EXHIBIT 7

LETTER FROM JEFF SHEPHERD AND PAUL BURNS OF CEC REGARDING APPLICABLE OREGON DEQ PERMITS

February 26, 2024

Mr. Ian Macnab
Environmental Manager
Republic Services, Inc.
28972 Coffin Butte Rd
Corvallis, OR 97330

Subject: Oregon Department of Environmental Quality
Required Landfill Permits

Dear Mr. Macnab;

CEC has compiled the following information to provide an overview of the Oregon Department of Environmental Quality (ODEQ) permits required for the expansion of the Coffin Butte Landfill. The Coffin Butte Landfill holds permits for the existing facility and operation, but will need to obtain permit modifications from the ODEQ for approval to expand the landfill.

Modifications to the existing permits will be required for the ODEQ Solid Waste Facility Permit, the ODEQ 1200-Z stormwater Permit and the ODEQ title V (Air) Operating Permit. Following is a brief overview of each permit. The information in the overview is from the ODEQ Solid Waste Landfill Guidance Document, Department of State Lands website and ODEQ Air Quality and Water Quality websites.

As noted in the bulleted list below, a Land Use Compatibility Statement (LUCS) must accompany the application for the ODEQ permit modification application. Upon completion of the land use process by Benton County (Republic Services Conditional Use Permit Application), the County planning office completes Section 2 of the LUCS to indicate the use is compatible with the land use regulations and attaches written findings supporting the decision of compatibility. The LUCS will be included in the ODEQ Solid Waste Facility permit modification application.

<u>ODEQ Solid Waste Permit:</u>

The following documentation and information must be included with the permit application:

- A Land Use Compatibility Statement
- A recommendation from the local solid waste planning authority
- Demonstration of the need for a new, modified or expanded facility
- A Certificate of Business Registry
- Identifying any other known or anticipated permits
- Application fee and compliance fees (if required)
- Any other information DEQ deems necessary

Solid Waste facility Permit applications must include the following information:

Section 1: Location Restrictions

The location restrictions address the following:

- Airport safety
- Flood plains
- Wetlands
- Fault areas
- Seismic impact zones
- Unstable areas
- Critical habitat
- Sensitive hydrogeologic environments

Section 2: Phase I Site Characterization

- Phase I Site Characterization, the initial stage of data collection, establishes a preliminary framework for understanding the soils, geology and hydrogeology and plans the Phase II Site Characterization

Section 3: Phase II Site Characterization

- Phase II Site Characterization evaluates subsurface conditions in greater detail including the depth and extent of the uppermost (water bearing) geologic units and hydraulically interconnected units, the lithologic and hydraulic properties of these units, groundwater flow patterns, and other factors

Section 4: Geotechnical Investigations

- Phase I Geotechnical Investigation - Conduct a preliminary geotechnical investigation designed to accomplish the following objectives:
    - Characterize the variability, depth, aerial extent and engineering properties of on-site soils and other overburden deposits
    - Inventory soils and other overburden deposits suitable for use in construction, and identify the proposed use for these materials
    - Identify geotechnical considerations (such as settlement and slope stability) which must be addressed in the engineering design and/or further characterized by a Phase II Geotechnical assessment, and
    - Develop a work plan for conducting a Phase II Geotechnical investigation, as necessary, to adequately characterize on-site soils and other geotechnical considerations
- Phase II Geotechnical Investigation
    - Perform additional geotechnical investigations as required in the Phase II work plan and for design calculations and analyses.

Section 5: Conceptual Design of Landfill Facilities

- This section describes the elements of a Site Development Plan, including:
  - Facility operation
  - Conceptual design of landfill facilities
  - Leachate management
  - Surface water management
  - Landfill gas management
  - Environmental monitoring
  - Closure and end use
  - Supporting information

Section 6: Leachate Treatment and Disposal Feasibility Study

- Available leachate treatment alternatives should be evaluated. Methods that reflect site-specific conditions, and a full consideration of cross-media impacts should be selected for the facility

Section 7: Detailed Design

This section provides guidance on preparing detailed design plans and specifications for the following environmental control systems:

- Liner system
- Soil liner component
- Geomembrane component
- Primary leachate collection and removal system
- Secondary leachate collection and removal system
- Leachate treatment and storage impoundments
- Leachate holding tanks and conveyance pipelines
- Leachate treatment process
- Final cover system
- Surface water control system, and
- Landfill gas control system

Section 8: Facility Construction Program

The facility construction program should include the following elements:

- An organized, qualified construction project team
- Department-approved design drawings and specifications for each phase of landfill development
- A Construction Quality Control (CQC) program
- A Construction Quality Assurance (CQA) program, and
- Construction Certification Reports based on an evaluation of CQC and CQA documentation which certify that construction was completed in accordance with Department-approved plans and specifications

Section 9: Landfill Operations

- During the design phase of the project, prepare an operations plan that integrates the site development plan, the facility design elements, and the operational elements described in this subsection. Submit the plan to DEQ for review and approval.
- Once the landfill unit and related facilities are constructed and activated, prepare the O&M manual. Incorporate the operations plan elements, construction documents, and equipment manufacturers and suppliers data. Prepare separate O&M manuals for complex systems, such as leachate treatment systems, landfill gas control systems. Make the O&M manual available to operating personnel and place a copy of the manual(s) in the facility operating record.

Section 10: Environmental Monitoring

- 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.
- 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

Section 11: Closure and Post-Closure

- Minimum requirements for closure plans and post-closure plans for MSW landfills are specified in the Department's Financial Assurance Rule, OAR 340-94-100 through 145. The closure and post-closure requirements for Subtitle D landfills differ from those of non-Subtitle D MSW landfills (i.e., closing facilities).
- There are two separate categories of closure and post-closure plans:
  - Subtitle D ("worst case") Closure and Post-closure Plans are based on a hypothetical "worst case" scenario for closure and post-closure costs. This scenario establishes a conservative basis for estimating financial assurance funding requirements.

The Final Engineered Site Closure and Post-closure Plans are linked to the Closure Permit which must be obtained at least 5 years prior to anticipated final closure. The Final Engineered plans reflect the intended closure design. The Final Engineered plans contain all the elements of and replaces the Subtitle D plans.

Section 12: Financial Assurance

  - Proper financial planning early in the development of landfill facilities is required to ensure that adequate funding will be available to cover the cost of closure(s), post-closure care, and any corrective action activities

- Maintain financial assurance to cover the costs of:
  - Closure of the landfill
  - Post-closure monitoring and maintenance of the landfill facilities, and
  - Any corrective action required by the Department

Two other Oregon Department of Environmental Quality Permits that are required for the landfill include:

Stormwater 1200-Z Industrial Stormwater General Permit –

- This permit regulates stormwater discharges from industrial facilities that may reach Oregon waterways, directly or through conveyance system such as ditches or storm drains.

The 1200-Z Permit modification is prepared and submitted to ODEQ concurrently with the ODEQ Solid Waste Facility permit modification process.

Oregon Title V (Air) Operating Permit -

- Air quality permits include enforceable conditions with which the owner or operator of a facility must comply. Some permit conditions are general to all types of emission units, and some permit conditions are specific to the source. The permit establishes limits on the types and amounts of air pollution allowed, operating requirements for pollution control devices or pollution prevention activities, and monitoring and reporting requirements

The Title V (Air) Operating Permit modification is prepared and submitted once the ODEQ Solid Waste Facility permit is issued.

A new permit which will be required for the project includes a Removal-Fill Permit for activity associated with fill required to construct an access road in a small area of wetland in the northeast corner of the development area (south side of Coffin Butte Road).

Oregon Department of State Lands Removal-Fill Permit

- Oregon's Removal-Fill Law (ORS 196.795-990) requires people who plan to remove or fill material in wetlands or waterways to obtain a permit from the Department of State Lands. This permit is broadly referred to as the "Removal-Fill Permit." The law applies to all landowners, whether private individuals or public agencies

Please let us know if you have any questions.

Sincerely;
Civil & Environmental Consultants, Inc.

Jeffery A. Shepherd, P.E.
Principal

Paul F. Burns
Principal

Attachment – ODEQ Solid Waste Landfill Guidance Document

ATTACHMENT

Section 1: Location Restrictions

1.1 Introduction

Regulatory reference

OAR 340-94-030 and 40 CFR Part 258 include location restrictions for new landfills or lateral expansions of existing landfills.

Location restrictions

The location restrictions address the following:

- airport safety
- flood plains
- wetlands
- fault areas
- seismic impact zones
- unstable areas
- critical habitat
- sensitive hydrogeologic environments

In this section

This section provides guidance on

- how to determine if the proposed new or lateral expansion of an existing municipal solid waste landfill is located in a restricted area, and
- how to make the associated location restriction demonstrations

How to respond

Complete the appropriate location restriction demonstrations and place the associated documentation in the facility operating record. Notify the Department when the demonstration has been placed in the operating record. Cite all sources used in making each of the analyses and demonstrations.

Inadequate demonstrations

If an existing landfill unit cannot successfully meet the location restrictions, then the unit must be closed in accordance with OAR 340-94-120 and post-closure activities must be conducted in accordance with OAR 340-94-130.

Related information

Site Characterization Reports, Site Geotechnical Investigations, and the facility conceptual design should provide relevant information for making location restriction demonstrations.

1.2 Airport Safety

Notification to FAA

Determine if the proposed new or lateral expansion of an existing municipal solid waste landfill is located within a five-mile (eight kilometer) radius of any airport runway end used by turbojet or piston-type aircraft. If so, notify the affected airport and the Federal Aviation Administration (FAA).

Need for demonstration

Determine if the proposed new or lateral expansion of an existing municipal solid waste landfill is within

- 10,000 feet (3,048 meters) of any airport runway end used by turbojet aircraft, or
- 5,000 feet (1,524 meters) of any airport runway end used by only piston-type aircraft

If so, demonstrate that the landfill is designed and operated so that the landfill does not pose a bird hazard to aircraft. Include a copy of the notifications, and any responses received from the FAA or affected airport.

The hazard of birds

Birds may be attracted to landfill units to satisfy a need for water, food, nesting, or roosting. Scavenger birds such as starlings, crows, blackbirds, and gulls are most commonly associated with active landfill units. Where bird/aircraft collisions occur, these types of birds are often involved due to their flocking, feeding, roosting, and flight behaviors.

Bird hazard demonstration

A demonstration that a landfill unit does not pose a bird hazard to aircraft within specified distances of an airport runway end should address at least the following elements:

- regulated distance
- public use
- collision risk
- landfill operation and design

Demonstration of regulated distance

The distance measurement can be made using existing maps showing the relationship of existing runways at the airport to the existing or proposed new unit or lateral expansion. The measurement can be made by drawing a circle of appropriate radius from the centerline of each runway end. The measurement only should be made between the end of the runway and the nearest landfill unit perimeter, not between any other boundaries.

Maps: Topographic maps (USGS 15-minute series) or State, regional, or local government agency maps providing similar or better accuracy would allow direct scaling, or measurement, of the closest distance from the end of a runway to the nearest landfill unit

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Demonstration of public use

The demonstration of whether the runway is part of a public use airport and whether all applicable public airports have been identified can be made by contacting the airport administration or the regional FAA office.

Note: The demonstration is not required for private airfields

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Demonstration of collision risk

The demonstration should address the likelihood that the landfill unit may increase bird/aircraft collisions. One approach is to determine whether birds are attracted to the landfill unit and whether this increased population may result in more in bird/aircraft collisions. The evaluation of bird attraction can be based on field observations at existing facilities that have similar geographic location, design features, and operational procedures.

Demonstration of landfill operation and design

The landfill unit design features and operational practices significantly effect the potential for bird/aircraft collisions. The demonstration should include a discussion of techniques to reduce collision risk. The following landfill design and operation techniques may be employed to reduce the bird hazard to aircraft:

- waste management
- bird control
- landfill design

Waste management techniques

Waste management techniques to reduce the supply of food to these birds include:

- frequent covering of wastes
- shredding, milling, or baling wastes, and
- diverting wastes that represent a food source for birds by source separation, composting, waste minimization, or other methods

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Frequent covering

Frequent covering of wastes effectively reduces the availability of the food supply. Depending on site operations, cover may need to be applied several times a day to minimize the working face.

Shredding, milling, or baling

Milling or shredding municipal solid waste breaks up food waste into smaller particle sizes and distributes the particles throughout non-food wastes, which dilutes food wastes and reduces the materials' attractiveness to birds.

Bird control techniques

The use of varying bird control techniques may prevent the birds from adjusting to a single method. The table below provides examples of various techniques. Many of these methods have limited long-term effects on controlling bird populations at landfills, as the birds adapt to the environment in which they find food.

Bird control technique	Example
visual deterrents	realistic models (still or animated) of the bird's natural predators (e.g., humans, owls, hawks, falcons)
sounds	cannons, distress calls of the scavenger birds, and sounds of its natural predators
physical barriers	fine wires strung across or near the working face
other more labor intensive methods	falconry and firearms

Landfill design Proper design and operation can also reduce bird habitat. For example, good stormwater management can prevent surface water ponding, which limits a source of water for the birds.

Birds may also be attracted to a landfill unit as a nesting area. Closed landfill cells may provide a roosting habitat due to elevated ground temperatures and freedom from disturbance. Nesting can be minimized by examining the nesting patterns and requirements of undesirable birds and designing appropriate controls. For example, nesting by certain species can be controlled through the mowing and maintenance schedule at the landfill.

1.3 Floodplains

Need for demonstration

Determine if the proposed new or lateral expansion of an existing solid waste landfill is located in a 100-year floodplain. If so, demonstrate that the landfill will not:

- restrict the flow of the 100-year flood
- reduce the temporary water storage capacity of the floodplain, or
- result in washout of solid waste that poses a hazard to human health, the environment, wildlife, or land or water resources

Identification of floodplains

Identify floodplains using:

- flood insurance rate maps (FIRM) and flood boundary and floodway maps published by the Federal Emergency Management Agency (FEMA), or
- floodplain maps available through other agencies such as the U.S. Army Corps of Engineers; the U.S. Geologic Survey, the U.S. Soil Conservation Service, the Bureau of Land Management and state and local agencies

Maps not available: If floodplain maps are not available, and the facility is located within a floodplain, then a field study to delineate the 100-year floodplain may be required

Demonstration of temporary storage

To demonstrate that the facility does not significantly reduce the temporary storage capacity of the floodplain during the base flood, estimate the

- floodplain storage capacity that would likely exist in absence of the facility
- floodplain storage capacity available in the vicinity of the facility, and
- change in storage capacity and base flood elevation due to facility construction

Demonstration of washout

The location of facilities relative to the velocity distribution of floodwaters will greatly influence the susceptibility to washout. To demonstrate that the facility will not result in washout of solid wastes, provide a conservative estimate of the shear stress of the landfill components caused by the depth, velocity, and duration of impinging river waters during a 100-year storm event.

1.4 Wetlands

Need for demonstration

Determine and describe whether the proposed new or lateral expansion of an existing municipal solid waste landfill is located in wetlands. If so, demonstrate that the unit will not cause or contribute to significant degradation of the wetland.

Other required permits

If the municipal solid waste landfill unit is to be situated or significantly expanded in wetlands, then consult with and obtain a permit from the Corps of Engineers (COE). Include a copy of the permit or permit application in the demonstration, if applicable.

Reference: Section 404(b)(1) of the Clean Water Act

Involvement of other agencies

During the permitting process, the Department and the State Division of Lands will need to be contacted to schedule a site visit. In general, the COE will require notification and/or consultation on any proposed impact on any wetland regardless of the actual degree of the impact. Other agencies such as the Fish and Wildlife Service and the SCS may also need to be contacted.

Mitigation

Mitigation plans must be approved by the appropriate regulatory agencies and must achieve an agreed-upon measure of success. Examples of mitigation include restoration of degraded wetlands or creation of wetland acreage from existing uplands.

Wetlands identification

Wetlands are identified based on the presence of hydric soils, hydrophytic vegetation, and the wetland hydrology. These characteristics affect the functional value of a wetland in terms of its role in:

- supporting fish and wildlife habitats
- providing aesthetic, scenic, and recreational value
- accommodating flood storage
- sustaining aquatic diversity, and
- its relationships to surrounding natural areas through nutrient retention and productivity exportation (e.g., releasing nutrients to downstream areas, providing transportable food sources)

Examples of wetlands

The term "wetlands" includes swamps, marshes, bogs, and any areas that are inundated or saturated by ground water or surface water at a frequency and duration to support, and that under normal circumstances do support, a prevalence of vegetation adapted for life in saturated soil conditions.

Wetlands assessment

A wetland assessment will need to be conducted by a qualified and experienced multi-disciplinary team. The assessment should identify:

- the limits of the wetland boundary based on hydrology, soil types and plant types
- the type and relative abundance of vegetation, including trees, and
- rare, endangered, or otherwise protected species and their habitats (if any)

Delineation methods

The current methods used to delineate wetlands are presented in "COE Wetlands Delineation Manual," 1987, per a January 1993, EPA and COE agreement. The Federal manual for “Identifying and Delineating Jurisdictional Wetlands” (COE, 1989) contains an extensive reference list of available wetland literature. For example, lists of references for the identification of plant species characteristic of wetlands throughout the United States, hydric soils classifications, and related wetland topics are presented. USGS topographic maps, National Wetland Inventory (NWI) maps, Soil Conservation Service (SCS) soil maps, wetland inventory maps, and aerial photographs prepared locally also may provide useful information.

Evaluation of wetland value

Evaluation of ecological resource protection may include assessment of the value of the affected wetland.

Methods for evaluating wetland value

Available methods include:

- analysis of functional value
- the Wetland Evaluation Technique (WET), and
- the Habitat Evaluation Procedure (HEP)

The most appropriate technique for a specific site should be selected in conjunction with the Department and other applicable regulatory agencies.

Analysis of functional value

The functional value of a given wetland is dependent on its soil, plant, and hydrologic characteristics, particularly the diversity, prevalence, and extent of wetland plant species. The relationship between the wetland and surrounding areas (nutrient sinks and sources) and the ability of the wetland to support animal habitats, or rare or endangered species, contributes to the evaluation of functional value.

WET

Wetland Evaluation Technique (WET) allows comparison of the values and functions of wetlands before and after construction of a facility, thereby projecting the impact a facility may have on a wetland. WET was developed by the Federal Highway Administration and revised by the COE (Adamus *et al*., 1987).

HEP

Habitat Evaluation Procedure (HEP) was developed by the Fish and Wildlife Service to determine the quality and quantity of available habitat for selected species. HEP and WET may be used in conjunction with each other to provide an integrated assessment.

Locating in a wetlands

Erosion potential and stability of wetland soils and any dredged or fill material used to support the landfill unit should be identified as part of the wetlands evaluation. Any adverse stability or erosion problems that could affect the landfill or contaminant effects that could be caused by the landfill unit should be resolved.

Minimizing impacts

All practicable steps are to be taken to minimize potential impacts of the landfill unit to wetlands. A number of measures that can aid in minimization of impacts are available. Appropriate measure are site-specific and should be incorporated into the design and operation of the landfill unit. For example, placement of ground water barriers may be required if soil and shallow ground water conditions would cause dewatering of the wetland due to the existence of underdrain pipe systems at the facility.

It is possible that the landfill unit/facility will not directly displace wetlands, but that adverse effects may be caused by leachate or run-off. Engineered containment systems for both leachate and run-off should mitigate the potential for discharge to wetlands.

Unavoidable impacts

All unavoidable impacts must be "offset" or compensated for to ensure that the facility has not caused, to the extent practicable, any net loss of wetland acreage. Wetland offset studies require review and development on a site-specific basis. This compensatory mitigation may take the form of

- upgrading existing marginal or lower-quality wetlands, or
- replacement of wetlands

Upgrading existing wetlands

To identify existing wetlands that may be proposed for upgrade, a cursory assessment of surrounding wetlands and uplands should be conducted. The assessment may include a study to define the functional characteristics and inter-relationships of these potential wetland mitigation areas. An upgrade of an existing wetland may consist of transplanting appropriate vegetation and importing low-permeability soil materials that would be conducive to forming saturated soil conditions. Excavation to form open water bodies or gradual restoration of salt water marshes by culvert expansions to promote sea water influx are other examples of compensatory mitigation.

Replacement of wetlands

The Division of State Lands (DSL) has established offset ratios to determine how much acreage of a given functional value is required to replace the wetlands that were lost or impacted. Preservation of lands, such as through perpetual conservation easements, may be considered as a viable offset option. DSL offset ratios require for wetlands of an equivalent functional value, that a larger acreage be created than was displaced.

Monitoring the mitigation

Due to the experimental nature of creating or enhancing wetlands, a monitoring program to evaluate the progress of the effort should be considered and may be required as a wetland permit condition. The purpose of the monitoring program is to verify that the created/upgraded wetland is successfully established and that the intended function of the wetland becomes self-sustaining over time.

1.5 Critical Habitat

Need for demonstration	Determine if the municipal solid waste landfill unit is located where landfill activities could cause or contribute to the reduction of the likelihood of survival and recovery of a threatened or endangered species. If so, demonstrate the measures that will be taken to protect the species. Reference: OAR 340-94-030(3)
Other permits required	If the municipal solid waste landfill unit is to be situated or significantly expanded in a critical habitat, obtain a permit from the Secretary of Interior.
Information on threatened and endangered species	The Oregon Department of Fish and Wildlife maintains an up to date database of information on threatened and endangered species. The database coordinator can be reached at (503) 229-5454.

1.6 Fault Areas

Need for demonstration

Determine if faults, having displacement in Holocene time, are likely or have been identified in the vicinity of the proposed new or lateral expansion of an existing municipal solid waste landfill unit. If so, demonstrate that the landfill:

- is more than 200 feet (60 meters) of a fault that has had displacement in Holocene time, or
- that an alternative setback distance of less than 200 feet (60 meters) will prevent damage to the structural integrity of the landfill unit and protect human health and the environment

Fault danger

Proximity to a fault can cause damage through:

- movement along the fault which can cause displacement of facility structures
- seismic activity associated with faulting which can cause damage to facility structures through vibratory action, and
- earth shaking which can cause ground failures such as slope failures

Locating fault areas

U.S. Geological Survey (USGS) mapping can be used to determine if a proposed landfill unit is located in a Holocene fault area. A series of maps known as the "Preliminary Young Fault Maps, Miscellaneous Field Investigation (MF) 916" was published by the USGS in 1978. For information, call the USGS at 1-800-USA-MAPS (USGS National Center in Reston, Virginia) or by calling (303) 236-7477 (USGS Map Sales Center in Denver, Colorado). The Oregon Division of Geology and Mineral Industries (DGAMI) is a good local source of data on Holocene faults. They can be reached at (503) 731-4444 (Nature of Oregon Information Center).

Locating a fault zone that has moved since the USGS maps and other sources were published may require a geologic reconnaissance of the site and surrounding areas to identify and map these features.

1.7 Seismic Impact Zones

Need for demonstration

Determine if the proposed new or lateral expansion of an existing municipal solid waste landfill is located in a seismic impact zone. If so, demonstrate that all containment structures are designed to resist the maximum horizontal acceleration in lithified earth material for the site. To make the demonstration:

- determine the expected peak ground acceleration from a maximum strength earthquake that could occur in the area
- determine the site-specific seismic hazards such as soil settlement, and
- design the facility to withstand the expected peak ground acceleration

Note: containment structures include liners, leachate collection and storage systems, and surface water control systems

Definition: seismic impact zone

A Seismic Impact Zone is an area with a ten percent or greater probability that the maximum horizontal acceleration in lithified earth material expressed as a percentage of the earth's gravitational pull (g), will exceed 0.10g in 250 years.

Determining horizontal acceleration

The determination of the maximum horizontal acceleration of the lithified earth material for the site (see Figure 1-1) can be made by reviewing the seismic 250-year interval maps in U.S. Geological Survey Miscellaneous Field Study Map MF-2120, entitled "Probabilistic Earthquake Acceleration and Velocity Maps for the United States and Puerto Rico" (Altermissin *et al*., 1991). To view the original of the map that is shown in Figure 1-1 (reduced in size), contact the USGS office in your area. The original map (Horizontal Acceleration - Base modified from U.S.G.S. National Atlas, 1970, Miscellaneous Field Studies, Map MF 2120) shows county lines within each state. For areas not covered by the aforementioned map, USGS State seismic maps may be used to estimate the maximum horizontal acceleration. The National Earthquake Information Center, located at the Colorado School of Mines in Golden, Colorado, can provide seismic maps of all 50 states.

