TERRA ENERGY PARTNERS

Piceance Basin Storm Water Manual of Best Management Practices (BMPs)
Revision 4
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1 Introduction

The primary purpose of this Storm Water Manual of BMPs is to provide Terra Energy Partners personnel, contractors, and subcontractors with information on the proper selection, design, installation, and management of Best Management Practices (BMPs) to manage oil and gas (O&G) related storm water and to meet federal and state Storm Water Management Plan (SWMP) requirements as well as Colorado Oil & Gas Conservation Commission (COGCC) post-construction storm water requirements. The BMPs found in this manual are operating practices used to control erosion, runoff, and sedimentation associated with storm water runoff from areas disturbed by clearing, grading, and excavating activities related to site preparation, construction, and operation of oil and gas production facilities. The BMPs were derived from both common industry practices and from practical field experience. Personnel responsible for storm water management, whether it be design, construction, maintenance, operation, or environmental compliance, should have a thorough knowledge of the applicable erosion and sediment control measures and the related specifications.

The main objectives of this manual are to:

1. Serve as an easy-to-use guide for selecting, designing, constructing, and maintaining BMPs.

2. Function as a reference for construction plans and specifications.

3. Ultimately lead to the avoidance of any net increase in off-site erosion and sedimentation of waters of the U.S. (see Section 2).

4. Provide a basis for field handbooks and training.

In the preparation of this document, emphasis was placed on the selection and practical application of BMPs, given a variety of basic physical circumstances. This document is provided as a tool to quickly evaluate which BMPs may be useful at a given construction or post-construction site, whether new or existing. This document anticipates that the user will be prudent and exercise good judgment in evaluating site conditions and deciding which BMP or combination of BMPs is to be used at a specific site. If the BMPs selected are not effective to prevent discharges of potentially undesirable quantities of sediment to a regulated water body, different or additional BMPs should be employed.

2 Determination of BMP Applicability

There are several physical conditions that can determine whether BMPs are applicable and if so, which BMPs will be effective at a given construction site. Two primary factors are the proximity to waters of the U.S. (regulated water body) and the amount of vegetative cover between the construction site and the regulated water body. Other physical considerations include the slope of the terrain, rainfall, and soil erodibility.

A regulated water body is any body of water that is subject to the U.S. Environmental Protection Agency's (EPA's) jurisdiction under the Clean Water Act. EPA's jurisdiction extends over "waters of the U.S." as defined in 33 CFR 328. The U.S. Army Corps of Engineers regulates the discharge of dredge and fill material into waters of the U.S. through a permit program under Section 404 of the Clean Water Act. The Corps jurisdiction over waters of the U.S. includes major rivers, streams, and creeks such as the Colorado River, Parachute Creek and Piceance Creek. Drainages and wetlands that are tributary or adjacent to waters of the U.S. such as Wheeler Gulch, Riley Gulch, Starkey Gulch, and Cottonwood Gulch are also typically considered by the Corps to be waters of the U.S. and within their jurisdiction.

Terra Energy Partners Piceance Basin O&G operations are primarily located north and east of Parachute, CO. Lower elevations at the site are categorized as deserts while higher elevations are categorized as xeric mountains. Common characteristics of deserts include slopes from 0 to 40%, shallow rocky or sandy soils with low erodibility, low vegetation cover, and low annual precipitation. Common characteristics of xeric mountains include slopes exceeding 10%, variable vegetation cover, shallow rocky soils with low to moderate erodibility, and low to moderate annual precipitation.

Although construction practices may be similar, Piceance Basin oil and gas well pad sites are quite different from conventional construction projects located in urban areas. The Denver metropolitan's Urban Drainage and Flood Control District (UDFCD) has identified a number of issues concerning urban stormwater. Urban runoff was identified as a significant source of stormwater pollutants including sediment, fecal indicator bacteria, nutrients, organic matter, and heavy metals (e.g., lead, zinc, cadmium). Sediment loading occurred regardless of the existence of major land disturbances causing erosion. In addition, nutrients from urban runoff were identified as an eutrophication concern for lakes and reservoirs. In addition to these pollutants, it has been reported that atmospheric fallout is a significant contributor to urban runoff pollution. Snow and ice management activities also affect the quality of urban runoff since snow and ice may be contaminated by hydrocarbons, pet waste, deicing chemicals and sand. Pollutant problems, therefore, multiply with increased urbanization.

