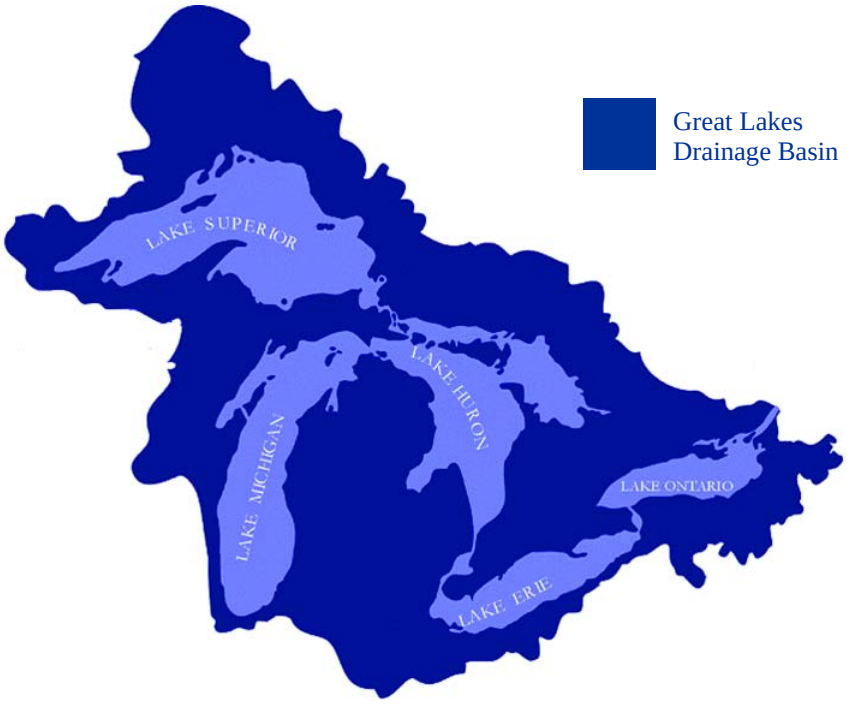
Great Lakes
Better Backroads Guidebook

Clean Water by Design



September 2007, 3rd Edition
Prepared by:

Huron Pines

501 Norway Street
Grayling, MI 49738
www.huronpines.org

Conserving the Forests, Lakes and Streams of Northeast Michigan

Good design and maintenance
will save $$$
by decreasing road problems
and untimely repairs.

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Keeping It On the Land
Great Lakes Basin Program for Soil Erosion and Sediment Control
www.glc.org/basin

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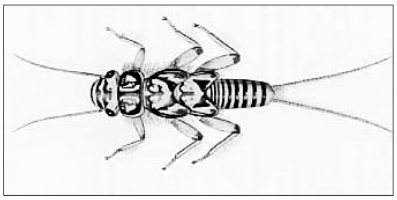
Stonefly Nymphs
Common Stonefly Nymph
Order Plecoptera, Family Perlidae



- Measures 8-15 mm in length (not including tails)
- 2 tails
- 2 sets of wing pads
- Branched gills between legs on underside of body
- Yellow to brown in color; often patterned yellow and brown when mature
- Superficially similar to certain flattened mayfly nymphs, however, stonefly nymphs always have two tails, prominent antennae, and two claws at the end of each leg.
- Stoneflies are not tolerant of low levels of dissolved oxygen and therefore prefer cold, swift-moving streams. The streamlined, flattened bodies of stonefly nymphs enable them to move about the rocky streambed in rapid currents.

Great Lakes Trivia Test (answers on back):

1) Name the five Great Lakes.

2) What popular song immortalized the sinking of a Great Lakes ship?

3) Name the eight U.S. states that border the Great Lakes.

4) Name the two Canadian provinces that border the Great Lakes.

5) Name the two major shipping ports on the Great Lakes that begin with the letter "D."

GUIDING PRINCIPLES

1. **Plan projects. (All projects should be planned!)**
2. Move water off road surfaces as soon as possible.
3. Direct runoff into vegetated filter areas or rock-lined turnouts.
4. Address road runoff from the top of both approaches.
5. Avoid directing runoff into surface waters.
6. Stabilize bare areas.
7. Keep runoff velocities low and avoid concentrating runoff.
8. Minimize areas of disturbance.
9. Revegetate disturbed areas ASAP.
10. Maintain and monitor all practices.

Answers:

1) Erie, Huron, Michigan, Ontario, and Superior
2) "The Wreck of the Edmund Fitzgerald"
3) Michigan, Wisconsin, Minnesota, Illinois, Indiana, Ohio, Pennsylvania, and New York
4) Ontario and Quebec
5) Detroit and Duluth

1.0 INTRODUCTION

1.1 Purpose

The overall purpose of this program is to improve the water quality in the Great Lakes region by providing cost effective techniques and hands-on instructions for the design and maintenance of non-paved backroads. County road managers and crews, private road maintenance and construction companies, lake associations, and the general citizenry can all effectively use this manual.

Properly constructed and maintained road/stream crossings and roadways will lead to long-term savings by decreasing the amount of repairs and replacements that will be required “down the road.” At the same time, properly constructed road/stream crossings and roadways will control erosion and reduce sediment and road contaminant pollution entering into our waters.

1.2 Need

Soil erosion occurs when soil particles are carried away from the road surface, road bank, ditch, or road base by water, wind, ice, or gravity. Exposed soil, rapid water velocity, and sand and silt soils all increase the potential for soil erosion. Other pollutants such as oils, greases, and salts can also be washed from roads. These sediments and pollutants are then carried away into nearby streams, ponds, and wetlands. Graveled roads, by nature of their topography and design, can, if not properly managed, contribute heavily to this significant water pollution problem.

1.3 Effects of Increased Sediments

Small quantities of sediment generated at a road/stream crossing increase overall sedimentation downstream by shallowing and widening the channel, thereby increasing streambank erosion. The increased streambank erosion contributes more sediment, causing a domino effect at a geometric rate.

Sediments impact surface water ecosystems by

- Smothering spawning, rearing, and feeding habitat.
- Disturbing the reproductive cycle of many water organisms.
- Disrupting the food chain.
- Adding excess nutrients.
- Warming the water.

Large quantities of sediments and other pollutants can

- Destroy small bottom-dwelling stream animals which provide food for fish.
- Destroy fish habitats (fish eggs need a clean, gravel/cobble/boulder stream bottom for incubation).
- Irritate the gills of fish making them more prone to disease.
- Increase the frequency of flooding by filling river channels.
- Drastically change water quality.
- Diminish recreational uses.
- Destroy the aesthetic value of a stream.

1.4 Site Planning

Planning is the most important step in beginning a road maintenance or construction project. It is essential because

- Good planning saves money in the long run.
- Planning ensures improved protection of water quality.
- Planning allows a holistic look at a project. Every factor (including water quality) is carefully considered.
- Basic road siting concepts can avoid environmentally sensitive areas where possible.

The reader must understand that this guidebook needs to be considered in its entirety. Although made up of ten separate chapters dealing with different practices, a holistic viewpoint must be taken so that not only the structure is considered, but all the Best Management Practices involved in the process are considered in order to maintain and protect clean water. This can only be assured through good planning. Planning must start with an attempt to integrate all the Best Management Practices found within the guidebook into each project.

The following serves as a step-by-step example of holistic project planning for any road construction procedure:

Step 1. What You Need to Know

a) Whether the structure needs replacement or renovation
b) If the site is a source of pollution or concern
c) Specific sources or causes of concern (i.e. gullies)
d) Watershed hydrology and site hydrology
e) Stability, texture, and limitations of soil
f) Relevant slopes
g) Users of waterbody and roadway
h) Interest level of project stakeholders/landowners
i) Whether project is consistent with watershed goals
j) What permits are needed

Step 2. Plan Development

a) List the necessary Best Management Practices (BMP's)
b) Estimate a budget for each BMP and for the system
c) Schedule the implementation
d) Identify the funding sources
e) Prepare a conceptual drawing of the site
f) Take pre-construction photographs
g) Seek a maintenance agreement (unless it is provided by the manager)
h) Make application for necessary permits

Step 3. Detailed Plan

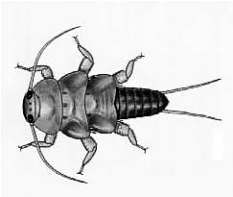
a) Water quality practices must be in the plan
b) Specifications for all BMP's must be listed
c) Detailed drawings showing elevation and natural features
d) Engineered drawings (if needed)
e) Basis of designs (including calculations)
f) Maintenance plan (if not provided by manager)
g) Schedule of implementation
h) Final costs
i) Who covers each specific cost

At the beginning of each chapter of the guidebook we have listed our Ten Guiding Principles and have **bolded** those that apply to that chapter. These Guiding Principles are essential to planning a successful project and should be considered when reading each chapter.

