsaturated zone<br>• TDRs<br>These methods monitor the soil water quality indirectly, by measuring other mediums (soil gas) or parameters, such as moisture content or conductivity, that can be used to predict water chemistry. |

Note: These may not be the only available methods. Other methods may be proposed to meet the site's monitoring needs.

## 10.7 Monitoring Network Design -- Landfill Gas

**Objective of landfill gas monitoring**

Monitor for landfill gas migration at the facility boundary and within on-site structures. Design the landfill gas monitoring network to meet the following objectives:

- evaluate the performance of landfill gas control measures
- provide accurate, representative field measurements of methane and oxygen concentrations and static pressure
- monitor the efficiency of landfill gas recovery and control systems, and
- monitor the effectiveness of gas migration control wells

**Network design**

Describe the landfill gas monitoring network, including:

- proposed perimeter landfill gas monitoring probes to at least the same depth as the landfill's base elevation
- at least one proposed shallow probe between the landfill and each on-site structure with a maximum depth of 20 feet (6.1 meters)
- site-plan drawings showing proposed landfill gas monitoring probe locations
- design drawings showing proposed landfill gas monitoring probe depths, screened intervals and construction details
- the rationale for proposed monitoring probe locations, depths, and designs
- procedures for integrating gas monitoring system installation and operation with landfill development, and
- proposed operation and maintenance procedures

**Probe construction**

Probes should have maximum screened intervals of 30 feet (9.15 meters). For monitoring intervals greater than 30 feet, multiple-completion probes or probe clusters are required. Separate monitoring capabilities should be provided for each successive 30-foot interval.

**Design considerations**

The number and location of landfill gas probes is dependent on:

- subsurface conditions at the site
- hazards to surrounding land use
- public safety risks
- location and design of facility structures
- other underground structures or conduits
- landfill gas generation rates and migration potential, and
- the size and configuration of the landfill

**Landfill gas composition**

Landfill gas is composed of:

- approximately 50-60 percent methane
- approximately 40-50 percent carbon dioxide, and
- trace amount of VOC and other organic and inorganic gases

**Hazards of landfill gas**

Methane is combustible and explosive at concentrations of 5 - 15 percent by volume in air. Some of the trace gases, including VOCs, are toxic. Other hazards associated with landfill gas include the:

- accumulation of explosive concentrations of methane in on-site or off-site structures
- exposure of workers on or near landfills to high concentrations of toxic gasses
- exposure of workers to atmospheres lacking sufficient oxygen due to its displacement by landfill gas
- potential source of air emissions and water pollution, and
- potential impacts to groundwater from gas-born VOCs that can dissolve into solution under wet soil conditions

## 10.8 Monitoring Network Design -- Air Quality

| | |
|---|---|
| **Objective of air quality monitoring** | Monitor point sources and diffuse area-wide sources for potential air contaminants. Point sources may include gas combustion flares. Diffuse area-wide sources may include raw landfill gas or fugitive dust from construction. |
| **Contaminants** | Potential air contaminants may include methane, odorous compounds, particulates, and volatile organic compounds. |
| **NSPS** | New source performance standards (NSPS) for municipal solid waste landfills have been issued to control emissions of non-methane organic compounds from large landfills. Landfills with a design capacity of 2.5 Mg (2.75 million tons) and emissions of non-methane organic compounds in excess of 50 Mg (55 tons per year) are subject to NSPS and may be required to implement control technologies. |
| **Requirements** | Contact the Department's Air Quality Program for monitoring and permit requirements. |

## 10.9 Groundwater Monitoring Network Construction

**EMP contents**

Describe how wells will be constructed and evaluated to continually meet construction requirements and ensure accurate, representative samples are obtained, including:

- evaluation of monitoring network
- evaluation of monitoring points
- procedures for installation of new monitoring points
- plans for routinely evaluating monitoring points

**Construction standards**

New and existing monitoring wells proposed for the monitoring program should:

- be constructed to meet the construction criteria defined in
  - OAR 690 Division 240, and
  - the Department's August 24, 1992, Groundwater Monitoring Well Drilling, Construction and Decommissioning Guidelines
- be compatible with site-specific hydrogeologic conditions including physical, chemical, and hydraulic properties of the monitored zones
- use construction techniques that are protective of groundwater resources by preventing:
  - the introduction of surface contaminants, and
  - the vertical migration of contaminants between water bearing zones
- be designed for maximum well efficiency and minimum turbidity when sampling
- designed to last throughout the landfill's active life and post-closure period

Note: Multiple well screens or depth completions in a single borehole are not acceptable, unless approved by the department. Wells may only be screened in a single aquifer and zone.

