COGCC POST-CONSTRUCTION STORMWATER MANAGEMENT PLAN

WATTENBERG FIELD, COLORADO

MARCH 2009

Prepared for:

KERR-McGEE OIL & GAS ONSHORE LP
Evans, Colorado

COGCC POST-CONSTRUCTION STORMWATER MANAGEMENT PLAN

MARCH 2009

Prepared for:

KERR-McGEE OIL & GAS ONSHORE LP
3939 Carson Avenue
Evans, Colorado 80620

Prepared by:

LT ENVIRONMENTAL, INC.
4600 West 60th Avenue
Arvada, Colorado 80003
(303) 433-9788

TABLE OF CONTENTS

TABLES

APPENDICES

- Erosion and vehicle tracking from well pads, production facilities, tank batteries, road surfaces, and pipelines;
- Waste disposal practices;
- Leaks and spills; and
- Ground disturbing and maintenance activities.

4.1 Transport of Chemicals and Materials: Loading and Unloading Operations

Activities associated with this pollution source are potential spills during delivery and unloading of materials at a given site. BMPs selected to control this source are materials management practices and personnel training.

Hazardous materials and petroleum products used in post-construction of a pad include fuel and lubricants for equipment and vehicles; small quantities of paints and solvents; water or gel based frac fluids (surfactant, friction reducer, dilute hydrochloric acid, potassium chloride) used during well completion; produced water; and crude oil/condensate. Material Safety Data Sheets (MSDS) for materials to be used or that are produced, are maintained at Kerr-McGee's Evans, Colorado office, located at 3939 Carson Avenue. If a spill of pollutant(s) threatens stormwater or has the potential to discharge from the site, the primary or secondary Post-Construction Stormwater contact will be notified immediately.

Spill Prevention, Control and Countermeasure (SPCC) Plans are required for post-construction sites which meet the applicability criteria set forth in Section 112.1 of 40 CFR Part 112. These regulations require SPCC Plans for non-transportation related facilities that could reasonably expect to discharge oil into or upon a navigable body of water of the United States; and the facility has a total combined above ground storage tank capacity of greater than 1,320 gallons of oil. Loading and unloading operations are addressed in the SPCC Plan. Both regulations further add that an SPCC Plan is required if any single aboveground oil storage tank's capacity exceeds 660 gallons.

Operators are trained in the safe handling of materials and spill discovery, response, and cleanup procedures as appropriate during regularly-scheduled environmental, health and safety (EHS) meetings. The SPCC Plan for Kerr-McGee and emergency numbers are located at the Evans office.

4.2 Vehicle and Equipment Fueling

Activities associated with this pollution source are fueling and equipment repair. Selected BMPs are related to proper containment. Routine vehicle maintenance and fueling of vehicles generally will not occur on-site. However, if refueling would occur or on-site maintenance may become necessary, containment BMPs will be implemented as necessary.

4.3 Outdoor Storage Activities

Kerr-McGee will adhere to the following good housekeeping practices regarding outdoor storage activities as applicable:

- Storage containers will be stored away from direct traffic to prevent accidents. They will also have proper labels;
- Dumpsters and trash receptacles will be enclosed in order to prevent the dissemination of refuse;
- Storage areas will be kept free of refuse;
- Chemical substances will have proper spill containment; and
- Chemical containers will be clearly and properly labeled, and an MSDS will be kept on file.

4.4 Produced Water and Drilling Fluids Storage

Produced water is stored in partially-buried vessels or aboveground vessels at production facilities. Earthen or metal berms are placed around these vessels during the construction phase. Post-construction management of produced water includes general berm maintenance.

Drilling fluids can be stored in frac tanks, drums, pits, or other containers. During post-construction, drilling fluids should have already been removed from the well sites. Kerr-McGee does not anticipate long term storage of these fluids.

4.5 Outdoor Processing and Machinery

Well pad and/or production facility post-construction sites can include many types of processing equipment and machinery, such as processing lines, valves, treaters, separators, meters and generators. Processing equipment is regularly maintained. Field personnel are instructed to keep machinery in a working order and clean environment. Leaking machinery is immediately repaired and cleaned up. Good housekeeping measures are performed during routine site visits.

4.6 Significant Dust or Particulate Generating Processes or Activities

Dust and/or particulates generated from vehicle traffic on graveled access roads may produce fugitive emissions. Dust and particulate generation are highest during dry and hot times of the year. If dust from vehicle traffic on graveled access roads becomes significant, dust suppression procedures (which may include road watering) will be implemented.

4.7 Erosion and Vehicle Tracking from Well Pads, Production Facilities, Tank Batteries, Road Surfaces, and Pipelines

Properly constructed vehicle tracking BMPs will provide the best off-site tracking control. Access road entrances from well pads, dirt road surfaces, and pipeline right of ways (ROWs) adjacent to paved roads may be graveled when practicable (subject to landowner approval) to prevent or minimize any off-site soil tracking. In some instances, cattle guards are used to drop off caked mud before the vehicle exits the site areas.

4.8 Waste Disposal Practices

Trash, debris, scrap, or other discarded materials will be properly disposed when encountered. If impacted soils are excavated at a Kerr-McGee site, additional BMPs may be employed to ensure containment of any stormwater runoff. In addition, stockpiles of impacted soil will be removed from the site and disposed or land-farmed as soon as possible.

4.9 Leaks and Spills

Spills or leaks will be handled by Kerr-McGee personnel or contractors, according to the Kerr-McGee *Wattenberg Field, Colorado SPCC Plan* as well as the *Emergency Response/Oil Spill Contingency Plan.* Kerr-McGee personnel conduct discharge prevention training, including procedures for routine, safe handling of products. Loading and transfer issues are discussed as appropriate in monthly EHS meetings. In addition, operators are trained in spill discovery, response, and cleanup procedures on an annual basis (minimum). Emergency numbers are contained in Kerr-McGee's Emergency Response/Oil Spill Contingency Plan, which is readily available to field personnel.

