United States Department of Agriculture

Natural Resources Conservation Service

CONSERVATION PRACTICE STANDARD

HEAVY USE AREA PROTECTION

CODE 561

(sf)

DEFINITION

Stabilization or protection of an intensively used area.

PURPOSE

This practice is used to accomplish one or more of the following purposes:

- Reduce soil erosion
- Provide a stable, noneroding surface for areas frequently used by animals, people, or vehicles
- Protect or improve water quality

CONDITIONS WHERE PRACTICE APPLIES

This practice applies to all land uses where a frequently or intensively used area requires relocation ortreatment to address one or more resource concerns.

CRITERIA

General Criteria Applicable to All Purposes

All planned work must comply with Federal, State, Tribal, and local laws, and permit regulations. The landowner is responsible for obtaining any required permits.

Design load

Base the design load on the type and frequency of traffic (vehicular, animal, or human) anticipated on the heavy use area.

Foundation

Evaluate the site foundation to ensure that the presumptive bearing capacity of the soil meets the intended design load and frequency of use for the anticipated climate conditions. Prepare the foundation by removal and disposal of materials that are not adequate to support the design loads.

Use a base course of gravel, *crushed stone*[1], other suitable material, geotextile, or a combination of materials on all sites that need increased load-bearing strength, drainage, separation of material,

[1] Words in the standard that are shown in italics and underlined are described in the Glossary section. The words are italicized the first time they are used in the text.

and soil reinforcement. Refer to NRCS Technical Note (Title 210), Design Engineering, Design Note 24, "Guide for the Use of Geotextiles," or NEH, Part 650, Engineering Field Handbook (EFH), Chapter 17, WI Supplement.

Surface treatments

Select a surface treatment that is stable and appropriate to the purpose of the heavy use area. Use concrete, bituminous concrete pavement, cementitious materials, mulches, aggregates, geotextiles, or a combination of materials to prevent punching or rutting failure in a heavy use area. Surface treatments must meet the following requirements according to the material used.

Concrete

Design concrete structures in accordance with NRCS National Engineering Manual (NEM) (Title 210), Part 536, "Structural Engineering."

Slabs-on-ground subject to cattle traffic or infrequent use by light agricultural equipment may utilize the surfacing options listed in Table 1.

Design slabs-on-ground subject to distributed stationary loads, light vehicular traffic, or infrequent use by heavy trucks or agricultural equipment in accordance with American Concrete Institute (ACI) Guide for the Design and Construction of Concrete Parking Lots (ACI 330R).

Design slabs-on-ground subject to regular or frequent heavy truck or heavy agricultural equipment traffic in accordance with the Guide to Design of Slabs-on-Ground (ACI 360R) or Guide to Design with Fiber-Reinforced Concrete, Macro-Synthetic Polyolefin Fibers, (ACI 533.4R-18).

Bituminous concrete pavement

Refer to the American Association of State Highway and Transportation Officials (AASHTO) "Guide for Design of Pavement Structures" or the ~~applicable State highway department's specification for design criteria for bituminous concrete paving.~~Wisconsin Asphalt Pavement Association (WAPA) 2001 Design Guide for designing the bituminous concrete pavement.

In lieu of a site-specific design for areas that will be subject to light use, pave with a minimum of 4 inches of compacted bituminous concrete over a subgrade of at least ~~4~~ 6 inches of well-compacted gravel. Use bituminous concrete mixtures commonly used for road paving in the area.

Other cementitious materials

Cementitious materials such as soil cement, agricultural lime, roller-compacted concrete, and coal combustion byproducts (flue gas desulphurization sludge and fly ash) can be used to provide a durable, stable surfacing material. Based on the properties of the surface material, develop a site-specific mix design with compressive strengths necessary for the expected use and loading on the heavy use area. Select materials that are nontoxic and that have chemical properties that are compatible with the intended use.

Aggregate

Design aggregate surfaces for expected wear and intended use. In lieu of a site-specific design for areas that will be subject to light nonvehicular use, ~~install a minimum combined thickness for aggregate surfacing and base course of 6 inches for animals and 4 inches for other applications.~~use Table 1.

For other applications, use NRCS Technical Note (Title 210), Agricultural and Biological Engineering, Agricultural Engineering Technical Note 4, "Earth and Aggregate Surfacing Design Guide," or other appropriate methodology to design aggregate thickness.

Mulches

Use a minimum layer thickness of 6 inches for materials such as limestone screenings, cinders, tanbark, bark mulch, brick chips, or shredded rubber. Mulches are not recommended for livestock or vehicular applications.