**Evaluation of monitoring network**

Describe and evaluate the current status and integrity of the monitoring network as a whole.

**Evaluation of monitoring points**

Describe the current status and integrity of each monitoring point within the network. Evaluate monitoring wells to determine whether each is capable of obtaining representative samples. An Oregon Registered Geologist must certify this evaluation. Wells not capable of obtaining representative samples must be recommended to be decommissioned, and, if required by the Department, replaced. Provide records of the installation of existing monitoring wells including construction details and lithologic logs.

**Procedures for installing new monitoring points**

Install new monitoring points in accordance with the construction standards. Describe installation procedures, including:

- drilling methods, type of drilling equipment, drilling fluids, and methods to isolate surface soils and/or shallow water zones during borehole drilling and construction
- handling and decontamination of well material and equipment
- methods for subsurface sampling, including sampling intervals and provisions for collecting samples and describing color, texture, composition, moisture content, evidence of contamination and other relevant characteristics
- storage, testing, and disposal of drilling fluids and drill cuttings
- size (diameter) and depth of the borehole
- construction methods and materials, including the size and type of casing and screen, screened interval, and type and placement of filter pack and annular seal
- well development methods and procedures
- borehole geophysical methods to log the monitoring well, and
- field testing methods for aquifer characteristics

Note: Prepare a scaled construction diagram of each monitoring well

**Plans for evaluating monitoring points**

Describe procedures for routinely evaluating each monitoring point within the network to ensure that each point is capable of providing representative samples throughout the active and post-closure periods of the landfill.

## 10.10 Sampling and Analysis

**EMP contents**

Propose a sampling and analysis plan for collecting valid and representative groundwater, surface water, vadose zone, leachate, and landfill gas samples that will produce reliable and credible analytical results. The EMP should include:

- training provisions
- identification of devices
- sample point inspection procedures
- sampling procedures, and
- monitoring parameters and schedule

**Training provisions**

Describe how sampling personnel will be trained to use the sampling and analysis procedures.

**Identification of devices**

Provide the location, depth, and construction details of all environmental monitoring devices. Provide all monitoring point locations on a scaled, accurate map by monitoring type and identification numbers.

**Sample point inspection**

Describe procedures for inspecting and reporting on each monitoring point and the immediate surrounding area during sampling. Inspect each environmental monitoring point for:

- structure
- security features such as locks, cap, protective casing
- unusual conditions
- identification, and
- anything that could influence the collection of representative data or signify changing conditions.

**Sampling procedures**

Describe site-specific field sampling procedures for each monitoring type:

- field recordkeeping procedures
- field meter operation and calibration
- sampling order
- water level measurements
- sample equipment and collection methods
- purging equipment and method (include well volume calculation, field parameter monitoring, pump intake placement, disposal of purge water);
- sample containers and labeling
- sample filtration and preservation
- sample preservation and holding times
- sample transport/shipment
- equipment decontamination
- chain of custody
- proposed field and reporting forms

---

**Monitoring parameters and schedule**

Prepare a summary of sample parameters, frequency, and schedule, including the following:

- monitoring parameters
- approved analytical methods
- detection limits (for parameters that have a federal or state standards, the detection limit should be no more than 10% of the standard, or the rationale for setting such a detection limit should be explained)
- container type and volume
- preservative
- holding time
- sampling frequency and schedule

Typical monitoring parameters and sampling schedule for each type of environmental monitoring is discussed below.

