PERMANENT EROSION AND SEDIMENT CONTROL DESIGN GUIDELINES

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MONTANA MDT DEPARTMENT OF TRANSPORTATION

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APPENDICES

LIST OF ACRONYMS

AGR	Alignment and Grade Review
BMP	Best Management Practice
BOD	Biochemical Oxygen Demand
CalTrans	California Department of Transportation
CWB	Constructed Wetland Basin
DNRC	Department of Natural Resources and Conservation
ECM	Erosion Control Mats
EPM	Engineering Project Manager
HDPE	High Density Polyethylene
MDEQ	Montana Department of Environmental Quality
MDT	Montana Department of Transportation
MS4	Municipal Separate Storm Sewer System
NRCS	Natural Resources Conservation Service
PESC	Permanent Erosion and Sediment Control
PFR	Preliminary Field Review
PIH	Plan-in-Hand
SWMP	Storm Water Management Program
TMDL	Total Maximum Daily Load
TRM	Turf Reinforcement Mats
USBR	US Bureau of Reclamation
USDA	US Department of Agriculture
WQV	Water Quality Volume

SECTION 1.0: INTRODUCTION

The purpose of these Permanent Erosion and Sediment Control Design Guidelines is to describe procedures and methods to address the following:

1. Long-term erosion that could potentially result from highway construction.

2. Sedimentation resulting from highway-related storm water runoff.

These guidelines include procedures for evaluating the need for permanent erosion and sediment control (PESC) measures during the project development process and determining which PESC measures can practicably be incorporated into the design. The guidelines also provide design details that address specific erosion and sediment control issues and discussions of construction issues and maintenance considerations.

The primary objective of this guidance document is to provide adequate information for the selection of the appropriate PESC measures to be included in the plans package. Those PESC measures would be intended to reduce soil erosion and sediment deposition into adjacent waterways and to protect the highway facility. It is anticipated that including PESC measures in the plans will clarify the Montana Department of Transportation's (MDT's) expectations of contractors, reduce maintenance needs, improve control efficiency, facilitate efficient permitting and reduce long-term control costs.

Inclusion of PESC measures into project plans should be evaluated on a project-by-project, site-specific basis. Inclusion of PESC measures into the project plans should be coupled with proactive management of basic design considerations such as limiting the area exposed to construction, maximizing use of existing and proposed vegetative cover, minimizing sliver cuts and fills, weighing appropriateness of flat-bottomed ditches as opposed to v-ditches, and using natural topographic features to the best advantage. Proactive steps could reduce the need for PESC design measures.

Erosion is uncontrolled soil movement caused by wind or water action. The byproduct of erosion, sediment, is soil particles being transported away from their natural location by wind and water action. Erosion control measures are used to stabilize disturbed or highly erosive soils. Sediment control measures are used to trap and contain, and potentially treat, sediment caused by the erosion process.

SECTION 2.0: EVALUATION AND DESIGN PROCESS

2.1 General

Incorporation of PESC measures should be considered with projects disturbing 1 acre or more, or projects having the potential to adversely affect water quality. Incorporation of PESC measures will typically be limited to projects with scopes related to rehabilitation or reconstruction and locations in proximity to sensitive resources such as impaired waterways or high quality aquatic habitat and spawning areas. PESC measures can also provide solutions for areas with a history of erosion or sedimentation problems. The PESC evaluation process will begin at the Preliminary Field Review (PFR), continue through coordination with resource agencies in permitting actions, and should be completed at the Plan-in-Hand (PIH) Review.

Site-specific factors must be taken into consideration early in the design and evaluation process. As a result, site-specific information should be gathered as early as possible in the design process.

Appendix A of this manual includes detailed information on each PESC method as well as a decision matrix to aid in the selection of appropriate measures. Appendix B of this manual provides sample plan sheets displaying how PESC measures should be shown in the plans.

2.2 Preliminary Field Review

For rehabilitation and reconstruction projects, the following location information can be obtained at, or prior to, the PFR:

A. General
- Soil characteristics,
- Vegetative cover,
- Topography near roadway, and
- Climate and typical weather conditions.

B. Sediment Control
- Locations of any waterways near the project,
- Presence of impaired waterways adjacent to the project. (An impaired waterway is a waterway that does not meet water quality standards for one or more reasons. See http://www.cwaic.mt.gov/ to determine if an impaired waterway exists on or near the project.)
- Stream and river crossings, and
- Areas of heavy sanding.

C. Permanent Erosion Control – the following areas should be identified on the as-built plans and/or reviewed in the field:
- Cut-to-fill transitions,

- Cut slopes,
- Fill slopes steeper than 3:1,
- Ditches with long grades in cut (>1500 ft or 460 m),
- Steep embankment slopes behind guardrail,
- Bridge ends,
- Intercepting drainages in back slope,
- Existing culverts, and
- Evidence of existing erosion.

D. When possible the following information associated with erosion and sediment control should also be discussed at the PFR.
- What potential control measures can be used?
- Will additional soils or geotechnical information be needed?
- Will an additional, or more detailed, field survey be required? (This information is most critical for rehabilitation projects where the amount of field survey is typically limited.)
- Will right-of-way or construction permits be necessary?
- What type of regulatory requirements will apply?

A discussion of the above information should be included in the PFR report. The Road Designer will coordinate with the District Hydraulics Engineer and the Environmental Services Bureau to determine the appropriate treatment for various types of erosion.

2.3 Alignment and Grade Review

When a project involves modifications to the roadway alignment, the majority of the site-specific information discussed in Section 2.2 may not be available until the Alignment and Grade Review (AGR) stage of design. Additionally, for projects with or without modifications to the alignment, considerably more information is available at the AGR than the PFR. That additional information, especially cross-sections and major drainage structures, will allow more detailed identification and evaluation of sites that would benefit from PESC measures and sites where design could be optimized for issues such as elimination of sliver cuts and fills. Document in the AGR report all efforts to minimize: soil erosion, the amount of soil exposed during construction activity, disturbance of steep slopes, and soil compaction.

At the AGR stage of development, sufficient information is provided to make preliminary recommendations of site-specific measures. Maintenance access to the PESC measures can also be assessed at this time. If an on-site review will not be held for the project, designers should request that Environmental Services Bureau personnel review the project to determine the appropriateness or need for sediment and/or erosion control measures.

2.4 Plan-in-Hand

A complete set of plans that includes the various PESC measures should be distributed for the PIH review. Since all of the information concerning PESC measures should be available and the plans package should be essentially complete at this stage of project development, the most in-depth review should occur at this time. The following information contained in the PIH plans should be evaluated and reviewed in the field:

A. **Assess Locations of PESC Measures.** Are the appropriate PESC measures shown at the correct locations? The reviewer should compare what is shown in the plans to the recommendations that were previously provided to the designer and evaluate whether additional PESC measures are needed. This task will involve a review of the plan and profile sheets, cross-sections and summaries.

B. **Assess Constructability.** Can the PESC measures be constructed within the normal contractor operation? The reviewer should evaluate whether the sequence of work for the construction of the PESC measures will have to be specified or if specialized equipment will be needed.

C. **Special Provisions.** Do the special provisions adequately describe the work, materials, equipment, and process required to construct the PESC measures?

D. **Accessibility.** Is adequate access provided to the PESC measures that will require long-term maintenance? PESC measures should be designed and constructed to allow maintenance personnel to access these measures for long-term maintenance activities. Maintenance personnel will likely use heavy equipment such as skid steers, backhoes, and loaders to perform ongoing maintenance activities of these PESC measures, particularly sediment control measures. It is essential that these PESC measures are accessible.

E. **Minor Drainage.** The plans should be reviewed for the elimination of drainage culverts and the concentration of flows to new locations. The existing drainage patterns should be maintained by replacing culverts as close as possible to the existing culverts or at least within the same drainage basin. In cases where the existing culverts cannot be replaced, the design should include provisions to handle the increased flows downstream at the roadway and approach crossings and to properly reduce the energy and erosion potential at the outlet. Additionally, adequate PESC measures should be shown on the plans at cut-to-fill transitions, where drainages intercept back slopes, on long ditch grades, and along guardrail sections. (See Section A11.0: Maintenance of Existing Drainage for additional information.)

G. **Avoidance.** Avoidance of ground disturbance should be considered throughout all phases of the design process. Preservation of ground in a stable, vegetated condition lessens the amount of ground exposed to erosional forces. Protection of ground on the perimeter of the project area reduces run-on from adjacent lands and surface flow through unprotected soils.

Avoidance has additional benefits in reducing right-of-way needs, utility relocations, clearing/grubbing costs, reclamation costs and long-term noxious weed control.

Simple measures such as limiting backslope grading to 3:1 or steeper slopes, constructing V-ditches to reduce sliver cuts and establishing strict construction limits, all provide immediate and long-term benefits.

H. **Slope Rounding.** Slope rounding (not to be confused with contour grading) is a grading technique at the tops and sides of cuts and transitions to facilitate plant establishment and minimize soil erosion. Rounding of cut slopes also is an important element in achieving operational, environmental and visual functions. While engineered slopes define grades to meet engineering requirements, slope rounding should be designed so that the constructed slope blends smoothly into the surrounding landscape. Use on cut slopes and transitions prior to the application of temporary soil stabilization or permanent seeding. Some limitations can include potential increase in design and construction costs, and increased right-of-way requirements.

2.5 Final Plan Review

The final plan review is an opportunity to review the completed plans. This review should be a relatively minor activity unless substantial changes were made to the PESC measures at the PIH. Coordinate with the Environmental Services Bureau to ensure permit conditions are incorporated appropriately into the plans.

SECTION 3.0: CONSTRUCTION

An appropriately developed and detailed plan will help the contractor understand MDT's expectations in regard to the work required and will assist the Engineering Project Manager in assuring that erosion and sediment control is adequately provided.

The complexity of the plans and the types, locations and quantities of various erosion and sediment control measures will be dependent upon the scale and scope of the project and the natural and man-made resources requiring protection.

The special provisions, plan sheets, and/or appropriate tables must contain adequate details for construction and inspection of the PESC measure, and should include any or all of the following:

- Specific locations, sizes and lengths of each required erosion and sediment control measure;
- Material, dimensional, and installation details for erosion and sediment control practices and facilities;
- Timing or scheduling necessary for appropriate installation, especially when a measure is intended for both temporary control during construction and permanent control following construction;
- Site preparation requirements, such as grading, compaction, or subgrade needs; and
- Details of alternatives for sites where alternative measures are considered practical.

Items or requirements specific to a given PESC measure will be included in the contract documents for the identified measure. See Appendix B of this manual for the minimum amount of detail that should be shown in the plans for each PESC measure.

SECTION 4.0: MAINTENANCE

The long-term costs of operating and maintaining a PESC measure will depend on a number of factors such as frequency and duration of maintenance, equipment/materials utilized, regulatory requirements, and off-site disposal costs. The designer should evaluate these long-term costs before selecting a specific PESC measure. Regular maintenance of PESC measures is necessary to keep them functioning properly. If PESC measures are not maintained on a regular basis, they may become sources of pollutants. For example, the failure of a settling basin during a large rainfall event could discharge a measurable amount of sediment downstream. Therefore, it is important to develop and implement a schedule for monitoring and maintaining these PESC measures.

Maintenance activities may include cleaning, repairing, and replacing PESC measures, reseeding areas with poor vegetative cover, conducting required sampling, and controlling noxious weeds. Maintenance frequency will be related to the type of PESC measure and site-specific conditions such as soil type, highway grade, cut/fill slopes, storm intensity/duration and traction sand application rates. MDT Maintenance personnel will be responsible for conducting the majority of the maintenance for these measures after the construction project passes final acceptance.

A detailed description of each PESC measure and, if available, associated maintenance activities, frequency, and cost are included in Appendix A.

SECTION 5.0: ADDITIONAL CONSIDERATIONS

5.1 Municipal Separate Storm Sewer System (MS4)

The process of evaluating projects for PESC measures as discussed in this manual can help MDT meet some of the requirements of the Small Municipal Separate Storm Sewer System (MS4) permit. See the MDEQ web site for information on the MS4 permit. As of the date of this printing, the MS4 permit information was available at http://deq.mt.gov/wqinfo/MPDES/StormWater/ms4.mcpx.

The MS4 permit is required for urban areas within the state of Montana that have storm sewer systems that serve a population of at least 10,000 people. Areas currently required to have an MS4 permit are **Billings, Missoula, Great Falls, Butte, Helena, Kalispell, and Bozeman**. Cities, counties, universities, military bases, and MDT are some of the entities required to obtain permits within these areas. Under the MS4 requirements, a permit holder must regulate the discharge of potential pollutants in storm water runoff within the storm sewer system.

Each permit holder must develop, implement, and enforce a Storm Water Management Program (SWMP). The SWMP must address six "minimum control measures," one of which is post-construction storm water management in new development and redevelopment. In other words, the PESC process is a designated element of the SWMP. As a result, coordination and tracking is needed to demonstrate permit compliance.

Beginning January 1, 2012, new development or redevelopment projects in an MS4 area will be required to implement low impact development practices that infiltrate, evapotranspire, or capture for reuse the runoff generated from the first 0.5 inches of rainfall from a 24-hour storm preceded by 48 hours of no measurable precipitation whenever practicable. (If a designer concludes that meeting this requirement is not practicable in a given circumstance, he/she will need to coordinate with the Environmental Services Bureau for concurrence that the project, as proposed, will comply with the MS4 permit.)

Designers working in one of the seven urban areas listed above will need to coordinate with the Environmental Services Bureau to ensure compliance with MS4 permit requirements.

5.2 Total Maximum Daily Load (TMDL)

Section 305(b) of the federal Clean Water Act (and related regulations) requires states to assess the condition of their waters to determine where water quality is impaired (does not fully meet standards) or threatened (is likely to violate standards in the near future). Section 303(d) requires states to develop plans, called Total Maximum Daily Loads (TMDLs), to achieve compliance with the water quality standards for impaired waterbodies. The result of this review are the **305(b)** and **303(d) Lists**, which must be submitted to the U.S. Environmental Protection Agency (EPA) every two years. Section 303(d) also requires states to prioritize and target water bodies on their list for development of water quality improvement strategies for impaired and threatened waters.

MDEQ is required to develop TMDLs for all water bodies on the 303(d) list. A TMDL is the total amount of a pollutant that a water body may receive from all sources without exceeding water quality standards. A TMDL can also be defined as a reduction in pollutant loading that results in meeting water quality standards.

Appropriate PESC measures should be considered in the early development stages of projects adjacent to listed impaired streams. MDEQ maintains the list of impaired waterways. As of the date of printing, a list of impaired waterways for Montana was available at the following website: http://www.cwaic.mt.gov/

5.3 Section 404 Clean Water Act Permit

Section 404 of the federal Clean Water Act requires permits for the discharge of dredge or fill material into Waters of the United States. If activities are proposed that require a Section 404 Permit, specific conditions related to the type of erosion control material allowed in or adjacent to Waters of the U.S. may apply. Environmental Services should be consulted to determine if there are any prohibitions on the type of PESC measure proposed.

APPENDIX A: PERMANENT EROSION AND SEDIMENT CONTROL MEASURES

This appendix provides design information for permanent erosion and sediment control (PESC) measures. The following information is included in each detail and should be evaluated to select appropriate measures for the given situation.

1. Definition and Purpose
2. Appropriate Applications
3. Limitations
4. Design Considerations
5. Materials
6. Construction Considerations
7. Operation and Maintenance
8. Initial Cost and Cost per Year
9. Method of Payment

The decision matrix on the following pages is provided to assist in the selection of appropriate measures.

Guidelines for Minor Drainage and Erosion Control

Roadway Feature	Application	Reference	Comments
Cut-to-Fill Transitions	Embankment Protector	Section A6.0	
	Drainage Chute	Section A7.0	
Intercepting Drainages in Back Slope	Embankment Protector	Section A6.0	
	Drainage Chute	Section A7.0	
	Interceptor Ditch	Section A4.0	
Steep Fill or Cut Slopes	Slope Soil Stabilization	Section A9.0	
Steep Embankment Slopes Behind Guardrail	Slope Soil Stabilization	Section A9.0	
	Embankment Protector or Drainage Chute w/Channelizing Curb	Sections A6.0, A7.0, and A5.0.	
	Leave Curbing in Place When Replacing Guardrail		Plan-in-Hand team to evaluate if curbing should be removed.
Long or Steep Ditch Grades	Check Dams	Section A2.0	
	Lined Ditch	Section A3.0	
	Ditch Block and Culvert to Divert Flows	Section A1.0	Use to maintain existing drainage patterns.
Elimination of Existing Culverts	Maintain Existing Drainage	Section A11.0	
High Velocities at Culvert Outlets	Outlet Protection and Velocity Dissipation Devices	Section A8.0	
Direct Discharge to TMDL Streams [303(d)]	Vegetated Buffer	Det. Dwg. 208-26	
	Preserve Existing Vegetation		
	Infiltration Basins	Section A13.0	
	Wetland Basin	Section A14.0	
	Settling Basin	Section A12.0	
Erosion Along Stream Banks near Bridge Crossings or Roadway Embankments	Stream Bank Stabilization	Section A10.0	
	Riprap Bank Protection	Det. Dwg. 613-16	
Bridge Ends	Divert Flows Before the Bridge End		Diverted flows should flow through a vegetation strip before entering a stream.
	Embankment Protector or Drainage Chute w/Channelizing Curb	Sections A6.0, A7.0, and A5.0.	Provide outlet protection and vegetation strip before flows enter a stream.
	Settling Basin	Section A12.0	

Roadway Feature	Application	Reference	Comments
Sanding Material Collection on Mountain Passes	Ditch Blocks / Gravel Check Dams	Sections A1.0 and A2.0	
	Channelizing Curbs	Section A5.0	
	Settling Basins	Section A12.0	
	Vegetated Buffer	Det. Dwg. 208-26	
Large Paved Parking Areas at Rest Stops or Weigh Stations	Settling Basin	Section A12.0	
	Wetland Basin	Section A14.0	
	Infiltration Basin	Section A13.0	

A1.0: DITCH BLOCKS

A1.1 Definition and Purpose

A ditch block is a berm placed across a natural or man-made channel or drainage ditch to divert flows into a cross drain.

A1.2 Appropriate Applications

Ditch blocks are typically installed in the following locations:

- In roadside ditches in cut sections to divert water from the ditch to a cross drain that accesses a natural drainage.
- In roadside ditches in cut sections to divert water from the ditch to a cross drain that discharges to the roadside ditch on the other side of the roadway. When used in this case the ditch block essentially acts as a check structure to reduce the volume and velocity of flow in the ditch.
- Near a cross drain in a natural drainage to ensure that the flow does not overtop the drainage divide.

A1.3 Limitations

Severe erosion may result when a ditch block fails by overtopping.

A1.4 Design Guidelines and Considerations

- Ditch blocks should have sufficient height to divert all of the designed flow to the cross drain. The height should be a minimum of one foot below the finished roadway shoulder and preferably no higher than the top of the subgrade.
- The cross slopes of the ditch block should be no steeper than 6:1 and 10:1 slopes are desirable when the ditch block is adjacent to a high speed facility (45 mph, 70 kph or greater).
- See MDT Detailed Drawing 203-20 for ditch block details.
- The ditch block height and the capacity of the cross drain need to coincide to ensure that runoff is not forced onto the roadway.
- Erosion protection (ECM, riprap, etc.) may be necessary on the upstream bank particularly for sites that experience higher flows and velocities. Riprap may be needed on the downstream bank if overtopping is anticipated for more frequent storm events or if the failure of the ditch block will result in damage to property or adverse environmental impacts.
- An approach may be used as a ditch block when installed in conjunction with a cross drain. The approach landing must be a 3% downgrade so the approach can be overtopped without overtopping the mainline when used in this application.
- The Hydraulics Section may provide the design requirements for ditch blocks in unique situations, such as high flows and velocities, or where overtopping of the

roadway is a concern. The details provided may include ditch block spacing, height requirements and emergency spillways.

A1.5 Materials

Normally a ditch block is a standard grading item (unclassified excavation or embankment-in-place). ECM and/or riprap with geotextile can be used in special situations.

A1.6 Construction Considerations

Ordinary placement and compaction in accordance with the Standard Specifications.

A1.7 Operation and Maintenance

- Inspect ditch blocks annually and after each major storm event. Repair damage as necessary.
- If a ditch block is a chronic maintenance problem, contact district engineering staff. A designed solution may be needed.

A1.8 Initial Cost and Cost per Year

Initial Cost:	Low
Cost per Year:	Low

A1.9 Method of Payment

Included in additional excavation or roadway quantities (unclassified excavation or embankment-in-place).

ECM is paid for by area, square yards (meters).

Riprap is paid for by the cubic yard (meter).

A2.0: CHECK DAMS

A2.1 Definition and Purpose

Check dams are structures (generally porous) placed across a natural or man-made channel, swale, or drainage ditch that work to reduce scour and channel erosion by reducing the velocity of concentrated storm water flows to non-erosive flow velocities and by encouraging sediment dropout. A series of check dams functions as a large sediment filter that gradually improves water quality as the sediment load is removed from the runoff. Check dams are generally considered temporary sediment control; however, check dams are designed for long-term functionality.

Check dam options include:

- Option 1 - Gravel Berm
- Option 2 - Vegetated Earth Berm

A2.2 Appropriate Applications/Selection Criteria

- Check dams are recommended for use with all steeper channel grades (4-7%) and ditches with long grades in cuts greater than 1500 ft (460 m).
- When using check dams in combination, always consider the specific site conditions (channel grade, soil conditions, drainage area, precipitation, etc.) and project experiences, and give consideration to the effects and reach of the impounded water and sediment.

A2.3 Limitations

- Use only in small open channels which drain 10 acres (4 ha) or less.
- Do not use in continuous flow streams.
- Do not use in already vegetated areas unless erosion is expected, as installation may damage vegetation.
- Promotes sediment trapping which can be re-suspended during subsequent storms or removal of the check dam; therefore, requires maintenance following high velocity flows and may require repair.
- May be difficult to seed around.

A2.4 Design Guidelines and Considerations

A2.4.1 General

- An erosion control mat may be used with vegetated earth berms to maximize the check dam performance. Erosion control mats prevent undermining of the check dams and encourage the earliest vegetative growth. Geotextile may be used to enhance the performance of gravel check dams.

- Install the first check dam approximately 15 ft (5 m) from the outfall device and at regular intervals based on slope gradient and soil type.
- Recommended spacing for check dams given various channel slopes is as follows:

1%-3%:	place check dams at approximately 300 ft (90 m) spacing
3%-4%:	place check dams at approximately 200 ft (60 m) spacing
> 4%:	place check dams at approximately 100 ft (30 m) spacing

  Check dam spacing may be adjusted on a project-by-project basis by the Engineering Project Manager. See Detail Drawing 208-36 for additional details.
- The approach face of the check dam slope within the clear zone is 10:1. The outlet face on the check dam, if within the opposing traffic clear zone, is also 10:1

A2.5 Materials

Check dams constructed from gravel must be 100% passing the 2 inch (50 mm) screen and 10% maximum passing the No. 4 sieve (4.75 mm). Dam material may be pit-run or crushed aggregate. Vegetated earth berms should be constructed of compacted soil, topsoiled, and seeded.

A2.6 Construction Considerations

- Install the gravel berm perpendicular to the direction of flow.
- Gravel may be placed by hand or by mechanical method to achieve complete ditch or swale coverage.
- Vegetated earth berms should be compacted, topsoiled, and seeded.
- Space the gravel berms as indicated above. Check dam spacing may be adjusted on a project-by-project basis by the Engineering Project Manager.

A2.7 Operation and Maintenance

During construction

- Inspect check dams after each significant storm event [0.5 inch (13 mm) in one hour], or, according to permit requirements if there is an active storm water permit.
- Remove sediment from behind the dam when it accumulates to one-half the original check dam height.
- Remove accumulated sediment and dispose of properly, or seed accumulated sediment to stabilize, whichever is most practical for the situation.

After Construction

- Inspect for erosion along the edges of the check dams and repair as required immediately.

A2.8 Initial Cost and Cost per Year

Initial Cost:	Moderate
Cost per Year:	Low

A2.9 Method of Payment

Gravel check dams will be paid by the cubic yard (meter) of the appropriate gravel bid item on the project. Vegetated earth check dams will be paid as additional excavation (unclassified excavation or embankment-in-place).

A3.0 LINED DITCHES

A3.1 Definition and Purpose

Lined ditches are utilized to convey surface water in areas that are susceptible to erosion and discharge this surface water to a stabilized watercourse, drainage pipe, or channel. Ditches may be lined with asphalt, riprap, turf reinforcement mats (TRM), or erosion control mats (ECM). Riprap-lined ditches may be grouted in place for high flow velocities and steep slopes.

Lined ditches are ideal for collecting and dispersing surface water in a controlled manner. Well-designed ditches provide an opportunity for sediments and other pollutants to be removed from runoff water before it enters surface waters or groundwater. Efficient removal of runoff from the roadway will help preserve the roadbed and banks. In addition, a stable ditch will not become an erosion problem itself.

A3.2 Appropriate Applications

Lined ditches may be utilized in the following areas/situations:

- Areas that are susceptible to erosion where vegetation is difficult to establish,
- Steep slopes/high flow velocities,
- Below steep grades where runoff begins to concentrate,
- At the top of slopes to divert run-on from adjacent or undisturbed slopes, and
- At bottom and mid-slope locations to intercept sheet flow and convey concentrated flows.

Riprap, TRM, and ECM-lined ditches should be considered before concrete and asphalt since they decrease flow velocities (thus decreasing the erosion potential). In addition, TRM and ECM promote vegetative growth. Concrete and asphalt-lined ditches may be appropriate for ditches located within the clear zone and on heavily sanded mountain passes.

A3.3 Limitations

- Lined ditches are not suitable as sediment trapping devices. Sediment-laden runoff should be discharged into a sediment trapping facility and/or treated in the ditch via check dams.
- Asphalt-lined ditches do not provide any energy dissipation; therefore, these ditches may have considerable erosion at the outlets if they are not properly protected.

- Under the 2007 Nationwide 404 Permits, erosion control materials, including ECM and TRM, used in or adjacent to Waters of the U.S. must be natural and biodegradable. In addition, materials that include synthetic or UV stabilized mesh are not allowed. Environmental Services should be contacted to determine if other materials would be allowed under an individual 404 permit.

A3.4 Design Considerations

- Do not use on channels where vegetation is already established.
- Lined ditches should be considered for slopes steeper than 2%, flow velocities greater than 5 ft/sec (1.5 m/s), and/or areas that are susceptible to erosion and difficult to establish vegetation. Specify ECM, TRM, concrete, asphalt, or riprap for the ditch liner.
- Select the ditch liner according to the following slopes:
  - Unlined: <2%
  - ECM: 2-5%
  - TRM: 5-8%
  - Asphalt: >8%
  - Riprap/grouted riprap: >8%
- Verify that flow velocities for ECM and TRM do not exceed the manufacturer's recommendations.
- In a constructed channel do not design intermittent lining installations unless the channel is interrupted by another BMP.
- Size riprap based on slope and expected flow velocities in the ditch. Place geotextile between the riprap and the underlying soil surface to prevent soil movement into or through the riprap. Riprap may be grouted in place for high flow velocities and steep slopes.
- The designer should contact the Hydraulics Section for drainage areas greater than 10 acres.
- Within the clear zone, use traversable trapezoidal or triangular ditch sections meeting the requirements of section 14.3.6.1 of the MDT Road Design Manual.
- Outside the clear zone, shape the ditch bottom so that it is trapezoidal or parabolic-shaped and at least 2 ft (0.6 m) wide and 2 ft (0.6 m) deep to help slow and disperse water. Use 2H:1V or flatter side slopes. Use 3H:1V or flatter side slopes in areas where ditches will be mowed.
- Provide energy dissipation measures as necessary to prevent erosion at the ditch outlet.

A3.5 Materials

The materials utilized for lining ditches include asphalt, riprap, TRM, or ECM.

ECMs and TRMs commonly used by MDT are described in section 713 of the Standard Specifications. Typical ECMs include Straw Blankets, Jute Mats, and Coconut Mats.

Typical TRMs include Synthetic Erosion Control and Revegetation Mats, and Turf Reinforcement Mats.

Under the 2007 Nationwide 404 Permits, erosion control materials, including ECM and TRM, used in or adjacent to Waters of the U.S. must be natural and biodegradable. In addition, materials that include synthetic or UV stabilized mesh are not allowed. Environmental Services should be contacted to determine if other materials would be allowed under an individual 404 permit.

When applying topsoil, no more than 2 inches (50 mm) of soil should be placed on the TRM.

A3.6 Construction Considerations

- Remove all vegetation, roots, and rocks and construct the ditch according to the design plans and specifications.
- Install the ditch liner according to the design plans and specifications. Install TRM and ECM according to the manufacturer's recommendations.
- Place outlet protection before, or in conjunction with, the construction of the ditch so that it is in place when the channel begins to operate.

A3.7 Operation and Maintenance

- Inspect channel linings, embankments, beds, and outlets of ditches for erosion and accumulation of debris/sediment after major storm events. Remove debris/sediment, replace lost riprap, and repair ditches, linings, and embankments as necessary.
- Regrade/reshape ditches for improving flow capacity, as necessary. Repair/replace liners immediately following grading activities.

A3.8 Initial Cost and Cost per Year

Construction and maintenance costs for ditches are dependent on a number of factors such as:

- Type (concrete, asphalt, riprap, TRM, or ECM),
- Size (length, width, and depth), and
- Location (mountainous or prairie terrain).

Construction costs are low to medium and maintenance costs are low.

A3.9 Method of Payment

Plant mix lined ditches are paid by the linear foot (linear meter).

For riprap lined ditches, the riprap is paid by the cubic yard (meter) and the underlying geotextile is paid by the square yard (square meter).

For TRM and ECM lined ditches, the liner is paid by the square yard (square meter).

Typically the grading work for lined ditches is included in mainline grading quantities.

A4.0: INTERCEPTOR DITCHES

A4.1 Definition and Purpose

Interceptor ditches are designed ditches utilized to intercept, divert, and convey surface water away from steep slopes (including cut and fill slopes) and discharge this surface water into a stabilized watercourse, drainage pipe, or channel. These ditches reduce the volume of water that is discharged into the roadside drainage system and protect slopes from excessive runoff and erosion. Interceptor ditches are ideal for collecting and dispersing surface water in a controlled manner.

A4.2 Appropriate Applications

Interceptor ditches may be utilized in areas where surface water is causing (or has the potential to cause) erosion on a steep slope. Berms may be used in combination with interceptor ditches in areas where runoff is hard to control or when constructed on a slope. Interceptor ditches should discharge into a stable area for collecting sediment. Interceptor ditches may be lined in areas that are susceptible to erosion and/or where it is difficult to establish vegetation.

A4.3 Limitations

Interceptor ditches are not suitable as sediment trapping devices. Sediment-laden runoff should be discharged into a sediment trapping facility and/or treated in the ditch via check dams.

Interceptor ditches should not be placed adjacent to steep cut or fill slopes in regions with soils susceptible to failure. Consult with the Geotechnical Section to determine the location of the interceptor ditch as well as to identify slope or soil stability concerns and recommendations.

A4.4 Design Considerations

- The Hydraulics Section will determine if an interceptor ditch needs to be designed. If a designed ditch is required, the Road Designer will coordinate the design, quantities summary, details, and special provisions with Hydraulics.
- Design and grade ditch and bank side slopes at a maximum 2H:1V ratio.
- Provide energy dissipation measures as necessary to prevent erosion at the ditch outlet.
- Interceptor ditches may be lined with asphalt, riprap, TRM, or ECM for slopes steeper than 2%, flow velocities greater than 5 ft/sec (1.5 m/sec), and/or areas that are susceptible to erosion or difficult to establish vegetation. See Section A3.0 – Lined Ditches, for liner selection criteria.