In general, small spills will be handled by Kerr-McGee personnel. The primary Post-Construction SWMP contact or secondary contact will direct cleanup activities related to spills. Spill response equipment is located at the Evans office. In the event of a larger spill, the primary Post-Construction SWMP contact or secondary contact will be notified and a contractor will likely be utilized to assist with the spill response.

For the protection of spill response personnel, all drums, tanks, and other containers are clearly labeled to identify contents, in the event of a spill.

4.10 Ground Disturbance Maintenance Activities

Structural and non-structural practices primarily include physical attributes of pads sites, production facilities, access roads, and pipeline ROWs and are designed to reduce erosion and sediment. Disturbed areas will be seeded and stabilized as needed.

Areas that become unstabilized over time (erosive conditions) may be seeded using seed mixes appropriate to the location as noted in Table 2, unless the landowner wishes to return the land to agricultural production or has some other requirement for the land. Additional revegetation guidance can be obtained from soil conservation authorities related to the U.S. Natural Resources Conservation Service, Local Conservation Districts, or reclamation contractors familiar with the area.

Post-Construction erosion control will be addressed as necessary by using all or combinations of various erosion control methods. These methods include, but are not limited to the following:

- Diversion and control of run-on/run-off water;
- Vegetation establishment and maintenance;
- Application and maintenance of tracking, mulches (with crimping and tackifier techniques), and erosion control blankets;

- Check dams; and
- Culvert protection.

Refer to Table 1 for a list of potential erosion control BMPs to be used throughout the Wattenberg Field. Appendix A includes details on BMP installation and maintenance procedures.

Post-Construction sediment controls that may be used to mitigate and control sediments generated from the erosive transport forces of stormwater may include but will not be limited to the following:

- Silt fence;
- Straw bales;
- Wattles;
- Berms; and
- Vehicle tracking pads or cattle guard.

Refer to Table 1 for a list of potential sediment control BMPs to be used throughout the Wattenberg Field. Appendix A includes details on BMP installation and maintenance procedures.

5.0 SELF INSPECTION, MAINTENANCE, AND GOOD HOUSEKEEPING PROCEDURES

5.1 Inspections

COGCC Rule 1002 (f) requires stormwater inspections until abandonment; however, there are no mandated frequencies. Kerr-McKee will assess all of their Non-Tier 1 sites according to topography, distance to any waterways, and soil types. Personnel responsible for inspections will be trained to evaluate, track and report stormwater management concerns.

5.2 Good Housekeeping

Housekeeping practices include regular cleaning, organization and maintenance of equipment, and erosion and sediment control structures throughout the project. When practicable, chemicals will be stored in containers or sheltered areas, where there is limited potential for stormwater contact.

The following items will be addressed in order to maintain clean and orderly pads, production facilities and access roads during post-construction:

- Inspect post-construction areas routinely;
- Correct deficiencies noted during inspections;

- Maintain stormwater management structures and components;
- Collect trash routinely and properly dispose;
- Storage containers, fuel tanks, and equipment used will be visually inspected routinely for obvious leaks. Sites with "low" runoff potential will be inspected on an annual basis, and sites with "high" runoff potential will be inspected on a quarterly basis;
- Drums will be properly labeled so an enclosed substance can be quickly identified. OSHA-approved labeling and sign systems will be followed for all secondary containers;
- Erosion damage to the berms, outfalls, silt barriers, collection channel, containment ponds, and any other erosion and sediment controls will be repaired as soon as practical;
- Areas of stained soil will be inspected in order to identify the sources of the staining. Impacted soil will be removed and properly disposed;
- When appropriate (and subject to landowner approval), energy-dissipating material, such as riprap, cobbles or gravel may be placed, or existing materials may be utilized at the stormwater outfalls to prevent erosion damage. Ditches under control of Kerr-McGee should be free from vegetation and debris which may cause impounding of stormwater; and
- Stormwater management structures will be cleared of debris and repaired when necessary; and surface runoff controls such as culverts, and ditches may be used to control runoff.

6.0 EMPLOYEE TRAINING

Kerr-McGee will inform and train employees who are involved with SWMP activities. Training will cover information and procedures contained in the SWMP and will be conducted on an as-needed basis. Personnel work responsibilities will be used to identify the appropriate attendees. Safety and environmental elements of the SWMP will also be covered.

TABLES

TABLE 1
POST-CONSTRUCTION
EROSION AND SEDIMENT CONTROL BMPs
WATTENBERG FIELD, COLORADO
KERR-MCGEE OIL & GAS ONSHORE LP

POST-CONSTRUCTION
Pads
Berm
Diversions
Erosion Control Blanket
Mulches, with or without a tackifier
Revegetation
Silt Fence
Vehicle Tracking Control (Cattle Guard)
Straw Bales
Wattles
Wind Erosion Control
Access Roads
Berm
Check Dams
Culvert Protection
Diversions
Erosion Control Blanket
Mulches, with or without a tackifier
Revegetation
Silt Fence
Vehicle Tracking Control (Cattle Guard)
Straw Bales
Wattles
Wind Erosion Control

