

Source: Caltrans Construction Site Best Management Practices Manual, 2003.

Description Seeding and planting of trees, vines, shrubs, and ground cover for temporary or permanent stabilization of soil.

Applications Soil stabilization during or after the construction phase applies to the following site conditions:

- Graded/cleared areas without on-going construction activity;
- Open space and fill areas;
- Steep slopes;
- Spoil piles or temporary stockpile of fill material;
- Vegetated swales;
- Landscape corridors; and
- Stream banks.

Installation and Implementation Requirements Requirements for each seeding/planting application shall be considered and include:

- Type of vegetation;
- Site and seedbed preparation;
- Seasonal planting times;
- Fertilization; and
- Water.

Grasses

- Ground preparation requires fertilization and mechanical stabilization of the soil.
- Short-term temperature extremes and waterlogged soil conditions tolerable.

Installation and Implementation Requirements (Continued)

- Appropriate soil conditions include a shallow soil base, good drainage, and 2:1 or flatter slope.
- Quickly develops from seeds.
- Vigorous grass growth dependent on mowing, irrigating, and fertilizing.

Trees and Shrubs

- Selection dependent on vigor, species, size, shape, and potential wildlife food source.
- Consider wind/exposure and irrigation requirements.
- Use indigenous species where possible.

Vines and Ground Cover

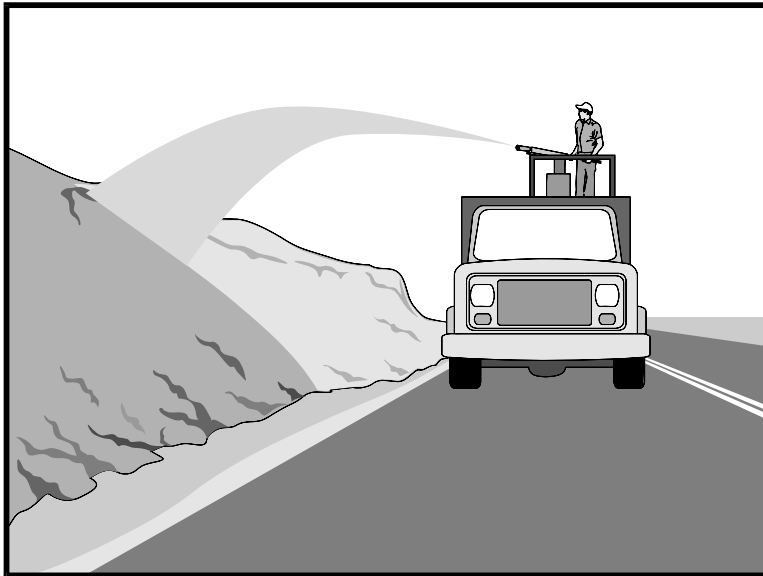
- Lime and fertilizer required for ground preparation.
- Use appropriate seeding rates.
- Consider requirements for drainage, acidity, and ground slope.
- Use indigenous species where possible.
- Avoid species which require irrigation.

Limitations

- During dry periods without irrigation, permanent and temporary vegetation may not be appropriate.
- Improper application of fertilizer may contribute to storm water pollution.

Inspections and Maintenance

Monitor vegetation growth and water, fertilize, mow, and/or prune the grasses/plants as needed.



Source: Caltrans Construction Site Best Management Practices Manual, 2003.

Description

Application of loose bulk material to stabilize disturbed soil by protecting bare soil, increasing infiltration, and reducing runoff. Materials used for mulching include green material, hydraulic matrices, hydraulic mulches of recycled paper or wood fiber, stone and aggregate, vegetable fibers (hay or straw), and wood/bark chips.

Applications

- Temporary ground cover until permanent vegetation has been established.
- Method used in combination with temporary or permanent seeding to enhance plant growth.
- Areas requiring soil moisture retention to prevent cracking of the soil.
- Ground cover for exposed soil between trees or shrubs.

Installation and Implementation Requirements

VEGETABLE FIBERS (HAY OR STRAW)

- Loose hay or straw which may be used in combination with seeding. Mulching usually follows seeding and the process is described in the following:
 - Apply seed and fertilizer to bare soil;
 - Apply loose hay or straw over top of seed and fertilizer prior to seed germination. Apply at a rate of 2,000 pounds per acre by machine or hand distribution;
 - Evenly distribute mulch on the soil surface to cover 80% to 90% of the ground;
 - Maintain maximum fiber length. Average fiber length shall be greater than 6 inches;

Installation and Implementation Requirements (Continued)

- Use a tackifier, netting, or mechanical “punching” method to anchor mulch. Method depends on slope steepness, accessibility, soil conditions, and longevity; and
- “Punching” straw or hay into soil is the preferred method of anchoring mulch for the following conditions:
 - Use a spade or shovel on small areas,
 - Use a knife-blade roller or straight bladed coulter (“crimper”) on slopes with soil, which can support construction equipment without undesirable compaction or instability,
 - Use plastic netting or jute on small areas and/or steep slopes. Geotextile pins, wooden stakes, or 11 gauge wire staples shall secure netting in place. This condition warrants consideration of the use of matting rather than mulch, and
 - Use tackifiers on steep slopes unable to support construction equipment or large application areas where use of nettings, straw, or hay is not cost-effective. Tackifiers glue vegetable fibers together and to the soil surface until the establishment of permanent vegetation.

GREEN MATERIAL

- Consists of recycled vegetation trimmings such as grass and shredded shrubs and trees.
- Generally applied by hand.
- Temporary ground cover with or without seeding.
- Evenly distribute green material on soil surface. Depth shall not exceed 4 inches.
- Anchor with a tackifier or netting on steep slopes or for areas with anticipated overland sheet flow. This condition warrants consideration of the use of matting rather than mulch.

WOOD/BARK CHIPS

- Suitable for areas which will not be mowed such as around trees, shrubs, and landscape plantings.
- Test soils prior to application. Add a minimum of 12 pounds of nitrogen per ton of mulch to counteract the effect of decomposing wood-based materials, which extract nitrogen from soil. Use a balanced, slow-release fertilizer or an organic source such as compost.
- Apply mulch by hand.
- Evenly distribute wood/bark chips on soil surface and maintain a mulch depth of 2-inch to tree basins and 4-inch to shrub beds.

HYDRAULIC MULCHES OF RECYCLED PAPER

- Consists of recycled newsprint, magazines, and other waste paper sources.
- May be applied with or without tackifiers.

Installation and Implementation Requirements (Continued)

- Hydraulic mulch materials shall conform to *2005 Hawaii Standard Specifications for Road and Bridge Construction*.
- Mix mulch in a hydraulic application machine (hydroseeder) and apply as a liquid slurry.
- May be sprayed from a cannon up to 200 feet or from a hose up to 1,500 feet away from the application area.
- Mix mulch with seed and fertilizer as specified by the manufacturer. Apply mulch at the manufacturer's recommended rate to ensure uniform, effective coverage.