Urban development typically involves the construction of permanent impervious surfaces such as parking lots, driveways, sidewalks and rooftops. In turn, peak runoff flows and runoff volumes increase and there is greater runoff frequency from each discrete precipitation event. Whereas only a few runoff events per year may occur prior to development, many runoff events per year may occur after urbanization. Each of these hydrologic changes can lead to increased pollutant transport and loading to receiving waters. As peak discharge rates increase, erosion and channel scouring become greater problems requiring the employment of enhanced BMPs. Urban storm water planning may also include provisions and BMP's to replicate historic runoff patterns to reduced or eliminate overloading of urban storm water infrastructure systems.

With regard to construction-phase stormwater runoff, U.S. Environmental Protection Agency (USEPA) reports sediment runoff rates from construction sites can be much greater than those from agricultural lands and forestlands, contributing large quantities of sediment over a short period of time, causing physical and biological harm to receiving waters (EPA 2005). The Federal Register, Vol. 64, No. 235, entitled National Pollutant Discharge Elimination System – Regulations for Revision of the Water Pollution Control Program Addressing Storm Water Discharges, dated December 1999, reported a number of findings of studies conducted in Virginia, Maryland, West Virginia, Hawaii and Wisconsin concluding, among other things, that sediment yields from construction sites can be orders of magnitude above pre-development levels.

In 2005, the USEPA awarded a grant to the City of Denton, Texas, to monitor and assess the impact of gas well drilling pad sites on stormwater runoff, and to provide, if necessary, regulatory and management strategies for these activities. The study compared sediment and pollutants yields from three well pads and two undisturbed, natural sites. The two reference sites were located in close proximity to the gas well sites, with one reference site described as relatively treeless densely vegetated tallgrass prairie dominated by little bluestem (Schizachyrium scoparium) and the other as rangeland covered with thickets of mesquite.

USEPA Study Areas
Precipitation Comparison*

State	Annual Precipitation inches
Virginia	43.3
Maryland	40.7
W.Virginia	44.0
Wisconsin	34.5
Hawaii (1)	37.1
Texas (2)	38.1
Average	**39.6**
Colorado (3)	**13.5**

(1) Island of Oahu
(2) Denton, TX
(3) Grand Valley, CO Weather Station
* Source: U.S. Climate Data (usclimatedata.com)

Unlike the USEPA study sites, referenced in the Federal Register, the Piceance Basin receives considerably less precipitation than the study sites. The Precipitation Comparison table indicates that the states, in which the study sites were located, receive on average 256% to 326% more annual precipitation than the Parachute/Grand Valley, CO site located in the Piceance Basin.

The availability and volume of precipitation affects plant growth, density and biomass. The Natural Resources Conservation Service (NRCS) soil survey provides estimates of site specific vegetative productivity or yield data measured in pounds per acre. Total range production, as defined by NRCS, is the amount of vegetation that can be expected to grow annually in a well-managed area that is supporting the potential natural plant community. It includes all vegetation, whether or not it is palatable to grazing animals.

It includes the current year's growth of leaves, twigs, and fruits of woody plants. It does not include the increase in stem diameter of trees and conditions are about average.

NRCS comparisons tables of range production from the USEPA's Denton, TX study site and a representative site in the Parachute/Grand Valley, CO area indicate the Texas site produces 657% to 844% more vegetation. This difference can be attributable to soil characteristics and, more explicitly precipitation volume.

Table—Range Production (Normal Year) (Parachute CO Reference Area Soils Report 4-26-16)

Range Production (Normal Year)— Summary by Map Unit — Rifle Area, Colorado, Parts of Garfield and Mesa Counties (CO683)				
Map unit symbol	**Map unit name**	**Rating (pounds per acre per year)**	**Acres in AOI**	**Percent of AOI**
35	Ildefonso-Lazear complex, 6 to 65 percent slopes		3.2	42.8%
57	Potts-Ildefonso complex, 3 to 12 percent slopes	533	4.3	57.2%
Totals for Area of Interest			**7.5**	**100.0%**

Table—Range Production (Normal Year) (Denton, TX Reference Area)

Range Production (Normal Year)— Summary by Map Unit — Denton County, Texas (TX121)				
Map unit symbol	**Map unit name**	**Rating (pounds per acre per year)**	**Acres in AOI**	**Percent of AOI**
56	Medlin-Sanger clay, 5 to 15 percent slopes	4500	1.4	18.3%
57	Medlin-Sanger stony clay, 5 to 15 percent slopes	4150	3.8	49.9%
75	Somervell gravelly loam, 1 to 5 percent slopes	3500	2.4	31.8%
Totals for Area of Interest			**7.6**	**100.0%**

Pre-development runoff characteristic from heavily vegetated areas, as associated with the USEPA reference studies, can be significantly different from the sparsely vegetated areas of the Parachute/Grand Valley, CO site as indicated in the NRCS range production data values. This is evidenced by vegetation cover types that are recognized in accepted rainfall runoff models as in runoff coefficient values in the Rational Method and in roughness coefficients in the Chezy-Manning open channel flow equation. Lawns, forests, meadows, and pastures runoff coefficients, for example, are differentiated with various runoff values in the Rational Method. Chezy-Manning roughness coefficients for channel flows vary between heavily vegetated weedy and clean channels.