Other sources of information

The National Earthquake Information Center maintains a database of known earthquakes and fault zones. Information on the location of earthquake epicenters and intensities may be available through DGAMI or the Earthquake Information Center. For information concerning potential earthquakes in specific areas, the Geologic Risk Assessment Branch of USGS may be of assistance. Other organizations that study the effects of earthquakes on engineered structures include the National Information Service for Earthquake Engineering, the Building Seismic Safety Council, the National Institute of Science and Technology, and the American Institute of Architects.

Impact of seismic activity on landfills

Studies indicate that earthquakes produce superficial (shallow) slides and differential displacement, rather than massive slope failures (U.S. Navy 1983). Stresses created by superficial failures can affect the liner system, final cover systems, and leachate and gas collection and removal systems. Tensional stresses within the liner system can result in fracturing of the soil liner and/or tearing of the flexible membrane liner.

Design considerations

The design of the facility slopes, leachate collection system, and other structural components should have built-in conservative design factors. Additionally, redundant precautionary measures should be designed and built into the various landfill systems. Establish precautions using the table below.

If the maximum horizontal acceleration in the area is	and the facility is	then
greater than 0.1g	-----	complete an engineering evaluation of seismic effects when preparing the landfill design
less than 0.1g	situated in an area with low strength foundation soils or soils with potential for liquefaction	complete an engineering evaluation of seismic effects when preparing the landfill design
less than 0.1g	not situated in an area with low strength foundation soils or soils with potential for liquefaction	assess the facility for the effects of seismic activity, and design the landfill accordingly

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Engineering evaluation of seismic effects

The engineering evaluation should examine soil behavior with respect to earthquake intensity, including an evaluation of seismic effects on foundation soil stability and waste stability under seismic loading. When evaluating soil characteristics, it is necessary to know the soil strength as well as the magnitude or intensity of the earthquake in terms of peak acceleration. Other soil characteristics, including degree of compaction, sorting (organization of the soil particles), and degree of saturation, may need to be considered because of their potential influence on site conditions.

Example: deposits of loose granular soils may be compacted by the ground vibrations induced by an earthquake resulting in large uniform or differential settlements of the ground surface

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Design implications

Design modifications to accommodate an earthquake may include shallower waste sideslopes, more conservative design of dikes and run-off controls, and additional contingencies for leachate collection in case primary systems are disrupted. Strengths of the landfill component should be able to withstand these additional forces with an acceptable factor of safety. The design should be based on the evaluation of seismic effects.

Materials to use

Well-compacted cohesionless embankments or reasonably flat slopes in insensitive clay are less likely to fail under moderate seismic shocks (up to 0.15g and 0.20g acceleration). Embankments made of insensitive, cohesive soils founded on cohesive soils or rock may withstand even greater seismic shocks. For earthen embankments in seismic regions, designs with internal drainage and core material most resistant to fracturing should be considered.

Vulnerable landforms and materials

Slope materials vulnerable to earthquake shocks include:

- very steep slopes of weak, fractured and brittle rocks or unsaturated loess are vulnerable to transient shocks caused by tensional faulting
- loess and saturated sand may be liquefied by seismic shocks causing the sudden collapse of structures and flow slides
- similar effects are possible in sensitive cohesive soils when natural moisture exceeds the soil's liquid limit, and
- dry cohesionless material on a slope at an angle of repose will respond to seismic shock by shallow sloughing and slight flattening of the slope

In general, loess, deltaic soils, floodplain soils, and loose fills are highly susceptible to liquefaction under saturated conditions (USEPA, 1992).

Computer modeling

Geotechnical stability investigations frequently incorporate the use of computer models to reduce the computational time of well-established analytical methods. Several computer software packages are available that approximate the anticipated dynamic forces of the design earthquake by resolving the forces into a static analysis of loading on design cross sections. A conservative approach would incorporate both vertical and horizontal forces caused by bedrock acceleration if it can be shown that the types of material of interest are susceptible to the vertical force component. Typically, the horizontal force caused by bedrock acceleration is the major force to be considered in the seismic stability analysis.

Examples of computer models: PC-Slope by Geoslope Programming (1986), FLUSH by the University of California

Staffing

The use of professionals experienced in seismic analysis is strongly recommended for design of facilities located in areas of high seismic risk.

1.8 Unstable Areas

Need for demonstration

Determine if the site is located in an unstable area. If so, demonstrate that engineering measures have been incorporated into the appropriate landfill design to protect the structural integrity of the landfill.

Note: The results of the site stability investigation (see section 4) should be assessed in making this determination

Geotechnical factors

Consider the following factors when determining whether an area is unstable:
- on-site or local soil conditions that may result in significant differential settling
- on-site or local geologic or geomorphologic features, and
- on-site or local man-made features or events (both surface and subsurface)

Natural unstable areas

Natural unstable areas include those areas that have poor soils for foundations or are susceptible to mass movement. Examples are described below:
- Areas with compressible or expansive soils.
- Expansive soils usually are clay-rich soils that, because of their molecular structure, tend to swell and shrink by taking up and releasing water and thus are sensitive to a variable hydrologic regime. Bentonite is a commonly used example.
- Soils that are subject to rapid settlement (subsidence) include saturated silts, unconsolidated clays, and wetland soils in general.
- Sloped areas subject to mass movement such as avalanches, landslides, debris slides and flows, and rock slides. Such areas can be situated on steep or gradual slopes.

Human-induced unstable areas

Examples of human-induced unstable areas are described below:
- The presence of cut and/or fill slopes during landfill construction causing slippage of existing soil or rock.
- Excessive drawdown of ground water increases the effective overburden on the foundation soils underneath the unit causing excessive settlement or bearing capacity failure of the foundation soils.
- A closed landfill as the foundation for a new landfill ("piggy-backing") becoming unstable if the foundation wastes have not undergone complete settlement.

Unstable area demonstration contents

Assess the ability of the soils and/or rock to serve as a foundation and the ability of site embankments and slopes to maintain a stable condition. Develop a design that will address these types of concerns and prevent possible associated damage to structural components.

Stability assessment

In designing a new unit or lateral expansion or re-evaluating an existing unit, conduct a stability assessment to identify stability problems and preventive measures.

Source of information on natural features

- Nature of Oregon Information Center, Oregon Department of Geology and Mineral Industries at 731-4444
- Regional or local U.S. Soil Conservation Service soil maps
- Aerial photographs, and
- Site-specific investigations

Finding human-induced instability

To evaluate possible sources of human-induced ground instability, the site and surrounding area should be examined for activities related to extensive withdrawal of oil, gas, or water from subsurface geologic units. Evaluate construction or other operations that may result in ground motion (e.g., blasting).

Types of soil and rock failures

Principal modes of failure in soil or rock include:

- rotation (change of orientation) of an earthen mass on a curved slip surface approximated by a circular arc
- translation (change of position) of an earthen mass on a planar surface whose length is large compared to depth below ground
- displacement of a wedge-shaped mass along one or more plans of weakness;
- earth and mud flows in loose clayey and silty soils, and
- debris flows in coarse-grained soils

Common landfill failures

Two common types of failures can occur at a landfill unit:

- settlement
- loss of bearing strength

Settlement

Settlement beneath a landfill unit, both total and differential, should be assessed and compared to the elongation strength and flexure properties of the liner and leachate collection pipe system. Small amounts of settlement can damage leachate collection piping and sumps.

Allowable settlement is typically expressed as a function of total settlement because differential settlement is more difficult to predict. However, differential settlement is a more serious threat to the integrity of the structure than total settlement. Differential settlement generally occurs beneath a landfill in response to consolidation and dewatering of the foundation soils during and following waste loading.

Loss of bearing strength

Loss of bearing strength is a failure mode that can occur in areas that have expansive, compressible, or liquefaction-prone soils. Loss of bearing strength has occurred at sites where excavations for new landfill units near existing filled areas reduced the mass of the soil at the toe of the slope and the overall strength (resisting force) of the foundation soil.

1.9 Sensitive Hydrogeologic Environments

Need for demonstration	Determine if the landfill unit is located in a sensitive hydrogeologic environment.
Definition: sensitive hydrogeologic environments	Sensitive hydrogeologic environments are defined as: • gravel pits excavated into or above a water table aquifer • areas underlain by a sole source aquifer or other sensitive aquifer, and • designated wellhead protection areas Reference: OAR 340-90-030(4)
Definition: sensitive aquifer	A sensitive aquifer is defined as ". . . any unconfined or semi-confined aquifer which is hydraulically connected to a water table aquifer, and where flow could occur between the aquifers due to either natural gradients or induced gradients resulting from pumpage . . . ."
Location prohibition	OAR 340-94-030(4) does not allow landfill units to be located in sensitive hydrogeologic environments where the Department has determined that: • groundwater must be protected from pollution because it has existing or potential beneficial uses, or • existing natural protection is insufficient or inadequate to minimize the risk of polluting groundwater

1.10 Additional Resources

References

U.S. EPA's Solid Waste Disposal Facility Criteria, Technical Manual (EPA 530-R-93-017)

40 CFR Part 230 (Guidelines for Specification of Disposal Sites for Dredged or Fill Materials)

Section 2: Phase I Landfill Site Characterization

2.1 Introduction

Characterizing the site

Phase I Site Characterization, the initial stage of data collection, establishes a preliminary framework for understanding the soils, geology and hydrogeology and plans the Phase II Site Characterization.

Phase II Site Characterization (see Section 3) will evaluate site-specific subsurface conditions in greater detail including the depth and extent of the uppermost (water bearing) geologic units and hydraulically interconnected units, the lithologic and hydraulic properties of these units, groundwater flow patterns, and other factors.

Regulatory reference

OAR 340-93-130(4) requires a soils, geology and hydrogeology report and a feasibility study report for a new landfill or an expansion of an existing landfill. OAR 340-94-080, OAR 340-40 and 40 CFR Part 258 address groundwater hydrology, quality and groundwater monitoring.

Objectives of Phase I

The main objectives of the Phase I site characterization study are to

- describe existing site conditions
- determine if the site is suitable for landfill construction
- provide sufficient base-line information for developing the facility design, construction program, operations plan and environmental monitoring program.

How to respond

Prepare and submit to the Department a report describing the work performed in the Phase I Site Characterization. Geologic and hydrogeologic tasks should be performed by or under the direct supervision of an Oregon Registered Geologist with experience in conducting hydrogeologic investigations.

Report content

The Phase I Site Characterization report should address, at a minimum, completion of the tasks described in this subsection and the location restrictions defined in Section 1. Following the organizational format of this guidance will expedite Department review of the report. The report should be stamped by the Registered Geologist who performed or supervised the investigation.

In this section

This Section describes the recommended tasks that should be completed in preparation of Phase I Site Characterization study report. The following topics are addressed:

- existing conditions
- climate/meteorology
- hydrology
- water balance
- water use inventory
- geology and hydrogeology investigation, and
- phase II workplan

This guidance identifies the scope of investigations necessary to comply with the Solid Waste rules and provide the Department with sufficient data to evaluate the permit application or other submittals.

Related references

This Section focuses on technical guidance and format for the Phase I Site Characterization Report. Groundwater Monitoring requirements are addressed in more detail in Section 10 (Environmental Monitoring). Monitoring well construction standards are contained in a separate document ("Guidelines for Monitoring Well Drilling, Construction and Decommissioning," August 24, 1992).

2.2 Existing conditions

Site characterization task

Describe existing site conditions by providing the information in this subsection.

Site location

Describe the site location with respect to known or easily identifiable landmarks. Describe the site location in terms of the section, township, and range location for the site. Describe access to the site from the nearest U.S. or State Highway.

Legal description

Provide a legal description of the tract or tracts of land which have been or are proposed to be used for waste disposal activities.

Vicinity map

Prepare a map or series of maps showing the facility site and the area within at least a five-mile radius of the site boundary. The map(s) should clearly show the following:

- the site location
- the existing and proposed zoning and land uses
- residential areas
- public and private water supply wells
- surface waters and surface water intakes
- boundary of any municipal water supply service areas
- access roads, bridges, railroads, and airports
- historic sites
- other existing and proposed man-made or natural features relating to the facility, and
- the drawing date, a North arrow, and a bar scale

Map format: The map should be on a U.S. Geological Survey (USGS) 7 1/2 minute quadrangle base or, if such a map is not available, a substitute base such as an enlargement of a USGS 15 minute quadrangle map, an Oregon Department of Transportation county map or city map at a similar scale.

Aerial photographs

Prepare a stereo pair of standard size (9 inches by 9 inches) recent vertical aerial photographs with a scale up to 1:40,000 which show the site and the area within at least a one-mile radius of the site boundary. Mark the site boundaries and actual fill areas on one of the photographs. Oblique aerial photographs or surface level photographs from various points around the site perimeter may also be submitted in support of the application. Photocopied reproductions of aerial photographs will not be accepted as fulfillment of this requirement.

Information concerning public agency sources for aerial photographs may be obtained by contacting:

Nature of Northwest
Oregon Dept. of Geology & Mineral Industries
800 NE Oregon Street #5, Suite 177
Portland, OR 97232
Phone: (503) 731-4444

Adjacent landowners

Show on a location map or on County Tax Lot map(s), the names and mailing addresses of all landowners within one quarter mile of the property and any other landowners identified as being affected by the proposed facility. Summarize this information on a separate list cross-referenced to the location map or the County Tax Lot map(s). Cite the source for obtaining the names and mailing addresses of persons identified as affected parties.

Site map

Prepare a detailed site map scaled at not more than one inch equals 200 feet (or other scale approved by the Department) that shows the following:

- the geographical location and boundaries of the disposal site
- the topography of the site and area within at least 1/4 mile of the site with contour intervals not to exceed five feet for slopes greater than five percent, or two feet if slopes are less than five percent
- natural features of the land including seeps, springs, streams, ponds and wetlands
- man-made features, including buildings, excavations, pipelines, utilities, recycling facilities, fences, roads, parking areas, drainage culverts, ditches, ponds, berms and dikes
- boundaries of all proposed, active, and closed waste disposal areas, and boundaries of all existing and proposed soil borrow areas
- locations of all existing and proposed borings, piezometers, monitoring wells, test pits, water supply wells, and any other facility monitoring or sampling points or devices
- benchmarks and permanent survey markers, and
- the drawing date, a north arrow, a bar scale, and an explanation of all map symbols

Use the National Geodetic Vertical Datum of 1929 as the vertical elevation datum, and the Oregon State Plane Coordinate System (ORS 93.330) as the horizontal control.

Map preparation: The map(s) 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
- describe the location in either latitude and longitude coordinates accurate to 0.1 seconds in latitude and longitude or UTM coordinates

2.3 Climate/Meteorology

Site characterization task	Provide current information based on or extrapolated from data collected at the closest reporting weather station or stations including: • average annual precipitation and monthly distribution of precipitation • average annual evaporation and monthly distribution of evaporation • average annual prevailing wind direction and monthly variation in wind direction • average and maximum wind velocities and monthly variations in wind velocity, and • average annual temperature and monthly variations in temperature
Obtaining information	This information can be obtained from the National Oceanic and Atmospheric Administration (NOAA), or other federal or state agencies reporting meteorological data.
On-site station	A site-specific station may need to be created if data from the nearest established meteorological station is not representative of site conditions.

2.4 Hydrology

Site characterizatio n task	Evaluate and describe the surface water drainage of the site and of the surrounding area within at least a one-mile radius of the site. This information should include a map or maps at a scale of 1:24,000 showing major perennial, ephemeral and inter-mittent drainage channels, and their tributaries.
Map content	The maps should identify all existing wetlands and estuaries, and show the boundaries of the 100-year floodplain, based on data collected by the Federal Emergency Management Agency or other federal or state agencies reporting flood management data. Provide the minimum, maximum and average annual flow rates including monthly variations for all major streams. Values should be based on stream gauging data collected by the U.S. Geological Survey or other federal or state agencies reporting stream gauging data.

2.5 Water balance

Site characterizatio n task	Analyze the average annual site water budget including precipitation, runoff, infiltration and evapotranspiration. Determine the monthly variations of each of these parameters for a one-year period.
Methods	Acceptable water balance methods include Thornthwaite-Mather (1957), the EPA Water Balance (1975), the EPA Help Model (1984), and/or other methods approved in advance by the Department.

2.6 Water Use Inventory

Site characterization task	Inventory and identify all water wells and water usage on-site and within a one-mile radius of the site boundary. Prepare a water well inventory report.
Well inventory	Identify all active and inactive water wells, irrigation wells, and surface water usage points within the targeted radius. Identify and field check all water usages within this radius which are listed in the drillers' log files or other records of the Oregon Water Resources Department (OWRD). Areas within the radius of investigation that are served by a municipal water supply should be included in the OWRD well records search.
Survey	Conduct a door-to-door field survey to identify wells not accounted for in OWRD files. For all wells identified in the OWRD files and the door-to-door survey, record the following information: • name and address of the well owner • name and address of the driller • date of drilling • well location • aquifer screened • approximate land surface elevation • depth of well • materials and construction (including casing, screen and annular seal depths and intervals) • reported yield • use of the water • reported or measured static and pumping water levels (or well drawdown) and dates of measurement, and • any available water quality data

Alternative to survey

In lieu of the door-to-door survey, provide the following information for areas served by a municipal supply:

- a map scaled at 1:24,000 or larger showing the boundary of the service area and the raw water intake location
- a record search for any other water usage within the radius of investigation
- a description of surface water supplies including the intake location, average daily and yearly withdrawal rates, and monthly distribution of withdrawals, and
- a description of groundwater supplies including their location, geologic logs and construction, average daily and yearly pumpage, monthly distribution of pumpage, and static and pumping water levels by well and aquifer

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Report content

The water well inventory report should include a map at a scale of 1:24,000 or larger showing the location and use of each well/surface water use point, and a table presenting the required information for each point. The report should include a copy of each available drillers' log, and cross-reference the logs to the well inventory maps and forms.

2.7 Geology and Hydrogeology Investigation

Site characterization task

Conduct a preliminary geology and hydrogeology investigation. Evaluate the regional geology and hydrogeology based on geological reconnaissance field mapping and existing published or unpublished reports and data from state and federal agencies, universities, consultants or other sources.

Investigation report

In the Phase I Site Characterization report:

- describe the regional geology including the age, areal and subsurface distribution, thickness, physical properties and genesis of major stratigraphic units; and the age, occurrence, orientation and physical description of major structural features
- describe the regional hydrogeology including the depth, thickness, physical characteristics and lateral persistence of major and minor aquifers and aquitards, rates and directions of groundwater flow, areas of recharge and discharge (including water wells), hydrologic boundaries, seasonal variations in groundwater levels and flow, and chemical quality of the groundwater
- describe the thickness, lateral extent, hydraulic conductivity and attenuative capacity of all in-situ geologic materials between the proposed base excavation for the landfill and the uppermost aquifer
- evaluate and explain the degree of protection afforded by the properties and extent of geologic materials described above
- prepare a hydrogeologic map of the site and the area within at least a one-mile radius of the site scaled at not more than one inch equals 2,000 feet that shows the surficial geology, the elevation of the water table or potentiometric surface and the regional groundwater flow direction (from published sources or field measurements), and the locations of known discharging wells
- prepare two cross-sections oriented at approximately right angles to each other, which illustrate the regional geology and hydrogeology of the site and vicinity, and
- list sources used to prepare descriptions

Geologic hazards

Geologic hazards may include seismic impacts, mass movement (e.g., landslides), unstable soils, flood inundation, shallow groundwater levels, tsunami, and volcanic eruptions. Location restrictions under OAR 340-94-030 address considerations such as Holocene fault zones, seismic impact areas and unstable areas.

Earthquake safety

Evaluate the earthquake safety of the site. The analysis should include

- a description of the seismo-tectonic setting and seismic history of the area, including size, frequency, and location of historic earthquakes
- potential for area to be affected by surface rupture, including sense and amount of displacement, and width of surface deformation zone
- probable response of site to likely earthquakes, including estimated ground motion, maximum ground acceleration, velocity and displacement
- potential for area to be affected by earthquake-induced landslides or soil liquefaction, and
- potential for area to be affected by regional tectonic deformation (subsidence or uplift)

To the extent possible, identify and evaluate all other known or suspected geologic hazards which may affect the design, construction, and operation of the facility.

2.8 Phase II Workplan

Propose workplan	Prepare a proposed work plan and schedule for conducting the Phase II Site Characterization Study and preparing a final report.
Workplan approval	This work plan should receive Department approval prior to the actual onset of site work. Section 3 of this guidance describes Phase II Site Characterizations.

2.9 Additional Resources

Reference	"Location Information Needed for the Groundwater Database," March 8, 1992 (DEQ)
Contacts	Oregon Maps and Aerial Photography, Oregon Department of Geology and Mineral Resources Driller's log files, Oregon Water Resources Department
Methods to determine water balance	Thornthwaite-Mather (1957) U.S. EPA Water Balance (1975) U.S. EPA "Hydrologic Evaluation of Landfill Performance (HELP) Model" (1984)

Section 3: Phase II Landfill Site Characterization

3.1 Introduction

Characterizing the site

Phase I Site Characterization (see Section 2), the initial stage of data collection, established a preliminary framework for understanding the soils, geology and hydrogeology and for planning the Phase II Site Characterization.

Phase II Site Characterization evaluates subsurface conditions in greater detail including the depth and extent of the uppermost (water bearing) geologic units and hydraulically interconnected units, the lithologic and hydraulic properties of these units, groundwater flow patterns, and other factors.

Basis for investigation

The scope of the investigations for Phase II site characterization should be based on the Phase I study results and the work plan developed as part of the Phase I study. If the proposed project involves a lateral expansion of an existing landfill unit, portions of the Phase II work may have previously been completed. If so, the appropriate documents should be referenced in the Phase II report.

Phase II Site Characterizations are frequently negotiated with the Department and may include direct Department involvement.

Objective of Phase II

The main objective of the Phase II site characterization study is to describe and evaluate the site geology and hydrogeology, including all stratigraphic units encountered, the uppermost aquifer or waterbearing zone, and all other potential zones of contaminant transport.

Definition: uppermost aquifer

U.S. EPA has defined the "uppermost aquifer" as the geologic formation nearest the natural ground surface that is an aquifer, as well as lower aquifers that are hydraulically interconnected with this aquifer within the facilities boundary. U.S. EPA guidance refers to any saturated strata capable of producing representative groundwater samples as an aquifer.

How to respond

Prepare and submit to the Department a report describing the work performed in the Phase II site characterization. Geologic and hydrogeologic tasks must be performed by or under the direct supervision of a Registered Geologist with current Oregon registration and with experience in conducting hydrogeologic investigations, in accordance with OAR 340-93-130.

Report content

The Phase II Site Characterization report should address, at a minimum, completion of the tasks described in this subsection. Following the organizational format of this guidance will expedite Department review of the report. The report should bear the stamp of the Registered Geologist who performed or supervised the investigation.

Report illustrations

The report should contain illustrations, including the following:

- maps showing the as-built location of all borings, monitoring wells and other sampling locations
- boring logs
- as-built well construction details
- geologic maps and cross sections
- water table or potentiometric surface maps for all major aquifers or water-bearing zones, and
- geologic-structure contour maps depicting the soil-bedrock interface or other important subsurface features

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In this section

This Section describes the recommended tasks that should be completed in preparation of the Phase II Site Characterization Report. The following topics are addressed:

- surface investigation
- subsurface exploration
- environmental testing
- groundwater quality testing

Related references

This Section focuses on technical guidance and format for the Phase II Site Characterization Report. Groundwater Monitoring requirements are addressed in more detail in Section 10 (Environmental Monitoring). Monitoring well construction standards are contained in a separate document ("Guidelines for Monitoring Well Drilling, Construction and Decommissioning," August 24, 1992).