A4.5 Materials

No specialized materials are needed to construct interceptor ditches. If the ditch will be constructed in an area that is susceptible to erosion, then the designer should consider lining the ditch (see Section A3.0 - Lined Ditches). The designer should also evaluate the need for installing outlet protection for the ditch (see Section A8.0 – Outlet Protection/Velocity Dissipation Devices).

A4.6 Construction Considerations

- Remove all vegetation, roots, and rocks, and construct the ditch according to the design plans and specifications.
- Place outlet protection before, or in conjunction with, the construction of the ditch so that it is in place when the channel begins to operate.

A4.7 Operation and Maintenance

- Inspect embankments, beds, and outlets of ditches for erosion and accumulation of debris/sediment after major storm events. Remove debris/sediment, replace lost riprap, and repair ditches, linings, and embankments as necessary.

- Regrade/reshape ditches for improving flow capacity as necessary. Reseed immediately following grading activities.

A4.8 Initial Cost and Cost per Year

Operation and maintenance costs for ditches are dependent on a number of factors such as:

- Size (length, width, and depth),
- Location (mountainous or prairie terrain), and
- Liners installed (if applicable).

Initial Cost:	Low
Cost per Year:	Low

A4.9 Method of Payment

Payment for unlined interceptor ditches will be included in mainline or additional grading quantities. If interceptor ditches require lining, see section A3.9 for payment of lined ditches.

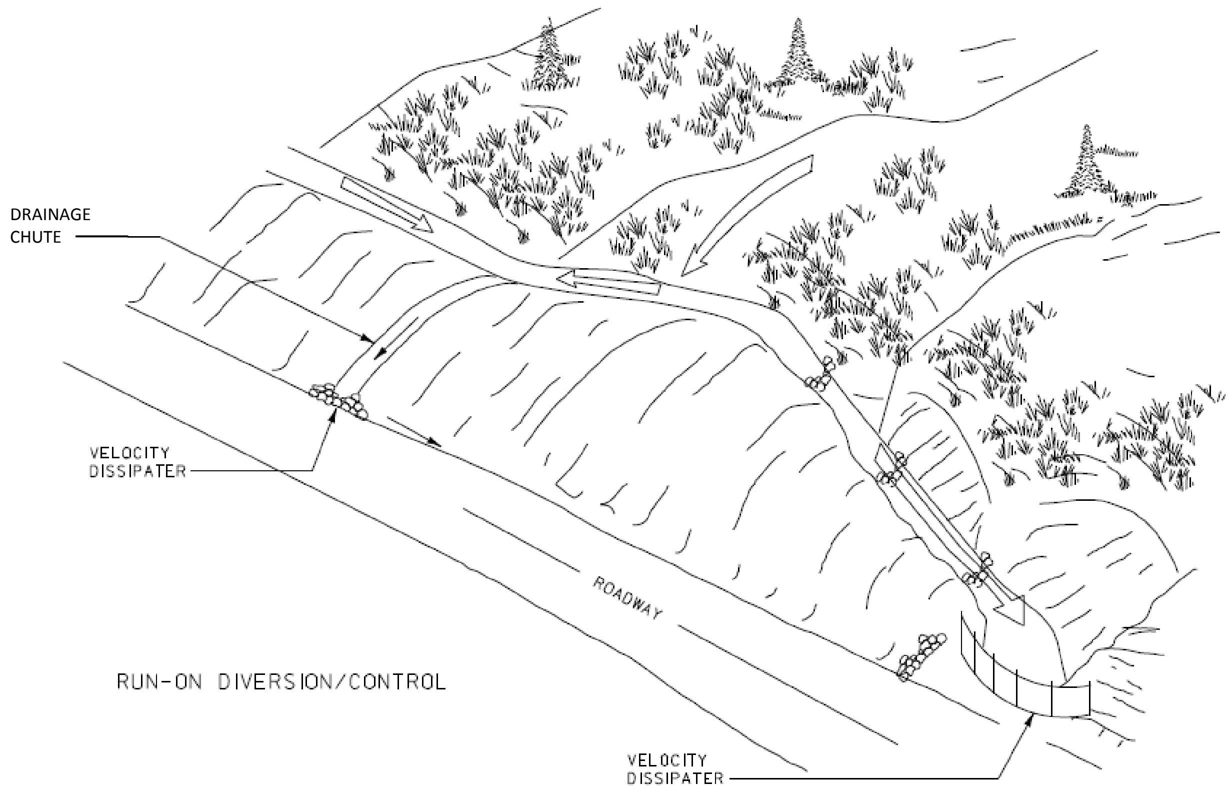


Figure A4-1: Interceptor Ditch

A5.0 CHANNELIZING CURBS

A5.1 Definition and Purpose

A channelizing curb is any curb that intercepts surface runoff and directs it to a specific outfall such as a drainage chute or embankment protector.

A5.2 Appropriate Applications

Channelizing curbs are used to divert runoff from slopes that are susceptible to erosion, due to their steepness or lack of vegetation. Channelizing curbs have often been considered as a temporary measure until vegetation is established on a slope. However, before a curb is removed, the slope should be evaluated to ensure that the vegetation is sufficient to prevent erosion.

Channelizing curbs can also be used to divert runoff from a sensitive watercourse.

A5.3 Limitations

- Severe erosion may occur if the spacing or capacity of the outfalls is inadequate.
- When used in conjunction with guardrail, maximum curb height is 4”.
- The Hydraulics Section should evaluate the spread width of the flow contained by the curb if the embankment protector spacing exceeds the calculated spacing. A safety issue for vehicles can occur if the spread width of the flow encroaches on the travel lane.

A5.4 Design Guidelines and Considerations

- The dimensions of channelized curbs should be in accordance with Detailed Drawing 609-05 unless special conditions exist.
- Channelized curbs must be used in conjunction with other PESC BMPs.
- The primary design consideration is the spacing of the outfalls as described in detail in Section 17.2 of the Road Design Manual.
- The outfall sites must be evaluated to determine if additional erosion control measures are needed at the outfall.
- Curb materials and construction practices need to comply with MDT Standard Specifications and special project conditions.
- See Detail Drawing 603-28 for channelizing curb in conjunction with embankment protectors.

A5.5 Materials

Plant mix or concrete.

A5.6 Construction Considerations

Construct channelized curbs in accordance with the Standard Specifications and Detailed Drawings.

A5.7 Operation and Maintenance

The maintenance of channelizing curbs is minimal unless they are damaged by vehicle or snowplow impacts. Channelized curbs should be inspected annually.

A5.8 Initial Cost and Cost per Year

Initial Cost: Low
Cost per Year: Low

A5.9 Method of Payment

Channelized curbs are measured and paid by the linear foot (linear meter) of new curb.

A6.0 EMBANKMENT PROTECTORS

A6.1 Definition and Purpose

An embankment protector is a type of drainage chute consisting of a pipe extending down a slope to a designed outfall. It is used to intercept and direct surface runoff into a stabilized watercourse, trapping device or stabilized area.

A6.2 Appropriate Applications

Embankment protectors are typically used in conjunction with channelized curbs, at bridge ends and in cut-to-fill transitions.

They can also be used on back slopes where the height of the drop, the steepness of the slope or the volume of surface runoff exceeds the capability of other types of drainage chutes.

The installation of embankment protectors is not necessary for bridges that have rail configurations without curbs.

A6.3 Limitations

Severe erosion may result when the inlet is overtopped or as the result of piping or pipe separation.

Where embankment protectors are used on back slopes, energy dissipation/erosion protection at the outfall in the roadside ditch should consist of some type of hard armoring. This may consist of riprap, paving a section of ditch or installing a concrete dissipater. Riprap should not be used in the roadside ditch if it is within the clear zone.

A6.4 Design Considerations

An embankment protector with channelized curb should be designed in accordance with the criteria provided in Section 17.2 of the Road Design Manual.

Where embankment protectors are used in cut-to-fill transitions, the pipe size is determined through hydraulic analysis. The designer should have the Hydraulics Section evaluate the capacity of the embankment protector if the drainage area at the cut-to-fill-transition is greater than 10 acres (4 ha). The drainage area can be determined from aerial photos, topographic maps, or a field survey.

The outfall of the embankment protector should be evaluated to determine which energy dissipation or erosion control measures are needed. A riprap apron sized according to hydraulic practice is generally sufficient.

- Securely anchor and stabilize pipe and appurtenances into soil.
- Check to ensure that pipe connections are watertight.
- Use standard flared end sections at the inlet and outlet for pipes 12 inches (300 mm) in diameter or greater.
- Embankment protector materials and construction practices need to comply with MDT Standard Specifications, MDT Detailed Drawing 603-28 and special project conditions.
- In areas of heavy sanding, provide sediment traps to collect the sanding material upstream of the embankment protector inlet.

A6.5 Materials

Embankment protectors are typically constructed with corrugated metal pipe. Optional pipe materials and coatings may be considered depending on soil conditions.

A6.6 Construction Considerations

Embankment protectors should be constructed in accordance with the Detailed Drawings and Standard Specifications.

A6.7 Operation and Maintenance

- Inspect after each major storm, but at least once per year.
- Inspect outlet for erosion and downstream scour. If eroded, repair damage and install additional energy dissipation measures. If downstream scour is occurring, it may be necessary to reduce flows being discharged into the outfall area unless other preventative measures are implemented.
- Inspect embankment protector inlet for accumulations of debris and sediment.
- Inspect the embankment protector for distortion, leakage or pipe separation.
- Remove built-up sediment from entrances and outlets as required. Flush pipe if necessary; capture and settle out sediment from discharge.

A6.8 Initial Cost and Cost per Year

Initial Cost: Moderate
Cost per Year: Low

A6.9 Method of Payment

Embankment protectors are paid by the linear foot (linear meter). This includes any preparatory work at the inlet. Any measures installed at the embankment protector outlet will be paid separately under the appropriate item for the specific measure.

A7.0 DRAINAGE CHUTES

A7.1 Definition and Purpose

A drainage chute is a measure used to intercept and direct surface runoff or groundwater into a stabilized watercourse, trapping device or stabilized area. Drainage chutes are often used to intercept and direct surface flow away from slope areas to protect cut or fill slopes.

A7.2 Appropriate Applications

- Drainage chutes are typically used on back slopes where surface runoff is concentrated due to natural or man-made features. These features may consist of minor drainages intercepted by the back slope or at the outfalls of furrow ditches constructed on the top of the back slope.
- Drainage chutes can be used in cut-to-fill transitions. (If the volume of runoff or the slope steepness limits the use of a drainage chute in these locations, utilize embankment protectors to protect the cut-to-fill transition.)
- Drainage chutes can be used in conjunction with a channelized curb. The type of drainage chute is usually limited to concrete chutes or pipes, due to the height of drop typically associated with channelized curbs.

A7.3 Limitations

Severe erosion may result when drainage chutes fail by overtopping, piping, pipe or joint separation. Limitations to the height of drop and slope depend on the type of material used for the drainage chute.

Under the 2007 Nationwide 404 Permits, erosion control materials, including Turf Reinforcement Mats (TRM), used in or adjacent to Waters of the U.S. must be natural and biodegradable. In addition, materials that include synthetic or UV stabilized mesh are not allowed. Environmental Services should be contacted to determine if other materials would be allowed under an individual 404 permit.

A7.4 Design Considerations

When using drainage chutes, limit drainage area to 10 acres (4 ha) per chute. The designer should contact the Hydraulics Section for drainage areas greater than 10 acres. Utilize outlet protection/velocity dissipation devices at the drainage chute outfall. Where drainage chutes outfall into roadside ditches, the outlet protection may have to extend up the inslope of the roadway. In areas of higher flows where drainage chutes are intercepting furrow ditches, consider regrading the furrow ditches and providing additional drainage chutes.

- Channelization on top of the slope to direct flow to the drainage chute is essential. Direct surface runoff to drainage chutes by using furrow ditches, berms or other dikes as shown on Detailed Drawing 613-18.

- Drainage chute materials need to comply with MDT Standard Specifications or special project conditions.

- Where an approach is installed in cut sections, the roadside ditches for the approach will act as drain chutes. Therefore, the ditches should be evaluated and designed using drainage chute criteria.

Drainage chutes include concrete, riprap, erosion control and turf reinforcement mat drainage chutes. The use of culverts for drainage chutes is discussed in Section A6.0 Embankment Protectors. Recommended design parameters for various drainage chutes are summarized below. See Detail Drawing 613-18 for additional details.

A7.4.1 Concrete Drainage Chute

- Maximum drop = 30 ft (9 m)
- Maximum slope = 1.5:1*

*For slopes steeper than 1.5:1, a culvert is generally more cost-effective (see Section A6.0 Embankment Protectors).

A7.4.2 Riprap Drain Chute

- Maximum drop = 30 ft (9 m)
- Maximum slope = 3:1

A7.4.3 Erosion Control Mat (ECM) and Turf Reinforcement Mat (TRM)

- Maximum drop = 20 ft (6 m)
- Maximum slope = 4:1 (Maximum slope for ECM/TRM is determined ultimately by the soil stability and manufacturer's maximum permissible velocity)

A7.5 Materials

Concrete, riprap, ECM or TRM can be used depending on the type of slope drain selected.

ECMs and TRMs commonly used by MDT are described in section 713 of the Standard Specifications. Typical ECMs include Straw Blankets, Jute Mats, and Coconut Mats. Typical TRMs include Synthetic Erosion Control and Revegetation Mats, and Turf Reinforcement Mats.

Under the 2007 Nationwide 404 Permits, erosion control materials, including ECM and TRM, used in or adjacent to Waters of the U.S. must be natural and biodegradable. In addition, materials that include synthetic or UV stabilized mesh are not allowed. Environmental Services should be contacted to determine if other materials would be allowed under an individual 404 permit.

When applying topsoil, no more than 2 inches (50 mm) of soil should be placed on the TRM.

A7.6 Construction Considerations

When installing slope drains:

- Install drainage chutes perpendicular to slope contours.
- Use geotextiles in conjunction with riprap slope drains. Input from the Geotechnical Section may be necessary.
- Compact soil around and under entrance and outlet, and along the length of the slope drain.
- Protect area around inlet with geosynthetic liner meeting MDT Standard Specifications. Protect outlet with riprap or other energy dissipation devices. For high-energy discharges, reinforce riprap with concrete or use reinforced concrete device.

A7.7 Operation and Maintenance

- Inspect after each major storm, but at least once per year.
- Inspect outlet for erosion and downstream scour. If eroded, repair damage and install additional energy dissipation measures. If downstream scour is occurring, it may be necessary to reduce flows being discharged into the channel unless other preventative measures are implemented.
- Inspect slope drainage for accumulations of debris and sediment.
- Remove built-up sediment from entrances and outlets as required. Flush drains if necessary; capture and settle out sediment from discharge.
- Make sure water is not ponding at inappropriate areas (for example, inlet of slope drain, roadside ditch, etc.).

A7.8 Initial Cost and Cost per Year

Initial Cost:	Moderate
Cost per Year:	Low

A7.9 Method of Payment

- Concrete drainage chutes are measured and paid by the cubic yard (cubic meter) of concrete. The payment includes any necessary reinforcement.
- Riprap drainage chutes are measured and paid by the cubic yard (cubic meter).
- ECMs and TRMs are measured and paid by the square yard (square meter).

A8.0: OUTLET PROTECTION/VELOCITY DISSIPATION DEVICES

A8.1 Definition and Purpose

Outlet protection for culverts, storm drains, or even steep ditches and flumes is essential to preventing major erosion and damage to downstream channels and drainage structures. Outlet protection can be a channel lining or a structure or flow barrier. Outlet protection is designed to lower excessive flow velocities from pipes and culverts, prevent scour, and dissipate energy. Effective outlet protection must begin with efficient storm drainage system design that uses adequately sized pipes, culverts, ditches, and channels placed at the most efficient slopes and grades.

A8.2 Appropriate Applications

Outlet protection is needed wherever discharge velocities and energies are sufficient to erode the immediate downstream reach. These devices may be used at the following locations:

- Outlets of pipes, drains, culverts, conduits, diversion ditches, swales, or channels.
- Outlets located at the bottom of mild to steep slopes.
- Discharge outlets that carry continuous flows of water.
- Outlets subject to short, intense flows of water, such as flash floods.
- Points where lined conveyances discharge to unlined conveyances.
- Outlets of other PESC measures including embankment protectors and drainage chutes.

A8.3 Limitations

- Riprap outlet protection can occupy a large area, which may require additional easements.
- Loose rock may be washed away during high flows.
- Grouted riprap and concrete structures may break up in areas of freeze and thaw. Weepholes and adequately drained foundations are necessary for these types of outlet protection.
- Sediment caught in the rock outlet protection device may be difficult to remove without removing the rocks.

A8.4 Design Considerations

The MDT Hydraulics Section typically designs permanent outlet protection and velocity dissipation devices for cross culverts and storm drains. Outlet protection is also required with the installation of other permanent erosion control devices including embankment protectors, drainage chutes, interceptor ditches and settling basin outlets.

- There are many types of energy dissipaters. A rock apron is the most common and the one that is represented in Section B8. The Engineering Project Manager may approve other types of devices including stilling basins, impact barriers, and baffle chutes. Coordinate with the Hydraulics Section for design of these types of outlet protection and velocity dissipation devices.
- Rock outlet protection is effective at limiting erosion when the rock is sized and placed appropriately. Increase rock size for high velocity flows. Use sound, durable, angular rock.
- When designing the outlet protection, consider flow depth, roughness, gradient, side slopes, discharge rate, and velocity. The discharge pipe size governs the rock depth and outlet protection length.
- For proper operation of apron:
    - Align apron with receiving stream and keep it straight throughout its length. If a curve is needed to fit site conditions, place the curve in the upper section of the apron.
    - If the apron riprap is large in size, protect underlying filter fabric with a gravel blanket.
- Outlets on slopes steeper than 10% will need additional protection.
- Where lump sum payments are used for structural devices provide quantities for information purposes.

A8.5 Materials

The type of material will depend on the measure selected (channel lining, flow barrier, structure).

A8.6 Construction Considerations

Refer to Section 613 of the Standard Specifications and Detailed Drawing 208-18.

A8.7 Operation and Maintenance

- Inspect outlet protection on a regular basis for erosion, sedimentation, scour or undercutting.
- Repair or replace riprap, geotextile or concrete structures as necessary to handle design flows.
- Remove trash, debris, grass, sediment or burrowing animals as needed.

A8.8 Initial Cost and Cost per Year

Initial Cost:	High
Cost per Year:	Low

A8.9 Method of Payment

- Cubic yards (cubic meters) for riprap.
- Lump sum for structural devices.

A9.0 SLOPE SOIL STABILIZATION

A9.1 Definition and Purpose

Slope soil stabilization is the use of one or more methods to stabilize the soil of a portion of a slope that is often unaddressed. Steep slopes, exposure of unweathered parent material (bedrock), lack of moisture infiltration capacity, and difficulty in reestablishing a cover of vegetation, create an environment that produces large amounts of sediment movement into roadside ditches. This sediment can move with flowing water off-site and increases maintenance costs by clogging culverts. Slope soil stabilization is intended to retain sediment on the slope, as opposed to trying to contain the eroded material once it reaches the ditch section.

A9.2 Appropriate Applications

For most situations, treating the lower 1/3 of the slope should act as an effective filtering zone to reduce the amount of sediment from reaching a ditch section. These measures would also serve to prevent headcutting from erosion originating near the slope toe. Use one of the following methods individually, or in combination, to stabilize the lower portion of large cut slopes.

- Rock veneer,
- Erosion control blanket, with seeding,
- Compost blanket, with seeding,
- Topsoil treatment, with seeding.

Use is restricted to large cuts where any of the above measures is cost-prohibitive to treat the entire slope.

This BMP does not eliminate the MDT standard seeding protocol for the entire slope. It is meant to supplement standard seeding by incorporating practices that either foster vegetation establishment or act as a barrier to sediment transport into the ditch.

A9.3 Limitations

Any of the methods involving seeding should only be specified on slopes capable of supporting plant growth. An assessment of whether soil conditions are capable of supporting plant growth should be made by the MDT Reclamation Specialist prior to the plan-in-hand. If the slopes in the general area from the original road construction appear likely to support plant growth, then the selection of one of the seeding treatments is a viable option.

If the slope faces exposed after grading will be composed of hard bedrock, little plant growth can be expected, as well as limited sediment generation from weathering. No treatment is necessary in such cases.

Rock veneer is appropriate in areas where the finished slope is composed of highly erodible material, but plant growth is not expected due to contributing factors such as high salt levels, excessive steepness and/or extreme clay or fine silt content.

Rock veneer may also be appropriate around exposed seepage zones where piping erodes soil particles. Seepage zones are most prevalent where a water-bearing zone lies atop a salt-rich layer of clay (shale).

With any of the treatments, a hard point in the slope must be constructed along, and parallel to, the top edge of the BMP. The hard point is necessary to prevent undercutting of the installation, whether rock or one of the seeding methods. The hard point will be constructed of a trenched-in piece of turf reinforcement mat.

A9.4 Design Considerations

The use of this BMP will be contingent upon the location and size of large cuts that are constructed at 2:1 or steeper slopes. The MDT Reclamation Specialist may decide that none of the specialized treatments is necessary or practical given the size and number of cut slopes. Regardless of selected treatment, the BMP is not to extend higher than about 20 ft (6 m) vertical elevation up the slope from the ditch bottom. It may be necessary to leave the bottom 5 ft (1.5 m) of the slope untreated if the rock veneer is used in order to eliminate a hazard in the recovery zone.

The MDT Reclamation Specialist will recommend appropriate BMP slope method(s) to be incorporated into the design once the construction limits are established and an assessment is made of the appropriateness of slope soil stabilization. The default treatment will always be topsoiling/erosion control blanket and seeding of the lower third of the slope [or maximum 20 ft (6 m) high].

The remaining upper portions of the slope will be seeded according to the “Area 2” instructions in the seeding special provision.

Following coordination with the MDT Reclamation Specialist, the designer will calculate the quantity of each designated method, summarize the methods by stationing and list them separately in the schedule of items for bidding purposes. A summary frame will be provided in the set of plans detailing the location and size of each of the methods.

A9.5 Materials

The materials will depend on the measure that is selected.

A9.6 Construction Considerations

A9.6.1 Rock Veneer, with Seeding

Grade the treated area of the slope to a smooth, even surface. Broadcast seed (wet or dry) the area with the "Area 2" seed mixture and rates. Following seeding, install a coconut erosion control blanket meeting MDT Standard Specification 713.12.4 - Type B. Only use blankets constructed with 100% non-synthetic, biodegradable netting and stitching.

Cover the blanket with a single layer of Class I riprap, meeting MDT Standard Specification 701.06.2. Place the riprap in a manner that limits blanket ripping or dislodgement. Rocks must not be dropped from a distance greater than 1-2 ft (0.3-0.6 m) from the soil surface.

A9.6.2 Compost Blanket, with Seeding

Prepare the area to be treated by first scarifying it with a chisel plow or disk, operated parallel to the slope. Alternative methods of preparation that produce a roughened surface may be approved by the EPM. Dry broadcast seed the area with the "Area 2" seed mixture and rates. Following seeding, apply an equivalent amount of compost over the area to attain an average depth of 1 inch (25 mm). It is assumed that depths will be variable given the surface roughness. Overspray the compost with a tackifier to assure retention and performance of the compost for 6 months.

A9.6.3 Erosion Control Blanket, with Seeding

Grade the treated area of the slope to a smooth, non-compacted surface. Broadcast seed (wet or dry) the area with the "Area 2" seed mixture and rates. Lightly rake the seeded area to incorporate the seed into the upper ½ inch of soil. Following seed incorporation, install a 70% straw and 30% coconut erosion control blanket meeting MDT Standard Specification 713.12.2 – C. Type STC. Only use blankets constructed with 100% non-synthetic, biodegradable netting and stitching. Erosion control mats may be used on slopes steeper than 3:1 with limited growth potential.

A9.6.4 Topsoiling and Erosion Control Blanket, with Seeding

Prepare the area to be treated by first scarifying it with a chisel plow or disk. Following scarification, place a 2 inch (50 mm) layer of salvaged or furnished topsoil over the treated area. Broadcast seed (wet or dry) the area with the "Area 2" seed mixture and rates. Lightly rake the seeded area to incorporate the seed into the upper ½ inch of soil. Following seed incorporation, install an erosion control blanket meeting MDT Standard Specification 713.12.2 – C. Type STC. Only use blankets constructed with 100% non-synthetic, biodegradable netting and stitching.

A9.7 Operation and Maintenance

Maintenance of the ditches is restricted to avoid damaging the slope soil stabilization BMPs.

A9.8 Initial Cost and Cost per Year

Initial Cost:	Moderate
Cost per Year:	Low

A9.9 Method of Payment

The slope soil stabilization ECM's are typically measured and paid for by the square yard (square meter). Riprap is typically measured and paid by the cubic yard (cubic meter) when utilized.

A10.0: STREAMBANK STABILIZATION

A10.1 Definition and Purpose

Streambank erosion is the loss of soils along streams and rivers predominantly due to the force of flowing water. The seepage of groundwater and the overland flow of surface water runoff also contribute to the erosion of streambanks. The purpose of this control measure is to protect streambanks from the erosive forces of flowing water through use of designed vegetative and/or structural measures.

Bioengineered methods integrate plant materials and landform modifications in order to stabilize slopes and streambanks. Bioengineered techniques utilize natural elements such as trees, shrubs, rocks and native vegetation to stabilize banks as opposed to manmade structures constructed of synthetic materials.

A10.2 Appropriate Applications

Biostabilization is applicable to stream channels whose banks are susceptible to erosion due to water flows, excessive runoff, groundwater seepage, ice, or debris. Biostabilization is generally applicable where flow velocities exceed 5 ft/sec (1.5 m/s) or where simple revegetation methods are inappropriate or ineffective for streambank protection. Biostabilization is desirable where riprap or other hard methods pose aesthetic concerns and in areas where erosion poses a lower risk to the transportation facility.

The control measure selected should be compatible with improvements planned or being carried out in other channel reaches. The type of vegetative cover to be used should be based on the soil type, stream velocities, adjacent land use and anticipated level of maintenance to be performed.

Refer to the individual methods outlined below for more specific applications/ information.

A10.3 Limitations

- These control measures may require special permitting from resource agencies such as the Montana Departments of Environmental Quality; Fish, Wildlife and Parks; the Environmental Protection Agency; and the U.S. Army Corps of Engineers.
- Because of the sometimes complex issues, Hydraulics and Environmental Services should be involved throughout the process.

A10.4 Design Considerations

Since each reach of channel requiring protection is unique, measures for structural streambank protection should be installed according to a plan based on specific site conditions. The Hydraulics Section will coordinate with the Environmental Services Bureau to determine the appropriate design.

Develop designs according to the following principles:

- Make protective measures compatible with other channel modifications planned or being carried out in adjacent channel reaches.
- Ensure that streambank protection extends between stabilized or controlled points along the stream.
- Do not change channel alignment without a complete evaluation of the anticipated effect on the rest of the stream channel, especially downstream.
- Give special attention to maintaining and improving habitat for fish and wildlife.
- Ensure that all requirements of state law and all permit requirements of local, state, and federal agencies are met.
- All methods listed below must be designed for structural stability and erosion resistance.

Stream channel erosion problems vary widely in type and scale and no one measure works in all cases. Where long reaches of stream channels require stabilization, make detailed stream studies.

Before selecting a structural stabilization technique, the designer should carefully evaluate the possibility of using vegetative stabilization in conjunction with structural measures to achieve the desired protection. Vegetative techniques are generally less costly and more compatible with natural stream characteristics.

A10.4.1 Brush Layering

Brush layering consists of placing live branch cuttings in small benches excavated into the base of the slope. Cuttings taken from willow species when properly installed will root and stabilize slopes. The portions of the brush that protrude from the slope face assist in retarding runoff and reducing surface erosion. Brush layering is somewhat similar to live fascine systems because both involve the cutting and placement of live branch cuttings. The two techniques differ principally in the orientation of the branches and the depth to which they are placed in the slope. In brush layering, the cuttings are oriented more or less perpendicular to the slope contour. In live fascine systems, the cuttings are oriented more or less parallel to the slope contour. The perpendicular orientation is more effective from the point of view of earth reinforcement and mass stability of the slope.

A10.4.2 Joint Planting

Joint planting (or vegetated riprap) involves tamping live cuttings of rootable plant material into soil between the joints or open spaces in rocks that have previously been placed on a slope. Alternatively, the cuttings can be tamped into place at the same time that rock is being placed on the slope face. A bedding material or penetrable fabric must be used under the rock.

A10.4.3 Live Staking

Live staking is a form of soil bioengineering involving the planting of live, rootable vegetative cuttings into the ground along the streambank (also known as woody cuttings, posts, poles, or stubs). If correctly prepared and placed, the live stake will root and grow. As cuttings develop, they create a living root mat that stabilizes the soil by reinforcing and binding soil particles together and by extracting excess soil moisture. They protect streambanks from erosion, minimizing sediment and associated nutrient impacts downstream. Established cuttings also moderate bank and water temperatures, facilitate colonization of other species, and provide forage. Most willow and cottonwood species are ideal for live staking because they root rapidly. Live staking is an appropriate technique for repair of small earth slips and slumps that are frequently wet.

A10.4.4 Stream Deflectors (aka Vanes)

Structures that limit channel width and push flow away from the bank are referred to as stream deflectors. Single-wing deflectors, the most common type, consist of a main log or placed rock angled downstream. When properly constructed, either singly or in series in low gradient meandering streams, deflectors divert base flows toward the center of the channel and, under certain conditions, increase the depth and velocity of flow thereby creating scour pools and enhancing fish habitat. Stream deflectors should be constructed in the lower half of long riffles to prevent undesired backwater effects from reaching upstream. Banks opposite these structures should be monitored for excessive erosion.

A10.4.5 Tree Revetment

In a tree revetment, uprooted, live, whole trees are cabled tightly together, laid on their sides and secured to the bases of banks along eroded stream segments, tops pointed downstream and overlapped about 30%. Anchoring is usually accomplished through a system of cables, in a shingled pattern, like the shingles on a roof. The technique is most useful when stream bank heights are at least 6 ft (1.8 m), with a steep incline; revetments cannot be constructed on gradually sloped streambanks. Species used are those with abundant, dense branching to promote sediment trapping, and those which are decay-resistant (juniper, for example). Tree revetments can greatly slow the stream current along an eroding bank, which decreases erosion and allows sediment to deposit in the revetment's tree branches. In addition to trapping sediment, the deposited materials form an excellent seedbed in which the seeds of riparian trees and other plants can sprout and grow. The resulting growth spreads roots throughout the revetment and into the streambank. Tree revetments also provide excellent habitat for birds, fish, and other wildlife.

A10.4.6 Vegetated Geogrid (Soil Wrap)

Vegetated geogrids, also known as soil wraps, are used to rebuild a bank. They are similar to the brush layering fill technique except that an erosion control fabric (geotextile) is wrapped around each soil lift. Live branch cuttings are laid between the layers.

A10.4.7 Log Spur

A log spur bank feature is constructed by partially burying the top of a large cut tree in the stream channel with the lower branches pointing into the current. The lower half of the tree lies on the bottom of the stream and is anchored by boulders along the stream bottom. Log-spur bank features are designed to stabilize the stream channel and provide in-stream habitat for aquatic organisms.

A10.5 Materials

Materials will vary depending on the specific stabilization measure used.

A10.6 Construction Considerations

Refer to the specific stabilization measures in Section 10.4 Design Considerations.

A10.7 Operation and Maintenance

Check stabilized streambank sections after spring runoff, and make any needed repairs immediately to prevent further damage.

A10.8 Initial Cost and Cost per Year

Initial Cost:	Moderate
Cost per Year:	Moderate

A10.9 Method of Payment

The installation of stabilization measures varies.

A11.0: MAINTENANCE OF EXISTING DRAINAGE

A11.1 Definition and Purpose

The purpose of maintaining the existing drainage patterns is to ensure that a new roadway configuration does not result in concentration of runoff or obstruction of minor drainages. The failure to do so can result in water trapped next to the roadway and can potentially impact the hydrology of a drainage. Alteration in site runoff characteristics can cause an increase in the volume and frequency of runoff flows (discharge) and velocities that cause flooding, accelerated erosion, and reduced groundwater recharge, and contribute to degradation of water quality and the ecological integrity of streams.