---

**Parameters and frequency**

The following table discusses typical parameters and frequency that could be required for each type of monitoring. This is intended for general guidance purposes only. Parameters and frequency will be determined on a site-specific basis.

| Media | Discussion and considerations |
|---|---|
| Groundwater | • Appropriate monitoring parameters will be based on site-specific hydrogeologic characteristics, leachate and landfill gas characteristics, regulatory requirements, anticipated contaminant mobility and persistence and contaminant concentrations relative to ambient groundwater conditions.<br>• Quarterly monitoring of groundwater will usually be required until nine valid data points have been collected for background determination, statistical analysis, and establishment of permit-specific concentration limits. |
| Surface water | • Minimum monitoring and reporting requirements are specified in the Stormwater Discharge (NPDES) permit issued by the Department's Water Quality Program.<br>• Sampling parameters should be good indicators of potential leachate discharge<br>• Monitoring of groundwater discharges to surface water (i.e., seeps, drainages, springs) will usually require routine quarterly sampling. The monitoring parameters and schedule will be based on site-specific hydrogeology, surface hydrology and other environmental factors. |
| Vadose | Vadose zone monitoring parameters and sampling frequencies will vary depending on the type of monitoring devices used, site specific environmental and hydrogeologic conditions |
| Leachate | Leachate monitoring and frequency will be similar to the groundwater monitoring program, described above. Leachate quantity (flow rates) should be measured on a daily basis when leachate generation is occurring. |
| Secondary LCS | The secondary leachate collection system should be monitored on a routine basis for the presence of any liquids. If liquids are present, samples should be taken immediately and analyzed for leachate constituents. |
| Landfill gas | The monitoring schedule should be based on the following site specific factors:<br>• soil conditions<br>• hydrogeologic conditions<br>• facility design and development history<br>• location of facility structures and property boundaries<br>• surrounding land use and location of off-site structures<br>• changing site conditions which may affect gas generation and migration (e.g., barometric pressure, temperature, soil moisture, snow cover etc.)<br>Minimum sampling frequency is quarterly. If possible monitoring should be conducted during periods when strong barometric lows are anticipated. |
| Air | Contact the Department's Air Quality Division |

**Groups defined** Monitoring group parameters are defined in the table below.

<table>
<tr><th>Group</th><th>Parameters</th><th>Notes</th></tr>
<tr><td>1a - Field indicators</td><td>Elevation of water level<br>Specific Conductance<br>pH<br>Dissolved Oxygen<br>Temperature<br>Eh</td><td>These parameters must be measured in the field at the time samples are collected, either down-hole in situ, in a flow-through well, or immediately following sample recovery, with instruments calibrated to relevant standards</td></tr>
<tr><td>1b - Leachate indicators</td><td>Hardness (as $CaCO_3$)<br>Total Dissolved Solids<br>Total Alkalinity (as $CaCO_3$)<br>Total Suspended Solids<br>Specific Conductance (lab)<br>Chemical Oxygen Demand<br>pH (lab)<br>Total Organic Carbon</td><td>Sample handling, preservation, and analysis are determined by requirements for each individual analyte: EPA or AWWA Standard Methods techniques must be followed.</td></tr>
<tr><td>2a - Common anions and cations</td><td>Calcium (Ca)<br>Manganese (Mn)<br>Sulfate ($SO_4$)<br>Magnesium (Mg)<br>Ammonia ($NH_4$)<br>Chloride (Cl)<br>Sodium (Na)<br>Carbonate ($CO_3$)<br>Nitrate ($NO_3$)<br>Potassium (K)<br>Bicarbonate ($HCO_3$)<br>Silica ($SiO_2$)<br>Iron (Fe)</td><td>Groundwater samples: Dissolved concentrations must be measured. Samples must be field-filtered and field-preserved according to standard DEQ and/or EPA guidelines and analyzed by appropriate EPA or AWWA Standard Methods techniques. Results must be reported in mg/L and meq/L.</td></tr>
<tr><td>2b - Trace metals</td><td>Antimony (Sb)<br>Chromium (Cr)<br>Selenium (Se)<br>Arsenic (As)<br>Cobalt (Co)<br>Silver (Ag)<br>Barium (Ba)<br>Copper (Cu)<br>Thallium (Tl)<br>Beryllium (Be)</td><td>Groundwater samples:
<table>
<tr><th>If the Total Suspended Solids concentration is...</th><th>then analyze for...</th></tr>
<tr><td>less than or equal to 100 mg/L in the sample</td><td>total concentrations (unfiltered)</td></tr>
<tr><td>greater than 100 mg/L in the sample</td><td>both total (unfiltered) and dissolved (field-filtered)</td></tr>
</table></td></tr>
</table>

