FDM 10-5-1 Communication and Coordination

January 24, 1997

An effective erosion and sediment control plan spans the entire planning, design construction and maintenance stages of a project. To be successful, it is imperative that communication be established and maintained throughout each stage of development to ensure a coordinated effort. This effort should include both internal and external feedback from those affected within and outside the Department.

1.1 Internal Communication and Coordination

Internal communication and coordination for the designer includes that which needs to be established and maintained within the Department in order for the design erosion control (EC) plan to be carried out effectively. Therefore, designers should obtain information from or relay information to:

1. Planning Section, on budget needs or adjustments.
2. Real Estate Section, on erosion or sediment control land acquisition requirements or information on property owners.
3. Construction Section, on whether the desired EC practice is constructable.
4. Maintenance Section, to see if there are any existing erosion and sediment control problems that need to be addressed.
5. Soils Engineer on the types of soil in the area or whether soil stabilization measures will be required.
6. Central Office Landscape Section for special seed mixtures or landscape planning assistance.

In addition to obtaining technical assistance, designers and planners must be aware of what is practical, reasonable and achievable during construction as well as over the life of the project when selecting design features and control criteria for use in developing the design EC plan.

1.2 External Communication and Coordination

1.2.1 With the Department of Natural Resources (DNR)

To help define the coordination effort needed between the DOT and the DNR, the "Cooperative Agreement Between Wisconsin Department of Transportation and the Department of Natural Resources" as well as the "Memorandum of Understanding on Erosion Control", was developed in 1987 (see https://wisconsindot.gov/Pages/doing-bus/eng-consultants/cnslt-rsrces/environment/formsandtools.aspx) environmental concerns can provide information and requirements regarding existing stream and impoundment quality classifications, their present and potential use, and the impact that differing levels of sediment input may produce.

In addition, the U.S. Geological Survey (USGS) and the DNR are primary sources for stream sediment and sediment related data.

FDM 10-5-5 Planning and Location Considerations

January 24, 1997

If damage from erosion and sediment is considered during the planning and location stages of the project development process, the cost of solving problems can be minimized. Therefore, it is important that the following be identified as early as possible:

1. Sensitive locations including environmental and customer sensitive areas as well as those with highly erosive soils. Where possible, these areas should be avoided (see FDM 10-5-10 and FDM 10-5-15).
2. Drainage patterns and quantity of water coming to the project site.
3. Potential soil loss given the amount of grading or soil disturbance involved. Where possible, existing vegetation should be preserved and a limitation on the amount of erodible surface area which may be exposed at any one time should be considered near sensitive areas.

Erosion control costs should be estimated for each of the route alternatives under study, as well as the risks associated should the measures not be implemented. Costs can be minimized if the site design can be adapted to existing on-site conditions and if good soil conservation principles are used.

FDM 10-5-10 Erosion Sensitive Areas — January 24, 1997

Some soil types are known to be more erosive than others and their identification is a valuable aid in route selection. Areas with unstable or troublesome soils such as landslide areas, loess soils, alluvial fans, and some glacial deposits, are potential problem areas when disturbed.

Information on soil erodibility can be obtained from WisDOT's soil engineers, as well as:

1. geological maps,
2. local agricultural offices,
3. local Soil Conservation Service (SCS) offices,
4. WisDOT maintenance and local highway personnel familiar with previous work in particular soil types.
5. Local elected officials and property owners.

The natural drainage pattern and subsurface flows should be examined for each alternative route considered. Steep gradient channels present a greater erosive potential than flatter gradients. Subsurface flows, if left unmanaged, can present slope stability problems especially in areas requiring extensive cut sections. Therefore, designers should consult with their soils engineer for appropriate soil stabilization measures.

Climatic conditions such as rainfall and snow melt, wind intensity, and temperature extremes should be taken into account when evaluating use of various EC items. In addition, soil loss should be evaluated given the amount of soil to be disturbed and the duration of exposure. Erosion and sediment control measures should be implemented to protect the project as needed.

FDM 10-5-15 Environmental and Customer Sensitive Areas — January 24, 1997

Federal and State regulations, as well as the Department's policy dictate the need for careful evaluation and protection measures. To help ensure this effort, environmental and customer sensitive areas should be identified early in the planning and design process. There are two general types of sensitive areas that must be protected from erosion and sedimentation. They are:

Environmentally Sensitive Areas: Areas that must be protected as mandated by law and enforced by state and federal regulatory agencies.

Customer Sensitive Areas: Areas that must be protected as a matter of being a good neighbor.

