Earthwork & Culvert Pipe Installation and Inspection Manual

This manual is intended to present basic earthwork design, construction, and culvert pipe inspection to new or inexperienced engineers and inspectors.

January 2019

Preface

Earthwork and Culvert Pipe Inspection E-Manual is designed for entry-level Wisconsin Department of Transportation (WisDOT) employees and consultant engineers and technicians. This course will also serve as a review for more experienced personnel.

The purpose of this manual is to present information to individuals as to the proper earthwork design, subgrade construction, and the installation of culvert pipe and storm sewers. This manual is one step toward preparing the new project engineer and inspector to fairly and pro-actively represent the best interests of the State in providing quality transportation facilities to the people of Wisconsin.

"Interpretation and Application of Plans, Standard Specifications and Contract Proposals" course is prerequisite to the use of this manual.

More information on soils and bedrock, subsurface investigations, foundation design and earthwork can be found in the WisDOT Geotechnical Manual, which can be found on the Departmental website. This website also contains the Facilities Development Manual (FDM), the Standard Specifications for Highway and Structure Construction manual (Standard Specifications), and the Construction and Materials Manual (CMM).

UW-Platteville also offers a Grading Technician certification course through the Highway Technician Certification Program (HTCP) that is very useful to anyone overseeing construction earthwork operations. Completion of this course is highly recommended.

In addition to thoroughly reading and understanding the project contract documents, it is recommended that the above documents are reviewed, and the training completed, before overseeing a grading or culvert project.

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Section 1 General Soils Knowledge

The State of Wisconsin consists of a wide variety of soils and rock. A good reference of Wisconsin Soils is the WisDOT Geotechnical Manual. This chapter will identify the major groups of soils and rock and will explain their specific properties. Soil can be defined in different ways depending on use or application. Generally, soil used for construction is defined as “all of the unconsolidated material at or near the earth’s surface, plus air, water and organic material.

Section 1.1 Sand, Silt, Clay, Topsoil, Rock, Marsh

The three major soil types used for highway construction in the state of Wisconsin are sand, silt and clay.

Sand or granular soil is classified as coarse-grained soil, and is an excellent foundation, embankment and backfill material. It has high permeability and is not susceptible to frost action. Sand settles rapidly when loaded. Strength is developed through individual particle contact and fiction. Table 1.1.1 shows the size range of granular soils. Individual particles that are angular in nature develop more friction and strength than particles that are more rounded in nature.

Silts and Clays are considered fine-grained soils. Clays are plastic and are capable of being shaped or formed. If properly worked, clay can be a good construction soil. Silts are fine-grained soils having low permeability. They are generally difficult to work, are highly influenced by water content, and susceptible to frost action.

Topsoil or organic soil usually is removed prior to the construction of embankments. Topsoil can generally be classified as mineral or organic. Mineral topsoil generally contains less than 10% organics and can remain if a fill of five feet or more is placed on top of it. Organic topsoil can contain as much as 50% organics and should be removed prior to any embankment construction. Topsoil is generally removed with a bulldozer.

Rock is defined by WisDOT as hard solid ledges, bedded deposits, and unstratified masses, and all conglomerate deposits of any other material so firmly cemented they present all the characteristics of solid rock. WisDOT also classifies boulders of 1 cubic yard or more as rock excavation.

Marsh material is highly organic. It consists of decaying plant material, peat or organic silts. These materials have little support strength and will generally exhibit large consolidation or settlement when loaded. A wet marsh can contain as much as 50% water. Marsh soil is required to be removed or bridged prior to embankment construction. Generally, marsh is removed by a backhoe, dragline or surcharge. Typically, there is no need to attempt dewatering wet/saturated marshes for removal.

Section 1.2 Texture, Color, Grain Size

The engineer or inspector can perform simple field tests to determine general soil properties and types. Placing and working some dry or wet soil in your hand determines basic soil types.

Dry sand is gritty and feels similar to dry sugar or salt. Sand is usually brown, gold or orange in color. It cannot be rolled into a ball under any moisture content. The individual particles usually can be seen by eye. Sand is a granular, or coarse-grained, soil.

Clay can be rolled into a ball, ribbon or molded under proper moisture content. It feels like putty in the hand. Clay becomes hard and strong if allowed to dry. It usually is orange, red, or tan in color. Individual clay particles are the size of dust when dry. Clay is fine-grained plastic soil.

Silt is not easily molded, and a ball will fall apart or crumble if allowed to dry. Silt is usually brown or tan. In its natural state different colored layers may be observed as it is broken apart. Particles of silt, if separated, will be a combination of gritty and dust particles. Silt is a fine-grained, non-plastic soil.

Often there will be combinations of inter-mixed soil types within project limits.

Figure 1.2.1 shows the relative sizes of sand, silt and clay. Figure 1.2.2 shows how to estimate soil texture.

Section 1.3 Liquid Limit, Plastic Limit, Moisture, Compaction

Soil laboratory tests will help determine the difficulty associated with placing and compacting a given soil type. Simple gradation tests will determine if material is predominately sand, silt, clay, or a mixture. Once these tests determine which material(s) will be encountered on the project site, other more complicated tests are performed to determine what moisture content is required to obtain maximum compaction.

Tests such as the liquid limit, plastic limit and moisture content are performed to determine the effort required to achieve desired compaction. What follows is a very general explanation of these somewhat complicated and tedious tests.

The liquid limit is the moisture content percentage at which a soil will begin to exhibit the properties of a liquid rather than a plastic solid. It will move under load, but not on its own.

The plastic limit is the moisture content percentage at which the soil changes from a plastic state to semi-solid. The soil will no longer flow or compress under load.

The Plasticity Index (PI) is expressed as a whole number, and is the difference between the liquid and plastic limit. It is the range in which the soil can be easily worked and compacted.

A Proctor test is used to determine the maximum dry unit weight (also called dry density) and corresponding optimum water content of any material, under a specific, repeatable, compactive effort. Soil is compacted by a standard procedure in a steel mold under different moisture contents. Two types of tests are commonly used, the Standard Proctor Test (AASHTO T-99) and the Modified Proctor Test (AASHTO T-180).

In the Standard Proctor Test, soil is compacted in three equal layers in a 1/30 cubic foot steel mold. Each layer receives 25 blows with a 5.5-pound hammer dropped from a height of 12 inches. The compacted sample is weighed, and the moisture content is determined. From these values, the dry unit weight of the sample is determined. Normally five tests are performed with different moisture contents. Figure 1.1.3 shows a typical laboratory worksheet for the Standard Proctor Test. These calculated dry unit weights and associated moisture contents are then plotted on a graph as shown on Figurer 1.3.2. The peak of this graph is the maximum dry unit weight for that soil sample. The moisture content corresponding to the maximum dry unit weight is referred to as the optimum moisture content, and it represents the moisture value that facilitates getting the highest compaction in the field for that soil.

In the Modified Proctor Test, the soil is compacted in five equal layers in a 1/30 cubic foot mold. Each layer receives 25 blows with a 10.0-pound hammer dropped from a height of 18 inches. As with the Standard Proctor Test, usually five tests are performed with different moisture contents and the dry densities and moistures are plotted on a graph, so that the maximum dry unit weight and corresponding optimum soil moisture are determined.

WisDOT generally employs the Standard Proctor Test for transportation projects.

Section 1.4 Zero-Air-Voids

A Zero Air Voids line should be plotted for all proctor curves. The Zero Air Voids line represents the theoretical maximum dry density at a particular moisture content, with complete removal of air voids. The Zero-Air-Voids line is plotted on the moisture – density graph, figure 1.3.2.

The following equation can be used for determining the Zero Air Void line.

$$\gamma_{zav} = \gamma_w / (w + 1/G_s)$$

γ_{zav} = Theoretical maximum dry density with zero air voids

γ_w = Unit Weight of Water = 62.4 pcf
G_s = Specific Gravity of typical Wisconsin Soils = 2.65*
w = Moisture content (in decimal form)

* The 2.65 factor is generally considered the Specific Gravity of Wisconsin soils.

The following table shows the corresponding theoretical maximum density (Zero Air Void curve) for a range of moisture contents at a Specific Gravity of 2.65. For soils with a Specific Gravity different than 2.65 the following table is not valid.

Zero Air Voids Curve (Specific Gravity = 2.65)

Moisture Content	Zero Air Voids Dens (pcf)
1%	161.09
2%	157.04
3%	153.18
4%	149.51
5%	146.01
6%	142.67
7%	139.49
8%	136.44
9%	133.52
10%	130.72
11%	128.04
12%	125.46
13%	122.99
14%	120.61
15%	118.33
16%	116.12
17%	114.00
18%	111.96
19%	109.98
20%	108.08
21%	106.24
22%	104.46
23%	102.74
24%	101.08
25%	99.46

Table 1.1.1

Size and Range of Granular Soils

Component	Size Range
Boulders	Above 8 inches
Cobbles	3 – 8 inches
Coarse Gravel	¾ - 3 inches
Fine Gravel	#4 – ¾ inch
Coarse Sand	#10 - #4
Medium Sand	#40 - #10
Fine Sand	#200 - #40

Sieve Sizes: #4 (4.75mm)
#10 (2.00 mm)
#40 (0.42mm)
#200 (0.75mm)

Figure 1.2.1 The Relative Size of Sand, Silt, and Clay

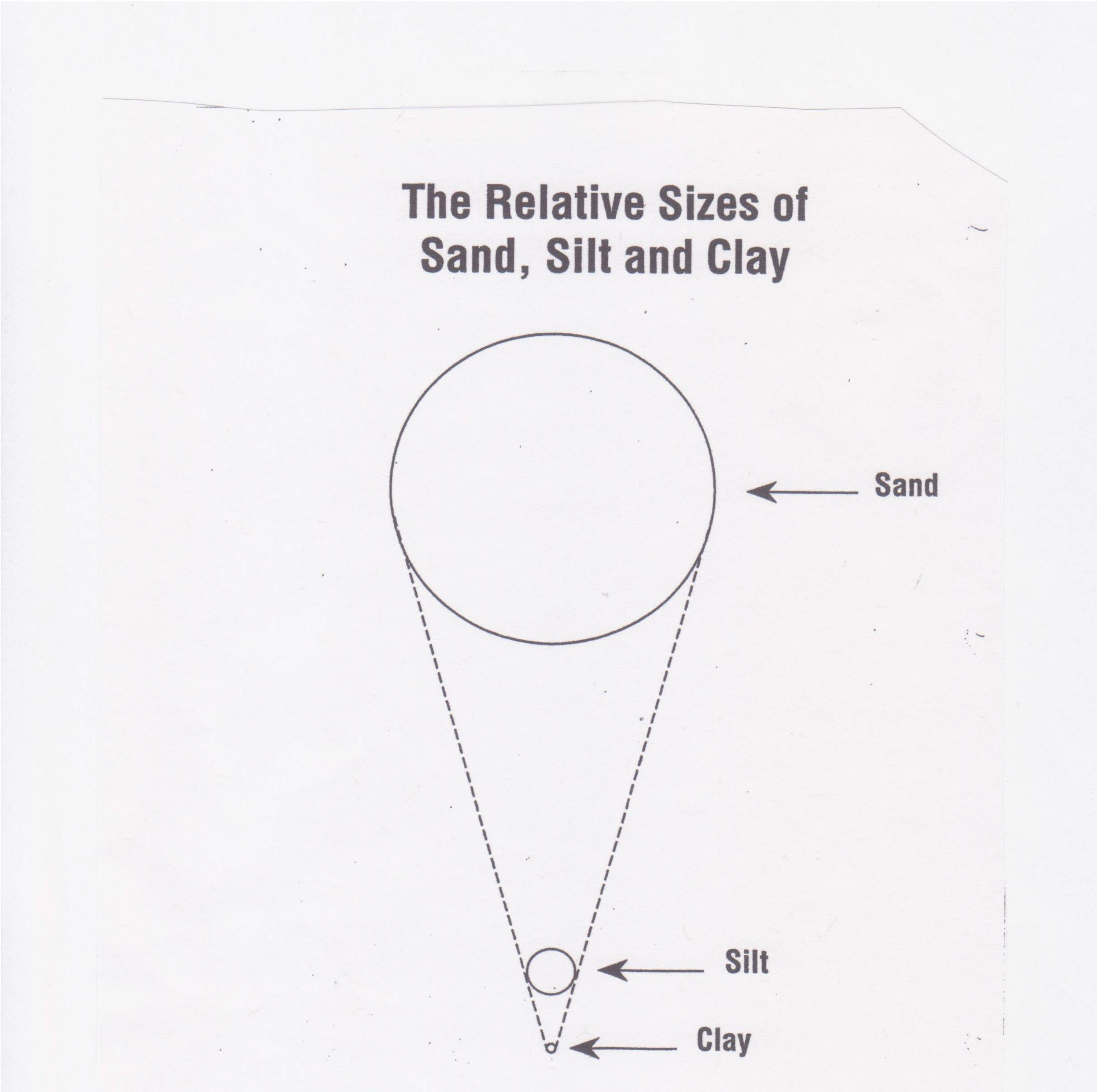


Figure 1.2.2 Estimating Soil Texture

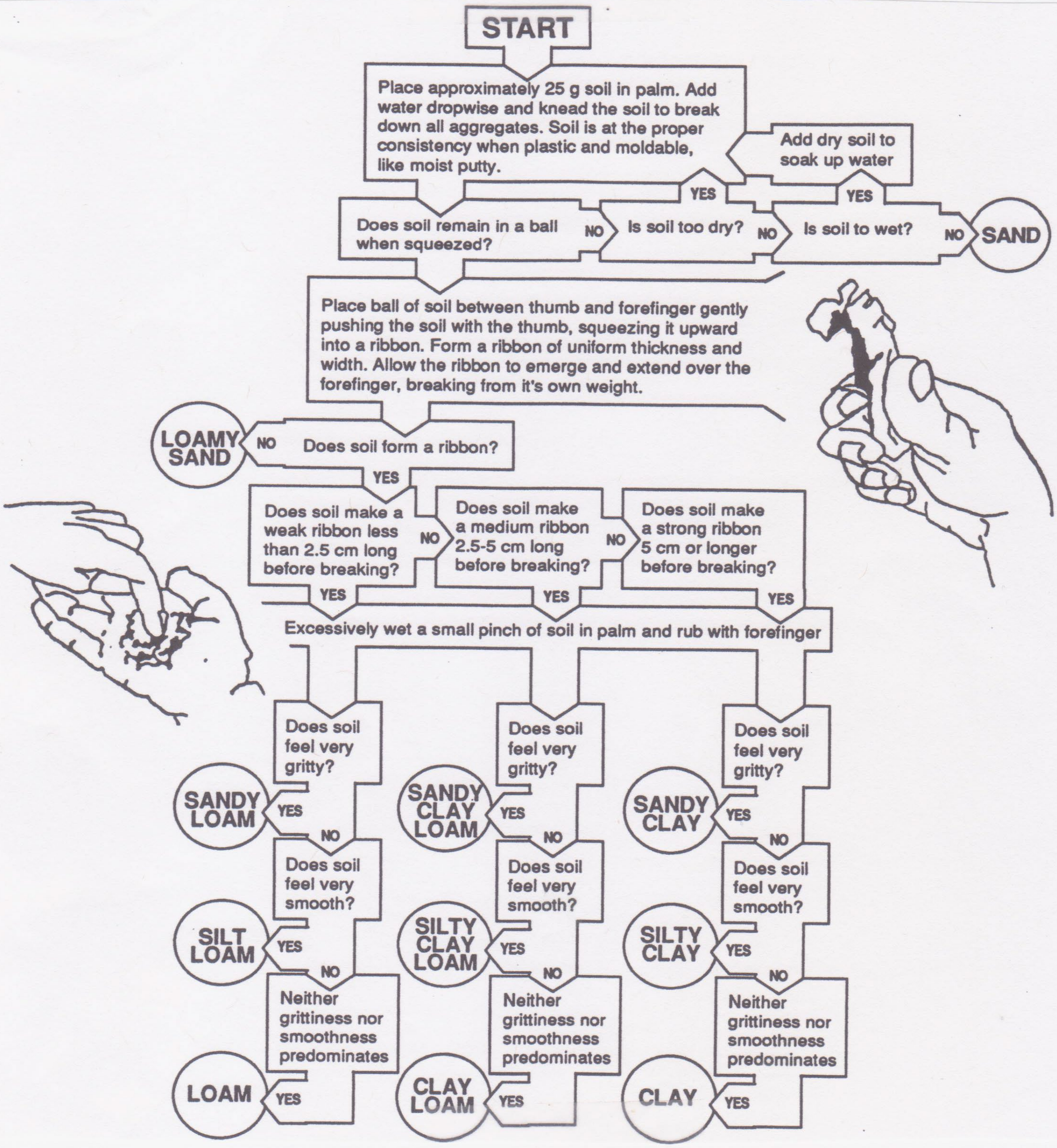


Figure 1.3.1 Moisture – Density Relationship

ATTACHMENT 13 **SAMPLE NO.** # 1 A

DETERMINATION OF MOISTURE-DENSITY RELATION OF SOIL **SHEET 1 OF 2**

Determination of Maximum Density and Optimum Moisture Content Based on Oven Dry (110°C) Weights.