Vegetation

Use vegetative measures only on areas where traffic can be managed so the vegetative cover can be maintained. Select grass species or other plant materials that are wear resistant, have fast recovery from heavy use, and are suitable to the site. Establish the vegetation in accordance with the criteria in NRCS Critical Area Planting (Code 342)

~~For heavy use areas managed as vegetated lots, provide an adequate number of lots in the system to allow the vegetation to be sustained by moving the animals. Establish a rotation that ensures the vegetated lot will be used only when vegetation has had time to recover between animal activities.~~

~~Other~~

~~Other materials can be used for surface treatment if they will serve the intended purpose and design life.~~

Drainage

Include provisions in the design for surface and subsurface drainage, as needed. Design positive grade in the planned direction of flow. Fill low areas that may contribute to subgrade instability or ground water contamination.

Diversion of clean water

To the extent possible, prevent surface water from entering the heavy use area. Refer to NRCS CPSs Diversion (Code 362), Underground Outlet (Code 620), Roofs and Covers (Code 367), Roof Runoff Structure (Code 558), or other appropriate CPSs for drainage control.

Stabilization and erosion control

Stabilize all areas disturbed by construction as soon as possible after construction. Refer to the criteria in NRCS CPS Critical Area Planting (Code 342) for establishment of vegetation. If vegetation is not appropriate for the site, use the criteria in NRCS CPS Mulching (Code 484) to stabilize the disturbed area.

Water quality

If there is the potential for ground water contamination from the heavy use area, select another site or provide an impervious surface to reduce infiltration of pollutants. Use Tables 2, 3, or 4 for storage areas if groundwater contamination is a resource concern.

For heavy use areas with surface water quality concerns, relocate the site or make provisions to collect, store, treat, or utilize contaminated surface runoff from the heavy use area. Include provisions to address runoff without causing erosion or water quality impairment. Use NRCS CPSs Waste Transfer (Code 634), *Vegetated Treatment Area* (Code 635), Critical Area Planting (Code 342), Fence (Code 382), Prescribed Grazing (Code 528), Filter Strip (Code 393), Access Control (Code 472), or other similar CPSs as supporting practices, when needed.

Recreation

Address accessibility requirements for new construction and when existing facilities are being altered. The Americans with Disabilities Act of 1990 (ADA) requires recreation areas that are used by the public to be accessible to people with disabilities.

Separation from Subsurface Saturation or Bedrock

Use the criteria in Tables 1, 2, 3, 4, or 5 to determine separation distance from subsurface saturation or bedrock.

Subsurface saturation and bedrock are defined in NRCS CPS Waste Storage Facility (Code 313). The criteria for handling subsurface saturation and bedrock separation is also included in NRCS CPS 313.

Additional Criteria for *Permanent Feed Storage Areas*

These criteria apply to *feed storage areas* to evaluate and address *leachate* and runoff for the protection of ground and surface water.

This practice standard criteria does not apply to the conditions listed below. Consult with the Wisconsin Department of Natural Resources (DNR) on feed storage, feed storage leachate collection, and *contaminated runoff* control for a Concentrated Animal Feeding Operation (CAFO) in accordance with NR 243, Wis. Adm. Code.

- Industrial inputs or waste stored at an industrial facility (i.e., cannery, distillery, brewery);
- Commercial feed mills;
- Feeds considered dry (40% moisture or less) within storage areas protected from precipitation;
- Feed bunk/equipment; and
- Self-feeding structures (non-mobile).

Management Assessment

Conduct a management assessment of the existing and proposed feed storage areas with the owner/operator to document feed characteristics, management objectives, options, and available resources to handle feed. Include the following:

- Waste characterization – consistency, volume, nutrient content, sources;
- Current equipment, labor, and management capabilities;
- Expected changes to equipment, labor, management, and expansion needs; and
- Strategy for transfer, storage, and land application of contaminated runoff and leachate.