A11.2 Appropriate Applications

Impacts to the existing drainages most often occur as the result of projects that involve changes to the horizontal or vertical alignment. The locations of minimum sized [24 inch (600 mm)] culverts are often overlooked and new grades may result in new low spots where water may be trapped.

Roadway widening may also impact roadside drainage. Many older sections of roads were constructed using side borrow which resulted in substantial roadside ditches. New wider roadway templates often fill these ditches leaving no clear drainage path.

A11.3 Limitations

Maintaining the existing drainage patterns may not always be practical, but should always be considered as part of the design process.

A11.4 Design Considerations

Whenever a project involves adjustments to the horizontal or vertical alignment or includes major widening, the following items should be considered:

- Review as-built plans and conduct on-site reviews to determine the location of minimum sized culverts.
- Perpetuate minor drainage crossings unless it is impractical to do so.
- If a crossing must be eliminated, direct the flow to the nearest natural drainage. Determine if the drainage can accommodate the additional flow.
- Since the elimination of the minor drainage crossing will often result in additional flow in the roadside ditch, evaluate the need for erosion control measures in the ditch to prevent erosion that would result from the increased flow.
- Where new grades result in new low spots where runoff would otherwise be trapped, grade the ditch to drain. This may require a ditch profile that is independent of the roadway profile.

- Where new templates fill in existing roadside ditches, drain ditches may be needed at the toe of the fill to promote positive drainage to a natural drainage course. As in cut sections, these ditches may require a ditch profile that is independent of the roadway profile.
- In cases where the flow pattern is changed from the original situation, evaluate the effects of the additional flow on the existing features such as drainages and wetlands to ensure that it does not result in adverse impacts.
- When filling in existing drainage ditches is unavoidable, careful evaluation of new drainage patterns is required. In no instance is it acceptable to block an existing drainage route with fill material without providing an alternative drainage pattern.

A11.5 Materials

This section is not applicable.

A11.6 Construction Considerations

This section is not applicable.

A11.7 Operation and Maintenance

This section is not applicable.

A11.8 Initial Cost and Cost per Year

This section is not applicable.

A11.9 Method of Payment

This section is not applicable.

A12.0: SETTLING BASINS

A12.1 Definition and Purpose

Settling basins are permanent dams or basins that can be used to enhance storm water runoff quality and reduce peak storm water runoff rates. Settling basins can be designed to maintain a permanent pool (wet pond) or to drain completely dry (detention or dry pond). Either way, the basin detains sediment-laden runoff long enough to allow most of the large sediment particles to settle out.

A settling basin can be constructed by excavation or by placing an earthen embankment across a low area or drainage swale. The pond has a riser and pipe outlet with a gravel outlet or spillway to slow the release of runoff and provide some sediment filtration. The outlet structure should be designed to withdraw the relatively clear water from the surface of the pool and prevent sediment from flowing through the basin.

A12.1.1 Dry Detention Basins

A dry detention basin is a storm water temporary storage basin that does not have a permanent pool. Dry basins receive storm water runoff and temporarily store (or detain) it for a short period of time as the captured water is slowly released. Dry detention basins can be incorporated in underground chambers, athletic fields, open spaces, etc., and are relatively easy to fit into a site. Dry detention basins are best used for reducing storm water runoff peak flow to an acceptable rate. Because dry detention basins have a tendency to re-suspend accumulated sediments, they are not the best choice for water quality protection. However, by providing “extended detention” (water quality volume [WQV] is discharged over 24 hours), dry detention basins can provide modest pollutant removal, mainly of coarse sediments.

A12.1.2 Wet Ponds

A wet pond is a sedimentation facility that has a permanent pool of water that is replaced with storm water, in part or in total, during storm water runoff events. In addition, a temporary detention volume is provided above this permanent pool to capture storm water runoff and enhance sedimentation. The influent water mixes with the permanent pool water as it rises above the permanent pool level. The wet pond is designed so that the surcharge captured volume above the permanent pool is released over a 12-hour period. Wet ponds require a dry-weather base flow to maintain the permanent pool. They can be very effective in removing pollutants, and, under the proper conditions, can satisfy multiple objectives.

A12.2 Appropriate Applications

A basin can be used to enhance storm water runoff quality and reduce peak storm water runoff rates. If the basins are constructed early in the development cycle, they can also be used to trap sediment from construction activities within the tributary drainage area. A basin can sometimes be retrofitted into existing flood control detention basins. This Best Management Practice (BMP) can be effective in meeting the requirements of the Storm Water Management Program under the MS4 permit.

The dry detention basin performs well for reducing flow rates of small and large storm events. Dry detention basins can be sized to support small to large size drainage areas. Dry detention basins do not have the pollutant removal capability of wet ponds. However, dry detention basins with extended detention do a decent job in settling out coarse particles. Also, dry detention basins may be used as part of a “treatment train”; for example, as the pretreatment (sedimentation) basin to the surface sand filtration facility.

A wet pond can be used to improve the quality of urban runoff from roads, parking lots, residential neighborhoods, commercial areas, and industrial sites and is generally used as regional or follow-up treatment because of the base flow requirements. A wet pond works well in conjunction with other BMPs, such as upstream onsite source controls and downstream filter basins or wetland channels. A wet pond also can be easily adapted to provide quantity control for storms larger than the water quality storm event, require less periodic maintenance than other structural BMPs, and if desired can provide an amenity to a property such as “lakefront” residential property, wildlife habitat and fountain pools. Wet ponds seem to function better when the pond is larger and receives flow from a larger drainage area. Improved function may be attributed to several factors, such as the following:

- In larger drainage areas there is usually a better chance for seasonal or permanent surface or groundwater flow into the pond as opposed to smaller drainage areas. This flow may help the permanent pool to be “flushed” more often (as opposed to only during storm events), thereby preventing undesirable conditions (such as stagnant water, fluctuating permanent pool elevation, etc.) from developing.
- Wet ponds have a higher tolerance for runoff with sediment concentration than the other BMPs. Therefore, wet ponds are likely the preferred BMPs to use in large developments where construction will take place in phases or in residential development where site disturbance will occur for a period after the BMP is installed.
- For properties where the land may remain fully or partially unstabilized or if there are sources of sediments on the property (for example, gravel/dirt areas, areas where vegetation is slow to establish, etc.) the wet pond is a good choice.

A12.3 Limitations

- Safety concerns (such as clear zone issues, fencing near urban areas, etc.).
- Maintenance and sediment removal needs.
- Floating litter, scum, and algal blooms.
- Possible nuisance odors.
- Possible mosquito problems.
- Aquatic plant growth can be a factor in clogging outlet controls.

- The permanent pool can attract water fowl, which can add to the nutrient load entering and leaving the pond.

A12.4 Design Considerations

- Settling basins are typically designed by the Hydraulics Section. The Road Designer will review locations and ensure that the design details are included in the plans.
- Avoid placing these structures in environmentally sensitive areas such as perennial or intermittent streams and wetlands.
- The embankment slopes for open basins should be flatter than 3H:1V slope for safety and ease of maintenance. A 10-15 ft (approximately 3-4.6 m) bench (with maximum slope of 10%) placed around the pond near the normal pool surface is strongly encouraged. This bench will allow machinery to gain closer access to the pond during cleanouts. This break in the grade will be a safety amenity and can make the pond more aesthetically pleasing.
- Suitably designed vertical concrete walls may be used instead of earth embankments for open dry detention basins. In this case, it is recommended that a safety fence or other device be constructed around the basin perimeter to prevent accidents.
- When designing the dam and spillways, existing and potential future downstream development should be considered. Spillway design will be performed by the Hydraulics Section. Avoid placing the dam upstream of highly developed or traffic areas whenever possible. The discharge from the spillways should be directed to a conveyance system that can adequately handle the flow or, if no conveyance is present, the discharge should be directed away from existing development.
- The accumulated sediment will need to be removed after upstream land disturbances cease and before the basin is placed into final long-term use. The Road Designer will prepare a special provision to describe the removal of the material.

A12.4.1 Low Flow Orifices

Low flow orifices are designed to slowly release the volume stored in the basin. The release device may be a perforated riser, pipe with attached orifice plate, or skimming device. The designer should consider trash protection with any of these orifices.

A12.4.2 Spillways

Aboveground dry detention basins should have spillways designed to safely pass up to the 100-year storm event, at a minimum. Riser/barrel assemblies, concrete chutes, or riprap-lined channels may be used to pass larger storm events. Open channel spillways must not be placed in the fill section of earth dams. The spillways must have provisions to prevent erosion of the receiving conveyance.

A12.4.3 Basin Shape

Shape the pond whenever possible with a gradual expansion from the inflow area and a gradual contraction toward the outlet, thereby minimizing short circuiting. A basin length-to-width ratio between 2:1 and 3:1 is recommended. It may be necessary to modify the inlet and outlet points through the use of pipes, swales, or channels to accomplish this ratio. Always maximize the distance between the inlet and the outlet.

A12.4.4 Low-Flow Channel

Lining the low-flow channel with riprap is recommended, at least 9 inches (230 mm) deep if buried riprap is used. At a minimum provide capacity equal to twice the release capacity at the upstream forebay outlet.

A12.4.5 Basin Side Slopes

Basin side slopes should facilitate maintenance and access. Side slopes should be no steeper than 4:1 where practical.

A12.4.6 Dam Embankment

The embankment should be designed not to fail during a 100-year or larger storm. Embankment slopes should be no steeper than 3:1, and planted with turf-forming grasses. Poorly compacted native soils should be excavated and replaced.

A12.4.7 Vegetation

Bottom vegetation provides erosion control and sediment entrapment. Pond bottom, berms, and side sloping areas may be planted with native grasses or with irrigated turf, depending on the local setting.

A12.4.8 Maintenance Access

All-weather stable access to the bottom, forebay, and outlet controls area must be provided for maintenance vehicles. Maximum grades should not exceed 10% and should have a stable driving surface. Where possible, a gravel or hard surface should be provided.

A12.4.9 Inflow Point

Dissipate flow energy at the pond's inflow point(s) to limit erosion and promote particle sedimentation.

A12.4.10 Forebay Design

The Hydraulics Section will determine the need for a forebay. Forebays provide the opportunity for larger particles to settle out in the inflow area (the area that has a solid surface bottom) to facilitate mechanical sediment removal. A rock berm should be constructed between the forebay and the main extended detention basin. The forebay volume of the permanent pool should be about 5% of the design water quality capture volume. A pipe throughout the berm to convey water to the main body of the extended detention basin should be offset from the inflow streamline to prevent short circuiting and should be sized to drain the forebay volume in 15 minutes.

A12.4.11 Water Quality Volume

To design the basin for storm water quality control, the water quality volume (WQV) must be routed through the basin. The WQV is the amount of storm water runoff from any given storm that should be captured and treated in order to remove a majority of storm water pollutants on an average annual basis. The recommended WQV, which results in the capture and treatment of the entire runoff volume for 90% of the average annual storm events, is equivalent to the runoff associated with the first 1-inch of rainfall. This runoff is typically referred to as the “first-flush.”

A12.4.12 Wet Pond

The wet pond is designed similarly to the dry detention basin. The basin should be designed to reduce the peak flow from the 2-year storm and be able to pass a 100-year storm safely.

The permanent pool should be at least equal to the WQV for the watershed. The theory behind this requirement is that incoming runoff displaces old storm water from the basin and the new runoff is detained until it is displaced by more runoff from the next storm. A permanent pool equal to the WQV should then provide an adequate detention time for the storm water. Watershed size, soil conditions and groundwater elevation must be evaluated to ensure the capability of the site to support a permanent wet basin. To enhance pollutant and sediment removal, several other considerations may be taken into account, including a sediment forebay. The shape of the basin can affect the pollutant-removal efficiency. The length-to-width ratio should be at least 3:1. Basin depth should be between 5 and 10 ft (1.5 and 3.0 m); less could allow insect breeding and wind resuspension of settled particles, and more could lead to thermal stratification in the basin and anaerobic conditions in the deep water. A wedge-shaped basin, wider at the outlet, can also improve pollutant removal.

A12.5 Materials

Materials required will vary with site-specific conditions.

A12.6 Construction Considerations

Unclassified excavation can be used for the construction of dry basins and muck excavation may be necessary for the construction of wet ponds. If the settling basin is constructed early in the project construction process, construction-related sediment may need to be removed before project completion.

A12.7 Operation and Maintenance

Basins should be inspected annually. Remove sediment as necessary to ensure proper function.

A12.8 Initial Cost and Cost per Year

Initial Cost:	High
Cost per Year:	Moderate

A12.9 Method of Payment

Materials required for construction will be paid at appropriate unit prices.

A13.0: INFILTRATION BASINS

A13.1 Definition and Purpose

An infiltration basin is a shallow impoundment that captures and stores storm water until it can infiltrate into the soil. The soil acts as a natural filter to remove pollutants from the storm water before it eventually reaches the water table. Infiltration systems have high pollutant removal efficiency for constituents including fine sediments, nutrients, trash, metals, bacteria, oils, greases, and organics. Some soluble constituents can be effectively removed if proper vegetation is planted and managed, and detention time is maximized.

Infiltration basins offer benefits in addition to storm water control. One benefit is groundwater recharge that may augment base stream flow. Infiltration basins can effectively replace infiltration loss due to addition of impervious areas, and may be used strictly as a means to maintain the natural (pre-development) hydrologic balance of a site. Multiple uses of infiltration systems are recommended when and where practicable.

A13.2 Appropriate Applications

Use: Infiltration basins are used where outfalls are not available, such as developed areas and urban interchanges. (See A13.3 Limitations discussion below for appropriate distance between basin and structures.)

Drainage Area: Infiltration basins typically serve drainage areas from 5-50 ac (2-20 ha). For drainage areas less than 5 ac (2 ha), infiltration trenches are generally used. For drainage areas greater than 50 ac (20 ha), detention or wet ponds are generally used.

Soil Type: Soil type at the site will play an important role in determining if an infiltration basin is the preferred PESC measure. The soils should have an infiltration rate of at least 0.5 inch/hr (13 mm/hr). Soils should be comprised of less than 30% clay or less than 40% clay and silt combined. Infiltration basins will have higher potential for success when they are sited based on site-specific field data rather than on soil survey tables and mapping alone. (Please see Key Siting Criteria in Section A13.4 below.) A minimum of 4 ft (1.2 m) from the basin bottom to bedrock is recommended.

Depth to Groundwater: Groundwater separation should be at least 10 ft (3 m) from the basin invert to the measured groundwater elevation. In the absence of site-specific data, consult U.S. Department of Agriculture (USDA) soil survey tables to investigate the presence of a restrictive layer or seasonal high water table. A minimum of 4 ft (1.2 m) from the basin bottom to the seasonally high water table is recommended in order to ensure proper basin operation.

A13.3 Limitations

Soils: Restoring the functionality of a clogged infiltration basin can be difficult. If soil conditions do not match those listed in the A13.2 Appropriate Applications section, use a different PESC measure.

Pretreatment: Pretreatment may be necessary to minimize risk of groundwater contamination or to minimize maintenance requirements due to clogging of the basin. Consider use of a pretreatment measure (such as a sediment basin or oil/grit separator) or use of a PESC measure other than an infiltration basin for:

- Project sites near industrial sites, chemical or pesticide storage areas, or fueling stations;
- Areas with very coarse soils [where infiltration rates exceed 2.4 inch/hr (60 mm/hr)]; or
- Areas where coarse sediments or oils are expected.

Location: Site-specific conditions will play an important role in deciding if an infiltration basin is the appropriate PESC measure. Do not use infiltration basins:

- In or partially in fill sites (unless no silts or clays are present in a soil boring);
- On steep (greater than 15%) slopes;
- In areas where the slope of the contributing watershed is greater than 20%;
- Closer than 20 ft (6 m) from buildings, fill slopes or highway pavement; or
- Closer than 100 ft (30 m) up-gradient or 20 ft (6 m) down-gradient from drinking water wells or bridge structures.

A13.4 Design Considerations

Design: Infiltration basins are typically designed by the Hydraulics Section. The Road Designer will review locations and ensure that the design details are included in the plans.

Key Siting Criteria: Appropriate soil and hydrogeologic properties are critical for long-term successful performance. If soil and hydrogeologic conditions do not match those listed in the A13.2 Appropriate Applications section, use a different PESC measure.

Successfully siting the infiltration basin will likely require coordination with the MDT Geotechnical Bureau to gather site-specific soils and hydrogeologic data. When possible, use the following site-specific geotechnical investigations to evaluate the site.

- At least three in-hole conductivity tests should be performed by the Geotechnical Section. Two of the tests should be at different locations within the proposed basin and the third down-gradient by no more than approximately 33 ft (10 m). The tests measure permeability in the side slopes and the bed within a depth of 10 ft (3 m) of the invert.

- The minimum acceptable hydraulic conductivity as measured in any of the three required test holes is 0.5 inch/hr (13 mm/hr). If any of the three test holes shows less than the minimum value, the site should be disqualified from further consideration.
- The geotechnical investigation should be such that a good understanding is gained as to how the storm water runoff will move in the soil (horizontally or vertically) and if there are any geological conditions that could inhibit the movement of water.

Volume: Minimum design volume should be determined by local requirements or sized to capture no less than the water quality volume (WQV) from the entire contributing watershed. Larger design volumes are recommended, as they will provide treatment that is more effective.

Holding Time: The basin should be sized to infiltrate the entire WQV in 6-72 hours. Less than 6 hours of holding time provides little treatment, while greater than 72 hours can create nuisance and capacity problems for back-to-back storms. Many sources recommend sizing the basin for infiltration of the entire WQV in 48 hours.

Buffer Strip: A 25-foot (7.6 m) vegetated buffer strip should surround the infiltration basin to provide pretreatment and to ensure adequate access for maintenance. Consult the MDT Reclamation Specialist for specific seeding/planting guidelines.

Basin Configuration: An infiltration basin may be constructed in any shape to meet right-of-way restrictions. The basin floor should be as flat as possible with no noticeable depressions. Side slopes should be no more than 3:1 (h:v) to allow for mowing and other necessary maintenance. As appropriate with consideration to right-of-way needs, maximize basin floor surface area and reduce depth to optimize infiltration.

Emergency Spillway: Provide an emergency spillway in order to direct overflows from storms larger than the design storm.

Energy Dissipation: Provide energy dissipation (generally riprap) at inlets and outlets to prevent scouring, reduce flow velocities, and trap sediment.

Vegetation: Established vegetation can maintain and possibly improve infiltration, prevent erosion, and remove soluble nutrients in the storm water. Vegetation on the basin bottom and sides must be capable of surviving up to 72 hours under water. Tall fescues or bermuda grass are often used. Consult the MDT Reclamation Specialist for specific seeding/planting guidelines.

A13.5 Materials

Consult the MDT Reclamation Specialist for specific seeding/planting guidelines.

A13.6 Construction Considerations

Without precautions, sediments from the construction site can clog the basin, preventing post-project infiltration. Preferably, the basin would not be put into use until after the work site and the area draining to the basin are stabilized.

If the infiltration basin will also serve as a sediment basin during construction, it should only be excavated down to about 2 ft (0.6 m) above the infiltration basin design floor. Sediment that accumulates in the basin can then be excavated after all other construction is complete.

- A temporary diversion berm around the perimeter of the infiltration basin is recommended to prevent sediment entrance during construction and until the basin vegetation is established.
- Prior to any site construction, rope off the infiltration area to prevent entrance by unwanted equipment.
- Place excavated material such that it cannot be washed back into the basin if a storm occurs during construction of the facility.
- To prevent soil compaction, build the basin without driving heavy equipment over the infiltration surface. Equipment driven on the surface should have extra-wide ("low pressure") tires.
- After final grading, till the infiltration surface deeply.

A13.7 Operation and Maintenance

Maintenance and inspection are essential for the long-term successful operation of this PESC measure. Goals of inspections and maintenance should be to ensure that water infiltrates into the subsurface within 72 hours or less and that vegetation remains healthy. Recommended operation and maintenance guidelines include:

- Observe drain time for the design storm after completion or modification of the facility to confirm that the desired drain time has been obtained.
- Schedule semiannual inspections for the beginning and end of the wet season to identify potential problems such as erosion of the basin side slopes and invert, standing water, trash and debris, and sediment accumulation.
- Remove accumulated trash and debris in the basin at the start and end of the wet season.
- Inspect for standing water at the end of the wet season.
- Trim vegetation at the beginning and end of the wet season to prevent establishment of woody vegetation.
- Remove accumulated sediment and re-grade when the accumulated sediment volume exceeds 10% of the basin.
- If erosion is occurring within the basin, revegetate immediately and stabilize with erosion control mulch or mat until vegetation cover is established.
- To avoid reversing soil development, scarification or other disturbance should only be performed when there are actual signs of clogging, rather than on a routine basis.

Remove deposited sediments before scarification. For scarification, use a hand-guided rotary tiller, if possible, or a disc harrow pulled by a very light tractor.

A13.8 Initial Cost and Cost per Year

Initial Cost: Moderate
Cost per Year: Low

A13.9 Method of Payment

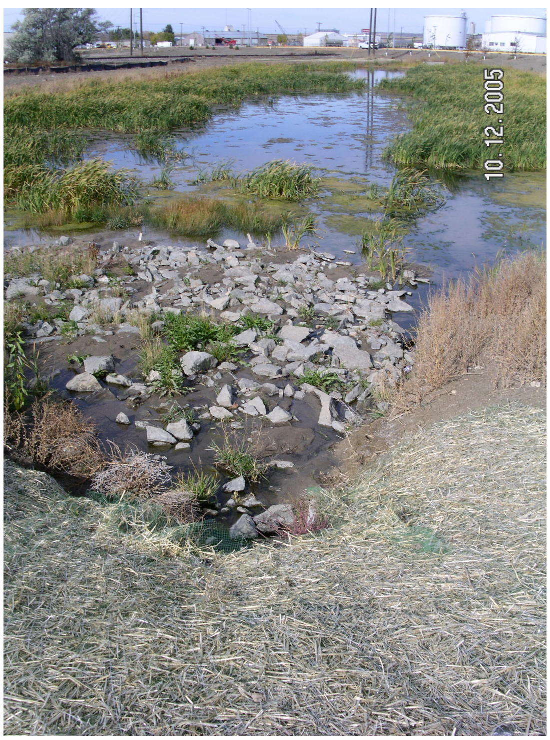
Materials required for construction will be paid at appropriate unit prices.

A14.0 WETLAND BASINS

A14.1 Definition and Purpose

A wetland basin (or wet basin) is a detention system comprised of a permanent pool of water, a temporary storage volume above the permanent pool, and a shoreline zone planted with aquatic vegetation. The wetland basin requires a perennial base flow to encourage and maintain the growth of rushes, willows, cattails, and reeds. It is a sedimentation basin and also serves a second function of treating the storm water, removing pollutants before discharge. Wetland basins are effective in removing sediments, nutrients, particulate metals, pathogens, litter and Biochemical Oxygen Demand (BOD) by temporarily capturing and detaining the Water Quality Volume (WQV) in order to allow settling, filtering, and biological uptake to occur.

A wetland basin can be used as a structural BMP in a watershed or as a stand-alone onsite facility. In a stand-alone situation, the owner must provide sufficient water to sustain the wetland. Flood control storage can be provided above the basin's WQV pool to act as a multiuse facility.



A14.2 Appropriate Applications

Wetland basins are permanent pools of water designed to mimic naturally-occurring wetlands. The main distinction between constructed and natural wetlands is that constructed wetlands are placed in upland areas and are not subject to wetland protection regulations. Wet basins should be considered when the site is located where the visual aesthetics of the permanent pool are considered a benefit (such as a roadside rest area or vista point) or where the added treatment the basin provides will be of benefit (such as areas where the basin will discharge to water quality sensitive areas or runoff is from areas likely to contain pollutants in addition to sediment).

This measure may also be a requirement or at least a consideration in urban areas where an MS4 program is in place. Inclusion of such measures in the MDT design will assist in complying with requirements under the Post Construction Storm Water Management aspects of the permit.

A wetland basin offers several potential benefits such as natural aesthetic qualities, wildlife habitat, erosion control, and pollutant removal. It can also provide an effective follow-up treatment to onsite and source control BMPs that rely upon settling of larger sediment particles. In other words, it offers yet another effective structural BMP for larger tributary catchments.

A14.3 Limitations

- **Flow** - The primary drawback of the constructed wetland is the need for a continuous base flow to ensure viable wetland growth. The site must have a high water table or another source of water must be present to provide base flow sufficient to maintain the plant community year-round. Acquisition of water rights may be necessary. Coordinate with the Environmental Services Bureau for further evaluation of water rights issues.

- **Maintenance** - Silt and scum can accumulate and unless properly designed and built, can be flushed out during larger storms. Along with routine good housekeeping maintenance, occasional “mucking out” will be required when sediment accumulations become too large and affect performance. Periodic sediment removal is also needed for proper distribution of growth zones and of water movement within the wetland.

- **Capacity Limitations** - In order to maintain a healthy wetland growth, the surcharge depth for WQV above the permanent water surface cannot exceed 2 ft (0.6 m).

- **Pollutants** - Pollutants are removed through sedimentation and entrapment with some removal through biological uptake by vegetation and microorganisms. Without a continuous dry-weather base flow, salts and algae can concentrate in the water column and can be released into the receiving water in higher levels at the beginning of a storm event as they are washed out.

- **Additional Right-of-Way** - Because of the size of the measure, additional right-of-way may need to be obtained to construct the wetland.

A14.4 Design Considerations

- The designer must coordinate with the District Biologist and the District Hydraulics Engineer. An analysis of the water budget is needed to show that the net inflow of water is sufficient to meet all the projected losses (such as evaporation, evapotranspiration, and seepage for each season of operation). Insufficient inflow can cause the wetland to become saline or to die off.
- Within the wet basin, a flow-path-to-width ratio of at least 2:1 configured in an irregular or meandering configuration must be provided. The invert of the wet basin may employ a 'micro topography' (contouring and benching of the invert to vary the water depth); care should be exercised to minimize stagnant areas (areas where incoming water does not displace or commingle with permanent pool). The basin may also be configured to fit the surrounding topography.
- For the ground above the WQV elevation, use 4:1 side slope ratios or flatter for a minimum 16 ft (3 m) horizontally, with 3:1 side slopes maximum if approved by Maintenance. Below the WQV and the permanent pool elevation, the side slope ratios should be no steeper than 3:1, and 4:1 is preferred along the entire shoreline. Within the wet basin, average water depth should be approximately 3.9 - 6.6 ft (1.2 - 2 m), and typical maximum depth between 8 and 10 ft (2.4 and 3.1 m). Usually the shallow (vegetated) areas are limited to between 25 and 50% of the surface water area of the wet basin. See the table and figure below.

Table A14-1: Wetland Basin Hydrologic Zones

Zone	Description and Topography	Hydrologic Condition and Water Depths Between Storm Events
1	Deep water pool (permanent pool; not used in all wet basins); volume of up to 25% of WQV; up to 35% of surface area; flat slopes, or slopes up to 3:1 where adjoining Zone 2.	1 - 6 ft (0.3 - 1.8 m); little or no plant growth in this zone, *especially between depths of 1.6 – 3.3 ft (0.5 -1.0 m).*
2	Shallow water bench (permanent pool); 35-75% of surface area; side slopes up to 3:1.	0.5 - 1 ft (0.15 - 0.3 m); hydrophytic plants in this zone.
3	Shoreline fringe (could also include any upstream forebay to the wet basin); 25-40% of surface area; side slopes up to 3:1.	Regularly inundated during rainy season (conceptually, frequent storm events); this zone is sized to hold the WQV; depth is project-specific; hydrophilic plants in this zone.
4	Riparian fringe; side slopes of 4:1 (up to 3:1 if approved by Maintenance).	Periodically inundated (conceptually, up to 10-year storm events).
5	Floodplain terrace; no set side slope ratio.	Infrequently inundated.
6	Upland slopes; no set side slope ratio.	Rarely or never.

- The outlet used to discharge the WQV is designed to complete the drawdown in 24-72 hrs, but typically 24-48 hrs. The WQV outlet should employ a debris screen (or equivalent) and riser. In addition to a device that safely discharges the WQV, an outlet device must pass the largest event that could reach the basin, which may be done using the same device that will discharge the WQV, or by a separate device.

- The wet basin should have a freeboard greater than or equal to 12 inches (300 mm), where freeboard is defined as the distance between the elevation at the top of the containment forming the basin, and the water surface elevation of the largest storm that can enter the basin. It is assumed that when that storm is passing through the wet basin, the initial water surface elevation in the wet basin includes the WQV retained above the permanent pool.
- The design for the wet basin must provide appropriate vegetation for each hydrologic zone. Native soils at invert may require added organics.
- Consider fencing around the wet basin to restrict public access.

A14.5 Materials

The materials will vary with the specific site conditions and wetland design, but the following items are typically included in most wetland designs:

- Grading – unclassified excavation or muck excavation
- Seeding and plantings
- Wetland soil salvage
- Fencing

A14.6 Construction Considerations

The following items need to be considered for wetland construction:

- Ensure that Tribal requirements and/or Corps of Engineers' special conditions contained in the 404 permit are met.
- Ensure necessary water rights have been obtained.
- Constructing the wetland to the design elevations is essential for the development of the wetland.
- Ensure that the stockpile sites for normal grading material and wetland soils are separate.
- When the wetland is constructed as a stand-alone project the disposal of the excavated material needs to be addressed.
- Special sequencing may be necessary when the wetland is constructed in conjunction with a road project if the excavated material is to be used in the construction of the roadway.

A14.7 Operation and Maintenance

- Inspect after each major storm, and at least once per year. Once wetland vegetation is established and basin performance is consistent, storm event inspection can likely be eliminated.
- Inspect outlet for erosion and downstream scour. If eroded, repair damage and install additional energy dissipation measures. If downstream scour is occurring, it may be necessary to reduce flows being discharged into the outfall area unless other preventative measures are implemented.
- Inspect inlet for accumulations of debris and sediment.
- Remove built-up sediment from inlet, outlet and elsewhere as required.

A14.8 Initial Cost and Cost per Year

Initial Cost:	High
Cost per Year:	Low to Moderate

A14.9 Method of Payment

The construction of the wetland will usually be paid as a lump sum. However, depending on the situation the wetland construction may be paid at the unit prices bid for individual items.