Environmentally Sensitive Areas	Customer Sensitive Areas

• Water resources such as Lakes, Streams, or Wetlands.
• Other areas that are potentially environmentally sensitive are:
  • Unique wildlife habitat areas especially those that preserve rare and endangered wildlife species.
  • Unique vegetation like prairies, endangered plants and trees
  • Drainage ways
  • Water supply sources
  • Public lands and parks
	• Farmland
	• Residential areas
	• Driveways and roadways
	• Industrial and commercial areas
	• Drainage districts and other drainage systems
	• Parklands

Designers should utilize the guidance in this Chapter to protect these areas with both temporary and permanent erosion and sediment control devices. In addition, contract provisions should consider limiting the amount of surface area exposed at any one time around these sensitive areas and provide for over winter and spring-thaw protection measures.

FDM 10-5-20 Soils Investigation — January 24, 1997

Soil properties such as natural drainage, depth to bedrock, depth to seasonal water table, permeability, shrink-swell potential, texture, and erodibility should exert a strong influence on design decisions. These properties can be found in the project's soils report.

The request for a soils investigation and report should be submitted as early in the project's data gathering stage as possible. Designers should submit this request to their soil's engineer, and, once received, investigate alternatives for resolving any potential problem areas. Also, see Section IX of FDM 10-5 Attachment 60.1 for groundwater and permanent infiltration system requirements.

FDM 10-5-25 Geometric Considerations *January 24, 1997*

25.1 Introduction

Geometrics can be used to an advantage in minimizing erosion and soil loss. The alignment, grade and cross section, as well as, stream crossings and encroachments are geometric features which may have a range of flexibility. Adjustments can often reduce potential damage due to erosion and considerably lessen the cost of control measures. In general, the following geometric considerations should be used where possible:

1. Obtain adequate right-of-way or temporary easements for such purposes as avoiding steep, unstable slope angles and providing detention ponds or other sediment trapping devices. When adequate right-of-way or slope easements for rounding and blending are obtained, appearance is also improved. The initial cost of additional right-of-way should be weighed against the long term costs of construction and maintenance.
2. Use a smooth grade line with gradual changes to avoid numerous breaks, minimize the number of cut-to-fill runouts, and avoid short lengths of grade.
3. Preserve the natural and existing drainage patterns to the greatest extent possible. Avoid placing low points of vertical curves in cut sections. Avoid low grade lines requiring ditch sections in areas of high water table or wetlands.
4. Avoid or minimize earthwork balancing that requires dirt to be hauled across streams. Avoid the need for placement of sediment-generating haul roads in stream areas.
5. Leave stabilized steep slopes of rock debris, soil or stream banks undisturbed, where possible. If the project is "short of dirt", it is generally better to obtain borrow than disturb these critical areas. If it is impossible to obtain borrow, purchase additional right-of-way or temporary easements in order to lay back the slopes.
6. Use independent alignments on divided highways to fit the highway to the terrain and better adjust grades.
7. Set construction limits that provide for slope rounding, preserve trees and shrubs, and prevent over-clearing, unless, they interfere with clear zone requirements.
8. Avoid irregular ditch profiles and steep ditch gradients. Adjust gradients with special ditch grades. If steep ditches are necessary, the steep section should be located at the head of the ditch, not at the outlet.
9. Provide vegetated ditches and drainage channels with wide, rounded cross sections that reduce the erosion potential.
10. Minimize channel changes. When channel changes are required, adjust the new channel cross section, alignment, or length to maintain the existing flow velocity.
11. Locate and align culverts to avoid erosion at the inlet and outlet. Place structures as close as possible to the natural flow line and in line with the flow direction to allow direct entrance and exit conditions. Avoid placing outlets at curved sections or channels or where the outflow can drop and cause scour.
12. Leave an undisturbed, vegetated buffer strip between disturbed soil and sensitive areas when possible.
13. Utilize "toe" ditches at the bottom of fill slopes as a means of protecting sensitive areas. To be effective, these ditches should be moved away from the fill intercept point, approximately 6 to 8 feet (1.8 to 2.4 m), by means of a minimum 6:1 ditch slope (see typical section detail in Channel Matrix, FDM 10-5-35).
14. Maximize the use of natural materials such as soils, sod, seed, mulch, and riprap. By so doing, costs will be reduced and permanent erosion control can be achieved. The use of open metal, concrete, or asphaltic concrete flumes should be avoided. These structures are costly to install, subject to undermining, deteriorate with freezing and thawing, and frequently fail over time.
15. Review the plans by watershed and/or sensitive area. Coordinate "Mobilizations for Erosion Control"

in these areas as grading is completed.

16. Evaluate the grade line and cross sections for possible erosion problems especially in ditches, cut runouts, at low points of the vertical curves, and any other area where water may concentrate.

17. Request and make use of available technical assistance. A quick detail review with additional Department input can save hours of costly changes and minimize problems.