Site Assessment

Conduct a site assessment to describe the physical site characteristics that will influence the construction, maintenance, and environmental integrity of a proposed feed storage area. Include the following:

- Locations of buildings, roads, lanes, soil test pits, property lines, setbacks, easements, wells, surface water features, surface drains, drain tile, utilities, cultural resources, and wetlands.
- If an existing feed storage area will be expanded or a tower silo is part of the project, then perform a test pit or boring to check for contamination from existing feed storage areas.
- Test pits or soil boring logs, soil test results, a soil survey photo and a narrative describing the design parameters that have been derived from the soils data. Extend test pit/soil borings to bedrock, a free water surface, or to a minimum depth to ensure the required separation distances for the proposed component are achieved. Include the number, depth, and distribution of pits or logs needed to characterize subsurface conditions.
    - Based on the facility *footprint*, dig a minimum of one test pit or boring per 15,000 square feet of footprint, with a minimum of two per facility. Locate test pits and borings in the footprint or no more than 100 feet from the footprint of proposed feed storage areas. Locate test pits/borings at the edge of existing feed storage areas. Add test pits or borings if there is inconsistency within or between test pits or borings. A feed storage area and a vegetated treatment area (VTA) for runoff treatment are considered separate facilities.
    - Soil layers with respect to thickness, texture using the Unified Soil Classification System (USCS) as per ASTM D2488. Include Munsell color, presence and color of redoximorphic features (soil mottling), *gleyed soil* and moisture conditions.

- Elevation of bedrock and bedrock type encountered such as sandstone, limestone, dolomite, or granite.
- Upper elevation of all saturated layers encountered

- Locations of *sinkholes* and other karst features within 1,000 feet of the facility.
- Locations, dimensions, elevations, soil volumes, soil samples, and reclamation plans of any borrow areas. Characterize borrow areas used to level the proposed feed storage area.
- Identification of potential impacts from failure of system components.

Separation from Subsurface Saturation or Bedrock

For the purposes of this standard, use factors to identify subsurface saturation such as observed saturation, gleyed soil, gray mottles, and soil color in conjunction with nearby surface water features. Identify the highest subsurface saturation elevation in a test pit/soil boring using the following soil properties.

- Free water or wet soil identified by glistening due to the slow release of water.
- Gleyed soil that may extend uninterrupted from an observed free water surface.
- The presence of distinct gray redoximorphic features with a chroma of 2 or less based on Munsell color charts.
- Depleted matrices having a value of 4 or more and chroma 2 or less based on Munsell color charts. In some cases soil parent materials have a natural color of 2 chroma or less or gleyed color that is not due to saturation. In these cases other indicators may be used: landscape position, elevation or soils in relation to nearby water features

In soils not conducive to mottling, such as sand, determine the subsurface saturation elevation by evaluating morphology of the soil profile, position of the soil in the landscape, topography, nearby wetlands and well construction logs.

Do not drain saturated soils (or have water-bearing layers removed) except as described for *perched conditions*. Perched conditions may be drained or water-bearing materials removed to achieve separation distances and relieve hydrostatic pressure. Document that subsurface saturation are perched and of drainable extent. Evaluate the effect of tailwater on drainage outlets. Locate *drainage systems* around the outside perimeter of the structural footprint and drain to a surface outlet.

If the site assessment indicates artesian features, complete a hydrogeologic and geotechnical evaluation of the site to determine the site suitability for in-ground components.

Excavation of bedrock is permitted to achieve the required separation distance as specified in the tables. Do not remove bedrock by blasting. Evaluate the competency of exposed bedrock surface to determine if it is fractured, weathered, or solid. Treat fractures or voids to prevent migration of soil material. Ensure the surface of excavated bedrock has a positive grade, minimum of 1 percent, under and away from the storage facility, as to prevent any significant ponding on the rock surface. If bedrock is excavated, ensure the material placed between the component and the bedrock has a minimum of 20 percent passing the No. 200 sieve.

Leachate Collection Below Permanent Feed Storage Areas

Feed storage bunkers can lose leachate through the floor (subsurface discharge) and around the perimeter (surface discharge).

When groundwater contamination is a resource concern, incorporate an earthen liner, flexible membrane liner, concrete with waterstop or concrete-soil composite liner that meets the criteria in Tables 2, 3, and 4.

If the surfacing material is permeable, include a subsurface collection system to intercept and direct leachate to a storage or treatment area. A subsurface collection system consists of a suitable subgrade, liner, and *leachate drainage layer* below the surfacing material of the feed storage area and the apron. Grade the collection system to flow by gravity to a low point (sump or underground outlet). Follow the liner criteria for feed storage areas in Tables 2, 3, and 4. If leachate is detected under or adjacent to an existing feed storage area or tower silo, install a subsurface collection system around the perimeter of the feed storage area to collect the leachate.

When surface water contamination is a resource concern, collect the contaminated rainfall runoff and compressed leachate from the feed storage area. Transfer the effluent to a storage or treatment area in accordance with the criteria in Waste Transfer (Code 634), Waste Storage Facility (Code 313), or Vegetated Treatment Area (Code 635). Land apply the effluent in accordance with the criteria in a Nutrient Management Plan (Code 590).