3.2 Surface Investigations

Site characterization task	Conduct appropriate surface mapping and surface geophysical logging to generate surface geology information, provide a basis for subsurface exploration, and delineate areas of previous waste disposal activities.
Surface geological mapping	Map the site in sufficient detail to determine the areal distribution of all surficial and bedrock units exposed across the entire site.
Standards	Practices and techniques used to obtain site-specific geologic and hydrogeologic data should be up-to-date, and consistent with industry-wide standards. All work should conform to applicable American Society for Testing and Materials (ASTM) standards, and/or appropriate U.S. Environmental Protection Agency (U.S. EPA) or Department guidelines.
Geophysical techniques	Geophysical techniques for performing surface investigations may include, but are not limited to, surface seismic, resistivity, gravity, radar, or magnetic surveys.

3.3 Subsurface Explorations

Site characterization task	Determine the geology and hydrogeology beneath the site through subsurface exploratory methods. Select the appropriate method(s) of subsurface exploration for the site that will allow collection of representative samples of subsurface media. A sufficient number of borings or other exploratory holes must be completed to adequately characterize the stratigraphy, and groundwater dynamics beneath the entire site.
Depth of investigation	The depth of investigation should be 100 feet below the landfill unit's proposed base excavation, or until the first encountered saturated zone is fully penetrated, whichever is deeper.
Methods	Borings, core drilling, test holes, test pits, cone penetration tests or other methods should be used.
Boring density	At least one boring should be continuously cored to obtain precise stratigraphic data and to obtain relatively undisturbed samples for laboratory testing and analysis. If a site is geologically complex or larger than five acres, additional continuously cored holes may be required to interpret stratigraphic and structural variations.
Standards	All borings should be constructed in accordance with applicable standards and guidelines, including: • "Guidelines for Groundwater Monitoring Well Drilling, Construction and Decommissioning," August 24, 1992 • standards developed by ASTM [such as D-5092-90] • OAR 690-240 Sampling methods should conform to ASTM D-1587, ASTM D-1586 or ASTM D-2113, as applicable.

Describe soil and overburden deposits

Classify soil and overburden deposits according to ASTM D-2488 and describe in detail according to their texture, color, mineralogy, moisture content, degree of weathering, geologic origin, and other relevant characteristics. The ASTM D-2488 visual method should be supplemented by appropriate ASTM D-2487 laboratory tests (i.e., mechanical and/or hydrometer grain size and Atterberg Limit tests) on representative samples from each stratigraphic unit.

Rock classification

Classify rock according to its lithology, mineralogy, color, grain size, degree of cementation, degree of weathering, density and orientation of fractures, other primary and secondary features, physical characteristics, and rock quality designation.

Documentation

Prepare a detailed geological log of each boring incorporating all information. Prepare a clear, labeled, photographic record of representative rock cores

Reference: Section 8.0 of the Department's August 24, 1992 guidance entitled "Groundwater Monitoring Well Drilling, Construction and Decommissioning"

Log content

The geological log should include, but is not limited to:
- the location of the hole
- the date drilled, driller's name and affiliation
- the site geologist's name and affiliation
- the elevation of the land surface surveyed to the nearest 0.01 foot
- the size (diameter) and total depth of the hole
- the type of drilling rig and method of drilling
- the type and volume of drilling fluids or additives used
- the penetration rate or standard penetration resistance
- the sampled intervals and the percent recovery
- the stratigraphic and lithologic information
- any aquifers, water-bearing zones and high permeability or fracture zones encountered
- any contamination observed
- any other drilling observations, including lost circulation zones or other difficulties encountered during drilling
- deposit classifications and descriptions
- the classification system used for deposit classification, and
- rock classifications

Geophysical	Perform appropriate downhole geophysical logging techniques to supplement data collected in the surface investigations.
Geophysical techniques	Geophysical techniques for subsurface explorations may include, but are not limited to, downhole caliper, SP, resistivity, induction, natural gamma, gamma-gamma, neutron density, sonic, dielectric, or other logging techniques.
Related activities	Subsurface exploration activities should be planned to maximize data transfer between geologic/hydrogeologic and geotechnical investigations.

3.4 Hydrogeologic Testing

Site characterization task

Conduct appropriate hydrogeologic testing to characterize the rate and directions of groundwater movement.

Unsaturated zone testing

Determine the saturated and unsaturated hydraulic conductivity and the vacuum pressure of unsaturated soils through field testing. Determine the porosity and moisture content of unsaturated soils through laboratory testing or geophysical techniques. Evaluate the spatial and temporal variability of these properties.

Saturated zone testing

Determine the hydraulic conductivity of all saturated water-bearing zones and aquifers identified in the subsurface investigation through field testing, as outlined in the Department’s August 24, 1992 guidance, "Groundwater Monitoring Well Drilling, Construction and Decommissioning."

If the estimated hydraulic conductivity is...	Then...
greater than 10^{-3} cm/sec	an aquifer pumping test should be performed
less than 10^{-3} cm/sec	rising or falling head slug tests should be performed

Aquifer parameters

Determine the following:
- water table or potentiometric surface gradient
- rate and direction of groundwater flow for each aquifer or water-bearing zone
- vertical gradient between water bearing zones
- porosity for all aquifers and water-bearing zones identified during subsurface exploration, using laboratory or geophysical techniques, and
- hydraulic conductivity of all aquitards through laboratory and/or field testing

3.5 Environmental Testing

Site characterization task

Conduct appropriate environmental testing to assess background environmental quality prior to waste placement or to identify impacts from prior waste disposal practices.

Groundwater quality testing

Collect groundwater samples that are representative of formation water. Analyze these samples for the constituents and parameters listed in the table below.

Group	Parameters	Notes
Field indicators	Elevation of water level Specific Conductance pH Dissolved Oxygen Temperature Eh	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
Laboratory indicators	Hardness (as $CaCO_3$) Total Dissolved Solids Total Alkalinity (as $CaCO_3$) Total Suspended Solids Specific Conductance (lab) Chemical Oxygen Demand pH (lab) Total Organic Carbon	Sample handling, preservation, and analysis are determined by requirements for each individual analyte: EPA or AWWA Standard Methods techniques must be followed.
Common anions and cations	Calcium (Ca) Manganese (Mn) Sulfate (SO_4) Magnesium (Mg) Ammonia (NH_4) Chloride (Cl) Sodium (Na) Carbonate (CO_3) Nitrate (NO_3) Potassium (K) Bicarbonate (HCO_3) Silica (SiO_2) Iron (Fe)	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.

<table>
<tr><td rowspan="2">Trace metals</td><td rowspan="2">Antimony (Sb)
Chromium (Cr)
Selenium (Se)
Arsenic (As)
Cobalt (Co)
Silver (Ag)
Barium (Ba)
Copper (Cu)
Thalladium (Tl)
Beryllium (Be)
Lead (Pb)
Vanadium (V)
Cadmium (Cd)
Nickel (Ni)
Zinc (Zn)</td><td><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>
<tr><td>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.</td></tr>
<tr><td>Volatile organics</td><td>Analysis for all compounds detectable by EPA Method 8260 or EPA Method 524.2, including a library search to identify any unknown compounds present.</td><td>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.</td></tr>
</table>

Surface water quality testing

Collect surface water samples as needed to characterize surface water quality up- and down-stream of the facility.

Other environmental testing

Conduct appropriate landfill gas testing, air quality test, or other environmental test as required to establish background environmental quality or to identify impacts from previous waste disposal practices.

Methods

Sample collection, handling, preservation, shipment, analysis and QA/QC should conform to procedures described in the approved work plan and in U.S. EPA SW-846, Test Methods for Evaluating Solid Waste, and Chapter 4 of the RCRA Technical Enforcement Guidance Document (TEGD), or other Department-approved methods.

3.6 Additional Resources

References "Guidelines for Monitoring Well Drilling, Construction and Decommissioning," August 24, 1992 (DEQ)

Section 4: Geotechnical Investigations

4.1 Introduction

Investigation	As part of the Phase I Site Characterization, or other efforts to characterize the site, a Phase I Geotechnical Investigation may be performed.
How to respond	Prepare and submit a Geotechnical Report to support the Site Characterization Report. Geotechnical tasks must be performed by or under the direct supervision of a certified engineering geologist or professional civil engineer with current Oregon registration and experience in conducting engineering geology or geotechnical investigations.
Relation to engineering	Phase I and II Geotechnical Studies should produce sufficient site data to perform all relevant engineering analyses.
In this section	This section describes the tasks that should be performed as part of Phase I and Phase II Geotechnical Investigations.

4.2 Phase I Geotechnical Investigation

Objective of investigation

Conduct a preliminary geotechnical investigation designed to accomplish the following objectives:

- characterize the variability, depth, aerial extent and engineering properties of on-site soils and other overburden deposits
- inventory soils and other overburden deposits suitable for use in construction, and identify the proposed use for these materials
- identify geotechnical considerations (such as settlement and slope stability) which must be addressed in the engineering design and/or further characterized by a Phase II Geotechnical assessment, and
- develop a work plan for conducting a Phase II Geotechnical investigation, as necessary, to adequately characterize on-site soils and other geotechnical considerations

Tasks to be addressed

The Phase I Geotechnical Investigation should address, at a minimum, the tasks described in this subsection.

Describe surficial soils

Evaluate agricultural soil types and their distribution site-wide and within at least a one-mile radius of the site. At a minimum, prepare a soils map and describe the soils in the area. Basic data should be obtained from the U.S. Department of Agriculture Soil Conservation Service (SCS), and supplemented by additional site-specific reconnaissance or tests, as necessary, to confirm the accuracy and reliability of the SCS data.

Describe subsoils

Excavate backhoe test pits in a grid pattern across the site to characterize the depth, areal extent and uniformity of subsoils (overburden deposits). Collect representative soil samples for testing. Plot all test pits on a site map and log each test pit to include

- the location of the excavation
- a description of surface features before excavation
- the date excavated, excavator's name and affiliation
- the site geotechnical engineer's or engineering geologist's name and affiliation
- the elevation of the land surface surveyed to the nearest 0.01 foot
- depth of the excavation
- a detailed description of each stratigraphic unit, its depth, texture, color, mineralogy, grain properties, consistency or relative density, moisture content, degree of weathering, geologic origin, macroscopic features (e.g., root holes, slickensids), and other relevant or distinguishing characteristics
- each stratigraphic units Unified Soil Classification, using ASTM D-2488 visual method, and
- a clear, labeled, photographic record of all test pits

Supplemental tests

Supplement ASTM-D2488 with appropriate grain size and Atterberg limit tests on a representative number of samples of each stratigraphic unit.

Evaluate engineering properties of on-site materials

Analyze representative soil samples to evaluate their engineering properties as follows:

- determine the stability of on-site materials for foundation and sidewall construction
- determine the suitability of on-site materials facility construction, and
- inventory usable soils

Test soils

Perform the following tests:

- strength and compressibility (e.g., triaxial compression tests, consolidation tests) of foundation materials
- the following properites of low-permeability liner layer materials:
  - natural moisture content
  - in-situ density
  - compaction curves
  - Atterberg Limits
  - percent fines passing a #200 sieve
  - percent clay size content
  - percent coarse material retained on a #4 sieve, and
  - laboratory hydraulic conductivity
- grain size distribution and representative laboratory hydraulic conductivity of proposed drainage layer materials, correlate grain size distribution conductivity data

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Investigate site stability

Evaluate the site to identify and characterize any unstable conditions that could adversely impact facility structures, and to obtain sufficient data to plan more detailed Phase II studies. Stability analyses should be based on the investigator's professional judgment, published literature, field investigation, and data obtained from representative field and laboratory tests.

Stability factors

To determine if an area is stable, evaluate the following factors:

- weak and unstable foundation materials including soils, overburden, existing solid waste, peat deposits or other materials subject to excessive settlement
- active slope failure
- soils that may fail with a small increase in pore pressure or shear stress, or a small decrease in shear strength
- signs of pre-existing slope failure or slope failure in geologically similar material near the site
  - any other features that indicate the site is susceptible to instability

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Design considerations

Develop engineering measures to protect the integrity of the landfill structures.

Reference: OAR 340-94-030 and 40 CFR Part 258.15

Evaluation

Based on the results of the Phase I Geotechnical Investigation and Site Characterization, evaluate the following scenarios:

- Potentially unstable natural slopes and other on-site areas that could be destabilized by construction activities such as excavation, regrading or other site modifications;
- Stability of the landfill foundation considering site-specific topographic and geologic conditions, static and dynamic loads, pore-water pressures at the subgrade-liner interface, and any other relevant factors; and
- Compressibility of underlying geologic units and potential settlement of the landfill unit. Estimate total and differential settlement based on appropriate field and laboratory methods and design parameters.

Workplan

Prepare a workplan for the Phase II Geotechnical Investigation.

4.3 Phase II Geotechnical Investigations

Phase II study Perform additional geotechnical investigations as required in the Phase II work plan and for design calculations and analyses.

Report Document the results of the geotechnical investigations and present the findings in the Phase II Site Characterization report. Identify any geotechnical considerations that require additional investigation or analysis prior to detailed design and construction of landfill structures. As needed, confirm the engineering properties of on-site soil and rock materials that will be impacted by or used for landfill construction and operation activities.

4.4 Additional Resources

References

Sowers, G.F. (1979). "Soil Mechanics and Foundations: Geotechnical Engineering," The MacMillan Company, New York.

U.S. Navy (1986). "Design Manual - Soil Mechanics, Foundations, and Earth Structures," NAVFAC DM-7; Department of the Navy, Washington, D.C.

Winterhorn, H.F. and Fang, H.Y., (1975). "Foundation Engineering Handbook," Van Nostrard Reinhold, 1975.

U.S. EPA, (1993) "Solid Waste Disposal Facility Criteria Technical Manual" EPA 530-R-93-017.

Section 5: Conceptual Design of Landfill Facilities

5.1 Introduction

Conceptual design phase

The Site Development Plan provides the framework for establishing overall goals for facility design, construction, operation, and environmental monitoring. This section describes the methods and procedures for establishing appropriate design criteria and selecting technologies that will satisfy regulatory requirements and performance objectives.

How to respond

Prepare a comprehensive Site Development Plan that presents the conceptual design of landfill facilities and environmental control systems and documents the analysis used to select the proposed technologies. The plan should be prepared by or under the direct supervision of a professional engineer with current Oregon registration.

Plan content

The Site Development Plan should describe the elements in this subsection. The plan should be stamped by the professional engineer responsible for its preparation. Following the organizational format of this guidance will expedite Department review of the plan.

In this section

This section describes the elements of a Site Development Plan, including:

- facility operation
- conceptual design of landfill facilities
- leachate management
- surface water management
- landfill gas management
- environmental monitoring
- closure and end use
- supporting information

5.2 Facility Operation

Facility operation	Describe the existing and proposed facilities, anticipated waste stream characteristics, and operational procedures, including the items in this subsection.
Capacity and projected life	Specify the proposed capacity and projected life of the site.
Population to be served	Identify and list the communities expected to be served by the facility, and estimate their corresponding current populations. Describe how the listing was compiled. Cite all sources used to estimate population.
Industry to be served	Identify and list major industries to be served by the landfill, and describe how the listing was compiled.
Rate of waste disposal	Estimate the future flow of waste to the facility from communities and industries served and from any other projected sources. Include estimates for maximum daily, maximum monthly and average annual volume and weight of waste to be received. Cite all sources used to calculate volume and weight estimates.
Overall description of operation	Describe the operation including on-site equipment on site (i.e., compactors, dozers, grinders or chippers), anticipated hours of operation, and mode of delivery of solid waste to the site.
Site economic viability	Provide key assumptions used to calculate the economic viability of the proposed facility.
Site screening	Describe how the active landfill area(s) will be screened from public view. <u>Reference</u>: OAR 340-94-040(11)(f)

Planned future use

Describe the planned future use of the disposal site after closure.

Waste stream types

List and estimate the quantity of each type of waste stream projected to be disposed of at the facility.

Examples: domestic wastes, commercial and institutional wastes, industrial wastes, construction and demolition wastes, agricultural wastes, sewage sludge and grit, contaminated cleanup materials, other wastes requiring special handling [see OAR 340-94-040(11)(b)(J)]

Acceptance of industrial waste

If proposing to accept industrial wastes for disposal, report the major industrial waste stream(s). For each weight or volume calculation, treat as one waste stream all industrial waste generated from industries identified by the same first three digits in their Standard Industrial Classification (SIC) code.

Example: Spent casting sand from an aluminum foundry and spent casting sand from a nonferrous foundry should be treated as one waste stream since they are generated from industries having the same first three digits in their SIC code.

Definition: a "major" industrial waste stream comprises greater than one-quarter percent, by weight or volume, of the total estimated waste flow.

Regional facility

If the facility is a regional disposal site, discuss the following:
- plans from the local board of county commissioners for establishing a local citizens advisory committee
- how the information necessary for the Department to review and approve a Waste Reduction Program for any person who will send more than 75,000 tons of solid waste a year to the site will be submitted, and
- how the county, state and country of origin of the waste will be tracked

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5.3 Phased Development of Landfill Facilities

Phased development

Describe the phased development of the landfill. Establish a systematic blueprint of the construction, operation, and closure of each major phase of development.

Contents

Address the following elements in the design:

- design criteria used to determine the landfill's size, configuration, capacity, location, and environmental protection features
- design, construction, and operation considerations for initial cell development
- individual cell construction and the fill sequence
- slope stability in relation to construction, fill sequence, and side-slope liner design
- facility development drawings
- utility requirements including electrical power, water supply, and wastewater treatment and disposal
- earthwork materials for site construction and development, and
- environmental control technologies

Design criteria

Define the basis and any assumptions used to establish the landfill's footprint boundaries, overall configuration, capacity, and location considering at least the following factors:

- regulatory standards for location, design, and operation
- waste stream characteristics
- waste processing (e.g., incineration, composting, shredding)
- buffer zone requirements
- surface drainage patterns and physical characteristics of the site
- slope limitations on the landfill base and final cover profile
- land use and zoning restrictions
- location of utilities and support facilities
- transportation and access patterns
- environmentally sensitive areas
- geotechnical and hydrogeologic constraints, and
- end use alternatives

Facility development drawings

Prepare a series of scaled drawings showing the phased development of the site. Show each phase of landfill cell(s) development and site status when new cells are ready to be placed into service. The drawings should include at least one scaled plan-view and two perpendicular cross-sectional drawings of the excavation plan, fill sequence plan, and final grading plan.

Content of drawings

Identify the following information on the drawings:

- environmental monitoring components including groundwater monitoring wells, and gas monitoring probes, and surface water monitoring stations
- layout of landfill components including support facilities (e.g., public receiving and recycling areas)
- entrance and on-site roads, gates and fencing
- site drainage and surface water control structures (e.g., berms, dikes, ditches, culverts)
- surface impoundments
- soil stockpiles (i.e., the extent, available volume, and intended use of each soil, sub-soil, or rock unit identified as a borrow source)
- leachate collection, storage, treatment and disposal facilities
- special waste management areas (e.g., tires, bulky wastes, asbestos)
- planned total landfill footprint including buffer zones, landscaping, and site screening features
- planned excavations and base grades for each major phase of site development, relationship to hydrogeologic features (e.g., watertable profile, water bearing formations)
- configuration of the completed landfill and final grading plan
- the final landfill surface profile and its internal components, existing topography, and underlying geology/hydrogeology (in landfill cross-section views)
- existing landfill cells, including their operational status and configuration (e.g., exposed waste, intermediate cover, final cover, leachate drainage layer), and
- gas control system components

Earthwork materials for construction and development

Inventory on-site borrow materials and characterize their intended use as follows:

- analyze the results of the Phase I and Phase II geotechnical investigations and identify the intended uses of borrow materials
- quantify the available borrow materials
- describe the management and storage of soils and other construction materials

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5.4 Leachate Management

Leachate management

Describe the proposed leachate management strategies for the landfill's active operation, closure and post-closure stages.

Strategies

The leachate management strategy should be based on a systematic analysis of design, construction, and operation techniques, and the following objectives:

- accurately predict leachate quality and quantity
- select leachate control methods that are technically and economically sound
- maximize leachate containment and collection efficiencies (through liner system and collection and removal system design)
- maximize the reliability of leachate containment systems
- monitor the effectiveness of leachate control systems
- treat and dispose of leachate in an environmentally sound manner, and
- minimize leachate generation

Leachate management analysis

Perform a conceptual design analysis to evaluate background data, establish a rational basis for design, and to evaluate the performance and cost effectiveness of alternative technologies. This analysis should complete the following tasks:

- Evaluate leachate quantity and quality using methods described in Section 6
- Identify key assumptions and design criteria
- Evaluate alternative leachate control technologies
- Prepare conceptual design drawings of major components

Liner system: leachate containment

Prepare conceptual design drawings showing typical cross-sections of the proposed liner system including layer types and thicknesses, minimum slopes, and hydraulic conductivities of each soil layer. Describe the liner system components, including the soil and geosynthetic materials, potential sources of these materials, and the overall design basis.

Standard liner design

The standard composite-liner design incorporates the following components:

- a two-foot thick soil layer with a maximum permeability of 1×10^{-7} cm/sec
- a geomembrane layer with a minimum thickness of 60 mil for HDPE or 30 mil for other materials

The Department may require an enhanced liner design if site specific conditions suggest a significant potential for adverse groundwater quality impacts (see OAR 340-94-060(6)).

Alternative liner design demonstration

If an alternative liner system design is proposed, a demonstration must be made to the Director of the Department that the proposed design will:

- meet the performance standard in 40 CFR 258.40(a)(1), "the design must ensure that the concentration values listed in Table 1 ... will not be exceeded in the uppermost aquifer at the relevant point of compliance", and
- comply with the policies and specific performance requirements of Oregon's Groundwater Quality Protection Rules (i.e., prevent a leachate release exceeding the statistical background concentrations at the relevant point of compliance)

Workplan for alternative design

To facilitate Department review and approval of such a demonstration, submit a workplan describing methods to predict potential water quality impacts. The workplan must specify how the permittee intends to:

- characterize leachate quality and estimate leachate quantity
- estimate liner leakage using a hydrologic model such as the latest version of EPA's HELP model, and
- evaluate groundwater quality impacts due to forecasted leakage, using an appropriate groundwater flow and solute transport model, which demonstrates that the alternative liner design would adequately protect groundwater and surface water quality

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Leachate collection and removal system

Describe the basis for the design, including key assumptions and design criteria on how the Leachate Collection and Removal System (LCRS) will maintain leachate depths of less than 30 cm. Prepare a conceptual design of the LCRS that includes drawings showing typical cross-sections and a plan-view of system layout, manholes, cleanouts, sumps.

LCRS design criteria

The Department's recommended design criteria are as follows:

- Drainage layer slopes should be at least 2% (after settlement)
- Collection pipes should:
  - have slopes of at least 1%
  - meet the recommendations of (not minimums) of OAR 340-52-030, and
  - have enough slope to maintain scouring velocity
- Manhole spacings should not exceed the capabilities of available cleanout equipment and should meet recommendations (not minimums) of OAR 340-52-030 for sewer pipelines. At a minimum, cleanouts should be provided at both ends of all leachate collection pipes with sweep ends used to allow smooth access to cleanout equipment
- Leachate pipe should have a minimum diameter of 6 inches and should be schedule 80 or equivalent strength pipe
- Granular drainage layers should consist of competent, non-angular rock or rounded gravel and have a minimum in-place hydraulic conductivity of at least 1 x 10^{-2} cm/sec

Secondary LCRS: Under certain circumstances (see OAR 340-94-060(6)), the Department may require a secondary leachate collection system. Suggested design criteria for the secondary LCRS and other pertinent design-related information are provided in Section 7 (Detailed Design).

Leachate storage

Prepare a conceptual design of the storage system including cross-section and plan-view drawings and describe the design basis. Leachate storage impoundments should be located, designed, constructed, and monitored to at least the same standards as landfills. Leachate storage impoundments should be equipped with a leak detection system beneath the entire liner system, creating a double liner system to protect against the high hydraulic head typically impinging on the liner system.

Leachate treatment and disposal

Perform a leachate treatment feasibility study as outlined in Section 6 of this guidance. The results of this study should be used to develop conceptual design drawings and preliminary equipment specifications for the proposed treatment and disposal methods. The Department recommends treatment methods that reduce leachate contaminants, not methods that transfer the environmental problem to another medium.