| Group | Parameters | Notes |
|---|---|---|
| | Lead (Pb)<br>Vanadium (V)<br>Cadmium (Cd)<br>Nickel (Ni)<br>Zinc (Zn) | Samples must be field-preserved according to standard DEQ and/or EPA guidelines and analyzed by EPA Method 6010 or Department-approved equivalent. Results must be reported in mg/L. |
| 3 - Volatile organic compounds | Analysis for all compounds detectable by EPA Method 8260 or EPA Method 524.2, including a library search to identify any unknown compounds present. | Method 8260 comprises the volatile organic constituents parameter group. Facilities that want to use Methods 8010 and 8020 as an alternative must obtain approval by the Department prior to use. |
| 4 - Assessment monitoring parameters | Analysis for all compounds detectable by the following EPA methods:<br>Semi-volatile Organic Constituents, according to EPA Method 8270<br>Mercury, according to EPA Method 7470<br>Cyanide, according to EPA Method 9010<br>Nitrite | All Method 8270 analyses must include a library search to identify any unknown compounds present |
| 5 - additional surface water and leachate parameters | Total Kjeldahl Nitrogen<br>Total Coliform Bacteria<br>Total Phosphorus<br>Fecal Coliform Bacteria<br>Orthophosphate<br>E. Coli<br>Biological Oxygen Demand<br>Total Halogenated Organics | In addition to Group 5, surface water samples should also be collected for Groups 1a, 1b, 2a (total concentrations) and 2b (total concentrations).<br><br>In addition to Group 5, leachate samples should also be collected for Groups 1a, 1b, 2a (total concentrations), 2b (total concentrations) 3 and semi-volatile organics (EPA 8270). |

## 10.11 Field QA/QC

**EMP contents**

Describe Field QA/QC procedures, including provisions for:

- documentation
- sample blanks and duplicates
- field blanks
- trip blanks
- equipment blanks
- duplicates

**Documentation**

Describe procedures to document sample collection, storage, including:

- maintenance of adequate field records and chain of custody
- recording sample collection data on field data sheets
- documenting sampling activities (collection, equipment calibration, decontamination) on field data sheets
- documenting any unusual conditions that may effect samples or any deviations from the normal sampling protocol
- proper labeling, storage and shipment

**Sample blanks and duplicates**

Describe how sample blanks and duplicates will be used to detect contamination coming from sample containers, preservation, equipment, storage, transport, and site conditions.

**Field blanks**

Describe procedures for managing field blanks. Field blanks should be collected and handled in the same manner as the sample group for which it is collected. Field blanks should be collected once per sampling day or once for every ten samples, whichever is more frequent.

**Trip blanks**

Describe procedures to ensure tat trip blanks are completed if volatile organic compounds (VOCs) are to be analyzed. Trip blanks are prepared by the laboratory at the same time and location for the sampling event. Trip blanks accompany the sample containers to and from the sample event. One trip blank for VOCs should be prepared for each sample shipment container.

**Equipment blanks**

Describe how equipment blanks will be used for non-dedicated sampling equipment requiring decontamination. De-ionized water is passed through the sampling equipment to the appropriate sample container. Equipment blanks are required for every sample parameter, once per sampling day or once for every ten samples, whichever is more frequent.

---

**Duplicates**

Describe procedures to collect duplicates under the same conditions as the original sample and treated the same as the sample parameter group. A duplicate for all analytes should be collected once per sample day or once every ten samples, whichever is more frequent.