2.0 ROAD SURFACE

Insects that are indicators of excellent water quality and provide nutrition for stream trout

Stonefly Nymphs
Roach-like Stonefly Nymph
Order Plecoptera, Family Peltoperlidae



- ❑ Measures 8-15 mm in length not including tails)
- ❑ 2 tails
- ❑ 2 sets of wing pads
- ❑ Flattened and roachlike in appearance
- ❑ Brown in color
- ❑ Superficially similar to certain flattened mayfly nymphs, however, stonefly nymphs always have two tails, prominent antennae, and two claws at the end of each leg.
- ❑ Roach-like stonefly nymphs consume living and decaying plant material and are often found among leafpacks in mountain streams.

Great Lakes Trivia Test (answers on back):

1) What is the largest bay on the Great Lakes and what Lake is it in?

2) How many gallons of Great Lakes water are used every day for irrigation, public water supplies, industrial and electric power plant uses?

3) What is the name of the largest freshwater island in the world and where is it located?

4) What is the only island national park in the United States?

5) What is the largest island city park in the United States?

GUIDING PRINCIPLES

1. Plan projects. (All projects should be planned!)
2. **Move water off road surfaces as soon as possible.**
3. Direct runoff into vegetated filter areas or rock-lined turnouts.
4. Address road runoff from the top of both approaches.
5. Avoid directing runoff into surface waters.
6. Stabilize bare areas.
7. Keep runoff velocities low and avoid concentrating runoff.
8. Minimize areas of disturbance.
9. Revegetate disturbed areas ASAP.
10. Maintain and monitor all practices.

Answers:

1) Georgian Bay in Lake Huron (Canadian waters)
2) 1 trillion gallons (about 2.5 billion gallons consumed and not returned)
3) Manitoulin Island (in Lake Huron)
4) Isle Royale (in Lake Superior)
5) Belle Isle (in the Detroit River)

2.0 ROAD SURFACE

2.1 Description

Backroads are unpaved or graveled roads. The top layer of these roads is shaped, compacted and smoothed so that surface water will move quickly from the road surface to established ditches.

Some backroads are maintained year-round and some are seasonal forest roads. Seasonal roads are usually regarded as much less traveled than year-round roads, yet because of tourism in the Upper Great Lakes region, year-round traffic can be considerable. Because many of these year-round and seasonal roads cross small feeder streams and other environmentally sensitive areas, it is important that road/stream crossings are designed to protect water quality.

2.2 Importance to Maintenance & Water Quality

Failure to direct surface water from the road surface to a drainage channel can result in deterioration of the road surface, safety problems (ice), and assorted erosion problems. Immediate removal of runoff from the road surface will prevent erosion and road surface deterioration. This will lessen the frequency and cost of maintenance, thereby lengthening the life of the road surface. It will also decrease the amount of sediment carried into our waters.

2.3 Surface Profile & Grading

Proper crowning and compacting of the road surface quickens the removal of runoff, thereby protecting the road surface from erosion.

- Grade roads in the spring as soon as the frost leaves the ground, or as soon as possible after a rain while the surface materials are still moist but not wet.
- Do not grade if rain is in the forecast (after rain is best).
- The amount of road surface disturbed should be limited to that which can be stabilized by the end of the work day.

Proper equipment for surface maintenance includes: grader (shaping and restoring), rake (smoothing before compaction), steel wheel roller (compaction), and slope board (slope confirmation) if time and equipment is available to road managers.

- Crown roads 1/2 to 3/4 inch for each foot of road width, measured from the center of the roadway to the outside edge to ensure good drainage.
- Slope roads with over-the-bank drainage problems entirely toward the ditched side of the road.

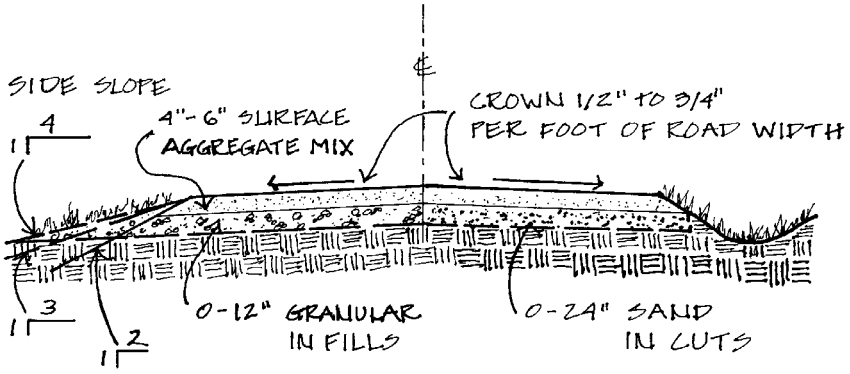


Figure 1—ROAD CROWN & PROFILE

2.3.1 Blading/Dragging

Blading/dragging is a smoothing operation that pulls loose material from the sides of the road or spreads windrowed aggregate to fill surface irregularities and restore the road crown.

- Perform blading/dragging with the moldboard tilted forward with light down pressure on the grader blade. Adjust the angle of the moldboard to between 30 and 45 degrees. In most cases, tilt the front wheels slightly 10 to 15 degrees toward the direction the aggregate should roll.
- Avoid blading during dry periods to minimize the loss of fine aggregates.

2.3.2 Grading

Grading cuts through the road surface crust and is used when reshaping or correcting major surface defects is necessary.

- Perform grading operation with the moldboard tilted backward and with sufficient down pressure on the blade to produce a cutting action. Outer edge of the moldboard should be at the edge of the road surface.
- Keep a minimum of one foot from the ditch line so that vegetation or rock stabilization is not disturbed.
- Modify grading practices near bridge approaches by lifting the blade to prevent furrowing (commonly referred to as “country curbs”) and to avoid blockage of turnout drainage.
- Place reflectorized stakes before bridge approaches or prior to surface waters to warn drivers to modify grading operations in these sensitive areas.

2.3.3 Gravel-surfaced Road

To shed water properly, gravel-surfaced roads should have a tight, impervious surface.

- Construct the surface layer with well-graded soils and crushed rock.
- An aggregate mix recommended by your state or local road agency would be uniformly graded from coarse to fine; approximate sizes for surface composition are: silts and clays (<0.074mm), sand (0.074 - 2.0mm), and aggregate (>2.0mm).
- Add approximately 2 to 3 inches of new material to correct any faults.
- Scarifying the existing surface blends the soils and improves compaction.
- Add new material by running a truck down the center of the roadway and dumping; blend the old material with the new using a grader, followed by compaction using a steel wheel roller if feasible.
- Regravel road surface every 4 to 5 years with 2 –3 inches of new gravel, if possible.

2.4 Distress Conditions - Surface Deteriorations

Common types of surface deteriorations include:

2.4.1 Dust

Dust in the air is the loss of fine, binder aggregates (silts and clays) from road surfaces and leads to other types of road distress.

- Sprinkling road surface with water is a very short-term solution.
- Can be minimized by applying calcium chloride which draws moisture from the air to improve fine aggregate cohesion; most effective if applied before roads become too dry and dusty and after any grading actions.
- Liquid calcium chloride is typically applied at a rate of 0.3 gallons per 5 square yards in the spring followed by 0.2 gallons per 5 square yards in the summer; dry calcium chloride is typically applied at 1.2 pounds per square yard in the spring and 0.8 pounds per square yard in the summer.
- NOTE: Calcium chloride should not be used adjacent to surface waters since its long term, extensive use can cause water quality problems. It should not be used within 100 feet of surface waters. Other non-calcium chloride products are now available for dust control.

2.4.2 Raveling

Raveling is the loss of coarse aggregate.

- Correct by grading or blading with the addition of a binder to improve surface composition.

2.4.3 Slipperiness

Surface containing excessive amounts of fine aggregates or soil can cause slippery road surface during wet weather.

- To correct, add coarse aggregate by grading, blading, and compacting.