HYDRAULIC MULCHES OF WOOD FIBER

- Consists of wood waste from lumber mills or urban sources.
- May be manufactured with or without a tackifier.
- Hydraulic mulch shall conform to *2005 Hawaii Standard Specifications for Road and Bridge Construction* or comply with the following requirements:
 - 100% wood fiber;
 - Maximum moisture content (total weight basis) shall not exceed 12% \pm 3%;
 - Minimum organic matter content (oven dry weight basis) of 99.3%;
 - Maximum inorganic matter (ash) content (oven dried basis) of 0.7%;
 - pH of 4.9 \pm 10% for a 3% water slurry; and
 - Minimum water holding capacity (oven dried basis) of 1.2 gallons per pound of fiber.
- Mix mulch in a hydraulic application machine (hydroseeder) and apply as a liquid slurry.
- Mix mulch with seed and fertilizer as specified by the manufacturer. Apply mulch at the manufacturer's recommended rate to ensure uniform, effective coverage.

HYDRAULIC MATRICES

- Hydraulic slurries consisting of wood fiber, paper fiber, or a combination of wood and paper fiber mixed with a binder system.
- Exceeds erosion control performance of blankets due to close contact with soil.
- Apply as an aqueous slurry (with seed) using standard hydroseeding equipment.
- Applications rates vary for different combinations of conditions and products.
- A typical mixture based on one acre of treated area includes the following:
 - 500 pounds wood fiber mulch;
 - 1,000 pounds recycled paper mulch; and

Installation and Implementation Requirements (Continued)

- 55 gallons acrylic copolymer with a minimum solids content of 55%.
- Bonded Fiber Matrix (BFM) consists of premixed fiber and binders.
 - After application and upon drying, BFM shall adhere to soil and form a 100% cover. The cover shall be biodegradable, promote vegetation, and prevent soil erosion.
 - Composed of long strand, thermally produced wood fibers (>88% of total volume by weight), held together by organic tackifiers (10%) and mineral bonding agents (<2%), which become insoluble and non-dispersible upon drying. Composition of BFM varies based on supplier.
 - Perform a free liquid quality control test on the liquid slurry.
 - Binder shall not dissolve or disperse upon watering.
 - Upon application to the soil, holes in the matrix shall not exceed 0.04 inches in size.
 - There shall not be any gaps between the matrix and the soil.
 - Minimum water holding capacity of the matrix shall be 1.2 gallons per pound matrix.
 - The matrix shall be free of germination or growth inhibiting factors and shall not form a water resistant crust.
 - Materials used for the matrix shall be 100% biodegradable and 100% beneficial to plant growth.
 - Testing and evaluation of the matrix by an independent research laboratory shall have been conducted to verify reported erosion control performance.
 - A trained and manufacturer certified applicator with knowledge of proper mixing and product application shall install the BFM.
 - Typical BFM application rates range from 3,000 to 8,000 pounds per acre per recommendations from various manufacturers.
 - BFM shall not be applied immediately before, during, or after a rainfall event to ensure a drying time of 24 hours after installation.
- Mulch used as temporary ground cover shall be reapplied to bare areas until permanent vegetation has been established.
- Avoid spraying mulch onto sidewalk, lined drainage channels, travelway, and existing vegetation.

Limitations

VEGETABLE FIBERS (HAY OR STRAW)

- Require three-step machinery.
- Labor intensive installation.
- Weed seeds and undesirable plant material may be introduced to sensitive areas.

Limitations (Continued)

- For applications using straw blowers, the applicable area must be located within 150 feet of a road or surface capable of supporting loads from large vehicles. If both hay and straw are available, it is preferable to use straw.

GREEN MATERIAL

- Limited commercial availability.
- Variable quality.
- Weeds or undesirable plant material may be introduced to the mulched area.
- Application primarily uses manual labor.
- Unpredictable effectiveness as an erosion control measure. Requires overspray with a tackifying agent to increase effectiveness.
- Application of fertilizer may be required.
- Limit use to non-critical steep slopes and areas where alternative erosion control measures may be readily applied.

WOOD/BARK CHIPS

- Poor erosion control effectiveness.
- Anchoring of chips onto steep slopes is difficult due to potential movement from high winds.
- Subject to displacement from concentrated flows.
- Use of a fertilizer with high nitrogen content is required to prevent nutrient deficiency in plants due to decomposing wood-based materials, which extract nitrogen from soil. Improper fertilizer use may contribute to water quality pollution.
- Limit use to non-critical steep slopes and areas where alternative erosion control measures may be readily applied.

HYDRAULIC MULCHES OF RECYCLED PAPER

- Limited erosion control effectiveness due to short fiber length and absence of a tackifier.
- Limited moisture and soil temperature moderation.
- Residual inks within mulches may be undesirable in environmentally sensitive areas.
- Significant decrease in longevity compared with wood fiber mulch.
- Difficulty budgeting for this product due to volatile prices for recycled paper products.

HYDRAULIC MULCHES OF WOOD FIBER

- Limited erosion control effectiveness.
- Short-term use of one growing season.

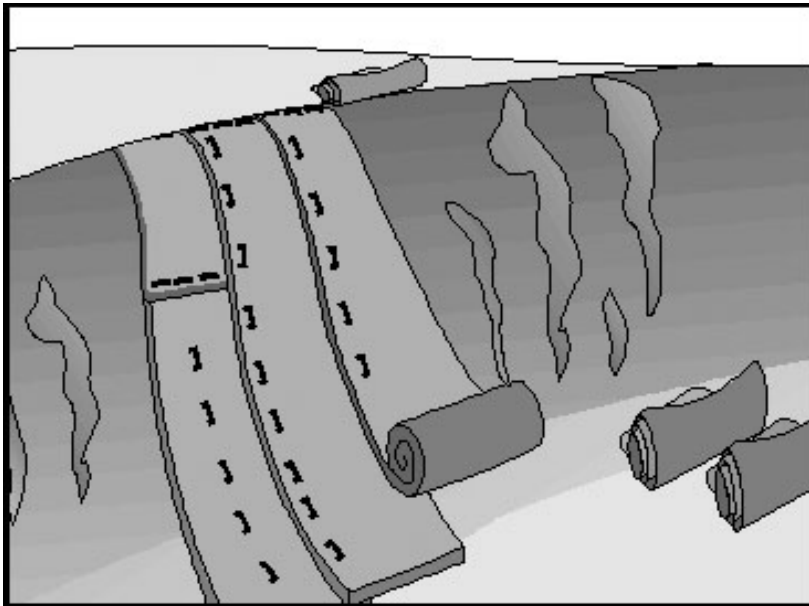
Limitations (Continued)

HYDRAULIC MATRICES

- Avoid application of mulch immediately before, during, or after a rainfall event.
- Requires drying time of 24 hours.

Inspections and Maintenance

- Mulches applied to seeded areas may be disturbed due to wind or runoff. Recover exposed areas until permanent vegetation has been established.
- Mulches applied to areas, which will be regraded and revegetated, shall be inspected weekly.
- Replace ornamental and landscape mulches of bark or wood chips if soil is visible in more than 75% of the designated area.



