Chapter 5

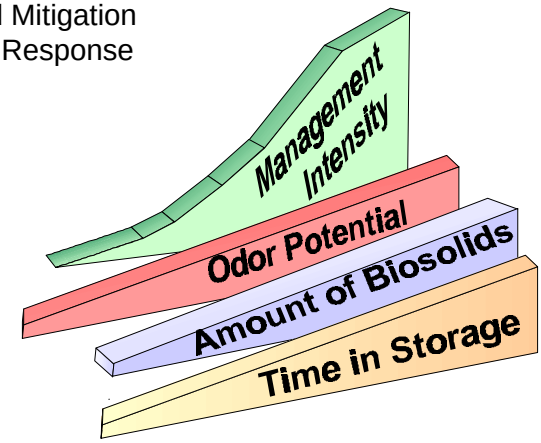
Recommended Management Practices

Introduction

This chapter deals with the various issues of Critical Control Point 2: *The Transportation Process* and Critical Control Point 3: *The Field Storage Site*. Design guidance and management recommendations are provided for storage of biosolids that meet state and federal standards and are suitable for use in land application programs. The operative concept for these recommendations is that site design and management requirements increase as the length of storage or volume of stored biosolids increases. These recommendations are based on practical field experience and are designed to protect water quality, minimize pathogen exposure risks, and reduce the potential for unacceptable off-site odors.

The five sections in this chapter are:

I. Site Selection Considerations: Applicable to All Storage
II. Field Storage: Stockpiles
III. Field Storage: Constructed Facilities
IV. Odor Prevention and Mitigation
V. Spill Prevention and Response



I. Site Selection Considerations: Applicable to all storage

SITE SELECTION FACTORS

CLIMATE

TOPOGRAPHY

SOIL/GEOLOGY

BUFFER ZONES

ODOR PREVENTION/AESTHETICS

ACCESSIBILITY AND HAULING DISTANCE

PROPERTY ISSUES

Climate

The climate of the area should be assessed to determine the likelihood of precipitation events over the planned storage period, the expected temperatures, wind speed and prevailing seasonal directions relevant to sensitive odor receptors. For constructed facilities, the anticipated length of inclement weather conditions and rainfall may influence the size of the facility. For instance, in many areas of the United States, land application of biosolids is severely limited from the months of November through March.

Topography

Field stockpiles and storage facilities should not be located in areas that are regularly inundated, in drainage ways or in wetlands. They should be placed on fairly level land. Stockpiles should be situated near the top of slopes to minimize exposure to up-slope runoff. Constructed storage facilities may require storm water controls if subjected to up-slope runoff. U.S. Geologic Survey (USGS) topographic maps are an excellent tool for screening of suitable locations. Biosolids should be stored in areas with adequate buffers.

Soils and Geology

Sites selected for field storage should not be located on excessively moist or wetland soils where very low infiltration rates regularly lead to standing water or excessive runoff after storm events. Stockpiles also should not be located on soils with extremely high hydraulic conductivities (such as gravels) that have excessive infiltration rates. Regulatory requirements and water quality protection standards regarding depth to seasonal high water table and to bedrock should also be considered. Stockpiles do not belong on or adjacent to karst features such as sinkholes or rock outcroppings.

For constructed storage facilities, the soil must provide a suitable foundation. The movement, settling and shifting of the underlying soil could result in leakage through cracks or even the total failure of the storage structure. High water tables may pose the risk of rupturing the water-tight seals of a lagoon (particularly with clay lined systems) causing groundwater infiltration into the storage facility or conversely leakage of the biosolids to the surrounding groundwater. High permanent or seasonal water tables may also exert enough flotation force on concrete or steel structures to lift them from their foundations. The soil at the site should be evaluated in regard to its suitability and strength for use in embankments, berms and backfill. It may be necessary to truck in suitable soils, which will significantly increase the cost of the storage facility.

Buffers

Adequate buffers are necessary to protect water resources and to prevent nuisances to adjacent properties. The storage site should comply with any federal (10 meters by the 503 rule), state, or local regulations regarding minimum buffer distances to waterways, homes, wells, property lines, roads, etc. They also prevent surface runoff from reaching streams by providing room for infiltration in crop areas and vegetative buffers or crop residue.

Odor Minimization and Aesthetics

Reducing the visibility of the storage site to the general public and maximizing the distance between the site and residential areas help minimize nuisance complaints. The length of time biosolids are stored should be minimized when sites are adjacent to residential areas. Storage during the summer months poses a greater potential for development of unacceptable odors and requires a higher level of management.

Accessibility and Hauling Distances

Potential sites should be evaluated based on economical hauling radii from the generating facility and the accessibility of the site during periods of inclement weather. Weight restriction and other roadway limits should be observed both on-site and along the haul route from the treatment facility. Consideration should also be given to traffic impacts on communities along the haul route and the least disruptive route selected.

Biosolids must be transported to the storage site in vehicles that are appropriate for the type of materials being transported, e.g., for dewatered or dried biosolids, trucks must be covered and have rubber sealed rear gates. Drivers should be briefed on haul routes and provided with a copy of a written spill response plan that describes emergency response and clean-up methods in the event of a spill, accident etc. It is advisable to keep one in each haul vehicle and at project offices. Investigate and comply with any local road use requirements or restrictions.

Prior to biosolids deliveries, mark field stockpile areas. Place signs or flags conspicuously enough for truck drivers to determine where to drive and unload biosolids. Make provisions for collection of load tickets to document deliveries.

Permanent storage facilities must have room for trucks to maneuver and pull-offs or staging areas to ensure vehicles do not queue up on the shoulder of public roads while waiting to be loaded or unloaded. In landscape and horticultural uses, where Class A biosolids will be combined with other materials, consider locating storage areas near other amendments to minimize the time required to collect and blend potting and landscaping mixtures.

Property Issues

Before constructed storage facilities are built, local zoning requirements and ordinances must be investigated. In addition, consideration should be given to the relative security and liability associated with leasing versus ownership of the land on which the storage facility will be located. Any leases should extend for several years and preferably over the expected life of the facility. Leases should have provisions that allow and guarantee proper management of the site and compliance with regulatory requirements. Plans should also be made for the eventual closure of the facility such as demolition and restoration of the site or conversion of the facility to other uses. Adequate insurance of the property, facility and equipment as well as environmental liability coverage is necessary. This coverage must be coordinated with any applicable state or local bonding requirements.