Sample Summary Frame (Embankment in Place)

ADDITIONAL GRADING					
STATION		cubic yards			REMARKS
		INCL. IN GRADING		ADD. EMB. IN PLACE #	
FROM	TO	EXC.	EMB. IN PLACE		
134+20			25		DITCH BLOCK LT.
SUBTOTAL			25		

EXCAVATION QUANTITIES-MATERIAL UNSUITABLE FOR ROADWAY EMBANKMENTS

DITCH BLOCK SUMMARY ENTRY

Sample Summary Frame (Unclassified Excavation)

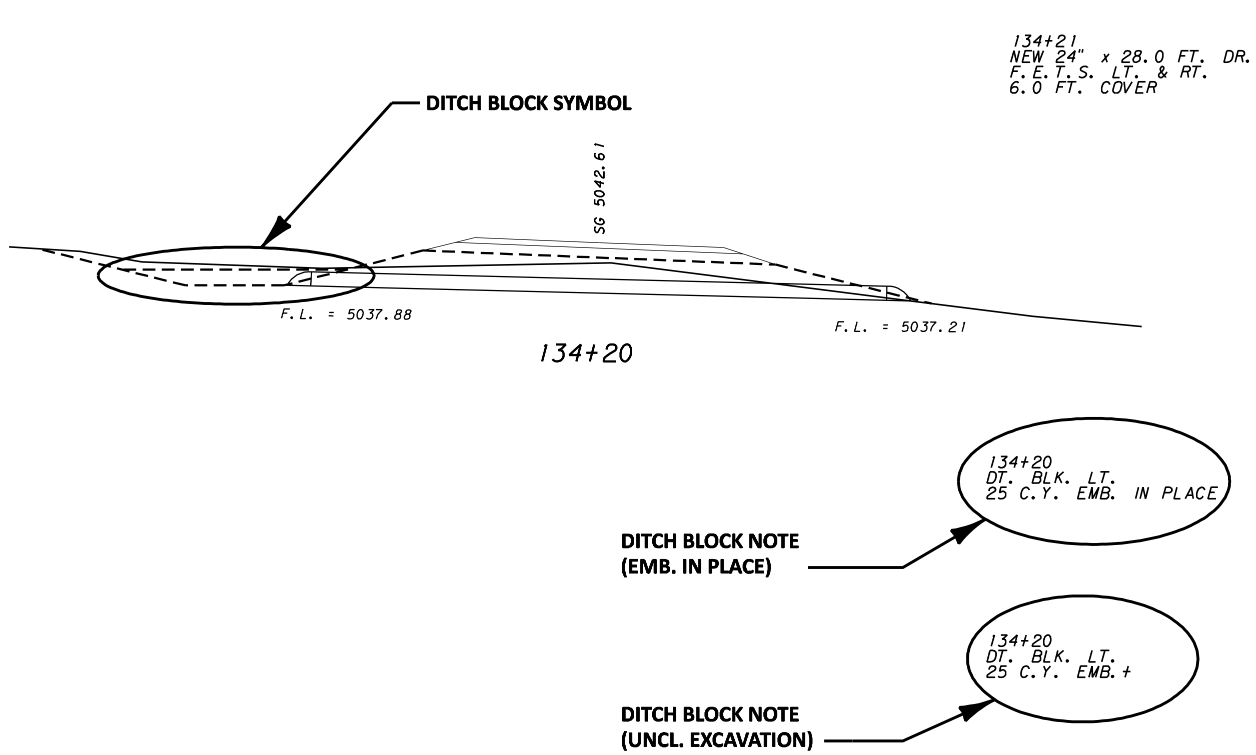
ADDITIONAL GRADING					
STATION		cubic yards			REMARKS
		INCL. IN ROADWAY		ADD. UNCL. EXC.	
FROM	TO	UNCL. EXC.	EMB.+		
134+20			25		DITCH BLOCK LT.
SUBTOTAL			25		

DITCH BLOCK SUMMARY ENTRY

Ditch Block Reminders:

① *See Detail Drawing 203-20 for additional ditch block details.*

Sample Cross Section



Sample Plan and Profile

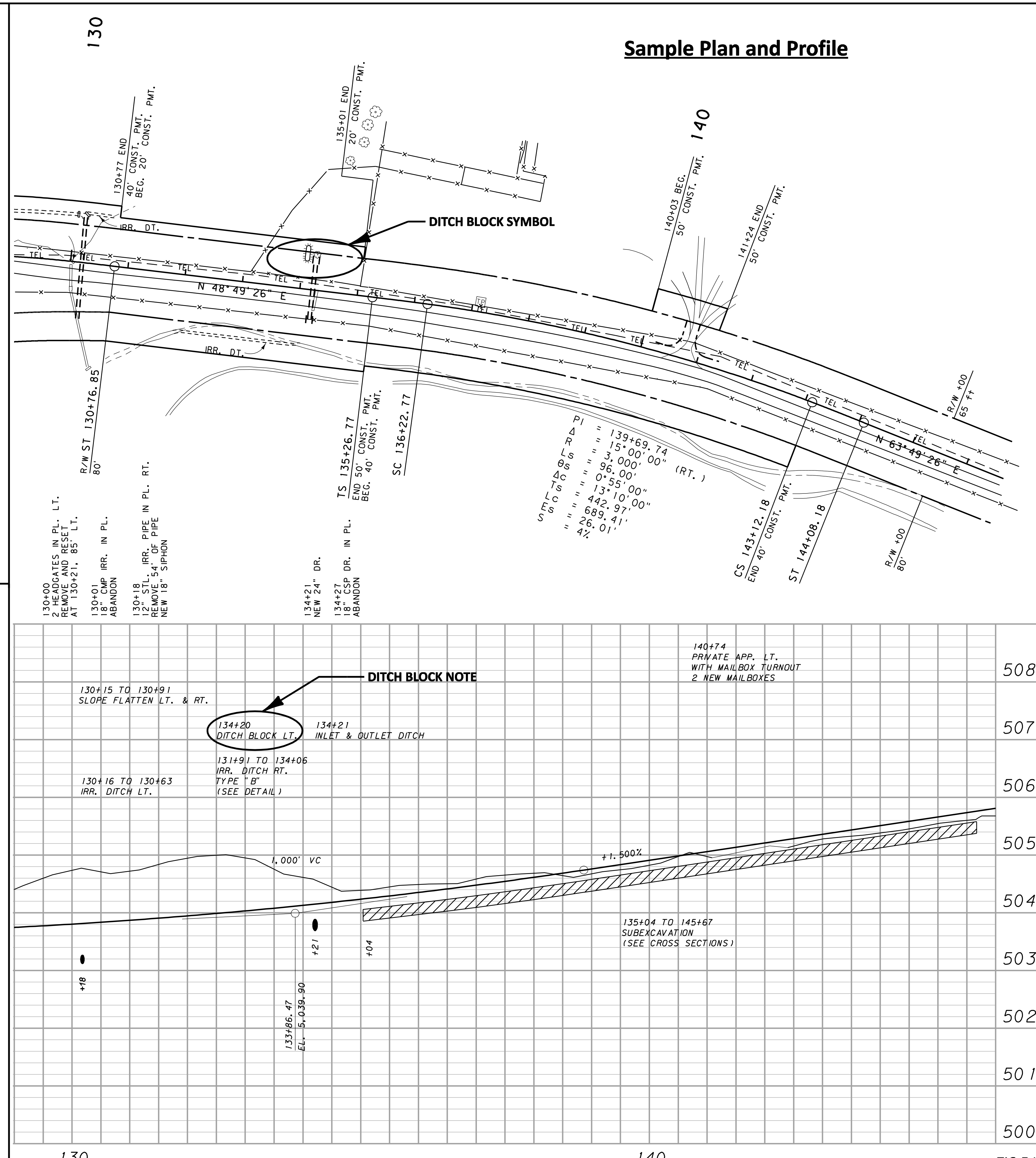


FIG B1-1

MDT MONTANA DEPARTMENT OF TRANSPORTATION	...\Dgn\PESCMANRDB01001.dgn 8/9/2010 12:51:37 PM u3326	DESIGNED BY DESIGNER NAME DATE REVIEWED BY SUPERVISOR NAME DATE CHECKED BY CHECKER NAME DATE	ROAD PLANS COUNTY NAME(S)	MONTANA PERMANENT EROSION & SEDIMENT CONTROL MANUAL SAMPLE PLAN SHEET	DITCH BLOCK SAMPLES CSF = 0.9999999 UPN NUMBER 12345678	PROJECT NO. SHEET 999 OF 999

Sample Summary Frame

CHECK DAMS				
STATION		AGGREGATE cubic yards		REMARKS
FROM	TO	CR. BASE COURSE TY.B GR.3		
135+00	141+00	6		GRAVEL CHECK DAMS RT., 300 FT. INTERVALS (3) - SEE DETAIL
TOTAL		6		

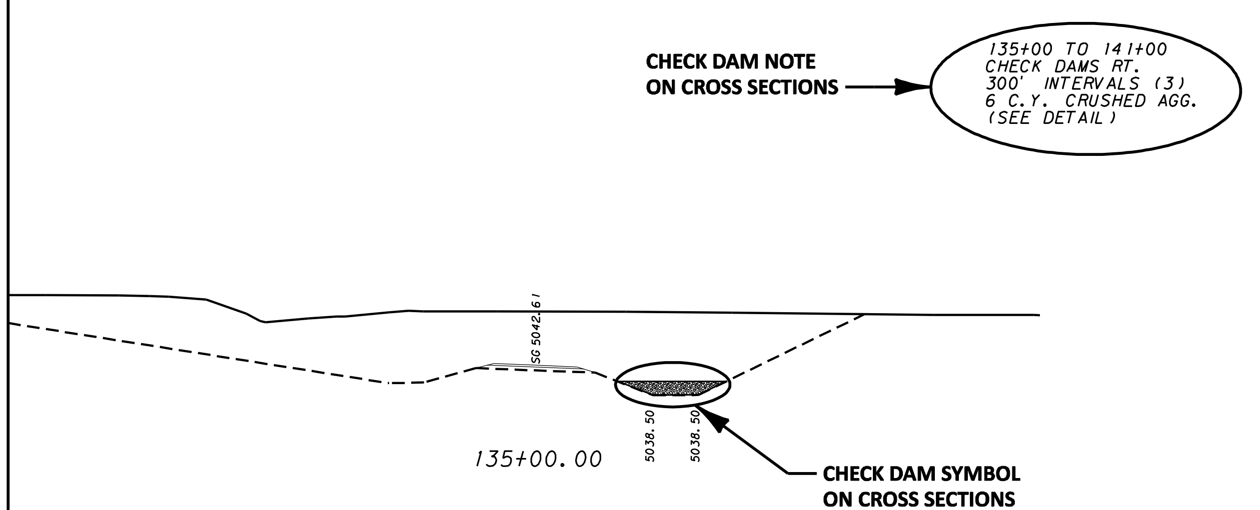
← **CHECK DAM SUMMARY ENTRY**

Check Dam Reminders:

① *See Section A2 for additional check dam information.*

② *Vary items as necessary in summary frame for vegetated earth or gravel berm.*

Sample Cross Section



Sample Plan and Profile

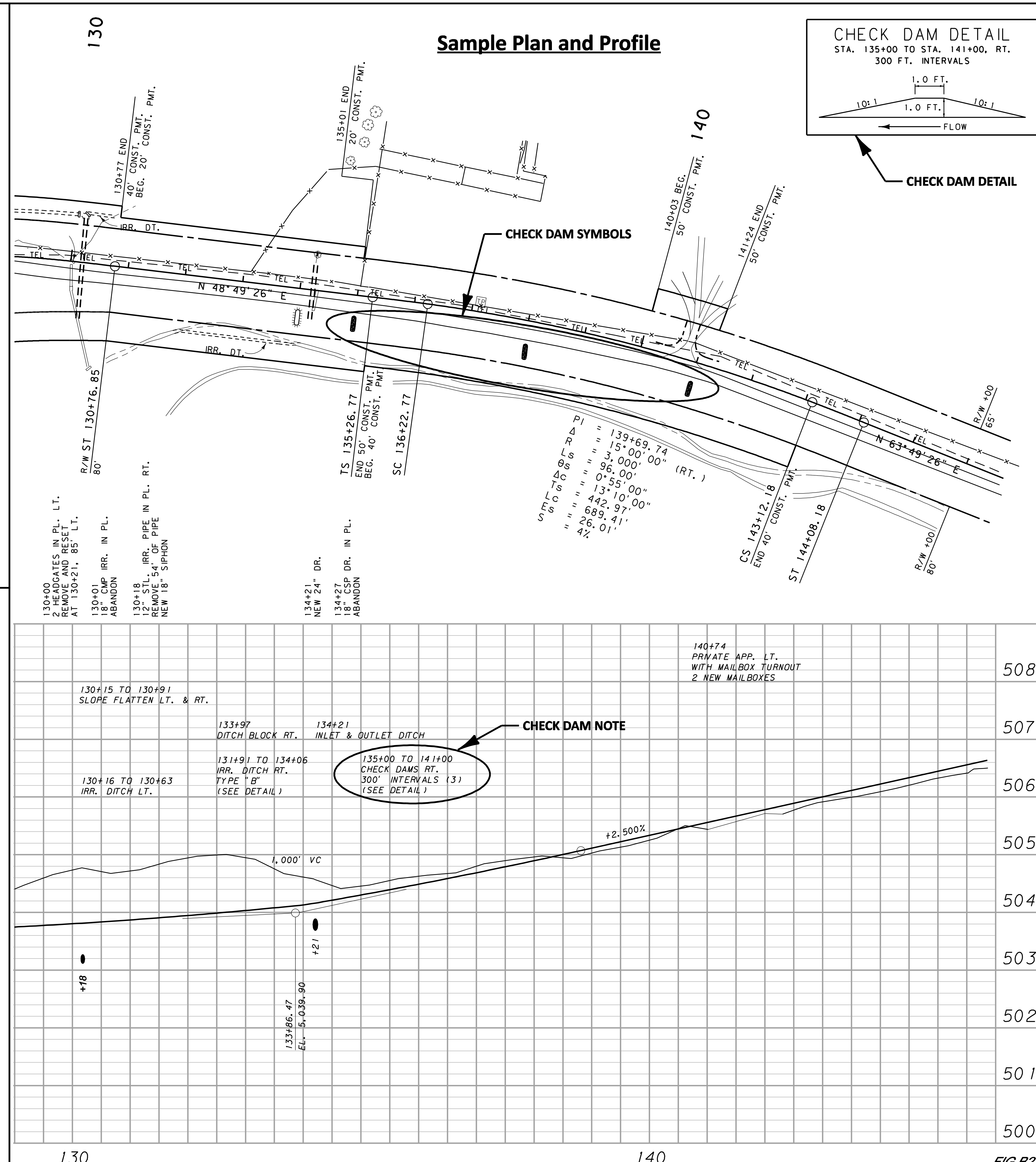


FIG B2-1

MDT MONTANA DEPARTMENT OF TRANSPORTATION	...\Dgn\PESCMANRDB02001.dgn 8/9/2010 12:53:56 PM u3326	DESIGNED BY *DESIGNER NAME* *DATE*; REVIEWED BY *SUPERVISOR NAME* *DATE*; CHECKED BY *CHECKER NAME* *DATE*	ROAD PLANS / COUNTY NAME(S)	*MONTANA PERMANENT EROSION & SEDIMENT CONTROL MANUAL SAMPLE PLAN SHEET*
CHECK DAMS SAMPLES	CSF = 0.9999999	UPN NUMBER 12345678	PROJECT NO.	SHEET 999 OF 999

Sample Summary Frames

PLANT MIX LINED DITCH *					
STATION		linear feet	tons		REMARKS
		PL. MIX LINED DITCH	PL. MIX SURF. GR. S	ASPHALT CEMENT PG 64-28	
FROM	TO				
123+65	128+75	510.0	12	4	LT.
134+20	142+75	855.0	24	8	RT.
TOTAL		1365.0	# 36	# 12	

* SEE DETAIL SHEET
\# FOR INFORMATION ONLY

PLANT MIX LINED DITCH SUMMARY FRAME

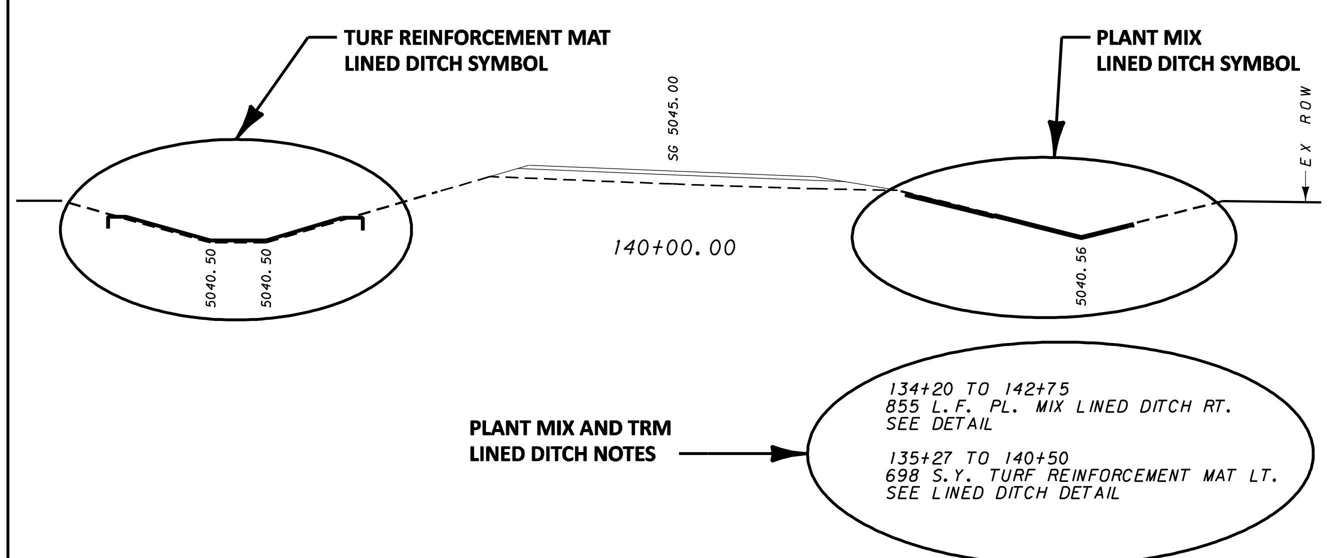
TURF REINFORCEMENT MAT			
STATION		square yards	REMARKS
		TURF REINFORCEMENT MAT	
FROM	TO		
135+27	140+50	698	DITCH LT. - SEE DETAIL
TOTAL		698	

TURF REINFORCEMENT MAT SUMMARY FRAME

Lined Ditch Reminders:

1. *Use Random Riprap frame as shown in Fig. 4.4 K-13 of the Road Design Manual for riprap lined ditches.*
2. *See the Road Design Manual, Fig. 4.4 K-13, for other applicable notes.*
3. *See Detail Drawing 208-12 for erosion control mat lined ditches.*
4. *See Section A3 of the Permanent Erosion and Sediment Control Manual for additional information on lined ditches.*

Sample Cross Section



Sample Plan and Profile

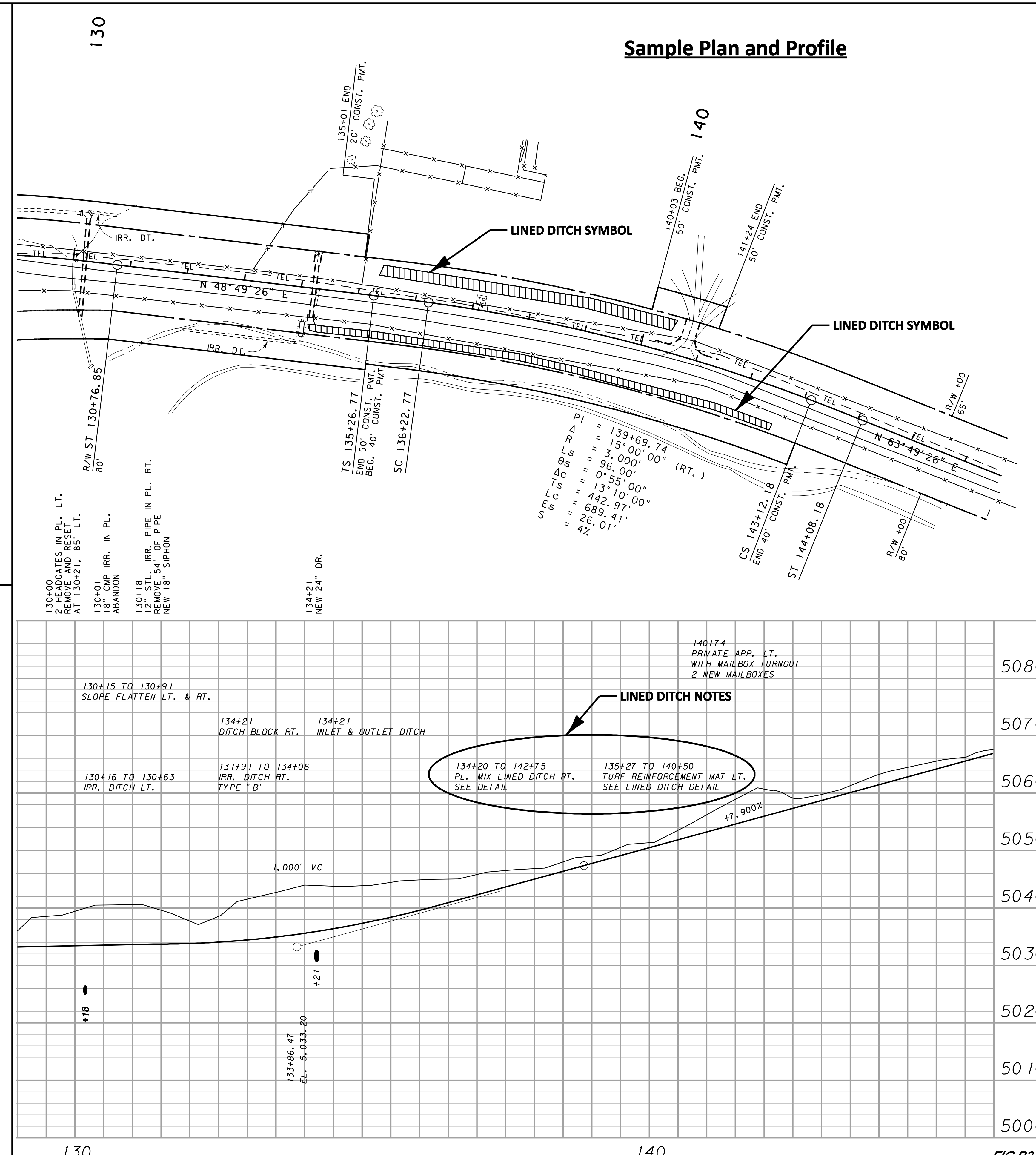
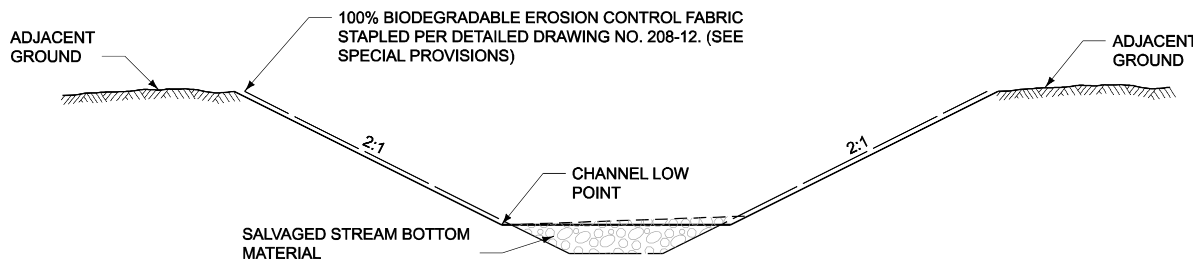


FIG B3-1

MDT MONTANA DEPARTMENT OF TRANSPORTATION	...\Dgn\PESCMANRDB03001.dgn 8/9/2010 12:54:50 PM u3326	DESIGNED BY: DESIGNER NAME, DATE; REVIEWED BY: SUPERVISOR NAME, DATE; CHECKED BY: CHECKER NAME, DATE	ROAD PLANS	*MONTANA PERMANENT EROSION & SEDIMENT CONTROL MANUAL SAMPLE PLAN SHEET*	**LINED DITCH SAMPLES**		PROJECT NO.
			COUNTY NAME(S)		CSF = 0.9999999	UPN NUMBER 12345678	SHEET 999 OF 999

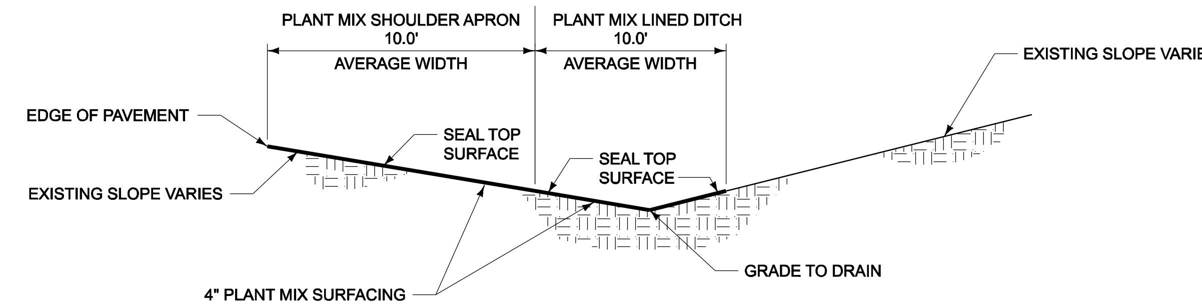


EROSION CONTROL MAT LINED DITCH

SCALE: 1"=5'

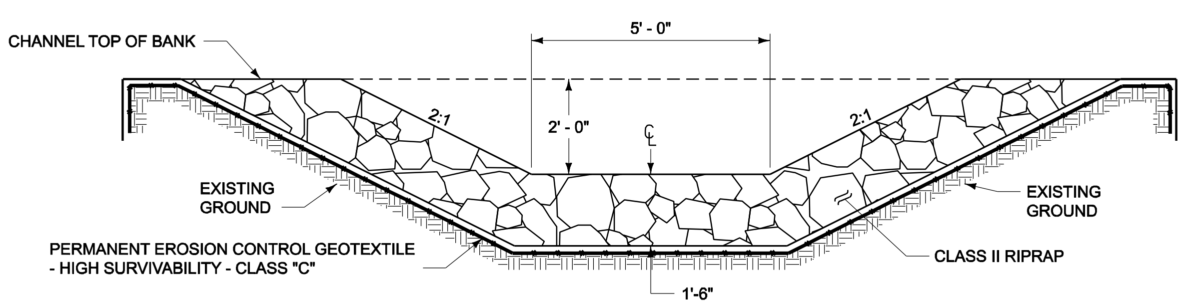
NOTE: VARY CHANNEL BOTTOM SO THAT THE LOW POINT OF THE CHANNEL IS ON THE OUTSIDE RADIUS OF THE BENDS.

SALVAGE EXISTING STREAM BOTTOM MATERIAL, FOR CONSTRUCTION IN NEW CHANNEL.

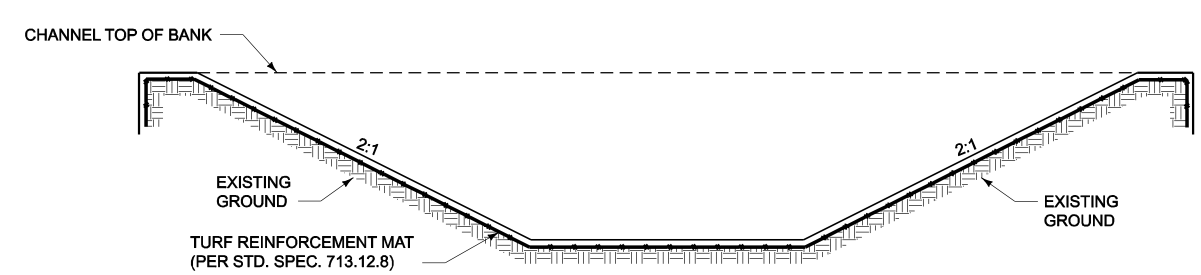


PLANT MIX LINED DITCH

RESHAPE AND COMPACT EXISTING SLOPES AS NECESSARY TO PROVIDE SUITABLE PAVING SURFACE. COMPACTION REQUIREMENTS FOR PLANT MIX AND GROUND ARE WAIVED BUT SUBJECT TO ENGINEER'S APPROVAL. RESHAPING PAID FOR WITH GRADER HOURS. COMPACTION TO BE INCLUDED IN COST OF OTHER ITEMS.



RIPRAP LINED DITCH



TURF REINFORCEMENT MAT LINED DITCH

FIG. B3-2

3 2 1	MDT MONTANA DEPARTMENT OF TRANSPORTATION	...\Dgn\PESCMANRDB03002.DGN 8/9/2010 12:55:34 PM u3326	DESIGNED BY DESIGNER NAME DATE REVIEWED BY SUPERVISOR NAME DATE CHECKED BY CHECKER NAME DATE	ROAD PLANS COUNTY NAME(S)	MONTANA PERMANENT EROSION & SEDIMENT CONTROL MANUAL SAMPLE PLAN SHEET	SAMPLE LINED DITCH DETAILS CSF = 0.9999999 UPN NUMBER 12345678	PROJECT NO. SHEET 999 OF 999

NOTE:

PAYMENT FOR UNLINED INTERCEPTOR DITCHES WILL BE INCLUDED IN MAINLINE OR ADDITIONAL GRADING QUANTITIES. NO ADDITIONAL SUMMARY FRAME NEEDED. SEE SECTION A3 FOR INTERCEPTOR DITCHES REQUIRING LINING.