2.5 Distress Conditions - Surface Deformations

Surface deformation problems are reduced with proper road surface drainage and include:

2.5.1 Rutting

Ruts are longitudinal depressions in the wheel paths cause by high moisture content in the subsurface soil, inadequate surface source thickness, and/or heavy traffic loads.

- Grade, add suitable material, and roll road surface to correct ruts if practical.
- Adding stone is a temporary solution and is not recommended; draining the ruts and filing them with roadbed material is preferred.
- For severe ruts, a layers of geotextile material may be required under at least six inches of crushed gravel.

2.5.2 Corrugations/Washboard

A series of ridges and depressions across the road surface caused by lack of surface cohesion and excessive vehicle speeds.

- Blading is not recommended, since this technique along will not solve the problem.
- Improve the cohesive qualities of the road surface by remixing with good fine percentage, scarify the road surface while damp, regrade, re-crown, and roll the surface if practical.

2.5.3 Depressions

Depressions are localized low areas one or more inches below the surrounding road surface caused by settlement, excessive moisture content, and improper drainage.

- Correct depressions by filling with well graded aggregate, grading, and compacting.

2.5.4 Potholes

Potholes are caused by excessive moisture content, poor drainage, and poorly graded aggregates.

- Repairs involve spot grading or patching with crushed aggregate.

2.5.5 Soft Spots

Soft spots are caused by lack of proper drainage.

- To correct, replace soft spot area with a suitable material such as well-graded stone or gravel.

2.6 Disposal of Excess Materials

Improper disposal of excess material can increase the amount of sediment that enters streams and damages sensitive areas, particularly wetlands. Some guidelines are:

- Excess materials should not be disposed of in: wetlands, drainage ditches and swales, streambanks, areas within 100 feet of (and drain into) a waterway, and slopes that are steeper than 2:1 (refers to 2 foot horizontal distance for a 1 foot change in vertical elevation).
- Ensure the area down slope of the disposal area has an adequate vegetated filter strip to trap sediments.
- Seed or vegetate any fill areas as soon as possible.
- Plan possible disposal areas ahead of time, giving the opportunity to utilize excess materials if possible.

2.7 Surface Treatment

By their nature, backroads are typically gravel. If approach slopes are excessive, or if ditches are not installed, the road surface should be treated by hardening. Hardening, coupled with water conveyance BMP's, will greatly reduce the potential for erosion. Surface hardening also minimizes maintenance and greatly reduces the potential for maintenance-related problems. The following are some general guidelines, in order of preference:

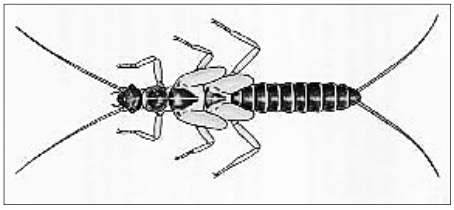
- Use a bituminous mixture as specified by your state or local road agency. Apply asphalt on the entire road surface and include rolled curbing and paved turnouts.
- Applications of seal-coat (tar and chip) are suitable in certain conditions; however, this treatment usually requires sufficient traffic to remain pliable without deteriorating and it requires periodic maintenance.
- A top course of high quality stabilized gravel, 100% crushed with a high binder content (such as crushed limestone gravel with fines), is suitable if funding for hard surfacing is not available. Once the material is sufficiently compacted, maintenance should be limited to periodic gentle grading. Avoid grading practices that develop 'country curbs', which render water conveyance structures nonfunctional.

NOTE: For all treatments, crown road to promote drainage to shoulders and into conveyance structures.

3.0 DITCHES

Insects that are indicators of excellent water quality and provide nutrition for stream trout

Stonefly Nymphs
Slender Winter Stonefly Nymph
Order Plecoptera, Family Capniidae



- ❑ Measures up to 1/2 inch in length (not including tails)
- ❑ 2 tails
- ❑ 2 sets of wing pads (occasionally absent)
- ❑ Small, slender and cylindrical
- ❑ Often darkly colored
- ❑ Habitat ranges from small springs to medium-sized streams. Nymphs are often found among decaying leaves on which they feed.

Great Lakes Trivia Test (answers on back):

1) How long is the shoreline of the Great Lakes (Canadian and U.S. coastlines combined)?

2) What is the nutrient that caused excessive algae in the Great Lakes and led to the "death" of Lake Erie?

3) Name three of the four places that Great Lakes toxics come from.

4) The Great Lakes make up what percent of the world's surface freshwater supply?

5) The Great Lakes make up what percent of our nation's surface freshwater supply?

GUIDING PRINCIPLES

1. Plan projects. (All projects should be planned!)
2. Move water off road surfaces as soon as possible.
3. **Direct runoff into vegetated filter areas or rock-lined turnouts.**
4. Address road runoff from the top of both approaches.
5. Avoid directing runoff into surface waters.
6. Stabilize bare areas.
7. **Keep runoff velocities low and avoid concentrating runoff.**
8. Minimize areas of disturbance.
9. Revegetate disturbed areas ASAP.
10. Maintain and monitor all practices.

Answers:

1) 9400 miles
2) phosphorus
3) land (through rainwater runoff), direct discharges, releases from bottom sediments, and the air (atmosphere)
4) 20 percent
5) 90 percent

3.0 DITCHES

3.1 Purpose

Ditches are constructed to convey water from storm runoff to an adequate outlet without causing erosion or sedimentation. A good ditch needs to be shaped and lined using the appropriate vegetative or structural material.

3.2 Importance to Maintenance & Water Quality

Efficient removal of runoff from the road will help preserve the road bed and banks. Well designed ditches provide an opportunity for sediments and other pollutants to be removed from runoff water before it enters surface waters. Achieve this by controlling, slowing and filtering the water through vegetation or structures. In addition, a ditch must be stable so as not to become an erosion problem itself.

3.3 Ditch Profile and Grading

Correct profile and grading techniques will remove water efficiently, decrease erosion, and increase the length of time between cleaning and regrading, thereby cutting maintenance costs. The preferred equipment for creating ditches is a rubber-tired excavator with an articulated bucket.

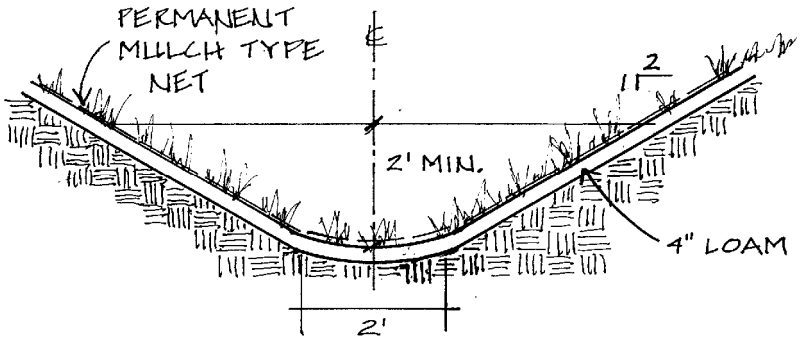


Figure 2—GRASS LINED DITCH

- Locate ditches on the up slope side of the road to prevent water from flowing onto the road from uphill.
- Size ditches so they are large enough to handle runoff from the drainage area.
- Design and grade ditch and bank side slopes at a maximum 2:1 slope.

- Excavate a ditch deep enough to drain the road base: 1-1/2 - 2 feet deep.
- The ditch bottom should be parabolic-shaped or at least flat and a minimum of 2 feet wide to help slow and disperse water.
- Line ditches which has a less than 5% slope with grass in order to filter sediments.
- Line ditches which have a greater than 5% slope with rock riprap.
- If rock lining is used, underlay the lining with geotextile (porous material).
- All ditches need an outlet; standing water weakens roads (see outlets for construction techniques, Section 5.0).