Source: Caltrans Construction Site Best Management Practices Manual, 2003.

Description

Natural or synthetic mats to be used for temporary or permanent soil stabilization.

Applications

- Drainage ditches, channels, and stream banks.
- Steep slopes.

Installation and Implementation Requirements

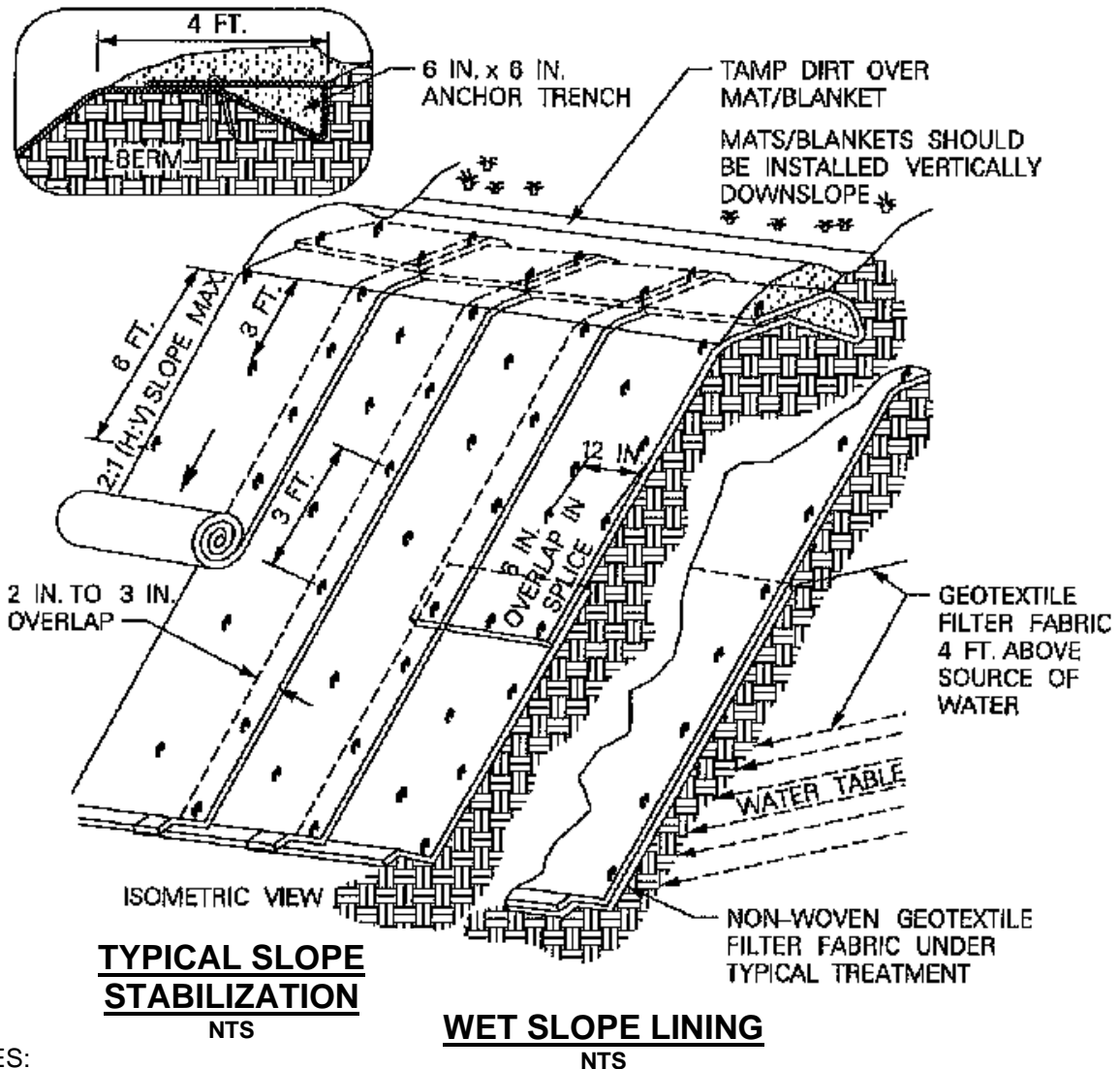
- Apply matting to disturbed soils and areas where vegetation has been removed.
- Organic matting provides temporary protection until permanent vegetation has been established, optimal weather conditions occur, or construction delays are resolved. Organic matting materials include the following:
 - Jute matting; and
 - Straw matting.
- Synthetic matting provides temporary or post-construction soil stabilization in both vegetated and non-vegetated areas. Synthetic matting materials include the following:
 - Excelsior™ matting;
 - Glass fiber matting;
 - Staples; and
 - Mulch netting.
- Other proprietary devices may be used and shall be installed per manufacturer's recommendations.

Limitations

- Minimize use of matting to areas where other erosion control measures are not applicable such as channels or steep slopes since matting is more costly compared to other erosion control measures.
- Seed germination may be delayed due to decreased soil temperature.
- An experienced maintenance engineer is required during installation.

Inspections and Maintenance

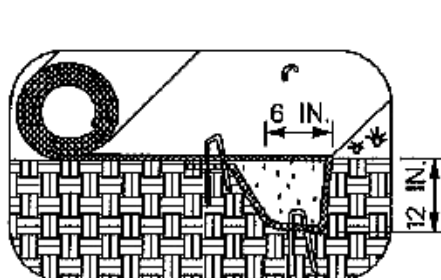
Periodically inspect matting after installation.



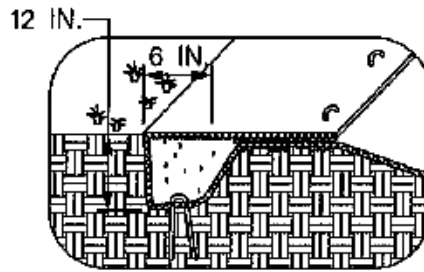
NOTES:

1. SLOPE SURFACE SHALL BE FREE OF ROCKS, CLODS, STICKS, AND GRASS. SOIL CONTACT SHALL BE MAXIMIZED.
2. LAY BLANKETS LOOSELY AND STAKE OR STAPLE TO MAINTAIN DIRECT CONTACT WITH THE SOIL. DO NOT STRETCH.
3. INSTALLATION MAY VARY ACCORDING TO MANUFACTURER'S RECOMMENDATIONS.