25.2 Topography

The primary topographic considerations effecting erosion potential are slope steepness and slope length. Because of the effect of accumulated runoff, erosion potential is greater on long, steep slopes especially when the slopes are left bare.

Slope gradients for bare soils can be grouped into three general ranges of soil erodibility:

0-7% - Low erosion hazard
7-15% - Moderate erosion hazard
> 15% - High erosion hazard

With these slope gradient ranges, the erosion hazard becomes greater as the slope length increases. Therefore, in determining potential critical areas, the site planner should be aware of excessively long slopes. As a general rule, the erosion hazard will become critical if the bare slope exceeds the following criteria: (2)

0-7% - 300 feet **(92 m)**
7-15% - 150 feet **(46 m)**
> 15% - 75 feet **(23 m)**

NOTE: The above information is based on bare soils. Since WisDOT recommends using seed and mulch on all disturbed areas, the erosion potential is minimized. Other erosion control devices can be used in addition to or in combination with seed and mulch to provide additional protection (refer to FDM 10-5-35).

25.3 Alignment and Grade

Alignment and grade of a highway are important to successful erosion control and their careful selection may be an option available to the designer. The alignment may be shifted to eliminate or minimize encroachment into a surface water environment. A change in grade may be used to avoid intrusion into known erodible soil strata. Alignment and grade alternatives must be consistent with highway safety criteria and should be blended and fitted to the natural landscape to minimize cut and fill sections and to reduce erosion and costly maintenance. These geometric features should be selected so that both ground and surface water can pass through the highway right-of-way or be intercepted with minimum disturbance to streams and without causing serious erosion problems.

Whenever practical, stream crossings should be made at stable reaches of a stream, avoiding meanders that are subject to rapid shifting and channel profiles that are degrading or aggrading. The direction and amount of flood flow at various stages must be considered in the location of hydraulic openings to avoid undue scour and erosion. To reduce the potential for problems every effort should be made to minimize the number of stream crossings and encroachments.

25.4 Cross Sections

Good landscaping and drainage design are compatible with both erosion control and vehicle safety. Slopes of the roadway cross section should be as flat as practicable and consistent with soil stability, climatic exposure, geology, proposed landscape treatment, and maintenance procedures. The cross section should be varied, if necessary, to minimize erosion and to be consistent with safety and drainage requirements. Designers should refer to FDM 13-30 to calculate flow depths in the channel based on the amount of water (discharge) being directed to the area, as well as, how to design channel sections.

Severe erosion of earth slopes is usually caused by a concentration of surface water flowing from the area at the top of cut or fill slopes. Diversion dikes and ditches, either temporary or permanent, should be included in the cross section to intercept and convey the runoff to a suitable outlet.

25.5 Proper Shaping for Erosion Control

Proper design features and natural materials or methods are the most effective means of erosion control. One of the most important erosion prevention items is proper shaping and/or contouring (refer to Attachment 25.1). Proper shaping means slope and ditch rounding, cut-to-fill blending, built-in gully elimination, and feathering cuts. Edges of slopes where cuts or fills intersect the natural ground line should be round. Slope angles should be constructed that will ensure slope stability. Existing vegetation and topographic features should be conserved and perpetuated to reduce erosion.

The solution to some erosion problems depends on avoidance. Sidehill locations where steep, deep cuts are required should be avoided. These steep, deep cuts are difficult areas to stabilize, especially in rock cuts with loose sloughing overburden, in water bearing soils, and/or in soils high in silt content. Before slopes can be stabilized, the foundation soils and/or geologic formations must be stable. In general, the degree of slope designed must be flatter than the natural angle of the weakest soils or rock formation encountered in the slope. Vegetation can only stabilize and control surface erosion (erosion normally contained to the top 1-ft (300 mm) of soil). Revegetation is directly dependent on slope stability. If slope angles are constructed to ensure stability, plant establishment can usually follow. Side slopes may vary with the height-of-fill or cut and right of way limits. At times, the designer may make adjustments to flatten the slope angle or shorten the length of slope.

25.6 Cut-To-Fill Transitions (Cut Runouts)

Cut-to-fill transition areas are highly susceptible to erosion. The erosion problem generally starts at the cut-to-fill transition and extends down along the toe of the embankment slope to the low point (refer to Attachment 25.2 and Attachment 25.3).

There are two conditions which affect the shape of the drainage channel at the toe of the fill.

1. The natural ground is level or slopes away from the fill;
2. The natural ground slopes toward the fill.

If the natural ground slopes toward the fill, a special ditch gradient should be constructed along the toe of the slope to reduce the erosion potential and to provide the desired rounded cross section. The designer should determine whether or not channel protection is required to convey runoff quantities down the cut-run-out ditch. Flumes are frequently necessary to convey drainage down the special ditch grades and to prevent erosion. The runoff to be conveyed down the flume will have to be determined.