Sample Plan and Profile

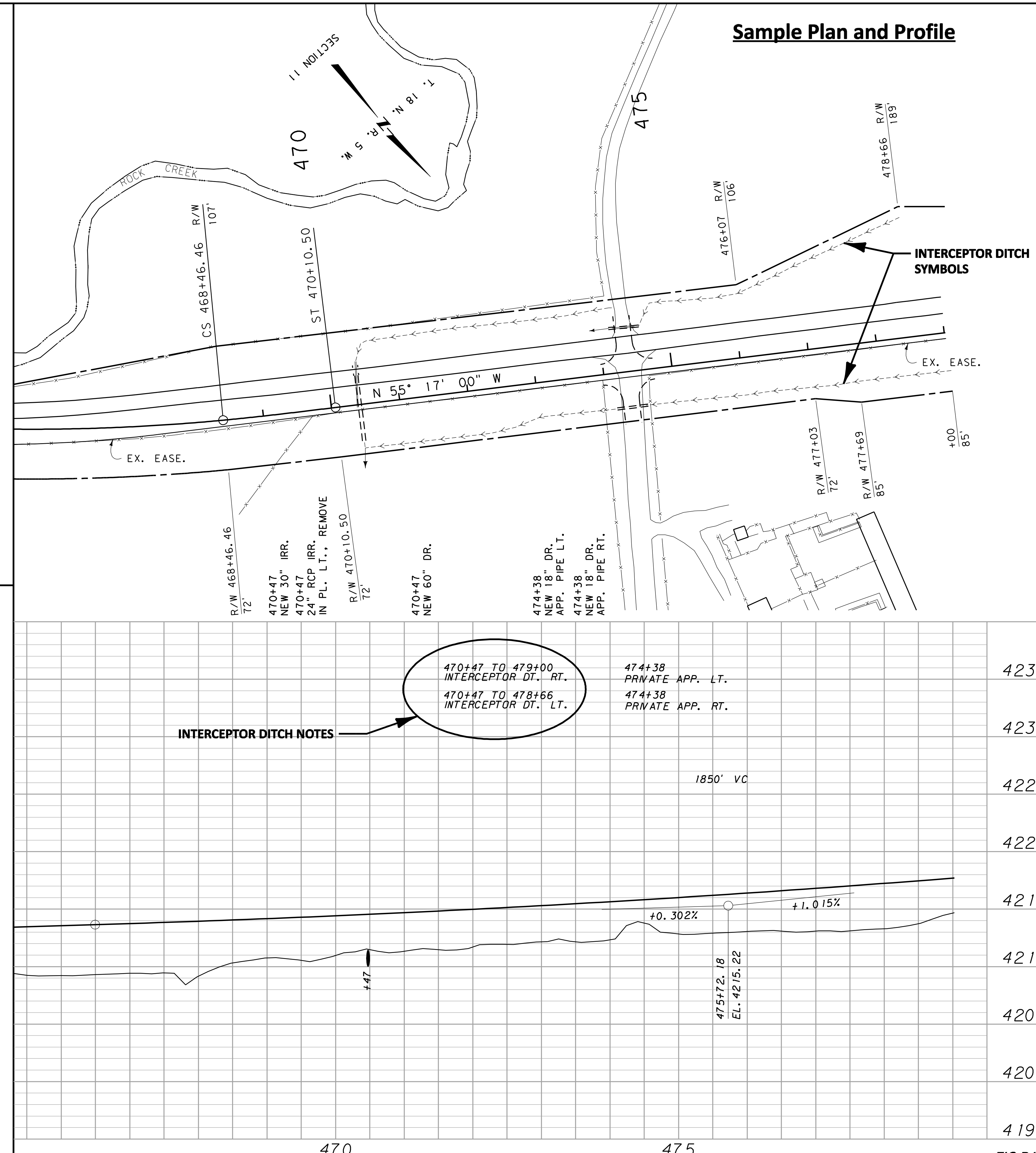
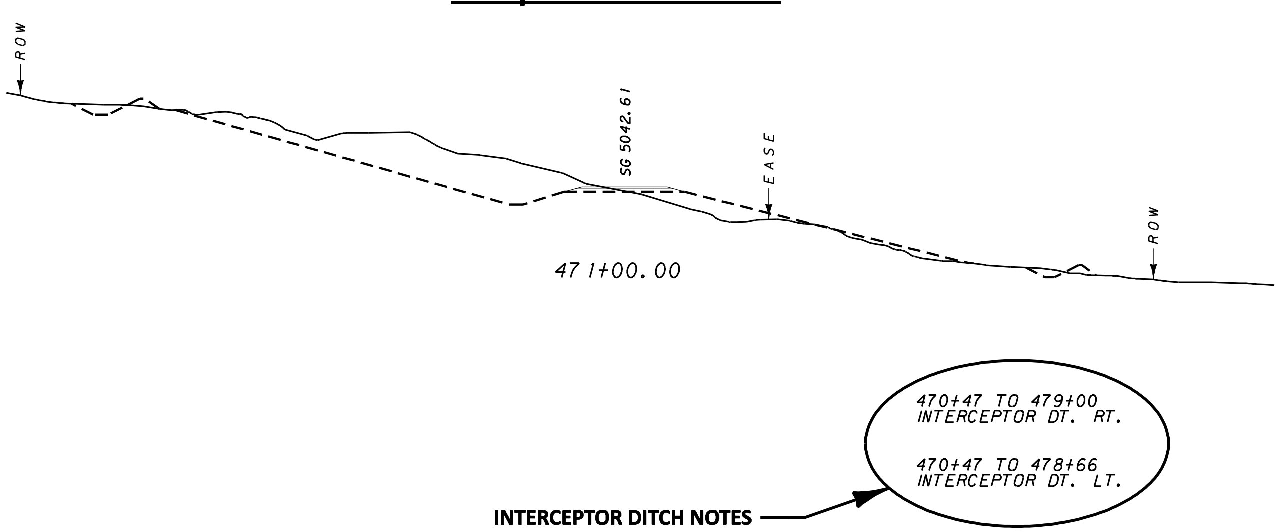


FIG B4-1

Sample Cross Section

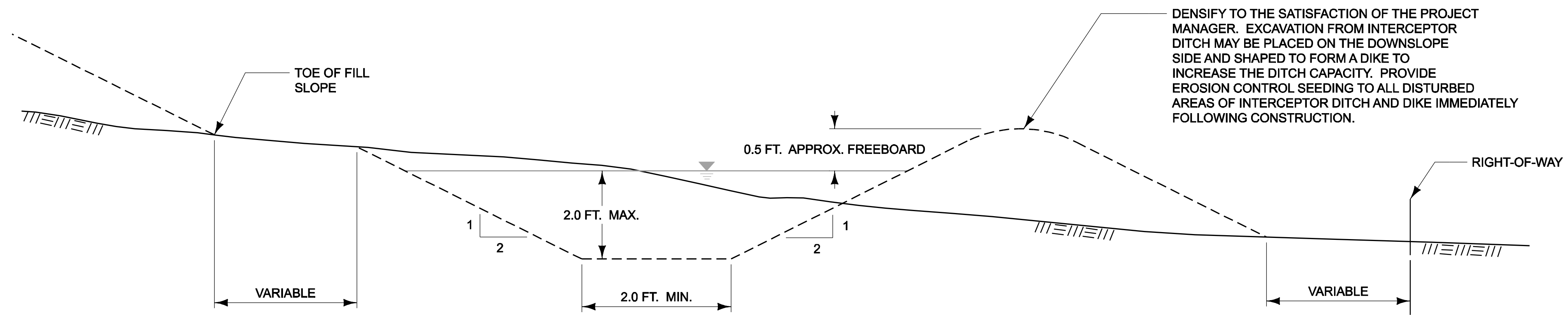


Interceptor Ditch Reminders:

① *See Section A4 of the Permanent Erosion and Sediment Control Manual for further Interceptor Ditch details.*

3 2 1	MDT MONTANA DEPARTMENT OF TRANSPORTATION	...\Dgn\PESCMANRDB04001.dgn 8/9/2010 12:56:16 PM u3326	DESIGNED BY DESIGNER NAME DATE REVIEWED BY SUPERVISOR NAME DATE CHECKED BY CHECKER NAME DATE	ROAD PLANS COUNTY NAME(S)	*MONTANA PERMANENT EROSION & SEDIMENT CONTROL MANUAL SAMPLE PLAN SHEET*	**INTERCEPTOR DITCH SAMPLES** CSF = 0.9999999 UPN NUMBER 12345678	PROJECT NO. SHEET 999 OF 999

INTERCEPTOR DITCH AT TOE OF SLOPE

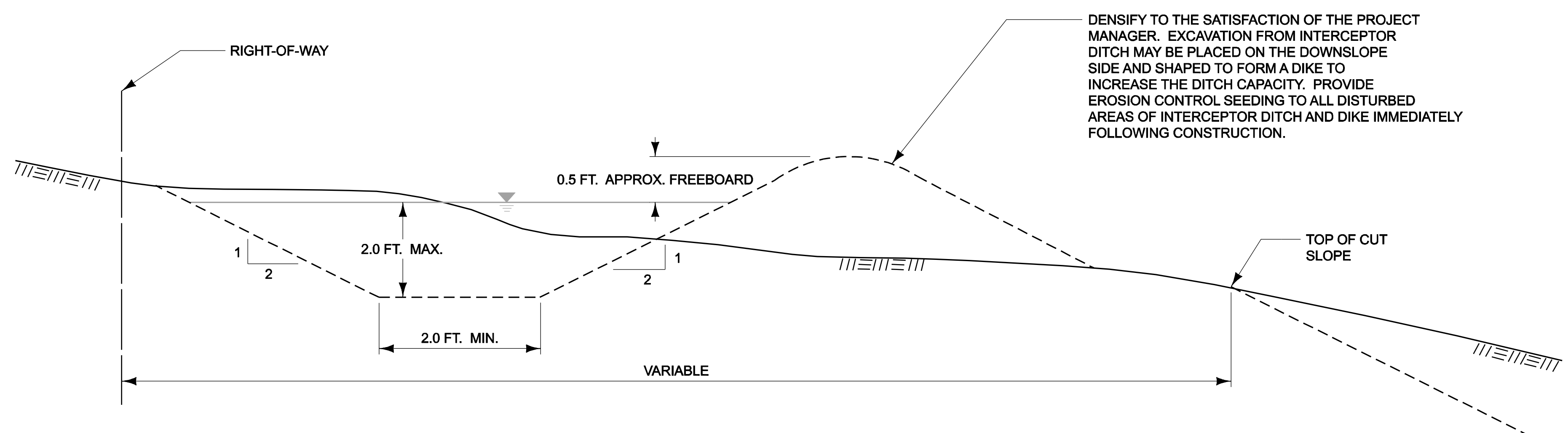


Interceptor Ditch Reminders:

① *Dimensions shown are preliminary only. Final dimensions to be determined by the Hydraulics Section.*

② *See Chapter A4 of the Permanent Erosion and Sediment Control Manual for additional guidance.*

INTERCEPTOR DITCH AT TOP OF CUT



Interceptor Ditch Reminders:

① *Dimensions shown are preliminary only. Final dimensions to be determined by the Hydraulics Section.*

② *See Chapter A4 of the Permanent Erosion and Sediment Control Manual for additional guidance.*

INTERCEPTOR DITCH DETAIL

NO SCALE

FIG B4-2

3 2 1	MDT MONTANA DEPARTMENT OF TRANSPORTATION	...\Dgn\PESCMANRDB04002.dgn 8/9/2010 12:58:21 PM u3326	DESIGNED BY REVIEWED BY CHECKED BY	DESIGNER NAME SUPERVISOR NAME CHECKER NAME	DATE DATE DATE	ROAD PLANS COUNTY NAME(S)	*MONTANA PERMANENT EROSION & SEDIMENT CONTROL MANUAL SAMPLE PLAN SHEET*

INTERCEPTOR DITCH SAMPLE DETAILS		PROJECT NO.
CSF = 0.9999999	UPN NUMBER 12345678	SHEET 999 OF 999

Sample Summary Frame

EMBANKMENT PROTECTORS							
STATION		linear feet				cubic yards	REMARKS
		EMBANKMENT PROTECTOR 12"		BITUMINOUS CURB		BANK PROTEC-TION	
FROM	TO	LEFT	RIGHT	LEFT	RIGHT	TYPE 3	
136+60.00	141+85.00				525.0		MAINLINE
136+80.00			50			1.5	25 DEGREE ELBOW
SUBTOTAL			50		525.0	1.5	
TOTAL		50		525.0		1.5	

CHANNELIZING CURB SUMMARY ENTRY

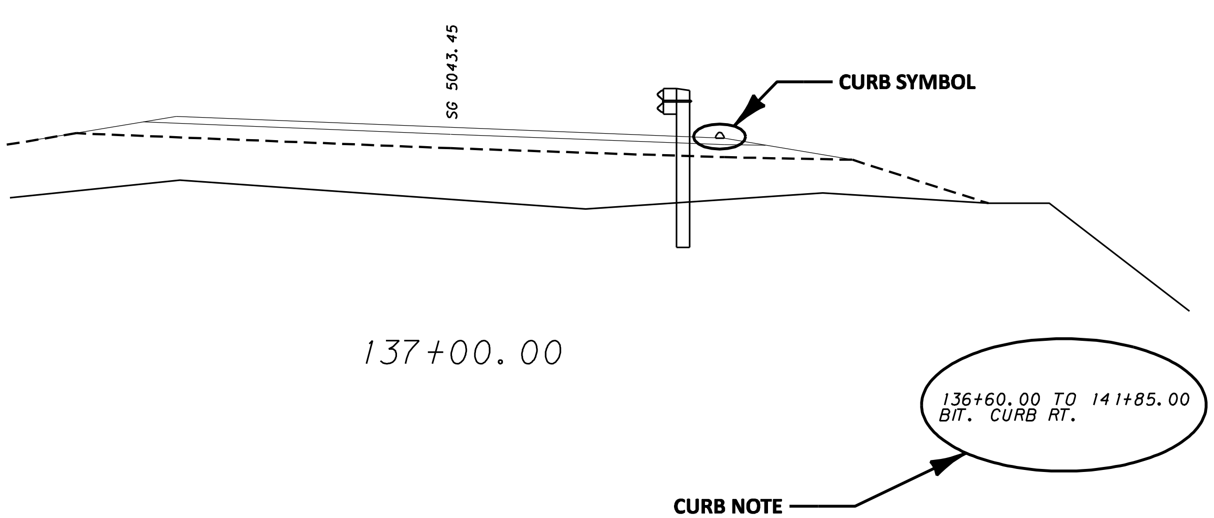
Channelizing Curb Reminders:

① See Detail Drawing 609-05 for additional curb details.

② See Detail Drawing 603-28 when using curb in conjunction with guardrail and embankment protectors. Use maximum of 4" high curbs with guardrail.

③ See Figure B6-1 for embankment protector sample drawing.

Sample Cross Section



Sample Plan and Profile

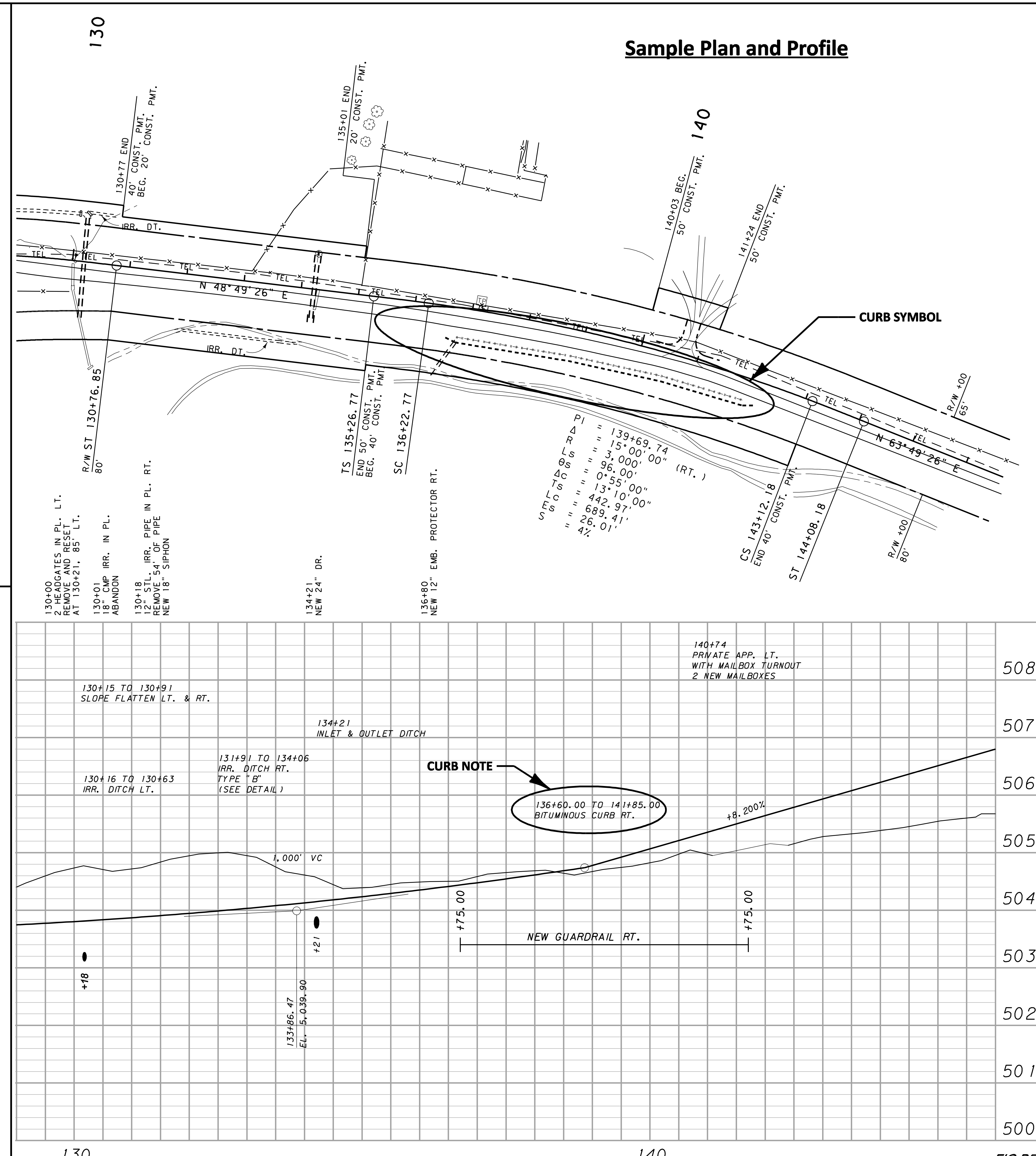


FIG B5-1

MDT MONTANA DEPARTMENT OF TRANSPORTATION	...\Dgn\PESCMANRDB05001.dgn 8/9/2010 12:59:43 PM u3326	DESIGNED BY DESIGNER NAME DATE REVIEWED BY SUPERVISOR NAME DATE CHECKED BY CHECKER NAME DATE	ROAD PLANS COUNTY NAME(S)	MONTANA PERMANENT EROSION & SEDIMENT CONTROL MANUAL SAMPLE PLAN SHEET	CHANNELIZING CURB SAMPLES CSF = 0.9999999 UPN NUMBER 12345678	PROJECT NO. SHEET 999 OF 999

Sample Summary Frame

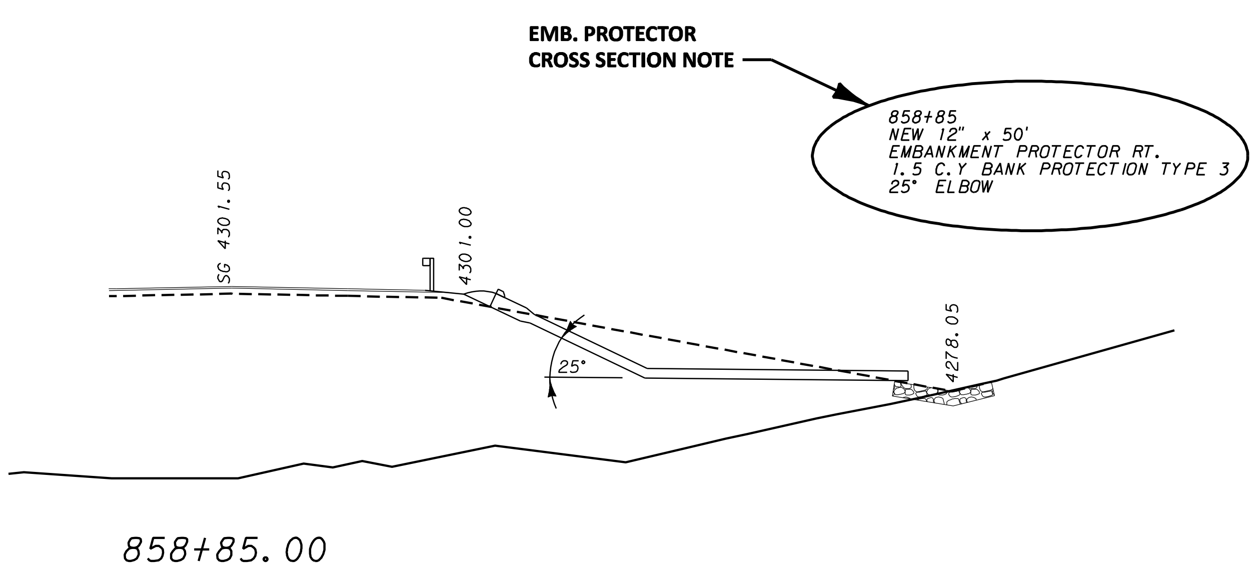
EMBANKMENT PROTECTORS							
STATION		linear feet				cubic yards	REMARKS
		EMBANKMENT PROTECTOR* 12"		BITUMINOUS CURB		BANK PROTEC-TION	
FROM	TO	LEFT	RIGHT	LEFT	RIGHT	TYPE 3	
852+50	858+85				635.0		
857+80	858+85			105.0			
858+85		50	50			1.5	25° ELBOW (1)
859+95	863+25				330.0		
859+95	865+15			520.0			
861+10		50	50			1.5	40° ELBOW (1)
SUBTOTAL		100	100	625.0	965.0		
TOTAL		200		1590.0		3.0	

* CULVERT EXC. INCLUDED IN COST OF EMB. PROTECTOR

Embankment Protector Reminders:

1. *Specify degree of bend on elbow.*
2. *See Detail Drawing 603-28 when using an Embankment Protector in conjuction with Curb and Guardrail.*
3. *See Road Design Manual section 17.2 for Embankment Protector criteria.*

Sample Cross Section



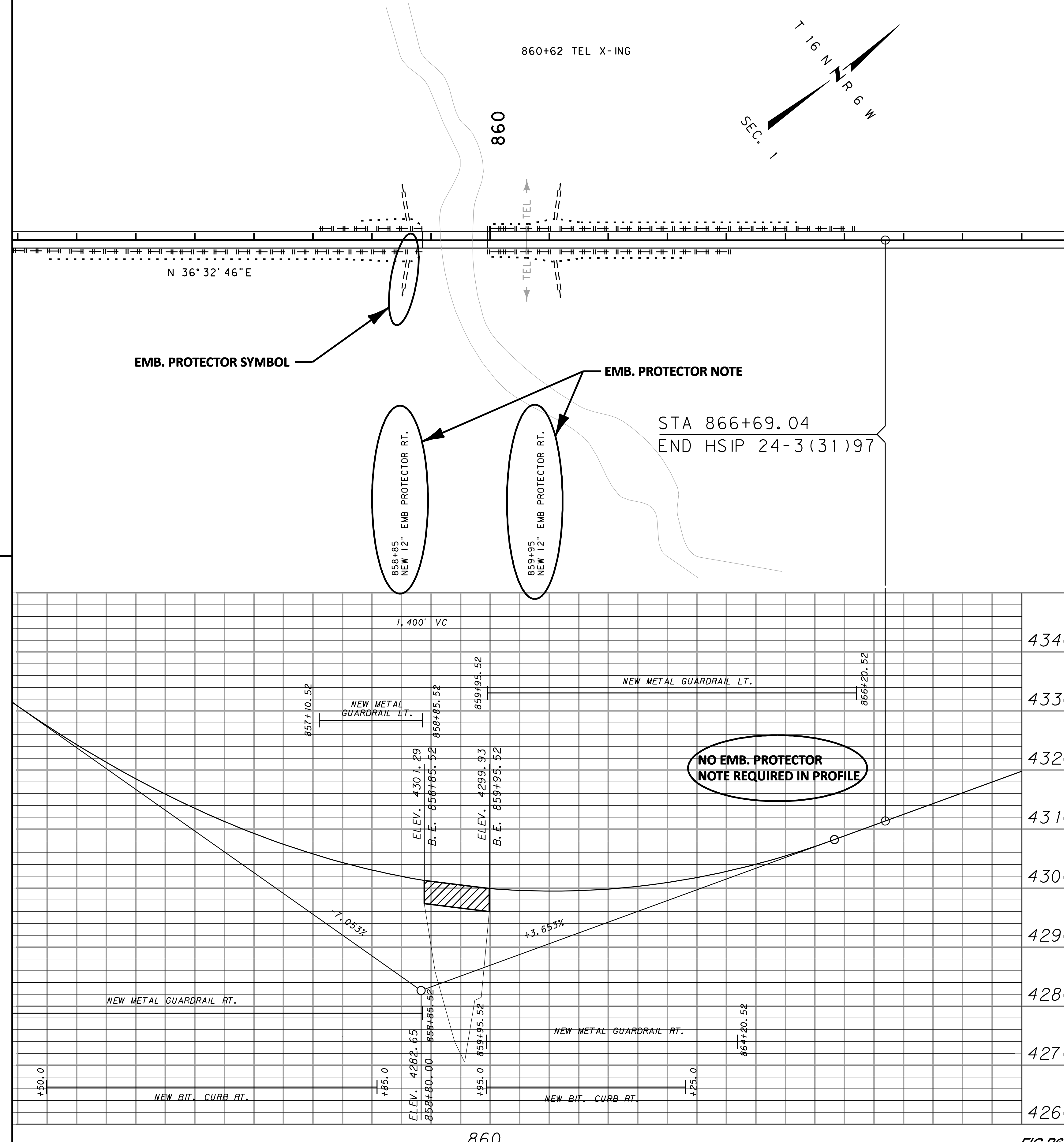


FIG B6-1

MDT MONTANA DEPARTMENT OF TRANSPORTATION	...\Dgn\PESCMANRDB06001.dgn 8/9/2010 1:00:52 PM u3326	DESIGNED BY DESIGNER NAME DATE; REVIEWED BY SUPERVISOR NAME DATE; CHECKED BY CHECKER NAME DATE	ROAD PLANS / COUNTY NAME(S)	MONTANA PERMANENT EROSION & SEDIMENT CONTROL MANUAL SAMPLE PLAN SHEET	EMBANKMENT PROTECTOR SAMPLES / CSF = 0.9999999 / UPN NUMBER 12345678	PROJECT NO. / SHEET 999 OF 999

Sample Summary Frame

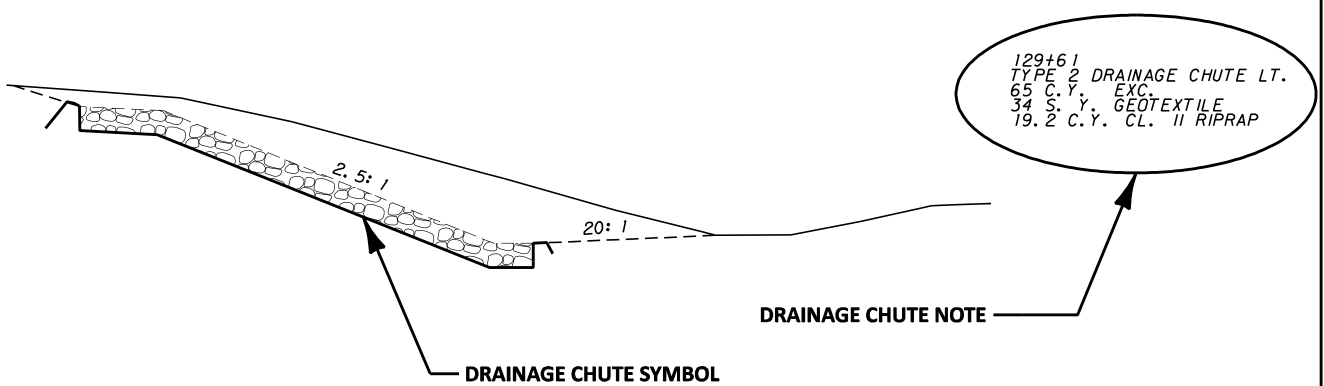
RANDOM RIPRAP					
STATION		cubic yards		square yards	REMARKS
		RANDOM RIPRAP		GEOTEXTILE PERM. EROS. CNTRL.	
FROM	TO	CL. II	CL.	HIGH SURV. CLASS B	
129+61		19.2		34	RAMP "C4" - TYPE 2 DRAINAGE CHUTE LT.
132+23		46.8		73	RAMP "C4" - TYPE 3 DRAINAGE CHUTE LT.
132+45		7.0		15	RAMP "C4" - OUTLET DITCH RT.
135+81		59.0		59	RAMP "C4" - TYPE 3 DRAINAGE CHUTE LT.
TOTAL		132.0		181	

DRAINAGE CHUTE SUMMARY ENTRY

Drainage Chute Reminders:

1. *See Detail Drawing 208-12 for additional geotextile details.*
2. *See Detail Drawing 613-18 for additional drainage chute details.*
3. *See Chapter A7 of the Permanent Erosion and Sediment Control Manual for additional guidance.*

Sample Cross Section (Backslopes)



Sample Plan and Profile

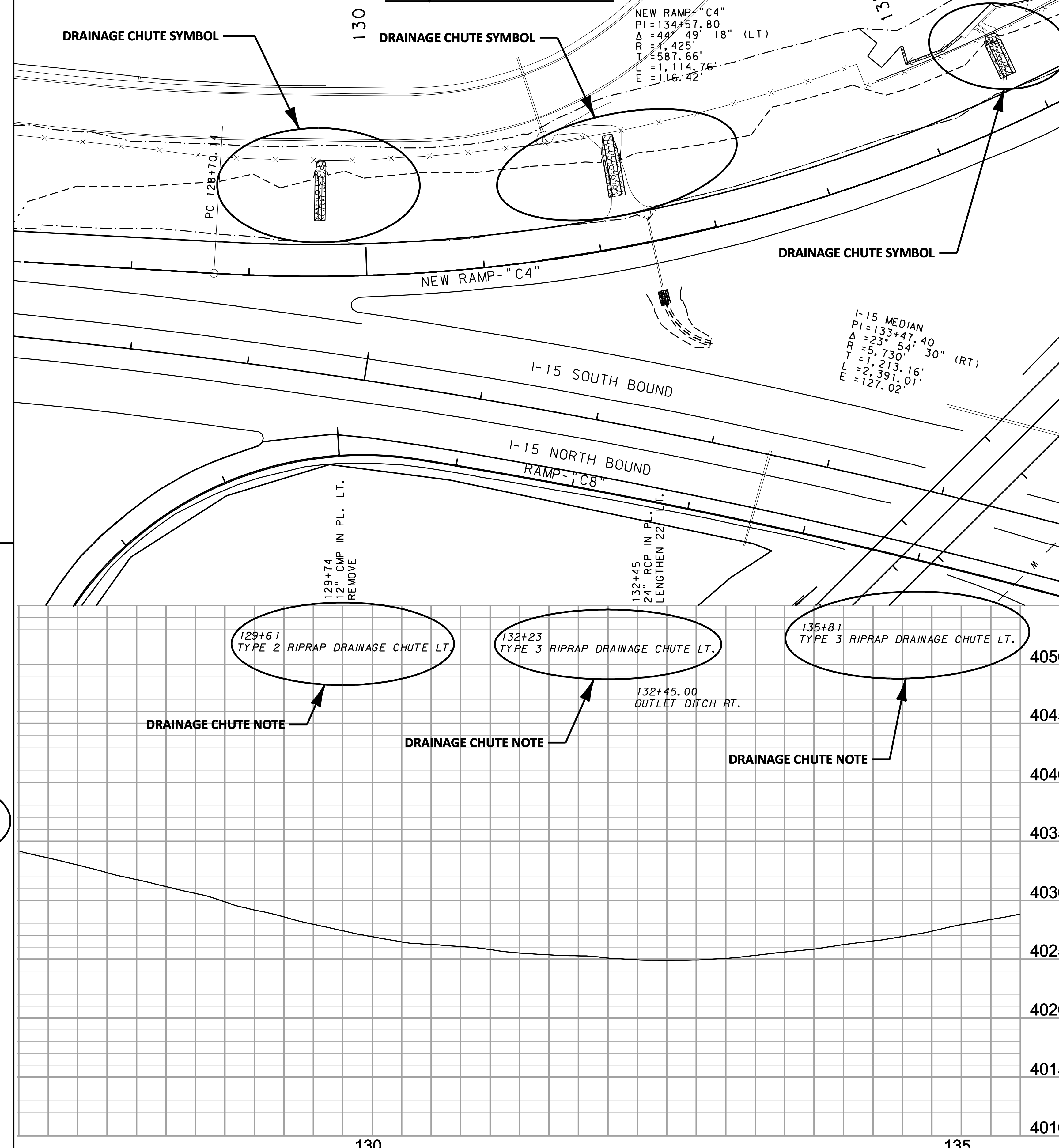


FIG B7-1

Sample Summary Frame

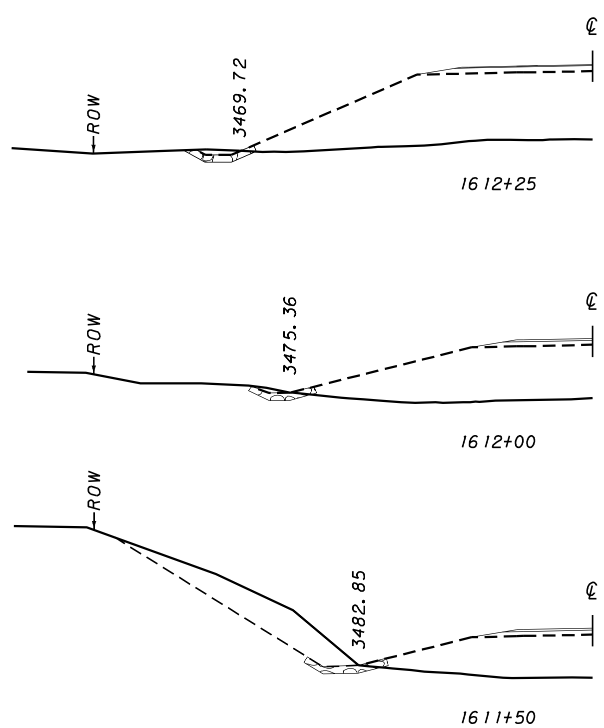
DRAINAGE CHUTES				
STATION		cubic yards RANDOM RIPRAP	square yards GEOTEXTILE PERM. EROS. CNTRL. HIGH SURV. CLASS B	REMARKS
FROM	TO	CL. 2		
1611+50	1612+50	64.0	145	TYPE 3 DRAINAGE CHUTE LT.
TOTAL		64.0	145	

DRAINAGE CHUTE SUMMARY ENTRY

Slope Stabiliztion Reminders:

1. *See Detail Drawing 208-12 for additional geotextile details.*
2. *See Detail Drawing 613-18 for additional drainage chute details, including material options.*
3. *See Chapter A7 of the Permanent Erosion and Sediment Control Manual for additional guidance.*