The Colorado Department of Public Health and the Environment, through the Water Quality Control Commission's Regulation 61, relied partly upon and took specific note of the USEPA studies as part of its justification for implementing stormwater discharge permit regulations at oil and gas sites. The Gunnison Board of County Commissioners and the West Slope Water Network are listed as the only parties to the March 2005 rulemaking hearing.

As stated in the Statement of Basis during the March 2005 Rulemaking Hearing:
The Commission makes the following findings and conclusions regarding the requirements of section 25-8-202(8)(a). In making its determination, the Commission relied upon the entire record before it, but took specific note of the following evidence.

- *Evidence produced by Gunnison County demonstrated that, if not properly managed, discharges from construction activity can impact the biological, chemical and physical integrity of receiving waters. This evidence includes EPA's analysis of water quality impacts from small construction sites in general (FR Vol. 64, No. 235, 68724-68731) and evidence of potential water quality impacts from specific oil and gas construction sites in Colorado. Sediment yields from smaller construction sites are as high or higher than the 20 to 150 tons/acre/year measured from larger sites. Siltation is clearly a significant cause of impairment in water quality in rivers and lakes. EPA, Report to Congress on the Phase II Storm Water Regulations, EPA 833-R-99-001, October, 1999, pp. 1-4. The Commission regards sediment deposition as a significant problem affecting water quality in the state.*

- *Finally, Division staff stated that there are no significant differences in oil and gas construction sites versus other types of construction sites that would affect the potential sediment yield from such disturbed areas. Although the oil and gas industry has asked EPA to consider the short time frame for actual construction at most oil and gas sites, this does not take into account the time it can take (up to several years) for revegetation of disturbed areas in Colorado. <u>In addition, no evidence was presented that the potential impacts on public health, beneficial use of water or the environment from oil and gas construction activities are significantly different from other small construction sites so as to warrant special consideration.</u> Other small construction sites are already subject to the application deadline in the Commission's Regulation 61 to avoid adverse water quality impacts. EPA's postponement of the permitting deadline for oil and gas construction activity disturbing one to five acres, from March 10, 2005, to June 12, 2006 (70 Fed. Reg. 45, March 9, 2005) was not based on any concern that these sites pose any less threat to health, beneficial uses, or the environment than other small construction sites. The postponement was, instead, implemented in order to allow EPA to further evaluate (1) the economic impacts of the rule; (2) the legal and procedural implications associated with several options that the Agency is considering with regard to regulation of stormwater discharges from oil and gas-related construction sites; and (3) best* *management practices available to control stormwater discharges from these activities.*

The Terra Energy operational area is geographically and climatically different and distinct from urbanization issues and effects described by the UDFCD and the USEPA study sites. The construction or placement of impervious surfaces is negligible with oil and gas operations reducing the impact to peak runoff flows, runoff volume increases, and runoff frequency. Unlike urban runoff, construction associated with oil and gas operations has not been identified as a significant source of stormwater pollutants including fecal indicator bacteria, nutrients, organic matter, heavy metals (e.g., lead, zinc, cadmium), pet waste, deicing chemicals and sand. As reported, urban sediment loading occurred regardless of the existence of major land disturbances causing erosion with atmospheric fallout reported as significant contributor to urban runoff pollution.

Oil and gas well pad construction generally involves the clearing and earthen grading of the site with the development of little or no impervious surfaces. While cut and fill slopes are typical with well pad construction, large open, level pad areas are constructed and maintained for drilling activities and to meet production equipment setback distances between tanks, separators and wellheads. These large open level pad areas can be utilized for stormwater management. Storage tanks are placed in secondary containment structures capturing storm water precipitation and eliminating contributions to peak flows and volumes. Separation equipment is typically skid-mounted allowing precipitation to settle under the units.

For consideration of BMPs, this manual will be useful in determining which BMPs would be effective for the given circumstances. The above identified minimum distances were determined using the assumed general physical characteristics for either deserts or xeric mountains. If local conditions in the immediate area do not meet those for deserts or xeric mountains the user should use good judgment in the determination of BMP applicability and selection.

As promoted in the UDFCD's Urban Storm Drainage Criteria Manual: Volume 3 Best Management Practices, the use of several hydrologic processes are available to reduce peak runoff flows and surface runoff volumes. Terra Energy will, when appropriate, implement these strategies.