II. Field Storage: Stockpiles

Field Storage Considerations for Stockpiles

DESIGN CONSIDERATIONS

SITE SELECTION & WATER MANGAGEMENT

OPERATIONAL PRACTICES

HOUSEKEEPING

SECURITY

SITE RESTORATION

A *Critical Control Point 3: Field Storage (Stockpile) Checklist* (page 48) summarizes material discussed in this section.

Design Considerations

Field stockpiling is used for short-term storage of dewatered cake, dried, or composted Class B or Class A biosolids at the land application site. Use biosolids that stay consolidated and non-flowing -- It is advisable to test the biosolids' ability to stay consolidated before field stockpiling operations are initiated; such testing can be conducted at the treatment plant. This should be rechecked if a treatment plant changes polymers or dewatering methods. This test is suggested because some polymers used in dewatering may break down after a couple days. If this occurs, bound water in the biosolids is released and the stockpiled biosolids may lose solidity and slump or flow.

If biosolids do not have the proper consistency, they may be blended with thicker biosolids from the treatment facility. If Class A is mixed with Class B, the material must be handled as a Class B biosolids unless the mixture is retested and/or retreated to meet Class A standards.

Alternatively, it may be feasible in some situations to stockpile biosolids on a layer of sawdust or other absorbent material. Such practice is not considered to change the quality of the biosolids, and hence does not require a federal "Treatment Works Treating Domestic Sewage (TWTDS)" application and additional testing for Part 503 compliance.

Site Selection and Water Management

Field stockpiles should be placed in the best physical location possible in or adjacent to the field(s) that will receive the biosolids. Stockpiles should be placed according to the general siting recommendations listed earlier in this chapter and conform to all state requirements. For sites with significant slope, provisions need to be made to manage up-and downslope water. Avoid forming windrows across slopes to reduce the potential for piles to become anaerobic at the base where overland flow accumulates. To the extent possible, shape piles to shed water. Clearly mark access routes and stockpile areas at field sites.

Upslope

The longer the storage period, the greater the potential precipitation, and hence, greater levels of runoff control are needed. Runoff from any up-slope areas should be diverted by using straw bales, silt fence, by discing soils up-slope of the stockpile along the contour line, or by constructing a berm with soil from the site. In some cases, inert, low nitrogen, residuals such as agricultural lime, pulp/paper sludge, or wood ash have been used successfully as berm materials. For schematic diagrams of several types of berm construction see Appendix C.

Downslope
Ensure that measures are placed down-slope of the stockpile to manage runoff. These measures could include buffers or filter strips consisting of established vegetation or crop residues, tillage across the slope to increase soil roughness, silt fencing, straw bales, or berms (see Appendix D for schematic details on construction). The extent of these measures should be based on the length of time the material is expected to remain stockpiled and the likelihood of significant runoff events occurring during this period. The amount of biosolids stored at a field stockpile site should be limited to that which can be used on the adjacent fields.

Covering
Stockpiled biosolids form an air-dried crust that sheds precipitation and prevents significant percolation of water through the pile. Nonetheless, some states require stockpiles to be covered. However, field experience has shown that tarps are not practical, except for very small stockpiles.

Biosolids stockpiles usually occupy a significant area; large tarps needed to cover them are expensive, difficult to anchor and handle. Spreading the tarp often requires workers to physically wade in biosolids. Furthermore, placing and removing tarps may lead to significant drag-out of biosolids and the soiled tarps themselves are a disposal problem. Shredded bark, compost, straw mulch, ash, or topical lime application at times have been used as covers for biosolids stockpiles (primarily to minimize odors as necessary).

For dried (at least 50 percent solids) or composted biosolids, tarps, wind barriers or periodic wetting may be necessary to minimize blowing of dust, particularly in arid, windy, climates when stockpiles are in close proximity to sensitive downwind areas, e.g., residential areas. There have been some instances of tarps catching fire when used on compost materials. Hence, monitoring for hot spots as described below in *'inspections'* is a useful preventive strategy.

On a practical basis, several methods of effectively minimizing potential water quality impacts include proper shaping of stockpiles, whenever possible, to shed water, up-slope runoff diversions, and down-slope filter strips or other practices. For biosolids-derived materials slated for use in highway projects, consider storing the material on paved surfaces below overpasses to shelter from precipitation.

Operational Practices

Inspection
Stockpiles should be inspected regularly and after severe precipitation events to ensure that runoff controls are in good working order; note any slumping, erosion, or movement of the biosolids; ensure there is no ponding or excessive odor at the site. It is recommended that an inspection report be completed,

documenting the time, date, person conducting the inspection, and any items requiring maintenance or repair.

Compost Inspection

Incompletely composted materials have the potential to self-heat because microbial growth can still occur on the remaining nutrients. Thus, it is important that only stable compost product be placed in storage. The compost reheat test is an easy, on-site test that a compost producer can use to determine if this level of compost stability has been achieved prior to storage. Alternatively, there are oxygen uptake and carbon dioxide test prosedures that can be used at the production facility. Temperature of stockpiles can be monitored conveniently and rapidly with hand-held, 'point and shoot' infrared temperature devices approved by the National Fire Protection Association to ensure the material does not become a potential fire hazard. Steel temperature probes inserted into various places in a pile for approximately 10 minutes can also be used, as can thermistor probes that are buried in piles and relay temperature data to a remote, electronic data-acquisition system.

Heat Dried Product Inspection

Heat dried products that are rewetted or have not been sufficiently dried and cooled (<95% solids, >85^{o}F) also can self-heat. In the presence of enough available water, microbes will utilize the nutrients in the biosolids and generate heat that cannot dissipate because of the mass of the stockpile. Therefore, piles should be monitored if rewetting occurs so that a fire hazard does not develop. A noticeable increase in odor is a reliable indicator of microbial activity and the potential development of hot spots. Temperature monitoring devices as used for composting can also be used with stored, heat-dried biosolids. If hot spots are found, the stockpile should be broken apart to vent the heat and dry, then restacked or the material should be land applied.

In arid regions or during droughts, prudent management practices for potentially combustible material might also include:

- A fire break of 30 ft. around stored materials by removing combustible vegetation
- Foam-type fire suppressant or emergency water source (tank), possibly including detergent to enhance the surface contact effectiveness of the water.