The leachate design volume is based on the harvest that will produce the largest unit weight of silage. The leachate design volume is ½ cubic foot of leachate per ton of stored feed. This represents the estimated 30-day volume. Unless determined otherwise, use 33.3 cubic feet per ton of stored feed.

Storage or transfer systems that require manual emptying shall be sized to contain a minimum of 20 percent of the leachate design volume and any initial runoff volume collected.

All pumps shall be capable of transferring effluent with fibrous material and be able to withstand acidic corrosive environment. Install and use pumps in accordance with the manufacturer's recommendations.

Safety

Identify and minimize the hazards to animals and people. At a minimum, safety design shall include the following, where applicable:

1. Warning signs and fences to notify of potential hazards.
2. Minimize the accumulation of gasses; provide ventilation for covered waste-holding structures to reduce the risk of inhalation of poisonous gasses, asphyxiation, or explosion. Note: Adding leachate to manure can produce poisonous gasses.

   If the facility includes a *confined space*, configure the confined space in such a way that monitoring for hazardous gases, ventilation, observation of workers in the confined space, and extraction of workers from the confined space are all possible and practicable. Follow provisions of American Society of Agricultural and Biological Engineers (ASABE) Standard EP 470.

Seeding and Mulching

Seed and mulch disturbed areas in accordance with NRCS CPS Critical Area Planting (Code 342) and NRCS CPS Mulching (Code 484).

Additional Criteria for *Non-Permanent Feed Storage Areas*

Do not store feed with over 75 percent moisture on non-permanent areas. Rotate the storage site annually and do not re-visit that location for a minimum of two consecutive years. Move the feed a minimum of 50 feet and re-vegetate the previous location. Meet the minimum criteria in Table 5.

CONSIDERATIONS

Heavy use areas can have a significant impact on adjoining land uses. These impacts can be environmental, visual, and cultural. Select a treatment that is compatible with adjoining areas. Consider such things as proximity to neighbors and the land use where the stabilization will take place.

Vegetated heavy use areas may need additional materials such as geogrids or other reinforcing techniques or planned periods of rest and recovery to ensure that vegetative stabilization will succeed.

Consider the safety of the users during the design. Avoid slippery surfaces, sharp corners, or surfaces and structures that might entrap users. For heavy use areas used by animals, avoid the use of angular aggregates that might injure livestock. When concrete is used for livestock imprint or texture concrete to provide traction in wet or freezing conditions.

Paving or otherwise reducing the permeability of the heavily used area can reduce infiltration and increase surface runoff. Depending on the size of the heavy use area, this can have an impact on the water budget of the surrounding area. Consider the effects to ground and surface water.

Consider the effects on improved animal health from the installation of heavy use area protection on muddy sites. Mud transmits bacterial and fungal diseases and provides a breeding ground for flies. Hoof suction makes it difficult for cattle to move around in muddy areas. In addition, mud negates the insulation value of hair coat and the animals must use more energy to keep warm. As temperatures fall, animal bunching may occur, which can reduce or eliminate vegetative cover and lead to erosion and water quality concerns.

To reduce the negative water quality impact of heavy use areas, consider locating them as far as possible from water bodies or water courses. In some cases, this may require relocating the heavily used area rather than just armoring an area that is already in use.

~~To the extent possible, maintain a 2-foot separation distance between the bottom of the surface material and the *subsurface saturation* or bedrock.~~

To reduce the potential for air quality problems from particulate matter associated with a heavy use area, consider the use of NRCS CPSs Windbreak/Shelterbelt Establishment (Code 380), Herbaceous Wind Barriers (Code 603), Dust Control from Animal Activity on Open Lot Surfaces (Code 375), or Dust Control on Unpaved Roads and Surfaces (Code 373) to control dust from heavy use areas.

Consider ways to reduce the size of the heavy use area as much as possible. This may require changes in how the livestock are managed but in the long run may result in less maintenance and a more efficient operation.

Consider a concrete or other durable surface for areas that require frequent scraping.

Considerations for Feed Storage Areas.

Limit how much feed is exposed to precipitation while removing plastic and/or feed from storage to reduce contaminated runoff and prevent waste.

If a runoff or collection system uses a sump and pump, incorporate a marker and high water level alarm. A run-time indicator on the pump provides insight into the transfer volume for management adjustments.

Consider a sediment basin to remove solids prior to entering a transfer system or vegetated treatment area. Design the sediment basin according to NRCS CPS Waste Separation Facility (Code 632).