If it is determined that a flume is inadequate for the runoff flow quantities to be conveyed down the special ditch, an enclosed pipe down drain should be considered.

When the natural ground slopes away from the fill, ditches are not necessary. However, attention should be paid to natural drainage courses and nearby sensitive areas which may receive sediment from the fill slope.

25.7 Culverts

Culverts generally constrict flood flows and increase velocities, giving a much higher than normal erosion potential for a particular site. In many instances, erosion and scour at culvert crossings are damaging to either the highway embankment, the structure itself, or the downstream channel if not designed and protected properly. A good indication of the need for outlet protection at culverts is the performance of other culverts in the area.

The culvert size, location, grade, and the provision of any necessary outlet protection are important design considerations in determining the erosive potential of a culvert crossing site.

Culverts should be located to minimize channel changes where practicable. Consideration should be given to constructing culverts on skewed alignments to minimize channel relocation and erosion.

The invert grade of the culvert should closely match that of the natural channels. A thorough evaluation of culvert invert grade alternatives will help identify which alternative will result in the least erosion and scour both during and following construction. Cantilevered outlets should be avoided unless they discharge onto a rock foundation or other protected outlet provisions.

LIST OF ATTACHMENTS

Attachment 25.1	Erosion Control Prevention
Attachment 25.2	Erosion Control At Cut To Fill Transition
Attachment 25.3	Transition From Cut of Fill

FDM 10-5-30 Drainage Guidance For Erosion Control — *January 24, 1997*

30.1 Natural Drainage

Early in the data gathering stage, it is important for planners and designers to review and take pictures of the project during, or shortly after, it rains to:

1. Identify or confirm existing drainage patterns.

2. Identify and record existing drainage problem areas.

The existing drainage patterns, which consist of overland flow, swales and depressions, and natural watercourses, should be identified in order to plan around critical areas where water will concentrate. Where possible, natural drainageways should be used to convey runoff over and off the site to avoid the expense and problems of constructing an artificial drainage system. Man-made ditches and waterways can become part of the erosion problem if they are not properly designed and constructed. Care should also be taken to be sure that the increased runoff from the site will not erode or flood the existing natural drainage system. Possible sites for storm water detention should be located at this time. Where possible, the natural drainage system of a site should be preserved.

30.2 Adjacent Areas

An analysis of adjacent properties should focus on areas down slope from the construction project. Of major concern should be watercourses which will receive direct runoff from the site. The potential for sediment pollution of these watercourses should be considered as well as the potential for downstream channel erosion due to increased volume, velocity and peak flow rate of storm water runoff from the site. The potential for sediment deposition on adjacent properties due to sheet and rill erosion should also be analyzed so that appropriate sediment trapping measures can be planned and installed prior to any land-disturbing activity.

30.3 Local Input

To gain an understanding of existing drainage problems or concerns, designers should gather information from those who are familiar with the project area such as maintenance personnel, nearby property owners, farmers, town officials or administrators, drainage district offices and the district DNR liaison.

30.4 Storm Design Guidance and Channel Capacity

In general, designers should use the following storm design guidance when designing for temporary and permanent erosion control measures:

1. For permanent roadside channel linings, a 10-year, 24 hour frequency storm is considered cost effective unless the risk associated with failure would warrant a larger frequency. Risks should be weighed against the cost and erosion control measures designed accordingly.
2. For temporary roadside channel linings and temporary devices such as silt fence and erosion bales, a 2-year, 24 hour frequency storm is considered cost effective unless as noted in #1 above.
3. Emergency spillways for detention basins are to be designed for the 100 year, 24 hour frequency storm.

NOTE: If environmental or customer sensitive areas are impacted, a longer frequency may be needed.

FDM 13-10 Attachment 1.1 requires roadside and median channels to have enough capacity for a 25-year, 24 hour design storm. However, designing channels to prevent erosion given the 25-year storm would produce very expensive channels. Therefore, it is recommended that designers provide:

1. Appropriate measures to minimize channel erosion during the 10-year, 24 hour storm, yet,
2. Enough channel capacity for the 25-year, 24 hour storm (refer to Chapter 13 for further information on hydraulic and channel capacity design).

If the permanent lining is to be a vegetative lining and a temporary lining is to be used during the establishment period, the mean annual flood (2.33-year recurrence interval, approximately 2 years) should be used for the design of the temporary lining. This is because the temporary lining is only required for a short period of time, and if the lining is damaged, repairs are usually inexpensive.