1. Flow Attenuation: BMPs that capture and slowly release the water quality capture volume (WQCV) help to reduce peak discharges. In addition to slowing runoff, volume reduction may also be provided to varying extents in BMPs providing the WQCV. Additionally, sediment loss associated with runoff may be reduced retaining soil for interim and permanent reclamation.

2. Infiltration: BMPs that infiltrate runoff reduce both runoff peaks and surface runoff volumes. The extent to which runoff volumes are reduced depends on a variety of factors such as whether the BMP is equipped with an underdrain and the characteristics and long-term condition of the infiltrating media. Examples

of infiltrating BMPs include (unlined) sand filters, bioretention and permeable pavements. Water quality treatment processes associated with infiltration can include filtration and sorption.

3. Evapotranspiration: Runoff volumes can be reduced through the combined effects of evaporation and transpiration in vegetated BMPs. Plants extract water from soils in the root zone and transpire it to the atmosphere. Evapotranspiration is the hydrologic process provided by vegetated BMPs, whereas biological uptake may help to reduce pollutants in runoff.

As shown in the Evaporation Table below, annual evaporation in the Parachute area exceeds annual precipitation by over 300%. At higher elevations, this number may be lower, however is will still exceed +200%. On a monthly basis, especially during the summer months, the evaporation rate can be over eight times the precipitation rate. The table below provides an overview of annual monthly evaporation and precipitation. The last column shows the evaporation / precipitation ratio or how much more evaporation exceeds precipitation. In all cases, evaporation is exceeding precipitation. Detention, along with subsequent evaporation may be utilized on the well pads through the use of sediment basins and berms to maximize evaporation.

Parachute, CO Area

NOAA Monthly Gross and Net Evaporation

	Monthly Evaporation Distribution[1] %	Gross Lake Evaporation[2] Prorated by Month 45.0 (in.)	Average Monthly Precipitation[3] (in.)	Net Evaporation (in.)	Evaporation/ Precipitation Ratio %
Jan	3.0	1.4	1.11	0.2	121.6
Feb	3.5	1.6	0.95	0.6	165.8
Mar	5.5	2.5	1.33	1.1	186.1
Apr	9.0	4.1	1.08	3.0	375.0
May	12.0	5.4	1.36	4.0	397.1
Jun	14.5	6.5	0.78	5.7	836.5
Jul	15.0	6.8	0.89	5.9	758.4
Aug	13.5	6.1	1.06	5.0	573.1
Sep	10.0	4.5	1.35	3.2	333.3
Oct	7.0	3.2	1.34	1.8	235.1
Nov	4.0	1.8	1.16	0.6	155.2
Dec	3.0	1.4	1.12	0.2	120.5
Total	**100.0**	**45.0**	**13.53**	**31.5**	**332.6**

(1) From the Colorado Division of Water Resources Guidelines for Substitute Water Supply Plans April 1, 2011.
(2) NOAA Technical Report NWS 33 - Map 3 'Free Water Surface Evaporation 1956 - 1970'
(3) Western Regional Climate Center - Grand Valley Weather Station

3 BMP Selection

If it has been determined that BMPs are applicable to the construction or post-construction site, the following steps should be followed in order to select the most appropriate BMP:

Step 1 – Area of Construction

In what type of area is the BMP required? Choose one of the following:

- Access roads
- Well pads (including any aerial disturbance such as compressors, plants, etc.)
- Pipelines

Step 2 – Stage of Construction

In what stage of construction will the BMP be installed? Choose one of the following:

- **Pre-construction** - Refers to all BMPs that could be implemented prior to commencement of construction on well pads, pipelines, and/or roads.
- **Construction** - Refers to all BMPs that could be implemented during/as part of the construction of well pads, pipelines, and/or roads.
- **Interim (Temporary) Reclamation -** Refers to all BMPs that could be implemented on completion of construction or during post-construction/operation for temporary reclamation of well pads and/or roads.
- **Final (Permanent) Reclamation -** Refers to all BMPs that could be implemented on completion of construction, during post-construction/operation OR on completion of any interim time period for permanent reclamation of well pads, pipelines, and/or roads.

Step 3 – Type of control

What is the primary purpose of the BMP and what will the BMP control? Choose from one of the following three main types of storm water control measures:

- **Erosion Control (EC)** – any source control practice that protects the soil surface and/or strengthens the subsurface in order to prevent soil particles from being detached by rain or wind, thus controlling raindrop, sheet, and/or rill erosion.

- **Runoff Control (RC)** – any practice that reduces or eliminates gully, channel, and stream erosion by minimizing, diverting, or conveying runoff.