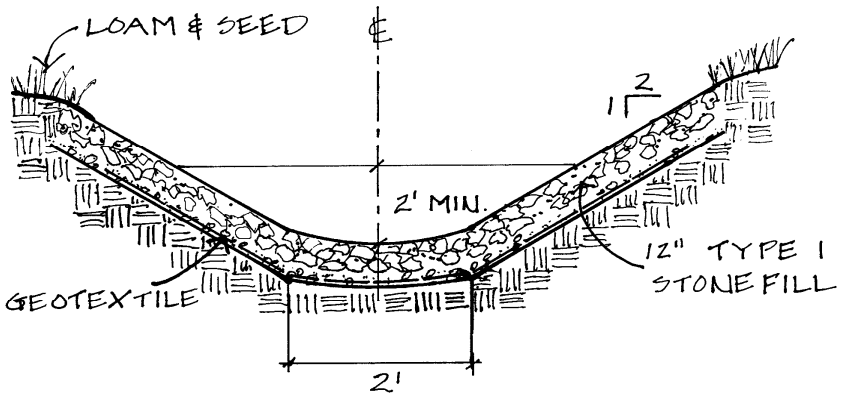


Figure 3—STONE LINED DITCH

Table 1 - DITCH LININGS		
Channel Slope	**Lining**	**Thickness**
0 - 5%	Grass	
5 - 10%	D50 - 4 inch (2 - 6 inch) diameter rock	7.5 inch
> 10%	D50 - 6 inch (3 - 12 inch) diameter rock	12 inch

3.4 Cleaning & Maintenance

Well designed ditches can be cleaned making maintenance quicker and easier.

- Clean ditches when they become clogged with sediments or debris to prevent overflows and washouts.
- Check ditches after major storm events for obstructions, erosion, or bank collapse.
- Regrade ditches only when absolutely necessary and line with vegetation or stone as soon as possible.

3.5 Diversion Ditches and Berms

Use diversion ditches and berms to intercept, consolidate, and direct runoff.

- Locate at the top of a slope to prevent erosion such as gullies and rills on the slope; may also be used across a slope to break up the length of the slope or to redirect water flow.
- Locate diversion ditches and berms where they will empty into stable disposal areas to collect sediments.
- May use a combination of a ditch and a berm or mound of earth or stone in areas where runoff is hard to control or when constructed on a slope.
- Design and line diversion ditches the same as other ditches.

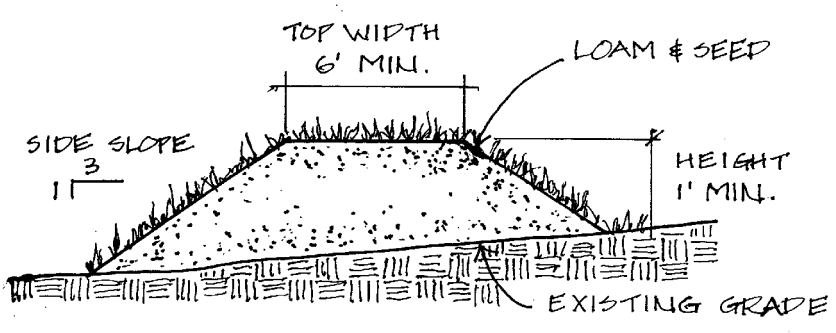


Figure 4—DIVERSION BERM

3.6 Velocity Controls & Energy Dissipaters

Velocity controls and energy dissipaters reduce erosion by preventing scouring of ditches and culvert beds and outlets. They are used to slow the water flowing through ditches and culverts. They also collect sediment and help ground water recharge. They are also a means of keeping brush, trash, and other debris from reaching culverts and becoming lodged inside.

- Locate in ditch channel or near culvert outlet.
- Construct dikes no higher than 1/2 the channel depth.

- Extend the ends of the velocity controls and energy dissapaters above the expected flow depth on the bank.
- Always provide channel bottom protection downstream from a velocity control.

Table 2-VELOCITY CONTROLS AND ENERGY DISSIPATERS		
Type	**Duration**	**Comments**
Stone Dike	Permanent	Most effective method. Can be used with concentrated flows. Maintenance is still required for this application.
Straw Bale Dike*	Short term (≤ 1 month)	Only to be used short term or during construction. Bales must be anchored in soil and changed frequently. Not for use with concentrated flows.
Silt Fence*	Short term (≤ 1 month)	Only to be used short term or during construction. Not for use with concentrated flows.
Logs and Brush*	Short term (≤ 2 weeks)	Only to be used short term or during construction. Not for use with concentrated flows.

* Use of short term velocity controls (straw bale dike, silt fence, and logs and brush) have very limited application due to their temporary nature. They required a high level of maintenance and may cause further erosion of not properly maintained.

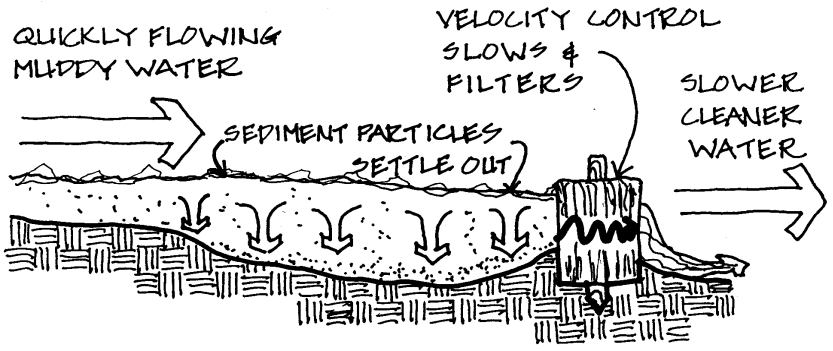


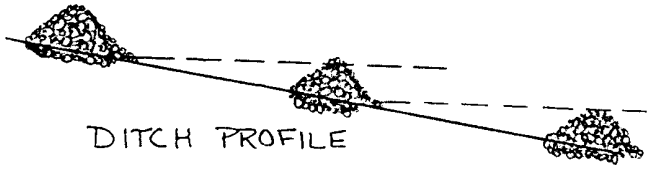
Figure 5—VELOCITY CONTROL

Types of velocity controls and energy dissipaters include:

3.6.1 Stone Dikes

Stone dikes are more permanent than most other types of controls. They are easy to install and can be easily expanded if necessary.

- Construct dikes of stone large enough to handle the expected velocity of water, but…
- The smaller the stone size the more sediment is removed.



Place top of downslope dike at or above same elevation as bottom of dike immediately upslope.

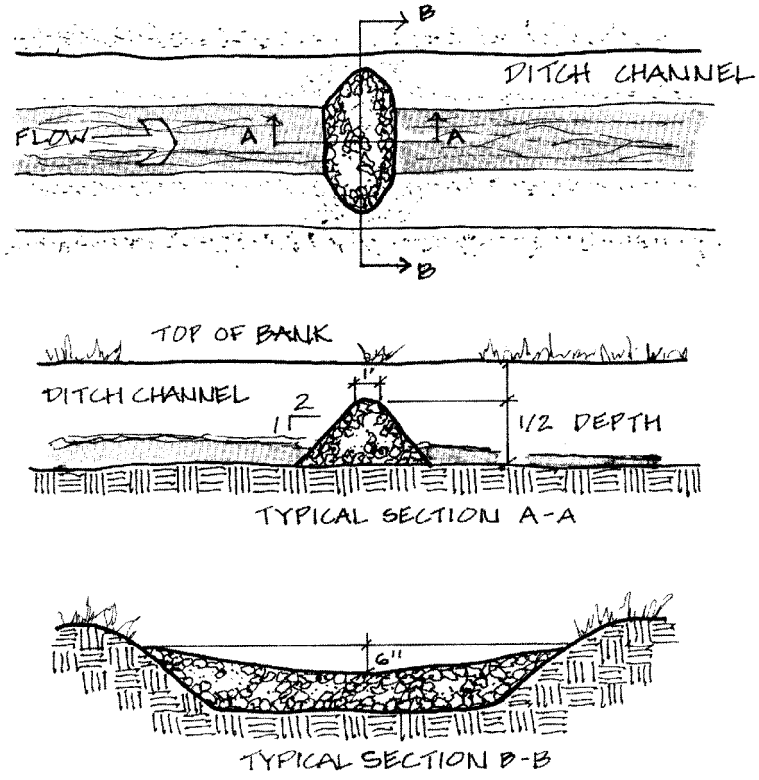


Figure 6—STONE DIKES

3.6.2 Straw Bale Dikes

Straw bale dikes are temporary dike structures since straw bales will rot. They may redirect water rather than detain it. The installation technique is critical to proper functioning of the dike. Periodic removal of trapped sediment is necessary for optimum performance. They also have the potential to introduce undesirable plant species.

- Construct with straw bales tightly butted together, embedded 4 inches into the ground and staked; ends of straw bales should be higher than centers such that water will spill over the top of the bales, not around the sides.
- Use in smaller ditches to slow water flow and at the toe of a slope to trap sediment.
- Remove sediment from behind bales when it is within 3 inches of the top of the bale.
- Do not use in concentrated flows.
- Replace bales frequently (when plugged).
- They are a less preferred option than rock check dams because of frequent maintenance.