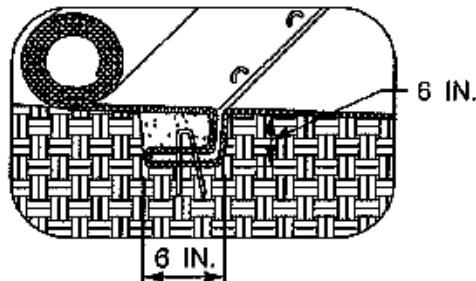
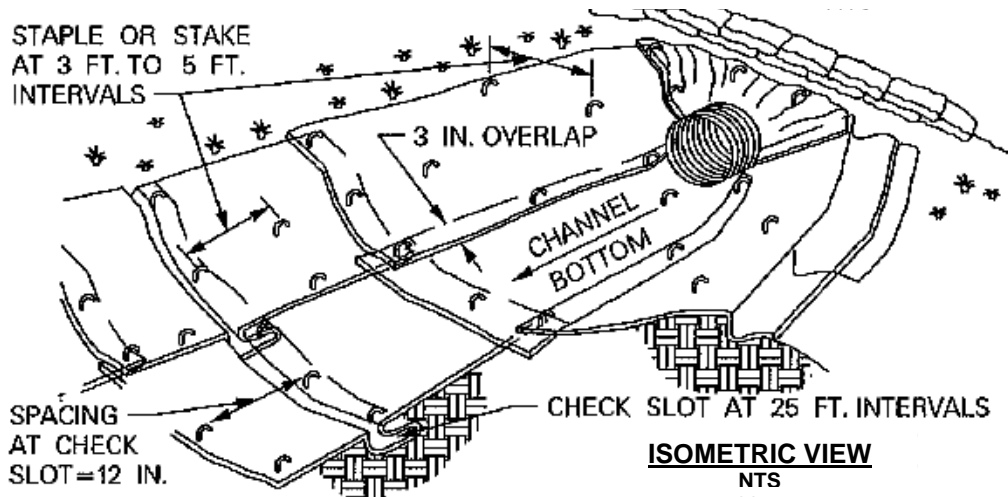
GEOTEXTILES AND MATS INSTALLATION DETAIL



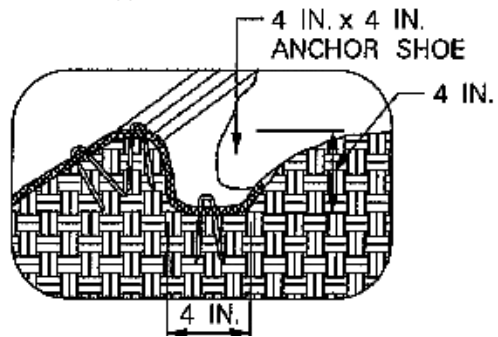
**INITIAL CHANNEL
ANCHOR TRENCH**
NTS



**TERMINAL SLOPE AND CHANNEL
ANCHOR TRENCH**
NTS



**INTERMITTENT
CHECK SLOT**
NTS



**LONGITUDINAL
ANCHOR TRENCH**
NTS

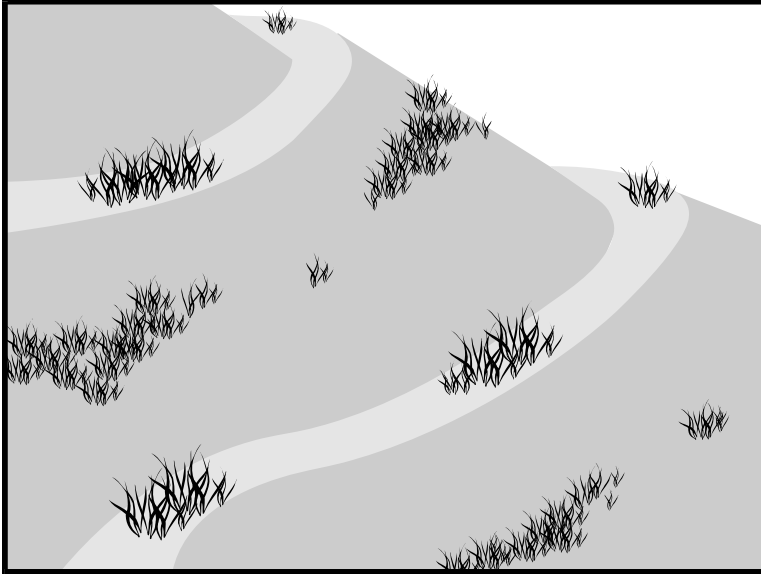
NOTES:

1. CHECK SLOTS TO BE CONSTRUCTED PER MANUFACTURER'S SPECIFICATIONS.
2. STAKING OR STAPLING LAYOUT PER MANUFACTURER'S SPECIFICATIONS.

GEOTEXTILES AND MATS DETAIL

Slope Roughening, Terracing, and Rounding

EC-9



Source: Caltrans Construction Site Best Management Practices Manual, 2003.

Description

Methods of slope grading to reduce potential erosion by decreasing runoff velocities, trapping sediment, shortening slope length, and increasing infiltration into the soil.

Applications

- Areas where seeding, planting, and mulching erosion control measures may be enhanced by roughening of the soil surface.
- Graded areas with smooth, hard surfaces.
- Areas requiring terracing to shorten the slope length.

Installation and Implementation Requirements

CUT SLOPE ROUGHENING

- Cut slopes steeper than 3:1 (H:V) shall use stair-step grading or furrows.
- Use stair-step grading on soft soils that may be ripped by a bulldozer. Stair-step grading is particularly suitable for slopes consisting of soft rock with some subsoil.
- The vertical cut distance shall be less than the horizontal distance. The “step” shall drain towards the slope.
- Avoid individual vertical cuts greater than 24 inches high in soft materials or greater than 36 inches high in rocky materials.
- Create ridges and depressions along the slope contours using machinery.

FILL SLOPE ROUGHENING

- Fill slopes steeper than 3:1 (H:V) shall be placed in lifts not exceeding 9 inches. Each lift shall be properly compacted.
- Slope faces shall consist of 4 to 6 inches of loose and uncompacted

Slope Roughening, Terracing, and Rounding

EC-9

Installation and Implementation Requirements (Continued)

- soil.
- Grooving or tracking shall be used to roughen slope faces as necessary.
- Apply seed, fertilizer, and mulch. Track or punch in the mulch. Refer to EC-6 (Mulching) and EC-5 (Seeding and Planting) in this manual for additional information.
- The final slope face shall not be bladed or scraped.

CUTS, FILLS, AND GRADED AREAS

- Slopes that will be maintained by mowing shall be no steeper than 3:1 (H:V).
- Create shallow grooves by normal tilling, disking, harrowing, or use of a cultivator-seeder. Final pass of tillage shall be along the contour. Spacing between grooves shall be 10 inches or less. Groove depth shall be a minimum of 1 inch.

ROUGHENING WITH TRACKED MACHINERY

- Roughening with tracked machinery is only applicable to soils with a sandy texture. Other types of soil may be over-compacted by tracked machinery.
- Leave horizontal depressions in the soil by operating tracked machinery up and down the slope. During the final grading operation, do not back blade.
- Roughened areas shall be seeded and mulched for optimum seed germination and growth.

TERRACING

- Slope grades of 5:1 (H:V) shall include terraces or benches when slope heights exceed 30 feet. Steeper slope or highly erosive soil conditions may warrant terraces or benches for slope heights of 15 feet or higher.
- Runoff collected along terraces and benches shall be routed to lined diversion ditches. Install lined diversion ditches at the intersection of the terrace and slope.

ROUNDING

- All slopes shall be rounded with no sharp breaks in plan or profile.