Housekeeping

During stockpile creation or removal, employees must ensure that, at the end of each work session, runoff controls are in place and stockpiles are properly shaped whenever possible to prevent ponding of water on top of the biosolids. They must also ensure that equipment is clean and the area is secured. For a list of practices useful in preventing the tracking of mud and biosolids onto public roads see p. 58.

Security

Locate field storage piles in remote areas of sites, when possible, to limit access. Install appropriate fencing around stockpiles located on fields where livestock will be grazed during the storage period to prevent their access.

Site Restoration

For most soils, stockpile areas exhibit soil compaction (especially when wet) due to heavy equipment operation. Evaluate soil sensitivity to compaction when selecting the loading and storage areas. Storage areas may also exhibit high levels of nutrients, salts, and pH (for limed biosolids), that may potentially inhibit seed germination and crop growth. For these reasons, the following measures are often needed after biosolids are removed from a stockpile and land applied:

- Remove and spread the residual biosolids in the stockpile area. This can be accomplished using a loader bucket to closely skim biosolids from the ground surface and, if necessary, dragging the area with the back of the loader bucket. In some cases, where equipment has churned biosolids into the soil, it may be advisable to scrape a thin layer of soil with the biosolids. Where biosolids are stockpiled on hay or pasture, it may be necessary to use a chain drag to breakup and spread out biosolids left in the loading area.

- When cropping practices allow, the soil in the stockpile area should be tilled with a disc, chisel plowed, subsoil tilled etc., to breakup compaction. The site should then be seeded or cropped to take up nutrients. If there are several suitable locations at a site, stockpiles should be rotated from year to year rather than repeatedly placed in the same location. If a single area of the site will be used repeatedly, this area will need a higher level of management.

	Critical Control Point 3: Field Storage (Stockpile) Checklist ***(Involving dewatered cake, dried, or composted Class A or Class B Biosolids)***	
	Management	✔
1	**Prepare and maintain a Field Management Plan**	
2	**Train employees to properly operate the site according to plan; conduct spill drills**	
3	**Critical Control Point 1: Work with WWTP to maximize biosolids stability, consistency, and quality; direct batches to appropriate sites.**	
4	**Critical Control Point 2: Transportation; Clearly mark site access routes and stockpile areas; conduct spill drills**	
5	**Maintain accurate and well organized records**	
6	**Designate a competent public relations person; maintain communication with stakeholders; notify agencies of reportable incidents; explain actions taken to respond to citizens concerns or complaints**	
	Operations	✔
1	**Use biosolids that stay consolidated and non-flowing; shape stockpiles whenever possible to shed water**	
2	**Minimize ponding and storage time to the extent feasible during hot, humid weather; manage accumulated water appropriately**	
3	**Inspect and maintain up-slope water diversions**	
4	**Inspect buffer zones to ensure run-off is not moving out of bounds**	
5	**Restrict public access and use temporary fencing to exclude livestock, where applicable; install signs; secure site appropriately**	
6	**Clean all vehicles and equipment before they exit onto public roads**	
7	**Train employees to use of appropriate sanitation practices; inspect for use**	
8	**Inspect for odors and conditions conducive to odors; apply chemicals or surface covering material to suppress odors if needed; consider the meteorological conditions and the potential for off-site odors when scheduling opening the storage pile and spreading of biosolids**	

Figure 5-1. Daily biosolids deliveries are temporarily stored in a steel box fabricated from two intermodal freight containers (Snoqualmie Tree Farm, WA). The box breaks down and stacks together lengthwise for relatively easy relocation to the next unloading site. Biosolids are loaded from the containers into the Aero-Spread applicator by a clam bucket.

Figure 5-2. Temporary stockpiles of biosolids in Maine covered with lime mud (high pH) that acts as an odor control measure until material is incorporated. (Courtesy of Mark King, Maine Dept. Environmental Protection)

III. Field Storage: Constructed Facilities

Introduction

A checklist of the items discussed in this section appears on page 59.

Longer-term storage is often conducted at constructed facilities where additional steps and management practices have been implemented to protect human health and the environment. Constructed facilities include: concrete, asphalt, clay, or compacted earth pads; lagoons; tanks; or other structures that can be used continually to store liquid, semi-solid or solid biosolids. Generally these facilities are made of impervious materials that prevent leaching and have specific design components to manage precipitation and runoff.

Design and management options presented here for short- or long-term storage of biosolids, are based on current technologies and actual experiences. These options are not the only effective ones. New or innovative options may provide equal or better management.

Design Considerations

Field stockpiling is generally limited to the amount of biosolids needed to meet agronomic or reclamation requirements at a field or site. Determining the storage period and suitable capacity for a constructed facility is more variable, and is a critical component of most well managed land application programs. If the capacity is for too short a period, the facility may fill before the biosolids can be used in a sound manner. A design that is based on an overly long storage period may result in an unjustifiable expenditure for unused storage capacity.

Factors to consider in determining the storage period include the daily production at the WWTP, storage alternatives, climate and land use characteristics, equipment and labor requirements, and management flexibility. The larger the capacity for storage, the greater the flexibility in managing biosolids to accommodate weather, equipment, etc.

Constructed facilities should be designed and built in accordance with good engineering principles. Excellent guidance on these types of facilities is available in the Natural Resources Conservation Service (NRCS) design manuals for animal manure storage facilities. State and local regulatory requirements and design criteria provide details. The time vs. amount vs. management intensity relationship applies to these facilities as much as it does to stockpiles. Table 5-1 provides key design considerations for the three types of constructed facilities customarily used to store biosolids products:

- Lagoons for liquid or dewatered biosolids
- Pads or other facilities for dewatered or dry biosolids
- Storage tanks for liquids