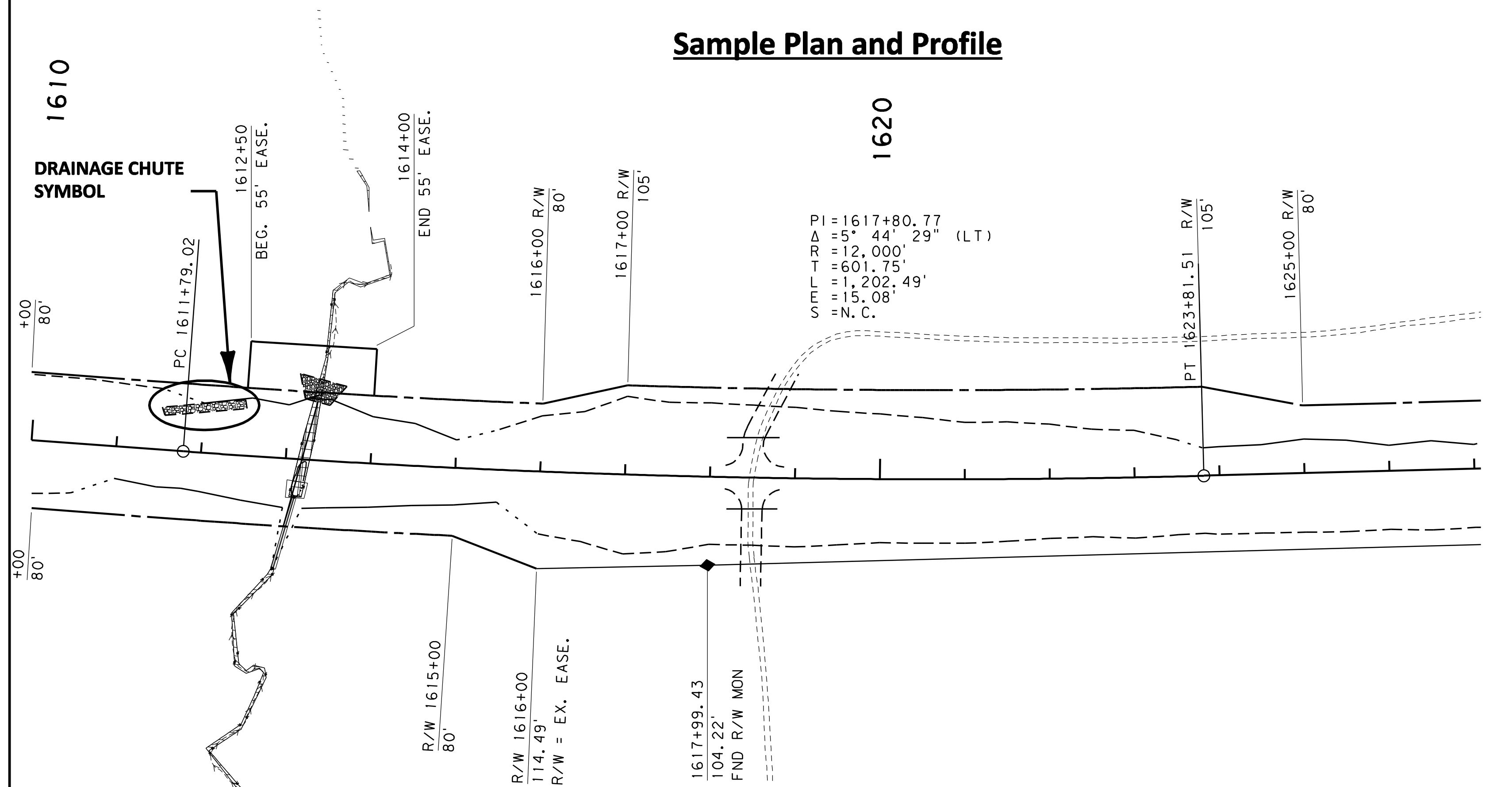
Sample Cross Section (Cut To Fill)



16 11+50 TO 16 12+50
TYPE 3 RIPRAP DRAINAGE CHUTE LT.
145 S.Y. GEOTEXTILE
64.0 C.Y. CL. 2 RIPRAP

DRAINAGE CHUTE NOTE

Sample Plan and Profile



DRAINAGE CHUTE NOTE

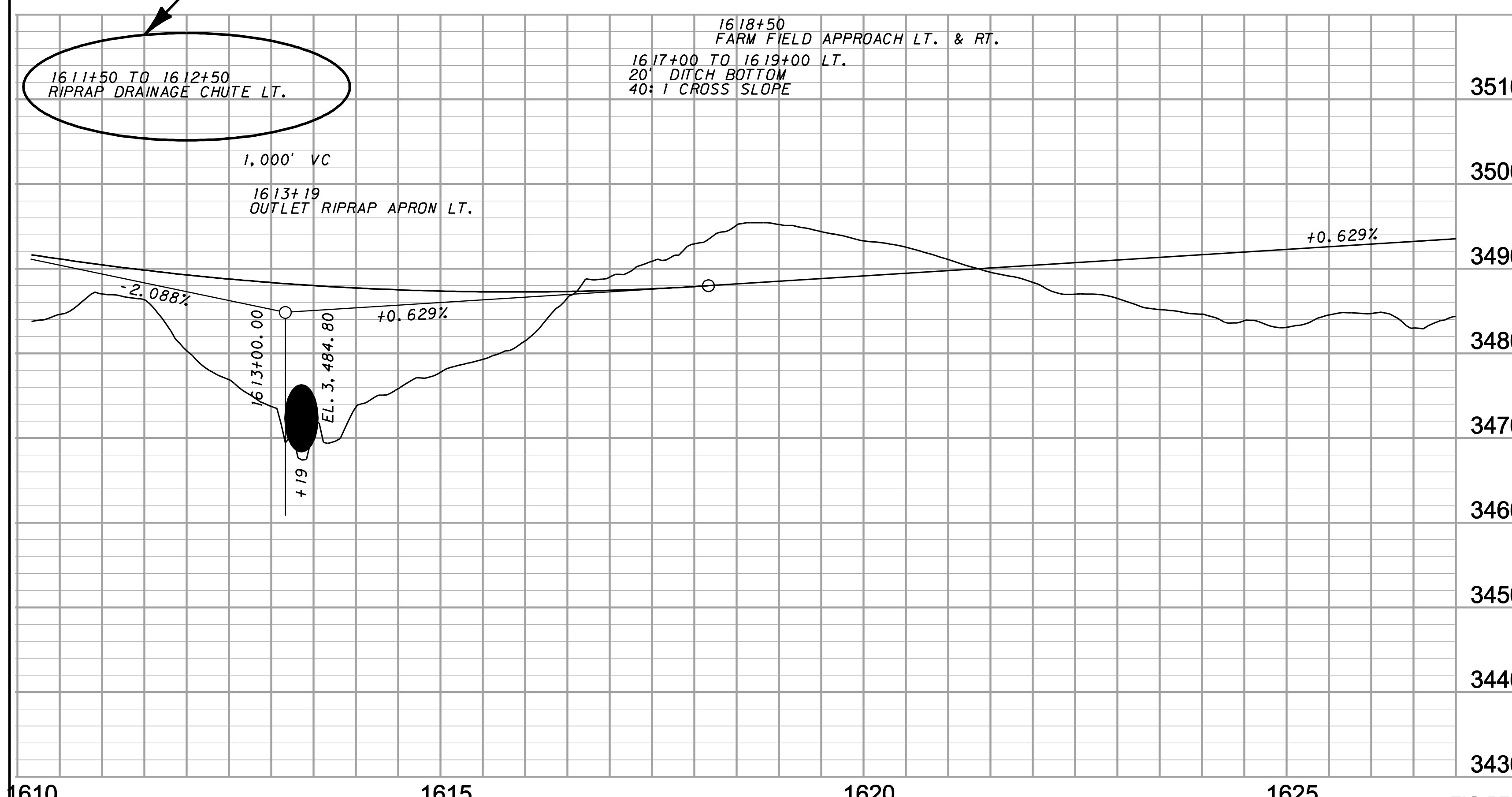


FIG B7-2

MDT MONTANA DEPARTMENT OF TRANSPORTATION	...\Dgn\PESCMANRDB07002.dgn 8/9/2010 1:02:44 PM u3326	DESIGNED BY DESIGNER NAME DATE; REVIEWED BY SUPERVISOR NAME DATE; CHECKED BY CHECKER NAME DATE	ROAD PLANS / COUNTY NAME(S)	MONTANA PERMANENT EROSION & SEDIMENT CONTROL MANUAL SAMPLE PLAN SHEET	DRAINAGE CHUTE SAMPLES : CUT TO FILL / CSF = 0.9999999 / UPN NUMBER 12345678	PROJECT NO. / SHEET 999 OF 999

Sample Summary Frame

RANDOM RIPRAP						
STATION		cubic yards		square yards		REMARKS
		RANDOM RIPRAP		GEOTEXTILE		
				PERM. EROS. CNTRL.		
FROM	TO	CL. 2	CL. 3	MOD SURV. CLASS A	HIGH SURV. CLASS A	
351+51.00		141.4		254		OUTLET APRON RT.
TOTAL		141.4		254		

OUTLET PROTECTION SUMMARY ENTRY

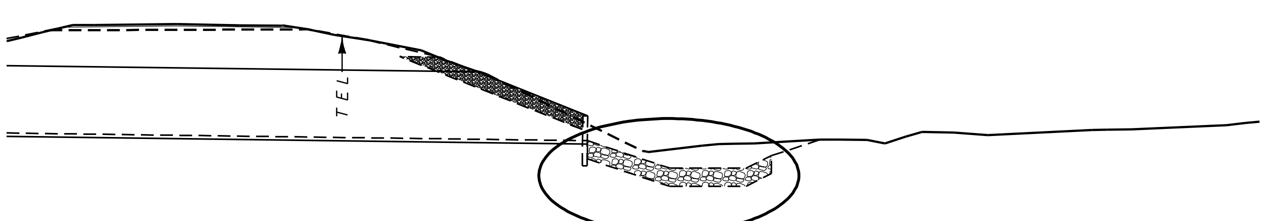
Slope Stabilization Reminders:

1. *See Detail Drawing 208-12 for additional geotextile details.*
2. *See Chapter A8 of the Permanent Erosion and Sediment Control Manual for additional guidance.*

Sample Cross Section

OUTLET PROTECTION NOTE (ADD QUANTITIES TO CULVERT NOTE)

351+51
NEW DOUBLE 15' 10" x 9' 10" SSPPA
15.2 C.Y. CL. DD CONC. CUTOFF WALL LT. AND RT.
36.8 C.Y. CL. I RIPRAP-OUTLET RIPRAP EDGE PROTECTION
141.4 C.Y. CL. II RIPRAP-OUTLET RIPRAP APRON
254 S.Y. GEOTEXTILE
(SEE DETAIL)



351+51.00

OUTLET PROTECTION CROSS SECTION SYMBOL

Sample Plan and Profile

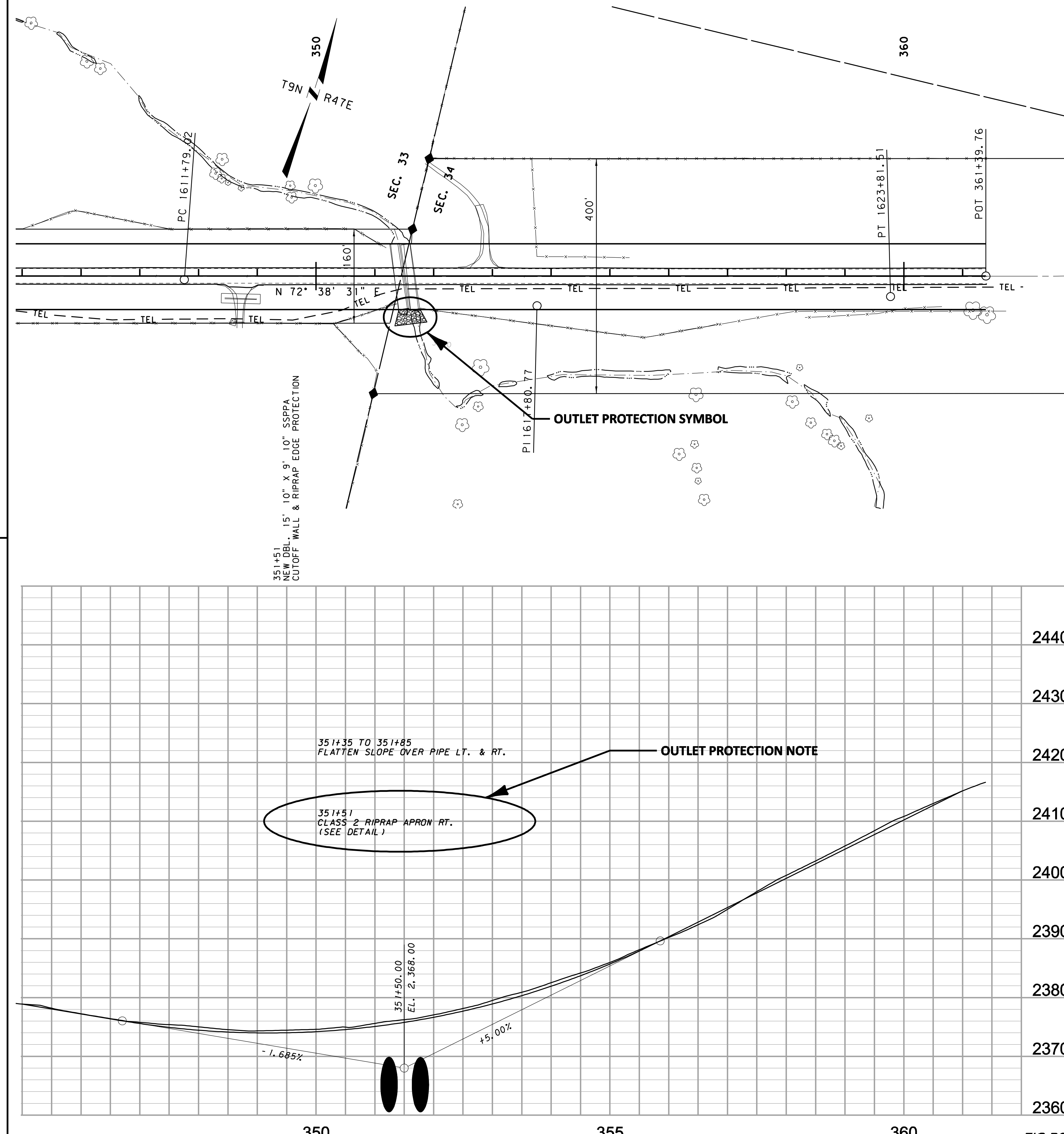
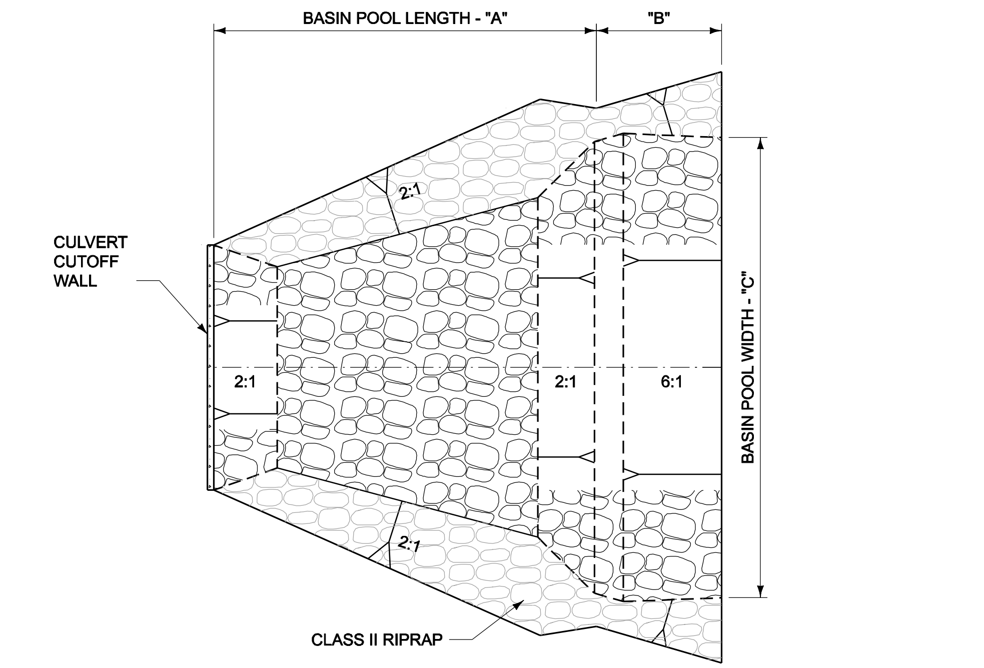


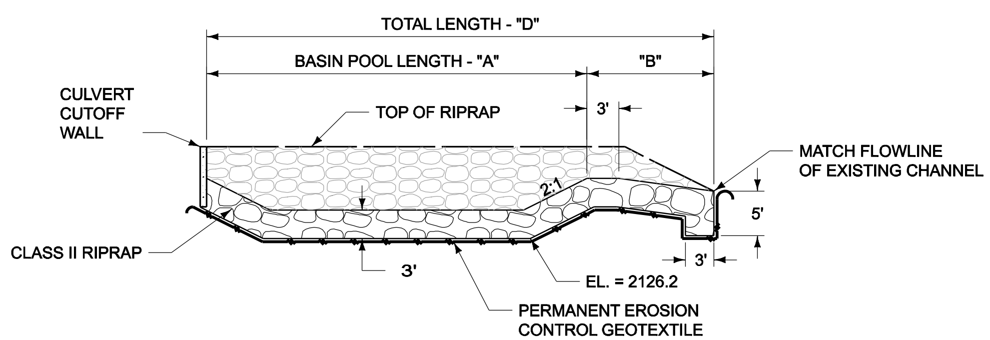
FIG B8-1

MDT MONTANA DEPARTMENT OF TRANSPORTATION	...\Dgn\PESCMANRDB08001.dgn 8/9/2010 1:03:19 PM u3326	DESIGNED BY: DESIGNER NAME, DATE; REVIEWED BY: SUPERVISOR NAME, DATE; CHECKED BY: CHECKER NAME, DATE	ROAD PLANS / COUNTY NAME(S)	*MONTANA PERMANENT EROSION & SEDIMENT CONTROL MANUAL SAMPLE PLAN SHEET*
OUTLET PROTECTION SAMPLES	CSF = 0.9999999	UPN NUMBER 12345678	PROJECT NO.	SHEET 999 OF 999



PLAN VIEW

SCALE ~ 1:100

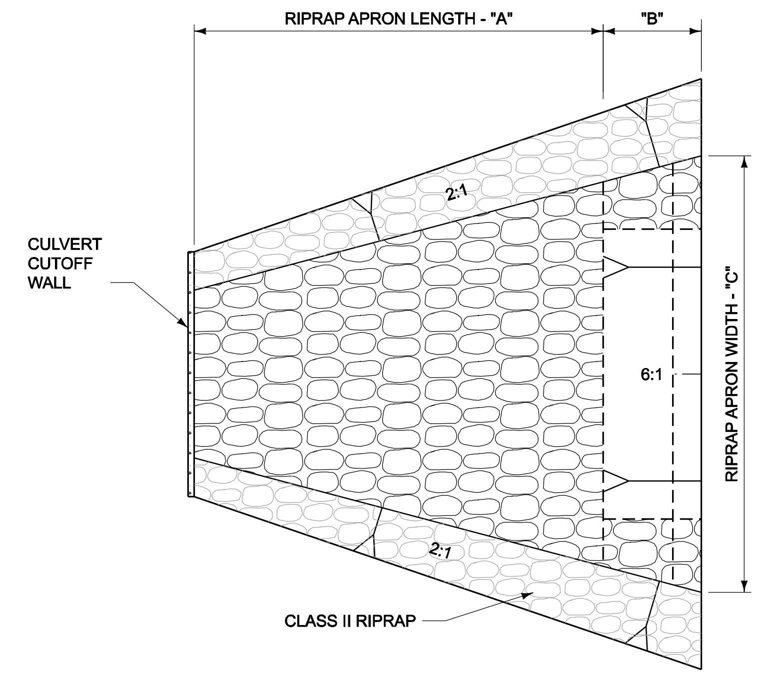


PROFILE VIEW

SCALE ~ 1:100

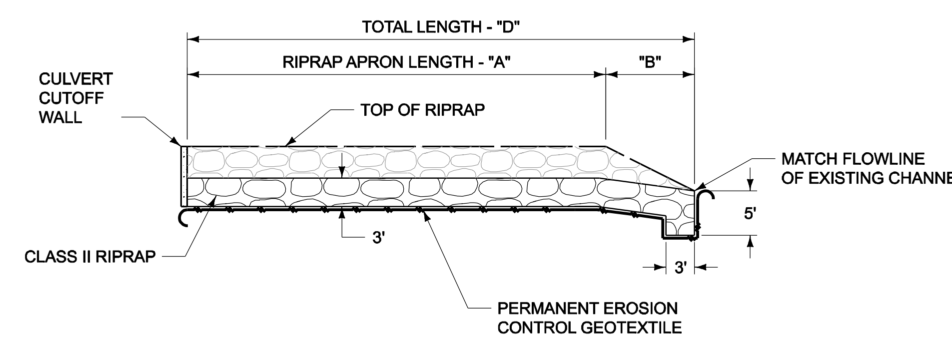
STATION	"A" (ft)	"B" (ft)	"C" (ft)	"A" (ft)	CLASS II RIPRAP (C.Y.)	PERMANENT EROSION CONTROL GEOTEXTILE (S.Y.)

RIPRAP BASIN



PLAN VIEW

SCALE ~ 1:100



PROFILE VIEW

SCALE ~ 1:100

STATION	"A" (ft)	"B" (ft)	"C" (ft)	"D" (ft)	CLASS II RIPRAP (C.Y.)	PERMANENT EROSION CONTROL GEOTEXTILE (S.Y.)

RIPRAP APRON

FIG B8-2

3 2 1	MDT MONTANA DEPARTMENT OF TRANSPORTATION	...\Dgn\PESCMANRDB08002.dgn 8/9/2010 1:03:53 PM u3326	DESIGNED BY *DESIGNER NAME* *DATE* REVIEWED BY *SUPERVISOR NAME* *DATE* CHECKED BY *CHECKER NAME* *DATE*	ROAD PLANS COUNTY NAME(S)	*MONTANA PERMANENT EROSION & SEDIMENT CONTROL MANUAL SAMPLE PLAN SHEET*

SAMPLE RIPRAP APRON DETAILS		PROJECT NO.
CSF = 0.9999999	UPN NUMBER 12345678	SHEET 999 OF 999

Sample Summary Frame

SLOPE SOIL STABILIZATION					
STATION		cubic yards	square yards		REMARKS
		RANDOM RIPRAP	TYPE STC EROSION CONTROL MAT	GEOTEXTILE PERM. EROS. CNTRL. HIGH SURV. CLASS B	
FROM	TO	CL. I	MAT	CLASS B	
29+99	40+88	2,400.0		1,543	SLOPE STABILIZATION LT.
34+60	40+05		3,500		SLOPE STABILIZATION RT.
TOTAL		2,400.0	3,500	1,543	

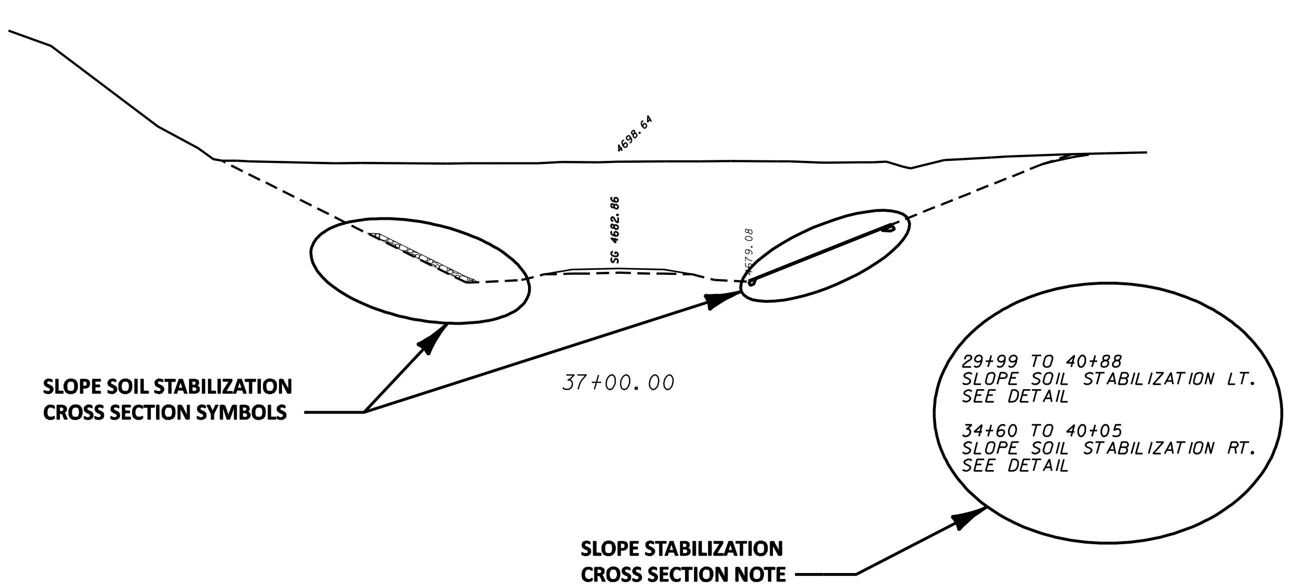
SLOPE SOIL STABILIZATION SUMMARY ENTRY

Slope Soil Stabilization Reminders:

① *See Detail Drawing 208-12 for additional slope soil stabilization details.*

② *See Chapter A9 of the Permanent Erosion and Sediment Control Manual for additional guidance.*

Sample Cross Section



Sample Plan and Profile

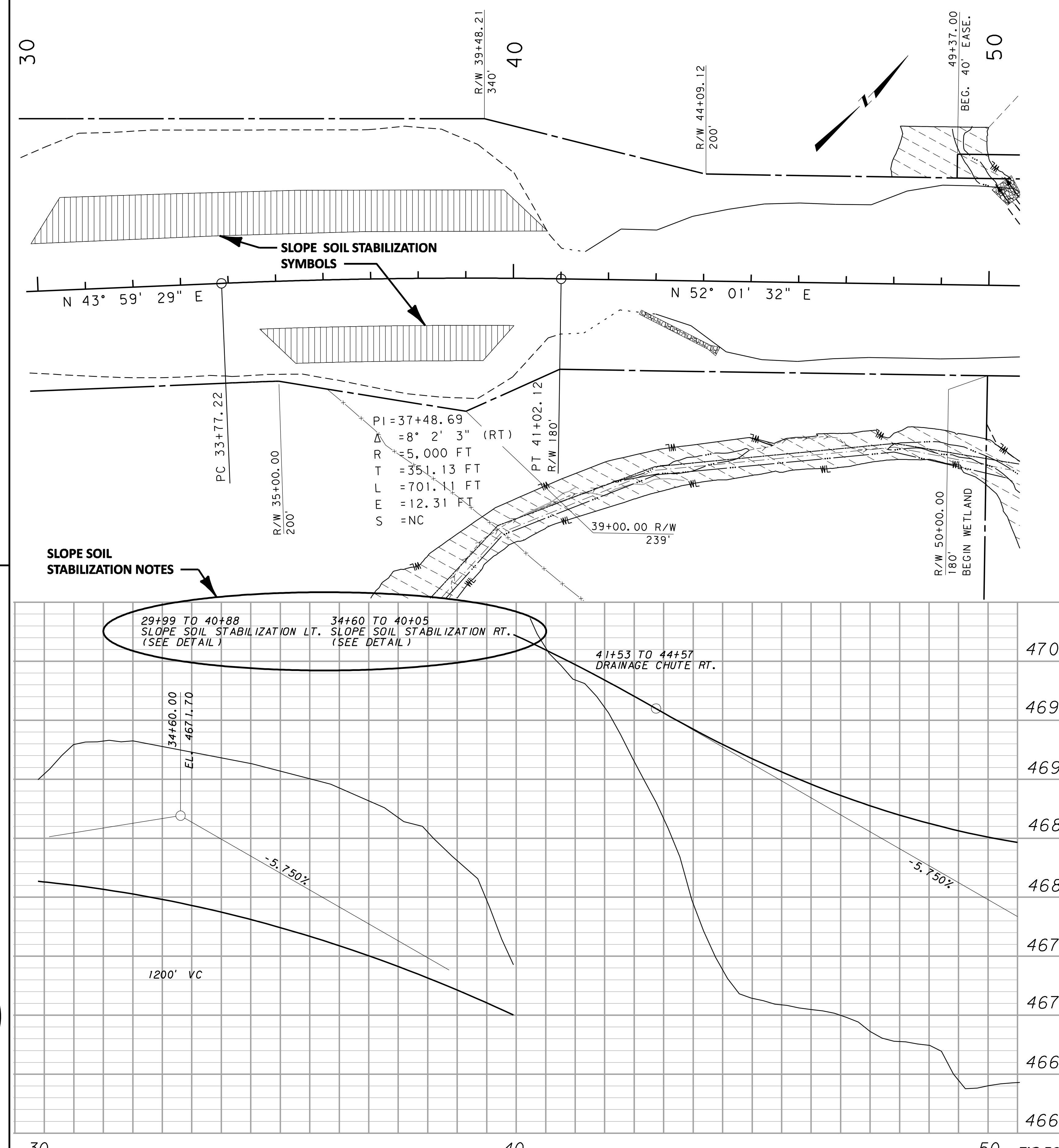
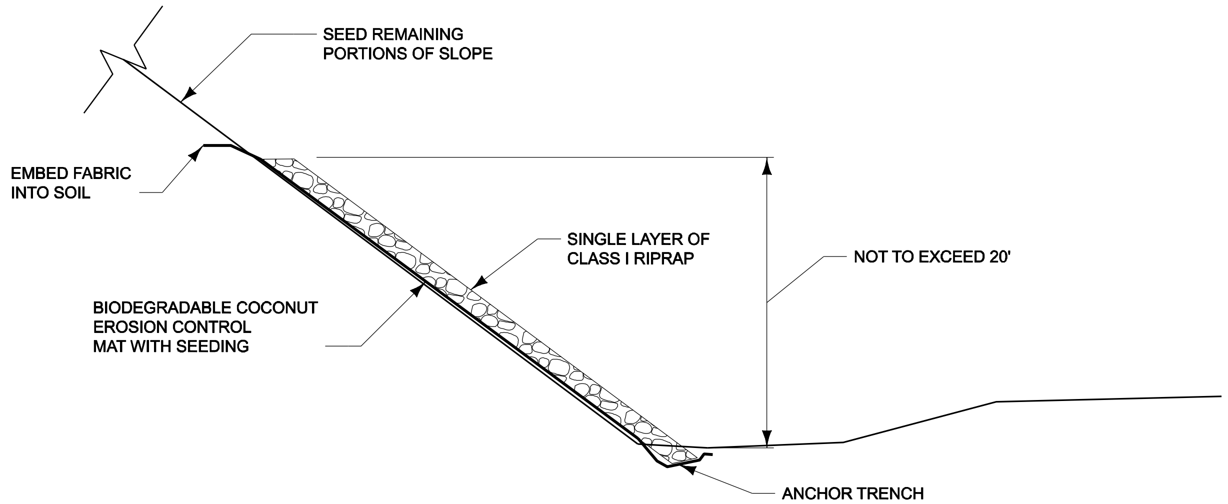


FIG B9-1

MDT MONTANA DEPARTMENT OF TRANSPORTATION	...\Dgn\PESCMANRDB09001.dgn 8/9/2010 1:04:34 PM u3326	DESIGNED BY: DESIGNER NAME, DATE; REVIEWED BY: SUPERVISOR NAME, DATE; CHECKED BY: CHECKER NAME, DATE	ROAD PLANS / COUNTY NAME(S)	MONTANA PERMANENT EROSION & SEDIMENT CONTROL MANUAL SAMPLE PLAN SHEET	SLOPE SOIL STABILIZATION SAMPLES / CSF = 0.9999999 / UPN NUMBER 12345678	PROJECT NO. / SHEET 999 OF 999

ROCK VENEER WITH SEEDING



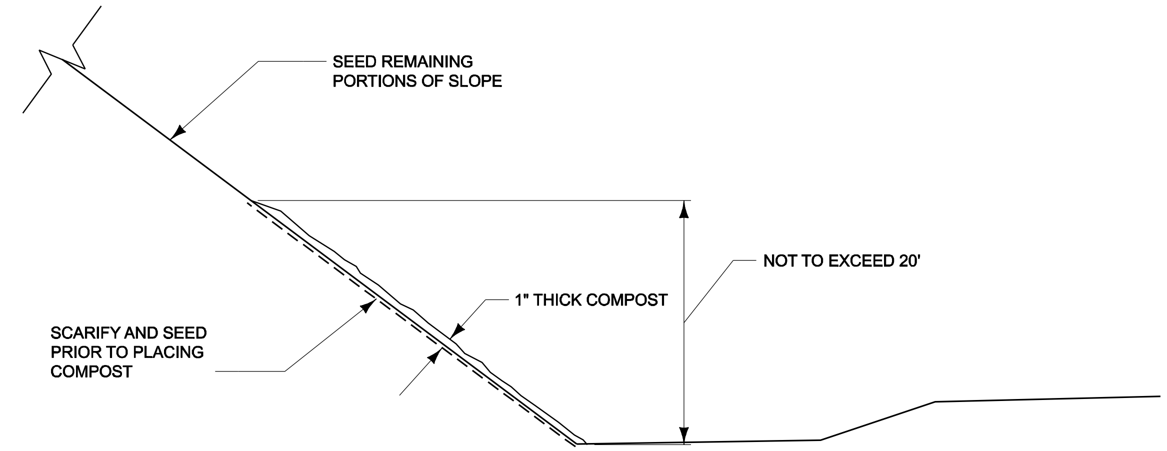
NOTES:

UPPER LIMIT OF SLOPE TREATMENT VARIES. TREAT BOTTOM THIRD OF SLOPE UNLESS 20 FOOT MAXIMUM HEIGHT IS EXCEEDED.