Limitations

- Since terracing is permanent, design and approval shall be under the direction of a licensed, qualified engineer.
- Design of terraces shall provide adequate drainage and stabilized outlets.
- Roughening may result in increased grading costs and sloughing in soil.

Slope Roughening, Terracing, and Rounding

EC-9

**Limitations
(Continued)**

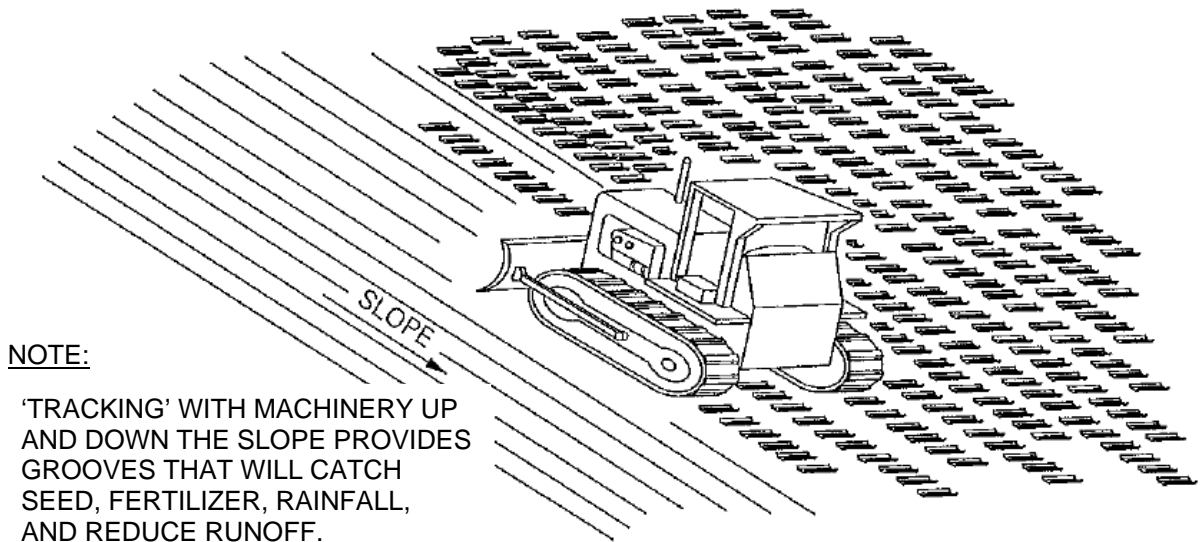
- Stair-step grading may not be applicable to sandy, steep, or shallow soils.
- During intense rainfall events, roughening may not be an effective temporary erosion control measure.

**Inspections and
Maintenance**

Inspect seeded and planted slopes for rills and gullies weekly during dry periods as well as within 24 hours of any rainfall of 0.5 inch or greater which occurs in a 24-hour period and daily during periods of prolonged rainfall.

Slope Roughening Terracing, and Rounding

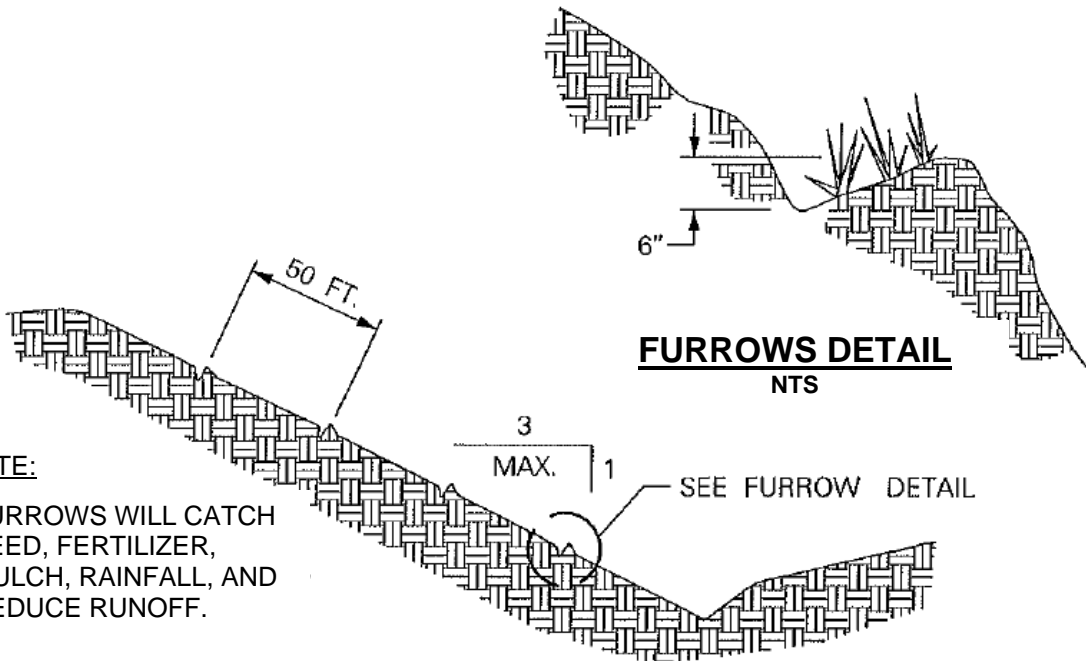
EC-9



NOTE:

'TRACKING' WITH MACHINERY UP AND DOWN THE SLOPE PROVIDES GROOVES THAT WILL CATCH SEED, FERTILIZER, RAINFALL, AND REDUCE RUNOFF.