- **Sediment Control (SC)** – any practice that traps the soil particles after they have been detached and moved by wind or water. Sediment control measures are usually passive systems that rely on filtering or settling the particles out of the water or wind that is transporting them prior to leaving the site boundary.

Step 4 – BMP selection

Which BMP will be used? Once the area of construction, stage of construction, and type of control are determined (steps 1 through 3), use the BMP Matrix (Figures 1, 2, and 3, below) to find suggested BMP alternatives. Each BMP is also numbered, which corresponds to a fact sheet. A fact sheet is a short document that gives all the information about a particular BMP. Typically, each fact sheet contains the following information:

- Description
- Applicability
- Limitations
- Design Criteria
- Construction Specifications
- Maintenance Considerations
- Removal/Abandonment
- References

The applicability section in each fact sheet contains information on specific site characteristics (such as slope and drainage area) where that BMP may be used. Determination of which BMP or combination of BMPs to install should ultimately be decided after reviewing the BMP applicability section.

4 BMP Implementation

Once this manual has been used to choose specific BMPs, each control should be incorporated into a site-specific plan drawing. Each BMP has a number/identifier (i.e. SC-2 for Silt Fence) that may be used on plan drawings to represent that BMP at the desired location of installation. The BMP name is also acceptable on the plan drawings.

The design criteria section in each BMP fact sheet should be used to properly locate and size each control (some controls may not require a formal design). The construction requirements and installation figures should then be used in the field to properly install the control with the appropriate materials and methods of construction and at the location indicated on the site-specific plan drawings. It is important to note that minor deviations from the construction specifications are acceptable as long as performance oriented specifications are maintained. For example, the performance oriented specification for a wattle is that sediment is not observed on the down gradient side of the wattle.

5 Inspection and Maintenance

All BMPs must be properly inspected and maintained throughout the life of the entire operation according to the "Maintenance Considerations" section in each BMP fact sheet. In general, the maintenance program should provide for inspection of BMPs in accordance with the SWMP. The inspection should include repair or replacement of the BMPs, where needed, to ensure effective and efficient operation.

6 References

California Stormwater Quality Association, *Stormwater Best Management Practice (BMP) Handbook – Construction.* January, 2003. <http://www.cabmphandbooks.com/Construction.asp>

City of Knoxville, Stormwater Engineering, *Knoxville BMP Manual - Best Management Practices*. July 2003. <http://www.ci.knoxville.tn.us/engineering>

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SC-6 Sediment Trap (ST)

Description

Sediment traps are small ponding areas that allow sediment to settle out of runoff water. They are usually installed in a drainage way or other point of discharge from a disturbed area. Diversion ditches can be used to direct runoff to the sediment trap. Sediment traps are formed by excavating below grade and/or by constructing an earthen embankment.

Applicability

Sediment traps are generally temporary control measures used at the outlets of storm water diversion structures, channels, slope drains, or any other runoff conveyance that discharges waters containing erosion sediment and debris. Sediment traps may also be used at the inlets to culverts. Each sediment trap should be used for a drainage area less than five acres, however multiple sediment traps may be constructed in series for larger areas or areas with larger expected flows.

Limitations

- Although sediment traps allow for settling of eroded soils, because of their short detention periods for storm water they typically do not remove fine particles such as silts and clays.

- Water will remain in trap for extended periods.
- Never construct a sediment trap on a flowing stream or in wetlands.
- Unless no other options exist, sediment traps should not be constructed in ephemeral draws where the BMP will trap natural run-off along with construction site stormwater.

Design Criteria

Location

Traps are typically located at points of discharge from disturbed areas. The location will be determined by the natural terrain, drainage pattern of the runoff, and the accessibility for maintenance. Sediment traps should not be located in areas where their failure due to storm water runoff excess can lead to further erosive damage of the landscape. Alternative diversion pathways may be designed to accommodate these potential overflows.

Storage Capacity

Sediment traps shall be sized to accommodate site runoff volumes resulting from the 2-year 24-hour precipitation event as provided by regional NOAA Precipitation Atlases and calculated from the Rational Method. From the table below, the sediment trap volume has been calculated by multiplying its tributary disturbed area in acres by the runoff volume for the appropriate runoff coefficient and adding 15% for sediment accumulation. A sediment trap should be designed to maximize surface area for infiltration and sediment settling. This will increase the effectiveness of the trap and decrease the likelihood of backup during and after periods of high runoff intensity. Half of the storage volume shall be in the form of wet storage or a permanent pool. The other half shall be in the form of dry storage. When possible, the wet storage volume should be contained within the excavated portion of the trap. The volume of each sediment trap should be based on site conditions and available space.