Table 5-1: Key Design Concepts for Constructed Biosolids Storage Facilities

	Liquid/ Thickened	Dewatered/Dry Biosolids Facilities		Liquid/ Thickened
	1-12% solids	*12-30% solids/ >50% solids (dry)*		*1-12% solids*
Issue	**Lagoons**	**Pads/Basins**	**Enclosed Buildings**	**Tanks**
Design	Below ground excavation. Impermeable liner of concrete, geotextile, or compacted earth.	Above ground, impermeable liner of concrete, asphalt, or compacted earth	Roofed, open-sided or enclosed. Flooring: concrete, asphalt, or compacted earth	Above or below ground, concrete, metal or prefab. If enclosed - ventilation needed
Capacity	Expected biosolids volume + expected precipitation +freeboard	Expected biosolids volume, unless precipitation is retained; then, biosolids volume + expected precipitation +freeboard	Expected biosolids volume	Enclosed: expected biosolids volume. If open-top - expected biosolids volume + expected precipitation +freeboard
Accumulated Water Management	Pump out and spray irrigate or land apply the liquid, haul to WWTP, or mix with biosolids	Sumps/pumps if facility is a basin for collection of water for spray irrigation, land apply or haul to a WWTP	Roof and gutter system, enclosure, or up-slope diversions	Decant and spray irrigate, land apply or haul to WWTP or mix with biosolids in tank
Runoff Management	Diversions to keep runoff out of lagoon	Diversions to keep runoff out of site, curbs and/or sumps to collect water for removal or down-slope filter strips or treatment ponds	Enclosure or up-slope diversions	Prevent gravity outflows from pipes and fittings. Diversions for open, below ground tanks
Biosolids Consistency	Liquid or dewatered - removal with pumps, cranes or loaders	If no side-walls, material must stack without flowing	Material must stack well enough to remain inside	Liquid or dewatered biosolids. If enclosed, material must be liquid enough to pump.
Safety	Drowning hazard - post warnings, fence, locked gates and rescue equipment on site	Drowning hazard - post warnings, fences, locking gates, and rescue equipment on site	Post 'No Trespassing',\ signs, remote location, lock doors, gates & fences	Posted warning., locking access points, e.g., use hatches, controlled access ladders, and confined space entry procedures to access

Lagoon Storage

Storage lagoons need to be large enough to provide adequate biosolids storage volumes during worst-case weather conditions (long periods of inclement weather when field application is restricted and the lagoon storage cannot be emptied). The design volume must also include space for accumulation of precipitation expected over the storage period plus capacity to hold severe storm events (e.g., a 2-year, 24-hour design storm). Lagoons must also have adequate freeboard (the distance from the maximum water level to the top of the berm).

An impermeable liner (i.e. earthen, geotextile, or concrete) is recommended to ensure against loss of biosolids constituents to groundwater by leaching. This type of design may negate the need for groundwater monitoring wells. Liners should be protected from damage by restricting vehicle access to concrete ramps and vehicle lanes. If vehicles must traverse the liner surface or if dredges will be used to remove biosolids, a layer of sand (approximately one-foot thick) or clay should be spread over the liner. This sand or clay base is protection in itself and provides a marker to indicate when removal operations are approaching the liner.

Fig. 5-5 A lined lagoon *(Courtesy of BioGro Division).*

Dewatered/Dry Biosolids Storage Facilities

Dewatered/dry biosolids storage facilities can be covered or uncovered and are designed to provide up to two years of storage for Class A or B dewatered, air-dried, heat dried, or composted biosolids. These facilities include open-sided or enclosed buildings and open topped bunkers or pads. Storage facilities need to be large enough to provide adequate biosolids storage volumes during worst-case weather conditions (long periods of inclement weather when field application is restricted and the facility cannot be emptied). If the facility is not under roof, the design must provide for stormwater retention apart from the stored biosolids with sufficient volume for precipitation accumulation or provide other management measures that prevent accumulation.

Unroofed facilities for semisolid cake materials (Class B or Class A with less than 50 percent solids) should have a durable hard pad with push walls and stormwater curbs, containment walls, and sumps. An impermeable floor is recommended to help control runoff, protect against loss of biosolids constituents to groundwater by leaching, and to accommodate vehicle traffic. Recommended materials include concrete or asphalt in humid areas; arid areas may also use compacted soils. Class A material with greater than 50 percent solids (compost, alkaline stabilized etc.) may be stored on bare ground or gravel with appropriate runoff controls, such as straw bales, sediment fence, and grassed filter strips. Facilities with roofs or impermeable floors, when accompanied by appropriate stormwater management provisions protect groundwater.

Figure 5-4. Concrete storage bunker with block push walls (Courtesy Mark King, Maine Dept. of Environmental Protection).

Figure 5-5. Permanent covered storage in Southern Maine (Courtesy Mark King, Maine Dept. Environmental Protection).

Storage Tanks

Storage tanks for Class A and Class B liquid biosolids may be temporary or permanent, above- or belowground structures. They are watertight and are generally concrete or steel structures, which may be prefabricated or constructed entirely on-site. Due to their impervious nature, these facilities generally do not warrant groundwater-monitoring wells -- particularly aboveground tanks.

Storage tanks may be open-topped or enclosed. Like lagoons, open-topped storage tanks must include space for expected precipitation accumulations, plus adequate freeboard. The tank volumes need to be large enough to contain daily biosolids produced during worst-case periods of inclement weather, or, back-up options must be part of the planning process.

Ventilation

Enclosed storage tanks should be ventilated through passive vents or mechanical fans. Depending on the type of biosolids, tank design, climatic conditions, and airflow rates, a gas meter and alarm system tied to ventilation fans may be advisable to eliminate buildup of explosive levels of methane that might result from anaerobic biological activity in the tank. Specific requirements for ventilation and electrical systems on or in the immediate vicinity of different types of enclosed storage facilities are specified in the National Electric Code requirements adopted by the National Fire Protection Association. Post "No Smoking" and "Confined Space" signs on all enclosed storage tanks.

Spills

Aboveground tanks have the potential for spills due to gravity flow of biosolids. Two approaches to protect from accidental spills are:

1. The tank may be designed so that valves and piping on the tank do not allow material to flow out by force of gravity (top feeding systems). In these systems, biosolids are lifted in and out of the tank by pumps. This prevents spills in the event that a valve is damaged by equipment or if an operator fails to shut the valve.

2. For gravity discharge systems, backflow prevention and emergency cut-off valves should be installed on all piping and valves located at elevations lower than the highest potential liquid level of the tank.

Berms

An earthen containment berm may be advisable if the facility is located fairly close to a drainage-way, surface waters, or other sensitive feature. The containment berm should be designed to retard the movement of biosolids spilled from a tanker truck, handling equipment, or the tank itself. The containment berm should detain a spill long enough for it to be cleaned up but include a dewatering device that will prevent ponding of rainwater (see Appendix D for diagrams of berms).