Project: ______ Operator: ______

Location: ______ Date: ______

Method of Test: Method: Mold #: ______

Standard (AASHTO T99): A ☐ C ☒ Scale #: (lb.) ______

B ☐ D ☐ Scale # (gm) ______

Type of Hammer: Manual ____ Electric ____ Field X

Tare of Mold: 10.27 lbs. Volume of old: 1/30 cu. ft.

% R4 Determination: 1.038 R4 lb. + 1.583 P4 lb. = 2.621 Total R4 & P4

1.038 R4 lb. ÷ 2.621 Total R4 & P4 x 100 = 39.6 % R4

TYPE OF SOIL							
TRIAL NUMBER			1	2	3	4	5
Weight of Wet Specimen and Mold (lbs.)			14.81	15.13	15.31	15.21	15.14
Tare of Mold (lbs.)			10.27	10.27	10.27	10.27	10.27
Wet Weight of Specimen (lbs.)			4.54	4.86	5.04	4.94	4.87
Wet Weight of Specimen (lbs.) x 30 Wet Weight (lbs./cu. ft.)		(W_t)	136.2	145.8	151.2	148.2	146.1
MOISTURE SAMPLE	Moisture Can No.		05	10	14	9	17
	Wet Sample & Can (gms.)	(A)	880.50	934.10	845.80	919.40	904.38
	Dry Sample & Can (gms.)	(B)	852.20	893.12	804.30	866.40	844.96
	Weight of Can (gms.)	(C)	337.80	332.80	326.20	332.30	289.65
	Moisture Loss (gms.)		28.30	40.98	41.50	53.00	59.42
	Dry Weight of Sample (gms.)		514.40	560.32	478.10	534.10	555.31
	Moisture (%)	(w)	5.50	7.31	8.68	9.92	10.70
DRY DENSITY (lbs./cu. ft.)		(W)	129.10	135.86	139.12	134.82	131.98

Calculations:

Moisture Content:

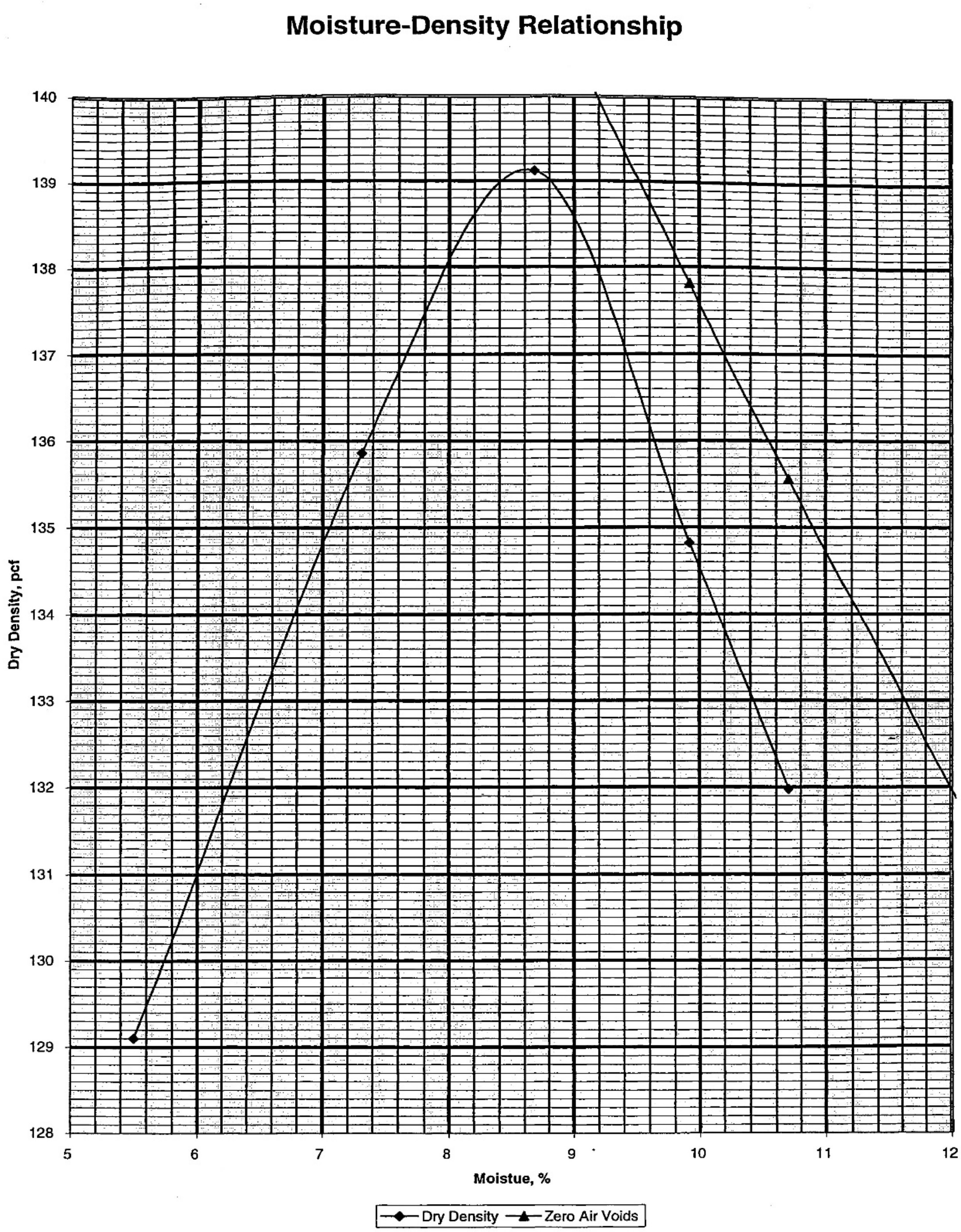
$$w = \frac{A - B}{B - C} \times 100$$

Dry Density (lbs./cu. ft.):

$$W = \frac{W_t}{w + 100} \times 100$$

w = Percentage of moisture in the specimen, based on oven-dry weight of soil;
A = Weight of container and wet soil;
B = Weight of container and dry soil
C = Weight of Can
W = Dry weight in lbs./cu. ft. of compacted soil, and
W_t = Wet weight in lbs./cu. ft. of compacted soil.

Figure 1.3.2 Moisture – Density Graph



Section 2 Design

This section will provide guidance on the use and properties of soils in the design process. Basic soil properties required by field personal will be discussed.

Section 2.1 The Soils Report

A soils report is required for all transportation earthwork projects. The soils report will be developed by the Region Soils Engineer or a consultant Geotechnical Engineer. The Geotechnical Report will contain basic soil information and properties required in the design process. The soils engineer will use a combination of Soil Conservation Service maps, soil borings and water table data to determine the type of soils expected on a project, soil characteristics and the reaction of soils in cuts and embankment construction. For new alignments and reconstruction projects, the soil and water table data are used to help determine the position of the final vertical grade line. The report will also present properties of the soils native to the area.

The soils report also provides the necessary parameters for the pavement design process. The Design Group Index (DGI) is used in an asphalt pavement design and the Soil Support Value (SSV) is used in a concrete pavement design. Future pavement design methodology may require soils Resilient Modulus (M_r) values be provided for determining the pavement structural design layer thicknesses.

If present within the project limits, the soils report will present data on areas of excess topsoil, marsh areas, rock lines, boulders and whether Excavation Below Subgrade (EBS) is required. EBS backfill recommendations will also be recommended.

If subgrade improvement is required, the soils report will identify which type of materials are most prevalent in the area. The use of subgrade improvement is detailed in Section 2.6.

Soil types react differently when they are removed, transported and compacted on a project. These differences will affect the amount of borrow or common excavation required to complete the project. The soils engineer determines the expansion factors and how they will affect the soil types found on the project.

Section 2.2 Basic Earthwork Computations

WisDOT has established several bid (or pay) items to estimate the cost of earthwork operations in a contract. The bid items used for earthwork are Borrow Excavation, Common Excavation, Rock Excavation and Marsh Excavation.

- <u>Borrow Excavation</u> is the estimated amount of satisfactory soil, or a mixture of satisfactory soil, stone, gravel, or other acceptable materials required to be hauled onto the project to complete the construction of the grade. Borrow cannot contain sod, stumps, logs, and any other perishable matter. On large earthwork projects, borrow is measured by surveying the proposed borrow site after the overburden is removed, but prior to soil being removed, and again when soil removal is complete. The difference in volume of these two surveys, in cubic yards, determines the borrow quantity taken from the site.

- Common Excavation is basically all material other than rock, boulders or marsh that is excavated to the required cross section or subgrade elevation. A survey of the cut excavation prior to the start of earthwork and again upon completion of the grade line determines the volume, in cubic yards, of common excavation. Excavation Below Subgrade or EBS is paid for as common excavation. See section 2.5 for a more detailed discussion of EBS.
- Rock Excavation is any solid rock or ledges, bedded material or material so cemented as to act like rock. Rock excavation also includes removing boulders that have a volume of one cubic yard or more.
- Marsh Excavation can contain as much as 50% organic material. Marsh/organic soils are generally highly compressible and have little support strength. Marsh is generally required to be removed and backfilled or bridged prior to the construction of an embankment. Marsh excavation usually requires special methods for removal such as a backhoe, dragline or surcharging.

Soil, in its natural state, is usually not as well consolidated as it is after being placed and compacted. Borrow and common excavation bid quantities must be estimated to ensure contract quantities are accurate. Inaccurate borrow quantities may require the contractor to obtain more borrow than the plan amount. This could delay the project or require expensive contract change orders.

When borrow or common excavation quantities are estimated, the designer must apply a shrinkage factor to borrow and common excavation or an expansion factor to the fill. Expansion of the fill is the common method used to determine earthwork quantities on Wisconsin DOT projects. Expansion factor ranges have been developed over the years for sand, silt and clay. They are dependent on a large number of factors including: soils types and moisture contents, estimated soil variability/distribution within the project limits, past experience, depth of grading operations, degree of final compaction, assumed waste/spillage, topsoil thickness, project staging impacts, assumed type of borrow soils, previous history of existing soils (natural or engineered fills), etc. Some accepted typical fill expansion ranges for common excavation are:

Sand:	0-2 feet cut,	Expand 1.15 – 1.30
	2-6 feet cut,	Expand 1.10 – 1.25
	6+ feet cut,	Expand 1.10 – 1.15
Silt & Clay:	0-2 feet cut,	Expand 1.30 – 1.60
	2-6 feet cut,	Expand 1.25 – 1.40
	6+ feet cut,	Expand 1.15 – 1.30

The designer or soils engineer often uses a blended expansion factor on a project where cut materials are consistent. If the project consists of mostly shallow grading a higher factor is generally used, but if large cuts are anticipated, the expansion factor for the same soil type is generally lower. This is because deeper soils within a soil profile are often denser than those near the top/ground surface. The expansion factor for borrow is generally assumed to be the same as soils within the project limits.

Marsh backfill expansion value is generally about 1.50, and partially depends on the amount of water within the marsh material. Dry marsh excavation can be measured using prior and finished, surveys to determine quantity in cubic yards. If the marsh excavation area is too wet to measure, the quantity can be determined by measuring the material removed in a vehicle or by performing post removal soil borings.

Rock excavation is usually accomplished by ripping or blasting. Rock lines need to be surveyed in the field at the top and completion of the rock cut to determine the amount of material removed. The amount of rock material is greater after being ripped or blasted. Some commonly accepted swell values for rock from excavation are:

Sandstone:	1 cubic yard = 1.05 – 1.10 cubic yards
Limestone:	1 cubic yard = 1.10 – 1.15 cubic yards
Granite:	1 cubic yard = 1.10 – 1.20 cubic yards

As mentioned above, expanding the anticipated fill area is the standard method of determining borrow quantities. Shrinking the cut and expanding the fill are related by the following simple equation:

$$Expansion\ Factor = \frac{1}{1 - Shrinkage\ Factor}$$

Therefore, a 20% shrinkage factor is equal to a 25% expansion factor, as the following example shows:

$$\frac{1}{1 - 0.20} = 1.25$$

To sum up, soil shrinks, or is better compacted, when building a compacted roadway foundation, then when in its natural state. If the expansion factor is 25%, 12.5 cubic yards are required to complete a 10.0 cubic yard fill. Conversely, when rock is placed in a fill, it generally swells from its in-situ condition. A 7.0-cubic yard volume of in-situ rock that is excavated and re-compacted, may encompass a compacted volume of 8.0 cubic yards.

Section 2.3 Use of Topsoil, Marsh and Rock

The use of excess topsoil, marsh and rock excavation will influence the cost of the grading portion of a construction project. Rock excavations can influence the proposed right-of-way.

The Standard Specification for topsoil, Section 625.3.2 (3) states "Under the salvaged topsoil bid item, remove topsoil from excavation areas and the roadway foundation up to the quantity necessary to cover the slopes". Any excess topsoil is paid for as per section 205.3.2 (2) of the Standard Specifications which states "Remove excess unstable topsoil from the roadway foundation as EBS". In areas where fills are expected to be five feet or more, topsoil may not need to be removed. This is especially true when mineral topsoil is present. Mineral topsoil may contain less than 10% organic material and would generally be stable under a 5-foot fill. Organic topsoil can contain up to 50% organics and should be removed. The designer should consult the regions soils engineer on the depths and utilization of excess topsoil. The designer should show areas outside the proposed 1:1 slope where topsoil can be disposed, keeping in mind sign placement, slope stability or future construction. A typical section showing the 1:1 slope and possible disposal areas is shown in figure 2.3.1.

The Marsh Excavation Item 205.2.5 requires the contractor to remove any unstable material "to ensure a stable foundation for the embankment". The soils engineer will determine the depth and extent of marsh by hand probes, boring logs or Ground Penetrating Radar. Marsh depths and possible disposal areas are shown on the cross sections. As with excess topsoil, marsh disposal outside the proposed 1:1 slope should be analyzed. Marsh excavation usually requires removal methods different than deep topsoil materials. Marshes are typically removed in a wet state and not dewatered. Marsh removal depths of up to 25 feet are not uncommon. Wet marsh may need to be disposed of offsite. Granular or Select Borrow Backfill is used to backfill marsh areas. Specifications for this granular material need to be detailed in the contract Special Provisions.

If it can be determined in the design process that granular or select borrow material is located within the project limits, include this information in the Special Provisions of the project. Include any lab tests or sieve analysis in the Special Provisions. In the bid process, this information could significantly lower the cost of Granular or Select Borrow Backfill.

Rock Excavation is accomplished by ripping, blasting or is defined as boulders greater than 1 cubic yard. As with marsh excavation, the soils engineer will provide the estimated depth and extent of rock within proposed cut areas. These depths are determined using hand probes, drill rigs or Ground Penetrating Radar. Rock lines, or the uppermost rock surface, are shown on the plan cross sections. This use of excess competent rock for fill or granular materials can lower the bid price of a project. If large quantities of rock are expected, run lab tests in the design phase of the project to determine if the rock can be used as breaker run, base course or in pavements. These test results, when included in the project documents, can significantly lower the bid prices.