A sediment trap can be utilized as a SC-10 Water Quality Capture Detention Area and may be designed to maximize surface area for infiltration, evaporation and sediment settling. If the sediment trap is to be utilized as a WQCDA, the minimum trap depth can be computed with:

Minimum Depth (ft.) = (Surface Area of the WQCDA + Tributary Runon Surface Area) / Surface Area of the WQCDA x 1.2 inches / 12 inches/foot + 0.5 ft. (freeboard & sediment)

Where:
Area = square feet (one acre = 43560 square feet)
NOAA Atlas 2, Vol III reports the 2-yr 24-hr precipitation for Northwest Colorado to be 1.2 inches
Cut slopes do not require a berm.

Runoff Volume Estimates Using the Rational Method for Northwest Colorado

Runoff Coefficient	Area (Acres)	2-year 24-hour Rainfall Intensity[1] (Inches/hour)	Peak Flow[2] (cfs)	Estimated Runoff Volume[3] (ft.3)
0.3	1	0.05	0.015	1296
0.4	1	0.05	0.02	1728
0.5	1	0.05	0.025	2160
0.6	1	0.05	0.03	2592
0.7	1	0.05	0.035	3024

(1) NOAA Atlas 2, Vol III reports the 2-yr 24-hr precipitation for Northwest Colorado to be 1.2 inches .

(2) Peak Flow using Rational Method: Q = C x I X A

where C = runoff coefficient; I = rainfall in inches/hour; A = tributary area in acres

(3) Runoff Volume = Peak flow in cfs x Storm Duration in seconds

Example: Sediment Trap as a WQCDA

Sediment Trap Surface Area (WQCDA): 50 ft. long by 6 ft. wide = 300 square feet
Tributary Runon Area : 0.25 acres = 0.25 acre x 43560 square ft./acre = 10980 sq. ft.

Minimum Depth (ft.) = (300 + 10980) / 300 x 1.2 / 12 + 0.5
= 11280 / 300 x 0.1 + 0.5
= 3.76 + 0.5
Minimum Depth (ft.) = 4.26 ft.

Construction Specifications

See Figure SC-6-1 and SC-6-2 for installation details.

1. If possible, sediment traps, along with other perimeter controls, shall be installed before any land disturbance takes place in the drainage area.

2. Area under embankment shall be cleared, grubbed and stripped of any vegetation and root mat. The pool area shall be cleared.

3. The fill material for the embankment shall be free of roots and other woody vegetation as well as over-sized stones, rocks, organic material or other objectionable material. The embankment shall be compacted by traversing with equipment while it is being constructed.

4. A spillway or slope drain may be utilize to drain the sediment trap. Slope drain pipe diameter sizes may be determined using the slope drain sizing table below. Should a spillway be desired, the spillway shall be compacted and lined with coarse angular aggregate/riprap, or local adequately sized rock to provide for filtering/detention capability and to prevent erosion of the spillway. The spillway may alternately be constructed with a small section of pipe or may consist of a level spreader, where the entire embankment is constructed at a uniform elevation. The spillway weir for each sediment trap should be at least four feet long for a 1-acre drainage area and increase by 2 feet for each additional drainage acre added, up to a maximum drainage area of 5 acres.

Pipe Slope Drains Sizing Table

Diameter inches	Estimated Flow Capacity* cfs
4	0.28
6	0.84
8	1.7
10	2.89
12	4.45
15	8.07
18	11.82
24	25.48

*Based on Chezy Manning open channel flow equation with a minimum slope of 3% for corrugated & smooth walled pipe.

5. If necessary, a geotextile may be placed at the stone-soil interface to act as a separator.

Maintenance Considerations

Inspection frequency shall be in accordance with the Storm Water Management Plan. The primary maintenance consideration for temporary sediment traps is the removal of accumulated sediment from the basin. Sediments should be removed when the basin reaches approximately 50 percent sediment capacity. A sediment trap should be inspected, according to the Stormwater Management Plan. Inspectors should also check the structure for damage from erosion. The depth of the spillway should be checked and maintained below the low point of the trap embankment.

Removal/Abandonment

The structure may or may not be removed when the drainage area has been properly stabilized.