Cover silage and bunker walls with plastic to exclude precipitation and prevent feed waste.

Use acid resistant materials (to pH 3.5) that will be in contact with feed leachate/seepage.

Store plastic and weighting materials in a manner that avoids infestation by rodents and insects. Use cut tires or drill holes to reduce water accumulation. Mow weeds to discourage vermin colonization.

Recycle or landfill the waste plastic on a regular basis.

PLANS AND SPECIFICATIONS

Prepare plans and specifications that describe the requirements for installing the practice according to this standard. As a minimum, include—

- A plan view showing the location and extent of the practice. Include the location and distances to adjacent features and known utilities.
- Typical sections showing the type and required thickness of paving or stabilization materials.
- A grading plan, as needed.
- Where appropriate, plans for ~~required~~ structural details.
- Methods and materials used to stabilize areas disturbed by construction.
- Construction specifications with site-specific installation requirements.
- Vegetative establishment specifications, as applicable.
- A quality assurance plan for construction.

OPERATION AND MAINTENANCE

Prepare an operation and maintenance (O&M) plan and review it with the operator prior to practice installation. The minimum requirements to be addressed in the O&M plan are—

- Periodic inspections—annually and immediately following significant rainfall events.
- Prompt repair or replacement of damaged components, especially surfaces that are subjected to wear or erosion.
- Requirements for the regular removal and management of manure, as needed, for livestock heavy use areas.
- Restricted uses, as needed, to protect the stand and to allow vegetative recovery for vegetated heavy use areas.
- Handling and disposal practices for snow storage associated with the feed storage area;
- Handling and disposal practices for *waste feed*;
- The frequency for cleaning the floor of accumulated feed;
- The interval for removing accumulated solids from the system components;
- Proper treatment and disposal practices for leachate and contaminated runoff.

REFERENCES

American Concrete Institute. 2010. Guide to Design of Slabs-on-Ground. ACI 360R-10. Farmington Hills, MI.

American Concrete Institute. 2008. Guide for the Design and Construction of Concrete Parking Lots. ACI 330R-08. Farmington Hills, MI.

American Concrete Institute. 2006. Code Requirements for Environmental Concrete Structures. ACI 350- 06, Appendix H, Slabs on Soil. Farmington Hills, MI.

American Association of State Highway and Transportation Officials. 1993. AASHTO Guide for Design of Pavement Structures. Washington, D.C.

Korcak, R.F. 1998. Agricultural Uses of Coal Combustion Byproducts. *In* R.J. Wright, et al. (eds.). Agricultural Uses of Municipal, Animal, and Industrial Byproducts. USDA-ARS, Conservation Research Report 44, pp. 103-119.

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GLOSSARY

Confined space – Confined space is a space that 1) contains or has the potential to contain a hazardous atmosphere; 2) is large enough and so configured that a person can bodily enter; 3) has limited or restricted means for entry or exit; and 4) is not designed for continuous human occupancy.

Construction joint – These joints are used where a fresh pour of concrete abuts an existing recent pour.

Contaminated runoff – Runoff that has come through or across a feed storage area. It generally includes the runoff and any sediment, feed, or other material carried in the runoff. It contains lower concentrations of contaminants than leachate from feed or manure.

Contraction joints – Contraction joints, often called control joints, are used to control the location of cracks caused by concrete shrinkage during setting and thermal changes.

Crushed stone – 100% passing the ¾-inch sieve and 10% maximum passing the No. 200 sieve.

Drainage system – Water conveyance measures of specified capacity, location, and material that insure the removal of water to a free outlet.

Expansion joints – These joints are used to prevent crushing of abutting concrete or other structural units due to compressive forces developed during expansion caused by high temperature.

Feed storage area – An area used to store livestock feed. Livestock feed may include corn silage, haylage, and industrial by-products (i.e., distillers grain, brewers grain, candy, pizza crust, bakery waste, cotton seed, soy bean meal, animal fats, blood meal, fish meal, cannery waste, beet pulp, citrus pulp, soy hulls, corn midlings, whey, potatoes, grocery store vegetables). This is the area defined by the outside edge of the surface of where the feed is stored, including the apron. This area does not include feed stored in bags.

Footprint – This is the horizontal area within the perimeter of a facility liner, or the perimeter of a work surface that may cover a liner. For a liquid or solids containment facility, the footprint is the maximum horizontal extent of containment. For a liquid impoundment facility or pond, the footprint is normally defined by the inside top of the embankment. For a solids storage facility, the footprint is normally defined by the edge of the pad, the curb on a pad, or the inside surface of bunker walls.