30.5 Storm Water Runoff

Runoff calculations must be done to determine the effect of the highway on the existing hydrologic system. To determine how runoff will travel over the site, divide the site into drainage areas and consider how erosion and sedimentation can be controlled in each small drainage area. Once the smaller sites have been evaluated, the entire site can then be reviewed to see how the erosion control measures fit together.

Designers should refer to Chapter 13 when calculating runoff and contact the locality, where applicable, to see if they have adopted more stringent runoff requirements.

Where existing conditions are being maintained, and there is no significant alteration to existing drainage patterns or areas, such as on 3R projects, or where the drainage area is small, the designer may rely upon the use of empirical design methods. A working system does not need to be altered or redesigned unless problems have been identified.

FDM 10-5-35 Channel and Slope Matrics February 27, 2004

Attachment 35.1 and Attachment 35.2 were developed for use as a guide to identify where to apply erosion and sediment control devices, given a specific set of parameters. These parameters are typically slope and slope length. In addition, they can be used as a tool to evaluate whether the project's channel or slope design will need to be modified to provide the required protection. The matrices are only a guide and should not replace critical engineering judgment or the need for careful design consideration.

These matrices were developed with information obtained from the American Association of State Highway Transportation Officials (AASHTO), Department of Natural Resources (DNR), Soil Conservation Service (SCS), data from the WisDOT PAL (found at: https://wisconsindot.gov/Pages/doing-bus/eng-consultants/cnslt-rsrces/tools/pal/default.aspx), other states, district offices and past practices. Each device is shown to the limit where it could function if used alone. Consider using a combination of these devices when developing an effective erosion control plan.

The channel matrix is based on the Department's typical section as shown in FDM 11-15-1. The use of the matrix does not mean that designers are restricted from using larger flows. However, if larger flows are used the channel section and/or erosion measures will need to be adjusted accordingly to protect the channel from erosion. One method for calculating the appropriate channel cross section and erosion measures is known as the "tractive force" or "shear stress" method (see FDM 10-5-40 for guidance.) Designers should also refer to FDM 13-30 on how to calculate flow depths based on the amount of water (ie., discharge) being directed to the area, as well as, how to design alternate channel section.

Costly erosion and sediment control measures can be minimized if the site design can be adapted to existing on-site conditions and if good conservation principles are used. Where possible, existing vegetation should be preserved. Costs should be estimated for each alternative under study and the risks analyzed should the measures not be implemented.

LIST OF ATTACHMENTS

Attachment 35.1	Channel Erosion Control Matrix
Attachment 35.2	Slope Erosion Control Matrix

FDM 10-5-40 Calculating Shear Stress in Channels January 24, 1997

To help determine the appropriate channel liner, designers can refer to the channel matrix in FDM 10-5-35. However, for channels not conforming to the typical section shown in the channel matrix or having a depth of flow greater than 6 inches (150 mm), the designer will need to design for an appropriate channel liner. One way to do this is to use the "tractive force" method presented in FHWA's Hydraulic Engineering Circular (HEC) No. 15. This method requires that the CALCULATED MAXIMUM SHEAR STRESS of a channel is not to exceed the PERMISSIBLE SHEAR STRESS of the channel liner.

To use this method, permissible shear stress values are stated next to each device listed in the channel matrix. Calculated shear stress values can be determined using the formula:

Calculated Shear Stress = (Unit Weight of Water)(d)(S)
Where:
- Calculated Shear Stress is in lbs/ft^2 or Pascals *
- Unit Weight of Water = 62.4 lbs/ft^3 (9800 $Newtons/m^3$)
- d = Depth of Flow in Channel (feet or meters)
- S = Channel Gradient (feet/foot or meters/meter)

* Note: 1 Pascal is defined as 1 $Newton/m^2$

If the calculated maximum shear stress exceeds the permissible shear stress of the mat being considered, the channel or channel liner must be adjusted. This may involve one or more of the following:

1. CHANNEL LINER: Use a stronger channel liner, either flexible or rigid, to meet the drainage requirements of the channel.
2. CHANNEL CROSS SECTION: Modify the channel's cross section such as widening the ditch bottom to decrease the depth of flow in order to reduce the stresses on the liner (refer to Chapter 13).

Once vegetation is established, the permissible shear stress of the channel increases. Engineering judgement should be used given the sensitivity of the area prior to vegetation establishment as well as long term performance requirements.

Caution: Even though the calculated shear stress may be less than the permissible shear stress, designers should still use their engineering judgement to decide whether the channel liner is appropriate based upon the project conditions. For example, if the calculated shear stress value falls just under the permissible shear stress for the channel liner selected, it may be appropriate to go to a different channel liner if the area is adjacent to a critical environmental or customer sensitive area.