Leachate minimization

Describe the design, construction, and operation techniques that will be used to minimize leachate production during the landfill's active and post-closure periods. The leachate minimization program should include the following elements:

- phased development and closure to minimize the active area footprint
- temporary geosynthetic covers to minimize infiltration in active cells
- run-on and runoff control systems for active and closed areas
- subsurface drainage systems to control groundwater seepage
- low permeability final cover systems to minimize infiltration during post-closure, and
- cell construction techniques that promote surface runoff rather than infiltration

5.5 Surface Water Management

Surface water	Describe the proposed methods for managing surface water run-on and runoff during the landfill's active operation and post-closure stages.
Surface water control during active landfill operations	Describe the surface water control measures and facilities that will be implemented and maintained during active landfill operations and how the system will • intercept and divert run-on away from active and closed landfill cells (subareas) • promote runoff from landfill areas capped with interim or final cover • minimize site erosion • temporarily store excess peak runoff flow until it can be discharged at a lower controlled rate • control sediment transport by removing suspended solids from surface water runoff as necessary to comply with the facility's NPDES stormwater discharge permit, and • collect and contain leachate-contaminated stormwater that accumulates in active landfill areas
Surface water control after final facility closure	Describe the surface water control measures and facilities that will be implemented and maintained after final closure of the facility and how the system will • protect the integrity and effectiveness of the landfill cover system, and • minimize long-term maintenance requirements after closure
Conceptual design	Prepare conceptual design drawings showing the complete surface water control systems that will be in place during active landfill operations and after cell closure.

5.6 Landfill Gas Management

Landfill gas

Describe the methods and technologies that will be used to control landfill gas.

Content

Evaluate the following design and construction considerations:

- site characteristics including topography, soils, geology, hydrogeology, climate
- fluctuations in groundwater levels, soil moisture, barometric pressure, and other environmental parameters
- locations of on-site structures, utilities, etc.
- adjacent land use and development
- size and age of the landfill and quantity of in-place refuse
- regulatory standards including federal air emission standards for landfills
- the landfill's operational history
- landfill gas monitoring results
- permitting requirements for flare units and other air emission sources
- operational status of the landfill unit (closed/full, active/partially full, new/empty, etc.)
- site development sequence
- suitable space for mechanical equipment (motor blowers, flares, electrical panels, etc.)
- moisture conditions within the landfill (saturated zones can impede gas flow)
- landfill gas quality (chemistry) and potential effects on leachate and groundwater quality
- design of existing and future landfill cells and potential influences on landfill gas flow paths
- current and future landfill gas production rates
- depth of in-place refuse below grade (interface between refuse and subsurface strata)
- available options for containing and managing landfill gas condensate
- capital costs and operation and maintenance costs of alternative designs

Types of control systems

There are two general types of landfill gas control systems: active systems and passive systems. Active control systems are recommended by the Department for most applications because of their superior flexibility and performance. However, active systems are usually substantially more expensive to construct and operate.

Conceptual design plans

Prepare preliminary engineering drawings showing the following landfill gas control system features:

- extraction well and/or horizontal collection trench locations and spacings
- configuration of collection lateral and header piping
- condensate drains, storage and treatment methods, and
- mechanical equipment complex (motor-blower, flare, and associated equipment)

Design criteria

The Department's recommended design criteria for landfill gas control systems are as follows:

- The landfill gas control system should be operationally flexible to accommodate changing gas production rates, migration patterns, gas chemistry, and other variables.
- Active control systems should be designed to provide 100 percent blower standby (backup) capability.
- The landfill gas control system should be designed for phased construction and expansion potential.
- Flame arresters should be incorporated into flare systems to prevent accidental ignition in the discharge piping system.
- Flare units should be equipped with automatic ignition systems and alarms.
- Header piping systems should have minimum (post-settlement) slopes of 3 percent for condensate drainage and collection.

Methane limits

The concentration of methane gas must not exceed

- 25 percent of the lower explosive limit for methane in facility structures, excluding gas control or recovery system components, or
- the lower explosive limit (LEL) at the facility property boundary

Reference: OAR 340-94-060(4) and 40 CFR Part 258.23(a)

Monitoring

Facilities must conduct routine monitoring, with a minimum frequency of once per quarter, to verify compliance with the allowable concentration limits.

5.7 Environmental Monitoring

Establishing monitoring	In most instances, detailed environmental monitoring programs will not be established until Phase II site characterization and detailed facilities design are completed.
Conceptual monitoring plan	Describe the overall monitoring strategies and objectives for • groundwater • surface water • leachate • landfill gas • air (if applicable)
Guidance	Guidance for preparing an environmental monitoring plan is provided in Section 10.

5.8 Closure and End Use

Closure and post-closure

Describe the general procedures for final facility closure and the end use plan for the facility property. Closure of modern landfills is accomplished in phases when discrete cells or subareas reach final capacity. Closed areas must be maintained and monitored while active operations continue in other cells. For financial assurance purposes, these activities should be considered as interim closures. The 30-year post-closure care period does not officially begin until final facility closure is complete.

Reference: OAR 340-130

Reference

Minimum regulatory requirements for final facility closure are prescribed in OAR 340-94-100 and 40 CFR Part 258.1. Detailed closure provisions should be incorporated into the closure plan (see Section 11 for further instructions).

5.9 Supporting Information

Local government endorsement

Submit written recommendations of the local government unit(s) having jurisdiction to establish a new disposal site or to substantially alter, expand, or improve a disposal site or to make a change in the method or type of disposal. Such recommendations should include, but are not limited to, a statement of compatibility with:

- the acknowledged local comprehensive land use plan and zoning requirements or the Land Conservation and Development Commission's Statewide Planning Goals (using the Department's Land Use Compatibility Statement form), and
- the adopted local solid waste management plan

Reference: OAR 340-93-070(3)(b) requires submittal of local government information to document that the proposed new landfill or expansion of an existing landfill has been reviewed and approved by the local host community

Compatibility with solid waste plans

Explain how the proposed facility or facility expansion is compatible with all elements of the local solid waste management plan, and the state integrated solid waste management plan.

Waste reduction

If any local government or other person will send more than 75,000 tons of solid waste per year to the disposal site, submit a copy of the person's plans for implementing a waste reduction program.

Other permits

Identify any local, state, or federal permits, in addition to the Solid Waste Disposal Site Permit, that will be required for the proposed facility or expansion. If the permit has been granted, include a copy of the permit. If the permit has been previously applied for but not yet granted, include a copy of the permit application.

Examples: Corps of Engineers Section 404 permit; NPDES permit

Statement of need

Submit a statement clearly demonstrating the need for the new or expanded facility. For the renewal of a permit for an existing facility, the statement should relate to the continuing need for the facility. The statement of need should address the following criteria:

- the availability and capacity of alternative disposal sites or resource recovery systems and facilities
- the relationship of the permit application to current or proposed state and local solid waste management plans for the affected area
- the existence of contracts for disposal of waste at the proposed site
- the potential costs of shifting to available alternative sites and the proximity of such sites, and
- the ability of the proposed site to comply with statutory and regulatory requirements

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5.10 Additional Resources

References

U.S. EPA Solid Waste Disposal Facility Criteria Technical Manual. November 1993

Washington D.O.E. Solid Waste Landfill Design Manual. June 1987.

Section 6: Leachate Treatment and Disposal Feasibility Study

6.1 Introduction

Evaluate treatment alternatives

Available leachate treatment alternatives should be evaluated. Methods that reflect site-specific conditions, and a full consideration of cross-media impacts should be selected for the facility.

Preferred methods

Preferred treatment methods are those that reduce the leachate contaminants rather than simply transferring the environmental problem to another medium. New landfills, and municipal solid waste landfills with significant expansions built after October 9, 1993, may need to complete a supplemental information form to help identify and prevent the transfer of pollutants from one medium to another.

How to respond

Submit a Feasibility Study Report that documents the analysis of treatment and disposal alternatives, including any assumptions. The Report should be stamped by the Profession Engineer who conducted the study.

Analysis of treatment options

Evaluate leachate treatment and disposal alternatives as follows:

- estimate leachate generation rates based on the latest Help Model analyses and/or actual leachate volume measurements from existing landfill cells
- determine the chemical and physical characteristics of the leachate and predict variations in leachate characteristics over time. For lateral expansion of existing facilities, sample and analyze leachate from an adjacent cell. For new facilities, obtain data from the nearest existing facility with a comparable physio-climatic setting and incoming waste stream
- identify final disposal alternatives and evaluate their feasibility in terms of cost effectiveness, environmental impact, technological constraints, regulatory requirements, and compatibility with other elements of the landfill design and operation
- define leachate treatment (effluent) requirements for the disposal alternatives and overall design criteria
- select a treatment process or processes which will achieve desired treatment performance for each disposal alternative
- estimate the capital and operation and maintenance costs of each alternative treatment and disposal method
- select the best alternative treatment and disposal system with regard to cost, reliability, flexibility and any other appropriate considerations

The study should be conducted by a Professional Engineer with current Oregon registration.

Selection of method

Leachate characteristics and treatability may be affected by landfill expansion and by partial or final closure. Therefore, the proposed treatment methods should be highly adaptable to accommodate variable chemical and hydraulic loading. The proposed system should consist of one or a combination of treatment options.

Treatability studies

If possible, selection of a process to treat leachate should be based upon treatability studies (laboratory or pilot scale) using the actual leachate. This is recommended for several reasons:

- Published leachate treatment performance data are rare. In the absence of treatability studies, inferences must be drawn from laboratory experimental studies, and industrial and municipal water and wastewater treatment experience.
- Lacking previous experience or treatability data, there is no guarantee that high levels of treatment can be achieved.
- It is likely that a combination of several unit processes will be needed to deal with the leachate. Arriving at the optimum system is unlikely without treatability studies.
- The complex leachate may not behave like other wastewaters, thus affecting design and operating criteria (e.g., chemical dosage requirements), and invalidating extrapolations from other experiences. Leachate composition also varies with age of the landfill.
- Capital investment, and especially operation and maintenance costs, are likely to be greater per unit volume treated than for municipal or industrial wastewater. However, costs will be difficult to estimate without treatment experience. Investment in a costly, unproven system that may not meet the required treatment objectives is imprudent.

Alternative evaluation

In spite of these considerations, treatability studies may not be possible at all sites. Representative leachate samples may be unavailable at new landfill sites or arid area sites. In such cases, use a more theoretical approach that relies on published data or data from another similar facility.

In this section

This section describes alternative treatment methods for landfill leachate, including:

- discharge to privately or publicly-owned treatment works
- land application
- on-site treatment with discharge to surface water
- re-application or re-injection to lined cell
- evaporation or impoundment, and
- other alternatives

6.2 Discharge to Privately or Publicly-Owned Treatment Works

The option

This alternative is subject to any pretreatment and/or wastewater connection requirements of the authority operating the treatment works. Discharges to publicly-owned treatment works (POTW) are not directly regulated by the Department.

Reference: "Management Plan Requirements for Leachate Disposal to Publicly-Owned Treatment Works," March 19, 1993

Examples of use

This method is currently practiced by several landfill in the Northwest, including:

- St. Johns Landfill, Portland, Oregon. Contact: Metro Solid Waste
- Cedar Hills Landfill, King County, Washington. Contact: King County Solid Waste Department
- Cathcart Landfill, Snohomish County, Washington. Contact: Snohomish County Solid Waste Department
- Kent Highlands Landfill, Kent, Washington. Contact: City of Seattle

6.3 Land Application

The option

This alternative is subject to possible pretreatment requirements.

Reference: "Standards for Leachate Spray Irrigation Management," October 28, 1992

Examples of use

This method is currently practiced by several landfills in Oregon, including:

- Coffin Butte Landfill, Benton County. Contact: Valley Landfills, Corvallis, Oregon
- Riverbend Landfill, Yamhill County. Contact: Sanifill of Oregon

6.4 On-site Treatment with Discharge to Surface Water

The option

This alternative is subject to effluent limitations as defined in a National Pollutant Discharge Elimination System (NPDES) permit. Application for a permit should be completed and submitted to the Department's Water Quality Division. If Total Maximum Daily Loads have been established or proposed for the receiving waters, additional requirements may be mandated above and beyond the NPDES permit.

Treatment processes

Generally, there are eight unit treatment processes applicable to leachate treatment:

- biological treatment
  - aerobic
  - anaerobic
- chemical precipitation
- ion exchange
- reverse osmosis
- carbon absorption
- stripping
- chemical oxidation
- wet oxidation

The applicability of each of these processes depends largely on the age of the leachate and the location and design of the landfill.

Examples of use

This method is currently practiced by Roseburg Landfill in Douglas County.
Contact: Douglas County of Public Works

6.5 Re-application or Re-injection to Lined Cell

The option

This alternative is permissible under the conditions of U.S. EPA's Solid Waste Disposal Facility Criteria 40 CFR Part 258. Only those cells where the composite liner and leachate collection system are equivalent to the minimum standards as described in 40 CFR 258.40(a)(2) can this form of leachate treatment be employed.

Minimum standards

Re-application of leachate is prohibited unless the landfill cell has at least the equivalent of each of the following three elements:

- upper component: a composite liner with 30-mil FML [60-mil HDPE], installed in direct and uniform contact with the compacted soil component
- lower component: a two-foot or thicker layer of compacted soil with a hydraulic conductivity no greater than 10^{-7} cm/sec
- leachate collection: a collection system capable of maintaining less than a 12 inch [30-cm] depth of leachate head

Considerations

The following considerations should be addressed:

- hydrogeology of the landfill site and the surrounding area within a 1/4-mile radius of the site
- climatic/meteorological data
- design details of the recirculation system
- monitoring of leachate levels in the landfill
- detailed contingency plans for leachate control, in the event that the leachate head levels cannot be maintained at less than a 12 inch [30-cm] depth
- metals accumulation in cover soils (if leachate is surface applied), and
- surface runoff and erosion control (if leachate is surface applied)

Examples of use

This method is practiced in limited use at Finley Buttes Landfill in Morrow County, Oregon.

6.6 Evaporation/Impoundment

The option

This alternative is subject to the same requirements as an application for a Water Pollution Control Facility (WPCF) permit. A lagoon, impoundment structure, or evaporation pond with a discharge to surface water is subject to a NPDES permit.

Inclusion in other documents

The Site Development Plan and detailed design plans and specifications should include:

- the rationale for selecting the proposed evaporation/impoundment technique
- water balance calculations
- pilot and bench tests, as appropriate, and
- alternative methods for residuals handling

Examples of use

This method is currently practiced at Columbia Ridge Landfill and Recycling Center in Gilliam County, Oregon.

6.7 Other Alternatives

Options

The Department will consider other treatment options, such as incineration, moisture source for composting if supporting information demonstrates consistency with DEQ regulations and water quality criteria.

6.8 Additional Resources

References

"Management Plan Requirements for Leachate Disposal to Publicly-Owned Treatment Works," DEQ, March 19, 1993

"Standards for Leachate Spray Irrigation Management," DEQ, October 28, 1992

Section 7: Detailed Design

7.1 Introduction

Detailed design phase

Fundamental design assumptions and criteria established during conceptual design should be reevaluated and refined at the outset of the detailed design stage. At this point, additional site characterization data, materials testing results, input from the Department and other reviewing agencies, permit requirements, and other available information should be incorporated into the design.

Regulatory references

Mandatory design standards and performance criteria are specified in 40 CFR 258 and OAR 340 Division 94. The design approach should also reflect current technologies, and conventional engineering principals and practices. Requirements for detailed design plans and specifications are described in OAR 340-93-140.

How to respond

Submit the following design documents to the Department for approval prior to construction, consisting of:

- detailed plans and specifications, stamped by a qualified professional engineer with current registration in Oregon
- a design report that describe the technologies and engineering analyses associated with the proposed design

Design plans and specifications

Base design plans and specifications on the results of Phase I and Phase II site characterization, geotechnical studies, and conceptual design analyses and reporting.

Design report

Prepare a design report that includes the following information:

- executive summary, conclusions, recommendations
- design basis, main assumptions, design criteria, and site constraints
- descriptions of key landfill components and their design functions
- a written explanation of the detailed design drawings and specifications
- a demonstration that landfill components will function as designed
- results of design-related materials testing
- preliminary specifications for construction materials, and
- engineering analyses and calculations used to develop the design

Format

To facilitate the Department's review, design reports, design plans and specifications and other related documents should have the same organizational format used in this guidance document. Design documents should be sufficiently detailed to enable the Department to determine whether mandatory standards and performance criteria have been achieved. Specifications should follow the standard format adopted by the Construction Specifications Institute.

In this section

This section provides guidance on preparing detailed design plans and specifications for the following environmental control systems:

- liner system
  - soil liner component
  - geomembrane component
- primary leachate collection and removal system
- secondary leachate collection and removal system
- leachate treatment and storage impoundments
- leachate holding tanks and conveyance pipelines
- leachate treatment process
- final cover system
- surface water control system, and
- landfill gas control system

7.2 Liner System

Performance criteria

Landfill liners are designed to protect the environment by preventing the release of leachate and landfill gas. New municipal solid waste landfill units and lateral expansions of existing landfill units must be equipped with either a composite liner, or a site-specific alternative design that meets the environmental performance criteria. Unless the Department approves an alternative design, liner systems must include:

- a soil liner component and
- a geomembrane liner component

These components are discussed in the following sections.

Reference: Minimum design standards for liner systems are specified in 40 CFR 258.2, 40 CFR 258.40(b), and 258.40(a)(1). Associated performance criteria are contained in the Department's groundwater protection rules [OAR 340-40-020(1),(2),(3)].

Proposing an alternative design

An alternative design proposal should be discussed with Department staff, before the development of formal design details. At this point, the Department will consider, from a technical and environmental standpoint, whether the proposal is viable. The Department will not approve alternative liner designs unless a convincing demonstration is made that the alternative design meets both the environmental performance requirements and the no-groundwater-degradation policy. Alternative design proposals will be subject to the opportunity for public comment.

Reference: See the Alternative Design discussion in Section 5: Conceptual Design of Landfill Facilities

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Design document content

The design documents should address technical considerations such as

- performance criteria
- construction details (anchoring, penetrations)
- material properties
- dimensions
- bottom and sidewall slopes
- site operations (particularly the cell filling sequence and configuration),
- interface friction properties of liner system components, and
- subgrade conditions such as groundwater levels and soil properties

7.3 Liner System -- Soil Liner Component

Soil characteristics

Soils have a wide range of physical characteristics that are relevant to liner construction. These characteristics, described below, effect the soil's potential to meet the specified permeability of 1 x 10^{-7}.

Characteristic	Description
Soil plasticity	The soil plasticity index (PI) should be greater than 10 percent. However, soils with very high PI (above 30 percent), are cohesive, sticky and difficult to work with in the field. When high PI soils are too dry, they may form clods that are difficult to break down during compaction. Perferential flow paths may form around the clods, increasing the liner's permeability. Large soil particles or rock fragments can also form perferential flow paths.
Soil density and moisture	A soil's maximum density corresponds to the optimum moisture content, the minimum permeability to a moisture content wet of optimum. Wet soils, however, have less shear strength and more potential for desiccation cracking. When specifying moisture content, consider shear strength and other engineering properties. Typically, the permeability criterion can be achieved at moisture values of 1 to 7 percent above optimum.

Liner construction

Soil liners should be constructed in a series of compacted lifts. To specify lift thickness consider soil characteristics, compaction equipment, foundation characteristics, compaction requirements and liner permeability. The compactor must reach the lower portions of the lift to establish good, homogeneous bonding between lifts.

Soil test methods

Use the following test methods to characterize prospective liner soils:
- grain size distribution (ASTM D-422)
- Atterberg limits (ASTM D-4318), and
- moisture/density relationships by standard or modified Proctors (ASTM D-698 or ASTM D-1557), whichever is appropriate for the compaction equipment the foundation characteristics

Design criteria: soil liner

Design the soil liner to meet the following criteria:

- maximum saturated hydraulic conductivity (permeability) -- 1×10^{-7} cm/sec
- minimum compacted thickness -- least two feet
- Atterberg limits -- plasticity index ³ 10%;
- percent fines -- ³ 50% passing a #200 sieve;
- percent coarse material -- 10% retained on a #4 sieve;
- maximum particle size including clods -- 1 - 2 inches.

Recommended design procedures

Design the soil liner component by following the procedures below.

Step	Action
1	Specify performance objectives and material properties
2	Specify Unified Soil Classification, percent clay content (by hydrometer analysis to the 2 micron particle size) and the additional soil properties in the design criteria
3	Establish liner dimensions including thickness and surface area
4	Prepare appropriate design details, including details of connections between existing and new sections of the liner
5	For bentonite amended soils, specify the bentonite application rate as a percentage of the original dry weight of the soil, and mixing techniques
6	Specify construction requirements for the soil test pad the full-scale liner and associated earthwork
7	Specify Construction Quality Control (CQC) and Construction Quality Assurance (CQA) requirements

Reference: Also refer to the construction requirements in Sections 8.3, 8.4, and 8.5.

7.4 Liner System -- Geomembrane Liner Component

Design criteria: geomembrane liner

Design the geomembrane component of the landfill liner to meet the following criteria:

- HDPE geomembranes of at least 60 mils thick (or at least 30 mil thick for other materials) should be installed in direct and uniform contact with the underlying soil liner
- the geomembrane should be chemically compatible with leachate, landfill gas, and other expected environmental conditions within the landfill
- the geomembrane should be physically compatible with the proposed subgrade and backfill properties
- the geomembrane should be capable of withstanding the anticipated short-term and long-term stresses due to facility construction and operation.
- the number of pipe penetrations through the geomembrane should be minimized to the extent possible
- the geomembrane's friction properties should be compatible with other components of the liner system to minimize mechanical stresses on any component

Design approach

A systematic approach to design will enhance the geomembrane's performance, reliability and compatibility with other landfill components.

Recommended design procedures

Design the geomembrane liner component by following the procedures below. Where listed, refer to the pages in Section 7.13 (Appendix of Engineering Analyses and Calculations) for additional details.

Step	Action	Ref. pg.
1	Specify performance criteria and material properties for geomembranes and associated geosynthetics	---
2	Perform a geomembrane design analysis to determine acceptable geomembrane properties	7-25
3	Analyze the liner system's stability in side-slope areas	7-26
4	Analyze geomembrane runout or anchor trench requirements and prepare design details	---
5	Prepare design details for sumps, pipe penetrations, mechanical attachments to structures, etc.	---

Step	Action	Ref. pg.
6	Specify Construction Quality Control (CQC) and Construction Quality Assurance (CQA) requirements	---

Geomembrane specifications

Identify the geomembrane's function and specify desired properties for:

- the geomembrane to perform its intended function
- construction survivability, and
- in-service durability (i.e., resistance to temperature variations, UV radiations, leachate, mechanical stress)

Testing and acceptance

Establish minimum requirements for testing and acceptance of geomembrane conformance, including:

- sampling frequency
- sample size
- sampling technique
- conformance testing procedures
- acceptance criteria, and
- rejection procedures

7.5 Primary Leachate Collection and Removal System

Performance criteria

The primary leachate collection and removal system (LCRS) must be designed to function automatically, continuously, and as efficiently as possible within practical limits. The LCRS should maintain a leachate depth of less than 30-cm above the liner.

Reference: 40 CFR 258.40(a)(2)

Design criteria

Design the primary leachate collection and removal system to meet the following criteria:

- granular drainage layer percent fines -- < 5% passing No. 200 sieve.
- granular drainage layer hydraulic conductivity -- 1 x 10^{-2} cm/sec.
- granular drainage material should consist of carbonate-free, rounded gravel or non-angular rock.
- leachate collection pipe -- minimum 6-inch diameter, schedule 80 or equivalent strength pipe.
- minimum slopes for collection pipes -- 1% after predicted settlement; comply with OAR 340-52-030 for sewer pipelines (enough slope to maintain scouring velocity).
- minimum slopes for leachate drainage layer -- 2% after foundation settlement.
- manhole/cleanout spacing -- Should be compatible with available cleanout equipment and meet recommendations (not minimums) of OAR 340-52-030 for sewer pipes. At a minimum, provide cleanouts at both ends of all leachate collection pipes and sweep bends to accommodate cleanout equipment.