The depth and stability of rock in cuts influences the required right-of-way of a project. The back slope of stable rock can be as little as ¼ horizontal to 1 vertical (¼H:1V) whereas soil usually requires a 2½H to 1V back slope. Determine rock depths and stability of rock cuts early in the design process to determine right-of-way requirements. If there are concerns with exposed rock slopes during construction, contact the BTS Geotechnical Unit for assistance. This should be done early in the rock cut construction, as typically slopes are more difficult to adjust as construction proceeds down in elevation, toward the final subgrade elevation.

Section 2.4 The Design Group Index and the Soil Support Value

The Wisconsin DOT currently uses a system of pavement design based on the adaption of pedology to highway engineering. Simply stated, this system applies strength coefficients to different soil types found within the state. The system, first developed in 1961, has been adjusted to account for Wisconsin's climate, topography, drainage and other unique soil properties present in the state.

The United States Department of Agriculture (USDA) Natural Resource Conservation Service (NRCS, formerly known as the Soil Conservation Service [SCS]) has done extensive work in the state defining, identifying and describing soil profiles. This system, initially established for agricultural uses, has been expanded to include various engineering properties and values. Every county in Wisconsin has been mapped by the NRCS to identify soil series (or types), and WisDOT has assigned pavement support values to these soil series. It should be noted that the NRCS soil mapping generally studied soils to a depth of five feet. Soil in cuts deeper than five feet will require additional study to determine pavement support values.

The soils engineer will study the NRCS mapping and any other soil boring information to determine the Design Group Index (DGI) for an asphalt pavement design and Soil Support Value (SSV) for a concrete pavement design for an entire project or segments within a project. These numbers are used by the pavement engineer to determine pavement layer thicknesses.

The current pavement design process was developed by the American Association of State Highway & Transportation Officials (AASHTO) in 1972 and was revised in 1981. The Wisconsin DOT has developed and uses the WisPAVE design program to determine pavement thickness.

In recent years the state has begun moving to replace the design group index and soil support values with a soil Resilient Modulus (M_r), using a new design philosophy called mechanical–empirical (ME) design. The issue with this method is determining the M_r of the numerous soil types that can be found along a typical highway project. Similar values linking the DGI, SSV and M_r have been determined and are available in the Facilities Development Manual, for the pavement design engineers' use. Resilient modulus can also be determined by analyzing Falling Weight Deflectometer (FWD) test results. Some pilot projects have been designed using M_r values and ME design methodology.

Section 2.5 Excavation Below Subgrade (EBS)

Excavation Below Subgrade (EBS) was referred to in Section 2.2 Basic Earthwork Computation in the Common Excavation portion. This section contains a more detailed explanation of EBS and ways to predict areas of EBS.

Accurately predicting EBS in the design phase of a project will limit delays and quantity changes when earthwork construction operations begin. The Soils Engineer and designer will review the proposed grade line and compare it to the native soil mapping and conditions in the area. To predict an EBS area, consider the following:

- Groundwater depths of three feet or less. With silty soils water will pump under repeated construction traffic and the grade will lose strength. Pumping is the capillary action or the ability of water to flow upward in narrow spaces, under repeated loading.
- Grade line is in the silty B horizon. This horizon just below the topsoil tends to hold water and is generally unstable.
- The finished subgrade is within two feet of the original ground surface.
- Topsoil depth exceeds 12 inches. Topsoil depths are generally considered to be 6-8 inches. Any additional depth beyond 12 inches may require an EBS quantity.
- Moisture levels are above the plastic limit and are approaching the liquid limit. As discussed in the General Soil Knowledge section, clays will become semi-solid and not support construction equipment or the base course.
- The existing roadbed was constructed prior to 1940. Many roads built prior to 1940 were built on top of the native topsoil and after removing the existing pavement the subgrade will become unstable.
- Extensive random filling has occurred in the past. (Generally urban areas.)
- The existing roadway pavement is distressed. Distressed existing pavement may signal a subgrade problem.
- The existing soil conditions are highly variable. Sands next to silts and clays will cause differential frost action and frost heaves.
- Cut to fill transitions to eliminate frost heaving and differential settlement.

After EBS areas are identified in the design, the nature of the backfill must be determined. If EBS is required because of excess moisture or groundwater concerns, granular or breaker run stone backfill is required. This type of backfill requires the material to be drained to the ditch or storm sewer. If the issue is excess topsoil or variable soils, the EBS area can be backfilled with common or borrow excavation.

EBS is bid as common excavation in the plan documents and can be shown on the cross sections. EBS material can often be used somewhere else on the project, or outside the proposed 1:1 roadway slopes.

Geosynthetics (geotextile or geogrids) may reduce the required depth of EBS. A general rule is that a geosynthetic can reduce the EBS depth by approximately six inches. This is a good option if the project is predicted to waste soil, or is located in an urban area where utilities can be near the surface or where removal depths must be minimized. Geosynthetics may also be used to “float” the roadway over extremely wet/soft subgrades or deep marsh areas. Geosynthetics generally do not reduce total settlements over soft soils, but may reduce differential settlements.

The width of any EBS must be the entire width of the any proposed pavement structure including any paved portion of shoulders. Excavating the entire paved width will reduce the potential for differential frost heaving, or uneven settling of the pavement. See Figure 2.5.1 for EBS width details.

At the end of an EBS area, a transition to the normal grade line is required. These transitions help minimize differential settlement and frost heaves. The transition is recommended to be 20H to 1V on higher speed facilities but can be steepened at lower speed limits. See Figure 2.5.2 for EBS transition details.

Section 2.6 Subgrade Improvement

WisDOT has divided the State of Wisconsin into geographical areas showing where subgrade improvement is generally recommended. Figure 2.6.1 shows the geographical areas where subgrade improvement is generally included on grading projects. Figure 2.6.1 also shows areas where existing localized soil conditions do not generally require subgrade improvement. These are large areas and exceptions of both inclusion and non-inclusion are not uncommon. Section 11-5-15 of the Facilities Development Manual (FDM) lists examples of where subgrade improvement is recommended. The Soils Engineer and designer will investigate the grade line placement, water table depths and nature of the soils along the project to determine if subgrade improvement is warranted.

In situations where the contractor is required to use wet cut material, is under tight time restrictions, has little or no space to dry soils, or generally when constructing an urban cross section, subgrade improvement should be considered in the design phase to ensure the contract is completed on time and the subgrade is stable.

If subgrade improvement is included in the design, one of ten typical sections is recommended. (If multiple granular materials are available, more than one may be recommended.) These typical sections are shown in Figure 2.6.2. The decision on which typical to use can depend on several factors. The most important factor is the type of granular materials that are native to the area. If bedrock or quarries are near the project site, a typical cross-section using breaker run stone or select crushed material may be selected. If sands and gravels are native to the area, a typical cross-section using these materials may be selected. Use of a geogrid may be warranted if the cost of the native granular material is expensive, or the project is anticipated to waste soil. Geogrid may also be a good choice in urban construction projects, where excavation/utility conflicts can be minimized by a thinner typical cross-section.

The standard subgrade improvements shown in Figure 2.6.2 have different layer thicknesses. The thickness shown recognizes the fact that different materials provide different levels of support. The different thicknesses provide equivalent construction support strength for all improvement types.

The choice of a subgrade improvement material is important to the final borrow and common excavation quantities of the project, as these materials have different required thicknesses.

Proper drainage of these subgrade improvement methods is also important. If these materials are not allowed to drain, water will be trapped under the pavement structure, leading to support and frost-heave issues. The FDM contains details showing the necessary drainage details for the various subgrade improvement methods. These generally involve daylighting drainage from these granular materials.

The DOT has recognized that the use of subgrade improvement has a minor impact on soil support value (SSV) and design group index (DGI) used in the pavement design. Section 14-10-1 of the FDM provides further information on subgrade improvement incorporation into the pavement design.

Figure 2.3.1 Detail of 1:1 Limits

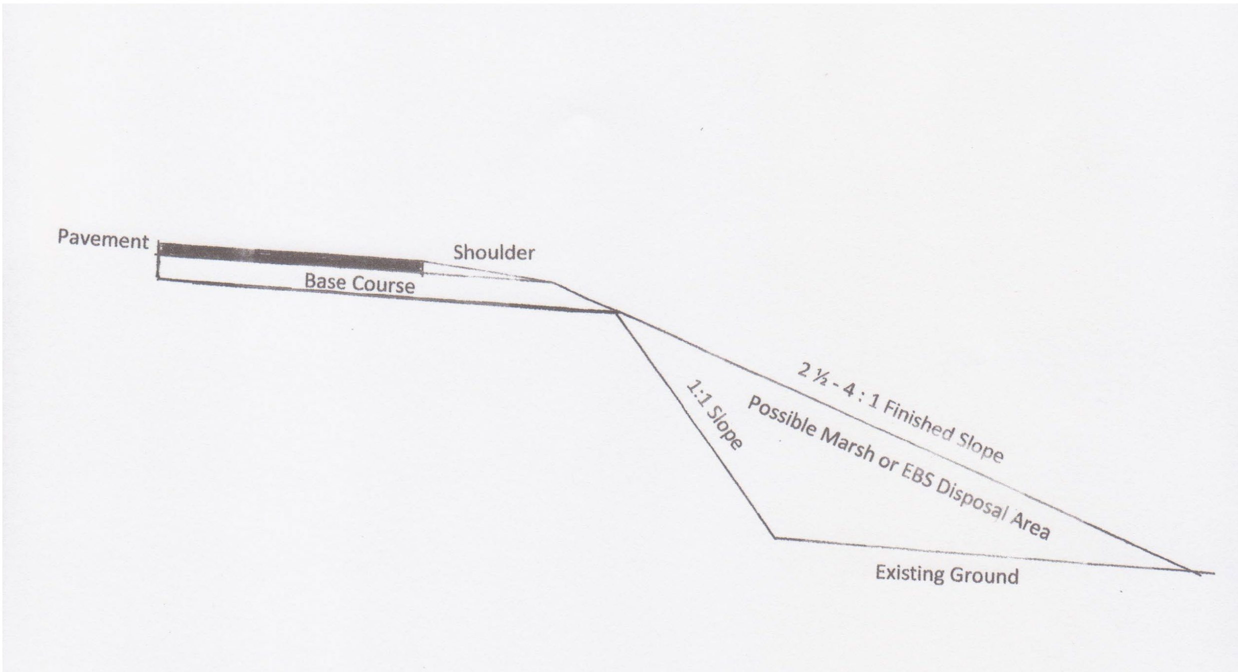


Figure 2.5.1 EBS Width Details

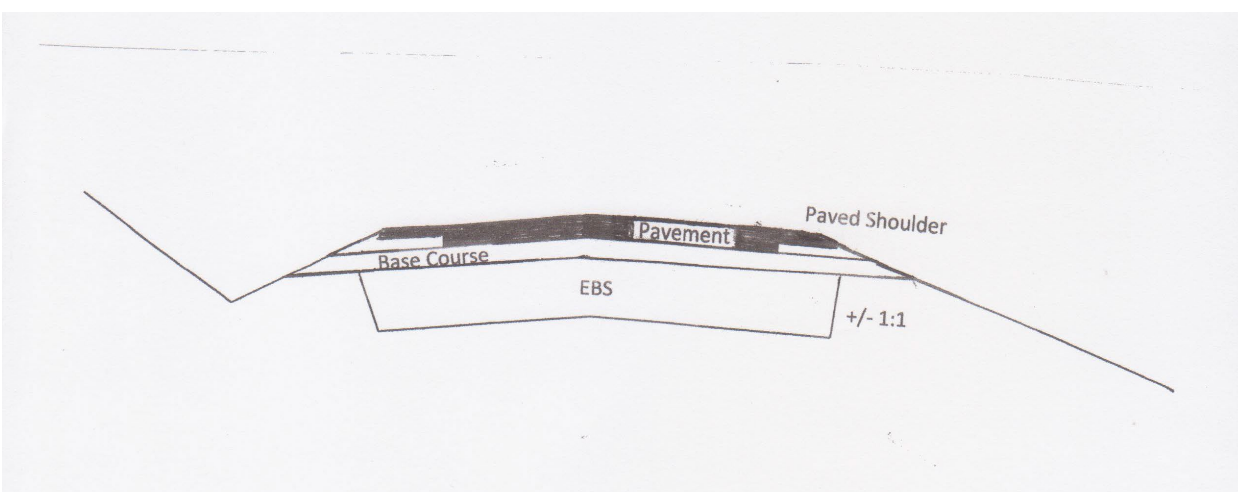
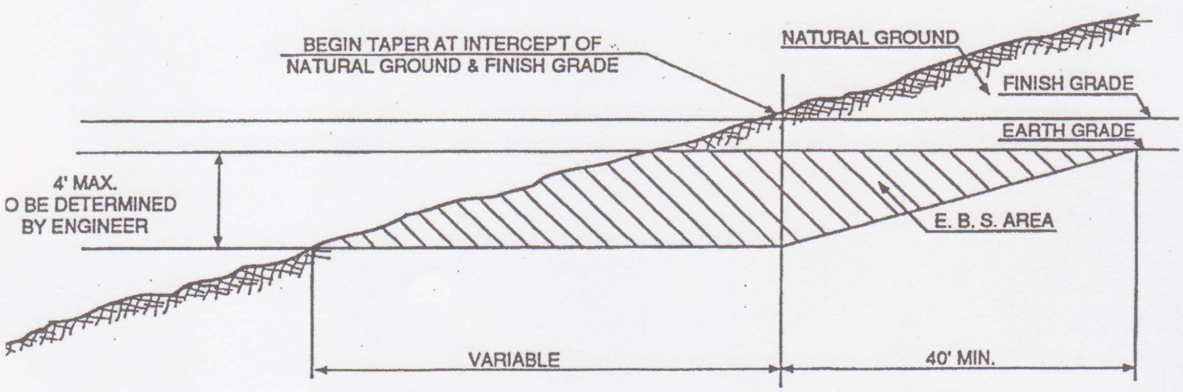


Figure 2.5.2 EBS Transition



NOTE:
E.B.S. ALL MOUTHS OF CUTS. THE EXACT LOCATION AND EXTENT OF E.B.S. SECTIONS SHALL BE DETERMINED BY THE ENGINEER IN THE FIELD. E.B.S. AREA TO BE BACKFILLED WITH MATERIAL ACCEPTABLE TO THE ENGINEER. BACKFILL MUST BE HOMOGENEOUS WITH ADJOINING FILL MATERIAL. THE FILL SECTION WITHIN 100' OF THE MOUTH OF THE CUT MUST BE KEPT 2' BELOW SUBGRADE UNTIL E.B.S. IS COMPLETED. ALL E.B.S. IS TO BE PAID FOR AS UNCLASSIFIED EXCAVATION.