In addition:

1. When riprap or grouted riprap is to be used, designers should refer to FDM 10-10-19 and FDM 13-30 for design guidance.
2. For steep slopes or critical channel sections, designers should refer to FDM 13-30 and consult with their Hydraulic or Soils Engineer.
3. Another method for designing channel liners is to compare the calculated velocity of the channel to the permissible velocity of the channel liner. For further information on this method, refer to FDM 13-30.

Sample Problem

Given: A 300 ft long triangular ditch with a 6:1 inslope, 4:1 backslope and a channel gradient of 4% (S=0.04). The ditch must handle a flow (Q) of 20 cfs.

Determine: An appropriate channel liner.

Discussion: Based on FDM 10-5 Attachment 35.1 there are several options available if the depth of flow does not exceed 6 inches. If this depth may be exceeded then the following procedure should be followed.

1. Assume a depth of flow (da) for the channel. Say 1 ft. (Caution: Avoid having the depth of flow equal to the ditch depth. There should be some freeboard.)
2. Pick a potential channel liner and determine its n value from Manning's Roughness Coefficients Table (refer to Attachment 40.1). For this example try a Class II, Type B, a "Straw with Net" erosion mat. From the table, n = 0.033 based on the assumed depth of 1 foot.
3. Use the nomograph in Attachment 40.2 to determine the actual depth of flow (d). Since the channel slopes are not the same, calculate "z" using the formula z = T/da where "T" is the width of the flow in the channel at the assumed depth.

   For an assumed depth of 1 ft, T = 10 ft and z = 10/1 = 10. The z/n ratio is then 10/0.033 or 303. Connect the z/n ratio of 303 with slope (S) of 0.04 on the nomograph. From the turning point draw a line through the discharge value of 20 cfs and extend the line to the far right depth of flow scale. The reading on this scale (d) is approximately 0.8 ft.
4. Check this revised depth against Attachment 40.1 to see if it still falls within the depth range originally selected for the Manning's roughness coefficient. If so, continue. If not then select a different channel liner with a different n value. In this example d = 0.8 ft which falls in the 0.5 ft - 2.0 ft range for the chosen channel liner. Therefore, the n value is the same as for the assumed depth of 1.0 ft and there is no need to choose another liner option.
5. Check if the channel liner selected meets the shear stress requirements of the channel. This is done using the formula from page 1:

   Calculated Maximum Shear Stress
   $= (62.4 \text{ lbs/ft}^3)(d)(S)$
   $= (62.4 \text{ lbs/ft}^3)(0.8 \text{ ft})(0.04)$
   $= 2.00 \text{ lbs/ft}^2$

   This equals the permissible shear stress of the Class II, Type B channel liner as shown in FDM 10-5 Attachment 35.1 therefore, the chosen option is acceptable.

If the calculated shear stress is greater than the permissible shear stress of the chosen channel liner, then a stronger liner would be needed. If another liner is used it should be checked using the procedure described above.

LIST OF ATTACHMENTS

FDM 10-5-45 Analyzing Costs

January 24, 1997

45.1 Cost vs. Effectiveness

The cost of implementing erosion and sediment control practices is highly variable and dependent upon many factors including regional cost trends, availability and proximity of materials, time of year, prevailing labor rates, maintainability, etc.

Those preparing a design erosion control (EC) plan must pay careful attention to the selection of each practice. The practice with the least expensive initial cost may require a great deal of maintenance over the length of a project. Accessibility for maintenance can often be a factor that determines effectiveness. Silt fence for instance, requires regular maintenance. If it is placed in a location that is difficult to reach or in a location that drains a large disturbed area, maintenance may become a problem, increasing the potential for failure. In such a case, a diversion dike leading to a sediment trap may be a better selection. The dike and trap are more suitable to handle larger runoff volume and would require less day-to-day maintenance, if installed properly.

Once installed, the costs associated with a particular erosion control installation can be kept to a minimum when maintenance is performed on a regular basis. Once a practice fails, the replacement cost can be double the initial cost of the practice. Regular maintenance also decreases the likelihood of damage to downslope property.

FDM 10-5-50 Estimating Erosion Control Quantities

April 27, 2011

In order for erosion control items to be successful they must be available in adequate quantities. When determining adequate quantities of these items, designers should include an extra amount of each item as "Undistributed" to provide for unforeseen circumstances and provide for any necessary repair work. Approximately 25% of the calculated quantity should be used as the undistributed amount. For example, if the calculated plan quantity for Class I, Type B erosion mat is 1000 yd2, the undistributed quantity would be 250 yd2, for a total of 1250 yd2. If the quantities are small to begin with or if the project will span more than one construction season, a higher percentage should be used for the undisturbed quantity.