DO NOT DROP RIPRAP FROM A DISTANCE GREATER THAN 2 FEET.

BROADCAST SEED THE AREA WITH "AREA 2" SEED MIXTURE BEFORE PLACING RIPRAP.

COMPOST BLANKET WITH SEEDING



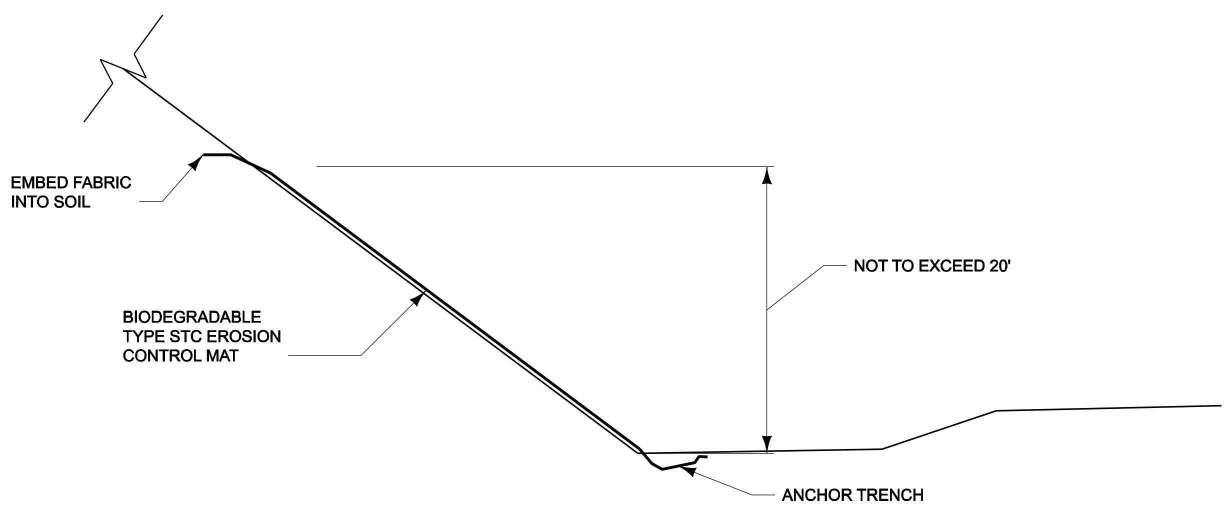
NOTES:

OVERSPRAY COMPOST WITH TACKIFIER TO ASSURE 6 MONTHS RETENTION AND PERFORMANCE.

UPPER LIMIT OF SLOPE TREATMENT VARIES. TREAT BOTTOM THIRD OF SLOPE UNLESS 20 FOOT MAXIMUM HEIGHT IS EXCEEDED.

BROADCAST SEED THE AREA WITH "AREA 2" SEED MIXTURE.

EROSION CONTROL BLANKET WITH SEEDING

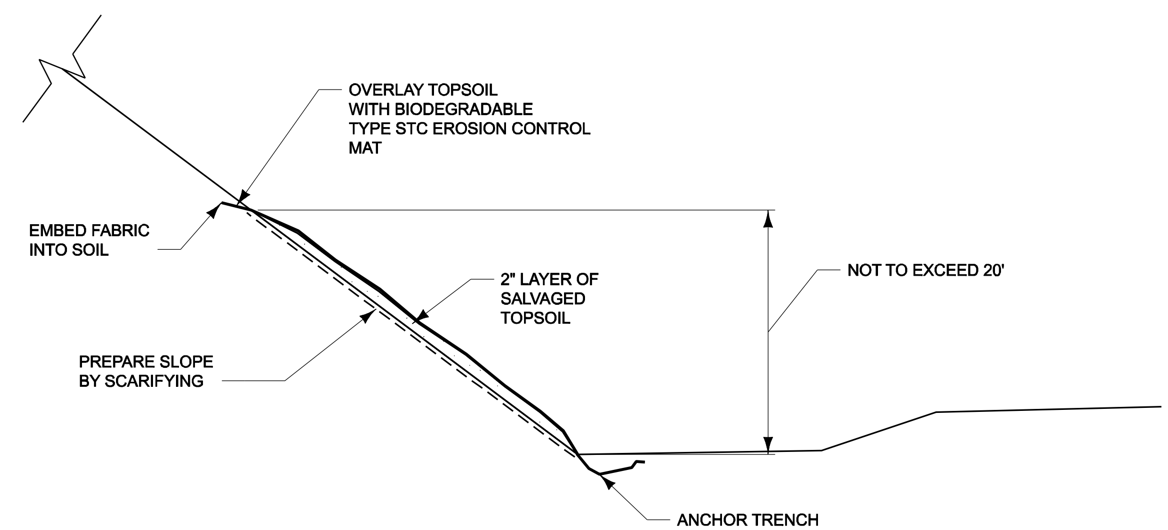


NOTES:

UPPER LIMIT OF SLOPE TREATMENT VARIES. TREAT BOTTOM THIRD OF SLOPE UNLESS 20 FOOT MAXIMUM HEIGHT IS EXCEEDED.

BROADCAST SEED THE AREA WITH "AREA 2" SEED MIXTURE.

TOPSOILING AND EROSION CONTROL BLANKET WITH SEEDING



NOTES:

UPPER LIMIT OF SLOPE TREATMENT VARIES. TREAT BOTTOM THIRD OF SLOPE UNLESS 20 FOOT MAXIMUM HEIGHT IS EXCEEDED.

BROADCAST SEED THE TOPSOIL WITH "AREA 2" SEED MIXTURE PRIOR TO PLACING EROSION CONTROL BLANKET.

FIG. B9-2

3 / 2 / 1	MDT MONTANA DEPARTMENT OF TRANSPORTATION	...\Dgn\PESCMANRDB09002.dgn 8/9/2010 1:05:11 PM u3326	DESIGNED BY *DESIGNER NAME* *DATE* REVIEWED BY *SUPERVISOR NAME* *DATE* CHECKED BY *CHECKER NAME* *DATE*	ROAD PLANS COUNTY NAME(S)	*MONTANA PERMANENT EROSION & SEDIMENT CONTROL MANUAL SAMPLE PLAN SHEET*	**SLOPE SOIL STABILIZATION EXAMPLES** CSF = 0.9999999 UPN NUMBER 12345678	PROJECT NO. SHEET 999 OF 999

Sample Summary Frame

STREAMBANK STABILIZATION (SEE DETAIL SHEETS & CROSS SECTIONS)								
		cubic yards			square yards	lump sum		
STATION		RANDOM RIPRAP	UNCL. EXC. #	GRANULAR FILTER #	FABRIC ENCAP. SOIL	REVEGETATION	REMARKS
FROM	TO	CLASS 2					
861+00.00	862+60.00	50.0	96	30	* 1,138	1	4 LAYERS TOTAL
TOTAL		50.0	# 96	# 30		1	

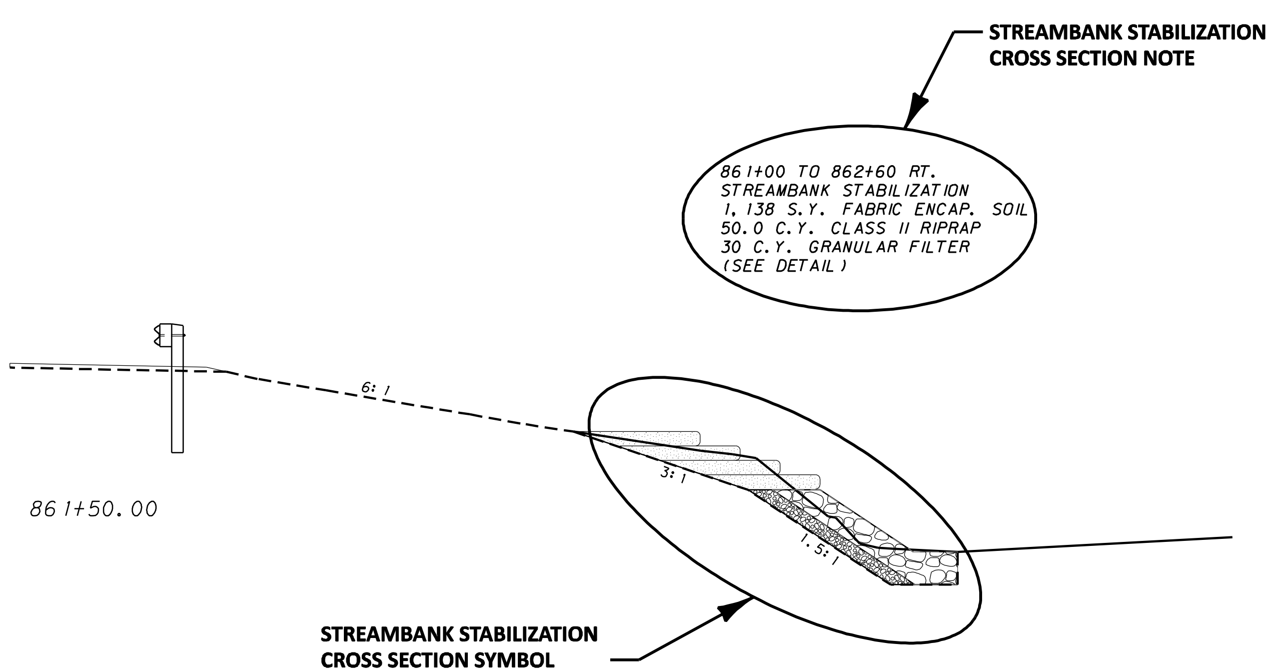
\# - FOR INFORMATION ONLY - INCLUDED IN THE COST OF RIPRAP
* - ESTIMATED AT 160 ft. LONG x 8 ft. WIDE AVERAGE PER LAYER

Streambank Stabilization Reminders:

① *See section A10 for additional information on streambank stabilization.*

② *Typically a detail should be prepared showing design features unique to the project as recommended by the Hydraulics Section.*

Sample Cross Section



Sample Plan and Profile

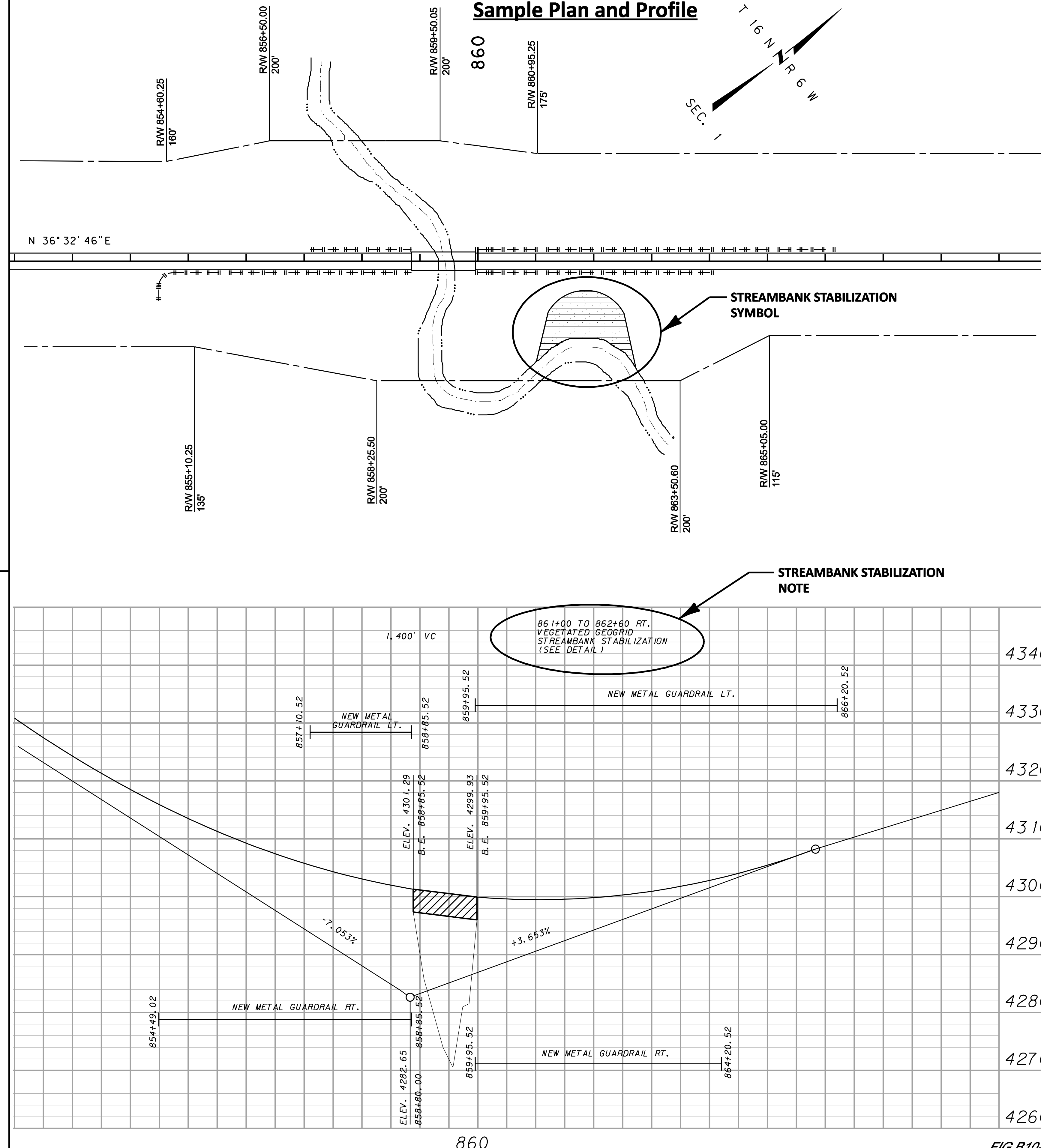
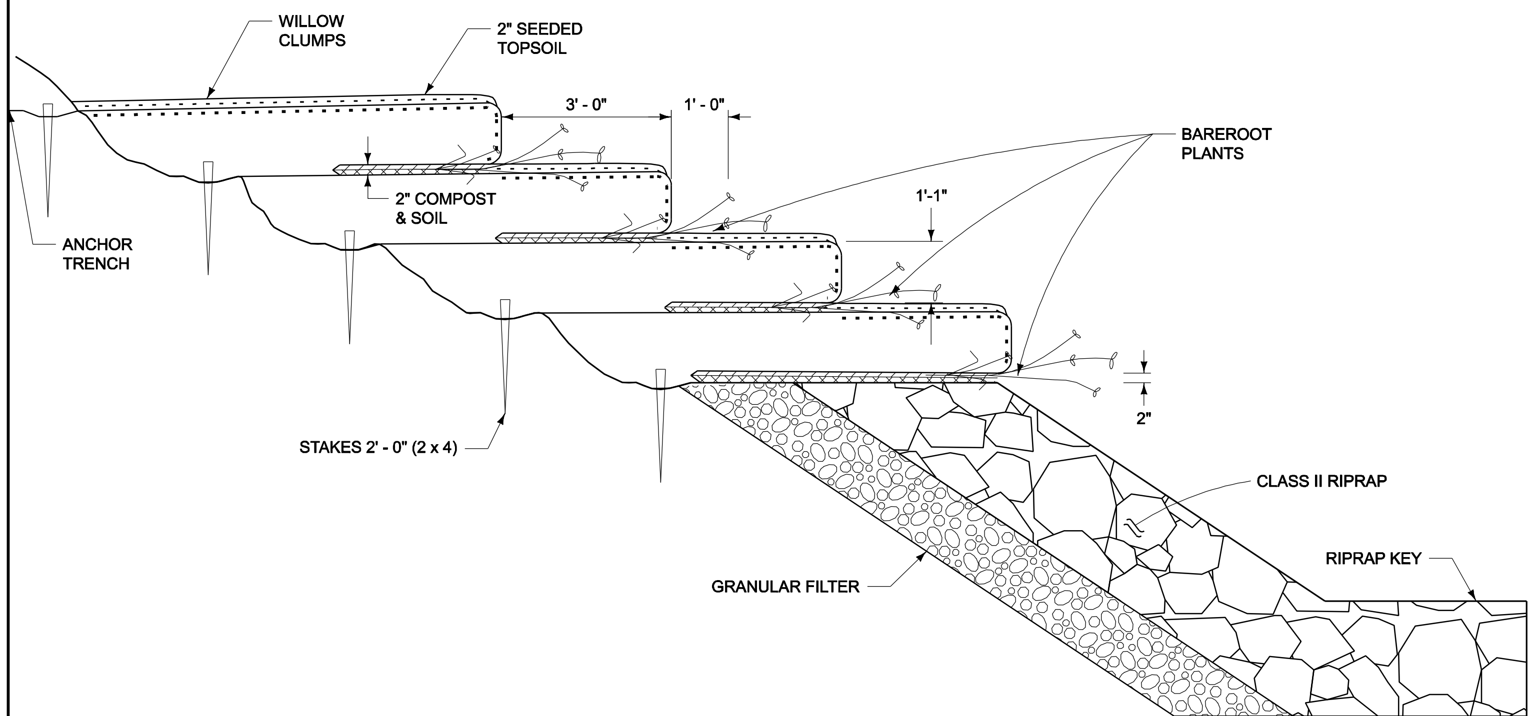
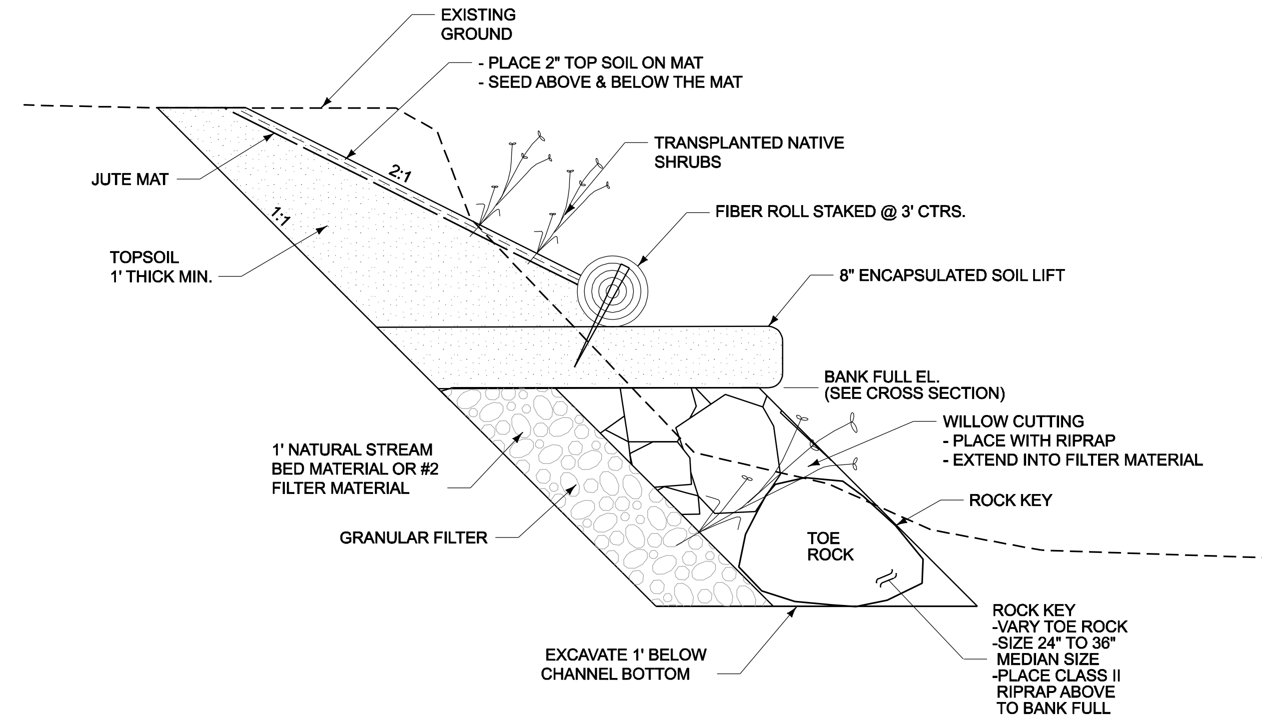


FIG B10-1

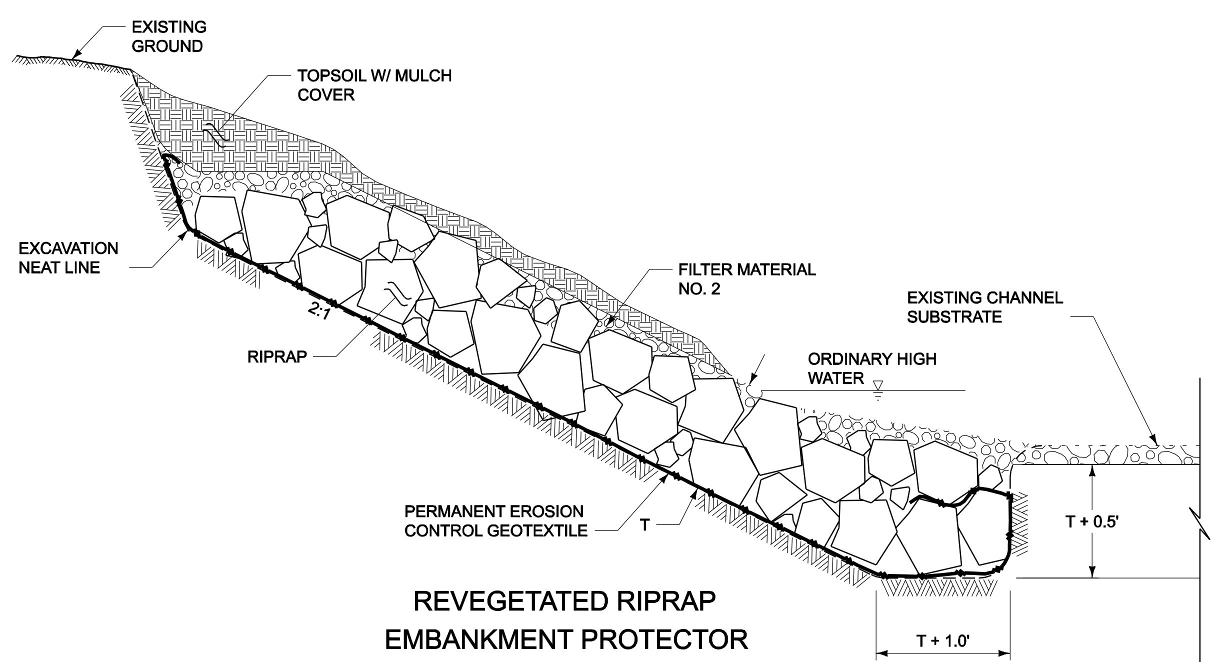
3 / 2 / 1	MDT MONTANA DEPARTMENT OF TRANSPORTATION	...\Dgn\PESCMANRDB10001.dgn 8/9/2010 1:06:08 PM u3326	DESIGNED BY DESIGNER NAME DATE REVIEWED BY SUPERVISOR NAME DATE CHECKED BY CHECKER NAME DATE	ROAD PLANS COUNTY NAME(S)	MONTANA PERMANENT EROSION & SEDIMENT CONTROL MANUAL SAMPLE PLAN SHEET	STREAMBANK STABILIZATION SAMPLES CSF = 0.9999999 UPN NUMBER 12345678	PROJECT NO. SHEET 999 OF 999



ENCAPSULATED SOIL WITH RIPRAP KEY



REVEGETATION/SLOPE WITH ROCK TOE DETAIL



REVEGETATED RIPRAP EMBANKMENT PROTECTOR

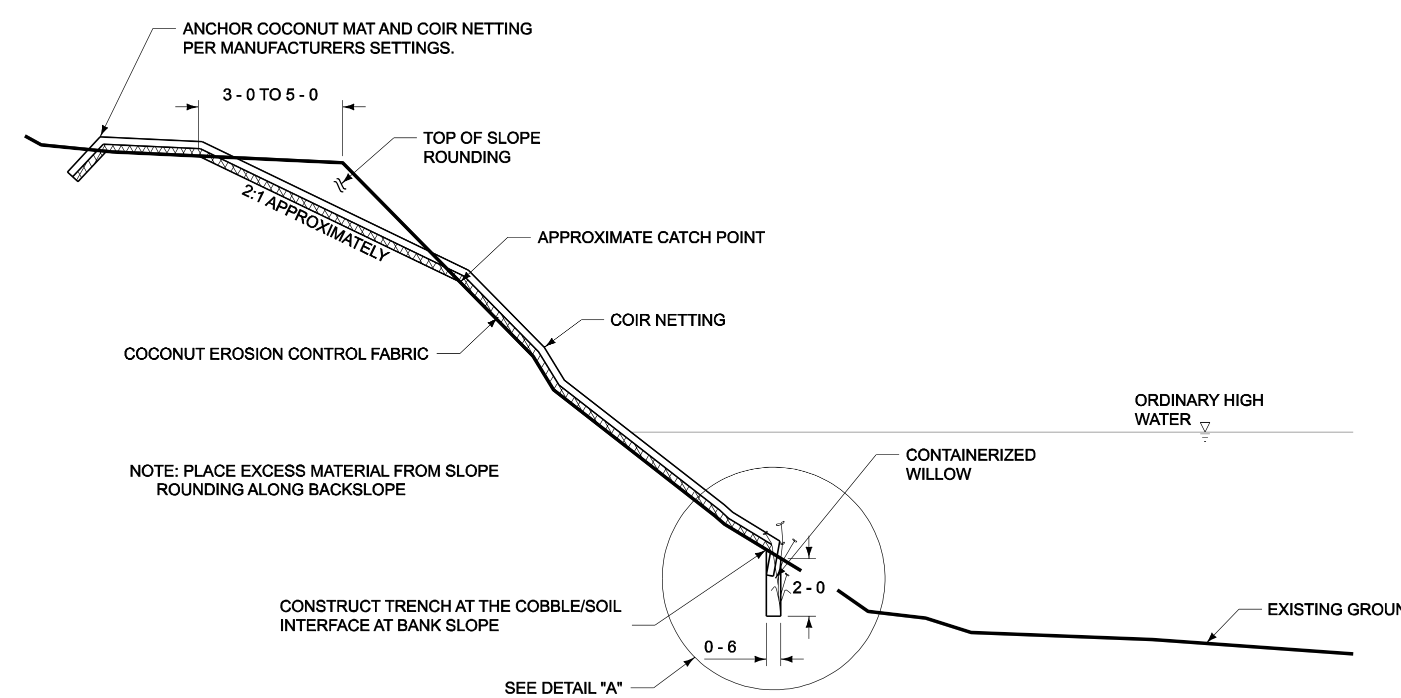
MINIMUM T FOR:

CLASS I RIPRAP = 1'-6"
CLASS II RIPRAP = 2'-6"
CLASS III RIPRAP = 3'-6"

NOTES:

FILL RIPRAP VOIDS WITH FILTER MATERIAL NO. 2, OR A MATERIAL OF SIMILIAR GRADATION OBTAINED ON SITE TO PROVIDE A UNIFORM SURFACE FOR THE PLACEMENT OF TOPSOII, AS APPROVED BY THE ENGINEER.

PLACE TOPSOIL WITH A MINIMUM THICKNESS OF 8".



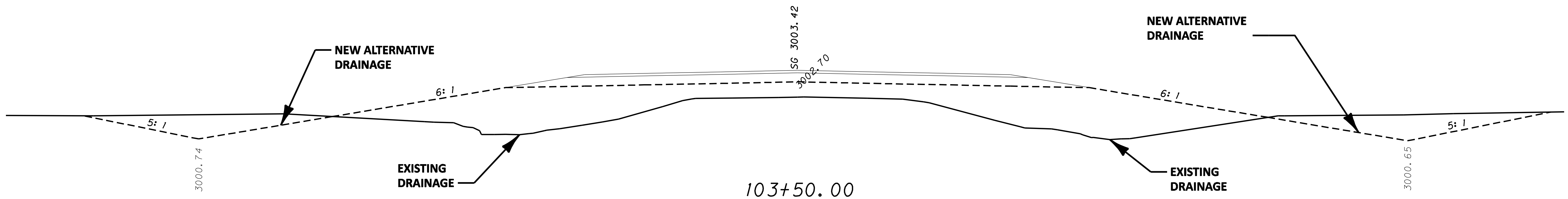
BANK STABILIZATION AND REVEGETATION DETAIL

FIG B10-2

3 / 2 / 1	MDT MONTANA DEPARTMENT OF TRANSPORTATION	...\Dgn\PESCMANRDB10002.dgn 8/9/2010 1:06:53 PM u3326	DESIGNED BY: DESIGNER NAME, DATE REVIEWED BY: SUPERVISOR NAME, DATE CHECKED BY: CHECKER NAME, DATE	ROAD PLANS COUNTY NAME(S)	*MONTANA PERMANENT EROSION & SEDIMENT CONTROL MANUAL SAMPLE PLAN SHEET*

SAMPLE STREAMBANK STABILIZATION DETAILS		PROJECT NO.
CSF = 0.9999999	UPN NUMBER 12345678	SHEET 999 OF 999

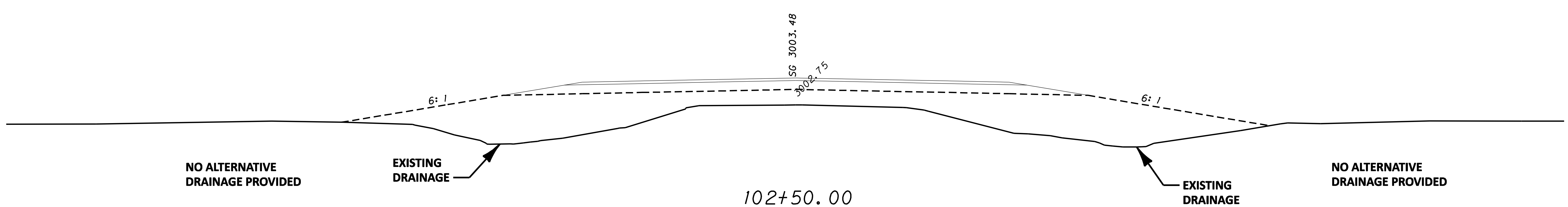
Good Example of Maintaining Drainage



Maintenance of Existing Drainage Reminder :

(1) *Traversable ditches are required within the clear zone and should also be used outside of the clear zone if practical. See Road Design Manual section 14.3.6.1.*

Bad Example of Maintaining Drainage



FILLING IN DITCHES AS SHOWN ABOVE IS GENERALLY NOT AN ACCEPTABLE PRACTICE UNLESS AN ALTERNATIVE DRAINAGE ROUTE IS PROVIDED OR SITE SPECIFIC CONDITIONS DICTATE.