More on Water Management

Surface Runoff/Erosion Controls

During Construction - Control of stormwater and runoff during construction of storage facilities is essential and may be regulated by federal, state or local erosion and sediment control and stormwater regulations. Erosion and sediment controls may include installation of up-slope runoff diversions to keep stormwater from crossing the construction area and by installation of silt fence or other structures along the lower perimeter of the disturbed area to trap stormwater and/or sediment. Areas disturbed during construction should be stabilized to prevent erosion by seeding and mulching.

After Construction - Depending on the type of constructed facility, it also may be necessary to install permanent diversions to keep up-slope surface runoff from entering facilities and other down-slope water management structures. Specifications for erosion and sediment control practices are available at local planning offices and Natural Resources Conservation Service (NRCS) offices. (See Appendix C).

Management of Accumulated Water

Accumulated water (i.e., precipitation) that forms a separate layer on top of liquid or semi-solid biosolids, or collects in puddles after contact with biosolids, is the primary cause of odors at storage facilities. There are two design approaches, prevention and mitigation, for dealing with water accumulation at storage facilities constructed for dewatered and dry biosolids:

Prevention **-** Construct roofed facilities to prevent water or precipitation from contacting biosolids, and provide additional water management as needed.

Mitigation -

1. Construct curbs, gutters, and sumps at unroofed facilities to collect and manage water that has come into contact with the biosolids; treat such water as liquid biosolids; and/or,
2. Establish gravity flow to on-site filter strips or treatment ponds. In arid regions of the U.S., accumulated precipitation may not need to be managed due to evaporation deficits; and/or,
3. Mix accumulated water with the biosolids, or decant it from the storage facility as quickly and regularly as possible -- especially during warm weather. Use an irrigation system or truck spray system for land application or back haul to the treatment facility (this option may be complicated by expensive tip fees or treatment plant acceptance limits on BOD and nitrogen concentrations).
4. Application to land should be based on nutrient loading rates and hydraulic loading limits to prevent ponding or runoff to adjacent land.

Land application of accumulated water should be treated under state and federal regulations as liquid biosolids, if the water has come in contact with biosolids, and all biosolids management practices and site restrictions should apply. State nutrient management plan requirements will specify nutrient testing. In the absence of state requirements, nutrient testing is recommended. When planning to irrigate accumulated water make sure that adequate land will be accessible when it is needed. Also, check state and local regulations regarding land application in the winter.

Effects of Storage: Application Rate Adjustments

The longer biosolids are stored, the more important it is to retest for nutrients. Before removal, biosolids should be sampled and tested for nitrogen, phosphorus, and percent solids. Liquid biosolids increase or decrease in percent solids over time due to precipitation additions or evaporation losses. In addition, settling may occur during storage. Depending on the degree of liquid/solids separation and the amount of recirculation and remixing that can be achieved, the percent solids of the material may vary from the surface to the bottom of the lagoon. Therefore, it is advisable to retest the percent solids of the material as the clean-out proceeds to ensure proper application rates.

Operational Practices for Constructed Facilities

Inspections

Inspections should be regularly scheduled while biosolids are stored in facilities to determine if any maintenance or repairs are necessary. The site should also be checked for odors, proper management of precipitation, housekeeping, and security. Inspections after rainfall events during periods of warm weather are particularly helpful in preventing the development of unacceptable odors. An

inspection report should be completed, documenting the time, date, person conducting the inspection, and any items requiring maintenance, repair, or adjustment.

Visual inspections should include examination of the condition of:

- **Liners**
- **Concrete - Cracks or openings, signs of infiltration, crumbling, or rust**
- **Wood - Splitting, buckling or rotting**
- **Earthen containment walls - Settling, seepage, slumps, or animal burrows**
- **Wall alignment (vertical and horizontal) - curves or bulges**
- **Foundation - erosion or piping**
- **Underdrains - check that they are functioning as intended**

Leak Detection

In addition, every few years the facility should be cleaned so that an internal structural inspection by a qualified individual can be conducted. For lagoons that cannot be emptied, such as clay lined lagoons which should be kept moist to prevent the clay from drying and cracking, liquid balance tests may be performed. These tests monitor the liquid level in the lagoon. A leak is indicated if the liquid level drops more than can be accounted for by precipitation inputs and evaporative losses.

Monitoring Wells

If facilities cannot be emptied and inspected, it may be advisable to install groundwater-monitoring wells, e.g., clay-lined lagoons. Three monitoring wells are recommended -- one up-gradient and two down-gradient (relative to the direction of groundwater movement). Test wells at least annually for nitrate content and coliform bacteria.

Housekeeping and Aesthetics

Regular housekeeping is essential for efficiency, safety and public acceptance. Employees should clean equipment and grounds regularly, and collect and properly dispose of any trash generated; prevent it from blowing to adjacent sites. Sites that are visible from roads or adjacent properties should be regularly mowed and kept neat and clean.

Dust

Vehicle traffic is usually the primary source of dust at storage facilities. Speeds should be limited, and access lanes for larger facilities should be graveled. Dried Class A or Class B and composted materials may be dusty and require appropriate dust abatement in arid, windy climates, such as tarps. Care must be used to be sure the tarps are only used on heat dried biosolids that are

already very dry, and have not been rewetted, or compost that has been well stabilized or there may be re-heating. Tarps place on self-heating materials can enhance heat retention and contribute to spontaneous combustion of materials and fire.

Practices to Prevent Mud or Biosolids from being Tracked onto Public Roadways

1. Vehicles transporting biosolids should be cleaned before they leave the WWTP
2. Concrete or asphalt off-loading pads at the storage facility, will help keep equipment clean and make clean up of drips or spills easier.
3. The storage facility should have provisions to clean trucks and equipment when the need arises. Mud on tires or vehicles can be hand-scraped or removed with a high pressure washer or with compressed air (as long as this does not exacerbate an existing dust problem).
4. All vehicles should be inspected for cleanliness before leaving the site.
5. Use mud flaps on the back of dump trailers to preclude biosolids getting on tires or undercarriage during unloading operations.
6. Install a temporary gravel access pad as necessary at the entrance/exit to avoid soil ruts and tracking of mud onto roads.
7. Public roadways accessing the site should be inspected each day during operational periods, and cleaned promptly (shovel and sweep).