50.1 Mobilization for Erosion Control

For the bid item of "Mobilizations Erosion Control", the designer should estimate how many times an erosion control or landscaping contractor may need to be mobilized given the type of work and environmental or customer sensitivity in the project area. It is important to provide adequate quantities for this item commensurate with applicable environmental requirements.

Practice indicates that landscapers are mobilized up to 5 times for small bridge projects. For example:

1. Install silt fence prior to earthwork.
2. Install temporary ditch checks.
3. Install turbidity barrier prior to abutment or pier work.
4. Bring erosion control measures up to the Q2 elevation after the substructure work is complete but prior to work on the superstructure.
5. Perform final restoration and landscaping.

Some examples of estimating Mobilizations Erosion Control are;

1. Three mobilizations for each earthwork balance point,or
2. Three mobilizations for each construction staging sequence,or
3. One mobilization for each 2-3 weeks of contract duration, or
4. One mobilization for each ¼ to ½ mile of project length, or

Use whichever method provides the most mobilizations. If there are environmental or site restrictions on how much area can be exposed at one time, include additional quantities of Mobilizations Erosion Control.

50.2 Emergency Mobilization for Erosion Control

For the bid item of "Mobilizations Emergency Erosion Control", the designer must estimate how many times it may be necessary to mobilize for emergency situations. A “rule of thumb” is to include one emergency mobilization for every 4-5 weeks of contract duration at a minimum, and more if any of the following are applicable:

1. The project is erosion sensitive (refer to FDM 10-5-10),

2. Environmental or customer sensitive areas are located within or nearby the project (refer to FDM 10-5-15),
3. The project will be constructed during normally wet months,
4. The project will span more than one construction season, thereby making it susceptible to spring runoff erosion.

FDM 10-5-55 Erosion Control Plan Preparation

January 24, 1997

55.1 Introduction

Erosion control during construction is highly dependent on the temporary and permanent measures contained in the design erosion control (EC) plan. The design EC plan includes all erosion and sediment control considerations made during the planning, location, and project development phases and is found in the construction plans, specifications and special provision's. To be effective, it must contain sufficient measures and adequate quantities.

The Department is required to meet the substantive legal requirements of the Wisconsin Pollution Discharge Elimination System (WPDES) as well as the terms and conditions presented in the WisDOT/WisDNR Cooperative Agreement (refer to https://wisconsindot.gov/Pages/doing-bus/eng-consultants/cnslt-rsrces/environment/formsandtools.aspx). By doing so, the Department is considered to be in compliance with the WPDES permit program requirements.

To meet the substantive requirements of the WPDES and the WisDOT/WisDNR Cooperative Agreement, designers should refer to FDM 10-5-60 for a checklist of erosion control plan requirements.

55.2 Special Provisions

The special provisions should contain a statement which explains any special erosion and sediment control measure, environmental protection measures and references to sensitive areas. It should contain information concerning existing site conditions, construction schedules, and other pertinent items. It should also indicate sensitive areas on the project and any special considerations for those areas.

When working near sensitive areas, designers should consider including, in the contract documents, a limitation on the amount of erodible surface area which may be exposed at any one time. In addition, projects should be evaluated to see whether they may be left uncompleted and carried over the winter. In such cases, these projects should be "buttoned up" by providing adequate quantities in the plans and include special provisions sufficient enough to prevent erosion and maintain devices through the spring-thaw season.

55.3 Construction Plans

Erosion and sediment control measures for a construction project should be detailed and quantified in the construction plans. Information required to be on the design EC plan, or for reviewing the design EC plan, is located in the:

1. TITLE SHEET: Indicates the general location of the construction activity.
2. GENERAL NOTE SHEET: Includes general plan information.
3. CONSTRUCTION DETAIL SHEETS: Includes non-standard details of erosion and sediment control devices that are needed for the project.
4. PROJECT OVERVIEW SHEET/MAP: May be used to show nearby receiving waters such as lakes, rivers, and wetlands.
5. ESTIMATE OF QUANTITIES: Lists the total quantity of each erosion and sediment control device used on the project.
6. MISCELLANEOUS QUANTITY SHEETS: Contains information on the specific location of erosion and sediment control devices.
7. EROSION CONTROL PLAN DETAIL SHEETS: Illustrates the location of all pertinent erosion and sediment control devices as well as other relevant information such as drainage patterns, slope intercepts and environmental and customer sensitive areas. Topographic features such as tree-lines, nearby buildings, parking lots and driveways, are also desirable.

   For complex projects, separate plan sheets are recommended in order to avoid clutter and allow the contractor to find the information as quickly as possible. For less complex projects, it may be appropriate to illustrate the location on the "Plan and Profile" sheets. In some cases, it may be appropriate to show the devices by station and location on the miscellaneous quantity sheets. Again, the object being to not clutter the plan.