Recommended design procedures

Design the leachate collection and removal system (LCRS) by following the procedure below. Where listed, refer to the pages in Section 7.13 (Appendix of Engineering Analyses and Calculations) for additional details.

Step	Action	Ref. pg.
1	Prepare scaled drawings of the leachate collection system layout and construction details	---
2	Specify properties, characteristics and performance criteria of granular drainage layers, including Unified Soil Classification, grain size distribution, maximum particle size, maximum percent passing No. 200 sieve, thickness, and hydraulic conductivity at anticipated field density	---

Step	Action	Ref. pg.
3	Specify properties, characteristics and performance criteria of geosynthetic drainage layers, including polymer type, transmissivity and evidence of chemical compatibility. Analyze requirements for geosynthetic drainage material to determine allowable properties	7-25, 7-26, 7-28
4	Specify properties and characteristics of any granular filter layers, including Unified Soil Classification, grain size distribution and thickness	---
5	Specify properties and characteristics of any geosynthetic layers used for filtration or for liner protection. By analysis, determine allowable properties for protection or filtration layers	7-26, 7-28
6	Describe leachate collection pipe configuration, dimensions and properties, and analyze pipe loading and structural strength	7-31
7	Identify minimum slope specifications for drainage layers and collection pipes	---
8	Prepare leachate collection sump capacity and design details	---
9	Prepare manhole/cleanout design details, describe cleanout equipment capability and procedures, and analyze manhole-foundation design requirements	7-31
10	Identify the location and minimum spacing of manhole/cleanouts	---
11	Conduct a filtration analysis to evaluate the primary LCRS's clogging potential	7-31
12	Conduct an analysis of primary LCRS performance	7-30

7.6 Secondary Leachate Collection and Removal System

Need for secondary system

Under certain circumstances (see OAR 340-94-060(6)), the Department may require a secondary leachate collection and removal system (LCRS) to provide for additional groundwater protection and/or enhanced monitoring.

Design criteria

Design the secondary LCRS to detect and collect leachate at locations of maximum leak probability (e.g., liner penetrations, leachate collection sumps and leachate drain lines). Consider the following criteria:

- locate the secondary LCRS
  - beneath areas of maximum leak probability;
  - directly below and parallel to the liner system; and
  - above or hydraulically isolated from the seasonal-high water table to prevent groundwater intrusion into the secondary LCRS and potentially erroneous monitoring results.
- granular drainage layer percent fines -- < 5% passing No. 200 sieve.
- granular drainage layer hydraulic conductivity -- 1 cm/sec (at field density).
- granular drainage layer physical properties -- non-angular rock or rounded gravel free of carbonate material
- geosynthetic drainage layer transmissivity -- 5×10^{-4} m^2/s.
- minimum slope specifications for drainage layer and collection pipes -- pipes should meet recommendations (not minimums) of OAR 340-52-030 for sewer pipelines. Drainage layer should slope at least 2% (after settlement)
- manhole/cleanout location and spacing should not exceed capabilities of available equipment

Recommended design procedures

Design the secondary leachate collection and removal system (LCRS) by following the procedure below. Where listed, refer to the pages in Section 7.13 (Appendix of Engineering Analyses and Calculations) for additional details.

Step	Action	Ref. pg.
1	Prepare scaled drawings of the secondary leachate collection and removal system layout and construction details	---
2	Describe the secondary LCRS lining system, including its physical properties and dimensions	---

Step	Action	Ref. pg.
3	Specify granular drainage layer properties and performance criteria, including Unified Soil Classification, grain size distribution, maximum particle size, maximum percent passing No. 200 sieve, thickness, and hydraulic conductivity at anticipated field density	---
4	Specify geosynthetic drainage layer properties, and performance criteria, including polymer type and transmissivity. Determine allowable properties for geosynthetic drainage material should be determined by analysis	7-25, 7-26
5	Specify granular filter layer properties and performance criteria, including Unified Soil Classification, grain size distribution and thickness. Granular filter material must be free of carbonate material	---
6	Specify geosynthetic protective or filter layer properties. Determine allowable properties for geosynthetic by analysis	7-25
7	Describe leachate collection pipe configuration, dimensions and properties. Determine allowable properties by a structural stability analysis	7-31
8	Identify minimum slope specifications for drainage layers and collection pipes	---
9	Prepare leachate collection sump capacity and design details	---
10	Prepare manhole/cleanout design and operation details, including cleanout equipment capabilities and operating procedures. Analyze foundation requirements for manholes.	7-31
11	Identify manhole/cleanout configuration and spacing	---
12	Analyze the clogging potential within secondary LCRS components	7-31
13	Analyze the collection efficiency of the secondary LCRS	7-30

7.7 Leachate Treatment and Storage Impoundments

Performance criteria

Environmental safeguards for leachate treatment and storage impoundments should be comparable to or more extensive than what is required for a Subtitle D landfill cell. For minimum standards on location, design, construction, and monitoring see OAR 340-94-060(3).

Design Criteria

Design leachate treatment and storage impoundments to meet the following criteria:

- impoundment liners equal or exceed the landfill liner design
- the leak detection system underlies the impoundment liner to account for the substantial liquid depths within such impoundments
- impoundments have sufficient freeboard to contain and prevent overflow due to the 24-hour, 25-year storm
- available storage capacity reflects adopted leachate management practices and seasonal operating restrictions

Recommended design procedures

Design the leachate treatment and storage system by following the procedures below. Where listed, refer to the pages in Section 7.13 (Appendix of Engineering Analyses and Calculations) for additional details.

Step	Action	Ref. pg.
1	Calculate required storage capacity, account for leachate flow projections and the impoundment's internal water budget	7-31
2	Incorporate landfill cell design procedures	---
3	Design the leak detection system, incorporate all applicable steps outlined in Subsection 7.6 for secondary leachate collection and removal systems	---
4	Design leachate impoundments using landfill-cell equivalent detail and engineering analysis	---
5	Use applicable information previously developed for landfill cell design analyses	---

7.8 Leachate Holding Tanks and Conveyance Pipelines

Design criteria: holding tanks

Design leachate holding tanks to be:
- watertight
- composed of landfill-leachate compatible materials
- located on a flat, stable foundation, and
- sized to support the LCRS and leachate management practices

Design criteria: conveyance pipelines

Design conveyance pipelines to be:
- composed of landfill-leachate compatible materials
- consistent with the Departments' guidelines for sewer pipelines
- watertight and
- capable of withstanding in-service conditions, physical loads, stresses

Recommended design procedures

Design leachate holding tanks to meet the same operational considerations as impoundments. Design conveyance pipelines according to the guidelines for sewer pipelines.

References: OAR 340-060(3); OAR 340-52-020, Appendix A

7.9 Leachate Treatment Process

Performance criteria

Design the leachate treatment and disposal system to achieve effluent quality (leachate strength) objectives as appropriate for direct discharge or for pretreatment followed by discharge to another treatment facility.

Designing the system

The design of a leachate treatment and disposal system should include the following main stages:

Stage	Description
A feasibility study	Evaluate treatment and disposal alternatives and identify preferred method
Conceptual design	Prepare Conceptual Design (Engineering) Report including conceptual design plans and specifications for the selected alternative
Detailed design	Prepare detailed design plans and specifications and the Design Report

Selecting a design

Leachate composition and flow rates are highly variable and subject to numerous, site-specific physical and environmental influences. Select treatment technologies which can be easily modified to accommodate substantial changes in hydraulic loading and leachate strength.

Treatability studies

If possible, conduct treatability studies on site-specific leachate before committing to a particular leachate treatment process or technology. Treatment process staging may be necessary to accommodate variations in leachate chemistry and flow rates. Staging involves adding or deleting treatment processes or changing capacity of existing processes as future conditions warrant.

Design criteria

Establish leachate treatment goals and design criteria (e.g., effluent quality, treatment efficiency) consistent with final disposal requirements and raw leachate characteristics.

Recommended design procedures

Design the leachate treatment process based on the results of the site characterization studies, a feasibility study, and the conceptual design report. Re-evaluate the following critical design parameters established during conceptual design:

Design parameter	Evaluation criteria
Leachate characteristics	additional testing may be needed to assess the leachate's variability and treatability
Site geotechnical conditions	additional, localized geotechnical testing may be required to augment site-wide investigations
Leachate flow projections (hydraulic loading)	accuracy
Storage capacity and detention times	accuracy
Treatment efficiency forecasts	accuracy
The adaptability of proposed leachate treatment technologies	ability to accommodate short-term and long-term variations in leachate characteristics and treatment requirements

7.10 Final Cover System

Performance criteria

The final cover system should minimize water infiltration and erosion. Other important design issues include landfill gas containment and control, settlement, erosion, long-term maintenance requirements, and slope stability. Landfills that undergo remedial action to alleviate groundwater contamination, may be required to meet more stringent design criteria for the final cover.

References: 40 CFR 258.60(a) and OAR 340-94-120

Alternative designs

EPA allows approved state permitting programs, like Oregon's, flexibility in interpreting Subtitle D cover design requirements. Accordingly, the Department may consider alternative designs provided that critical performance criteria (e.g., minimal infiltration) are met. In the State's arid regions, for example, a properly designed soil cover may perform as well as a geomembrane.

Design criteria

Design the final cover system to meet the following criteria:

- minimum slopes of 2% and maximum slopes of 30%
- accommodate anticipated settlements
- contain landfill gas and enhance gas collection and recovery efforts
- minimize erosion
- minimize surface water infiltration
- promote efficient surface water drainage and runoff
- maintain stability on side slopes, and
- enhance site aesthetics

Design procedures

Design the final cover system by following the procedure below. Where listed, refer to the pages in Section 7.13 (Appendix of Engineering Analyses and Calculations) for additional details.

Step	Action	Ref. pg.
1	Prepare typical cross-sections of the cover system design for top and side slope	----
2	Use the HELP Model to predict infiltration	7-25
3	Analyze slope stability	7-26, 7-27
4	Analyze potential settlement	7-28

5	Describe each layer of the cover system, including: • foundation layer • low permeability layer • drainage layer • protective layer • topsoil layer • vegetative layer	---

Foundation layer

The foundation layer will serve as a base for either a low-permeability soil layer, or a geomembrane layer. The foundation layer must support and protect the cover during and after the construction phase.

Specify appropriate material properties, thickness, and configuration.

Low Permeability Layer

Design the low permeability layer to minimize moisture infiltration, to enhance landfill gas containment and control, and to accommodate site specific physical and environmental conditions.

Reference: Section 6.2 of this guidance provides detailed information on designing geomembrane and low-permeability soil layers

Drainage layer

Design the drainage layer to minimize infiltration, leachate generation, slope stability problems, erosion, and to enhance access for maintenance equipment.

Design procedures: drainage layer

Design the drainage layer of the final cover system by following the procedures below. Where listed, refer to the pages in Section 7.13 (Appendix of Engineering Analyses and Calculations) for additional details.

Step	Action	Ref. pg.
1	Specify properties, and performance criteria of granular drainage layers, including Unified Soil Classification, grain size distribution, maximum particle size, maximum percent passing No. 200 sieve, thickness and hydraulic conductivity	---
2	Specify properties, and performance criteria of geosynthetic drainage layers, including polymer type and transmissivity	7-25
3	Identify properties of granular filter layers, including Unified Soil Classification, grain size distribution and thickness;	---

4	Specify properties of geosynthetics used for protective or filter layers. Determine allowable properties by analysis	7-28
5	Analyze filter layer performance	7-31
6	Specify configuration, dimensions and properties of the collection pipe system. Analyze structural parameters.	7-31
7	Develop exit drain design details	---
8	Analyze drainage layer performance	7-30

Protective layer

An additional soil layer may be used to protect low-permeability layers from physical or environmental damage.

Design of protective layer

Specify the protective layer's properties and dimensions, including Unified Soil Classification, grain size distribution, thickness, hydraulic conductivity and maximum particle size (if placed directly on a geomembrane layer). Design the protective layer to:

- provide adequate rooting depth and soil moisture storage for selected vegetation
- protect the low-permeability layer against root penetration, freezing, drying and desiccation, and
- protect geosynthetic layers from puncture and other physical damage

Topsoil layer

The primary function of the topsoil layer is to provide an optimal growing medium for desirable vegetation. Topsoil may be amended with woodwaste, sewage sludge, or compost if applied appropriately at agronomic rates. Soil amendments should not cause odors, air-born contaminants or surface water quality problems.

Design criteria: topsoil layer

Specify top soil characteristics based on a thorough analysis of vegetation alternatives and fertilizer requirements, such as:

- thickness
- U.S.D.A. textural classification
- Soil Taxonomy
- pH
- organic content
- salinity
- nutrient content, and
- carbon to nitrogen ratio

If the topsoil layer will function as the protective layer, follow procedures for the design of the protective layer

Note: For additional information on soil properties and enhancement techniques, contact the County Agent of the Oregon State University Extension Service

Vegetative layer

The vegetative layer's main functions are to:

- minimize erosion and long-term maintenance, and
- maximize evapotranspiration

Design criteria: vegetative layer

The vegetative layer should be compatible with other cover-system components and easy to maintain. Plant shallow-rooted, locally adapted perennial plants that:

- resist drought and temperature extremes
- thrive in low nutrient soil with minimum nutrient addition
- establish dense growth to minimize cover soil erosion (limit is no more than 2 tons/acre/year), and
- survive and function with little or no maintenance

Reference: Refer to the Page 7-33 in Section 7.13 (Appendix of Engineering Analyses and Calculations) for additional details.

Alternative to vegetative layer

A vegetative layer may be incompatible with site climatic conditions or end use plan. If an alternative layer is planned, assess soil erosion, long-term maintenance requirements, and compatibility with other cover system components. The specified material should:

- accommodate settlement without compromising function
- maintain positive slopes to promote surface drainage off the cover
- be stable and erosion resistant during extreme precipitation and/or wind, and
- limit soil erosion to no more than 2 tons/acre/year

Reference: Refer to the Page 7-33 in Section 7.13 (Appendix of Engineering Analyses and Calculations) for additional details.

Typical cover system design

A typical final cover system design meets the thickness, slope, and specifications listed in the table below.

Layer	Construction material	Thickness	Slope	Specifications

Layer	Construction material	Thickness	Slope	Specifications
Top layer	vegetation	---	---	persistent, drought resistant, adapted to local conditions, shallow-rooted
	on soil	≥ 12 inches	≥ 2%	erosion rate < 2 tons/acre/year
Drainage layer	Soil (sand and gravel mixes)	≥ 12 inches	≥ 2%	SP (USCS) soil, K > 10^{-2} cm/sec
	geosynthetic	variable	≥ 2%	performance equivalent to soil, hydraulic transmissivity > $3x10^{-5}$ m^2/s
Low-permeability layer	geomembrane (HDPE)	≥ 60 mils	≥ 2%	other types of FMLs should be at least 20 mils in thickness
	on low-permeability soil	≥ 24 inches	≥ 2%	in place K < 10^{-6} cm/sec

7.11 Surface Water Control System

Precipitation data

Select appropriate precipitation data for design analyses.

Reference: Refer to the Page 7-32 in Section 7.13 (Appendix of Engineering Analyses and Calculations) for additional details.

Design criteria

Design the surface water control system to meet the following criteria:

- prevent run-on flow onto active or inactive portions of the landfill (assuming peak discharge from the 25-year storm)
- collect and control run-off from active and inactive portions of the landfill (assuming a 24-hour, 25-year storm)
- comply with the provisions of the storm water discharge (NPDES) permit and the Clean Water Act
- control sediment transport and remove suspended solids as necessary to comply with the NPDES permit conditions
- collect and contain leachate contaminated stormwater that accumulates in active fill areas
- temporarily store excess run-off from peak flows until it can be discharged at a lower, controlled rate
- minimize site erosion
- protect the integrity and effectiveness of the landfill cover system, and
- minimize post-closure maintenance requirements

Design Procedures

Design the surface water control system for both the active landfill operation and post-closure phases by following the procedure below.

Step	Action
1	Define drainage basin boundaries
2	Identify potentially sensitive features, such as wetlands, fish migratory streams
3	Develop site grading plans for active and closed landfill scenarios
4	Develop design storm hydrographs and calculate peak flow volumes and velocities
5	Select and size appropriate control-system components, including ditches, culverts, and detention basins to safely pass peak flows
6	Specify permanent and temporary erosion control measures

Step	Action
7	Specify permanent and temporary siltation control measures, and
8	Perform applicable analyses and calculations Reference: Refer to the Page 7-32 in Section 7.13 (Appendix of Engineering Analyses and Calculations) for additional details.

7.12 Landfill Gas Control System

Designing the system

Design the landfill gas control system to accommodate a wide range of operational and environmental variables, withstand harsh physical/ environmental conditions, and function as long as needed.

Appropriate landfill gas control system technologies are:

- flexible operationally
- easy to construct and modify
- durable (physically and chemically)
- easy to monitor, and
- easy to maintain and repair

Design criteria

Design the landfill gas control system to:

- handle the maximum gas flow rate predicted for the landfill
- accommodate variability in gas generation, composition, and other operational parameters
- expand as needed to collect gas from future cells, and
- meet the applicable criteria in the table below

If designing...	then meet the following criteria:
an active control system	• extraction well boreholes should be at least 24 inches in diameter • construct extraction well casings and collection laterals and headers of PVC, HDPE or stainless steel • provide 100% blower standby (backup) capability • equip flare systems with flame arresters to prevent accidental ignition in the discharge piping system • equip flare units with automatic ignition systems and alarms • at sites with a high risk of off-site gas migration, install alarm systems with auto-dial-phone capabilities to contact response personnel 24-hours-a-day, 7-days-a-week • design perimeter extraction wells should be designed to provide 100-percent overlap of influence between adjacent wells (i.e., radii of influence of adjacent wells should completely overlap)
a passive control system	use only in combination with geomembrane cover and liner systems

Recommended design procedures

Establish the overall design basis by re-evaluating conceptual design criteria, landfill gas test data, and site characterization data. Incorporate the latest available engineering data and gas test data and following the design procedure below.

Step	Action
1	Determine the landfill's gas generation potential. Various modeling techniques may be used to predict approximate peak and total landfill gas production
2	Define the main operating functions of the landfill gas control system (i.e., landfill gas migration control, odor or air-emissions control, energy recovery, or multi-use)
3	Establish performance criteria, construction materials properties, equipment layout, and equipment types and characteristics. Design construction details (e.g., well or collection-trench depths and spacings and perimeter setbacks, header pipe sizes and configuration) to accommodate site-specific conditions
4	Prepare a facilities plan that depicts the following system components: • extraction well and/or collection trench locations and spacings • locations of adjustment valves and sampling ports • configuration of collection header piping • condensate drain locations • layout of mechanical equipment complex (i.e., blowers, flares, electrical panels) • locations of gas monitoring probes
5	Prepare design details that describe proposed materials and equipment for the major control system components (i.e., well casings, collection piping, granular materials, valves, blowers, flares) and typical design details for the following: • extraction wells • valves and sampling ports • condensate drains, sumps, pumps, storage tanks and associated equipment • mechanical equipment complex (blowers, flares, condensers, electrical panels, alarms, etc.), and • well or piping penetrations through the cover or liner systems

7.13 Appendix of Engineering Analyses and Calculations

Design report supporting information

As applicable, describe the assumptions, technical rationale, references, and factors of safety used for each engineering analysis or calculation. Incorporate relevant analyses and calculations into the Design Report.

Soil balance calculations

Calculate quantities of specialized and general-purpose soils:
- to construct and operate each phase of landfill development
- for phased closure and final closure construction
- available at the identified borrow source, and
- to be imported over the life of the site

Water balance analysis (HELP model)

Use the latest version of U.S. EPA's Hydrologic Evaluation of Landfill Performance (HELP) Model to estimate:
- water percolation through each barrier layer
- lateral drainage from each drainage layer, and
- hydraulic head build-up in each drainage layer

Model input should consist of site-specific climatological data, if available, and site-specific geotechnical and design data. Assume landfill operational status ? development plan and engineering design plans. Provide all input assumptions and the complete model output in the Design Report.

Use of geosynthetics

Geosynthetics such as geomembranes, geotextiles, geonets, geogrids and geocomposites have many possible applications in landfill design and construction. Non-structural materials such as geomembranes and geonets should not be subjected to significant physical stresses. Other liner or cover components must be designed to protect non-structural materials from physical stresses.

Note: For methods to evaluate interface friction and shear stresses of layered geosynthetic components see Stability Analyses on page 7-26.

Selecting a geosynthetic

Select geosynthetics by matching intended functions with compatible physical properties. Manufacturers' specifications are usually derived from laboratory tests which do not account or field conditions. Adjust for differences between laboratory and in-situ conditions by either:

- customizing laboratory and field tests to model field conditions, or
- using partial factors of safety to account for differences between laboratory tests and field conditions

Perform a "design by function" analysis to select the appropriate geosynthetic material, or establish material properties by following the procedure below.

Step	Action
1	Evaluate the geosynthetic layer and the materials above and below
2	Specify a design factor of safety that reflects the potential consequences of the geosynthetic's failure
3	Describe the geosynthetic's primary function(s) and other critical functions
4	Calculate the numerical value for each geosynthetic property in question (as appropriate for the geosynthetic's intended function)
5	Specify testing requirements for selecting a geosynthetic product
6	Determine the partial factors of safety needed to compensate for differences between laboratory testing and the field conditions
7	Specify the minimum allowable properties for a product in a particular application

Reference: The suggested "design by function" approach to designing with geosynthetics is summarized in pages 61-62 of R. M. Koerner's Designing With Geosynthetics, 2nd Edition, Prentice-Hall Publ. Co., Englewood Cliffs, NJ, 1990, 652 pgs

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Stability analyses: parameters

Analyze the stability of all waste containment structures. Consider facilities design, construction and operation, and site characteristics (e.g., naturally unstable or seismically affected areas). Seismic impact zones, as defined in 40 CFR 258.14, exist at most locations in Oregon. Use appropriate testing and analysis to determine the following parameters:

- strength of soils and solid waste materials
- effective angles of internal friction for soils and solid waste
- friction angles of adjoining layer interfaces
- density of soils and solid waste, and
- pore water pressure in soils

Stability analyses: scenarios

Analyze the following scenarios using appropriate factors of safety:

- Potential rotational failure of the soil mass beneath the liner system
- Potential rotational failure of any containment dike, or other engineered structures
- Potential sliding failure of the liner system along the plane of the side slope
- The general slope stability and liner system stability along the plane of the liner system (assume active landfill operations and worst-case site development conditions
- Potential sliding failure or the cover system side slopes, assuming maximum pore water pressure in the drainage layer or cover soils over a geomembrane

Factors of safety

Suggested factor of safety (FS) values are shown in the table below. Actual values reflect engineering analyses site geotechnical and environmental characteristics, construction materials, operational procedures and risk factors.

Consequences of Slope Failure	**Uncertainty of Strength Measurements**	
	Small[1]	Large[2]
No imminent danger to human life or major environmental impact if slope fails:	1.25 (1.2)[*]	1.5 (1.3)
Imminent danger to human life or major environmental impact if slope fails:	1.5 (1.3)	2.0 or greater (1.7 or greater)

[1] Strength measurements are most reliable when the soil conditions are uniform and high quality test data are available

[2] Strength measurements are most uncertain when the soil conditions are complex and test data are inconsistent and incomplete

[*] Numbers without parentheses apply for static conditions and those within parentheses apply to seismic conditions.

Modified from: U.S. EPA, (1993), "Technical Manual for Solid Waste Disposal Facility Criteria - 40 CFR Part 258," November 1993.

Settlement

Settlement may involve a landfill cell, geologic units beneath the cell, or both. The amount of settlement depends on the characteristics of the solid waste and the underlying geological units.

Settlement analysis

Calculate for each landfill cell:

- the total consolidation of underlying geological units
- the total waste settlement
- differential settlement beneath the flattest sections of the liner system and maximum differential settlement beneath the liner footprint
- maximum differential settlement of the cover system
- slope allowance required to compensate for differential settlement of leachate drainage layers and collection pipes, and
- final cover slope allowances required to compensate for estimated differential settlement

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Settlement tolerances

Post-settlement slopes for leachate collection systems and cover systems should meet original design criteria

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Geotextile filter analysis

A geotextile filter should provide adequate cross-plane permeability and soil retention. Therefore, the geotextile's void spaces need to be compatible with adjoining materials. Analyze geotextile filters following the table below.