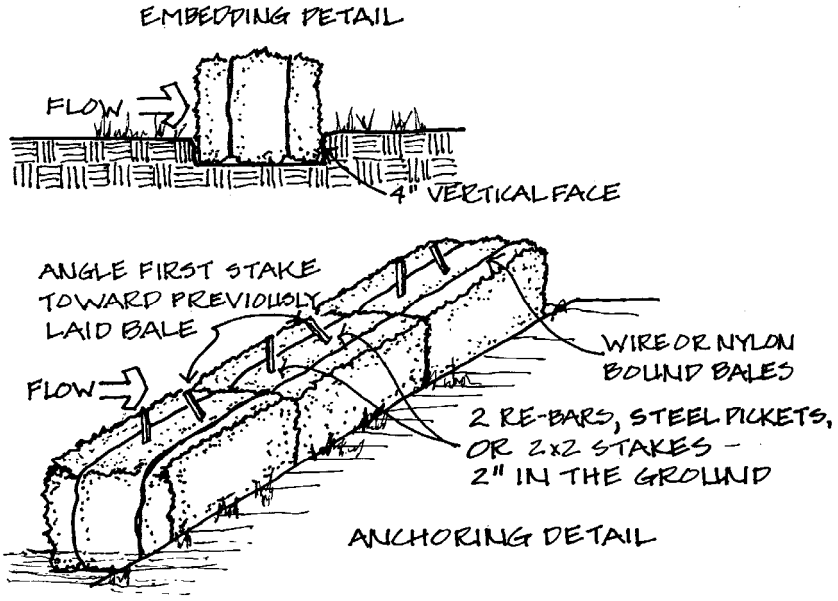
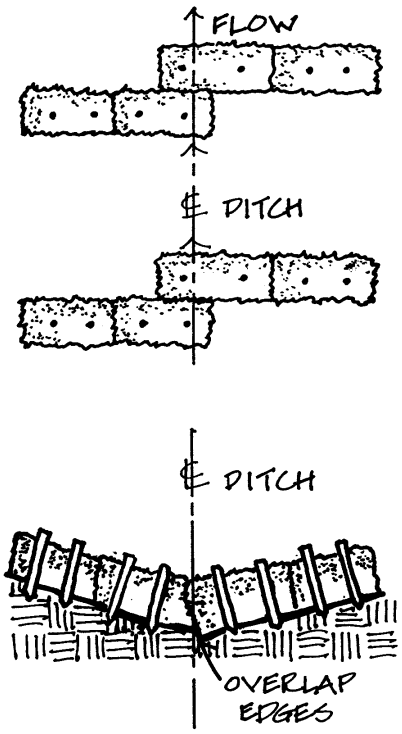


Figure 7—STRAW BALE DIKES

TYPE A

TO BE USED AT THE BASE OF A SLOPE OR IN AREAS WHERE THE EXISTING GROUND SLOPES AWAY FROM THE TOE OF THE FILLED EMBANKMENT



TYPE B

TO BE USED IN DITCHES OR IN AREAS WHERE THE EXISTING GROUND SLOPES IN TOWARD THE FILLED EMBANKMENT

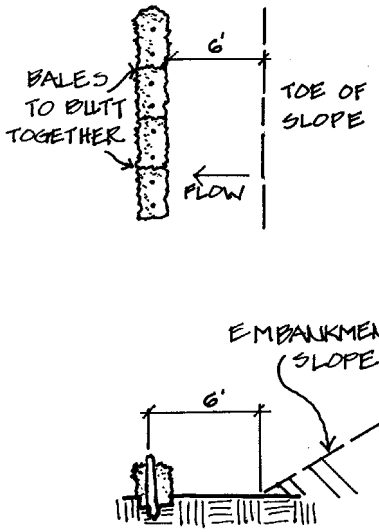


Figure 8—STRAW BALE DIKES

3.6.3 Silt Fences

Silt fences are temporary controls that have the advantage of being lightweight, portable, and often reusable. They can last up to a month. They may redirect water rather than detain it, but can detain great quantities of sediment.

- Install a pervious geotextile fabric with steel or wood posts.
- Use in ditches to slow water flow and at the toe of a slope to trap sediment.
- Install an imaginary contour line and turn both ends upgrade to filter all water and prevent flow around the ends.
- Periodic removal of trapped sediment is necessary for optimum performance.
- They are much less desirable than rock check dams when installed perpendicular to the water flow.

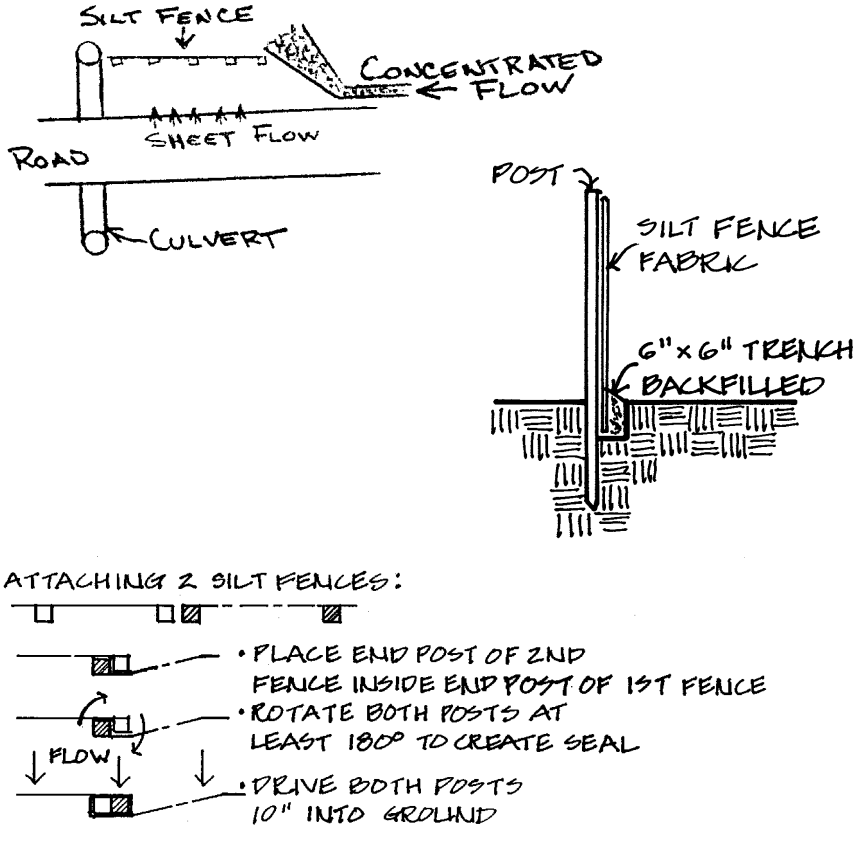


Figure 9—SILT FENCE DIKES

3.6.4 Log and Brush Check Dams

Log and brush check dams are good emergency controls (short term) because the materials for these dams can be gathered on site, also making them convenient and inexpensive. However, the installation technique is critical to performance and they are difficult to remove and repair. Long term use can cause flooding.

- Construct of brush intermeshed with logs staked into the ground.
- Remove when finished.
- Replace with rock check dams if long term use is necessary.