Gleyed soil – A soil condition resulting from prolonged soil saturation, which is manifested by the presence of bluish or greenish colors through the soil mass or in mottles (spots or streaks) among

the colors. Gleying occurs under reducing conditions, by which iron is reduced predominantly to the ferrous state.

Leachate – Concentrated liquid which has percolated through or drained from animal feed. It contains much higher concentrations of contaminants than contaminated runoff.

Leachate drainage layer – Material that allows leachate to flow to a collection point.

Non-permanent feed storage area – An area used to store livestock feed for no more than 12 months at one location followed by a minimum of two consecutive years of non-use.

Open channel – Open channels are assumed to begin where surveyed cross section information has been obtained, where channels are visible on aerial photographs, or where blue lines (indicating streams) appear on the United States Geological Survey (USGS) quadrangle sheets.

Perched conditions – Perched conditions describe a soil moisture regime where saturated soil is located above unsaturated soil.

Permanent feed storage area – An area used to store livestock feed for more than 12 months at one location.

Sinkholes – Closed, usually circular depressions which form in karst areas. Sinkholes are formed by the downward migration of unconsolidated deposits into solutionally enlarged openings in the top of bedrock.

Vegetated treatment area – A vegetated area designed to treat contaminated runoff from feed storage areas by physical, chemical and biological means.

Waste feed – Spilled, spoiled or unused feed not suitable for livestock consumption. Includes feed mixed with snow and other contaminants.

412 **Table 1: Surface Material Criteria and Separation Distances for Heavy Use Areas**
413

Option	Foundation Condition	Cross Section Option	Separation to Bedrock or Subsurface Saturation (ft.)[6]
A	Firm[1]	Raised Earth	3
B	Firm	Minimum 6” crushed stone[2]	3
C	Firm	Minimum 6” crushed stone over NRCS Wisconsin Construction Specification (WCS)-13, Geotextile, Class IV	3
D	Firm	Minimum 4” crushed stone over 6” base course of graded rock[3]	3
E	Firm	5” non-reinforced concrete with maximum control joint spacing of 16’ each way over 6” sand/gravel for livestock and light ag equipment load applications	2
F[4]	Firm	5” reinforced concrete with steel bars, macro-synthetic fibers, or GFRP bars for temperature and shrinkage in livestock or light ag equipment load applications	2
G	Firm	Minimum 4” asphalt over 6” sand/gravel	3
H	Soft[1]	Minimum 4” crushed stone over 8” base course of graded rock over 6” of sand and fine gravel	3
I	Soft	Minimum 4” crushed stone over 8” base course of graded rock over NRCS WCS-13, Geotextile, Class IV	3
J	Soft	Minimum 4” crushed stone over 18” base course of graded rock	3
K	Soft	Minimum 4” crushed stone over 18” base course of graded rock over 6” sand and gravel	3
L	Soft	Minimum 8” crushed stone over geogrid over NRCS WCS-13, Geotextile, Class III	3

414 Note 1: Guidance can be found in EFH Chapter 4 and Figure 4-32 for information regarding bearing capacity and
415 foundation properties.
416 Note 2: Crushed Stone: 100% passing 3/4” sieve and 10% maximum passing the #200 sieve.
417 Note 3: Graded Rock: 100% passing the base course thickness dimension and a maximum of 10% passing the
418 3/4” sieve. All sizes between the limits shown on the drawings are to be represented.
419 Note 4: Steel reinforcement of #4 bars at 24” o.c. each way, or fiber reinforcement of macro-synthetic polyolefin
420 fibers at a dosage rate of 5lbs/cy. GRFP bars to 3/8” bars at 12” o.c. each way with a 26” lap splice.
421 Note 5: Separation distance from bedrock and subsurface separation is measured from top of surface.
422