Notes:
BMP = Best Management Practice

TABLE 2
POST-CONSTRUCTION
SEED MIXES AND APPLICATION RATES
WATTENBERG FIELD, COLORADO
KERR-MCGEE OIL & GAS ONSHORE LP

SEED MIX	APPLICATION RATE (lbs/acre)
PBSI Dryland Aggressive Mix	**25**
(20%) Green Needlegrass, Lodorm	
(20%) Slender Wheatgrass, Native	
(20%) Western Wheatgrass, Native	
(20%) Pubescent Wheatgrass, Luna	
(20%) Intermediate Wheatgrass, Oahe/Rush	
PBSI Native Prairie Mix	**15**
(25%) Blue Grama	
(10%) Buffalograss	
(20%) Green Needlegrass	
(20%) Sideoats Grama	
(25%) Western Wheatgrass	
PBSI Native Sandyland Mix	**15**
(20%) Yellow Indiangrass	
(10%) LittleBluestem	
(10%) Indian Rice Grass	
(10%) Sideoats Grama	
(10%) Sand Lovegrass	
(10%) Prairie Sandreed	
(20%) Switchgrass	
PBSI Premium Irrig. Pasture Mix #1	**25**
(75%) Meadow Bromegrass, Paddock/Fleet	
(25%) Orchardgrass, Elsie/Megabite/Paiute	

Notes:
lbs/acre = pounds per acre
% = percent

APPENDIX A

BMP MANUAL

Best Management Practices (BMPs)

Berm (B)

Description

A berm is a ridge of compacted soil located at the top or base of a sloping disturbed area to contain or divert surface runoff. Berms may be constructed from either excavated topsoil or subsoil.

The purpose of a berm is to control runoff velocity, divert onsite surface runoff to a sediment trapping device, divert clean water away from disturbed areas, and to provide a safe slope barrier for vehicle traffic.

Applicability

Berms are usually appropriate for drainage basins smaller than five acres, but with modifications they can be capable of servicing areas as large as ten acres. With regular maintenance, earthen berms have a useful life span of approximately 18 months. Berms are applicable for the following applications:

- Along the outside shoulder of an insloped road to ensure that runoff from the roadway drains inward and to protect the fill slope from continual disturbance during road blading and maintaining.

- Upslope of cut or fill slopes to divert flows away from disturbed areas.

- Downslope of cut or fill slopes to divert onsite runoff to a stabilized outlet or sediment trapping device, although diversions are more commonly used for this application.

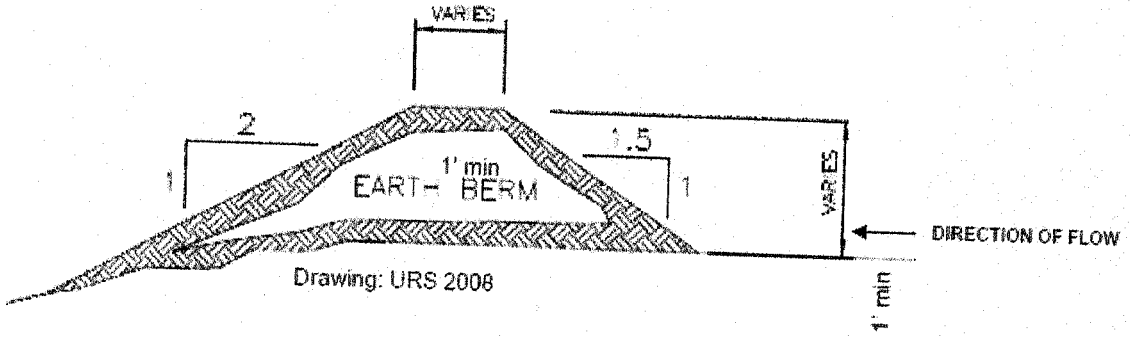
- Along the outside shoulder of a road to provide vehicle safety.

Limitations

- Berms may erode if not properly compacted and stabilized with vegetation. Berms which are adjacent to concentrated flows will require erosion blanketing.

- If a berm crosses a vehicle roadway or entrance, its effectiveness can be reduced. Wherever possible, berms should be designed to avoid crossing vehicle pathways.

Design Criteria



Construction Specifications

1. Prior to berm construction, remove all trees, brush, stumps and other objects in the path of the berm and till the base of the berm before laying the fill. Fill may consist of topsoil or subsoil excavated during the construction of nearby roads or well pads.

2. For roadside berms, construct according to Figure.

3. To remain effective, berms should be compacted with tracked equipment, if possible.

4. All berms shall have positive drainage to a stabilized outlet so that runoff does not collect in ponds on the upslope side of the berm, but instead flows along the berm until ti reaches a stabilized outlet. Field location should be adjusted as needed. Stabilized outlet may be a well-vegetated area, a well pad detention pond, or a sediment control such as a silt fence or sediment trap where sedment can settle out of the runoff before being discharged to surface water.

5. If the expected life span of the berm is greater than 15 days, it is strongly recommended that the berm be stabilized with vegetation or an erosion control blanket immediately after construction. Stabilization is required where concentrated flows are expected.

6. Berms should be constructed and fully stabilized prior to commencement of major upslope land disturbance. This will maximize the effectiveness of the structure as a storm water control device.

Maintenance Considerations

The frequency of inspections should be in accordance with the Storm Water Management Plan (SWMP). Berms should be inspected for evidence of erosion or deterioration to ensure continued effectiveness. Berms should also be maintained at the original height. Any decrease in height due

to settling or erosion, which impacts the effectiveness of the BMP, should be repaired immediately.

Removal

Berms should remain in place and in good condition until all upslope disturbed areas are permanently stabilized. There is no need to formally remove the berm on completion of stabilization until interim or final reclamation.