Figure 2.6.1 State of Wisconsin Subgrade Improvement Areas

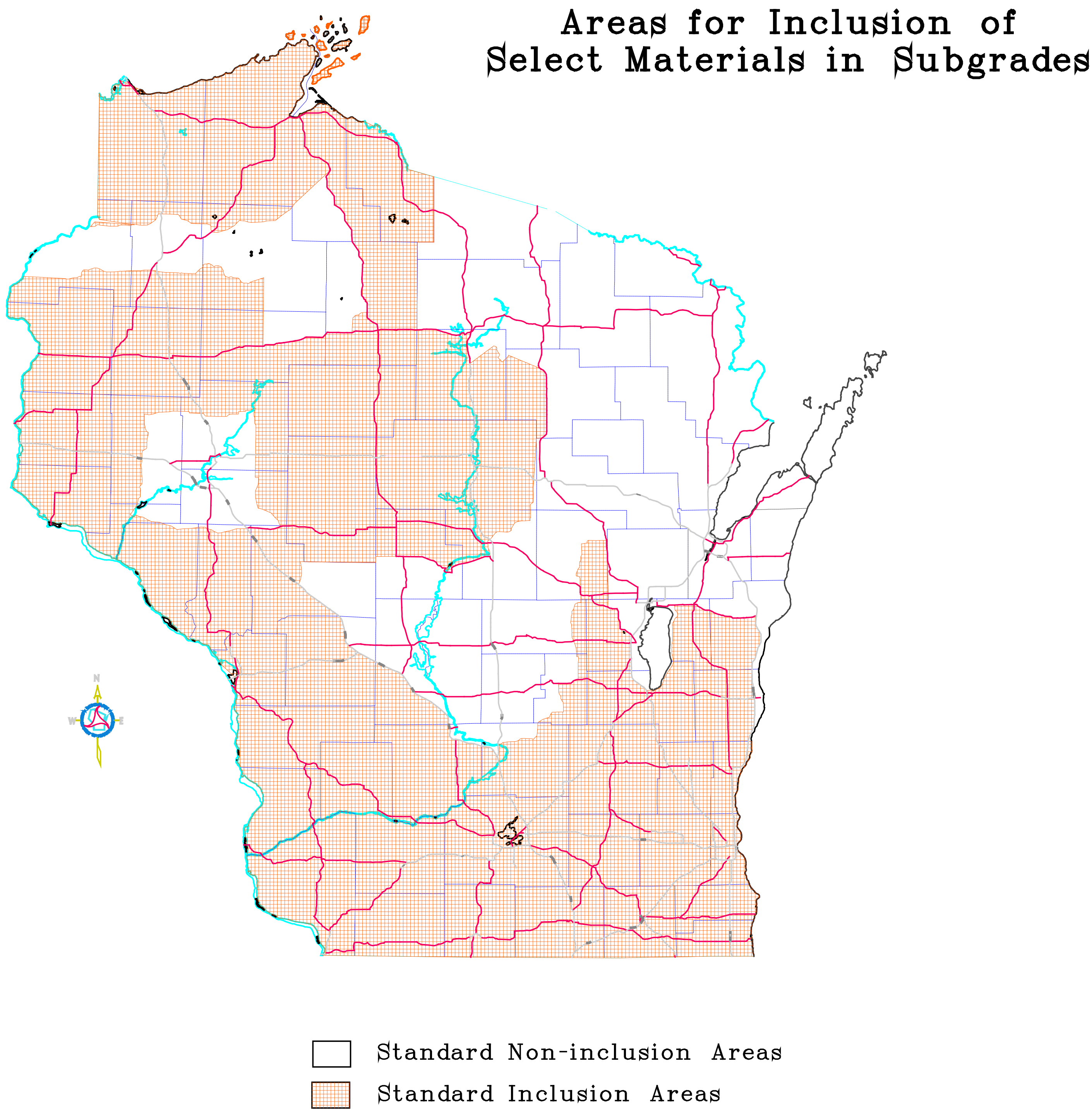
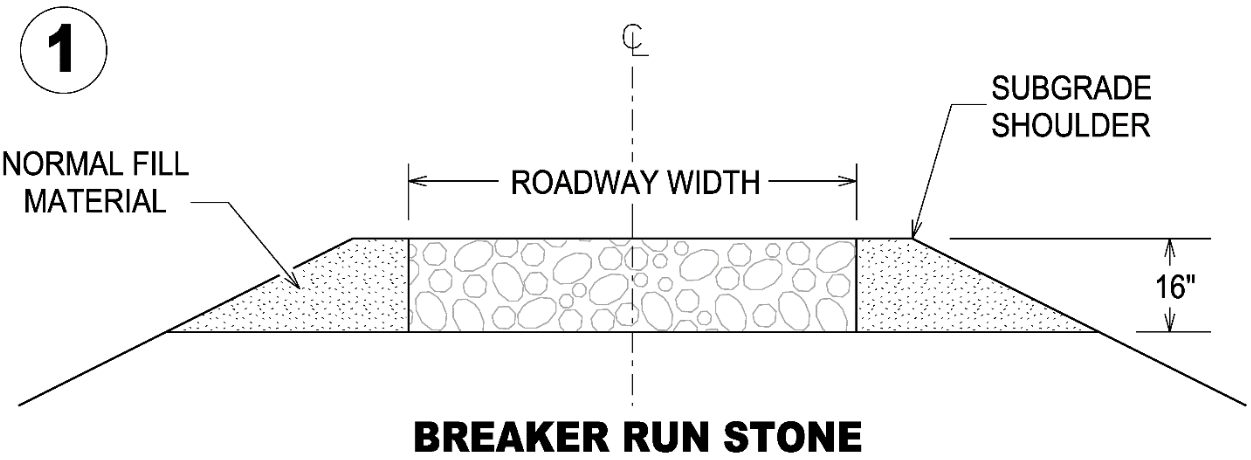


Figure 2.6.2 Typical Subgrade Improvement Sections



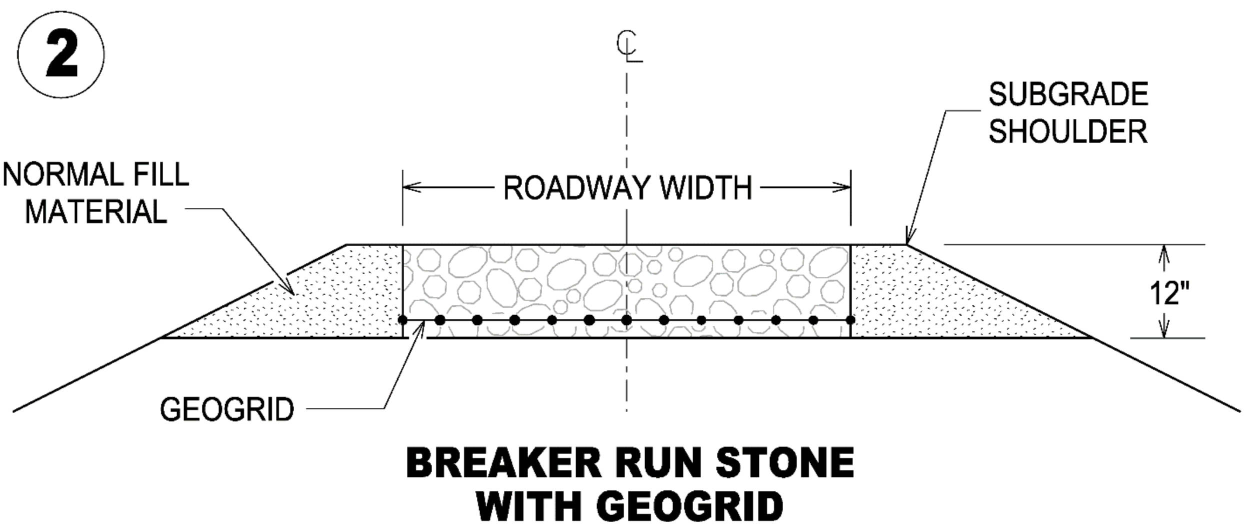
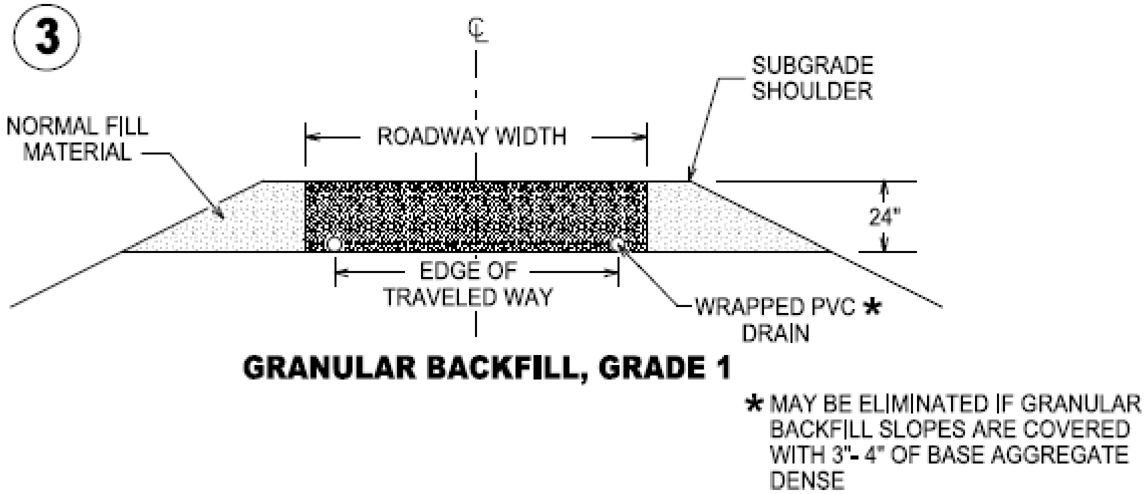


Figure 2.6.2 Continued



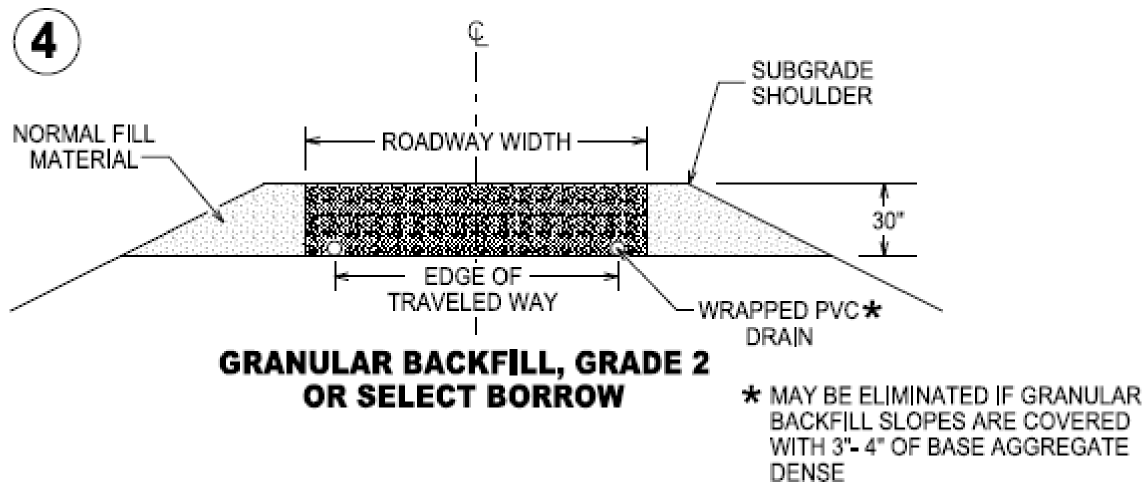
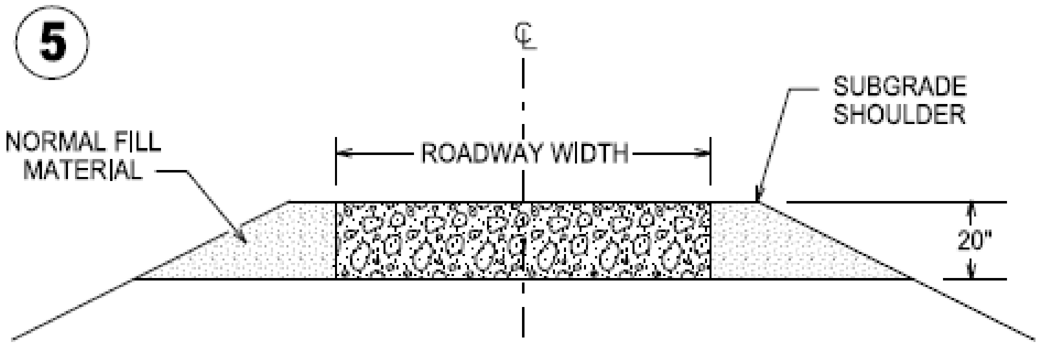
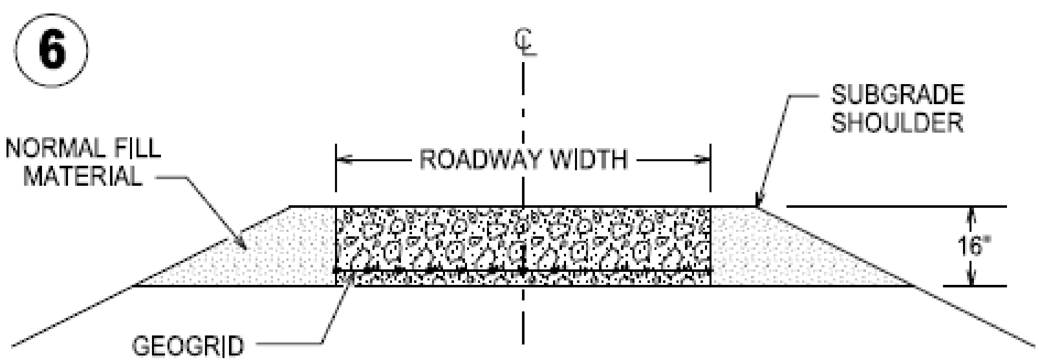


Figure 2.6.2 Continued

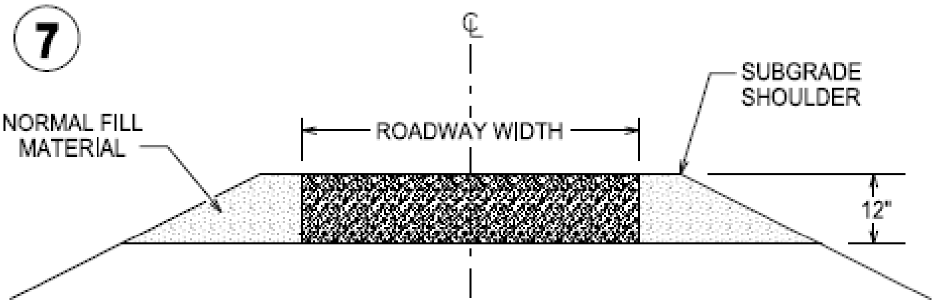


PIT RUN SAND & GRAVEL



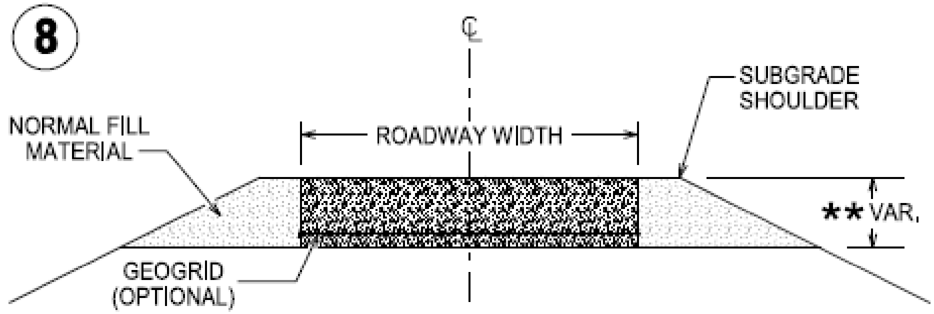
PIT RUN SAND & GRAVEL WITH GEOGRID

Figure 2.6.2 Continued



LIME, FLYASH, OR CEMENT STABALIZED SOIL

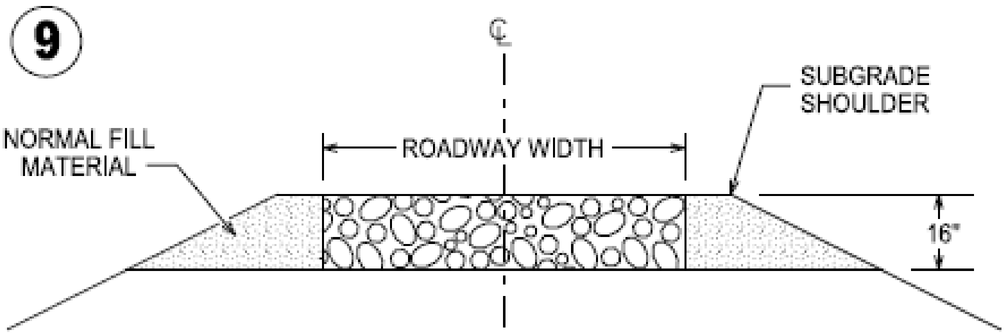
(APPLIES ONLY TO SUBGRADE SOILS CLASSIFIED AS CLAY SOILS)



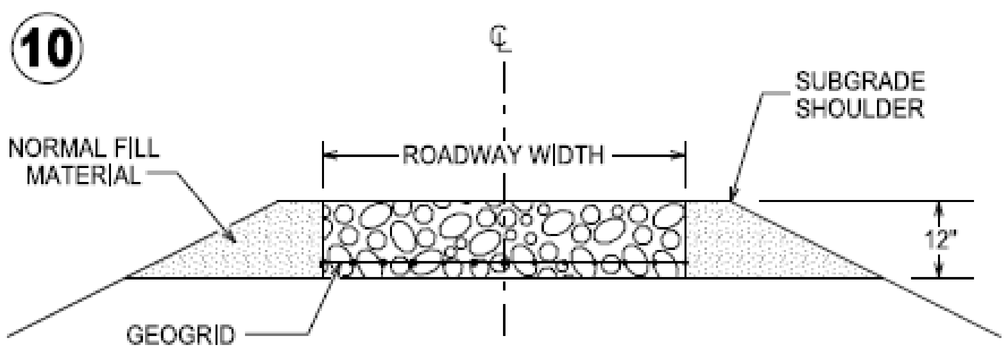
RECYCLED CONCRETE, STEEL SLAG, FOUNDRY SLAG, BOTTOM ASH, RECYCLED ASPHALTIC PAVEMENT WITH GEOGRID

** SEE RECOMMENDATION IN SOILS REPORT

Figure 2.6.2 Continued



SELECT CRUSHED MATERIAL



SELECT CRUSHED MATERIAL
WITH GEOGRID

THE RELIEF TRENCH DETAIL SHOWN IN FDM 11-5 ATTACHMENT 15.3 SHALL BE USED IN CONJUNCTION WITH ALL THE SELECT MATERIAL SYSTEMS EXCEPT #7.