---

## 10.12 Lab QA/QC

**EMP contents**

Describe laboratory QA/QC procedures, including:

- a written laboratory QA/QC plan from the laboratory conducting the analysis; each time the laboratory is changed, or a new lab is contracted, a new QA/QC plan is required
- routine equipment calibration to standards of known concentration on a schedule appropriate for the analytes of concern and analytical methods used
- analysis of laboratory method blanks, laboratory duplicates and matrix spikes for all analytes at a frequency of once per sampling event or once per day of analysis, whichever is more frequent
- analysis and reporting of the percent recovery of surrogate spikes in each sample analyzed for organic analytes

Reference: Contact the Department's laboratory (503-229-5983) for additional or updated laboratory QA/QC requirements.

## 10.13 Data Evaluation

**EMP contents**

describe site specific procedures for

- comparing groundwater sampling results to applicable standards
- performing statistical analyses, and
- identifying and addressing any field of lab data that did not meet lab quality objectives

**Review of results**

Review the groundwater analytical results after each groundwater sampling event:

| If data show results... | Then... |
|---|---|
| above permit-specific concentration limits (if established) | 1. notify the Department within 10 days of receipt of laboratory results, and<br>2. perform resampling within 15 days and evaluate results as described below<br>*Note: If this is a known release, previously confirmed to the Department in writing, resampling is not required* |
| indicating a significant change in water quality at any monitoring point<br><br>Examples of significant changes:<br>Detection of a VOC or other hazardous constituent not previously detected in background<br>Exceedance of a Table 1 or 3 value listed in OAR 340-40, unless the background water quality is above these numerical limits<br>Exceedance of a Safe Drinking Water Standard<br>Exceedance of an Action Limit<br>Detection of a compound in an order of magnitude higher than background | 1. notify the Department within 10 days of receipt of laboratory results, and<br>2. perform resampling within 15 days and evaluate results as described below<br>*Note: If this is a known release, previously confirmed to the Department in writing, resampling is not required* |
| neither of the above | continue groundwater monitoring with next scheduled sampling event |

**Resampling results**

Upon receipt of data from resampling, the results should be reviewed according to the following table

| If resampling data show results | Then |
|---|---|
| that confirm the exceedance of a permit-specific concentration limit | 1. notify the Department within 10 days of receipt of laboratory data, or within 60 days of the sample date (whichever comes sooner)<br>2. begin assessment monitoring<br>3. submit a Remedial Investigation workplan for Department approval within 90 days of the date of resampling; the plan must specify how the objectives of OAR 340-40-040(3) will be met by the proposed investigation |
| that confirm the significant change in water quality results noted in the routine sampling event | 1. notify the Department within 10 days of receipt of laboratory data, or within 60 days of the sample date (whichever comes sooner)<br>2. submit a plan within 30 days (unless another time period is authorized) for developing an assessment program with the Department; this may include the monitoring of Group 4 parameters, in addition to routine detection monitoring |
| that do not confirm the results noted in the routine sampling event | 1. continue with routine monitoring<br>2. discuss the data from the routine sampling event and the resampling results in the next annual environmental monitoring report |

## 10.14 Reporting

**Objective**

Present the environmental monitoring data to the Department in an organized and clear format. Evaluate and interpret data to

- determine regulatory and permit compliance
- determine if leachate impacts have occurred
- assess the effectiveness of any corrective actions
- monitor potential health and environmental effects, and
- prepare and submit an annual monitoring report

**EMP content**

Propose an the annual environmental report that will:

- discuss the results of all environmental monitoring performed during the year
- discuss the results of the previous year's Data Analysis and Evaluation
- itemize any activities resulting from the exceedance of a relevant standard or significant change in water quality, such as resampling, submittal of a Preliminary Assessment, or Assessment Monitoring
- discuss any preventative measures and the results of such actions, if applicable
- assess the current status of the environmental monitoring network
- provide updated information for each sampling event and monitored unit, depicting groundwater flow rates and directions, and piezometric water contours
- summarize Sampling and Analysis, Field QA/QC, and Lab QA/QC techniques implemented during the year
- provide copies of applicable information, including field data, laboratory analytical reports and chain-of-custody reports; all data must be cross-referenced and labeled with the designated field sampling location
- provide summary tables of the year's monitoring data by location and parameter
- provide updated time series and box plots for appropriate parameters
- provide results of a major anion-cation balance for each groundwater monitoring well sampled for major anions and cations
- provide an executive summary