TRACKING
NTS



FURROWS DETAIL
NTS

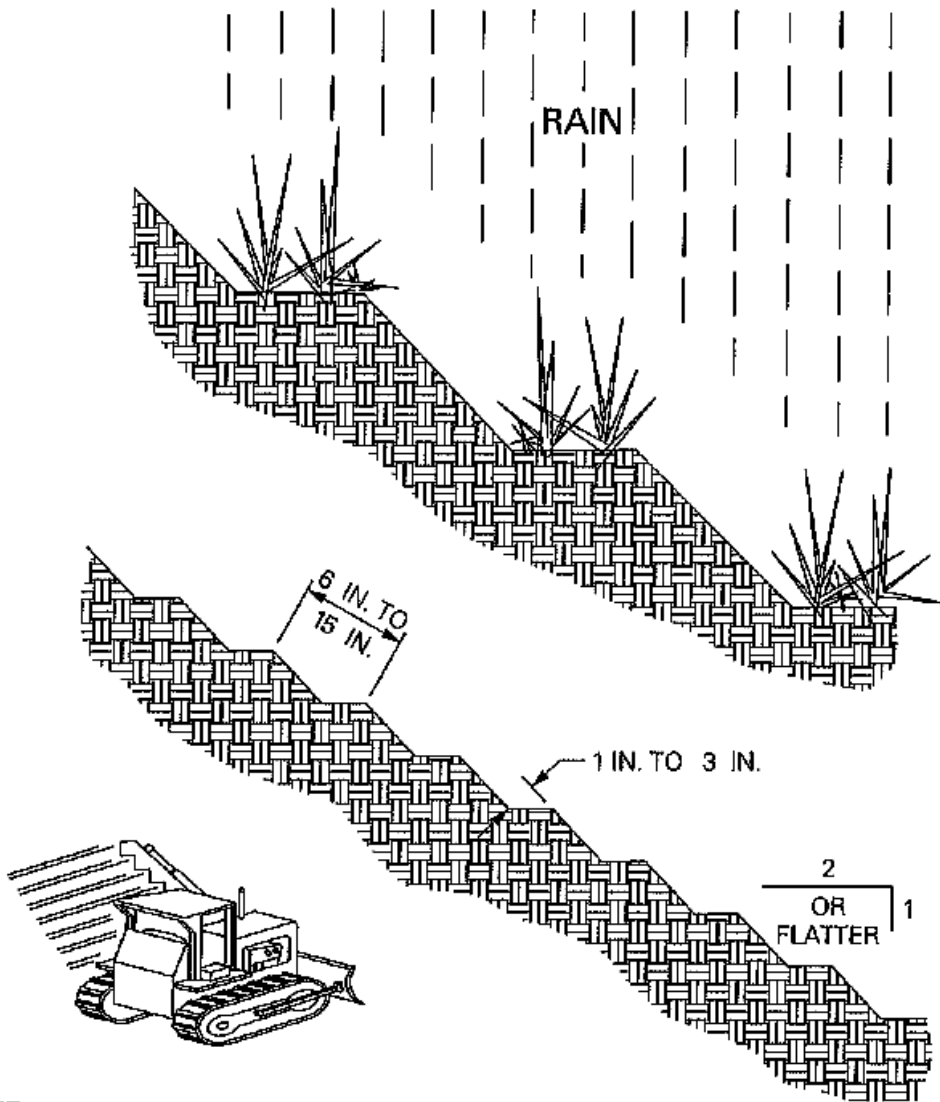
NOTE:

FURROWS WILL CATCH SEED, FERTILIZER, MULCH, RAINFALL, AND REDUCE RUNOFF.

CONTOUR FURROWS
NTS

Slope Roughening Terracing, and Rounding

EC-9

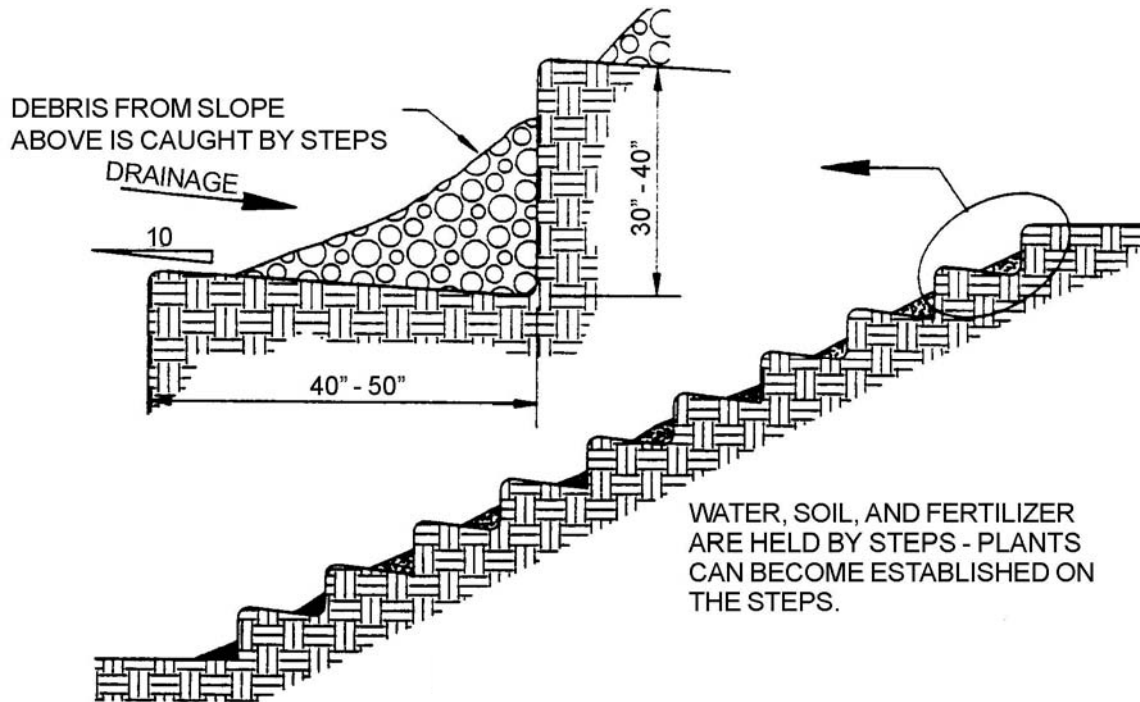


NOTE:
GROOVE BY CUTTING SERRATIONS ALONG
THE CONTOUR. IRREGULARITIES IN THE
SOIL SURFACE CATCH RAINWATER, SEED,
MULCH, AND FERTILIZER.

SERRATED SLOPE NTS

Slope Roughening, Terracing, and Rounding

EC-9

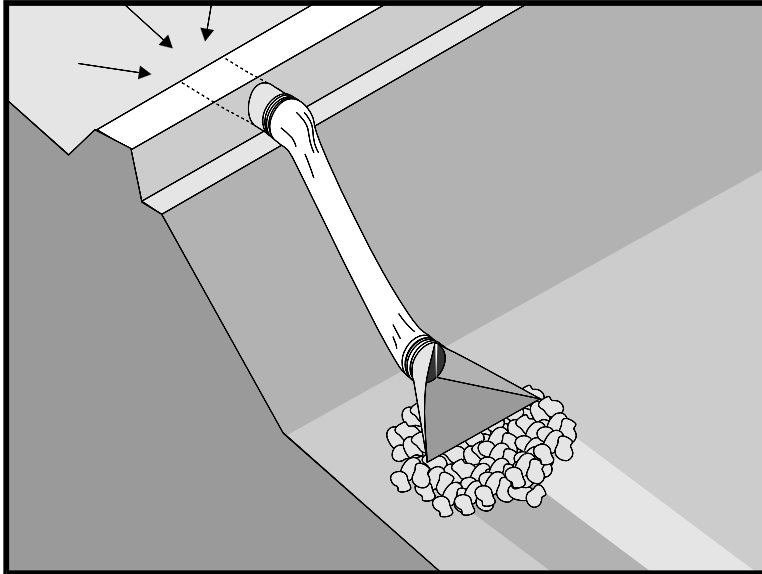


STAIR STEPPING CUT SLOPES
NTS

Source: CCH Best Management Practices Manual for Construction Sites in Honolulu, 1999.

Slope Drains and Subsurface Drains

SC-11



Source: Caltrans Construction Site Best Management Practices Manual, 2003.

Description

Pipes which prevent erosion along slopes by intercepting and conveying runoff or groundwater from the top of the slope to a stabilized discharge point located at the bottom of the slope. Slope drains are primarily used to convey runoff down cut or fill slopes. Subsurface drains are primarily used to remove water from the soil in sloped areas.