	Critical Control Point 3: Constructed Facilities Checklist *(Involving lagoons, pads, or storage tanks)*	
	Project Management	✔
1	**Prepare and maintain a Storage Site Management Plan with spill plan**	
2	**Critical Control Point 1: Work closely with the WWTP on stability and consistency**	
3	**Critical Control Point 2: Transportation; clearly mark site access routes and unloading areas**	
4	**Train employees to properly operate the storage facility and to perform inspections; conduct spill drills**	
5	**Maintain accurate and well organized records**	
6	**Designate a competent public relations person; maintain communications with stakeholders; notify agencies of reportable incidents; explain actions taken to respond to citizens concerns or complaints**	
	Operations	✔
1	**Minimize ponding and storage time; manage accumulated water properly**	
2	**Inspect and maintain up-and down-slope water diversion/collection systems**	
3	**Inspect and maintain tanks, ponds, curbs, gutters and sumps used to collect runoff**	
4	**Inspect buffer zones to ensure flow is not moving out of bounds**	
5	**Install signs and implement security measures to restrict public access**	
6	**Inspect concrete, wood, earth, walls, foundation and monitoring wells at constructed storage facilities**	
7	**Meet nutrient and hydraulic loading limits and state/local requirements when land applying accumulated water from storage**	
8	**Clean all vehicles and equipment before they exit onto a public road**	
9	**Train employees to use of appropriate sanitation practices; ensure practices are properly followed**	
10	**Retest nutrient and solids content prior to land application to re-calculate land application rate of biosolids, if the characteristics of the biosolids have changed significantly during storage**	
11	**Inspect for odors and conditions conducive to odors; mitigate appropriately**	
12	**Attend to site aesthetics**	

Security

Lagoons, tanks, and some pads or bunkers for storage of liquid or dewatered biosolids are potential drowning hazards. When surface crusts form on the stored biosolids, they deceptively appear as though they will support a person's weight, but they will not. In addition, geotextile liners are generally smooth, and when wet, the sloping walls of lagoons may become so slippery that no foothold can be achieved. Facility perimeters should be posted with warning and no-trespassing signs. Fencing should be installed to keep out people and animals, and locking gates should be installed at vehicle access points. Appropriate rescue equipment such as life rings, lifelines, and poles should be kept on-site.

For aboveground tanks, ladders on the outside of tanks should terminate above the reach of people, or have locked barriers to restrict access to ladders; all access hatches should be locked. Personnel who access enclosed tanks must follow OSHA confined space entry guidelines and procedures, and have access to self-contained oxygen supply equipment when entering tanks.

IV. Odor Prevention and Mitigation

Prevention

Three key efforts to managing stored biosolids in a manner that prevents the development of odors include:

- **Only Store Properly Treated Biosolids**
  Ensure that only properly treated biosolids that meet all state and federal pathogen reduction regulations are delivered to the facility. Unless biosolids will be stored at remote sites for limited periods (60 days) and/or during cool weather months, vector attraction reduction should be met prior to storage.

- **Plan**: Develop written odor control and response plans.

- **Train**: Operator training can increase sensitivity of personnel to odor concerns and ensure proper implementation of the odor control plan.

- **Inspect, Monitor, Respond, and Record**: Regular inspections and odor monitoring, coupled with appropriate corrective action and recordkeeping, will help site and facility managers maintain good neighbor status and public acceptance of the project.

On an operational basis, use of the following management practices (where appropriate) may greatly reduce the potential for unacceptable off-site odors.

Practices to Reduce the Potential for Unacceptable Off-Site Odors

- ✓ Ensure that the WWTP has used processes that minimize odor during processing.
- ✓ Minimize storage time.
- ✓ Monitor and manage any water to prevent stagnant septic water accumulations.
- ✓ Avoid or minimize storage of biosolids during periods of hot and humid weather if possible. During warm weather, check for odors frequently. Use lime or other materials to control odors before they reach unacceptable levels off-site.
- ✓ Empty constructed storage facilities as soon as possible in the spring, for cleaning and inspection; keep idle until the following winter if possible.
- ✓ Select remote sites with generous buffers between sensitive neighbor areas.
- ✓ Consider weather conditions, prevailing wind directions, and the potential for off-site odors when scheduling and conducting clean-out/spreading operations. For example, operations on a hot, humid day, with an air inversion layer, and wind moving in the direction of a residential area on the day of the block party greatly increases the risk of odor complaints.
- ✓ Conduct loading/unloading and spreading operations as quickly and efficiently as possible to minimize the time that odors may be emitted. Surface crusts on stored biosolids seal in odors, but they break during handling, and odors can be released.
- ✓ Enclosed handling or pumping systems at constructed facilities may reduce the potential for odors on a day-to-day basis, but theses facilities still have the potential for odors during off-loading operations when active ventilation is used.
- ✓ Observe good housekeeping practices during facility loading and unloading. Clean trucks and equipment regularly to prevent biosolids build-up that may give rise to odors. If biosolids spills occur, clean up promptly.

Provide local government and state agency representatives with a contact name and number. Ask them to call the storage facility operator immediately if they receive citizen questions, concerns, or odor complaints resulting from storage of biosolids. Operator staff should politely receive citizen questions or complaints, collect the individual's name and phone number, conduct a prompt investigation, undertake control measures, if necessary, follow-up with the person who filed the complaint, and document the event and actions.