References

Environmental Protection Agency (EPA), *National Pollutant Discharge Elimination System (NPDES). Construction Site Storm Water Runoff Control.*
Washington, D.C., February, 2003.
http://www.dec.state.ny.us/website/dow/toolbox/escstandards

New York State Department of Environmental Conservation, *New York Guidelines for Urban Erosion and Sediment Control.* New York. Fourth Edition, 1997.
http://www.dec.state.ny.us/website/dow/toolbox/escstandards

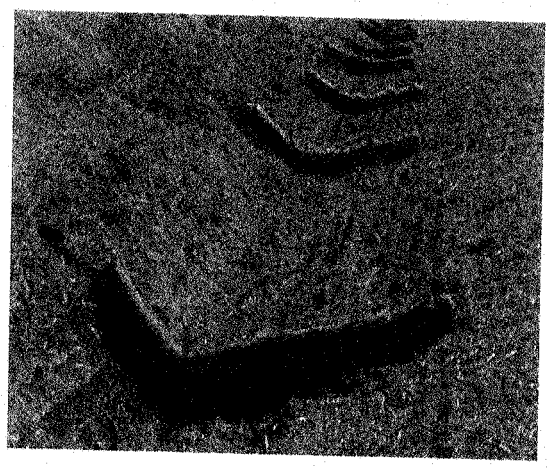
Table B-1
Berm Stabilization

Treatment Type	Channel Grade (1)	A (<5 Ac.)	B (5-10 Ac.)
1	0.5-3.0%	Hydro-seed and use tackifier	Hydro-seed and use tackifier
2	3.0-5.0%	Hydro-seed and use tackifier	Seed and cover with erosion control blanket, or lined with 2-inch stone
3	5.0-8.0%	Seed and cover with erosion control blanket, or lined with 2-inch stone	Line with 4 to 8-inch stone or rock (2)
4	8.0-20.0%	Line with 4 to 8-inch stone or rock (2)	Engineering Design

(1) In highly erodible soils, as defined by the local approving agency, refer to the next higher slope grade for type of stabilization.

(2) Site rock, if available, shall be broken into the required size.

Check Dam (CD)



Description

Check dams are small, temporary dams constructed across a diversion or road side ditch. Check dams can be constructed using gravel, rock, sandbags, gravel bags, earth with erosion control blanketing, straw bales, or synthetic materials to slow the velocity of concentrated flow in a channel and thus reduce erosion. As a secondary function, check dams can also be used to catch sediment from the channel itself or from the contributing drainage area as storm water runoff flows through or over the structure.

Applicability

Check dams are most often used in small, open channels with contributing drainage area of less than 10 acres, and side slopes of 2:1 or less. Check dams may be used in the following applications:

- In diversion or roadside ditches where it is not practical to line the channel or implement other flow control and sediment control practices.

- In diversions or roadside ditches where temporary seeding has been recently implemented but has not had time to take root and fully develop.

- As a series of check dams, spaced at appropriate intervals, used in one of the above two applications.

- Rock ditch checks should be **perpendicular** to the flowline of the ditch.

- Rock ditches must be designed so that water can flow over them, not around them. The ditch check should extend far enough so that the ground level at the ends of the check is higher than the low point on the crest of the check.

The following table provides check spacing for a given ditch grade:

Ditch Grade (Percent)	Check Spacing (feet)	Check Spacing (meters)
5	59	18
6	49	15
7	43	13
8	36	11
9	33	10
10	30	9

Limitations

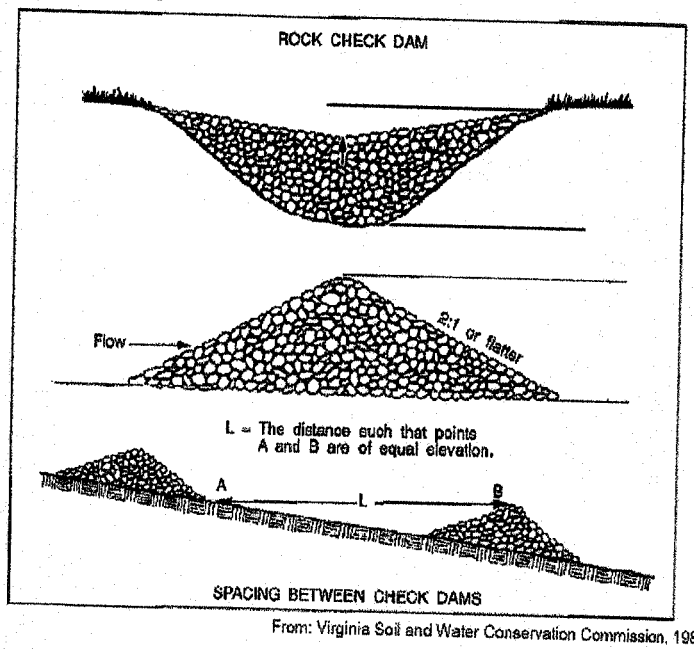
- Check dams should not be used in live, continuously flowing streams unless approved by an appropriate regulatory agency.

- Check dams may require frequent removal of accumulated sediments. Dams should therefore be located in areas accessible to maintenance vehicles.

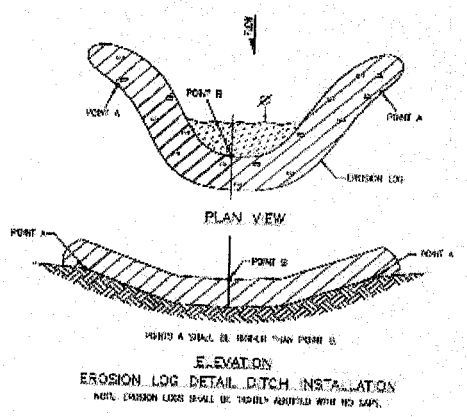
- Leaves have been shown to be a significant problem by clogging check dams in the fall. Therefore, they might necessitate increased inspection and maintenance.

- Straw bale check dams decompose over time, and may be consumed by livestock.