Applications

- Use of slope drains applicable to the following:
 - Drainage of concentrated runoff from within swales or behind dikes located at the top of slopes and
 - Drainage of surface runoff to prevent erosion along the slope.
- Emergency spillways for sediment basins.
- Use of subsurface drains applicable to areas where water must be removed from the soil to lower the groundwater table or to prevent excessive soil saturation.

Installation and Implementation Requirements

- Design of slope drains shall consider the following:
 - Consult with a hydro-geologist or qualified engineer regarding design flows;
 - Limit drainage area discharging to slope drain to 5 acres;
 - Direct surface runoff into slope drain using interceptor dikes at the top of slope. Refer to SC-6 (Earth Dike) and SC-7 (Temporary Drains and Swales) in this manual for more information;
 - Pipe slope drains exceeding 12 inches in diameter require a standard flared end section or headwall constructed at the inlet and outlet;

Slope Drains and Subsurface Drains

SC-11

Installation and Implementation Requirements (Continued)

- Install lining such as vegetation or geotextile filter fabric to protect area around inlet;
- Install rip-rap or other energy dissipation device at outlets;
- Compact soil under and around inlet, outlet, and along the pipe;
- Slope drains may be installed above ground or buried beneath the slope surface;
- Above ground installation shall utilize pipe anchors to secure pipe to ground;
- Align slope drain perpendicular to contours of slope;
- Generally limit maximum slope to 2:1 (H:V). For slopes exceeding 2:1 (H:V), velocity dissipation is required at the pipe outlet; and
- Direct sediment-laden stormwater to a sediment trap or sediment basin.

Limitations

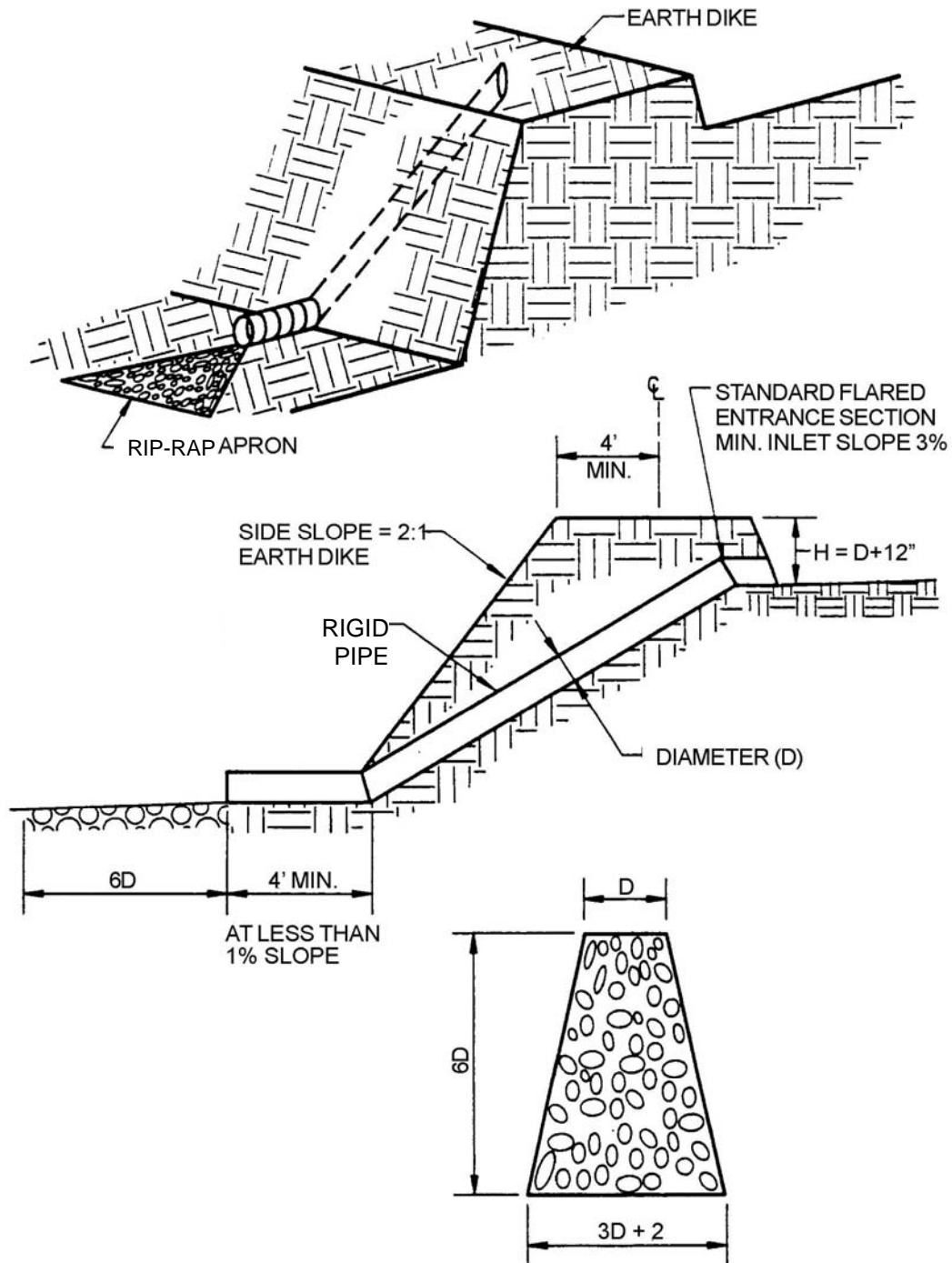
- Drainage area discharging to slope drains shall not exceed 5 acres. For larger areas, use multiple pipes, paved chute, or rock lined channel.
- Clogged slope drains direct runoff around pipe which may result in erosion along the slope.
- High flow velocities at the pipe outlet require implementation of velocity dissipation devices to prevent downstream erosion.
- Severe flooding and erosion may result from failure of slope drains.

Inspections and Maintenance

- Inspect weekly during dry periods as well as within 24 hours of any rainfall of 0.5 inch or greater which occurs in a 24-hour period and daily during periods of prolonged rainfall for erosion at outlet and downstream scour. Repair damage and install energy dissipation devices as necessary.
- Inspect slope drains for debris and sediment accumulation. Remove sediment and debris from entrances, outlets, and within drains.
- Inspect pipe anchors to ensure pipe remains anchored to slope.
- Verify ponding does not occur in areas such as active traffic lanes and material storage areas.

Slope Drains and Subsurface Drains

SC-11



RIP-RAP SHOULD CONSIST OF 6" DIAMETER STONE PLACED AS SHOWN AND SHOULD BE A MINIMUM OF 12" IN THICKNESS.