References

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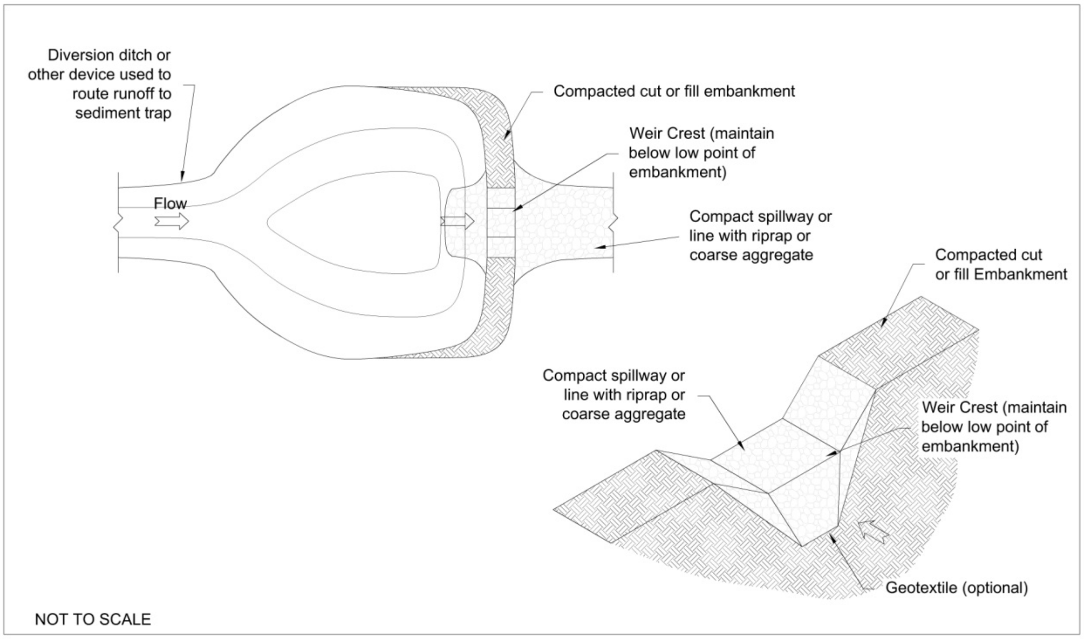
Figure SC-6-1
Sediment Trap Installation



Minimum trap volumes (ft.^{3})

0.25 ac.	0.5 ac	0.75 ac.	1.0 ac.
(373 ft.^{3})	(745 ft.^{3})	(1118 ft.^{3})	(1490 ft.^{3})

Figure SC-6-2
Diversion Ditch as Sediment Trap

Diversion Ditch As Sediment Trap Volume Computations
(ft.^{3})

2 ft. Wide Bottom Ditch with 1:1 Sideslopes

Length (ft.)	Depth (in.) 12	18	24	30	36	42	48
10	30	53	80	113	150	193	240
15	45	79	120	169	225	289	360
20	60	105	160	225	300	385	480
25	75	131	200	281	375	481	600
30	90	158	240	338	450	578	720
35	105	184	280	394	525	674	840
40	120	210	320	450	600	770	960
50	150	263	400	563	750	963	1200
60	180	315	480	675	900	1155	1440
70	210	368	560	788	1050	1348	1680
80	240	420	640	900	1200	1540	1920
90	270	473	720	1013	1350	1733	2160
100	300	525	800	1125	1500	1925	2400
110	330	578	880	1238	1650	2118	2640
120	360	630	960	1350	1800	2310	2880
130	390	683	1040	1463	1950	2503	3120
140	420	735	1120	1575	2100	2695	3360
150	450	788	1200	1688	2250	2888	3600
160	480	840	1280	1800	2400	3080	3840
170	510	893	1360	1913	2550	3273	4080
180	540	945	1440	2025	2700	3465	4320
190	570	998	1520	2138	2850	3658	4560
200	600	1050	1600	2250	3000	3850	4800

3 ft. Wide Bottom Ditch with 1:1 Sideslopes

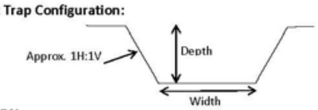
Length (ft.)	Depth (in.) 12	18	24	30	36	42	48
10	40	68	100	138	180	228	280
15	60	101	150	206	270	341	420
20	80	135	200	275	360	455	560
25	100	169	250	344	450	569	700
30	120	203	300	413	540	683	840
35	140	236	350	481	630	796	980
40	160	270	400	550	720	910	1120
50	200	338	500	688	900	1138	1400
60	240	405	600	825	1080	1365	1680
70	280	473	700	963	1260	1593	1960
80	320	540	800	1100	1440	1820	2240
90	360	608	900	1238	1620	2048	2520
100	400	675	1000	1375	1800	2275	2800
110	440	743	1100	1513	1980	2503	3080
120	480	810	1200	1650	2160	2730	3360
130	520	878	1300	1788	2340	2958	3640
140	560	945	1400	1925	2520	3185	3920
150	600	1013	1500	2063	2700	3413	4200
160	640	1080	1600	2200	2880	3640	4480
170	680	1148	1700	2338	3060	3868	4760
180	720	1215	1800	2475	3240	4095	5040
190	760	1283	1900	2613	3420	4323	5320
200	800	1350	2000	2750	3600	4550	5600