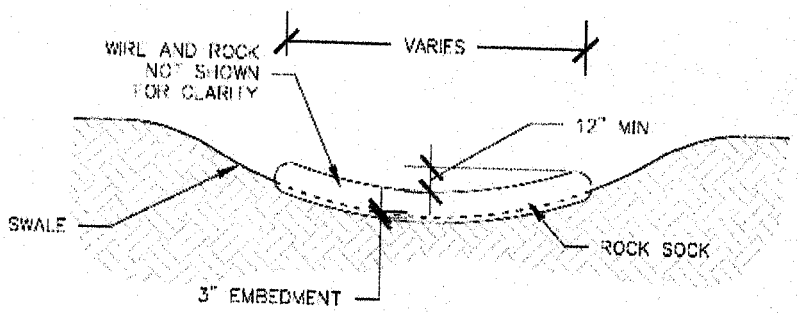
Design Criteria



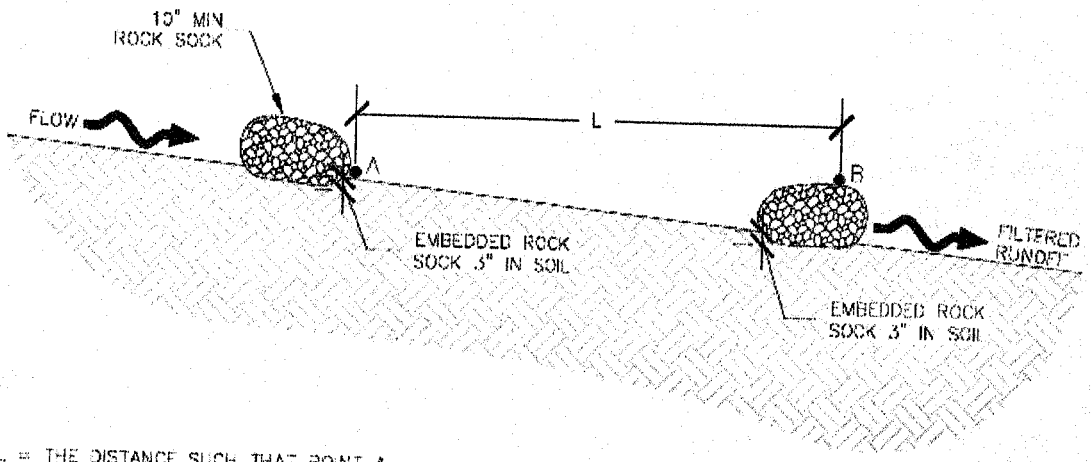
From: Virginia Soil and Water Conservation Commission, 1985



EROSION LOG DETAIL DITCH INSTALLATION



SWALE ELEVATION



L = THE DISTANCE SUCH THAT POINT A AND B ARE OF EQUAL ELEVATION.

SWALE SPACING

RSS

ROCK SOCK IN SWALE

Construction Specifications

- Install straw bale check dams (See Straw Bale detail, page 35), rock check dams and other check dams according to respective figures and notes.

- Check dams should be located in areas accessible to maintenance vehicles for the periodic removal of accumulated sediments.

- Check dams should be installed with careful placement of the construction material. Mere dumping of the dam material into a channel is not appropriate and will reduce overall effectiveness.

- Check dams can be constructed from a number of different materials. Most commonly, they are made of straw bales or rock. When using rock, the material diameter should be 4 to 8 inches depending on the expected velocity and quantity of runoff within the channel. Wattles or rock sacks may also be used.

- The center of the dam should be lower than the edges. This design creates a weir effect that helps to channel flows away from the banks and prevent further erosion.

- In order to be most effective, dams used in a series should be spaced such that the base of the upstream dam is at the same elevation as the top of the next downstream dam.

- When installing more than one check dam in a channel, outlet erosion stabilization measures should be installed below the final dam in the series. Because this area is likely to be vulnerable to further erosion, riprap, erosion control blanket lining, or some other stabilization measure is highly recommended.

Maintenance Considerations

The frequency of inspections should be in accordance with the Storm Water Management Plan (SWMP). During inspection, large debris, trash, and leaves should be removed. The center of a check dam should always be lower than its edges. If erosion or heavy flows cause the edges of a dam to fall to a height equal to or below the height of the center, and the effectiveness of the check dam is compromised, repairs should be made immediately. Accumulated sediment should be removed from the upstream side of a check dam when the sediment has reached a height of the dam (measured at the center). Close attention should be paid to the repair of damaged or rotting straw bales, end runs and undercutting beneath bales. Replacement of bales should be accomplished promptly.

Removal

Check dams within roadside ditches are usually used as temporary controls. If removing a check dam, all accumulated sediment should be removed. Removal of a check dam should be

completed only after the contributing drainage area has been completely stabilized. Permanent vegetation should replace areas from which rock or other material has been removed.

References

Colorado Department of Transportation (CDOT), *Erosion Control and Stormwater Quality Guide*. 2002. http://ww.dot.state.co.us/enviromental.envWaterQual/wqms4.asp

Environmental Protection Agency (EPA), *National Pollutant Discharge Elimination System (NPDES). Construction Site Storm Water Runoff Control.* Washington, D.C., February 2003.