Table 2: Earthen Feed Storage Area Liner System

	Liner A	Liner B
1. Liner		
• % Fines passing the #200 Sieve	≥ 50%	≥ 40%
• Thickness	≥ 2 feet	≥ 1 foot
• Plasticity Index (PI) [1]	---	≥ 12
• Compaction of placed material [2] • Compaction of undisturbed material	WI Spec. 204 ---	WI Spec. 204 ---
2. Leachate Drainage Layer [3, 6, 8]		
• % Fines passing the #200 Sieve	≤ 5%	
• Compacted Thickness	≥ 6 inches	
• Side Slopes	3H:1V or flatter	
3. Surfacing Material Options		
• Concrete	≥ 5 inches total thickness	
• Asphalt Pavement	≥ 4 inches asphalt in ≥ 2 lifts over 13 inches crushed stone subbase	
• Crushed Stone	1. 4 inches of crushed stone over 18 inches base course of angular rock [4], or 2. 4 inches of crushed stone over 18 inches base course of round graded rock, over an additional 6 inches pit run sand-gravel [4], or 3. 4 inches of crushed stone over 8 inches base course of graded rock[4], over non-woven geotextile [5]	
• Soil [6]	Increase earthen liner thickness by ≥ 2 feet	
4. Separation Distances [7]		
• Well Distance	100 feet [9]	
• Sinkholes	400 feet	
• Subsurface Saturation	2 feet	
• Bedrock	2 feet	

Note 1: PI shall be determined by ASTM D4318, Atterberg Limits.

Note 2: NRCS Wisconsin Construction Specification 204, Earthfill for Waste Storage Facilities.

Note 3: Other open cell material placed under the full footprint (i.e., geonet-type products) may be used in lieu of granular soils.

Note 4: The base course layer can also be considered the leachate drainage layer.

Note 5: The geotextile shall be Class I, non-woven and meet the requirements of Table 2 in Wisconsin Construction Specification 13, Geotextiles.

Note 6: When using the soil surfacing material option, the leachate drainage layer is not required.

Note 7: The separation distance is measured from the top of the earthen liner and does not include surfacing material or the leachate drainage layer.

Note 8: The crushed stone subbase can also be considered the leachate drainage layer.

Note 9: NR 243 permitted facilities require 250 feet separation from wells.

Table 3: Flexible Membrane Feed Storage Area Liner System

1. Liner Material [1]	Placed under crushed stone surface - 60 mil High Density Polyethylene (HDPE), 60 mil VeryFlexible Polyethylene (VFPE), 60 mil Linear Low Density Polyethylene (LLDPE), or 45 mil Ethylene Propylene Diene Monomer (EPDM) Placed under concrete or asphalt pavement surface - 40 mil HDPE,40 mil VFPE, 40 mil LLDPE, or 45 mil EPDM
2. Leachate Drainage Layer [2]	Shall extend to the edge of the footprint of the feed storage area
• % Fines passing the #200 Sieve	≤ 5%
• Particle Size and Shape	≤ 3/16 inch rounded
• Compacted Thickness	≥ 6 inches
3. Surfacing Material Options	
• Concrete	≥ 5 inches total thickness
• Asphalt Pavement	≥ 4 inches asphalt in ≥ 2 lifts over 9 inches crushed stone subbase [6] for subgrade soils [7] classified as SP, GP, SW, and GW. ≥ 4 inches asphalt in ≥ 2 lifts over 13 inches crushed stone subbase [6] for all other subgrade soils [7] except organic soils.
• Crushed Stone	4 inches of crushed stone over 8 inches base course of graded rock [3] over non-woven geotextile [4]
4. Separation Distances [5]	
• Well Distance	100 feet [8]
• Sinkholes	400 feet
• Subsurface Saturation	2 feet
• Bedrock	2 feet

Note 1: HDPE, VFPE, and LLDPE shall meet Wisconsin Construction Specification 202, Polyethylene Geomembrane Lining. EPDM shall meet Wisconsin Construction Specification 205, Ethyl Propylene Diene Monomer (EPDM) Geomembrane Lining. Install liners according to manufacturer's recommendations.

Note 2: The leachate drainage material must be stable to resist sliding on the side slopes. In addition to the granular soils, other open cell material placed under the full footprint (i.e., geonet-type products) may be used. Protect flexible membrane liners from puncture by use of suitable materials in the leachate drainage layer preparation.

Note 3: If the base course layer contains aggregates larger than 4 inches, the drainage layer shall be twice the depth of the largest aggregate.

Note 4: The geotextile shall be a minimum 12-ounce per square yard non-woven. Increasing the drainage layer to 12 inches can substitute for the geotextile.

Note 5: The separation distance is measured from the top of the liner, and does not include surfacing material or the leachate drainage layer.

Note 6: The leachate drainage layer is required under the crushed stone subbase to protect the liner.

Note 7: The subgrade consists of the first five feet of soil under the crushed stone subbase. If any of the subgrade consists of soil other than SP, GP, SW, or GW, then 13 inches of crushed stone subbase must be used.

Note 8: NR 243 permitted facilities require 250 feet separation from wells.