Section 3 Construction

Grading and embankment construction is affected by the types and properties of soils native to the project area. Adequate drainage of soils during the construction process is critical to the completion of a project on time and within budget.

Section 3.1 Preliminary Grading

The first few days of a grading project consists of clearing and grubbing vegetation, required removal of buildings/structures, salvaging topsoil and any other incidental items needed to clear the area for the start of grading. The nature of the common excavation and borrow source for the project will determine the type and method of proper embankment compaction. Utilities need to be addressed and preliminary erosion control must be in place prior to the start of major grading operations.

Clearing and grubbing of trees and brush is usually the first step when starting a grading project. The engineer must review the project's special provisions and the Standard Specifications to determine if there are any disposal restrictions or commitments to property owners. The extent of clearing and grubbing is generally five feet beyond the grading limits (see section 201.3 of the Standard Specifications). Clearing and grubbing must also be performed where fencing is required. In areas where fills of more than six feet are proposed, grubbing is not required (see section 201.3 of the Standard Specifications). Burning of trees and brush may not be permitted. Burying of stumps and other debris on the right-of-way needs to be investigated, so it does not interfere with future construction or the future sale of excess right-of-way.

Other removal items such as buildings, structures or tanks are addressed in the special provisions. The complete removal of basements may be required if their location is in the way of utilities or sign structures. As with stumps, any debris disposed within the right-of-way requires review of future land use.

Tanks or septic systems are addressed in the special provisions. Special disposal of these items is included in the bid items.

Asphalt or concrete can usually be broken down and used as part of the embankment construction or for other granular uses on the project. Do not bury any asphalt or concrete below the water table.

The project staff needs to determine where the contractor is disposing materials off the right-of-way. Materials cannot be disposed of improperly or in wetlands.

Other salvaged or removal items may become the property of adjacent property owners or the local government. These agreements are spelled out in the special provisions of the contract.

Preliminary grading also includes the salvaging of topsoil. The excavation and use of topsoil is detailed in Section 2.3 of this document.

Utilities are located prior to the start of any grading operations. Review the location and depth of utilities to ensure that they are not in the way of construction. Any damage to a utility must be reported to the owner and repaired prior to continuing grading. Document any time the contractor loses due to a utility conflict.

Installation of preliminary erosion control is required prior to the start of any grading operations. Careful review and understanding of the Erosion Control Implementation Plan (ECIP) prior to the start of the project is needed. Review the proposed placement and type of erosion control devices in the field to determine if the type of control or placement is correct or needs to be adjusted.

Section 3.2 Project Soils

The soils report will determine the types of soils along the proposed project route. Thoroughly review the soils report prior to the start of construction operations. The soils report will generally not address the nature of any borrow used on the project. Determine if the borrow and common excavation are similar in nature. If the common excavation is not similar in nature to the borrow excavation, construction of embankments will need to employ construction methods that will prevent future issues that could affect the pavement. Placing silts and clays adjacent to sands will cause the embankment to react differently during frost conditions. Thoroughly mix different soils types within the frost zone, generally the top five feet of the subgrade, while the embankment is being built to prevent differential frost action.

Section 2.2 Basic Earthwork Computations defines the bid item Common Excavation. Any EBS work performed while rough grading operations are underway is generally paid for as Common Excavation. If the grade has been accepted or base course has been allowed to be placed the payment for additional EBS is spelled out in section 301.5 of the Standard Specifications. That specification calls for payment of 3 times the quantity of EBS and 3 times the quantity of backfill required. Generally, EBS operations after the grade has been accepted, or base course is placed, require the contractor to move equipment back to the site or involve operations that cost more, and are often more time consuming. For these reasons the 3 times the quantity cost is used by WisDOT to compensate the contractor for this work. Monitor the grade during construction and remove any unsuitable material prior to accepting the grade to avoid this payment of 3 times the quantity. EBS was discussed in detail in Section 2.5 of this document. The bid item Common Excavation under Standard Specification 205.2.2 requires the removal of boulders greater than 1 cubic yard if the Rock Excavation bid item is not included in the contract. The contractor may request a change order if large quantities of boulders are encountered. Document the number and size of large boulders to avoid conflict if a change order is processed.

The nature of Borrow Excavation was also discussed in Section 2.2 of this document. On major grading projects borrow is usually hauled onto the project from off site and is measured in its original position. A survey crew will measure the borrow site prior to any removal of material, and after the site is finished, to determine the borrow quantity.

In Section 205.4.1 (2) of the Standard Specifications for minor quantities, the engineer may elect to measure Common Excavation by the cubic yard in the vehicle. Section 2.2 of this document explains how soil expands and compacts under different conditions. For example, 10.0 cubic yards of a clay soil in its natural condition can swell to 12.5 yards in a vehicle and shrink to 8.5 cubic yards when compacted. The Army Corps of Engineers has listed example expansion and shrinkage factors for commonly soil types. A copy of this is shown in Figure 3.2.1. When weight-to-volume conversions are necessary, come to an agreement with the contractor using this guide (and/or discussion with the Regional Soils Engineer) to determine the conversion factor for pay.

If the project has rock excavation, determine if the estimated rock line on the plan corresponds to the field conditions. The rock line must be determined in the field to ensure accurate quantities. Specifications require the measurement of boulders of 1.0 cubic yard or more for payment under the item Rock Excavation. In the Standard Specifications Section 205.2.3 rock is also defined as "all conglomerate deposits of any material so firmly cemented they present all characteristics of solid rock, and the engineer determines it is not practical to excavate this material without blasting or using rippers". The presence of this material is difficult to determine in the design phase of a project. Often an increase or decrease in the Rock Excavation quantity is necessary when this material is unexpectantly encountered in the field.

If Marsh Excavation is required, the depth and extent of the marsh must also be determined in the field. This is difficult if the marsh is wet, as it is very difficult to determine where the bottom is using conventional survey methods. Soil borings through the backfill material can be used to determine marsh depth and extent. The use of excavated marsh needs to be evaluated in the design phase of a project. Marsh is highly organic and can be as much as 50% water. Determine if marsh excavation can be used outside the proposed 1H:1V slope. Do not place marsh in areas where future construction is proposed or in areas where utilities or sign structures are to be placed. Evaluate the height and the extent the marsh is to be placed outside the 1H:1V slope with the Soils Engineer. Excess or unstable marsh can slide if placed too wet, too high or too steep. Figure 3.2.2 shows typical marsh excavation cross sections.

Excess topsoil can usually be used outside the proposed 1H:1V slope, from the subgrade break point. Marsh is highly organic, whereas topsoil is generally about ≤10% organic. Topsoil can be removed by a grader or bulldozer. Marsh excavation generally requires a dragline or backhoe to be removed.

Section 3.3 Compaction of Soils

Different types of compaction equipment are designed to work best for particular soil types. A vibrating steel or smooth drum roller works well with sandy soils but has little compaction effect on silts or clays. Rubber tired, sheep foot or pad foot rollers, work best for silts and clay type soils. If properly used, a contractor's hauling equipment (trucks and scrapers) can be effective compactors when they are routed to traverse over the complete grade. A grader is not a compaction device but can be used to smooth the grade and mix soils to lower the moisture content. WisDOT does not specify the type of equipment the contractor must use for the compaction of soils. Further discussion of compaction equipment can be found in the Construction and Materials Manual (CMM) in Chapter 3 Section 30.3. The DOT requires that each layer of an embankment be consolidated to the point that compaction equipment will no longer produce any significant consolidation/settlement. Compaction of soils is specified in section 207.3.6 of the Standard Specifications.

The most common problem with achieving adequate compaction in fine-grained soils is excess moisture in the material. If the soil is too wet, it will move under any compaction equipment and not achieve the desired embankment consolidation. Placing a layer over one that is too wet or not properly compacted is not allowed. The most common method to dry soils is by disking the material and allowing it to air dry. Granular soils may require the addition of moisture to achieve effective compaction.

Most WisDOT projects are constructed using Standard Compaction. This method does not require moisture or density (compaction) testing. However, the project engineer may perform testing if the grade is rutting excessively or appears too wet.

Special Compaction is not often used WisDOT projects. Special compaction requires density and moisture testing to be done by the engineer.

When specified in plan documents, the Subgrade Quality Management Program (QMP) defines procedures for testing and accepting embankment construction. The QMP grading process shifts the acceptance of the grade from WisDOT compliance specifications, to the responsibility of the contractor. The contractor is contractually required to perform a uniform and detailed process called quality control (QC). WisDOT tests a specific minimum of the samples taken by the contractor for quality verification (QV) to ensure the QC is being performed properly. Individuals performing these tests, whether DOT or contractor, are required to be certified as a HTCP Grading Technician 1 (GRADINGTEC-1). Grading Technician 1 training is offered through the HTCP program, at the University of Wisconsin – Platteville, in cooperation with WisDOT. A certified grading inspector, hired by the contractor, tests each soil layer placed using a random selection of test sites.

On some WisDOT projects, the compaction of base course materials is required in the contract. This testing is also part of the QMP process.

Section 3.4 Subgrade or Embankment Construction

The construction of the subgrade or embankment is the most critical processes on an earthwork project. The proper use of soils, layer placement, moisture content and compaction equipment all need to be monitored to ensure the final grade is stable, does not settle, and can support the base and pavement structure.

In addition to embankment compaction, Standard Specification 207.3.6.4 requires the contractor to compact areas of cut to the same degree as the embankment.

Proper soil moisture content is a very important property to achieving good compaction. Water issues can be the result of surficial/rainfall sources or be due to a naturally high water table. If present, the contractor needs to address both these conditions. Generally, issues are the result of trying to compact soils that are too wet. At times, disking may be required to allow soils to dry before compaction. The contractor also needs to ‘seal’ the open subgrade at the end of each day where there may be rainfall predicted. Sealing involves creating a roadway cross-slope to direct water to the shoulder areas (off the grade), and driving a smooth drum roller over the grade, to minimize water infiltration into the soil.

Start construction of the embankment at the lowest point of the fill in low areas or bottom of ravines. Construct the embankment in layers by spreading and leveling the material during placement using a grader, bulldozer or other bladed machine. Spread each layer evenly and approximately parallel with the finished grade the full width of the embankment. Compact each layer to the required consolidation prior to placing another layer.

The Standard Specifications require embankment to be constructed using 8-inch loose lifts prior to compaction. The only exception is when placing in low wet ground; the contractor may apply a layer just thick enough to support the hauling equipment prior to placing any additional layers. If rock is being used to construct the embankment and the rock is a size that placing 8-inch layers is impractical, place in layers no thicker than the average size of the large rocks. If constructing an embankment using rock, methods should be employed to minimize any voids in the material by using an adequate amount of fine material to fill the voids.

Section 205.3.2 (4) of the Standard Specification addresses widening and side slope requirements. The specification states: “If placing embankment on side slopes 10 feet high or higher and steeper than one vertical to 3 horizontal, provide vertically faced horizontal steps or benches in the slopes to support the embankment. The contractor may cut or form the steps or benches while placing the embankment.”

Section 207.2(3) of the Standard Specifications discusses placing stone in areas where pile is to be placed. This specification states: “For those portions of embankments that the contractor proposes to bore holes for piling, or to drive piling through, use materials that do not contain stone or broken concrete retained on a 3-inch ring and free from quantities of gravel, stone, or broken concrete passing a 3-inch ring or other material that significantly affects boring the holes or driving the piling.” Care should also be taken when placing rock in areas where signs or beam guard are proposed.

Section 3.5 Subgrade or Embankment Inspection

It is the responsibility of the inspector/Engineer to insure the embankment is being built to the requirements of Section 207.3.6 of the Standard Specifications. If the moisture content of the soil causes excessive rutting or displacement by the hauling or compaction equipment, do not place a subsequent layer. Allow the layer to air dry or mix the soil using motor graders, discs or other appropriate equipment before compacting. The contractor may attempt to mix drier soil into the layer. This method can be successful, but layer thickness is to remain at 8 inches. In the rare occasion the embankment material does not contain sufficient moisture content to properly compact (generally granular materials), mix water into the lift to adequately compact the material.

The person in charge of monitoring the construction of the subgrade must be in constant communication with the contractors grading foreman. To avoid differential frost action, monitor soil types to insure sands and gravels are not placed adjacent to silts and clays. If the project contains sands along with silts and clay, mix the material to ensure the final grade is a homogeneous material. If the inspector believes the grade is not being constructed to specifications, discuss this immediately with the grading foreman and the project engineer. If a dispute arises between project personnel and the contractor as to the acceptance of the layers, contact the regional soils engineer or project supervisor to resolve any conflicts. The regional soils engineer can perform moisture and density tests and provide information to help resolve the issue. The grading inspector must communicate and document concerns to the contractor. An inspector's lack of communication may imply the embankment is acceptable to the contractor.

It is the responsibility of the inspector to document all aspects of the grading operation. The types of equipment being used, soil type, layer thickness and moisture content are all part of the inspector's daily diary. Disputes and resolutions also need to be documented.

The construction of a well-built and long-lasting embankment begins with the first layer placed and ends at the finished grade line. It is important to insure each layer is adequately compacted with proper moisture content. Placing wet layers at the bottom of a subsequent fill is not acceptable. Wet layers may slide or consolidate during construction operations or after construction is complete or can cause premature pavement failure. When constructing an embankment using silt soils, this moisture may pump under the load/kneading action of construction equipment, causing the upper layer(s) to fail. Pumping is defined earlier in Section 2.5 of this document.

Section 3.6 Subgrade Acceptance

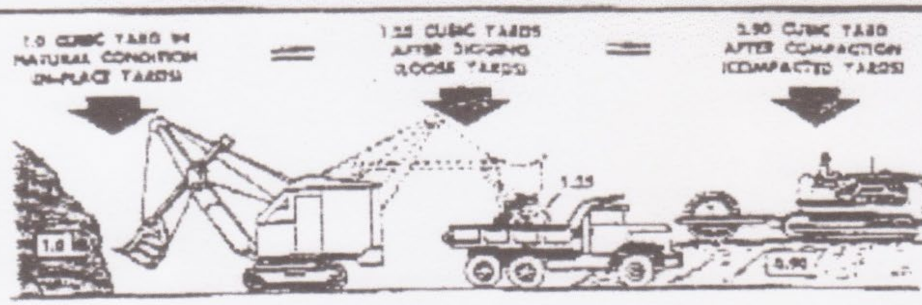
The final acceptance of the subgrade is a long-term process. As discussed in section 3.5 of this document, this acceptance begins when the first layer is placed. The subgrade also needs to be accepted in areas of shallow fills and in cut areas. The Standard Specifications address these two specific areas in more detail.