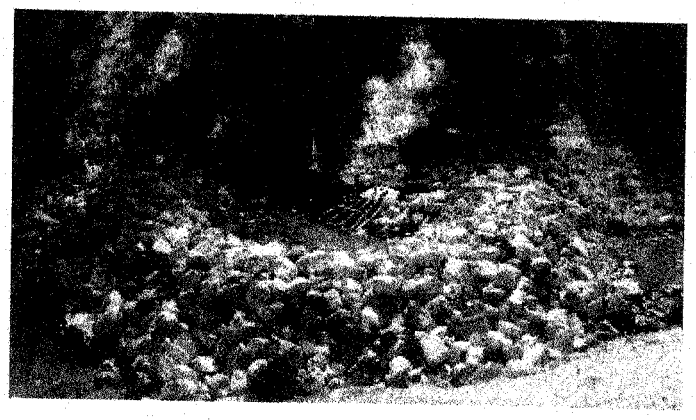
http://cfpud.epa.gov/npdes/stormwater/menufbmps/con_site.cfm

Horizon Environmental Services, Inc, *Guidance Document Reasonable and Prudent Practices for Stabilization (RAPPS) of Oil and Gas Construction Sites.* April 2004.

North Dakota Department of Health Division of Water Quality, *A Guide to Temporary Erosion-Control Measures for Contractors, Designers and Inspectors, June 2001*

*Other materials may be used instead of straw.

Culvert Protection (CP)



Description

Culvert inlet protection could involve placing boulders, riprap, gabions, rock retaining walls, slash, and/or any other protection at the inlet pipes. Riprap, or other energy-dissipating devices, will reduce the velocity of storm water flows and thereby prevent erosion and help protect the inlet structure.

Culvert outlet protection involves placing structurally lined aprons or other appropriate energy-dissipating devices, such as large boulders or plunge pools, at the outlets of the pipes to reduce the velocity of storm water flows and thereby prevent scouring at storm water outlets, protect the outlet structure, and minimize potential for erosion downstream.

Applicability

Riprap inlet protection should be used where velocities and energies at the inlets of culvert are sufficient to erode around the inlet structure. Riprap may also be used to help channel the storm water to the inlet of the culvert.

Culvert outlet protection should be used where discharge velocities and energies at the outlets of the culverts or channels are sufficient to erode the next downstream reach.

Limitations

Rock aprons at the culvert outlets should not be placed on slopes steeper than 10 percent. Runoff from pipe outlets at the top of cut/fills or on slopes steeper than 10 percent should be routed via slope drains or riprap chutes to a rock apron at the toe of the slope. Otherwise will re-concentrate and gain velocity as the flow leaves the apron.

Design Criteria

Tail-water depth: The depth of tail-water immediately below the pipe outlet must be determined for design capacity of the pipe. If the tail-water depth is less than half the diameter of the outlet pipe, and the receiving stream is wide enough to accept divergence of the flow, it shall be classified as a minimum tail-water condition. If the tail-water depth is greater than half the pipe diameter and the receiving stream will continue to confine the flow, it shall be classified as a maximum tail-water condition. Pipes that outlet onto flat areas with no defined channel may be assumed to have a minimum tail-water condition.

Riprap Apron Size & D50: The apron length (LA) and the D50 of the riprap shall be determined from table CP-1 according to the design flow and weather there is a minimum or maximum tail-water condition. The apron width (W) shall then be determined as (W=d+0.4LA) where d is the diameter of the culvert. If the pipe discharges directly into a well defines channel, the apron shall extend across the channel bottom and up the channel banks to an elevation one foot above the maximum tail-water depth or to the top of the bank, whichever is less. The upstream end of the apron, adjacent to the pipe, shall have a width of two (2) times the diameter of the outlet pipe, or confirmed to pipe and section if used.

Riprap Materials: The outlet protection may be done using rock riprap or grouted riprap. Riprap shall be composed of a well-graded mixture of stone size so that 50 percent of the pieces, by weight, shall be larger than the D50 size determined from table CP-1. A well-graded mixture, as used herein, is defined as a mixture composed primarily of larger stone sizes, but with a sufficient mixture of other sizes to fill the smaller voids between the stones. The diameter of the largest stone size in such a mixture shall be 1.5 times the D50 size. All grout for grouted riprap must be one part Portland cement for every three parts sand, mixed thoroughly with water.

Apron Thickness: The minimum thickness of the riprap layer shall be 1.5 times the maximum stone diameter for D50 of 15 inches or less; and 1.2 times the maximum stone size for D50 greater than 15 inches.

Riprap Stone Quality: Stone for riprap shall consist of field stone or rough un-hewn quarry stone. The stone shall be hard and angular and of quality that will not disintegrate in exposure to water or weathering. The specific gravity of the individual stone shall be at least 2.5. Site rock or site boulders may be used provided it has a density of at least 150 pounds per cubic foot, and does not have any exposed steel or reinforcing bars.

Construction Specifications

Culvert Inlet Protection:

1. After installation of a culvert, examine the stream channel for the amount of debris, logs, and brushy vegetation present. In channels with large amounts of debris, consider using oversized pipes.

2. Boulders should be dry-stacked around the culvert inlet and up the slope to the edge of the road.

Culvert outlet protection:

1. Prepare the sub-grade for the riprap to the required lines and grades. Any fill required in the sub-grade shall be compacted to a density of approximately that of the surrounding undisturbed material.

2. If a pipe discharges into a well-defined channel, the channel's side slopes may not be steeper than 2:1.

3. Construct apron to the design length and width with no slope. The invert elevations must be equal at the receiving channel and the apron's downstream end. No over-fall at the end of the apron of the apron is allowed. The elevation of the downstream and of the apron shall be equal to the elevation of the receiving channel or adjacent ground. The outlet protection apron shall be located so that there are no bends in the horizontal alignment.

4. If a culvert outlets at the top of cut/fills or on slopes steeper than 10 percent one of the following option is suggested:

5. Line slope below culvert outlet with a riprap channel to convey storm water to the bottom of the slope where a riprap apron, as designed above, shall prevent erosion at the bottom of the slope. The riprap channel shall be designed according to the table construction specification that is based on depth of flow and slope. The riprap channel shall dip into the slope so that all water is contained within the channel, flows to the riprap outlet apron at the base of the slope, and does not spill over the sides onto unprotected soil.