Mitigation

If significant odor should develop during handling operations, the following remedial measures can be taken:

Odor Remediation Measures for Use During Handling Operations

- ✓ Immediately correct any poor housekeeping problems (such as dirty equipment).
- ✓ Immediately treat any accumulated water that has turned septic with lime, chlorine, potassium permanganate or other odor control product; remove the water as quickly as possible to a suitable land application site.
- ✓ If odors are arising from lime stabilized biosolids, pH should be measured. If it has dropped below 9.0, lime can be applied, topically to dewatered material, or, in highly liquid systems, lime slurry can be blended into the biosolids by circulation. The pH should be monitored and dosed with lime until the desired pH has been achieved. Raising pH halts organic matter decomposition in the biosolids that can generate odorous compounds.
- ✓ For most types of biosolids (digested, lime stabilized, liquid, dewatered), applying a topical lime slurry will raise surface pH levels, create a crust, and reduce odors. Topical spray applications of potassium permanganate ($KMnO_4$) or enzymatic odor control products to neutralize odorous compounds may also be effective in some situations.
- ✓ Cover biosolids with compost or sawdust.
- ✓ If the odor is due to the combination of wind and weather conditions (hot, humid) and agitation and circulation of biosolids as part of unloading operations, it may be advisable to cease unloading operations until weather conditions are less likely to transport odors to sensitive off-site receptors.
- ✓ Spread and incorporate or inject odorous material as quickly as possible.
- ✓ For enclosed storage facilities, absorptive devices (charcoal or biofilters) incorporated into a ventilation system may be a feasible option for reducing odorous emissions.
- ✓ Cause the WWTP to change its processes to produce less odorous biosolids.

V. Spill Prevention and Response

Prevention

Liquid tankers, and trailers used for semisolid biosolids, should have rubber seals around all hatches and tailgates that can be mechanically tightened to prevent any leakage. At the beginning of each day, inspect the seal integrity on all vehicles. After loading, check each unit for leakage prior to operating the unit on public roadways. Seepage or dripping of biosolids is unacceptable.

When liquid biosolids are being handled, it is recommended that buckets be placed under hose connections to collect any drips when hoses are connected and disconnected. In addition, paving and curbing of the off-loading pad facilitates collection of small quantities of biosolids that may drip or spill.

Spill Response

A spill response plan should be a special part of the site management plan. Examples of the spill response plan and accompanying biosolids fact sheets used by Los Angles County Sanitation District are shown at the end of this chapter. Furthermore, staff should be trained to follow the plan. This means conducting periodic training and 'spill drills' that include training on contact with the media.

To ensure prompt reporting and initiation of clean-up activities, it is recommended that site supervisors have access to cell phones or to two-way radios. Also, road tractors and application equipment should have cell phones. If a spill occurs, the site supervisor should immediately initiate clean-up. The site supervisor should also contact appropriate emergency services if necessary (i.e. fire or rescue); notify supervisors; and communicate with the public on the scene or notify the designated community contact, and appropriate state regulatory agency. Site workers should also have media contact training.

The first step in the clean-up process is to ensure public and worker safety. Next, halt the source of the spill, e.g., a ruptured line or valve or damaged tanker unit, and contain the spill. In the event large quantities of liquid or semi-liquid biosolids are spilled off-site, straw bales, where available, may be used to contain and soak up biosolids.

Once the source is controlled, collect spilled material. For liquid spills, vacuum equipment on biosolids application vehicles can be used to collect as much material as possible. Residual amounts are usually removed by hand shoveling or sweeping. Straw, cat litter, or commercial adsorbents may be spread as necessary to complete removal of the material. Absorbent materials should be swept or shoveled up and taken to a permitted land application site or to an approved landfill. If necessary, roadways may then be flushed with water to complete the clean-up process.

Reporting

Prior to initiating a field storage operation, it may be advisable to contact the local police, fire, and hospital teams to brief them on the facility and its operation, including risks and types of injury that could potentially occur at the site. In the event of a spill or leak, state and local regulators with oversight responsibilities for the facility should be notified as required by state and local regulations. Generally, a written report documenting how the spill occurred and all remedial actions should be completed promptly after the incident and submitted to the regulatory authority or kept on file.

Biosolids Fact Sheet[1]

(Generator/ facility name)

DESCRIPTION

Biosolids (formerly referred to as sewage sludge) are reusable solids from the wastewater treatment process. At_____(treatment plant name), biosolids have been treated by _____(process, e.g. , anaerobic digestion) and dewatered by _____ (process type , e.g., filter presses). The dewatered, semi-solid form is referred to as cake.

Biosolids are not a hazardous material. The biosolids cake produced at _____ _____(treatment plant name) is primarily organic. It is beneficially reused as a soil amendment on agricultural land (land application), _____ (other uses here, e.g., compost). Routine analyses demonstrate that _____ (quality/allowable use, e.g., metals concentrations) meet EPA standards that allow the material to be land applied at unrestricted metals loading rates.

(Further information here, e.g., anaerobic digestion significantly reduces, but does not completely eliminate, pathogens (disease causing microorganisms). Digesters, which are operated at specific time and temperature parameters, produce EPA Class B biosolids. Class B quality is suitable for application to agricultural land in concert with certain EPA site restrictions.)

TYPICAL CHARACTERIZATION

Appearance	**Black, semi-solid**
Total Solids Content	**_____ % (_____ % moisture)**
Free Liquid	**None**
pH	**_____**
Nitrogen	**_____ % (dry weight basis)**
Phospate	**_____ % (dry weight basis)**
Potassium	**_____ % (dry weight basis)**
Metals Content	**_____e.g., Meets EPA Table 3**
Pathogen Reduction	**_____e.g., Meets EPA Class B**
Soluble Metals	**_____e.g., Non-hazardous per_____ STLC and TTLC**

(State)

HANDLING PRACTICES[2]

Biosolids are treated to reduce pathogens. Nonetheless, there is the potential for exposure to pathogenic microorganisms. Major routes of infection are ingestion, inhalation and direct contact. Good, common sense, personal hygiene and work habits provide adequate protection for workers handling biosolids. Recommendations include:

[1]Fact sheet was provided courtesy of Los Angeles County Sanitation District

[2]Much of the information contained herein was taken from Biological Hazards at Wastewater Treatment Facilities, Water Environment Federation (formerly, Water Pollution Control Federation), 1991.

- **Always wash hands after contact with biosolids.**
- **Avoid touching face, mouth, eyes, nose, or genitalia before washing hands.**
- **Eat in designated areas away from biosolids handling activities.**
- **Do not smoke or chew tobacco or gum while working in direct contact with biosolids**
- **Use gloves, when applicable.**
- **Keep wounds covered with clean, dry bandages.**
- **Change into clean work clothing on a daily basis.**
- **If contact occurs, wash contact area thoroughly with soap and water. Use antiseptic solutions on wounds, and bandage with a clean, dry dressing. For contact with eyes, flush thoroughly but gently.**
- **The Centers for Disease Control recommends that immunizations for diphtheria and tetanus be current for the general public. Boosters are recommended every ten years. The tetanus booster should be repeated in the case of a wound that becomes dirty if the previous booster is over five years old. Consult a doctor regarding direct exposure to an open wound or mouth.**

HAZARD POTENTIAL

Biosolids are not combustible under ordinary circumstances. If stored in airtight containers for an extended period, methane gas may be produced which could ignite in the presence of a spark or open flame. Extinguish with dry chemical, water spray or foam. Avoid use of open flames in confined areas and around sealed transport containers. Vent confined areas and transport containers if biosolids have been stored for any significant length of time.