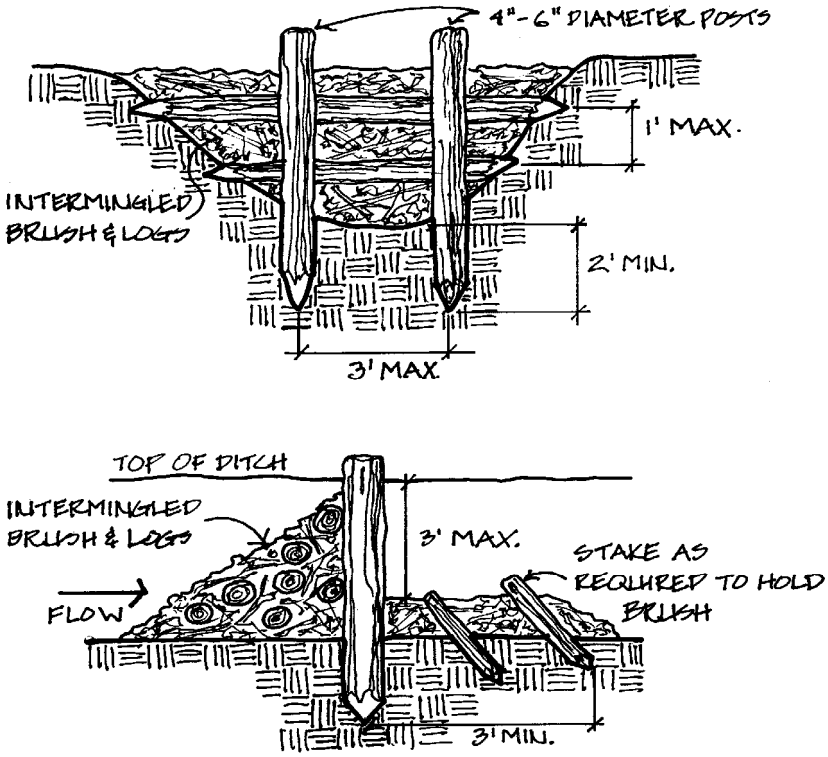


Figure 10—LOG & BRUSH CHECK DAMS

3.6.5 Buffer Zones

Buffer zones are undisturbed vegetated areas that separate roads, development, or construction sites from sensitive areas such as streams, wetlands, and lakes. If there is no vegetation between the road and stream, it would be beneficial to plant grass, shrubs, and/or trees. Assistance can be obtained from the Natural Resources Conservation Service and area Soil Conservation Districts including the purchase of plant materials. Buffer zones:

- Slow water by overland flow through vegetation
- Act as a natural sediment filter
- Do not require much maintenance
- Keep water cool
- Take up nutrients, toxins, and other potential pollutants
- Provide energy for biotic communities (leaf litter)
- Preferred method of slowing and filtering water before it enters surface waters
- Visual buffers
- Wildlife habitat

Table 3 - BUFFER STRIP WIDTHS	
SLOPE OF LAND ABOVE WATER BODY OR STREAM (%)	**MINIMUM WIDTH OF STRIP (FEET)**
0 - 10	100
10 - 20	115
20 - 30	135
30 - 40	155
40 - 50	175
50+ Activity may not be advisable due to erosion potential. Extreme care must be taken to prevent movement of soil.	

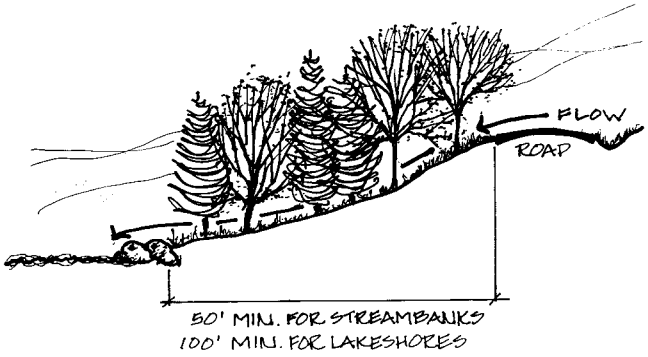


Figure 11—BUFFER ZONE

4.0 STREAM CROSSINGS

Insects that are indicators of excellent water quality and provide nutrition for stream trout

Mayfly Nymphs
Brush-legged Mayfly Nymph
Order Ephemeroptera, Family Oligoneuridae

- ❑ Mature larvae measure up to 3/4 inch in length (excluding tails)
- ❑ Two rows of long hairs present on inside of front legs
- ❑ 2 or 3 tails
- ❑ Slender antennae
- ❑ The conspicuous hairs growing on the inner front legs are used for filtering food particles from the water.
- ❑ Brush-legged mayflies may be minnowlike with a vertically oriented head and three tails (as pictured) or may be more flattened with a horizontally oriented head and tow tails.

Great Lakes Trivia Test (answers on back):

1) Which is the shallowest Great Lake?

2) Which is the largest Great Lake?

3) Which is the smallest Great Lake (by surface area)?

4) There are many Great Lakes in the world. What is the official name of our Great Lakes?

5) How many gallons of water do the Great Lake hold?
(a) 400 trillion gallons (b) 6 quadrillion gallons
(c) 100 quadrillion gallons

GUIDING PRINCIPLES

1. Plan projects. (All projects should be planned!)
2. Move water off road surfaces as soon as possible.
3. Direct runoff into vegetated filter areas or rock-lined turnouts.
4. **Address road runoff from the top of both approaches.**
5. **Avoid directing runoff into surface waters.**
6. Stabilize bare areas.
7. Keep runoff velocities low and avoid concentrating runoff.
8. Minimize areas of disturbance.
9. Revegetate disturbed areas ASAP.
10. Maintain and monitor all practices.

Answers:

1) Lake Erie
2) Lake Superior (which is also the largest lake in the world by surface area)
3) Lake Ontario
4) the Laurentian Great Lakes
5) (b) 6 quadrillion gallons

4.0 STREAM CROSSINGS

Because fisheries, recreational, aesthetic, and water quality values all can be seriously impacted by poorly designed stream crossings, much careful thought must go into determining what type of crossing would be most appropriate for each situation.

Some general guidelines taken from a position statement prepared by the Michigan Department of Natural Resources, Fisheries Division, are as follows (words in parentheses are ours):

1. **Bridges (<u>and bottomless culverts</u>) with adequate span and underclearance are normally preferred over all (other) types of culvert crossings.**

2. **Where bridges are not feasible and where crossings require 36-inch diameter pipe or smaller, culverts may be an acceptable alternative if carefully installed. (Boating and recreational wading are not major factors on these streams. Fish passage and water quality are of greatest concern on these streams.)**

3. **Culverts will not normally be an acceptable alternative to bridges where crossings require pipe of 72-inch diameter or larger (or the equivalent in multiple pipes). Such streams usually require provision for navigation by wading anglers and boats.**

4. **A careful environmental analysis is necessary where crossings call for pipe diameters between 36 and 72 inches.**

In order to minimize adverse impacts of stream crossings on aquatic and riparian stream habitat and navigability, the following criteria should be satisfied:

- *The structure should not encroach upon the stream channel. Encroachment onto the flood plain should be minimized.*

- *Dredging, filling and channel straightening or relocation should be avoided. Where no alternatives exist, changes should be held to a minimum.*

- *The natural downcutting process of rivers and streams should not be interfered with. A jump or leap at the downstream end of the sill or floor could interfere with fish passage. Navigation could also be jeopardized by elevation difference.*

- *The greatest possible end opening is desired to maximize passage of flood flows and to minimize blockage of light which is important to navigation and aquatic productivity.*

- *There must be no interference with navigation where recreational uses presently exist or may be significant in the future. Consideration should be given to animal passage down stream valleys. Stream valleys are important animal migration routes.*

- *Velocities at all flood flows should be such that all migrating fish are capable of swimming upstream against the flow.*

4.1 General Considerations for All Above-Ground Crossings

- A flood flow analysis should be done for all types of above-ground crossings and is required by various state statutes.
- Consider using existing (old) crossings and existing (old) grades instead of creating new crossings.
- Roadway approach fills should be minimized in temporary crossings and must be removed after use.
- Consider installing devices along the roadway itself to control runoff from the roadway. These devices can include Grade Stabilization Structure, Section 7.1 and Water Turnouts, Section 5.3
- Adequate vegetative cover must be established on all disturbed areas upon completion of finish grading.
- Determine permit requirements of state agencies for bridge and culvert replacements.

4.2 Bridge Spans

Bridges are desirable as crossing devices because they can be constructed in the dry except for any required support piers. Minimal encroachment into the floodplain will occur if abutments and wing walls are set back from the stream bank. Less environmental disturbance will result and free movement of wild animals and wading anglers will be permitted with these provisions. Sufficient structure height would allow for suitable watercraft and wading passage.

4.3 Planning Considerations for Bridges

- Obtain hydraulic clearances from appropriate regulatory agencies.
    - Locate the structure at the narrowest point in the floodplain/ wetland.
    - Indicate any alterations or reconstruction that is needed in the channel to accommodate the proposed structure.
    - For bridges which will be used as part of a roadway, indicate how stormwater runoff from the roadway will be managed to prevent erosive velocities. Alternatives are discussed below in Section 4.4 in Design Considerations.
- A cofferdam may be used to create a dry work site, or water may be flumed or pumped around the work site.
- In extreme situations, consider installing a sediment trap downstream of the road crossing if filter fences, floatation curtains, cofferdams and other practices will not be able to keep soil from moving downstream. These are temporary instream basins which will only be used to trap excess sediment from a particular project. Once a project is completed, the sediment basin will be removed and the channel bottom restored. You will need a permit from the appropriate state agency for any instream sediment basin.
- Disruption of the natural vegetation should be kept to a minimum.
- Follow Best Management Practices for treating timber when used in bridge construction or adjacent structures.