The inspector's observation of the contractor's hauling and compaction equipment is vital in the final acceptance of the sub grade. Loaded hauling equipment such as dump trucks or scrapers are acceptable compactors if they stagger their footprint the full width of the grade. Under load, this equipment should show little to no rutting, cracking or movement of the subgrade as they pass over it. Compaction equipment such as pads foot rollers, used for fine-grained soils, will begin to “walk out” or ride to the top of the subgrade. Smooth drum rollers, used for granular soils, will not leave roller marks when the grade is satisfactorily compacted.

Proof rolling is a common method of accepting the subgrade. Proof rolling may be a part of the contract, or the cost should be discussed with the contractor. Proof rolling involves slowly driving a loaded dump truck over the grade and observing the depth of the rutting it produces. Generally rutting of one inch or less under the weight of a loaded truck is considered acceptable. Short areas of up to two inches may also be acceptable. However, if the rutting is consistently one inch or greater, additional drying time, mixing or EBS may be required to correct any deficiencies in the subgrade. Compacted sand soils may exhibit subgrade displacement, which is different than rutting. Wheels may cause sand to move and create ‘ruts’, but these may simply be upward movement of the edges adjacent to the truck tires, due to inadequate confining pressure. Once sand is confined after compaction (generally by placing more fill/aggregate over it), it typically provides adequate support. It should be noted that these are general acceptance practices. Subgrade cracking or instability under load conditions may also signal a problem with the grade. Every soil and subgrade are unique and there is no substitute for an experienced inspector, contractor or soils engineer.

In areas of fill generally greater than two feet, excess rutting is usually the responsibility of the contractor.

Figure 3.2.1 Army Corps of Engineers Soil Factors



APPROXIMATE MATERIAL CHARACTERISTICS*

Material	Loose (lb/cu yd)	Bank (lb/cu yd)	Swell (%)	Load Factor
Clay, dry	2,100	2,650	26	0.79
Clay, wet	2,700	3,575	12	0.76
Clay and gravel, dry	2,400	2,800	17	0.85
Clay and gravel, wet	2,600	3,100	17	0.85
Earth, dry	2,215	2,850	29	0.78
Earth, moist	2,410	3,080	28	0.78
Earth, wet	2,750	3,380	27	0.81
Gravel, dry	2,780	3,140	13	0.88
Gravel, wet	3,090	3,620	17	0.85
Sand, dry	2,600	2,920	12	0.89
Sand, wet	3,100	3,520	13	0.88
Sand and gravel, dry	2,900	3,250	12	0.89
Sand and gravel, wet	3,400	3,750	10	0.91

*Exact values will vary with grain size, moisture content, compaction, etc. Test to determine exact values for specific soils.

TYPICAL SOIL VOLUME CONVERSION FACTORS

Soil Type	Initial Soil Condition	Converted to: Bank	Loose	Compacted
Clay	Bank	1.00	1.27	0.90
	Loose	0.79	1.00	0.71
	Compacted	1.11	1.41	1.00
Common earth	Bank	1.00	1.25	0.90
	Loose	0.80	1.00	0.72
	Compacted	1.11	1.39	1.00
Rock (blasted)	Bank	1.00	1.50	1.30
	Loose	0.67	1.00	0.87
	Compacted	0.77	1.15	1.00
Sand	Bank	1.00	1.12	0.95
	Loose	0.89	1.00	0.85
	Compacted	1.05	1.18	1.00

Figure 3.2.2 Typical Marsh Excavation Cross Section

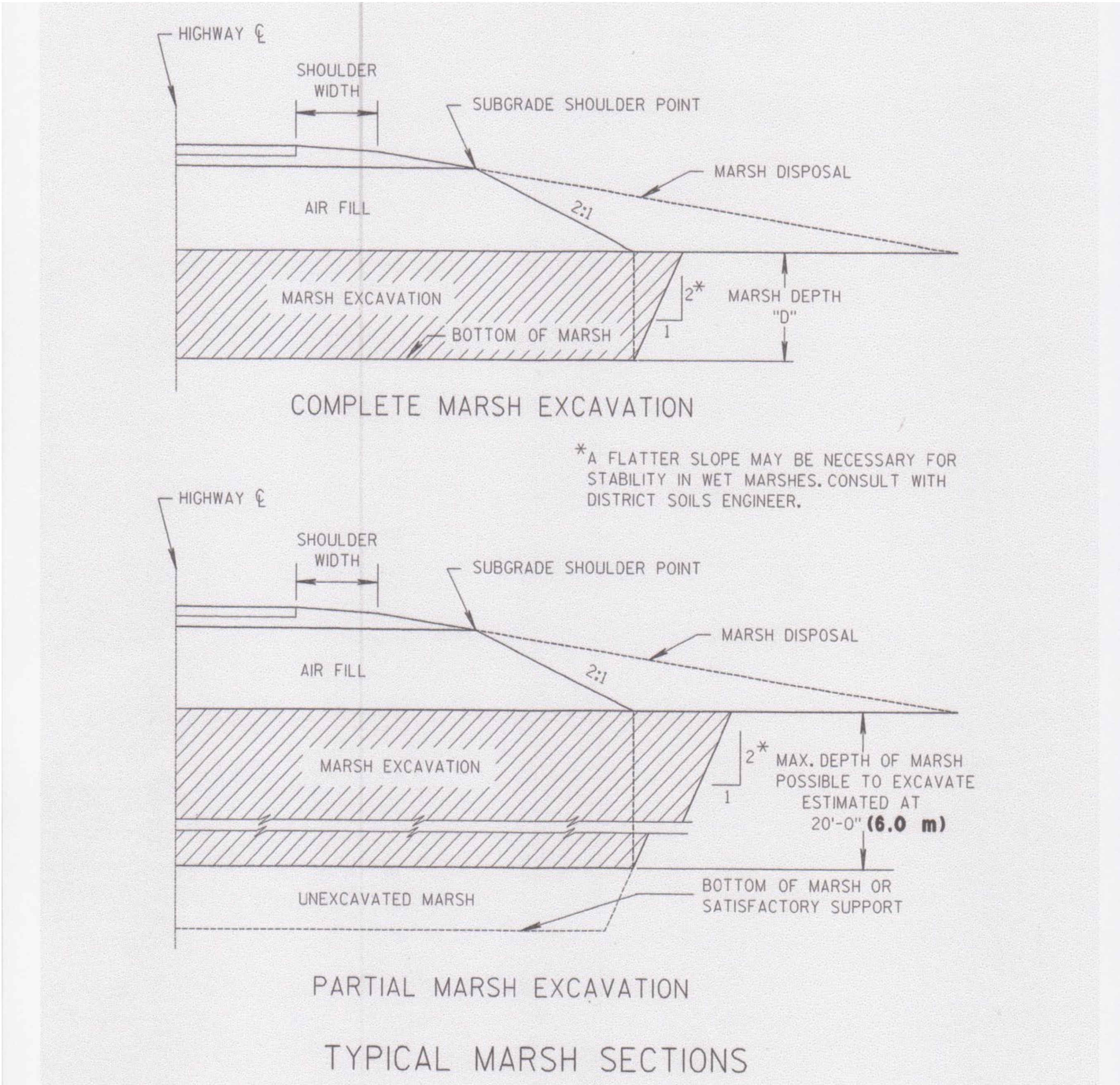
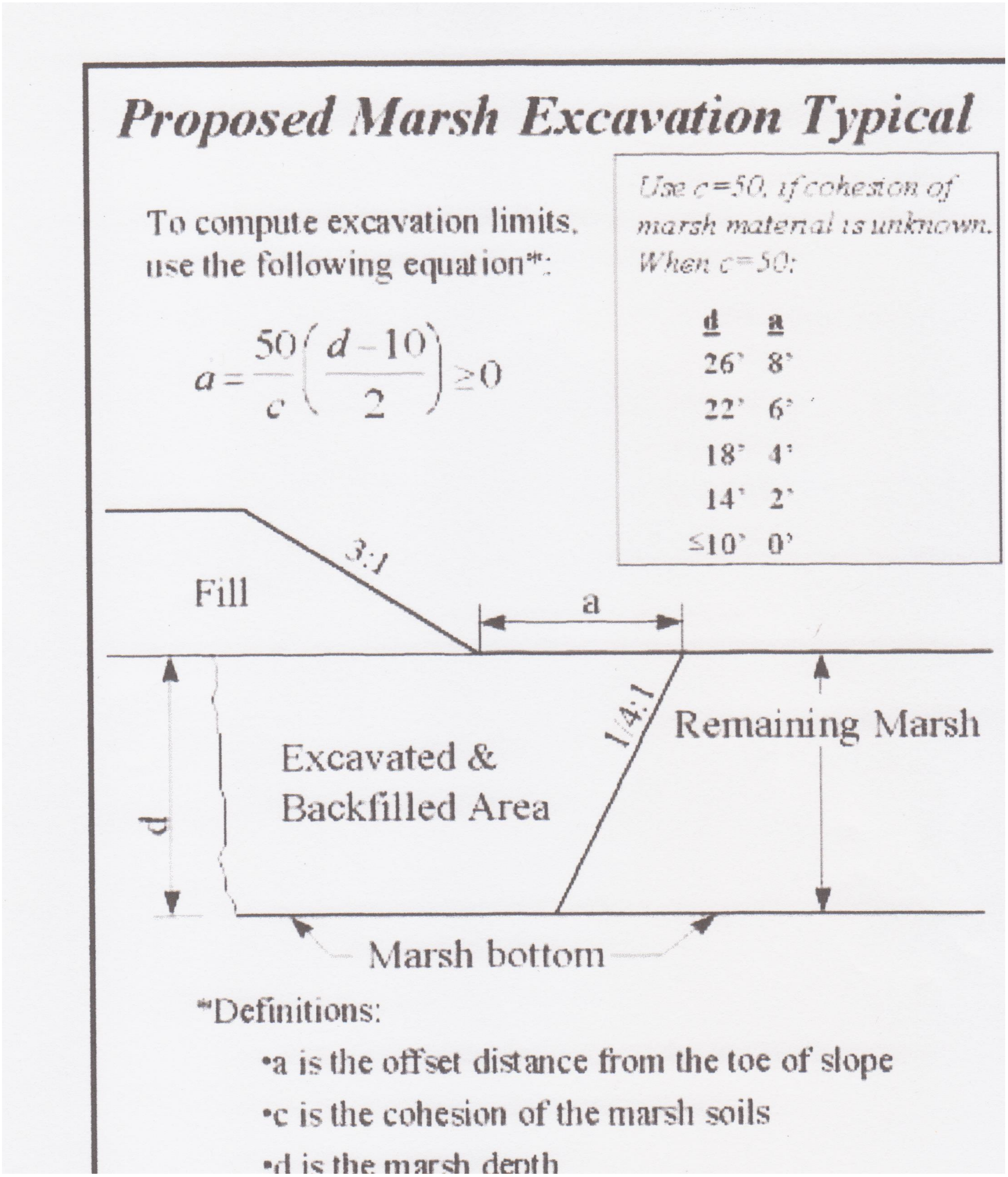


Figure 3.2.2 Continued



Section 4 Structures

WisDOT uses the word 'structure' as a general term to describe anything built or assembled independently, as part of a highway construction project. The most common types of structures constructed are box culverts, bridges and retaining walls. Other structures built along a project could include sign or light supports, high mast lights, and sound walls.

A Site Investigation Report (SIR), or Geotechnical Report, is generally required for all new and replacement structures, or for the rehabilitation of any bridge, retaining wall, box culvert or large sign structure. An SIR may also be required for any extensions to these structures. This report, prepared by WisDOT, or consultant Geotechnical Engineer, includes any appropriate soils information.

The structural design engineer and the soils engineer will determine the subsurface exploration program required to determine the subsurface conditions on which the structure is to be founded. Soil borings are taken to a depth that provides the designer adequate data to determine the strength and consistency of the foundation material. Generally, a minimum of one soil boring is necessary for each substructure unit, such as a pier or abutment. Box culverts and retaining walls generally require a minimum of one boring at each end, and intermediate borings at a predetermined distance along the length of longer structures. Historic subsurface data at structure replacement or widening projects is studied to determine if the number of new borings can be reduced or eliminated.

It is essential that the structure foundation inspector read and understand the information contained in the Site Investigation Report. The report will show the results of the subsurface investigation and indicate where the bottom of the footing, or the depth of the pile, is expected to be located. If foundation problems occur in the field, the first document reviewed is the Site Investigation Report. Construction assistance with unexpected conditions can be provided by the BTS Geotechnical Unit or the Bureau of Structures.

Section 4.1 Box Culverts

Box Culverts generally carry water through a transportation project. Box culverts can also be used to connect a pedestrian trail from one side of the road to the other, and in rare cases as a cattle crossing. A box culvert is usually founded on hard acceptable native soil. Often a base layer of stone or sand is recommended prior to placing the box culvert footing or bottom.

A cutoff wall at the inlet end is required to stop any water from flowing under the culvert and washing out the base material. It is critical that the cutoff wall is constructed according to plan to prevent flow beneath the culvert.

After excavation, inspect the bearing material to determine if it conforms to the Site Investigation Report findings. The founding material should be hard, dry and consistent. If the inspector has concerns with the foundation material, contact the Region Soils Engineer to determine if the founding material will support the box culvert and embankment load. After it is determined that the foundation material will support the culvert and embankment, follow section 504 of the Standard Specifications to properly construct the culvert. Ensure that proper compaction occurs adjacent to the box culvert walls/sides, so future consolidation/settlement of this backfill does not occur and lead to differential pavement settlements.

Box culverts that are wider than 20 feet along the project reference line are classified as bridges but are constructed and inspected the same as smaller box culverts.

Section 4.2 Bridge Foundation

Bridges are founded on deep foundations (piles or drilled shafts) or shallow foundations (spread footings). Findings in the Site Investigation Report allow the designer to determine which of these foundation types is best suited for the bridge structure and site conditions.

If piles are the chosen foundation, the type of pile, depth and axial capacity (bearing resistance) is determined by the designer. It is the responsibility of the field inspector to determine if the pile delivered meets the requirements in the structure plan. Section 550 of the Standard Specifications details the different types of piles and construction methods to properly install them. Once piles achieve the plan required driving resistance, driving should be stopped. Excessive driving or over driving may damage piles, especially end-bearing piles such as H-piles. The inspector needs to determine if the pile hammer being used, the drop of the hammer and the penetration per blow will adequately drive the pile, without damaging it. Pile damage is usually beneath the surface and not easy to detect without sophisticated electronic equipment, although it is sometimes evident at the top of the pile, or when abrupt changes in pile behavior occur during driving.

The two basic types of pile support are end bearing or friction. Generally, all piles exhibit some frictional, and some end bearing support. End bearing piles are usually H type (H-piles) or may be round thick-walled oil-field pipe. These types of piles are driven to an elevation where the tip of the pile is founded on either bedrock or extremely hard soil that provides most of the pile capacity. Friction piles are generally round tubes/pipes with the driven end capped and are normally called cast-in-place (CIP) piles. As the pile is driven into the soil, friction develops along the length between the pile and adjacent soil, as well as at the tip of the pile, and produces the desired support capacity. After driving is completed, CIP piles are filled with concrete.

Pile capacity issues can be experienced when piles are blindly driven into the ground. Estimating pile lengths in the design process is difficult, and some length variation can be expected when they are installed to the required capacity. Driven pile lengths are often slightly longer, or shorter than what is shown on the plan. If possible, drive the first pile near the area where the design soil boring was taken. If the first pile is not being driven to estimated or plan elevation, drive the second pile at the other end of the substructure unit. If there is a significant length difference from the estimated pile length, contact the Region soils engineer or the Bureau of Technical Services Geotechnical Engineering Unit. Study the SIR and soil borings to determine what may be affecting the pile lengths.

Piles are required to penetrate the native soil a minimum of 10 feet, to provide adequate lateral resistance. In some soil conditions (fine-grained cohesive soils), friction piles may develop additional capacity after driving. This is called pile set-up. If a friction pile is being driven excessively long, a set off for a period (generally 24-48 hours) may be recommended by the Geotechnical engineer, to allow pile frictional resistance to increase due to the reduction in excess pore pressures.