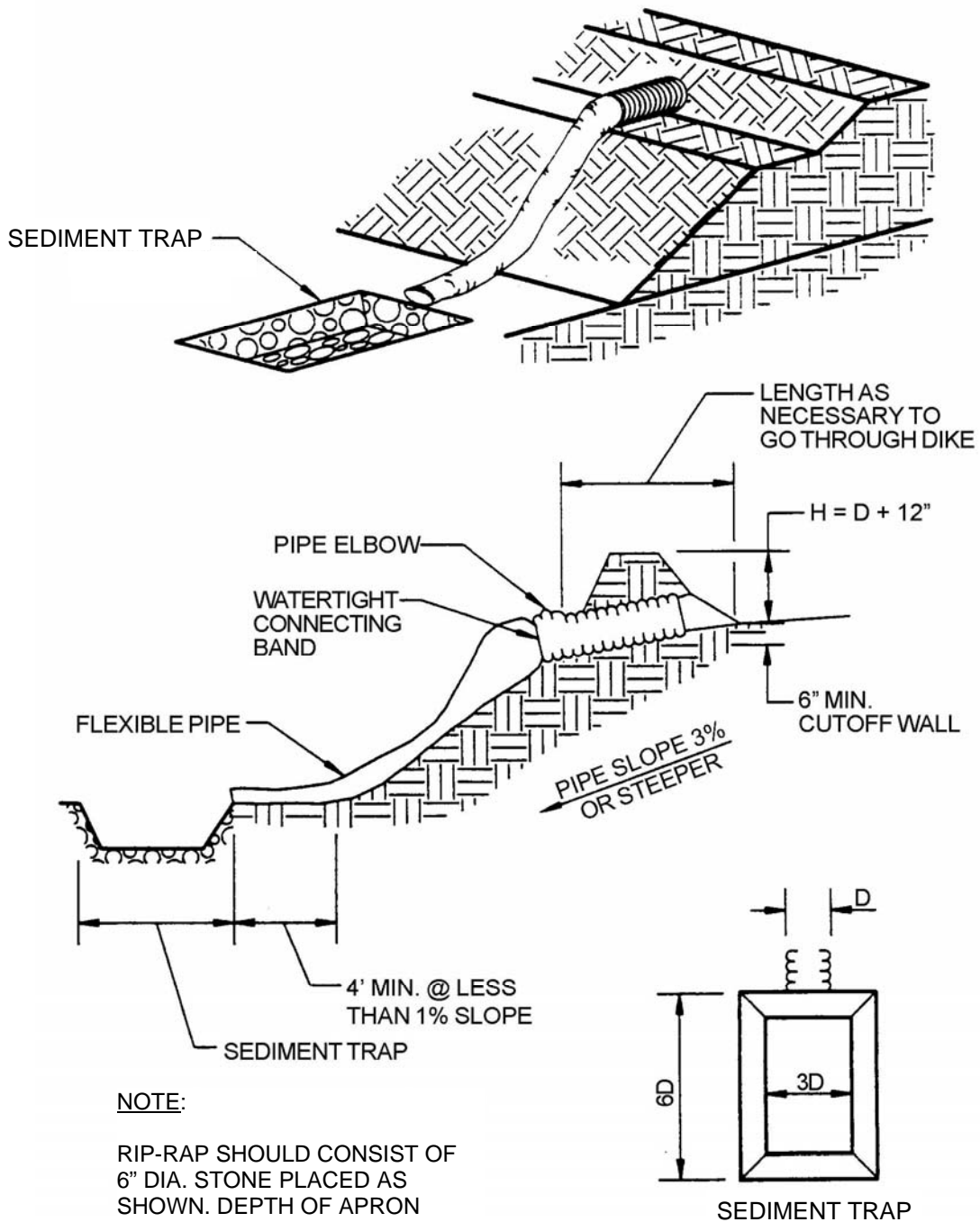
PIPE SLOPE DRAIN (RIGID)

NTS

Source: CCH Best Management Practices Manual for Construction Sites in Honolulu, 1999.

Slope Drains and Subsurface Drains

SC-11



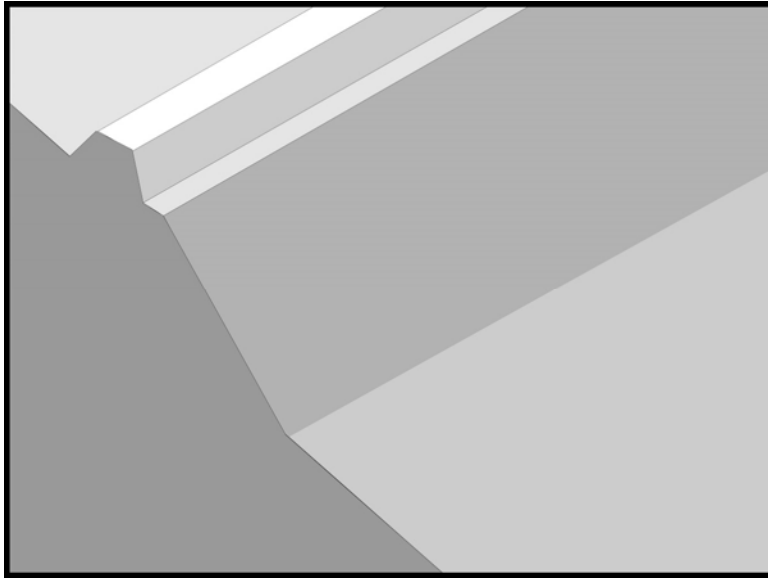
PIPE SLOPE DRAIN (FLEXIBLE)

NTS

Source: CCH Best Management Practices Manual for Construction Sites in Honolulu, 1999.

Top and Toe of Slope Diversion Ditches/Berms

SC-12



Source: Modified from Caltrans Construction Site Best Management Practices Manual, 2003.

Description	Devices used to minimize sheet flow over slopes and reduce erosion by intercepting and conveying runoff to sediment removing structures or a protected drainage system.
Applications	<ul style="list-style-type: none">• Areas which must be protected from runoff flowing down slopes.• Areas where runoff must be intercepted at bottom of slope.
Installation and Implementation Requirements	<ul style="list-style-type: none">• Design flows and safety factors shall be determined by an evaluation of risks associated with erosion and overtopping, flow backups, or structure washouts. Consult with the HWY-OM Engineer or Hydraulic Section to determine these values.• Line or stabilize ditches with high flow velocities.• Direct flows at top of slopes to slope drains. Refer to SC-11 (Slope Drains and Subsurface Drains) in this manual for more information.• Protect outlets from erosion.
Limitations	<ul style="list-style-type: none">• Additional sediment trapping BMP devices may be necessary for sediment-laden runoff.
Inspections and Maintenance	<ul style="list-style-type: none">• Inspect weekly during dry periods as well as within 24 hours of any rainfall of 0.5 inch or greater which occurs in a 24-hour period and daily during periods of prolonged rainfall.• Inspect ditches/berms for washouts. Repair requirements shall be reported and include replacement of rip-rap, damaged lining, or soil stabilizers and compaction and revegetation of fill berms and ditches.

Top and Toe of Slope Diversion Ditches/Berms

SC-12

**Inspections and
Maintenance
(Continued)**

- Inspect structures for accumulated sediment and debris and remove as necessary.