4.4 Design Consideration

- Bridge crossings (including bridges and roadways) must be designed to pass the 100-year flood flow without causing a harmful interference, as determined by the appropriate state agency.
- Bridge abutments should be parallel to the direction of flow. Exceptions may occur during the engineering review as a result of flood flow direction.
- The bridge should span the entire width of the stream, leaving the streambed beneath the structure undisturbed.
- If cofferdams are used, locate them to isolate the construction work site from the stream flow. Alternatives include:
    - Constructing a temporary run around the channel
    - Pumping water around the site to provide a dry work site (follow proper dewatering operations)
- Riprap should be installed beneath bridges on all fill slopes or exposed banks.

- Stormwater runoff from roadways should be directed away from the crossing using one of the following methods:
    - Turnouts, Section 5.3
    - Grade Stabilization Structures, Section 7.1
- Concentrated runoff can be directed to a detention or retention basin and either released slowly to the watercourse or allowed to infiltrate the soil.
- Provide stabilization of bridge abutments and all fill slopes using riprap and other critical area stabilization practices.

4.5 Construction Considerations

The construction of a bridge should be done with the least amount of impact on the natural resources. To do this, the operation must be done in steps which will decrease the amount of water crossings that occur. Follow the guidelines below.

- Where depth allows, place filter fences in the water adjacent to the bridge abutment which will be removed first. If filter fences will not work in water because of water depth, consider using floatation curtains. These are suspended in the water and help settle out larger particles so that they are not carried downstream.
- If flows or banks are such that filter fences cannot be used, consider using cofferdams alongside the channel.
- Where applicable, install the approved sediment trap.
- Where applicable, remove the first bridge abutment and replace with a new one.
- Stabilize the first side with vegetation and riprap following the methods found in Section 6.0 Bank Stabilization.
- Install riprap alongside the new abutment and on either side of the new abutment.
- Place filter fences and/or floatation curtains on the opposite side and repeat the sequence above for the second side.
- Complete the rest of the bridge using as few crossings with equipment as possible.
- Clean out the sediment trap upon completion. Restore the natural channel bottom.
- During construction, keep loose boards, nails, and other debris on site and in a way that will not result in them entering the waterway. Wash buckets, wheel barrows and shovels upland away from the water course.

4.6 Bridge Types

4.6.1 Concrete/Steel spans

- Usually for major highway crossings
- Expensive alternative
- Long lasting

4.6.2 Wood or timber

- Aesthetically pleasing
- Suitable for smaller spans
- Less expensive
- Native (local) materials can be used
- Long lasting
- Easy and quick to assemble

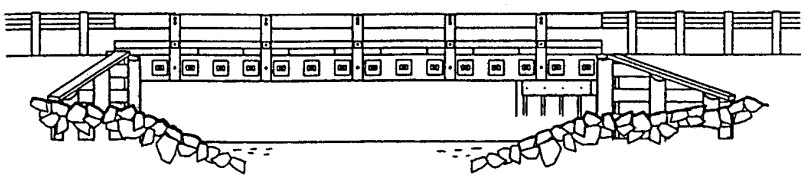


Figure 12—TIMBER BRIDGE

4.6.3 Temporary Portable Bridges

- Can be used for temporary crossing needs such as logging operations where a permanent bridge is unnecessary.
- Can be used in an interim bridge plan in high traffic backroads when a permanent bridge is being delayed.
- Easy installation and removal or relocation.
- Must be removed when completion of the needed work is finished.
- The crossing must be restored to its original condition when finished.
- Streambanks must be left in a stable condition.
- Sediment control measures may be needed downstream.

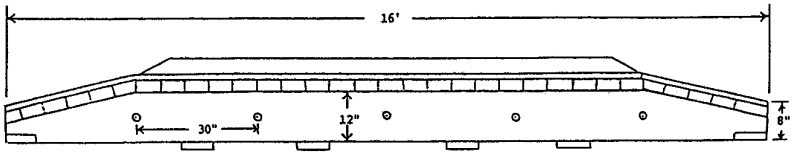


Figure 13—TEMPORARY PORTABLE BRIDGE

4.6.4 Other Possible Temporary Crossings

The following may be used upon approval:

- Temporary culverts
- Flatbed railroad car with wheels removed

4.7 Culverts

A culvert is a conduit used to convey water from one area to another, usually from one side of a road to the other side. Culverts can be used for stream crossings or ditches (roadside water conveyances).

Types of culverts:

4.7.1 Box Culverts-concrete, wood, steel, aluminum or plastic

- More fish friendly than cylindrical culverts
- More bridge-like in appearance
- Can be more expensive
- Natural stream bottom

4.7.2 Cylindrical Culverts - concrete, metal or plastic

- Round
- Elliptical

4.7.3 Bottomless Culverts - metal or concrete

- Box
- Corrugated metal pipe
- Natural stream bottom

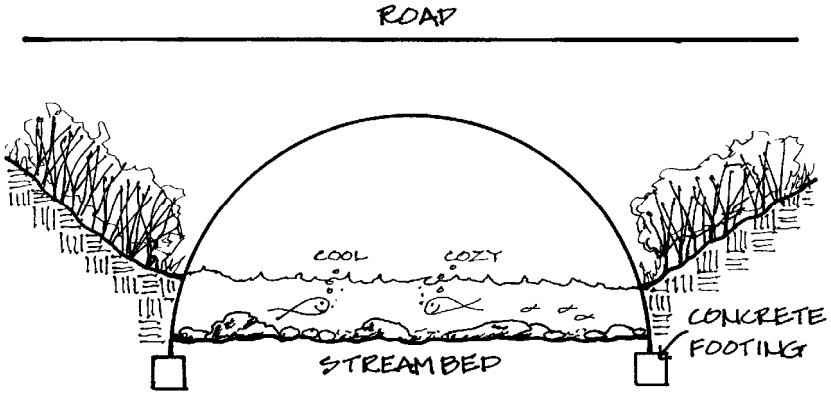


Figure 14—BOTTOMLESS ARCH CULVERT

4.8 Stream Culverts

Culvert installation should occur during periods of low stream flow. This will minimize disturbance to the natural land and water system. Note: It is best to divert or dewater the stream while culvert is being installed to avoid sedimentation of the stream.

Professionally trained engineers or hydrologists should determine the sizing and design of the culvert. Culverts should be designed to handle a 100-year flood flow and to maintain velocities that allow resident fish easy passage through the culvert.

The bottom width of the culvert trench should be twice the width of the culvert with sidewalls no steeper than 1:1. The grade of a culvert should be set by the existing channel. The minimum slope should be 0.05% to allow for positive drainage flow, and should be used in all culvert designs except equalizers. The up slope or inlet end must always be higher in elevation than the down slope or outlet end.

To determine proper pipe length with 4:1 embankment slope, take the road and shoulder width at the angle across the road plus 4x (cover plus pipe diameter); extra length will need to be added to accommodate for headwalls if they are needed.

Whenever possible, align culvert with the existing stream channel. Compact the soil around the lower one-third of culvert. A minimum of one foot of compacted fill over a culvert is recommended. Culvert outlets should be protected from erosion and undermining by use of rock aprons or slope drain/sediment basins.