Drilled shafts are another type of deep foundation system, but are not as common as piling in the State of Wisconsin. Similar to piles, shafts can be supported by end bearing or friction, or a combination of both. Drilled shaft foundations can be cost effective at sites with shallow rock/very dense soil and deep water, sites with underground spatial constraints such as urban areas, sites where cofferdams are difficult to construct, or sites with vibrational concerns. Shafts have special construction implications and the Special Provisions must be thoroughly reviewed to ensure proper construction.

Spread footings are common where bedrock or very hard soil is encountered near the proposed elevation of the bottom of the substructure unit. After the area of the footing is excavated, determine if the base is solid and the excavated and base soils corresponds to the material shown on the soil borings and discussed in the SIR. Contact the Region Soils Engineer if there are any concerns about the foundation support. Most plans require the Region soils engineer to inspect the site before the structure footing is built.

Section 4.3 Bridge Approaches

Adequate compaction of soil at bridge approaches is required to prevent the approach pavement from settling or failing. The approach fill may be built prior to the bridge construction. The bridge contractor then removes the fill to the abutment elevation to construct the foundation and the abutment. When abutment fills are constructed leading to a bridge, often the contractor does not fill above the abutment elevation near the bridge, until after the bridge is constructed. After the forms are removed, the contractor places a drain tile and backfills the area with structural backfill, as specified in the Standard Specifications. The drain tile must be installed correctly to intercept any water and not allow water to flow around or beneath the abutment. If water incorrectly flows around the drain tile, it may wash out the granular backfill and cause slope failure in front of the abutment or loss of support to the approach pavement. If the approach fill is fine grained (silt or clay) soil, transition the structure backfill to the subgrade elevation, to prevent differential frost movement. The inspector needs to ensure the abutment backfill is constructed and compacted in thin layers, as described in the Standard Specifications. Poor construction practices at approach embankments often lead to the common problem of approaches settling and causing a rough ride, (the bump-at-the-end-of-the-bridge). This rough ride also creates large live loads that are conveyed to the bridge deck leading to increased deterioration of the deck. Snow plow damage can also accrue.

At times, WisDOT uses a special backfill treatment or structural approach slab to reduce the potential for bridge approach settlement. These treatments are detailed in the plan and special provisions of the contract. The use of approach slabs does not reduce the need for proper compaction of the lower subgrade/backfill materials.

Section 4.4 Retaining Walls

The number of retaining walls constructed on WisDOT projects has substantially increased over the past several years. There are six common types of walls used for various applications on transportation improvement projects. These are:

- Cast-in-Place Concrete Cantilever Walls
- Modular Block Gravity Walls
- Mechanically Stabilized Earth Walls with Concrete Face Panels
- Mechanically Stabilized Earth Walls with Wire Face Panels
- Sheet Pile Walls
- Post and Panel Walls

In addition to these six, there are several other types that have been used on past projects, including bin/crib, gabion and secant/tangent shaft walls. Recently, almost 2/3 of new walls being constructed are Mechanically Stabilized Earth (MSE) with either modular block, or concrete panel, faces. These walls are relatively easy to build and can be used in a variety of situations. They are designed to accommodate some movement and settlement without damage and generally cost less than other wall types.

Cast-in-place Concrete Walls are built on site. They are founded on either a concrete footing or piling and can be designed to stand alone or, with a tie back system. They can be massive and labor intensive.

Modular Block Gravity Walls are constructed of modular masonry (dry cast) blocks that have some type of mechanical interlock. They are founded on either a small concrete pad, or aggregate base course pad, and are backfilled with a granular material.

There are several types of Mechanically Stabilized Earth (MSE) Walls. The main difference between the types is the facing material; which can be modular block, precast panels, cast-in-place panels or full height tip up precast panels. These walls are composed of parallel horizontal layers of geogrid, or metal layers, that extend behind the face to reinforce the granular soil behind the wall. These horizontal elements are then connected to the facing system. A small concrete pad is constructed under the facing members to ensure a good horizontal platform to begin face construction. The design of this type of wall is provided by the manufacturer/contractor and approved by WisDOT. These walls are constructed by placing the reinforcement layers (geogrid, metal strips or mesh) between shallow (8-24”) layers of compacted aggregate backfill. Good compaction is imperative and measured through compaction testing during construction. The reinforced soil mass is self-supporting, and the facing panels are mainly used to retain the granular soils near the face. Generally, the retained mass of granular soil extends back from the face, approximately 70% of the height of the wall.

Sheet Pile Walls can be used for temporary or permanent situations. Sheet piles can be removed and used again in temporary situations. Sheet pile walls work well when there is little room to tie back or place granular backfill behind a wall. Depending on site conditions, subsurface soils, sheetpile installation method, distance from work to adjacent structures, and type of adjacent structures, vibrational damage to nearby (<75' distance) structures may be a concern.

Post and Panel Walls use H-pile support members vertically driven into the ground (or installed in predrilled holes), at set intervals. After installation of the H-piles, panels can be inserted between the H-pile flanges to resist or retain the earth. This type of wall can also be used for sound barriers or in cut areas where the wall system must be constructed from the top down.

Proper wall construction techniques are critical to their stability and longevity. Backfill material must meet the contract material requirements and be properly compacted. Place any tie backs as shown in the design, and properly place the drainage material. It is imperative that water is not allowed to pool behind a wall, which will greatly increase the lateral earth pressure.

Generally, all walls higher than four feet exposed are field investigated and require a Site Investigation Report (SIR). The SIR is similar to the reports required for bridge and box culvert structures.

On some types of retaining walls, the density of the granular backfill material is tested through nuclear density tests. The Quality Management Program (QMP) is included in the wall special provisions. This describes the contractor quality control (QC) sampling and testing required, documentation of results, and documentation of related equipment, production and placement processes and changes. The special provisions also describe Departmental quality verification (QV) and independent assurance (IA), and dispute resolution.

The Special Provisions of any wall type need to be read, understood and followed so that proper wall construction is accomplished. Many retaining wall issues or failures have been traced to poor construction practices, techniques or materials.

Section 4.5 Miscellaneous Structures

Other structures found on transportation projects include landscape walls, noise walls, information signs, light supports, high mast lights, high-tension cable guard anchorages, and retention ponds.

Retaining walls with exposed heights of less than four feet are generally called landscape walls. They are generally constructed of modular concrete block and require granular backfill, and a drainage system. Contact the Region Soils Engineer to review the footing excavation of any landscape walls.

Cantilever and overhead information signs or light supports may be investigated in the design phase and may require a Site Investigation Report. Most ground-mounted signs are not investigated in the design phase because the Department has established standard foundation designs based on design parameters such as height above the ground and size of the sign. To support the sign, a hole is augured into the soil (assuming no caving) and filled with concrete to create a shaft member. Confirm that the soil augured out matches the boring log information or is firm and solid. Contact the Region Soils Engineer if there are any concerns about the foundation soil. Some sites may require a temporary casing to keep the hole open until it can be filled with concrete. The construction goal is to ensure there is an intimate contact between the in-situ undisturbed soils and the placed concrete. It is not acceptable to drill an oversized hole, drop a smaller diameter form into the hole, fill the form with concrete and then backfill between the form and the surrounding earth. Similarly, it is not acceptable to use a backhoe to create a trench, drop in a form and then backfill the trench with soil or concrete.

High mast lights are generally supported on deep foundations, either drilled shafts or piling. Construction operation inspections are similar to those needed for bridge piling or drilled shafts.

Storm water retention or detention ponds are sometimes required along WisDOT projects to settle out fine grained soils and slow the rate water enters native streams or storm sewer systems. Retention ponds are usually lined with impervious clay to stop the retained water from entering the groundwater. The liner is constructed in layers and has soil material and density specifications.

Section 5 Culvert Pipes and Storm Sewers

Culvert pipes and storm sewers are constructed of different types of materials. The most common are corrugated metal pipe and reinforced concrete pipe, respectively. PVC and composites can also be used. Pipes are generally round but can be elliptical or “squash pipes”. The construction of the trench, the bedding and backfill materials, the placement of the pipe and the method of backfilling are all critical to any pipe installation and are described in detail in the Standard Specifications.

Inspect pipe delivered onto the project for defects. Check concrete pipes for cracks, out of round, chips, exposed reinforcement and required manufacturer’s markings. The strength of concrete pipe is based on a numerical rating system. Most common concrete pipes are Type III, but occasionally a stronger, or Type IV pipe is required. A Type IV pipe has more steel reinforcement and a thicker wall than a Type III. Stronger concrete pipes are required if placed under a railroad, in large fills, or if less than the desired cover is necessary. Check metal pipes for dents, rust, out of round, coating damage, scratches and required manufacturer’s markings. Metal pipes also have strength requirements that will be stamped on the pipe or certified in a manufacture’s document. Strength of PVC or composite pipe such as “Schedule 40” is stamped on the pipe and must meet project requirements.

Culvert Pipes and storm sewers are required to be constructed beginning from the low (outlet) end to the high (inlet) end.

Occasionally an elliptical or squash pipe is required on a project due to space constraints. These pipes require more cover than a round pipe so using them when cover is an issue, may not solve the problem. A stronger elliptical or squash pipe may require less cover than a standard round pipe and may be used to solve a cover issue.

Section 5.1 Trench Construction

Pipes must be placed in a trench. The contractor is not allowed to place a pipe and build a fill around it. The fill must be constructed to above the top of the pipe plus the required cover, but never less than one foot above the pipe. After this fill has been placed, the trench is excavated to the desired flow line.

In most cases there are no soil borings or soil information for culvert or storm sewer pipes. When the trench is being excavated, inspect the bottom to determine if the soil is firm and consistent. The trench bottom requires the same degree of compaction as embankment construction. If there is muck, buried topsoil, wood, logs or any other detrimental material at the bottom of the trench, some over excavation may be an option. Backfill any Engineer-directed over-excavated areas with foundation backfill material. The contractor may request extra pay for large amounts of over excavation. Document the amount of extra material removed and the extra time required for this work. If the undesirable material is deep, contact the Region Soils Engineer.

Construct the trench beginning at the low point or discharge end of the pipe and proceed to the inlet end. The trench is constructed 6 inches lower than the bottom of the pipe to allow for foundation backfill (bedding material). Standard Specifications 520.3.2.1 (3) and (4), and 608.3.1.1 (3) and (4) provide guidance on trench widths. The intent is to provide the contractor approximately 18 inches on either side of the pipe for backfill material. A smaller trench is acceptable but must be wide enough to allow compaction with the contractor's equipment along both sides of the pipe. Make sure the trench is constructed to allow for a continuous flow, so no water ponds in the pipe. If utilities pass under or over the pipe, insure that the distance between them is adequate and meets the utility's clearance requirements.

Be sure to read and become familiar with the Standard Specifications relating to pipe installation methods including acceptable backfill types and compaction requirements. There are two types of backfill zones within a trench: areas of foundation backfill, and areas of trench backfill. Differing materials may be required in these different areas.

Pipe trenches through areas of bedrock are usually constructed 1.5 times wider than the outside diameter of the pipe, and must also be wide enough for the contractor's compaction equipment. The required depth is six inches deeper than the bottom of the pipe to allow for bedding/foundation backfill. If the contractor elects to over excavate beyond the accepted standards, do not pay for this excess rock excavation.

See Figure 5.1.1 for standard trench widths required for culverts and storm sewer pipes.

Section 5.2 Pipe Bedding

The specifications for pipe bedding are in Standard Specifications Section 520.2.5.2 (Pipe Culverts) and Section 608.2.2 (Storm Sewer). These sections define the foundation backfill gradations and allowable substitute materials. Bedding is composed of granular material that consists substantially of sand, with no particles larger than 1.25 inch. A minimum bedding thickness of six inches is required below the pipe. The backfill material is placed to the required grade and compacted with a mechanical vibrating compacter, generally either a hand compactor or one mounted on a backhoe. Further information on backfill materials can be found in Section 5.5.

Section 5.3 Pipe Joints

Metal pipe joints are locking type. They consist of a band that is placed around the two pipe ends and then tightened by screws or bolts. If infiltration is a potential issue, a fabric may also be wound around the joint to prohibit water or sediment from entering or leaving the pipe.

Concrete pipes use gaskets, masonry, or tar as a joint material. The tar or masonry material is placed completely around the clean bell end. A gasket joint is placed on the small end of the next pipe. The next pipe is fit inside the bell and pushed into place. Place concrete pipe with bells up grade, and with spigot or tongue ends fully inserted into bells. As with metal pipe, a geotextile may be required around the joint if infiltration is an issue. The bell must be dug into the bedding material so that the completed pipe rests on the entire bottom length, and not just the bell. The outer two sections of concrete culvert pipe, plus the end walls are tied together with metal joint ties to prevent separation after installation. Fill concrete pipe lift holes with precast filler cones provided with the pipe. Place masonry or tar around the hole prior to placing the filler cones.

PVC or composite pipes are glued together in the field, following the manufacturer's requirements for glued joints. Joints must be clean, and glue placed around the entire joint. Any polyethylene and polypropylene pipe will require deflection testing with a mandrel.

Section 5.4 Inlets and Manholes

Concrete inlets, manholes and other storm sewer structures can be precast or cast in place. Usually standard manholes and inlets are precast in sections and assembled in the field. The three main components are the base, structure and any risers required.

The bedding for the base of the structure is the same granular material used under pipes, and it is compacted using a vibratory compactor. The concrete base is placed in the correct position and leveled. Mortar is placed on the top of the base, where the structure will be mated to the base. This mortar secures the concrete base to the structure. Inlet and outlet pipes are cut and placed as required. The excess hole or void around the pipe is filled with approved brick or block, and then mortared into place. Any required rings or risers are installed above the structure and mortared into place. These risers or rings are required to be placed onto a full bed of mortar. Wood wedges or other fillers are not allowed to adjust the height of the structure.

It is the contractor's option, or stated in some special provisions, that an inlet or manhole may need to be constructed in the field. This is usually required if the proposed structure is not a standard type of inlet or manhole. Another situation can occur when several pipes enter the structure and a precast unit is not feasible. In this case, the base is placed or poured, pipes placed, and the structure is built around the pipes. The gaps between the pipes are filled with approved brick or block, and mortar is applied. In place of using bricks or blocks, the contractor may elect to form around the pipes and place cast-in-place concrete to complete the structure. To reach the required height, precast risers are placed on a bed of mortar.

After the structure is allowed to cure, concrete is placed on top of the concrete base to establish the required flow line. The cast iron inlet or manhole is then placed at the correct elevation and mortared to the top of the structure. As with risers, wooden wedges or other fillers are not allowed to adjust the cover to the correct elevation.

Section 5.5 Backfilling and Compaction

Proper backfilling and compaction of culvert pipes and storm sewer systems (pipes and structures) is required to prevent settlement, pavement distress, and maintenance issues, and allow the pipe support stresses to be distributed as designed. The required backfill materials for culvert pipes are different than the required backfill materials for storm sewer systems.