Maintenance Considerations

The frequency of inspection should be in accordance with the Storm Water Management Plan (SWMP). Inspect for debris at the entrance to culverts and within culverts. Inspect riprap at culvert inlets for damage and dislodged stones. The maintenance needs are usually very low for properly installed riprap aprons at culvert outlets. However, inspect for evidence of scour

beneath riprap at outlets aprons or for dislodged stones. Anything that is found to reduce the effectiveness of the culvert or culvert outlet protection should be repaired immediately.

References

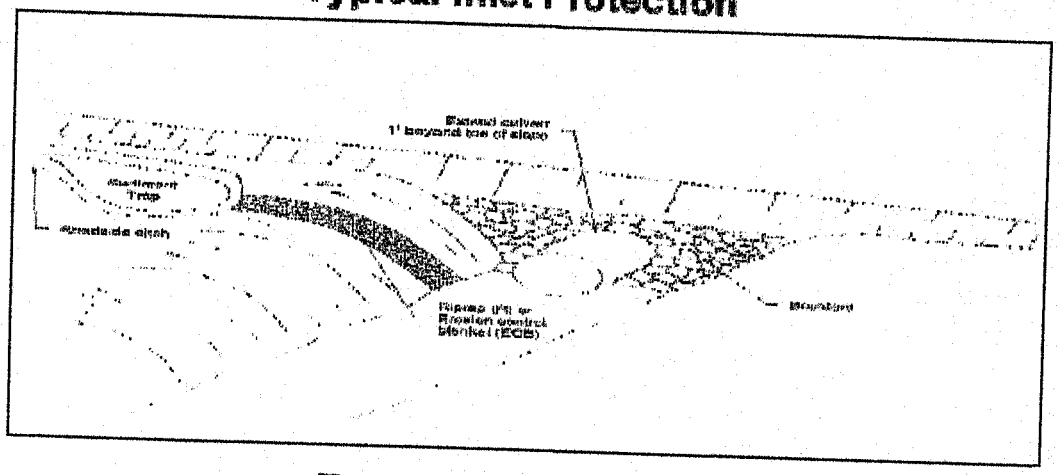
Keller, Gordon and James Sherar, *Low-Volume Roads Engineering, Best Management Practices Field Guide.* United States Department of Agriculture (USDA), Forest Service, US Agency of International Development (USAID), 2005. http://www.blm.gov/bmp/field%20guide.htm

New York State Department of Environmental Conservation, *New York Guidelinesfor Urban Erosion and Sediment Control.* New York. Forth Edition, 1997.http://www.dec.state.ny.us/website/dow/toolbox/escstandards

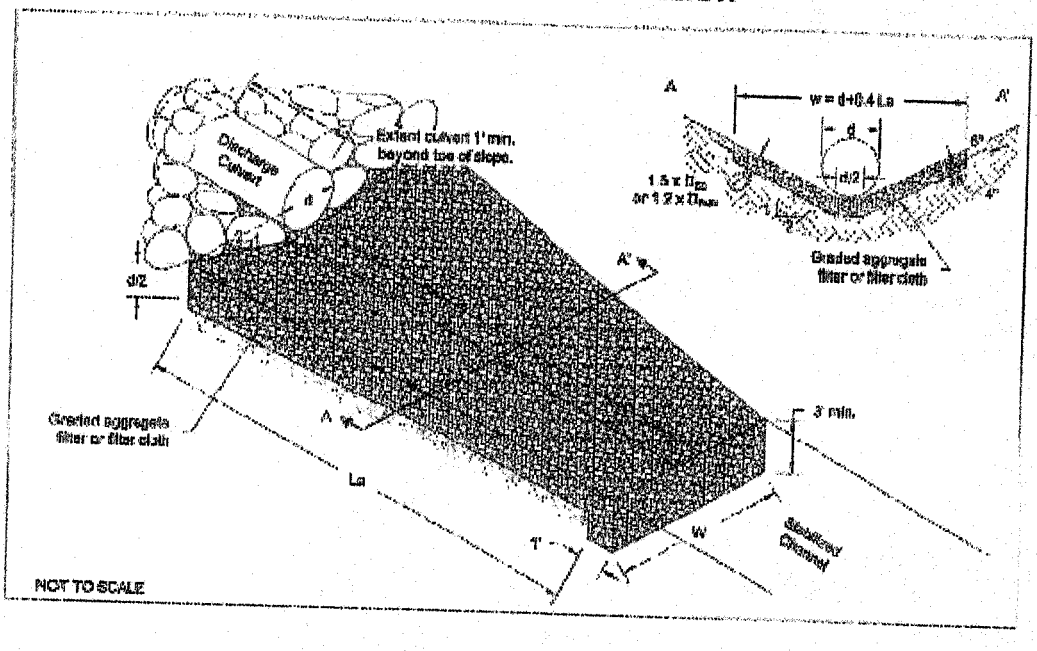
Riprap Aprons for Low Tailwater (downstream flow depth < 0.5 x pipe diameter)															
Culvert Diameter	Lowest Value			Intermediate values to interpolate from									Highest Value		
	Q	L_A	D_{50}	Q	L_A	D_{50}	Q	L_A	D_{50}	Q	L_A	D_{50}	Q	L_A	D_{50}
	Cfs	Ft	In	Cfs	Ft	In	Cfs	Ft	In	Cfs	Ft	In	Cfs	Ft	In
12"	4	7	2.5	6	10	3.5	9	131	6	12	16	7	14	17	8.5
15"	6.5	8	3	10	12	5	15	16	7	20	18	10	25	20	12
18"	10	9	3.5	15	14	5.5	20	17	7	30	22	11	40	25	14
21"	15	11	4	25	18	7	35	22	10	45	26	13	60	29	18
24"	21	13	5	35	20	8.5	50	26	12	65	30	16	80	33	19
27"	27	14	5.5	50	24	9.5	70	29	14	90	34	18	110	37	22
30"	36	16	6	60	25	9.5	90	33	15.5	120	38	20	140	41	24
36"	56	20	7	100	32	13	140	40	18	180	45	23	220	50	28
42"	82	22	8.5	120	32	12	160	39	17	200	45	20	260	52	26
48"	120	26	10	170	37	14	220	46	19	270	54	23	320	64	37