**Statement of compliance**

A one-page cover letter must accompany the Annual Environmental Monitoring Report that:

- compares the analytical results with the relevant monitoring standards (see Section 10.13)
- states whether or not federal or state standards were exceeded for the relevant media
- states whether or not a significant change in water quality occurred

The cover letter must be signed and stamped by an Oregon Registered Geologist with experience in hydrogeological investigations.

---

**Data presentation**

Below are some suggested formats for presenting the environmental monitoring data. Specific requirements may be discussed in the solid waste permit:

| Presentation Type | Description |
|---|---|
| Tables | Data tables work well for summarizing analytical data and statistical parameters.<br>For analytical and water level data:<br>• arrange table by monitoring point identification number, parameter, and/or sampling event<br>• present each type of monitoring data separately (i.e.; leachate, groundwater, surface water)<br>• group groundwater data according to well designation (upgradient, downgradient)<br>For statistical data:<br>• arrange in individual tables by parameter and location<br>• arrange sampling points on one axis and sample date on the other axis. Report statistical results in table body. |
| Time series charts | Useful for illustrating seasonal variations and changes in data over time.<br>Prepare as follows:<br>• plot a separate chart for each parameter of interest<br>• plot all monitoring points for comparison on one graph<br>• plot concentration on vertical axis using a consistent scale and equal spacing<br>• plot time on the horizontal axis using a consistent scale and equal spacing<br>• represent PSCL value as a line on graph<br>• identify parameter, sample location, and other pertinent features on the graph |

| Presentation Type | Description |
|---|---|
| Box plots | Evaluate spatial variability of a parameter. Useful for illustrating data dispersion or variability of a data set or between data sets about the median value.<br>Prepare as follows:<br>• construct individual plots for each well and each parameter<br>• plot boxes from multiple wells for a single constituent on a single grid for comparison<br>• plots should include median, interquartile range, and maximum and minimum values<br>• represent PSCL value as a line on the grid<br>• clearly identify parameter and sample location<br>*See the statistical references and guidelines in Section 10.12 below for details on the preparation, use, and interpretation of box plots.* |
| Potentiometric contour maps | Useful for plotting and contouring water level data to illustrate elevations, flow directions and gradients. Maps should include:<br>• measuring point<br>• date and season<br>• elevation<br>• contour interval<br>• scale<br>Plot different aquifers of interest on different maps and maps for each season or sample event. Incorporate surface water elevations with shallow aquifer elevations, if appropriate, and include leachate elevation levels. Do not include measurements of shallow and deep portions of the an aquifer on the same potentiometric map unless complete hydraulic communication has previously been established and there is no discernible vertical gradient |
| Other graphical methods | Other useful graphical methods for presenting and interpreting data include:<br>• hydrographs<br>• scatter plots<br>• cross sections<br>• histograms<br>• trilinear diagrams<br>• ion-concentration diagrams, and<br>• contour maps<br>Consult the Department hydrogeologist for the appropriate methods to use for individual facilities. |

Note: Electronic copy of data should be provided. Acceptable electronic formats include Excel, Lotus 123, and Quatro Pro.

**Water quality reporting concentrations**

Water quality concentrations should be reported in milligram per liter (mg/L) for most organic and inorganic parameters; both mg/L and milliequivalents per liter (meq/L) for common anions and cations; micro-ohms per centimeter (uohms/cm) for specific conductance; s.u. for pH; degrees centigrade for temperature; and nephelometric turbidity units (NTU) for turbidity.