8. STANDARD DETAIL DRAWINGS: Included for all erosion or sediment control devices applicable to the project.
9. CROSS SECTION SHEETS: Contains valuable information on existing and proposed drainage features such as channel and slope grades, culvert pipe locations & elevations, slope intercepts and intercepting embankments.

An erosion and sediment control plan must contain sufficient information to ensure that the problems of erosion and sedimentation have been adequately addressed for a proposed project. The length and complexity of the plan should be commensurate with the size of the project, the severity of site conditions, and the potential for off-site damage.

Plans for projects undertaken on flat terrain will generally be less complicated than plans for projects constructed on steep slopes where erosion potential is greater. The greatest level of planning and detail should be evident on plans for projects which are directly adjacent to sensitive areas.

FDM 15-1 Attachment 5.10 shows an example of an erosion control detail sheet.

FDM 10-5-60 Checklist for Erosion Control Plans *December 5, 2017*

A design erosion control plan is required on all projects having a potential to cause the discharge of sediments. The checklist in Attachment 60.1 summarizes the items that need to be included throughout the contract documents for a given project. The checklist was developed to:

1. Help designers meet the federal and state regulations
2. Improve statewide consistency in the development of erosion control plans

Most of the requirements are not new for WisDOT P.S.& Es. Those that are new are shown in bold type. For information only, items that need to be included in the soils report to meet the requirements are also given.

LIST OF ATTACHMENTS

FDM 10-5-65 Construction Considerations *January 24, 1997*

All erosion and sediment control considerations made during the planning, location, and plan development phases should be contained in the design erosion control (EC) plan. The design EC plan contains the erosion and sediment control plans and contract provisions necessary for the contractor and construction personnel to perform the work.

The control of soil erosion is an essential consideration in construction operations. The contract documents should require that the work be performed in a manner which will cause minimum soil disturbance. When working near sensitive areas, the designer should consider including, in the contract documents, a limitation on the amount of erodible surface area which may be exposed at any one time during the performance of the work.

The designer should also anticipate whether the project might be left uncompleted and carried over the winter. Adequate quantities and special provisions should be provided to "button up" the project sufficient enough to prevent soil loss.

Once the project is let, the design EC plan is used by the contractor to develop an "Erosion Control Implementation Plan", (ECIP). The ECIP is a narrative and pictorial plan based on the contractor's schedule of operations. It differs from the design EC plan, in that, it outlines a general timetable of when erosion control devices are expected to be installed by the contractor before, during and after construction based on the estimated schedule of operations. In addition, it includes all Wisconsin Pollution Discharge Elimination System (WPDES) requirements for borrow and waste site areas (refer to FDM 10-1-1).

Proper planning and scheduling of the construction operations are major factors in controlling anticipated erosion and sediment problems. The schedule should consider the probable weather conditions and the potential occurrence of storms, particularly if work in or adjacent to sensitive areas is involved.

This plan should be available to the construction project engineer prior to the pre-construction conference. For further information regarding the ECIP, see the Construction and Materials (C&M) manual, the Wisconsin Standard Specifications for Road and Bridge Construction and/or supplemental specifications.

It is now the contractor's and project engineer's responsibility to not only carry out the explicit contract plan provisions for erosion and sediment control, but also to adapt, adjust, add, and implement the measures through the different phases of construction to achieve an acceptable level of erosion and sediment control.

The construction project engineer and inspection staff must become thoroughly familiar with the erosion and sediment sensitive areas of the project and the control measures contained in the plans. This information should be reviewed with the contractor at the pre-construction meeting to facilitate the implementation of the design EC and ECIP plans.

The designer should attend the pre-construction conference and be ready to answer any questions pertaining to the project.

Periodic field reviews and inspections by the design and construction engineers to correct deficiencies and improve control procedures are highly recommended. The designer should try to schedule a time to meet with the construction project engineer in the field to evaluate the design and obtain feedback.

FDM 10-5-70 Maintenance Considerations *January 24, 1997*

The need for continual maintenance of temporary erosion and sediment control devices as well as the need for maintenance of permanently installed measures is as important as the initial installation. Access for future maintenance purposes must be considered when specifying devices.

Temporary sediment control devices such as silt fences, sediment traps and ditch checks, usually require frequent and periodic cleanout of accumulated sediment. To effectively control erosion on construction sites during extended periods of inactivity such as during winter months, it is essential that the designer consider maintenance in the contract special provisions and estimated quantities.

In addition, once the contractor has completed the project and the new vegetation has been firmly established, the project should be checked to see that all remaining temporary erosion and sediment control devices are removed if no longer needed.