FIG B11-1

3 2 1	MDT MONTANA DEPARTMENT OF TRANSPORTATION	...\Dgn\PESCMANRDB11001.dgn 8/9/2010 1:07:42 PM u3326	DESIGNED BY REVIEWED BY CHECKED BY	*DESIGNER NAME* *SUPERVISOR NAME* *CHECKER NAME*	*DATE* *DATE* *DATE*	ROAD PLANS COUNTY NAME(S)	*MONTANA PERMANENT EROSION & SEDIMENT CONTROL MANUAL SAMPLE PLAN SHEET*	**MAINTENANCE OF EXISTING DRAINAGE** CSF = 0.9999999 UPN NUMBER 12345678
								PROJECT NO. SHEET 999 OF 999

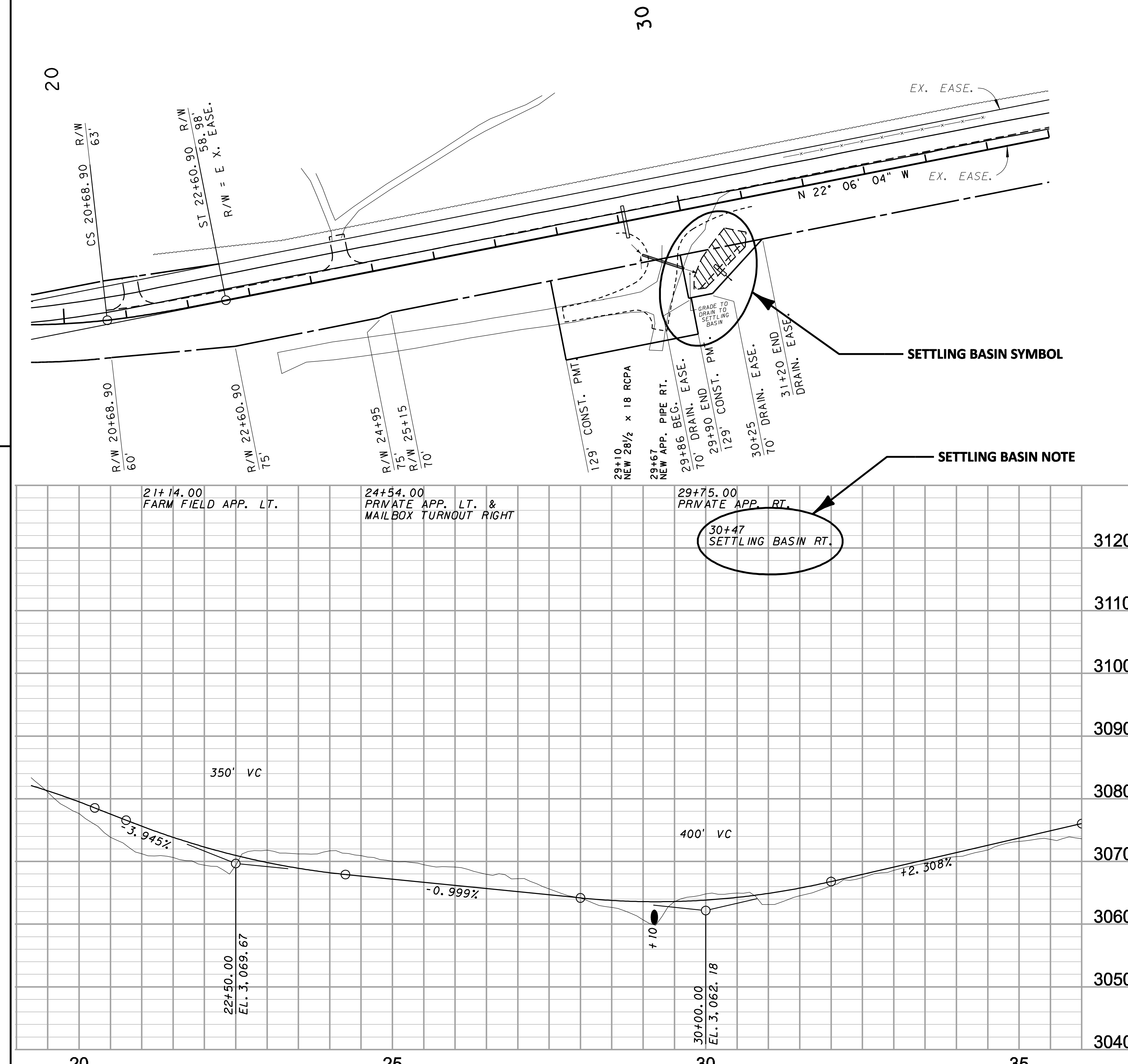
Sample Summary Frame

SETTLING BASIN							
		linear feet	square yards	cubic yards		each	
STATION		REINFORCED CONCRETE OUTLET PIPE	HEAVY DRAINAGE GEOTEXTILE	UNCL. EXC.	CLASS II RIPRAP	MANHOLE SPECIAL DESIGN	REMARKS
FROM	TO	12" CL.2					
30+47		24	50	40	11.6	1	SETTLING BASIN RT. (SEE DETAIL)
TOTAL		24	50	40	11.6	1	

Settling Basin Reminders:

1. *Settling Basins are typically designed by the MDT Hydraulics Section. The road designer will review locations and ensure that the design details are included in the plans.*
2. *Refer to section A12 of the Permanent Erosion and Sediment Control Manual for design guidlines.*
3. *A separate detail sheet will typically be needed for settling basins.*

Sample Plan and Profile



Sample Cross Section

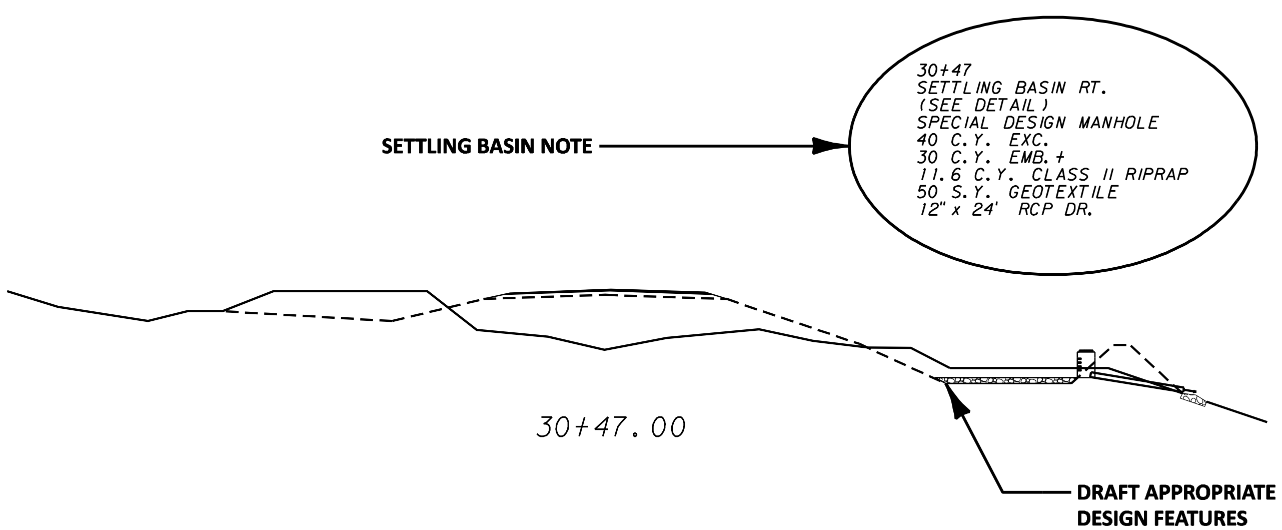


FIG. B12-1

MDT MONTANA DEPARTMENT OF TRANSPORTATION	...\Dgn\PESCMANRDB12001.dgn 8/9/2010 1:08:32 PM u3326	DESIGNED BY *DESIGNER NAME* *DATE* REVIEWED BY *SUPERVISOR NAME* *DATE* CHECKED BY *CHECKER NAME* *DATE*	ROAD PLANS COUNTY NAME(S)	*MONTANA PERMANENT EROSION & SEDIMENT CONTROL MANUAL SAMPLE PLAN SHEET*	**SETTLING BASIN SAMPLES** CSF = 0.9999999 UPN NUMBER 12345678	PROJECT NO. SHEET 999 OF 999

Sample Summary Frame

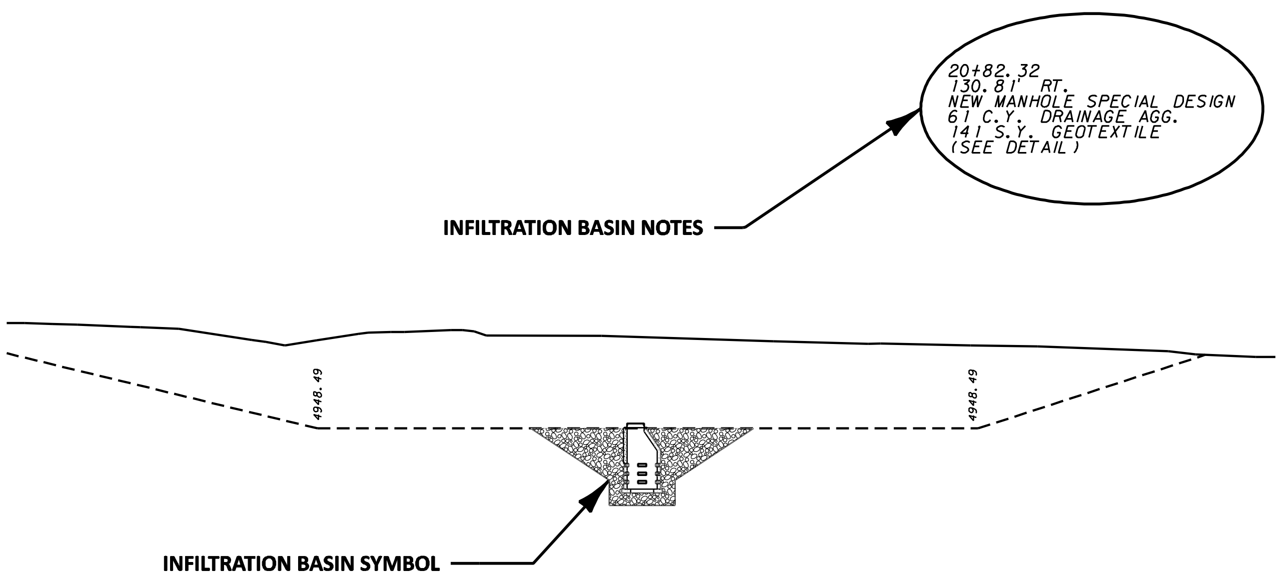
INFILTRATION FACILITY *					
STATION		square yards	cubic yards	each	
		HEAVY DRAINAGE GEOTEXTILE	DRAINAGE AGGREGATE	MANHOLE SPECIAL DESIGN	REMARKS
FROM	TO				
20+82.32		141	61	1	130.81' RT. OF GATEWAY S. RD.
TOTAL		141	61	1	

* SEE DETAIL

Infiltration Basin Reminders:

1. *Typically, a detail should be prepared showing necessary dimensions and elevations as recommended by the Hydraulics Section.*
2. *See Section A13 of the Permanent Erosion and Sediment Control Manual for further Infiltration Basin details.*

Sample Cross Section



Sample Plan and Profile

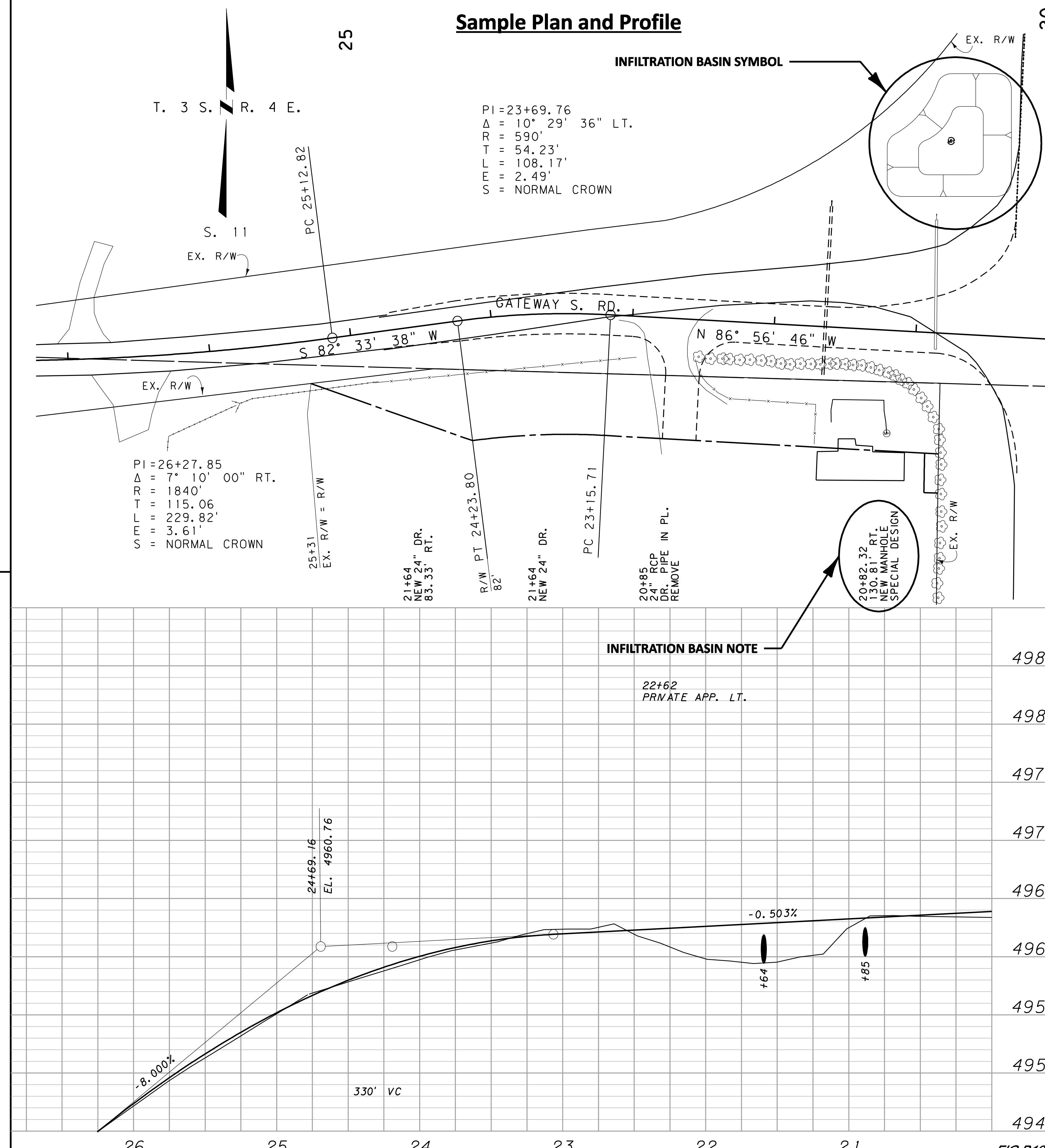
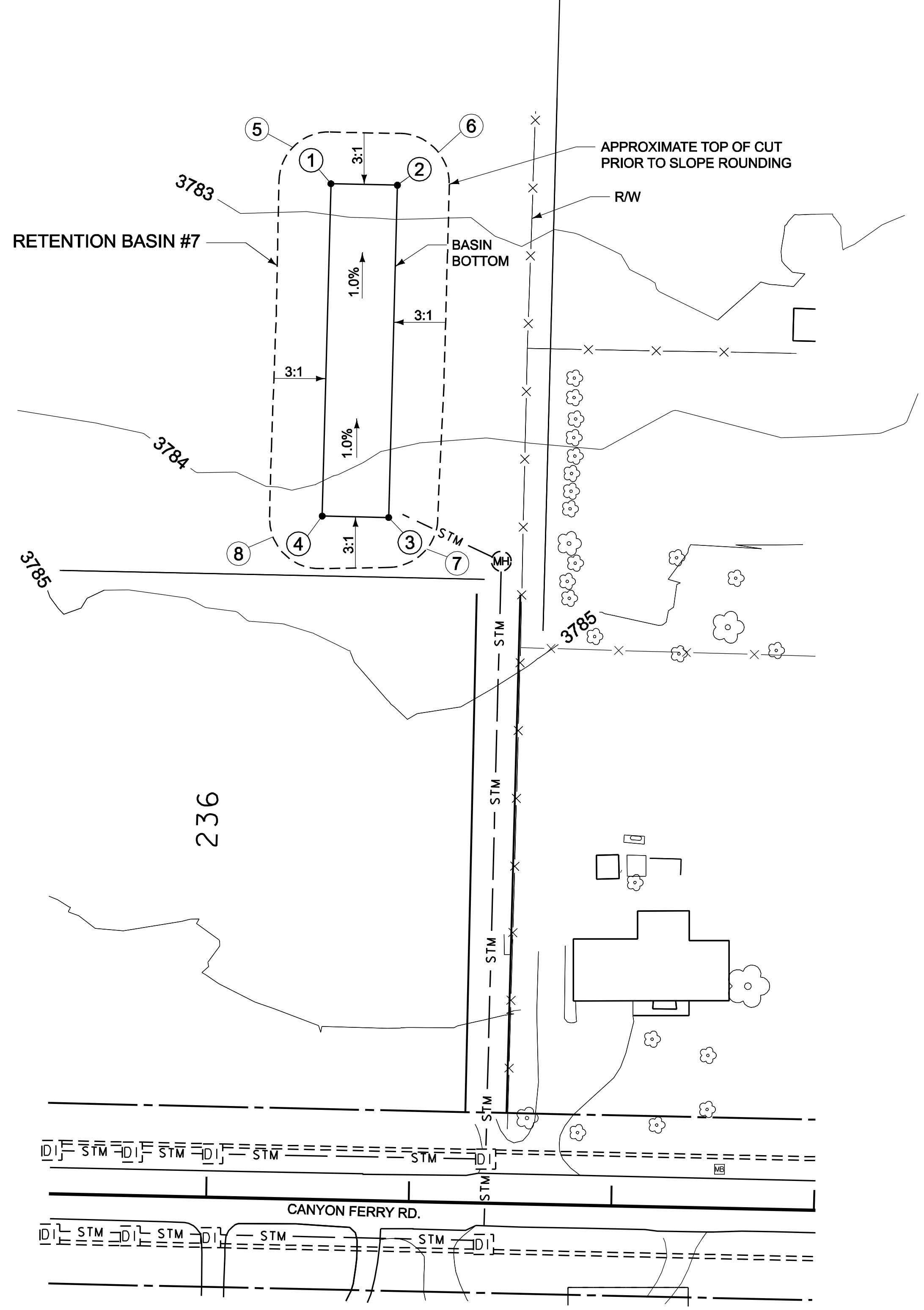


FIG B13-1

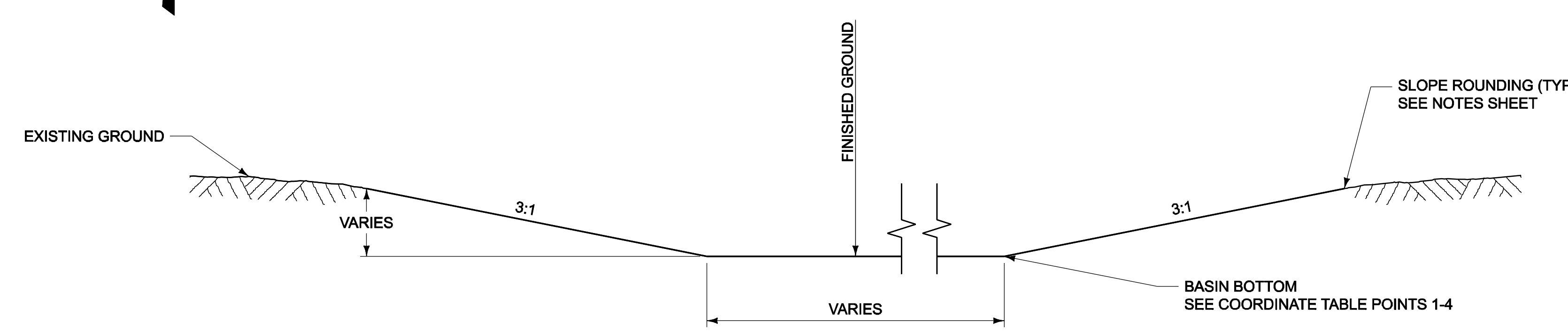
3	MDT MONTANA DEPARTMENT OF TRANSPORTATION	...\Dgn\PESCMANRDB13001.dgn	DESIGNED BY	DESIGNER NAME	DATE	ROAD PLANS	MONTANA PERMANENT EROSION & SEDIMENT CONTROL MANUAL SAMPLE PLAN SHEET	INFILTRATION BASIN SAMPLES		PROJECT NO.
2		8/9/2010	REVIEWED BY	SUPERVISOR NAME	DATE	COUNTY NAME(S)		CSF = 0.9999999	UPN NUMBER 12345678	SHEET 999 OF 999
1		1:09:09 PM u3326	CHECKED BY	CHECKER NAME	DATE					



RETENTION BASIN
PLAN VIEW

STA. 236+30 TO 237+02

COORDINATE TABLE							
POINT NUMBER	STATION	OFFSET	NORTHING	EASTING	ELEV.	RADIUS	REMARKS
1	236+50.75	501.00 FT. LT.	872,701.973	1,365,942.286	3775.92		
2	236+83.56	501.00 FT. LT.	872,701.265	1,365,975.086	3775.92		
3	236+82.84	337.00 FT. LT.	872,537.278	1,365,970.787	3777.56		
4	236+50.03	337.00 FT. LT.	872,537.986	1,365,937.988	3777.56		
5	236+32.35	519.50 FT. LT.	872,720.749	1,365,924.304	3784.22	24.5 FT. MIN.	
6	237+01.94	519.50 FT. LT.	872,719.248	1,365,993.862	3784.28	24.5 FT. MIN.	
7	237+00.07	319.75 FT. LT.	872,519.699	1,365,987.655	3785.70	24.5 FT. MIN.	
8	236+31.63	318.00 FT. LT.	872,519.343	1,365,919.174	3785.32	24.5 FT. MIN.	



RETENTION BASIN
TYPICAL SECTION

NOTES:

SALVAGE AND REPLACE TOPSOIL EVENLY OVER ALL DISTURBED AREAS, DEPTH NOT TO EXCEED 4". FINISHED GROUND ELEVATIONS INCLUDE TOPSOIL.

SEED ALL DISTURBED AREAS.

FINISH BASIN BOTTOM AND CUT SLOPES IN A ROUGHENED CONDITION. CONFORM TO SLOPE ROUGHENING BMP IN ACCORDANCE WITH DETAILED DRAWING NO. 208-22.

RETENTION BASIN
DETAIL

NO SCALE

FIG B13-2

3 2 1	MDT MONTANA DEPARTMENT OF TRANSPORTATION	...\Dgn\PESCMANRDB13002.dgn 8/9/2010 3:06:41 PM u0239	DESIGNED BY *DESIGNER NAME* *DATE* / REVIEWED BY *SUPERVISOR NAME* *DATE* / CHECKED BY *CHECKER NAME* *DATE*	ROAD PLANS / COUNTY NAME(S)	*MONTANA PERMANENT EROSION & SEDIMENT CONTROL MANUAL SAMPLE PLAN SHEET*	**RETENTION BASIN EXAMPLE** / CSF = 0.9999999 / UPN NUMBER 12345678	PROJECT NO. / SHEET 999 OF 999

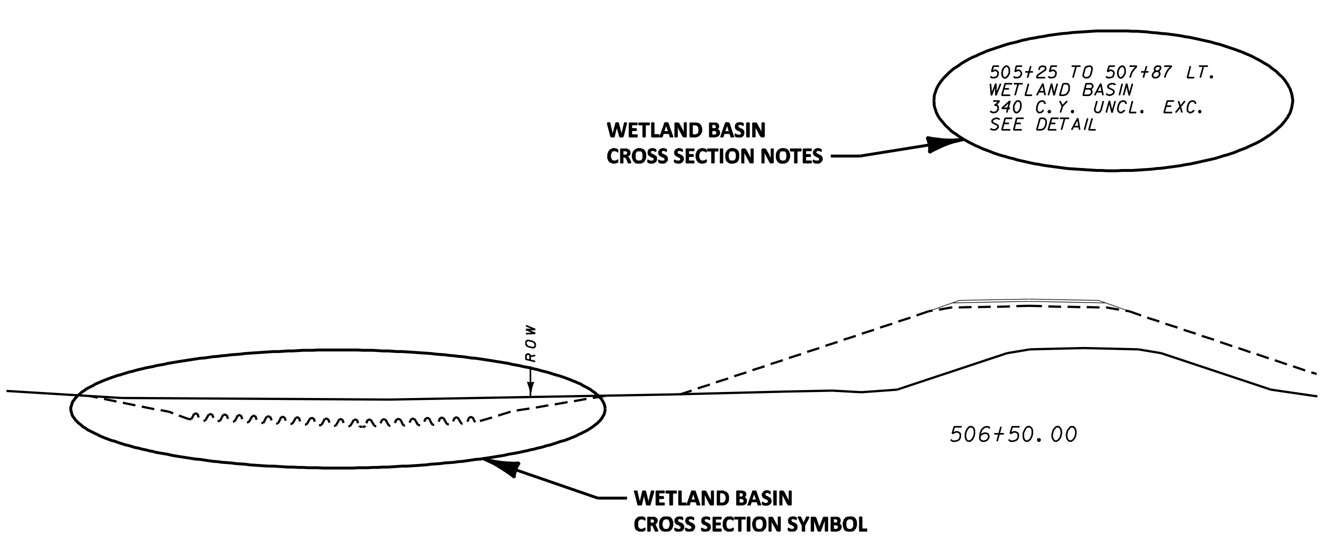
Sample Summary Frame

WETLAND BASIN				
STATION		cubic yards	acres	REMARKS
		UNCLASSIFIED EXCAVATION	WETLAND SEEDING	
FROM	TO			
505+25	507+87	340	0.2	SEE DETAIL
TOTAL		340	0.2	

Constructed Wetland Basin Reminders:

1. *Typically, a detail should be prepared showing necessary dimensions.*
2. *See Montana Permanent Erosion and Sediment Control Manual section A14 for additional constructed wetland details.*

Sample Cross Section



Sample Plan & Profile

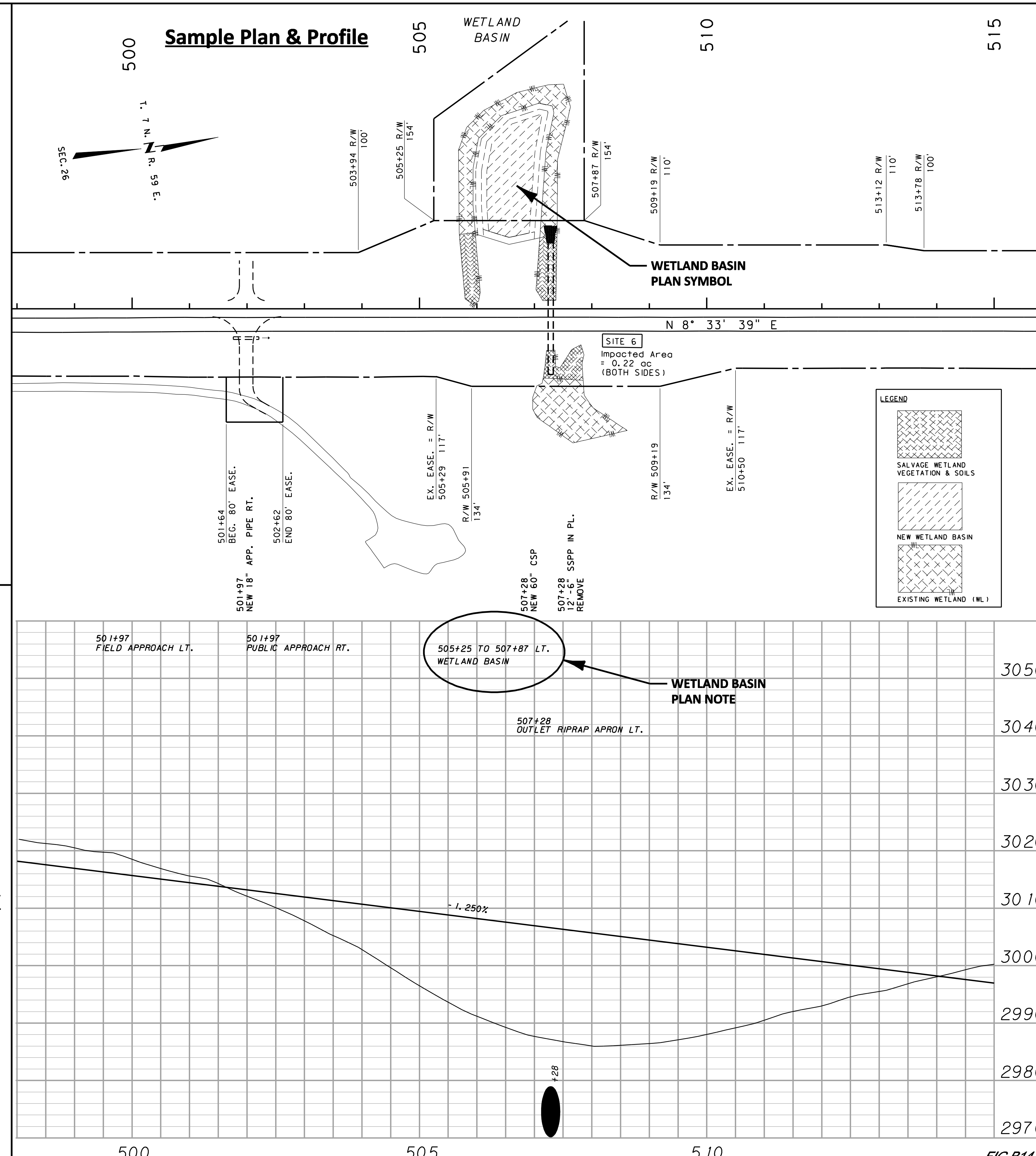


FIG B14-1

MDT MONTANA DEPARTMENT OF TRANSPORTATION	...\Dgn\PESCMANRDB14001.dgn 8/9/2010 1:10:25 PM u3326	DESIGNED BY: DESIGNER NAME, DATE; REVIEWED BY: SUPERVISOR NAME, DATE; CHECKED BY: CHECKER NAME, DATE	ROAD PLANS / COUNTY NAME(S)	MONTANA PERMANENT EROSION & SEDIMENT CONTROL MANUAL SAMPLE PLAN SHEET	WETLAND BASIN SAMPLE / CSF = 0.9999999 / UPN NUMBER 12345678	PROJECT NO. / SHEET 999 OF 999