Step	Action
1	Specify a design factor of safety and calculate: • the required flow rate through the geotextile filter, and • the apparent opening size of the geotextile from the soil gradation
2	Specify appropriate geotextile testing (e.g., apparent opening size, permittivity)
3	Determine allowable flow rate. Use partial factors of safety to account for soil clogging, creep reduction of void spaces, and biological clogging
4	Consider other critical properties including: • chemical compatibility with landfill contaminants • survivability (during packaging, transportation, handling, and installation), and • ultraviolet-light resistance

Step	Action
5	Specify a particular geotextile product, or specify the required properties (e.g., apparent opening size and permittivity)

Geomembrane liner system

The geomembrane must have appropriate physical properties to withstand physical and environmental stresses during construction and long-term use. Analyze the critical design parameters following the procedure below

Step	Action
1	Calculate and specify a design factor of safety for construction and operation related stresses (i.e., tensile, shear, impact, and puncture stresses). Stress sources include anchorage, geomembrane weight, waste-weight, foundation subsidence, waste settlement, construction equipment operation, and contact subgrade and backfill materials (e.g., drainage layers)
2	Specify geomembrane testing procedures for critical properties (e.g., tensile strength, seam strength, tear resistance, puncture resistance, impact resistance, geomembrane friction, etc.). Use partial factors of safety to account for discrepancies between laboratory tests and field conditions
3	Consider other critical properties including: • chemical compatibility with leachate and gas • survivability during packaging, transportation, handling, and installation • ultraviolet light resistance, and • coefficient of thermal expansion (required slack in the geomembrane and acceptable temperature ranges for installation)
4	Specify a particular geomembrane product, or the minimum allowable geomembrane properties

Primary LCRS performance evaluation

Design the primary leachate collection and removal system (LCRS) using redundant features and conservative factors of safety to enhance its reliability. Evaluate critical design parameters using the following assumptions and analysis:

- Precipitation impinging directly on the drainage layer; the drainage layer is saturated; precipitation equals the wettest month's average rainfall. Calculate the hydraulic head for these conditions. The hydraulic head should not exceed 12 inches [30-cm] or the thickness of the drainage layer at any point in the LCRS, and
- All leachate collection pipes fail with the final cover is in place; surface water infiltration enters the drainage layer at a rate equal to the HELP Model estimate; the drainage layer is saturated; precipitation equals the wettest monthly total. Calculate hydraulic head for these conditions. The hydraulic head should not exceed 12 inches [30-cm] or the thickness of the drainage layer at any point in the LCRS.

Secondary LCRS performance evaluation

Evaluate the performance of the proposed secondary LCRS design by calculating the following:

- Leakage detection sensitivity: ". . . the smallest primary liner leakage rate which can be detected."
- Leakage collection efficiency: the ratio of the leakage collected at the secondary LCRS sump divided by the leakage entering the secondary LCRS and
- Leak detection time: the time required for leachate to travel from the point of entering the secondary LCRS to a collection sump

References: Background Document: Bottom Liner Performance in Double-Lined Landfills and Surface Impoundments, EPA/530-SW-87-013, U.S.EPA, 1987, 301 pgs.
Background Document: Proposed Liner and Leak Detection Rule, EPA 530-SW-87-015, U.S.EPA, 1987, 526 pgs.

Cover system drainage layer performance

Evaluate drainage layer performance and reliability by using the HELP Model or other appropriate method(s) to calculate the maximum hydraulic head buildup within this layer.

LCRS filtration analysis

Demonstrate that the conveyance systems for the primary, and secondary LCRSs and the final cover drainage system are designed to prevent clogging. Use analysis and calculations to show that:

- geotextile filter layers will adequately retain solids and pass liquids (see page 7-28), and
- granular filter layers will adequately retain solids and pass liquids (use analytical methods on pages 19 - 20 of Technical Guidance Document: Final Covers on Hazardous Waste Landfills and Surface Impoundments, U.S. EPA, EPA/530-SW-89-047, July 1989, and page 7-68 of Lining of Waste Containment and Other Impoundment Facilities, U.S. EPA, EPA/600/2-88/052, September 1989, or other appropriate techniques.

Structural stability of leachate pipes

Generate structural calculations to show that leachate collection pipes will withstand:

- static and dynamic loading from construction equipment;
- maximum potential loading from vehicular traffic;
- maximum static loading from the completed landfill; and
- stresses from long-term differential consolidation of the landfill foundation.

Manhole foundation bearing capacity

Calculate the bearing capacity of manhole foundations. Demonstrate that the bearing capacity will support anticipated loads without damaging the liner system. Consider differential-settlement induced down-drag forces that may occur where compressible waste and rigid manholes meet.

Leachate storage capacity

Calculate the storage capacity of the leachate impoundment, accounting for all in puts and outputs. Demonstrate that leachate storage impoundments or holding tanks will provide:

- adequate storage capacity for the maximum leachate flows; assume the leachate collection system maintains less than 12 inches [30-cm] of leachate depth
- adequate storage capacity to manage leachate as planned and to satisfy any seasonal limitations, and
- sufficient freeboard to contain leachate and prevent overflows, assuming a 24-hour, 25-year storm

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Leachate treatment and disposal

Calculate the efficiency of the proposed treatment system considering the following factors:

- design criteria, including regulatory requirements;
- availability of representative leachate for testing;
- untreated (influent) leachate characteristics, (i.e., quantity and quality);
- temporal and spatial variability of leachate characteristics;
- method(s) of leachate disposal;
- periodic design modifications (certain treatment processes may be phased in to accommodate variable leachate quality and hydraulic loading);
- proposed unit treatment processes and associated technologies;
- potential temperature variations in leachate and ambient air;
- nutrient addition requirements (e.g., phosphorous and/or nitrogen addition may be required to enhance biological treatment.

Surface water control

Evaluate the effectiveness of the surface water control system for conditions throughout the landfill's development and operation. Use a 24-hour, 25-year or more severe storm if extreme impacts could result from control system failure.

Obtain storm recurrence information from the Weather Bureau's Technical Paper 40, Rainfall Frequency Atlas of the United States for Durations for 30 Minutes to 100 Years. Alternatively, analyze local meteorological data to estimate storm intensity. Use the Rational Method, the Soil Conservation Service (SCS) method (i.e., Urban Hydrology for Small Watersheds, SCS Technical Release #55, June 1986 (TR-55)) or other recognized methods to estimate design-storm-related peak flows.

Demonstrate by analysis, that:

- Diversion and conveyance structures (e.g., berms and channels) are designed to divert all stormwater run-on away from the landfill footprint (assume peak discharge from the 25-year storm). Use standard analytical methods recommended by the US Dept. of Transportation (Federal Highway Administration), the US Army Corps of Engineers, the US Dept. of Agriculture (Soil Conservation Services) or other appropriate engineering methods.
- Sedimentation and detention facilities will retain peak runoff flows from the 25-year storm , trap sediment effectively, and comply with the facility's NPDES permit. Use the SCS methods (TR-55) to develop inflow hydrographs for sedimentation/detention structures.
- Active landfill cells have adequate capacity to contain stormwater and leachate during a 24-hour, 25-year storm.

Post-closure surface water control

Analyze requirements for post-closure surface water runoff control. Assuming 24-hour, 25-year storm conditions, demonstrate that:

- culvert and drainage channel cross-sections and slopes will pass design-storm-generated flow volumes
- surface water control facilities will minimize runoff velocities and related energy, and erosion of the landfill cover and drainage channels
- all drainage channels will convey flow at or below the maximum permissible (mean) velocities. Select the proper channel section for the appropriate hydraulic condition, and
- site maintenance will be minimized.

Note: Use standard engineering methods and procedures such as described in the Engineering Field Manual for Conservation Practice, U.S. Soil Conservation Service, 1984; SCS Engineering Handbook #5; Open Channel Hydraulics, V. T. Chow, 1959; Handbook of Hydraulics, 3d. edition, King, 1939; or other published references and specifications.

Cover soil erosion

Use the U.S.D.A. Universal Soil Loss Equation to estimate the erosion loss from the proposed final cover system. U.S. EPA guidance recommends a maximum soil loss of < 2 tons/acre/day. Values for the Universal Soil Loss Equation parameters can be obtained from the U.S. Soil Conservation Service's (SCS) Technical Guidance Document available at local SCS offices.

Landfill gas control system

Calculate or estimate the following design parameters:

- landfill gas production (peak and total production over the life of the landfill)
- gas well spacings and depths
- individual extraction-well flow rates
- system-wide collection efficiency
- maximum allowable headloss criterion
- minimum allowable vacuum pressure at the remotest extraction well.
- headloss from wells to the blower
- total accumulative flow rate within the collection pipes and headers
- required sizes for collection pipes and vacuum-motor-blowers, and flare units (if applicable)
- requirements for blower backup capabilities, and phased expansion of the mechanical equipment complex (i.e., blowers, flares, etc.) disposal or recovery systems and the collection system.

7.14 Additional Resources

Landfill technologies, design, and construction practices	Draft Technical Manual for Solid Waste Disposal Facility Criteria - 40 CFR Part 258, U.S.EPA, April 1992. Seminars - Requirements for Hazardous Waste Landfill Design, Construction and Closure, CERI-88-33; U.S.EPA; Center for Environmental Research Information, Cincinnati, OH 45268, 1988. Lining of Waste Containment and Other Impoundment Facilities, EPA/600/2-88/052, U.S.EPA, Risk Reduction Engineering Laboratory, Cincinnati, OH 45268, September 1988. Design, Construction, and Evaluation of Clay Liners for Waste Management Facilities, EPA/530/SW-86/007F, U.S.EPA, Office of Solid Waste and Emergency Response, Washington, DC 20460, November 1988.
Designing with geosynthetics	Koerner, Robert M., Designing With Geosynthetics, 2nd Edition, Prentice-Hall Publ. Co., Englewood Cliffs, NJ, 1990, 652 pgs.
Landfill cover systems	Seminars-Design and Construction of RCRA/CERCLA Final Covers, CERI 90-50, U.S.EPA, Office of Research and Development, Washington, DC 20460, 1990. Technical Guidance Document: Final Covers on Hazardous Waste Landfills and Surface Impoundments, EPA/530-SW-89-047, U.S.EPA, Office of Solid Waste and Emergency Response, Washington, DC 20460, July 1989. Proceedings of the 4th GRI Seminar on the topic of Landfill Closures: Geosynthetics, Interface Friction and New Developments, Geosynthetic Research Institute, Philadelphia, PA 19104, December 1990, 260 pgs.

Leachate treatment

Thornton, Richard J., and Blanc, Fredrick C., Leachate Treatment by Coagulation and Precipitation, proceedings of the American Society of Civil Engineers, Vol. 99, No. EE4, August 1973.

Chian, E. S. K., and De Walle, F. B., 1976, Sanitary Landfill Leachates and their Treatment, ASCE Environmental Engineering Division, No. EE2.

Chian, E. S. K., and De Walle, F. B., 1977, Evaluation of Leachate Treatment, Vols. I and II, Washington, DC: U.S. EPA, EPA-600/2-77-186.

Boyle, W. C., and Ham, R. K., 1974, Treatability of Leachate from Sanitary Landfills, Journal of Water Poll. Control Federation, Vol. 46, No. 5.

De Walle, F. B., and Chian E. S. K., 1977, Leachate Treatment by Biological and Physical-Chemical Methods, Proceedings of the Third Annual Solid Waste Research Symposium, U.S. EPA, March 14-16, 1977.

Robinson, H. D., and Maris, P. J., 1985, The Treatment of Leachates from Domestic Waste in Landfill Sites, Journal of Water Poll. Control Federation, January 1985, pp. 30-38.

Nelson, P. O., and Storhaug, R., 1985, Treatment of Leachate in Aerated Lagoons, Lab-Scale Study, Oslo, Norway, Norwegian Institute for Water Research, Report No. 0-84022.

Landfill gas control

EMCON Associates, 1980, Methane Generation and Recovery from Landfills, Ann Arbor Science, Ann Arbor, Michigan, p. 139.

Ham, R. K., et al., 1979, Recovery, Processing, and Utilization of Gas from Sanitary Landfills, Cincinnati, OH: U.S. EPA 600/2-79-001.

Section 8: Facility Construction Program

8.1 Introduction

Objective

The objective of the construction program is to translate the Department-approved engineering design into a completed facility that meets or exceeds the design plan specifications and performance objectives.

Elements

The facility construction program should include the following elements:

- an organized, qualified construction project team
- Department-approved design drawings and specifications for each phase of landfill development
- a Construction Quality Control (CQC) program
- a Construction Quality Assurance (CQA) program, and
- Construction Certification Reports based on an evaluation of CQC and CQA documentation which certify that construction was completed in accordance with Department-approved plans and specifications

How to respond

Submit the information below to the Department for each phase of landfill development (i.e., construction of new cells, cell closure, or environmental control facilities).

Document	When to submit
CQA plan	prior to initiating construction
soil liner test pad evaluation report	prior to beginning construction of the soil liner
construction certification report	after completing each phase of construction

Reference: OAR 340-93-140 and OAR 340-93-150 provide information on construction documents

In this section

This section describes the major construction project elements, including:

- construction project team
- construction guidelines
  - soil test pad
  - soil liner
  - excavation and subgrade preparation
  - geosynthetic liners
  - leachate and gas collection systems
- quality control program
- quality assurance plan
- construction certification reports

Differences in materials

The physical properties of natural earth materials are generally more variable than the properties of manufactured materials (e.g., geomembranes) which are produced under factory controlled conditions. Accordingly, these guidelines concentrate more on methods for earth-materials construction.

8.2 Construction Project Team

Project team organization

Organize the project team in terms of "Owner", "Designer", and "Constructor" or other equivalent divisions of responsibility. Regardless of the contractual arrangement used, the Owner, Designer, and Constructor functions are discrete, independent responsibilities.

Establishing the team

Establish and document the construction project team organization, including:

- a list of key project team members and their roles and responsibilities
- the minimum required experience for each project team member
- key project team members, their qualifications, and phone numbers and addresses
- an organizational flow chart identifying members of the project team, lines of authority, and lines of communication between the various team members

Team roles

The table below shows a typical construction project team.

Team Member	Role
Project Manager	Individual who represents the owner and is responsible for the overall coordination and management of the project activities
Owner	Party who initiates the project and is responsible for establishing and directing the project to completion
Owner's Team	Persons who advise and assist the owner in specialized areas and, if applicable, person(s) to whom the owner delegates authority to act on the owner's behalf
Construction Quality Assurance (CQA) Consultant	Party(s), who is part of the Owner's Team, and independent from the Project Manager, Constructor and Manufacturer. The CQA Consultant is responsible for observing, conducting and documenting activities related to the quality assurance of materials and construction on behalf of the Owner
Designer	Party whose primary role is to conceive, plan and provide quality design solutions in response to the owner's stated requirements
Design Team	Experienced staff and subcontractors who are responsible for various aspects of the design

Team Member	Role
Constructor	May be a contractor. Party responsible for planning, managing, and accomplishing the construction activities
Construction Team	Construction staff, material and equipment suppliers, specialty sub-contractors assembled by the Constructor

Note: For smaller projects, multiple functions can be accomplished by a single individual

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Basis for organization

"Successful construction projects are conceived, planned, designed, and built by a project team consisting of an owner, design professional, and constructor. Quality is achieved when each team member's obligations are fulfilled competently and in a timely fashion, in cooperation with the other members." (ASCE Manual No. 73.)

8.3 Construction Guidelines - Soil Test Pad

Purpose of soil test pad

The purpose of a test pad(s) is to model the construction of the full-scale liner to verify that proposed construction materials and methods will produce the desired compaction and in-situ hydraulic conductivity. The assessment will enable the Project Team to establish final requirements for soil processing, placement and compaction.

Requiring a test pad

The design specifications should require the Constructor to complete a successful test pad evaluation before constructing the full-scale soil liner. An additional test pad should be prepared and evaluated for each significant change in construction materials, equipment, or methodology.

Construction procedures

Construct soil test pads according to the table below.

Step	Action
1	Use the same soil material, CQC program, and construction equipment and methods that will be used for the full-scale liner
2	Classify representative soil samples according to the Unified Soil Classification System (ASTM D2487)
3	Evaluate soil samples to define an acceptable range of water content and dry unit weight. Use careful judgment in interpreting laboratory hydraulic conductivity values, (i.e., there may be up to 1 order-of-magnitude difference between laboratory and field values) Reference: Daniel, D. E., and Benson, C. H. (1990), "Water Content - Density Criteria for Compacted Soil Liners," *Journal of Geotechnical Engineering*, Vol. 116, No. 12, pp. 1811 -1830.
4	Construct the test pad at least four times the width of the widest piece of equipment to be used
5	Construct the test pad long enough to allow the compaction equipment to attain normal operating speed before reaching the test area
6	Construct at least four compacted lifts

Achieving low hydraulic conductivity

The most important factors in achieving hydraulic conductivity criteria are:

- using suitable soil materials
- using appropriate construction equipment
- placing the soil at the correct water content
- properly preparing the surface between lifts
- achieving density specifications by using appropriate compaction equipment and procedures, and
- protecting completed lifts from damage

Duties of CQA consultant

Suggested duties of the Construction Quality Assurance (CQA) consultant include:

- Observe, approve and document the suitability of the prepared subgrade
- Observe, approve and document soil material selected for construction
- Observe and record during soil placement and compaction:
  - weather conditions
  - the construction equipment and methods used (e.g., equipment type and specifications, lift thickness before and after compaction, number of compactor passes, compactor speed), and
  - the CQC program
- Test the physical properties that will be used to evaluate construction of the full-scale soil barrier, including at least four water content (ASTM D2216) and four density (ASTM D1556) tests per compacted lift
- Collect at least four undisturbed samples from each compacted lift immediately adjacent to where physical properties are tested, and from those samples obtain at least four undisturbed test specimens from varying depths in the compacted lift. Test the specimens in the laboratory for hydraulic conductivity (ASTM D5084) to determine any correlation between laboratory hydraulic conductivity, tested physical properties, and in-situ hydraulic conductivity
- Repair or observe the repair of all holes left by density testing and soil sample collection
- Conduct field tests to determine in-situ hydraulic conductivity. The Department recommends at least one sealed double ring infiltrometer test (ASTM D5093 or equivalent method)
- Dig at least four (4) test pits in the test area, inspect for evidence of voids, large pores between remnant clods, signs of poor bonding between lifts, and other visible problems, and
- Prepare a report documenting the test pad(s) evaluation

Test pad evaluation report

The CQA consultant should prepare and submit to the Department a soil liner test pad evaluation report that includes:

- a summary of test data
- data analysis
- conclusions and recommendations regarding test pad performance and full-scale soil barrier construction.
- a detailed description of the construction materials, equipment and methods to be employed for full-scale liner construction

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Report review procedures

The Project Manager and Designer should evaluate the CQA Consultant's report and the test pad's conformance to the design specifications.

If the test pad's performance	then
conforms to design specifications	construct the full-scale soil liner using the same construction methods, equipment, and materials
fails design specifications	require the Constructor to construct and evaluate another test barrier using modified construction material, equipment, and methods

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Alternative to test pad assessment

The project schedule may not allow time to complete the test pad evaluation before the soil liner is constructed. If this situation arises, demonstrate to the Department that a full evaluation of the test pad is not needed to verify that the liner will meet the specifications.

Demonstration content

The demonstration should:

- show, with laboratory testing, that the proposed soil-liner material easily meets the specified hydraulic conductivity
- permit Department representatives to observe construction of the test pad and excavation of test pits
- show that the lifts are adequately bonded together and that soil clods are adequately remolded (few inter-clod voids or macro-pores should be visible)
- use the same materials, methods, and equipment to construct the soil liner, and
- recognize that completed liner segments may need re-construction or modifications if the soil test pad fails to meet the design specifications

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8.4 Construction Guidelines -- Soil Liner

Test pad results

The Project Manager and Designer should use the test pad modeling results to establish final requirements for liner construction and performance (specified compaction and hydraulic conductivity criteria).

Factors in establishing final construction requirements

In establishing final construction requirements, the Project Manager and Designer should carefully consider the following construction variables:

- properties of the low-permeability soils to be used for liner construction
- method of excavating and processing the soil prior to placement
- pre-compaction thickness and conditioning methods (e.g., disking, pulverizing, moisture adjustment)
- compaction equipment type, weight and length of feet (for footed rollers)
- compactor operations (number of compactor passes and maximum compactor speed)
- protection of compacted lifts that may be exposed to the elements
- scarification and moisture control between lifts
- mixing of bentonite and other soil additives

Key construction elements

Establish a construction program that has the following elements:

- systematic construction quality control (CQC) such that the resulting liner meets or exceeds the test pad's performance
- a CQA Consultant to monitor the construction and ensure that completed soil liners meet or exceed specifications, and
- provisions to protect completed soil liners from the effects of weather and other construction activities

Modifications to construction specifications

As the Constructor and CQA Consultant gain construction experience and "get a feel" for the soils, it may become desirable to modify certain construction criteria. Such adjustments should be made as described in the table below.

If the modification is	then	Examples
"functionally inferior"	obtain Department authorization prior to implementation	modifications including less compactive effort, reduced quality control, and increased lift thicknesses that potentially result in diminished hydraulic and strength properties
"functionally superior"	continue with construction	modifications, such as increased compactive effort, increased quality control, thinner lift thicknesses, that potentially reduce the hydraulic conductivity and enhance strength properties

8.5 Construction Guidelines -- Excavation and Subgrade Preparation

Excavation, stockpiling, and processing

Perform earthwork activities in accordance with the table below.

Step	Action
1	Segregate excavated soils according to their properties
2	Process excavated soils as necessary to meet required material specifications (e.g., pulverizing the soil to break down clods or screening the soil to remove large particles)
3	Place excavated/processed soils into compatible stockpiles of uniform material
4	Provide erosion control measures for excavation and stockpiling activities
5	Adjust the moisture content as necessary before using excavated or stockpiled soils (i.e., water needs to penetrate clods so they can be remolded)

Subgrade preparation

Construction procedures for liner or cover system subgrades should address the following factors:

- control of differential settlement
- removal of soft spots
- quality control testing (density, moisture content, soil classification, soil gradation)

8.6 Construction Guidelines -- Geosynthetic Materials

Typical geosynthetic materials

Landfill construction typically involves many applications for geosynthetic materials, including:
- geomembranes in liners and covers
- geotextiles as filters, cushions, and soil separators
- geogrids for slope and foundation support, and
- drain-nets for drainage

Installation specifications

Install geosynthetic materials in conformance with the specifications for:
- function and desired properties
- minimum testing and acceptance
- testing and acceptance procedures
- damage prevention, and
- installation procedures

Testing and acceptance procedures

Establish conformance testing and acceptance requirements that include the following procedures:
- The Constructor or Manufacturer should provide the Project Manager the Manufacturer's quality control certification (i.e., verification that the geosynthetic material meets project specifications)
- The Constructor or Manufacturer of a geomembrane should provide quality control certificates issued by the resin supplier, quality control certificates for each roll produced and certification that the supplied geomembrane and extrudate have the same material properties, and
- The Constructor or CQA Consultant should conduct sampling and conformance testing in accordance with ASTM D4759 "Standard Practice for Determining the Specification Conformance of Geosynthetics" to verify the manufacturer's certification

Damage prevention

Prevent damage to the geosynthetic material by using appropriate techniques for delivery packaging, labeling, transportation, handling and storage.