4 ft. Wide Bottom Ditch with 1:1 Sideslopes

Length (ft.)	Depth (in.) 12	18	24	30	36	42	48
10	50	83	120	163	210	263	320
15	75	124	180	244	315	394	480
20	100	165	240	325	420	525	640
25	125	206	300	406	525	656	800
30	150	248	360	488	630	788	960
35	175	289	420	569	735	919	1120
40	200	330	480	650	840	1050	1280
50	250	413	600	813	1050	1313	1600
60	300	495	720	975	1260	1575	1920
70	350	578	840	1138	1470	1838	2240
80	400	660	960	1300	1680	2100	2560
90	450	743	1080	1463	1890	2363	2880
100	500	825	1200	1625	2100	2625	3200
110	550	908	1320	1788	2310	2888	3520
120	600	990	1440	1950	2520	3150	3840
130	650	1073	1560	2113	2730	3413	4160
140	700	1155	1680	2275	2940	3675	4480
150	750	1238	1800	2438	3150	3938	4800
160	800	1320	1920	2600	3360	4200	5120
170	850	1403	2040	2763	3570	4463	5440
180	900	1485	2160	2925	3780	4725	5760
190	950	1568	2280	3088	3990	4988	6080
200	1000	1650	2400	3250	4200	5250	6400

Applicability: Sediment traps constructed with track hoe equipment.

Sediment Trap Configuration:



Instructions:

1. Select the appropriate bottom width table.
2. Select the tributary drainage area flowing into the sediment trap.

The acreages are coded by color with minimum trap volumes (ft.^{3}) provided below:

0.25 ac.	0.5 ac	0.75 ac.	1.0 ac.
(373 ft.^{3})	(745 ft.^{3})	(1118 ft.^{3})	(1490 ft.^{3})

3. Select any of the corresponding depths and length that fit the color code.

Example: Tributary area to the sediment trap is approximately 0.75 acres
Given: My equipment can dig a 3 ft. wide ditch.

Answer: Use the 3 ft. Wide Bottom Ditch table above & select a yellow box. You can select any of the yellow corresponding depths and lengths. There are several choices. If select 1260 then your sediment trap should be at least 36 inches deep and 70 ft. long or choice 1148 and use 18 inches deep and 170 ft. length.

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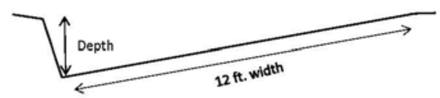
Figure SC-6-3
Diversion Ditch as Sediment Trap

Diversion Ditch As Sediment Trap - Volume Computations

Ditch Length (ft.)	Sediment Trap Volumes (ft.3) Depth (in.) 12	18	24
10	60	90	120
15	90	135	180
20	120	180	240
25	150	225	300
30	180	270	360
35	210	315	420
40	240	360	480
50	300	450	600
60	360	540	720
70	420	630	840
80	480	720	960
90	540	810	1080
100	600	900	1200
110	660	990	1320
120	720	1080	1440
130	780	1170	1560
140	840	1260	1680
150	900	1350	1800
160	960	1440	1920
170	1020	1530	2040
180	1080	1620	2160
190	1140	1710	2280
200	1200	1800	2400
210	1260	1890	2520
220	1320	1980	2640
230	1380	2070	2760
240	1440	2160	2880
240	1440	2160	2880
260	1560	2340	3120
270	1620	2430	3240
280	1680	2520	3360
290	1740	2610	3480
300	1800	2700	3600

Applicability: Sediment traps constructed with motor grader equipment.
(With Standard 12 ft. Wide Motor Grader Blade)

Sediment Trap Cross-Section Configuration:



Instructions:

1. Select the tributary drainage area flowing into the sediment trap.
The acreages are coded by color with minimum trap volumes (ft.3) provided below:

0.25 ac.	0.5 ac	0.75 ac.	1.0 ac.
(373 ft.^{3})	(745 ft.^{3})	(1118 ft.^{3})	(1490 ft.^{3})

2. Select the corresponding depths and lengths that fit the color code.

Example: Tributary area to the sediment trap is approximately 0.50 acres
Given: Motor Grader to cut a depth of 18 inches.

Answer: From the Table, select the green box in the 18 inch column. Move to the left of that green box and you will see the corresponding ditch length is 90 ft. The sediment trap ditch should be a minimum of 90 ft. long and 18 inches deep.

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