---

**Typical annual report**

A typical annual report includes the following information:

| Section | Content |
|---|---|
| Background Information and Data Reporting | • site background information<br>• presentation of water/leachate level data and groundwater flow rates using contour maps, tables, and graphs<br>• summary of all field data, laboratory analytical reports, chain of custody reports, all cross-referenced with the field sampling locations<br>• data validation (i.e.; cation/anion balance, comparison of blanks and duplicates, identify data problems or discrepancies, review of detection limits and holding times)<br>• time series graphs<br>• summary tables of the year's monitoring data by location and parameter |
| Water Quality Statistical Analysis | Box plots for the purpose of:<br>• establishing background water quality and proposing permit-specific concentration limits<br>• comparing monitoring results to compliance concentrations to determine if a release has occurred<br>• assessing whether any corrective/preventative actions have been effective in reducing contaminant concentrations or controlling leachate releases to the environment |
| Data Interpretation and Evaluation | • evaluation of data quality trends in each monitoring point for each parameter, and a determination if any significant changes have occurred<br>• review of statistical methods for background water quality and identifying potential impacts<br>• a comparison of water quality in the downgradient monitoring points to upgradient/background monitoring points<br>• comparison of data quality to any PSCLs that have been established<br>• comparison of groundwater quality data to existing federal and state groundwater standards<br>• assessment of whether any corrective or preventive actions have been effective in reducing or controlling releases<br>• assessment of the effectiveness of any closure measures undertaken<br>• list of any activities resulting for an identified exceedance |

| Section | Content |
|---|---|
| Conclusions and Recommendations | • summary of the data collection, evaluation, and results of all environmental monitoring performed during the year<br>• discussion of any impacts, trends in data, and violations of PSCLs, exceedences of a standard, or significant changes<br>• any recommendations for the monitoring program<br>• identify any impacts and action requirements<br>• discussion of the current status of the environmental monitoring network<br>• executive summary |

## 10.15 Establishing Permit-Specific Concentration Limits (PSCLs)

**Contents**

This section of the guidance discusses PSCLs and how to establish them. The requirement for proposing PSCLs will be included in the permit. References and guidelines on how to go about determining PSCLs are provided below. A proposal to establish PSCLs does not need to be included in the EMP, only provisions that it will be done in accordance with the permit requirements.

**Definition: PSCL**

OAR 340-40-010(3) defines a concentration limit as the maximum acceptable concentration of a contaminant allowed in groundwater at a Department specified compliance point.

**Objective**

To establish regulatory compliance concentration limits for pollutants of concern at the facility's compliance boundary. An exceedence of these limits would trigger concern and require some type of regulatory, assessment, preventive and/or corrective actions.

**Regulatory reference**

OAR 340-40-030(3) requires that PSCLs be specified in the permit for new and existing facilities.

**Data requirements**

Data requirements for establishing PSCLs are:

- a minimum of nine acceptable and valid data points for each parameter from the approved background well or wells is required for setting PSCLs.
- PSCLs are required for selected parameters that will be included in the long-term monitoring program at the site. These parameters will either be specified in the permit or should be discussed with the Department's hydrogeologist.
- statistical methods and calculations for determining PSCLs and background are provided in the references discussed below.

**Setting PSCLs**

Different methods are allowed for setting PSCLs at new and existing facilities.

**PSCLs for existing facilities**

PSCLs may be established anywhere between background water quality (as calculated below) and the reference/guidance levels in Tables 1, 2, and 3 of OAR 340-40. For parameters not in Tables 1, 2, or 3, background must be used for the PSCL.

---

**PSCLs at new facilities**

PSCLs must be established at the background water quality.

---

**PSCL calculations**

Calculations must follow one of the five methods listed in 40 CFR Part 258.53.

---

**PSCL references**

Available references for statistical guidelines and setting PSCLs include:

- Dessellier, Bruce, January 12, 1993, Draft Memorandum to Solid Waste Permits and Compliance, Subject: Statistical Guidance Memo for all RCRA Sites, Oregon Department of Environmental Quality
- USEPA, June 1992, Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, Addendum to Interim Final Guidance

---

**Reduction in monitoring or parameters**

Quarterly groundwater monitoring is typically required until nine valid data points are collected for each parameter. Once PSCLs are established, the permittee may request a reduction in the sampling frequency or parameter list. This request must be made, in writing, to the Department.