Installation procedure

Install the geosynthetic material as the specifications prescribe for:

- site preparation prior to placement of geosynthetic
- geosynthetics handling, placing, anchoring, seam overlaps, and post-installation inspection
- geomembrane seam welding (including preparation of geomembrane sheets and seaming equipment), weather and temperature constraints for seaming
- geomembrane wrinkles, folds, and bridging
- seam quality control testing and inspection
- repairing inadequate seams and damaged geomembranes, and
- covering or otherwise protecting geomembranes after installation to prevent damage

8.7 Construction Guidelines -- Leachate and Gas Systems

Leachate system construction

Construct the primary and secondary leachate collection and removal system(s) (LCRSs) according to specified requirements for:

- the performance objectives for each system component (i.e., for granular drainage material the hydraulic conductivity to be achieved)
- desired material properties (e.g., hydraulic conductivity, grain size distribution, non-carbonate rock for granular drainage material or inside diameter for LCRS piping)
- the required thickness for granular drainage and filter layers, and
- constructor requirements for LCRS work execution including:
  - slopes allowances to compensate for projected differential settlement
  - protection of liners during placement of overlying granular drainage materials
  - pre-operational cleaning and maintenance of the LCRS, and
  - demonstrating LCRS pipe continuity (e.g., pull a ball or other uniform object through the pipes)

Gas system construction

Construct the landfill gas control system according to the specified requirements for:

- construction staging and coordination with landfill operation and development
- connection of system components to and penetrations through geomembrane covers and other geosynthetics
- safety precautions for the Constructor's field crews and others who may be exposed (directly or indirectly) to landfill gas
- gas production and control system performance, and
- operational objectives

8.8 Quality Control Program

CQC defined

Construction quality control (CQC) refers to those actions taken by Manufacturers, Fabricators, or the Constructor to confirm that products and work quality meet the requirements of the contract. CQC includes inspections and testing of all furnished, constructed, and installed components. These activities are independent of construction quality assurance (CQA) activities.

CQC program

Establish detailed construction quality control (CQC) requirements for materials and workmanship, to show the Constructor how to furnish products and execute work. CQC should include systematic inspections and measures to control the quality of construction and to ensure conformance with the project specifications and contract requirements.

8.9 Quality Assurance Plan

CQA plan

Prepare a detailed construction quality assurance (CQA) plan that verifies and documents proper construction of facility components. The CQA plan should describe the proposed measures for monitoring the quality of materials and work performance. CQA plan elements pertaining to foundations, subgrades, embankments, soil barriers, geosynthetics, LCRSs, and landfill gas control systems should be developed and administered by a Professional Engineer with current Oregon registration and experience in the technical area.

CQA defined

CQA is an overview and inspection program consisting of systematic observations and tests to ensure that the final product meets design specifications. CQA plans, design plans and specifications, observations, and tests are used to provide quantitative criteria for evaluating final product acceptability.

Plan contents

The CQA plan should include site-specific information on the following topics:

- staff roles, responsibility, authority and communication
- qualifications of CQA consultant
- qualifications of construction team
- inspection activities
- geosynthetic construction
- earthwork construction
- documentation

Roles and responsibilities

The CQA plan should describe the role, responsibility, and authority of each party involved in executing the CQA plan. The plan should include an organizational flow diagram outlining the management structure, lines of communication, chain-of-command, and implementation procedures.

Qualifications of CQA consultant

The CQA plan should describe the technical expertise of the CQA consultant. The CQA consultant should represent the Owner's interests as an independent, qualified party and is responsible for observing, evaluating, and documenting quality of materials and construction.

Qualifications of construction team

The CQA plan should establish minimum qualifications for earthwork contractors, geosynthetic installers and geosynthetic material manufacturers.

Inspection activities

The CQA plan should outline the observations and tests that will be used to evaluate conformance with all design criteria, plans, and specifications for each project component.

Geosynthetic construction

The CQA plan should describe the responsibilities of the CQA consultant. Suggested duties include:

- monitoring geosynthetic material delivery, unloading and on-site storage and transport
- selecting geosynthetic material (destructive samples) for conformance testing
- determining the acceptability of geosynthetics according to ASTM D4759 "Standard Practice for Determining the Specification Conformance of Geosynthetics"
- monitoring the deployment of geosynthetics
- monitoring geosynthetic seaming operations
- monitoring and documenting CQC testing procedures (i.e., non-destructive seam testing, field tensiometer testing)
- monitoring and documenting geomembrane CQA testing (i.e., destructive seam sampling and testing, repair operations, sample labeling)
- documenting any on-site activities that could result in damage to the geosynthetics
- maintaining appropriate lines of communication with other project team members as specified in the CQA plan

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Earthwork construction

The CQA plan should describe procedures associated with earthwork, including:

- grading
- foundations
- embankments
- soil liners and covers
- granular drainage and filter layers
- excavations and backfill
- top soil (vegetative) layers
- road building, and
- soil processing (e.g., mixing with bentonite)

CQA of earthwork

CQA activities should include:
- earthwork monitoring
- earthwork sampling and testing
- evaluating prospective liner materials, and
- evaluating constructed soil liners

Earthwork monitoring

The CQA consultant should oversee all key phases of earthwork to monitor and document that materials and procedures meet the design specifications. The CQA consultant's oversight should include:
- borrow soils properties and performance
- test pad construction and performance
- borrow soils stockpiling methods
- raw material processing
- foundation and sub-grade preparation
- soil layer thickness and protection of underlying layers
- repair of any holes (e.g., from grade stakes) or other construction-related damage
- soil-liner construction (soil density, moisture content, permeability, equivalency to test pad construction)
- identification and repair of penetrations of the soil liner (e.g., penetrations resulting from CQC/CQA testing)
- protection of completed soil liner sections
- all other earthwork components (i.e., granular drainage or gas venting layers, operations layer, protective layers and topsoil layer)
- identification and modification of activities that could damage liners or drainage layers

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Earthwork sampling and testing

The CQA plan should describe sampling parameters and procedures for each discrete earthwork activity including testing frequency, rationale for selecting test locations, and acceptance and rejection criteria.

The QA Consultant should observe all aspects of earthwork, and personally perform the soil sampling and testing to develop a "feel" for the material. This hands-on involvement may improve the QA Consultant's observational skills and judgment, ultimately translating into better quality assurance.

Evaluating prospective liner materials

The CQA plan should specify parameters and testing frequencies for evaluating soils intended for liner construction. Test samples obtained from the borrow area, processing area, stockpile area or final placement area, provided:
- the samples meet low-permeability specifications, and
- the soil is suitable for or can be conditioned for compaction

Liner soil testing

The table below lists recommended parameters and testing frequencies for evaluating prospective soil liner material.

Parameter being tested	Test method reference	Testing frequency	Recommended performance
Percent fines (passing a No. 200 sieve)	ASTM D1140	1 per 1000 cy and 1 test each day soil is excavated or placed	≥ 50%
Percent gravel (dry-weight retained on the No. 4 sieve)	ASTM D422	1 per 1000 cy and 1 test each day soil is excavated or placed	≤ 10%
Atterberg limits	ASTM D4318	1 per 1000 cy and 1 test each day soil is excavated or placed	Plasticity Index ≥ 10%
Water content	ASTM D3017 ASTM D4643 ASTM D2216 (at least every 5th sample)	1 per 1000 cy and 1 test each day soil is excavated or placed	-----
Moisture/Density/ Permeability relationships	ASTM D698 ASTM D1557 ASTM D5084	1 per material type	

Note: Other equivalent tests may be used

Reference: Use relationships to define an acceptable range of Water Content and Dry Density Unit Weight, in accordance with procedures described by Daniel, and Benson, C. H. (1990), "Water Content - Density Criteria for Compacted Soil Liners," Journal of Geotechnical Engineering, Vol. 116, No. 12, pp. 1811 - 1830.

Evaluating the constructed soil liner

The CQA plan should specify parameters and testing frequencies for evaluating compacted soil liners. The plan should allow testing frequencies to be increased at the discretion of the CQA consultant.

Recommended parameters and frequencies

The table below lists recommended parameters and testing frequencies for evaluating constructed soil liners.

Parameter being tested	Test method reference	Testing frequency	Recommended performance

Water content	ASTM D3017 ASTM D4643 ASTM D2216(at least every 5th sample)	5/acre/compacted lift	
Density	ASTM D2922 ASTM D1556(at least every tenth sample)	5/acre/compacted lift	Nuclear density test should measure soil density near the bottom of each compacted lift; calibrate nuclear gauges to a known density each day of use
Thickness	Elevation monitoring	50 feet center to center or minimum 6 points per grade at top of first compacted lift and top of completed soil liner	

Note: Other equivalent tests may be used

Documentation

The CQA plan should specify detailed reporting requirements for the CQA activities, including:

- daily record keeping (observation and test data sheets)
- problem reporting and corrective measures data sheets
- project Manager and Designer acceptance reports (for errors, inconsistencies, and other problems)
- final documentation including as-built drawings, and
- the signature or initials of the person maintaining the records and generating the reports

8.10 Construction Certification Reports

Submittal

Construction Certification Reports must be submitted to the Department each time a landfill development phase is completed and/or before a newly constructed waste management unit (a landfill cell or leachate impoundment) is activated. The report should document and certify that all required components and structures have been constructed in compliance with the permit requirements and approved design specifications.

Reference: OAR 340-93-150

Report content

Construction certification reports should include the following elements:

- an executive summary describing how well the project went and major problems encountered
- a summary of all construction and CQA activities
- a summary of all CQA observations, daily inspection/photo/video logs, and test data sheets
- problem identification/corrective measures
- designer's acceptance reports for errors and inconsistencies
- deviations from design and material specifications, including justifying documentation, and copies of change orders and recorded field adjustments
- certificates of acceptance (e.g., acceptance of subgrade for geomembrane liner installation)
- as-built drawings and photographs, including record surveys of soil liner and granular drainage layer thicknesses
- a certification statement(s) and signatures legally representing the CQA Consultant, Designer and Owner, one of the which is that of a professional engineer registered in Oregon, and
- a copy of the notation on the deed to the facility property for all closed cells, as required by 40 CFR 258.60(i)

8.11 Additional Resources

Low-permeability soil liner	Daniel, D. E. (1987), "Earthen Liners For Land Disposal Facilities," Geotechnical Practice for Waste Disposal '87 Proceedings, ASCE, Geotechnical Special Publication No. 13., pp. 21-39; Daniel, D. E., and Benson, C. H. (1990), "Water Content - Density Criteria for Compacted Soil Liners," Journal of Geotechnical Engineering, Vol. 116, No. 12, pp. 1811 - 1830; U.S. EPA (1988), Design, Construction, and Evaluation of Clay Liners for Waste Management Facilities, EPA/530/SW-86/007F; U.S. EPA (1988), Lining of Waste Containment and Other Impoundment Facilities, EPA/600/2-88/052, Chapter 9; and U.S. EPA (1989), Seminar Publication: Requirements for Hazardous Waste Landfill Design, Construction, and Closure, EPA/625/4-89/022, Chapter 6.
Geosynthetics -- construction quality control	U.S. EPA (1988), Lining of Waste Containment and Other Impoundment Facilities, EPA/600/2-88/052, Chapter 9; and. U.S. EPA (1989), Seminar Publication: Requirements for Hazardous Waste Landfill Design, Construction, and Closure, EPA/625/4-89/022, Chapter 6. For guidance on seaming geomembranes: U.S. EPA (1991), Technical Guidance Document: Inspection Techniques for the Fabrication of Geomembrane Field Seams, EPA/530/SW-91/051.
Leachate Collection and Removal	U.S. EPA (1988), Lining of Waste Containment and Other Impoundment Facilities, EPA/600/2-88/052, Chapter 9.

Construction Quality Assurance

U.S. EPA (1988), Lining of Waste Containment and Other Impoundment Facilities, EPA/600/2-88/052, Chapter 10;

U.S. EPA (1985), Construction Quality Assurance for Hazardous Waste Land Disposal Facilities, Public Comment Draft, EPA/530-SW-85-021;

Daniel, D. E., "Summary Review of Construction Quality Control for Compacted Soil Liners," Waste Containment Systems: Construction, Regulation, and Performance, R. Bonaparte (ed.), ASCE, New York, pp. 175 - 189; and

Chemical Waste Management, Inc. (June 15, 1990), Quality Assurance Manual For The Installation Of Geosynthetic Lining Systems.

General reference

For further information on construction principles and procedures, and project organization see ASCE (1990), Quality in the Constructed Project, ASCE Manual No. 73.

Section 9: Landfill Operations

9.1 Introduction

Operations plan

Develop an operations plan that describes the facility's operation and maintenance and incorporates the facility's planned development and specific design elements.

Reference: OAR 340-94-040(11)(b)

Operations and maintenance manual

Once new landfill units or related facilities are constructed and activated, prepare a detailed operations and maintenance (O&M) manual. The O&M manual should incorporate pertinent information from the following sources:

- operations plan
- final design documents
- post-construction documents
- hands-on operating experience, and
- equipment manufacturers

How to respond

During the design phase of the project, prepare an operations plan that integrates the site development plan, the facility design elements, and the operational elements described in this subsection. Submit the plan to DEQ for review and approval.

Once the landfill unit and related facilities are constructed and activated, prepare the O&M manual. Incorporate the operations plan elements, construction documents, and equipment manufacturers and suppliers data. Prepare separate O&M manuals for complex systems, such as leachate treatment systems, landfill gas control systems. Make the O&M manual available to operating personnel and place a copy of the manual(s) in the facility operating record.

O&M manual content

The O&M manual should be a practical document intended for day-to-day use by on-site operations personnel that:

- reflects the scope and content of field operations
- provides clear and detailed direction to landfill operating personnel
- addresses all topics identified in the operations plan
- includes a detailed table of contents
- includes definitions of all technical terminology, and
- is assembled as a loose-leaf binder to facilitate periodic revisions

Updating operations documents

Update the operations plan and the O&M manual as necessary to reflect significant facility expansions or changes in site operations and equipment.

In this section

This section describes the operational elements that should be addressed in the operations plan, including:

- general operations
- disposal operations -- waste handling
- disposal operations -- management of working area
- special waste management
- ancillary operations
- inspection and maintenance
- operating record
- contingency
- incremental post-closure operations, and
- personnel

9.2 General Operations

Security

Establish security measures to prevent unauthorized entry, waste disposal, and unsafe scavenging practices.

Signs

For public-use landfills, post signs bearing the following information:

- facility name
- business address and telephone number of the facility owner/operator (person or municipality)
- an emergency telephone number
- hours of operation
- current permit number, and
- a list of general types of materials which will be accepted or not accepted

Access hours and controls

Establish operating hours and man-made or natural barriers to:

- discourage entry by unauthorized persons
- limit access to the site to times when an attendant is on duty
- prevent unauthorized vehicular traffic and illegal dumping of wastes, and
- protect human health and the environment.

Reference: OAR 340-94-040(9) and 340-94-040(11)(h)

Aesthetics

Screen the active landfill area from public view.

Access roads

Construct and maintain on-site access roads to minimize traffic hazards, dust and mud and to provide reasonable all-weather access. Specify the maximum sustained grade of an access road. Construct stream crossings using culverts or other structures that do not increase the potential for flooding or excessive soil erosion. Incorporate roadway design in the detailed engineering drawings and specifications (Section 7).

Open burning

Prevent uncontrolled and/or unauthorized open burning.

Endangered species	Establish operating procedures to prevent the harming, killing, capturing or collecting of any endangered or threatened species, or to the direct or indirect alteration of critical habitat for those species. Protect any such species.
Floodplain integrity	Determine if facilities are located in the 100-year floodplain. The facility must not restrict the flow of a 100-year flood, reduce the temporary water storage capacity of the floodplain, or result in washout of solid waste.
Sewage disposal	Manage on-site sewage in accordance with Department-approved plans.

9.3 Disposal Operations -- Waste Handling

Weighing	Install equipment for weighing incoming loads or establish procedures for estimating weight by volume of waste loads. Account for the amount of incoming waste.
Scavenging controls	Prevent uncontrolled and unauthorized removal of solid waste. Material recovery activities must not create adverse health or environmental impacts.
Waste acceptability procedures	Establish waste acceptance procedures that include the following elements: • A random inspection program at the facility for detecting and preventing the disposal of regulated hazardous wastes, polychlorinated biphenyl wastes or any other unacceptable wastes as specified in the permit or determined by the Department. • Waste screening to control prohibited waste and special wastes which require prior Department approval. • Procedures used wherever prohibited or special wastes could enter the facility, including the working face, transfer stations, direct haulers, and landfill scale houses. • Procedures for managing prohibited wastes detected in landfilled waste. • Measures to handle unusual peak waste loads which may exceed the facility's capacity. References: 40 CFR 258.20 describes the requirements for a random inspection program; OAR 340-93-040 defines prohibited wastes
Liquid wastes	Prevent the disposal of bulk or non-containerized liquid waste and meet the requirements of 40 CFR 258.28(b).
Out of state wastes	For imported wastes, establish procedures to follow prohibitions or restrictions.
Salvage	Recover salvage materials in a planned and controlled manner. Reference: OAR 340-94-040(11)(k)

Litter control

Control litter by establishing good waste compaction practices, a small working face, and physical controls (e.g., permanent and portable fences), and cleanup procedures to prevent on and off-site windblown litter accumulations.

Reference: OAR 340-94-040(11)(l)

Vector and bird control

Control or prevent on-site populations of flies, rodents, other disease vectors, and birds.

References: OAR 340-94-040(10); 40 CFR 258.10

Inclement weather operations

Develop procedures for inclement weather operation, including provisions for:

- all-weather roads, wet-weather, and alternate disposal areas
- operating in extreme dry weather conditions or when dust emissions are excessive
- operating during other severe climatic conditions such as severe winds or snow, and
- notifying customers when severe climatic conditions require closure of disposal facilities

Reference: OAR 340-94-040(11)(b)(D)

Leachate system

Establish operation and maintenance procedures for the leachate management system and if applicable, the alternative leachate disposal system, scheduling of key activities during landfill development. Prepare a separate, detailed O&M manual for complex leachate treatment systems. Address the topics in the table below, as applicable.

System component	Topics to be addressed
Leachate Collection	Leachate collection system operation and performance Leachate level measurement techniques, frequency, location, for normal and wet weather operations Measures to prevent clogging and physical damage of collection system components
Leachate Storage	Odor control Leachate level monitoring Prevention of leachate releases to the environment (such as overflows or leaks) Liner system maintenance

System component	Topics to be addressed
Leachate Treatment/ Disposal	Influent and effluent testing Treatment efficiencies Treatment process adjustments and monitoring

Landfill gas control

Manage landfill gas to prevent subsurface migration of methane.
Describe detailed operation and maintenance procedures for the landfill gas control system in the facility O&M manual. Prepare a separate O&M manual for complex gas control systems.

References: OAR 340-94-040(5) and 40 CFR 258.23

Surface water control

Establish measures to prevent stormwater run-on onto active portions of the landfill and to control runoff. Incorporate a copy of the storm water pollution control plan into the operations plan.

Reference: Clean Water Act Sections 208, 319, and 402 involving wetlands; NPDES requirements in 40 CFR 258.26 and 258.27

Groundwater control

Operate and maintain the groundwater control system and associated equipment. Groundwater control measures may include dewatering systems (e.g., under drains and wells) and barrier systems (e.g., slurry walls, geomembrane walls) accompanied by pumps, manholes, buried piping, catch basins, outlets, and other equipment requiring operation and maintenance.

9.4 Disposal Operations -- Management of Working Area

Compatibility

Landfill disposal operations should be compatible with engineered structures and environmental control and monitoring systems, and should be consistent with the Site Development Plan and other aspects of facility operations.

Waste unloading

Develop waste unloading procedures for incoming vehicles and inspection procedures to identify and isolate prohibited or unacceptable wastes. Establish the size of the refuse unloading area from the following:

- incoming waste quantities
- number, size, and type of delivery vehicles
- compacting equipment requirements, and
- litter control and other environmental considerations

First layer of fill

Establish precautions to protect the geomembrane liner when the first layer of waste is placed and compacted in lined disposal areas. The first operations layer should be "select waste". Consider the following factors in establishing appropriate safeguards:

- the thickness and physical characteristics of the initial waste layer
- the availability of desirable "select waste" materials
- the thickness and physical characteristics of the drainage and operations layers
- whether the landfill cell design incorporates special-purpose geosynthetic materials (e.g., geotextiles) for added protection of the liner, and
- the type of equipment used to place and compact the initial waste layer

Definition: “Select waste” includes household waste but not demolition or land-clearing debris or other materials that may damage the liner system

Leachate minimization

Minimize leachate generation with appropriate landfill development and operations techniques.

Active face

Specify the nominal size of the active working face, and establish compatible waste unloading and filling procedures. Consider the following in determining the size of the working face:

- The width of the working face should only be wide enough to accommodate waste unloading and compaction equipment operation
- The cell height and length should be selected based on the daily volume of refuse received, and
- Cell end slopes should be kept as steep as possible (20 to 30 degrees)

Compaction

Establish procedures for waste spreading and compaction including layer thickness, maximum lift height, daily cell configuration and slopes, compaction equipment and compactive effort (i.e., minimum number of compactor passes over each layer of waste), and the intended density of solid waste.

Recommendation: The Department recommends that waste be spread in thin (about 1-foot-thick) layers and compacted with 3 to 5 passes of the compactor on slopes of about 3 horizontal to 1 vertical. The most effective compaction occurs with the compactor operating on a level surface.

Benefits of compaction

Proper compaction of solid waste at landfills can provide several important benefits including:

- conserving landfill space
- minimizing and controlling litter
- reducing daily cover efforts and cost
- reducing total and differential settlement of the waste and associated closure and post-closure costs, and
- creating a more aesthetic operation

Daily cover

Place "daily cover" on all exposed solid waste at the end of each operating day, or more often if necessary to control problems such as fly propagation, blowing litter, vectors, and fires. Place at least six inches of earthen material on exposed solid waste at the end of each working day, unless alternative cover designs or procedures are approved by the Department.

Reference: 40 CFR 258.21 describes requirements for daily cover

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Alternative daily cover

Alternative cover materials must provide the same level of control as earthen material. Example alternative covers include the following materials:

- Geosynthetic tarps (e.g., geotextiles and geomembranes)
- Spray-on foams
- Slurry products
- Inert waste materials (e.g., shredded tires, foundry sands)

Specifications should be established for cover material type, minimum thickness and frequency of application. Cover material sources and stockpile requirements should be identified.

Reference: 40 CFR 258.21(b) or (c), and OAR 340-94-040(8) describe the requirements for obtaining approval of alternate daily cover

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Intermediate cover

Place "intermediate cover" on the top and side slopes of an advancing lift which will not receive additional waste for at least two months. Design the intermediate cover to control surface water infiltration, disease vectors, fires, odors, blowing litter and scavenging. Intermediate cover should consist of at least one foot of compacted low-permeability soil. A geomembrane cover may also be required in areas where average annual rainfall exceeds 25 inches.

Interim cover

Place “interim cover” on segments of the landfill that reach final elevations before final cover installation. During the rainy season, place interim cover immediately after a cell reaches final elevations. Design the interim cover to minimize surface water infiltration, and potentially to serve as part of the foundation for the final cover system. Develop specifications for the interim cover's configuration, material properties (e.g. permeability), thickness, installation schedule and techniques, and raw-material sources.

9.5 Special Waste Management

Special waste management plan

Develop a Special Waste Management Plan including procedures for special waste acceptance, characterization, handling, storage, recordkeeping and disposal.

Contents

The plan should include the following elements:

- an analysis of special waste management alternatives
- a rationale for the proposed disposal alternative
- the physical and chemical characteristics of each waste
- the proposed (EPA and DEQ-approved) procedures for waste sampling, testing, and analysis
- an evaluation of whether the waste is compatible with the landfill (or other impoundment) liner and leachate management systems
- procedures to document and record daily and annual waste quantities (weight or volume), and waste sources and generating processes

Potential hazards

The table below descries the potential hazards associated with some wastes that may require special handling for disposal.