Riprap Aprons for High Tailwater (downstream flow depth > 0.5 x pipe diameter)															
Culvert Diameter	Lowest Value			Intermediate values to interpolate from									Highest Value		
	Q	L_A	D_{50}	Q	L_A	D_{50}	Q	L_A	D_{50}	Q	L_A	D_{50}	Q	L_A	D_{50}
	Cfs	Ft	In	Cfs	Ft	In	Cfs	Ft	In	Cfs	Ft	In	Cfs	Ft	In
12"	4	8	2	6	18	2.5	9	28	4.5	12	36	7	14	40	8
15"	7	8	2	10	20	2.5	15	34	5	20	42	7.5	25	50	10
18"	10	8	2	15	22	3	20	34	5	30	50	9	40	60	11
21"	15	8	2	25	32	4.5	35	48	7	45	58	11	60	72	14
24"	20	8	2	35	36	5	50	55	8.5	65	68	12	80	80	15
27"	27	10	2	50	41	6	70	58	10	90	70	14	110	82	17
30"	36	11	2	60	42	6	90	64	11	120	80	15	140	90	18
36"	56	13	2.5	100	60	7	140	85	13	180	104	18	220	120	23
42"	82	15	2.5	120	50	6	160	75	10	200	96	14	260	120	19
48"	120	20	2.5	170	58	7	220	85	12	270	105	16	320	120	20

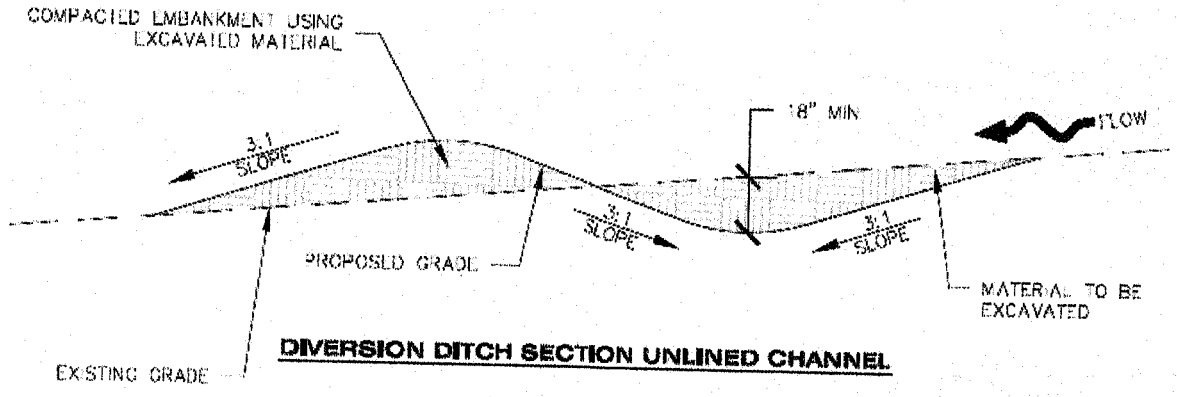
Typical Inlet Protection



Typical Outlet Protection



Diversion Ditch Embankment Bases or Midslopes (DD)



DIVERSION DITCH SECTION UNLINED CHANNEL

DIVERSION DITCH FOR EMBANKMENT BASES OR MIDSLOPES

Diversion Ditch Installation Notes

- See the Plan view for the location(s) of the diversion ditches.

- A plastic liner, riprap, or erosion control blanket may be necessary to protect the diversion ditch.

- All material excavated from the ditch shall be used to construct the berm on the downhill side of the ditch.

- The diversion ditch shall be a minimum of 18" deep with 3:1 side slopes. The adjacent berm shall be a minimum of 18" in height with 3:1 side slopes. All embankments shall be firmly compacted.

- The discharge from the diversion ditch shall be directed towards an appropriately sized and constructed slope drain, or sediment pond.

- In locations where construction traffic must cross a diversion ditch, the erosion control supervisor shall install a temporary culvert with a minimum diameter of 12".

Diversion Ditch Inspection and Maintenance Notes

- The erosion control supervisor shall inspect the diversion ditch at the following intervals:
    - Immediately following initial installation.
    - Every 14 days while the site is under construction.
    - Immediately following any storm event that causes soil erosion.
    - Once a month following the end of construction, until vegetative cover has reached a consistent density of at least 80% of full vegetative cover.

- Accumulated sediment shall be removed once the sediment has reached a depth equal to ¼ the crest height.

- Diversion ditches shall be re-graded immediately following any signs of soil erosion.

- Diversion ditches are to remain in place and properly maintained until vegetative cover has reached a consistent density of at least 80% of full vegetative cover and erosion and sedimentation is no longer a possibility as determined by the County inspector. In some instances, the diversion ditches may remain in place permanently.

- When diversion ditches are removed, excavation shall be filled with suitable compacted topsoil. The berm portion of the diversion ditch shall be graded out and any disturbed areas associated with the installation, maintenance, and/or removal of the diversion ditches shall be roughened, seeded, mulched, and crimped. An erosion control blanket may be used in lieu of straw mulch.