---

**Long-term monitoring**

Once PSCLs are established, the permittee may be required to propose an updated monitoring program for the wells to be monitored, the list of indicator parameters, new sampling frequency, and schedule. This should be discussed with the Department's hydrogeologist. Other limits, such as Action Limits, may be established in the permit. If warranted, Action Limits may be established for Table 3 (OAR 340-40) or other non-table, non-hazardous parameters depending upon site specific background concentrations.

---

## 10.16 Action Requirements, Assessment, and Corrective Action

**Objective**

Follow and implement the necessary notification, reporting, assessment and corrective actions required by 40 CFR Part 258 and OAR 340-40 when a contaminant release is identified at a facility during routine monitoring.

**Assessment monitoring**

Assessment monitoring is required if routine groundwater monitoring indicates a statistically significant increase above background in one or more of the constituents in Appendix I of the 40 CFR 258, or from an approved alternate list (40 CFR 258.54 (a)(2)) as is the case in Oregon. Individual permits may specify assessment monitoring requirements. Assessment monitoring should be discussed with the Department's hydrogeologist.

**Preliminary assessment plan**

The Department's Groundwater Quality Protection Rules require submittal of a plan for developing a preliminary assessment within 30 days after a confirmed exceedance of a PSCL, an Action Limit, or a significant change in water quality (as defined above), unless the Department approves another time schedule. The assessment should evaluate the source, extent, and potential migration of the contaminants.

**Corrective action**

Corrective action is required if an assessment monitoring parameter is detected at a concentration in excess of the PSCL or if the preliminary assessment determines that remedial action is necessary to maintain groundwater quality. Corrective action could consist of the following steps:

- perform a remedial investigation to determine the need for remedial action including a characterization of the contamination, characterization of the facility, and an endangerment assessment
- conduct a feasibility study that includes but is not limited to the development and evaluation of remedial action options
- select and implement the most appropriate remedial action

The specifics of the remedial investigation/feasibility study should be discussed with and approved by the Department prior to implementation.

**Gas monitoring limits**

Review gas monitoring results after each monitoring event for exceedences of methane limits. If methane levels exceed the specified limits the owner or operator must:

- immediately take necessary steps to protect human health and safety and notify the Department
- within 7 days of detection (unless the Department approves an alternative schedule), enter the methane levels in the operating record and describe the steps taken to protect human health and safety

Within 60 days of detection ( unless the Department approves an alternative schedule) implement a remediation plan for the methane releases, incorporate the plan into the operating record, and notify the department that the plan has been implemented. The plan should describe the nature and extent of the problem and the proposed remedy.

---

**Air quality and surface water**

Follow specific air quality, water quality, and solid waste permit requirements.

---

## 10.17 Additional Resources

**References**

Oregon Department of Environmental Quality, October 27, 1989. Oregon Administrative Rules, Chapter 340, Division 40, Groundwater Quality Protection.

Oregon Department of Environmental Quality, August 24, 1992. Groundwater Monitoring Well Drilling, Construction, and Decommissioning.

Oregon Water Resources Department, July 1995. Administrative Rules, Chapter 690, Division 240, Construction, Maintenance and Abandonment of Monitoring Wells, Geotechnical Holes, and Other Holes in Oregon.

U.S. EPA, October 9, 1991. 40 CFR Parts 257 and 258, Solid Waste Disposal Facility Criteria; Final Rule.

U.S. EPA, November 1993. Technical Manual for Solid Waste Facility Criteria - 40 CFR part 258.

Oregon DEQ, March 1994, Water Quality Division. Draft Groundwater Monitoring Plan - Part B: Guidelines.

Washington Department of Ecology, June 1987, Solid Waste Landfill Design Manual.

Dessellier, Bruce, August 3, 1992, Draft Memorandum to Solid Waste Permits and Compliance, Subject: Statistical Guidance Memo For all RCRA Sites, Part 1. Oregon Department of Environmental Quality.

U.S.EPA, 1992, Statistical Analysis to Groundwater Monitoring Data at RCRA Facilities - Addendum to Interim Guidance.