Potential hazard	Example waste
personnel safety hazards	asbestos
odor and vector problems	large dead animals
excessive leachate generation	sewage sludge
excessive settlement in the landfill	yard debris
puncturing or tearing the landfill liner	construction and demolition debris
fire hazards	tire chips
increasing the toxicity of landfill leachate	cleanup materials contaminated with hazardous substances

Reference: OAR 340-94-040(11)(b)(J)

Examples: special wastes

Special wastes include but are not limited to, the following specific items:

- asbestos
- treated infectious waste
- large animal carcasses
- hazardous-substance contaminated cleanup materials
- septage
- sewage sludges and grit
- industrial waste sludges
- industrial solid wastes
- ash
- construction and demolition waste, and
- over 25 gallons of petroleum-bearing wastes such as used oil filters, oil-absorbent materials, tank bottoms or oil sludges

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9.6 Ancillary Operations

Recycling	Provide a place and opportunity for collecting source separated recyclable material. Specify the procedures to be followed in accepting recyclable materials at the facility. Reference: OAR 340-93-160
Truck washing	Design truck washing facilities to reuse or recycle the waste water, or to discharge it to a sanitary sewer or leachate treatment system. Describe the following: • truck washing facilities and the circumstances for their use, and • methods for managing wash water Required permits: Discharges to the land or to waters of the state require a National Pollutant Discharge Elimination System (NPDES) or a Water Pollution Control Facilities (WPCF) permit. The type of permit will be determined on a site-specific basis by the Department's Water Quality staff.
Operations equipment	Acquire and maintain adequate operations equipment. Select equipment for its type, important physical and mechanical specifications (i.e., ground pressure, length of compactor wheel cleats),. identify any operating restrictions (e.g., preventing compacting equipment contact with the liner), quantity and purpose. Maintain standby equipment for use in the event of breakdown or maintenance of primary equipment. Note: The equipment types should be consistent with facility design, construction, and operational criteria
Electrical distribution system	Maintain the electrical distribution system at the facility to ensure proper function of metering points, transformers, disconnects, breakers, connections, and other power-system appurtenances.

9.7 Inspection and Maintenance

Schedule

Develop detailed inspection and maintenance procedures and a schedule for all facility components and items which require periodic inspection. Describe the activities to be conducted on a regularly scheduled basis.

Inspection form

Develop a standard inspection form to guide implementation and reporting. Form use should help maintain procedural and informational consistency.

Preventive program

Establish a preventative inspection and maintenance program schedule for all equipment and facilities including those in the table below.

Equipment/facility	Examples
personnel safety equipment	fire extinguishers
operating equipment	scrapers, dozers, compactors, loaders
support facilities	scale house, scales, public receiving area, administrative buildings
environmental control systems	landfill gas collection system, leachate collection and treatment systems sedimentation basins, cover system, liner system
environmental monitoring systems	groundwater monitoring wells, landfill gas monitoring probes, leachate monitoring sumps
transportation system	access roads, directional signs

9.8 Operating Record

Regulatory reference

Establish and maintain an operating record. Develop procedures to describe how the operating record will be established and maintained.

Reference: 40 CFR 258.29

Location

Retain the operating record near the facility or in an alternative location approved by the Department. Specify the location in the operations plan.

Content

Include the following information in the Operating Record:

Content	Regulatory source
Any required location restriction demonstrations (airport safety, floodplains, seismic impact zones or unstable areas)	40 CFR Part 258 Subpart B
Inspection records, training procedures and notification procedures included in the facility's hazardous waste screening program	40 CFR Part 258.20
Gas monitoring results and any required gas remediation plans	40 CFR Part 258.23
Documentation that the landfill meets design criteria if leachate or gas condensate is placed in the facility	40 CFR Part 258.40(a)(2)
Any demonstration, certification, finding, monitoring, testing, or analytical data (groundwater monitoring including detection and assessment monitoring, selection of a remedy and implementation of a corrective action program)	40 CFR Part 258 Subpart E
Closure and post-closure care plans and any monitoring, testing or analytical data	40 CFR Part 258 Subpart F
Any cost estimates and financial assurance documentation	40 CFR Part 258 Subpart G; OAR 340-94-140
For a landfill claiming the small community exemption, any information required by that paragraph to demonstrate compliance with the small community exemption	40 CFR Part 258.1(f)(2)

9.9 Contingency

Contingency plan scenarios

Develop a contingency plan that includes procedures for responding to the following scenarios:
- on-site personal injuries
- leachate releases
- surface water or groundwater contamination
- landfill gas migration and associated fire and explosion hazards
- liquid spills
- fires (e.g., equipment fires, "hot load" fires, disposal site fires, building fires)
- explosions, accidents, and other emergencies
- detection of leachate in any secondary leachate collection and removal system
- leachate storage facility at or above capacity
- tank and surface impoundment spills or leakage, and
- storms and inclement weather

Notification list

Create an emergency notification list in the contingency plan (e.g., contact person, address, telephone number) and procedures for:
- emergency assessment
- communication
- identification of emergency response organization
- identification of community, civil authorities and regulatory personnel, and
- reporting.

Layout map

Prepare a site layout map showing:
- facilities
- fire hydrant locations
- individual building floor plans showing locations of fire extinguishers, first aid kits and stations, exits and communication equipment, and
- other relevant site features

Fire prevention and control

Establish comprehensive procedures for fire prevention and control of equipment and solid waste fires.

Equipment fire prevention

Equipment fires generally are started by an electrical failure or fluid leak and oil and grease that spreads on the machine and on nearby refuse. Preventative maintenance on the machines will reduce the potential for leakage of flammable fluids. Routine cleaning of equipment will further contribute to fire prevention. Furnish a fire extinguisher with each piece of equipment. Consider automatic fire control systems for dozers and compactors.

Solid waste fire prevention

Landfills fires can be started by "hot loads," spontaneous combustion, unknown combustible materials subjected to sparks, and by equipment fires. On-site personnel must always be on the lookout for "hot loads" and flammable materials. Subsurface fires resulting from spontaneous combustion can be difficult to locate and extinguish. Extinguish near-surface fires by covering the area with dirt. If the fire is deep, excavating the burning material may be necessary. Follow appropriate personnel safety precautions in all of these situations. Inaccessible fires require a different strategy. Extinguish these fires by cooling the burning mass in-place, or reduce available oxygen by closing cracks and fissures, or by adjusting the gas control system operations.

9.10 Incremental Post-Closure Operations

Continuous closure

Landfill development is a continuous construction and operations activity. As areas are prepared to receive future waste, active areas are being filled and completed areas are closed. At large landfills this cycle may be repeated many times prior to final facility closure.

Relation to other plans

The site development plan provides for phased construction, operations, and closure. Final facility closure and post-closure are addressed in the closure, post-closure, and financial assurance plans.

Beginning of post-closure

The 30-year post-closure care period starts after final facility closure, not after each incremental closure. Incremental closure may involve one or more landfill modules. Final facility closure and the "worst-case closure" scenario (Subtitle D closure) involve the cessation of landfill operations.

Reference: OAR 340-94-130; Section 11 of this guidance

Inspection and maintenance

Establish routine inspection and maintenance procedures for completed landfill modules and activities to protect the integrity of the final cover system and other closure-related facilities.

Inspection and repair components

Establish procedures and a schedule for inspection, repair, and closed modules. The following critical components should be addressed:

- final cover
- surface water drainage system
- erosion and sedimentation control system
- landfill gas monitoring and control system
- leachate collection and removal system
- access control (e.g., security fence, gates, locks), and
- access roads (for inspection and maintenance)

9.11 Personnel

Operations staff	Establish an adequate operations staff and systematic qualifications, responsibilities and duties, and lines of authority.
Training topics	Train operations personnel in landfill development, construction and operation, as applicable. Training should emphasize the following: • how to inspect waste loads and identify hazardous waste or PCB waste containers and labels • hazardous waste handling procedures • safety precautions, employee protective clothing and equipment, health • first aid, 40 hour OSHA, and emergency procedures • landfill operational practices • record keeping, and • permit requirements and regulatory compliance
Documentation	Place training documentation in the operating record. <u>Reference</u>: 40 CFR Part 258.29

9.12 Additional Resources

References	U.S. EPA "Solid Waste Disposal Facility Criteria - Technical Manual", October 9, 1993

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 • Direct method of collecting soil water for chemical analysis • Collection of quantity and quality data from a discrete area

suction lysimeters	• Perform poorly in arid regions • 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 • ion probes - measure the ion concentrations • conductivity probes - measure the conductivity • tensiometers - measure the moisture content in the unsaturated zone • TDRs 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

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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. • 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. • Sampling parameters should be good indicators of potential leachate discharge • 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: • soil conditions • hydrogeologic conditions • facility design and development history • location of facility structures and property boundaries • surrounding land use and location of off-site structures • changing site conditions which may affect gas generation and migration (e.g., barometric pressure, temperature, soil moisture, snow cover etc.) 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
Specific Conductance
pH
Dissolved Oxygen
Temperature
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 $CaCO_3$)
Total Dissolved Solids
Total Alkalinity (as $CaCO_3$)
Total Suspended Solids
Specific Conductance (lab)
Chemical Oxygen Demand
pH (lab)
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)
Manganese (Mn)
Sulfate (SO_4)
Magnesium (Mg)
Ammonia (NH_4)
Chloride (Cl)
Sodium (Na)
Carbonate (CO_3)
Nitrate (NO_3)
Potassium (K)
Bicarbonate (HCO_3)
Silica (SiO_2)
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)
Chromium (Cr)
Selenium (Se)
Arsenic (As)
Cobalt (Co)
Silver (Ag)
Barium (Ba)
Copper (Cu)
Thallium (Tl)
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)	
	Vanadium (V) Cadmium (Cd) Nickel (Ni) 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: Semi-volatile Organic Constituents, according to EPA Method 8270 Mercury, according to EPA Method 7470 Cyanide, according to EPA Method 9010 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 Total Coliform Bacteria Total Phosphorus Fecal Coliform Bacteria Orthophosphate E. Coli Biological Oxygen Demand 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). 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 2. perform resampling within 15 days and evaluate results as described below *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 Examples of significant changes: Detection of a VOC or other hazardous constituent not previously detected in background Exceedance of a Table 1 or 3 value listed in OAR 340-40, unless the background water quality is above these numerical limits Exceedance of a Safe Drinking Water Standard Exceedance of an Action Limit 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 2. perform resampling within 15 days and evaluate results as described below *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) 2. begin assessment monitoring 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) 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 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. For analytical and water level data: • arrange table by monitoring point identification number, parameter, and/or sampling event • present each type of monitoring data separately (i.e.; leachate, groundwater, surface water) • group groundwater data according to well designation (upgradient, downgradient) For statistical data: • arrange in individual tables by parameter and location • 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. Prepare as follows: • plot a separate chart for each parameter of interest • plot all monitoring points for comparison on one graph • plot concentration on vertical axis using a consistent scale and equal spacing • plot time on the horizontal axis using a consistent scale and equal spacing • represent PSCL value as a line on graph • 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. Prepare as follows: • construct individual plots for each well and each parameter • plot boxes from multiple wells for a single constituent on a single grid for comparison • plots should include median, interquartile range, and maximum and minimum values • represent PSCL value as a line on the grid • clearly identify parameter and sample location *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: • measuring point • date and season • elevation • contour interval • scale 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: • hydrographs • scatter plots • cross sections • histograms • trilinear diagrams • ion-concentration diagrams, and • contour maps 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 • presentation of water/leachate level data and groundwater flow rates using contour maps, tables, and graphs • summary of all field data, laboratory analytical reports, chain of custody reports, all cross-referenced with the field sampling locations • data validation (i.e.; cation/anion balance, comparison of blanks and duplicates, identify data problems or discrepancies, review of detection limits and holding times) • time series graphs • summary tables of the year's monitoring data by location and parameter
Water Quality Statistical Analysis	Box plots for the purpose of: • establishing background water quality and proposing permit-specific concentration limits • comparing monitoring results to compliance concentrations to determine if a release has occurred • 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 • review of statistical methods for background water quality and identifying potential impacts • a comparison of water quality in the downgradient monitoring points to upgradient/background monitoring points • comparison of data quality to any PSCLs that have been established • comparison of groundwater quality data to existing federal and state groundwater standards • assessment of whether any corrective or preventive actions have been effective in reducing or controlling releases • assessment of the effectiveness of any closure measures undertaken • 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 • discussion of any impacts, trends in data, and violations of PSCLs, exceedences of a standard, or significant changes • any recommendations for the monitoring program • identify any impacts and action requirements • discussion of the current status of the environmental monitoring network • 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.

Section 11: Closure and Post-Closure

11.1 Introduction

Regulatory reference

Minimum requirements for closure plans and post-closure plans for MSW landfills are specified in the Department's Financial Assurance Rule, OAR 340-94-100 through 145. The closure and post-closure requirements for Subtitle D landfills differ from those of non-Subtitle D MSW landfills (i.e., closing facilities).

Types of plans

There are two separate categories of closure and post-closure plans:

Subtitle D ("worst case") Closure and Post-closure Plans are based on a hypothetical "worst case" scenario for closure and post-closure costs. This scenario establishes a conservative basis for estimating financial assurance funding requirements.

The Final Engineered Site Closure and Post-closure Plans are linked to the Closure Permit which must be obtained at least 5 years prior to anticipated final closure. The Final Engineered plans reflect the intended closure design. The Final Engineered plans contain all the elements of and replace the Subtitle D plans.

How to respond: Subtitle D facilities

Landfills subject to Subtitle D should:

- prepare a "Worst-case" (Subtitle D) Closure Plan and a “Worst-case" (Subtitle D) Post-closure Plan for determining appropriate costs for financial assurance planning. Place the plans in the facility operating record and notify the Director of that action
- prepare a Final Engineered Closure Plan and a Final Engineered Post-closure Plan and submit them to the Department five years before the anticipated final closure date
- revise financial assurance cost estimates based on the final engineered plans

How to respond: Closing facilities

Non-Subtitle D facilities (closing facilities) are within the five-year final closure window and therefore should:

- prepare a Final Engineered Closure Plan and a Final Engineered Post-closure Plan and submit the plans to the Department at the date specified in the permittee's closure permit
- determine closure and post-closure costs for financial assurance planning, based on the Final Engineered Closure and Post-closure Plans

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Approval

The Final Engineered Site Closure Plan and Final Engineered Site Post-Closure Plan must be submitted to the Department for review and written approval.

In this section

This section describes the contents of the closure and post-closure plans.

11.2 Closure Plans

Subtitle D "Worst-Case" Closure Plan

The Subtitle D "Worst-Case" Closure Plan should include all elements specified in 40 CFR 258.60:

- a description of the steps necessary to close all landfill cells at any point during their active life
- a description of the final cover system
- an estimate of the largest area of the landfill ever requiring a final cover
- an estimate of the maximum inventory of wastes ever on site over the active life of the landfill
- a schedule for completing all activities necessary to satisfy the closure criteria in 40 CFR 258.60

Final Engineered Site Closure Plan

The Final Engineered Site Closure Plan should supplement all the elements of the "Worst Case" Closure Plan by adding the following:

- detailed design plans and specifications for the closure improvements, including final cover system, gas control system, runoff/run-on control system, leachate treatment and disposal system
- an updated final grading (topographic) plan for the site
- an end use plan
- a landscaping plan
- an assessment of long-term settlement and its potential effects on the integrity of the closure
- a detailed description of the design, function, and operation of all environmental control systems
- a description (plan) of how and when the facility will be closed (i.e., the procedures that will be used to ensure that facility operations are compatible with closure objectives and requirements)
- a detailed description of the environmental monitoring system;
- a schedule for implementing the closure plan
- a detailed closure cost estimate, and
- other information requested in the closure permit or otherwise required to comply with all applicable DEQ and federal regulations

Previously submitted information

If some of the required information has been previously submitted, review and updated it to reflect current conditions and any proposed changes in the closure program.

11.3 Post-Closure Plans

"Subtitle D" Post-closure Plans

The "Subtitle D" Post-closure Plan should identify and describe the post-closure activities required to properly monitor and maintain the closed landfill site. This post-closure plan should address all elements specified in 40 CFR 258.61 and include procedures for the following:

- maintaining the integrity and effectiveness of the final cover system
- maintaining and operating the leachate collection, treatment, and disposal systems
- maintaining and operating the environmental monitoring systems
- conducting Environmental quality monitoring (groundwater, surface water, landfill gas, leachate, air, etc.)
- maintaining and operating the landfill gas control system
- maintaining and operating the surface water runoff/run-on control systems
- providing overall, site-wide monitoring and security, and
- establishing appropriate uses of the property during the post-closure care period

Final Engineered Post-closure Plan

Incorporate in the Final Engineered Post-closure plan all elements of the "Subtitle D" post-closure plan, along with detailed closure design information. Include the following:

- a detailed schedule for post-closure monitoring, inspection, and maintenance and repairs
- detailed operation and maintenance procedures for all environmental monitoring and control systems that will be in active use during the post-closure period, and
- any other information required to comply with DEQ and federal regulations

Previously submitted information

Review and update any previously submitted post-closure informaiton to reflect current conditions and any proposed changes in closure or post-closure activities.

11.4 Additional Resources

References

Technical Manual for Solid Waste Disposal Criteria - 40 CFR Part 258, Subpart F (Chapter 6). U.S. EPA, November 1993.

Section 12: Financial Assurance

12.1 Introduction

Purpose of financial assurance

Proper financial planning early in the development of landfill facilities is required to ensure that adequate funding will be available to cover the cost of closure(s), post-closure care, and any corrective action activities.

Coverage

Maintain financial assurance to cover the costs of:
- closure of the landfill
- post-closure monitoring and maintenance of the landfill facilities, and
- any corrective action required by the Department

Exemptions

Exempt landfills must satisfy the exemption criteria in OAR 340-94-140(2) and meet the waste acceptance and final cover deadlines below:

Landfill type	that stopped receiving waste by...	and completed installation of final cover by...
any landfill	October 9, 1993	October 9, 1994
"small landfill" [40 CFR 258.1(e)(2)]	April 9, 1994	October 9, 1994
"very small landfill serving certain small communities" [40 CFR Part 258.1(f)(1)]	October 9, 1997	October 9, 1998

How to respond Respond to applicable financial assurance requirements, as determined by the table below.

If the facility is...	Then...
subject to Subtitle D	place a financial assurance plan in the facility operating record and submit to the Department a copy of the mechanism and certification that the plan meets requirements
seeking an exemption	demonstrate to the Department that the facility meets the exemption criteria

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Updating financial assurance

Review and update the cost estimates and the financial assurance annually during the operating life and post-closure care period, or until the corrective action is completed, as applicable. Place annual adjustments to the financial assurance plan in the facility operating record. Submit a certification to the Department that the annual update has been completed.

Review date: The annual review should occur on the anniversary of the date when the financial assurance plan was placed in the facility operating record and the certification was submitted to the Department, or at the end of the corporation's fiscal year if the mechanism is the corporate guarantee.

Schedule

The appropriate schedule for providing financial assurance will depend on each facility's operating status, size, anticipated closure date, and need for corrective action. Refer to OAR 340-94-140(3) for detailed schedule requirements associated with "worst case " closure plans, "Subtitle D" post-closure plans, Final Engineered Site Closure and Post-closure Plans and corrective action.

Cost calculations

For permittees meeting the criteria in 40 CFR Part 258.75 (a) through (c), the current value of future costs should be calculated using a discount rate no greater than the Department's current reference rate. The Department will determine the reference rate annually during the month of June. It shall be in effect for the fiscal year beginning the first day of July immediately following the determination date and ending on June 30 of the following calendar year. Refer to OAR 340-94-140 (4)(a) for detailed information.

Permittees can use discounting to determine costs only if they:

- certify that the closure date is certain and there are no foreseeable circumstances that will change the estimate of site life
- comply with all applicable permit requirements
- submit a statement from a registered engineer certifying that cost estimates are complete and accurate.

Contact: Department of Environmental Quality (503) 229-5378

12.2 Financial Assurance Plan

Contents of financial assurance plan

The financial assurance plan should contain the following elements:

- cost estimates for third-party closure, post-closure, corrective action (if required) and any other requirements the Department may impose as a condition of issuing a closure permit, closing the site, implementing post-closure care activities, or implementing corrective action
- the source of the cost estimates
- a detailed description of the form of the financial assurance and a copy of the financial assurance mechanism
- a method and schedule for acquiring and managing the required financial assurance funds
- a proposal for disposing of any excess moneys received or interest earned on moneys received for financial assurance
- adequate accounting procedures to insure that funds are collected in the correct amounts and used only for authorized purposes
- certification to the Director of DEQ that the financial assurance mechanism meets all state and federal requirements (at the time a financial assurance mechanism is submitted to the Department and when a financial assurance plan is placed in the facility operating record)
- annual updates of the cost estimates and financial assurance

Cost estimate

The financial assurance plan should include written cost estimates for the Final Engineered Site Closure Plan and Final Engineered Post-closure Plan, or the "worst case" closure and Subtitle D post-closure scenarios, as applicable.

Basis for estimate

Estimate costs based on detailed engineering analyses or construction contractor bids and itemize costs for expenses such as the following:

- mobilization of equipment
- construction materials
- construction activities
- overhead
- engineering and other consulting services
- operation and maintenance of environmental monitoring and control systems
- environmental monitoring and associated laboratory analyses
- general site maintenance activities
- miscellaneous expenses, contingencies, etc.

Considerations: closure estimate

Estimate closure costs based on the Final Engineered Site Closure Plan with consideration of the following factors:

- amount and type of solid waste deposited in the site
- the effectiveness of any buffer zones designed to protect adjacent land and drinking water sources
- the cost of the site's engineered closure improvements (i.e., final cover system, run-on/runoff control systems, other environmental control and monitoring systems, etc.)
- planned future use of the disposal site property
- the extent of site area closed prior to final closure of the entire site
- any other closure conditions imposed by the Department

Considerations: post-closure estimate

Estimate post-closure costs based on the Final Engineered Post-closure Plan. Consider the following factors:

- a minimum post-closure care period of 30 years after the date of final facility closure
- annual costs associated with the operation and maintenance of any required environmental control and monitoring systems
- any other conditions imposed by the Department relating to post-closure care of the site

Considerations: corrective action

Estimate costs based on site-specific corrective action activities outlined in a Corrective Action Report (see 40 CFR Part 258.73). Estimate in current dollars and account for the cost of hiring a third party to perform the corrective action. Account for the total costs of corrective action activities for the entire corrective action period.

Form of financial assurance

Describe in detail the form of the financial assurance, using one of the allowable mechanisms. Include a copy of the mechanism in the plan.

Mechanisms for closure and post closure

Use any of the following forms of financial assurance for closure and post-closure activities:

Form of financial assurance	Requirements specified in...
trust fund	OAR 340-94-145(5)(a)
surety bond	OAR 340-94-145(5)(b) or OAR 340-94-145(5)(c)

irrevocable letter of credit	OAR 340-94-145(5)(d)
closure or post-closure insurance policy	OAR 340-94-145(5)(e)
corporate guarantee from a private corporation	OAR 340-94-145(5)(f)
local government financial test	OAR 340-94-145(5)(g)
local government guarantee	OAR 340-94-145(5)(h)
alternative form	OAR 340-94-145(5)(i); third party certification and prior approval of the form by the Department is required

Mechanisms for corrective action

Use any of the following forms of financial assurance for corrective action:

Form of financial assurance	Requirements specified in...
trust fund	OAR 340-94-145(5)(a)
performance surety bond	OAR 340-94-145(5)(c)
irrevocable letter of credit	OAR 340-94-145(5)(d)
corporate guarantee from a private corporation	OAR 340-94-145(5)(f)
local government financial test	OAR 340-94-145(5)(g)
local government guarantee	OAR 340-94-145(5)(h)
alternative form	OAR 340-940145(5)(i); third party certification and prior approval of the form by the Department is required

Method of acquiring and managing funds

Describe in detail the method and schedule for providing for or accumulating the appropriate amount of funds to ensure proper closure and post-closure care or implementation of corrective action, as applicable. The financial assurance mechanisms for closure, post-closure care and corrective action must ensure the funds will be available in a timely fashion when needed.

Excess moneys

Include a proposal for disposing of any excess moneys received or interest earned on moneys received for financial assurance. [OAR 340-94-140(4)(e)]

Collection of funds

Establish adequate accounting procedures to ensure that the disposal site operator does not:

- collect funds in excess of the amount specified in the financial assurance plan, or
- use the funds for any purpose other than required by OAR 340-94-140(1)

12.3 Additional Resources

Reference	Federal Reserve Statistical Release H.15 (519) Selected Interest Rates. Department of Commerce, Bureau of Economic Analysis, Survey of Current Business.
Contact	Department of Commerce Bulletin Board: (202) 482-1986.