Culvert Pipes: Standard Specification 520.2.5 describes the proper material required to backfill culvert pipes. There are two types (and zones) of backfill: foundation backfill, and trench backfill. See Figure 5.5.1 for general backfill information. Foundation backfill is virgin granular material used for pipe bedding, and extends from the base of the excavation, upward to 12” over the top of the pipe. Trench backfill extends from 12” over the pipe, to the subgrade elevation. Granular foundation backfill must meet the gradation specifications of 520.2.5.2.2. Crushed concrete, reclaimed asphalt, reprocessed material or blended materials shall not be used for foundation backfill. Trench backfill for pipe culverts is intended to be the native material from the trench, or material hauled in that is similar to the native material. Trench backfill should be free from large lumps, clods, rocks and other perishable and deleterious matter. Use of trench backfill material that was removed to install the culvert (or materials similar to this excavated material), will reduce the potential of differential frost heave due to differing material types and properties. If granular material is used for trench backfill that is adjacent to silts or clays, a gradual transition or taper of materials should be provided to reduce this potential differential heave issue. This transition is shown in Figure 5.5.2

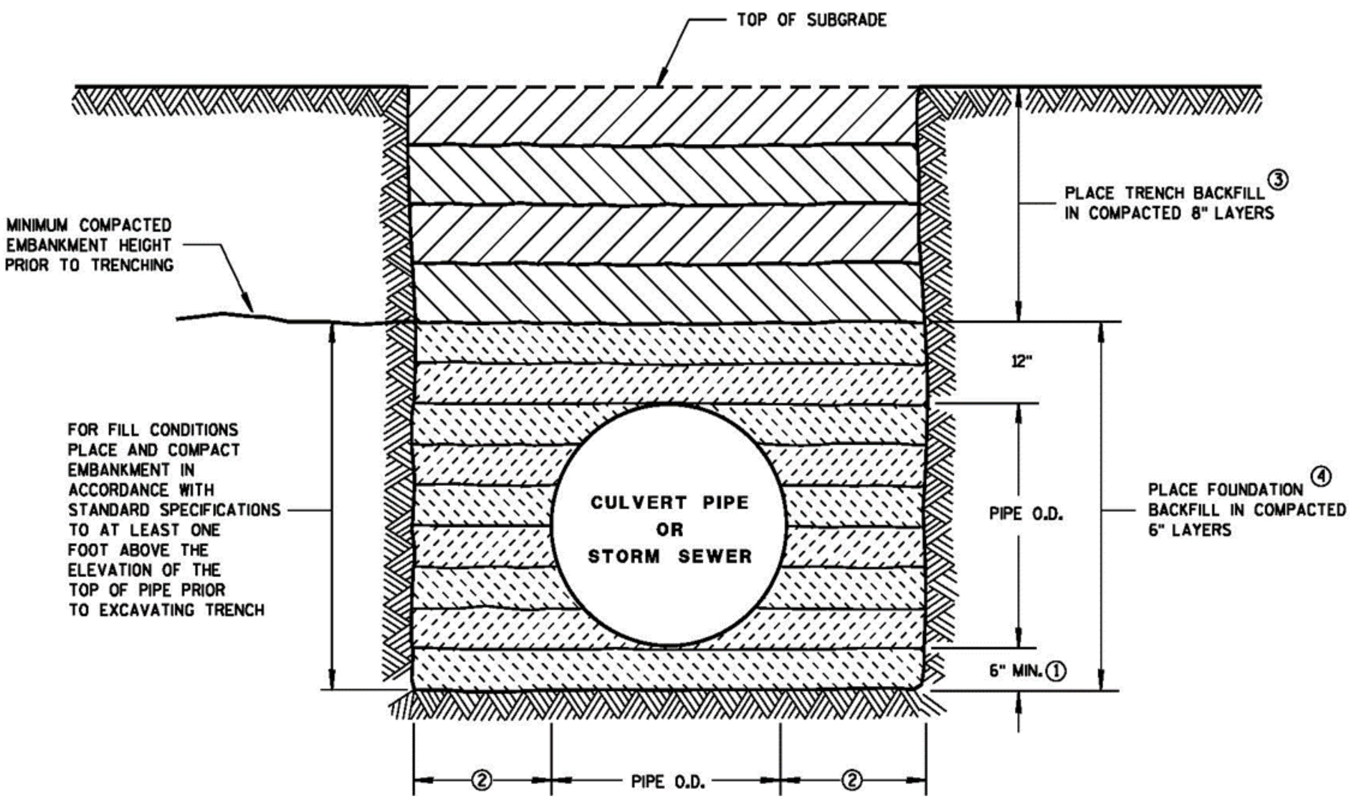
Storm sewer: Storm sewer systems have the same two backfill zones (foundation and trench) as pipe culverts, but have different types of required backfill materials. Foundation backfill gradations for storm sewers shall conform to 520.2.5.2, or meet the gradations of Standard Specifications 608.2.2.2. Trench backfill for storm sewers is granular. and shall conform to Standard Specifications 209.2 (Granular Backfill) or 520.2.5.2. Mechanically compact the foundation backfill around culvert pipes or storm sewer systems with lifts six inches or less (after compaction), and place on both sides of the pipe or structure at the same time to avoid movement. Compact trench backfill material (from 12” above the top of pipe to subgrade elevation) with lifts of eight inches or less (after compaction). Ensure there is adequate moisture in the aggregate backfill to facilitate compaction and prevent segregation.

One area of particular concern for compaction effort, is the area from the bottom of the pipe to the “spring line”. The spring line is located approximately 1/3 of the diameter of the pipe above the invert. This area provides the most support for the pipe and requires special compaction efforts, such as the use of a ramming tool or jumping jack to assure the material is properly compacted around this zone of pipe. Figure 5.5.3 shows the spring line and ramming tools required to compact this area.

If there is a density requirement for the backfill material, a nuclear density gauge is used to determine if the specified density is being achieved. Additional guidance for this can be found in Section 8-15 of the CMM.

Pipe cover requirements are defined in Standard Specifications 520.3.4.1 and 608.3.5. This soil cover must meet the manufacturer's minimum specifications or be a minimum thickness of at least two feet before allowing normal construction traffic to operate over the pipe. If large off-road dump trucks or earth moving equipment is expected to traverse over the pipe, cover thicker than two feet may be required to avoid damage. Protection of the pipe during construction is the responsibility of the contractor.

Figure 5.5.1 Trench and Foundation Backfill Details for Pipe Culverts and Storm Sewers



1. Excavate and place foundation backfill at least 6 inches below the bottom of the pipe. If rock, hardpan, or fragmented material exists, the depth is the greater or 6 inches below the pipe or to a depth equal to ½ inch per foot of proposed embankment above the top of the pipe.
2. 6 inches minimum. In general, this width not to exceed 1/2 the O.D. of the pipe.

   For CMP or concrete pipe, the trench width should not exceed the pipe's O.D. by more than 36 inches. For polyethylene and polypropylene pipe minimum trench width is not less than the greater of either the pipe outside diameter plus 16 inches or the pipe outside diameter times 1.25, plus 12 inches.
3. For culvert pipe, trench backfill is to conform to standard spec 520.2.5.3. For storm sewer, trench backfill is to conform to Standard spec 209.2 or 520.2.5.2.
4. For culvert pipe, foundation backfill is to conform to Standard spec 520.2.5.2.

   For culvert pipe and storm sewer, foundation backfill is to conform to Standard spec 608.2.2.2.

Figure 5.5.2 Frost Heave Transition

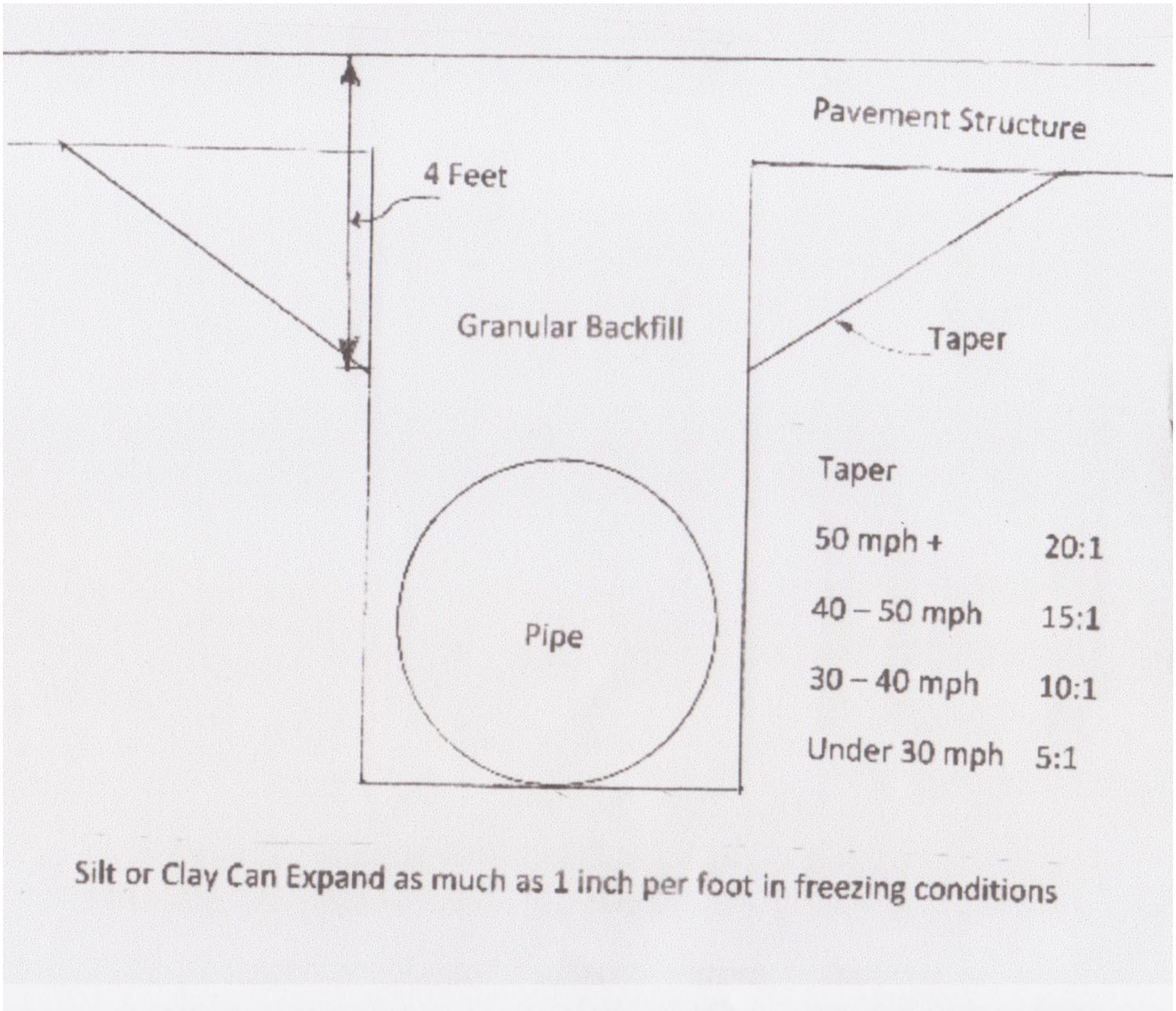
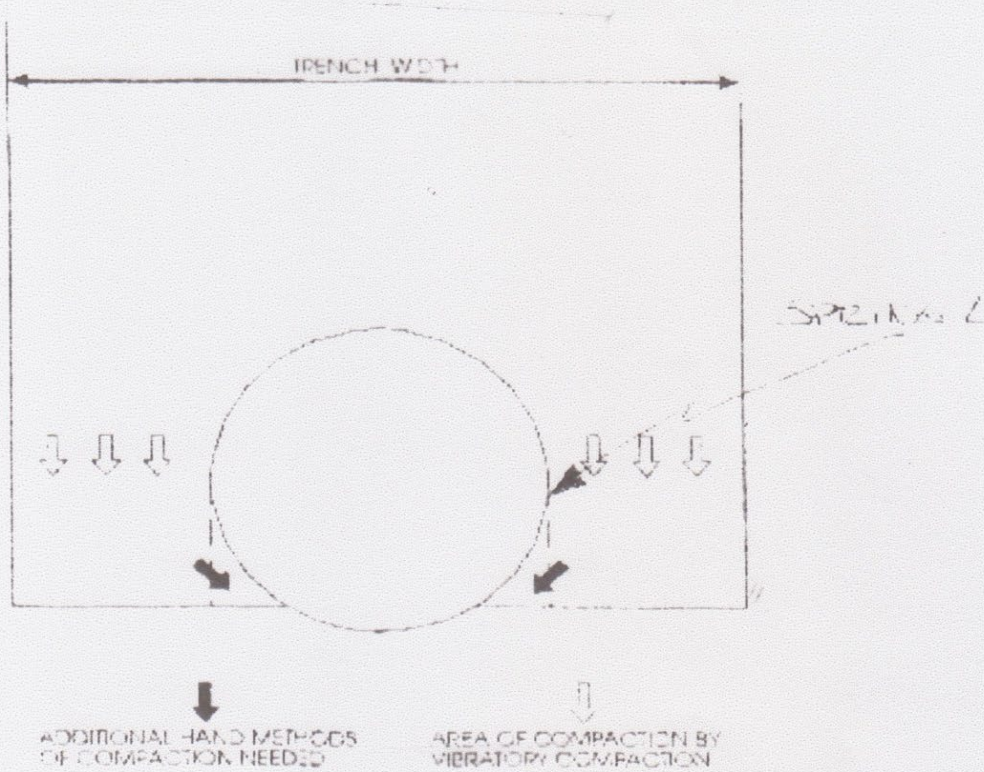
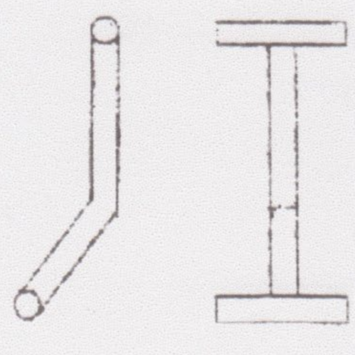


Figure 5.5.3 Spring Line Compaction



EXAMPLE
Special made T-Bar for hand compaction
below round of pipe.
Made of 1 ¼" pipe welded to provide
Handles and "dog leg"
The "dog leg" effect allows good compaction
To be achieved below the round of the pipe.



Section 6 Erosion Control

The control of soil erosion on transportation construction projects is a high priority for WisDOT. Erosion within the project limits must be kept to a minimum, and release of sediments to adjacent streams, lakes or storm sewer systems is prohibited.

Section 6.1 Erosion Control Implementation Plan (ECIP)

Any grading projects constructed by WisDOT require an Erosion Control Implementation Plan (ECIP). The ECIP is prepared by the contractor and approved by WisDOT. The project is not allowed to begin without an approved ECIP. Review the ECIP with the Region's Environmental Staff.

The ECIP is a guide and can be changed by the contractor and reapproved by WisDOT staff as the project progresses. The contractor addresses erosion control on the project, at borrow sites, and at any waste sites, if they are needed. For example, slight changes such as expanding a borrow pit by a few feet does not require an ECIP revision, but large expansions or opening of new borrow pits require an ECIP revision.

Section 6.2 Types of Devices

Section 628 of the Standard Specifications describes the types, usage and acceptance of typical erosion control devices. Typical temporary erosion control devises are silt fence, erosion mat, mulch, hay bales, silt screen, turbidity barriers and temporary sediment basins or bags. Permanent devises include geotextiles, riprap and permanent sediment basins.

Section 6.3 Proper Use of Devices

Silt fence prevents sediment from leaving the limits of a project. Proper placement and installation is required for silt fence to control erosion. It is a perimeter control and should not be used for ditch checks.

Erosion mat is placed on slopes where new vegetation needs to be held in place until adequate root systems develop to control erosion. It can consist of straw held together by webbing or a synthetic mat. Erosion mat is required to be staked or pinned in place.

Mulch is placed on newly seeded areas. The mulch is crimped into the ground with a disk-like machine or held in place by a binding agent. Mulch should be placed as soon as an area is seeded.

Hay bales, rock bags or similar devices are used as ditch checks and can be used to prevent silt from entering inlets. These devises are required to be properly anchored to prevent failure.

Silt screens and turbidity barriers are used to prevent sediment from entering streams or lakes when structures are constructed. Other devises such as sheet pile or even concrete barrier are acceptable to control erosion along water ways.

Temporary or permanent sediment basins are a common way to stop erosion or other sediments from leaving the project site. They may require a liner to prevent runoff water from entering the ground water.

Geotextile and riprap are used to line ditches and streams to prevent erosion while the project is being built. These materials are left in place to prevent future erosion. Riprap is placed on fabric to slow the flow of water and prevent soil erosion below the rock.

Any erosion control device installed on a project needs to be reviewed prior to opening the road to traffic. Devices cannot pose a hazard to vehicles in the safety section of the highway.

Section 6.4 Maintenance

Erosion control devices are required to be reviewed weekly or after any major rain event. Any damage needs to be repaired, and sediment removed if required. The ECIP addresses the maintenance of erosion control devises. Offsite areas such as borrow sites and waste sites are also required to be reviewed.