Table 4: Concrete Feed Storage Area Liner System [1]

	Concrete with Waterstop [2, 3]	**Concrete-Soil Composite** [4]		
1. Soils (Directly Below Liner)				
• % Fines Passing the #200 Sieve	---	≥ 20%	≥ 20%	Foundry Sand [7]
• Plasticity Index	---	≥ 7	----	----
• Thickness	---	≥ 1.5 feet	≥ 3 feet	≥ 1.5 feet
• Compaction of placed material • Compaction of undisturbed material	WI Spec. 204 ---	WI Spec. 204 ----	WI Spec. 204 ----	WI Spec. 204 ----
2. Separation Distances [5]				
• Well Distance [6]	≥ 100 feet	≥ 100 feet	≥ 100 feet	≥ 100 feet
• Sinkholes	≥ 400 feet	≥ 400 feet	≥ 400 feet	≥ 400 feet
• Subsurface Saturation	≥ 2 feet	≥ 3 feet	≥ 4 feet	≥ 3 feet
• Bedrock	≥ 2 feet	≥ 3 feet	≥ 3 feet	≥ 3 feet

Note 1: The liner material is also the surfacing material.

Note 2: Design the concrete liner thickness and reinforcement for equipment loadings and crack control. Design slabs-on-ground in accordance with American Concrete Institute, ACI 360, "Design of Slabs-on-Ground," and Portland Cement Association, "Concrete Floors on Ground," Chapter 5. The concrete shall be a minimum of 5 inches thick with steel reinforcement. All contraction, *expansion joints*, and *construction joints* shall have embedded non-metallic waterstops in accordance with WI Wisconsin Construction Specification 4, Concrete.

Note 3: Joints having waterstops shall be protected from differential movement by the use of dowels. Space dowels no farther than the rebar oriented in the same direction. Thicken concrete an additional four inches at the joint and taper the concrete thickness back to the slab with a transition ratio of 1 inch of thickness change over 10 inches or longer run from the joint in each direction.

Note 4: The concrete is in intimate contact with the soil, and the two work together to reduce seepage losses. The concrete liner thickness shall be a minimum of 5 inches.

Steel reinforcement shall be #4 deformed billet bars spaced at 18 inches on center each way. No expansion or *contraction joints* are required. Place concrete in intimate contact with the foundation soils. If construction joints are required, steel shall be continuous through all construction joints and no waterstop is required. If the soil material below the floor meets Table 2 criteria, then Table 2 design criteria may be used.

Macro-synthetic polyolefin fins or Glass Fiber Reinforced Polymer bars (GFRP) may be used as a substitute for steel reinforcement for concrete-soil composite liners. Slabs-on-ground shall be designed in accordance with ACI 544.4R-18, "Guide to Design with Fiber-Reinforced Concrete" or ACI PRC-440.1-15 Guide for the Design and Construction of Structural Concrete Reinforced with Fiber-Reinforced Polymer Bars. Fiber-reinforced or GFRP reinforced concrete shall have steel rebar dowels through all joints to transfer loads.

Note 5: The separation distance is measured from the top of the concrete.

Note 6: NR 243 permitted facilities require 250 feet separation from wells.

Note 7: The foundry sand must be ferrous foundry sand with only minimal concentrations of hazardous constituents, cores and other over-size materials crushed or removed, and at least 5% bentonite content. A site specific DNR approval is required under NR 538 that may specify greater separation distances and parameters not addressed by this standard. An NR 538 Category I or II ferrous foundry sand may be appropriate. Material between foundry sand and bedrock must be mineral soil, not organic.

Table 5: Non-Permanent Feed Storage Area Requirements

1. Hydrologic Soil Groups	B, C, D	A
2. Subsurface Separation Distance		
• Subsurface Saturation	≥ 3 feet	≥ 5 feet
• Bedrock	≥ 3 feet	≥ 5 feet
3. Surface Separation Distance		
• Wells	≥ 250 feet	≥ 250 feet
• Lakes	≥ 1,000 feet	≥ 1,000 feet
• Sinkholes, or other Karst Features	≥ 1,000 feet	≥ 1,000 feet
• Quarries	≥ 1,000 feet	≥ 1,000 feet
• Streams	≥ 300 feet	≥ 300 feet
• Wetlands and Surface Inlets	≥ 300 feet	≥ 300 feet
• *Open channel* flow	≥ 100 feet	≥ 100 feet
• Land Slope	≤ 6%	≤ 6%
• Floodplain (100 yr.)	≥ 100 feet	≥ 100 feet

Note 1: Separation distance from bedrock and subsurface saturation is measured from top of ground surface.