Hydrogen sulfide may also be generated in sufficient quantities to be a hazard in enclosed areas such as tarpped transport containers. Hydrogen sulfide gas, which smells like rotten eggs, can be toxic. Exposure can be avoided by removing the container tarp prior to unloading, and discharging as much material as possible prior to employees entering the container.

GENERATOR DATA

Generator Name
Address
City, State, Zip Code
Area Code & Phone Number
Contact

Facility Name (if different)
Address
City, State, Zip Code
Area Code &Phone Number
Contact

Biosolids Hauler Spill Response Procedure[3]

1. General

A. Biosolids are non-hazardous and non-toxic. If a spill occurs, there is no need for special equipment or emergency protocol beyond that outlined in this procedure. Biosolids are primarily processed solids produced by sewage treatment plants.

B. Biosolids spilled onto pavement pose a potential road hazard because they can create wet, slick surfaces for motor vehicles, and/or can obstruct traffic flow. If biosolids remain on the surface for a sufficient time, they could be a source of potential contamination of nearby storm drains, waterways, or ground water. Biosolids should be thoroughly removed so that no significant residues remain to be washed into any storm drain or waterway by surface water. All spilled biosolids must be returned to the trailer from which they spilled, or be loaded into another appropriate transport vehicle.

2. Biosolids Characteristics and Personal Hygiene Procedures

A. Biosolids are processed organic residual solids from domestic sewage treatment, containing nitrogen, phosphorus, trace metals, and some pathogenic (disease-causing) organisms. Biosolids being transported are typically _____ % total solids, with a _____consistency (Fill in description). Biosolids become dirt-like when solids exceed 45%. The material contains x % volatile solids, with a pH of .

B. Personnel cleaning up a spill of biosolids should:

- Wear gloves for shoveling, sweeping or handling biosolids.
- Not eat, drink, smoke or chew while working directly with biosolids
- Wash hands (and as necessary all other exposed parts of the body) with waterless hand cleaner, or soap and water, following spill clean-up and prior to eating, drinking, smoking or chewing.

3. Over-the-Road Spill Response Procedures

A. Park the truck on the side of the road and place traffic cones, reflectors and/or flares to divert traffic around the spill. Remain with the truck and spilled materials, unless it is necessary to leave temporarily to contact emergency services.

B. Drivers shall notify their Supervisor as soon as possible by radio or by phone (Area code & phone number) _____. Give the location and amount of biosolids spilled. Also notify the California Highway Patrol by telephone [911], if the spill has occurred on a public right of way.

[3] ***Procedure courtesy of Los Angeles County Sanitation District***

C. Inform the authorities that you are hauling biosolids which is non-hazardous and non-toxic.

D. Cooperate with the authorities, assist with traffic control and clean-up.

E. Do not leave the scene of any spill, even a small one, until it is cleaned up. You may clean up small spills first and then report the spill.

4. Spill Response Procedures

A. Load spilled biosolids back into the vehicle if it is operable. If the vehicle is disabled, the spill must be loaded into an alternate vehicle.

B. Spilled biosolids must be prevented from migrating off the incident site, into storm drains, or into surface waters. This is especially important if an incident occurs in rain conditions. Biosolids spills may be diked or controlled with sand, sand bags, straw, absorbents, or other blocking material.

C. Two people working with shovels can load a small spill into a vehicle. A large spill must be loaded into the vehicle by an appropriate rubber tired loader. The scene coordinator is best suited to choose the appropriate loading option to deal with the spill, based on equipment availability and spill size.

D. After the spill has been loaded, the incident site must be cleaned. Spills may be cleaned by sweeping the site free of remaining debris. Do not wash off tools or trucks at the spill location; return tools and trucks to the wastewater treatment plant for cleaning.

E. Cleaned up spills should either be taken to the original destination or to a landfill permitted to receive biosolids. They may also be accepted by the originating sewage treatment plan.

F. Spill response drills should be conducted periodically.

References

Brinton, W.F., Jr., E. Evans, M.L. Droffner, and R.B. Brinton. 1995 Standardized test for evaluation of compost self heating. BioCycle 36 (11): 64-69.

National Fire Protection Association. 1994. NFPA 298: Standard on Fire Fighting Foam, Chemicals for Class A Fuels in Rural, Suburban, and Vegetated Areas. NFPA, Quincy, MA

National Fire Protection Association. 1997. NFPA 299: Standard for Protection of Life and Property from Wildfire. NFPA, Quincy, MA

NRCS. 1992. Agricultural Waste Management Field Handbook, Part 651. National Engineering Handbook 210-VI. Natural Resource Conservation Service, USDA.

Sullivan, D.M., D.M. Granatstein, C.G. Cogger, C.L. Henry, and K/P. Dorsey. 1993. Biosolids management guidlines for Washington State. Washington State Dept. of Ecology Publication 93-80.

Sullivan, D.M. 1999. Towaqrd Quality Biosolids Management: A Trainer's Manual. Northwest Biosolids Management Assoc. Seattle, WA.

USDA. National Handbook of Conservation Practices. Natural Resource Conservation Service. http://www.ftw.nrcs.usda.gov/nhcp_2.html for specific engineering and practice standards about Diversion (362), Composting Facility (317), Field Border (386), Filter Strip (393), Hillside Ditch (423), Runoff Management System (570), Waste Management System (312), Waste Storage Facility (313), Waste Treatment Lagoon (359), Waste Utilization (633).

USDA. 1992. Agricultural Waste Management Field Handbook, Part 651. National Engineering Handbook 210-VI. Natural Resource Conservation Service. Washington, D.C.

Wilber, C. (ed.) 2000. Operations and Design at the Wastewater Treatment Plant to Control Ultimate Recycling and Disposal Odors of Biosolids. USEPA sponsored project.