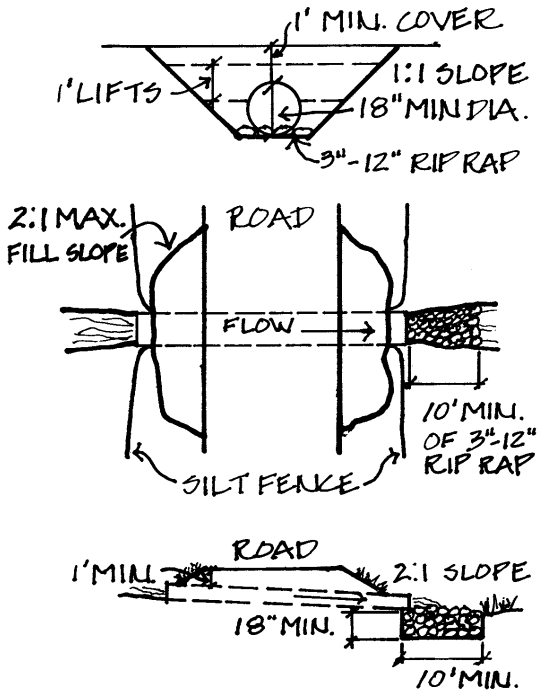


Figure 15—PROPER CULVERT PLACEMENT

FISH FRIENDLY CULVERTS

A culvert installation should not change the conditions in the stream that existed prior to the installation. Trout and other species move upstream and downstream to spawn and meet other habitat needs.

Culverts can impede fish passage by creating the following conditions:

- Excessive water velocities
- Vertical barrier - fish must jump too high
- Inadequate water depth
- Icing and debris problems
- Insufficient or excessive design flows in relation to the range of flows encountered during the seasons of fish passage
- Culvert design does not accommodate the size and species of fish passing through the structure

- When crossing a stream, select the culvert site so there is no sudden increase or decrease in gradient.
- Align the culvert with the natural stream channel.
- Use bridges, bottomless arches or partially buried culverts in areas where fish passage is an important consideration.
- Design culverts so that water velocities passing through the pipe are equal to water velocities in the stream.
- Provide resting pools using riprap at culvert inlet and outlet for culverts installed across streams with high gradients.
- Place riprap securely at upstream culvert end to avoid dislodging that may result in lower culvert capacity, higher velocity flows and reduced inlet efficiency.
- Contact the local state fisheries biologist or state bridge transportation specialist for assistance with stream crossings.

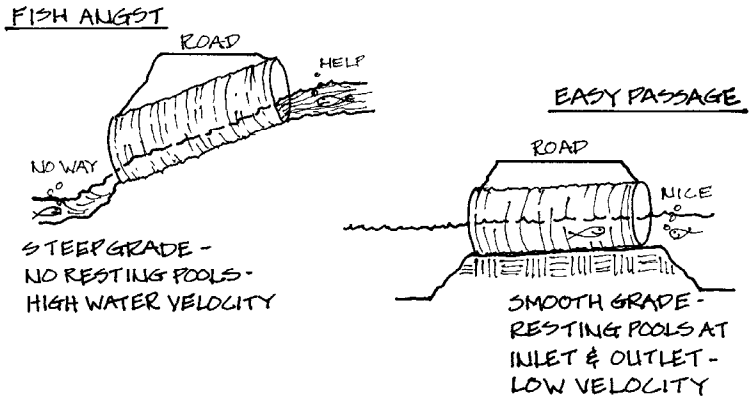


Figure 16—FISH ANGST vs. EASY PASSAGE

INSTALLATION/REPLACEMENT INSTRUCTIONS

1. Prepare the site by using diversion or dewatering techniques to allow for construction in the dry.
2. Excavate the culvert area, removing old culvert if this is a replacement.
3. Recess the pipe into the streambed to provide a natural stream substrate within the structure.
4. Lay pipe up slope, starting at outlet end.
5. Place culvert level with the streambed and backfill in one foot lifts, compacting the lower 1/3, then tamping the remaining fill in place.
6. Place 3 - 12 inch diameter riprap in the excavated outfall area tamping it level with the stream bottom.
7. Seed and mulch all disturbed areas.
8. Complete all work on culvert installation before diverting the stream back to the stream channel and through the culvert.

4.9 Ditch Culverts

Properly placed culverts will help alleviate ditch maintenance problems by outletting water in a timely manner. Culverts also preserve the road base by draining water from ditches along the road, keeping the sub-base dry. Sizing and maintaining culverts correctly will prevent flooding problems that can lead to erosion and repairs. Placing culverts and other outlets based upon road slope will control volume and velocity of discharges, reducing sedimentation from entering surface waters.

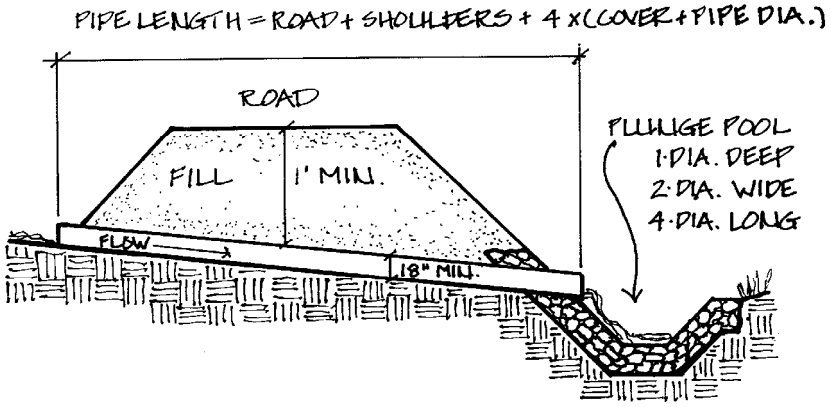


Figure 17—CULVERT PROFILE & CROSS SECTION

4.9.1 Ditch Culvert Profile

- Culverts for small watersheds (less than 20 acres) may be sized by adding the acreage of the water to “8”.
  Example: A 15-acre watershed would use a 24-inch culvert:
  15 + 8 = 23 inches,
  Then rounded to the nearest even inch = 24 inches
  (**Minimum** culvert diameter should be 12 inches.)
- Outlet the ditch culverts to a vegetated area - never directly into a stream, thereby diverting as much road runoff as possible away from the surface water.
- Ideally, culvert should be placed below frost depth to avoid problems caused by frost heaving.
- Culvert outlets should be protected from erosion and undermining by use of rock aprons, plunge pools, slope drain/sediment basins or vegetation.

4.9.2 Intersection of Public Roads with Private Roads/Drives

- To ensure the integrity of road ditch it may be necessary to provide culverts or a protective lining where private roads or drives intersect with public roads.
- Culverts on private roads/drives should follow the same criteria in placement and sizing as described for public roads.
- An open top culvert may be used when drainage is entering a public road by way of the private road surface - this open top culvert can be used to divert the drainage into the existing ditch.

4.10 Headers

- Headers can be used in both stream and ditch applications.
- Headers mark the location of a culvert, protect the culvert from damage during grading and ditch cleaning, increase the hydraulic efficiency, and prevent erosion around the culvert inlet.
- Use headers only when hydraulic capacity needs to be increased by 10% or less and if installing a header will be easier than replacing the culvert.
- Headers should be flush with the end of the culvert.
- Dry laid field stone, treated wood, concrete bags, or sand bags are typical materials used in header construction.
- Header extensions help direct the flow of runoff into the culvert, preventing water from flowing in undesirable directions.

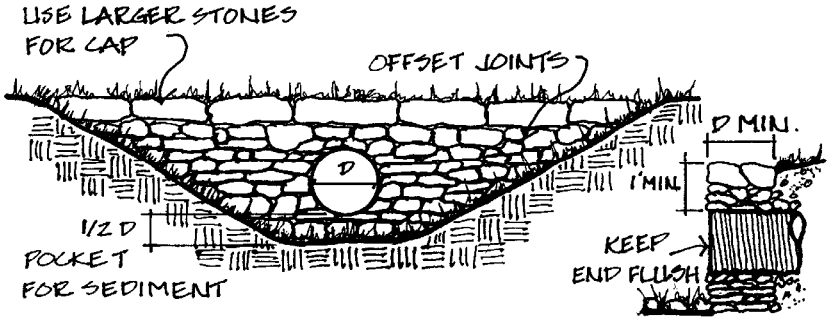


Figure 18—HEADER

4.11 Cleaning and Maintenance

Avoid clogging, collapsing, washouts, and settlement by practicing preventive maintenance. Inspect culverts as often as possible, but at least in the spring and fall, and after major storms.

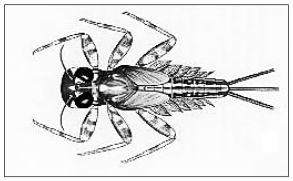
- Mark or inventory culverts so they do not get missed during inspections.
- Inspect underdrain and keep outlet of underdrain clear.
- Use high pressure hose to flush (with water) plugged culverts.
- Flush culverts from the outlet end.
- Check culverts during freezing weather and take action if the culverts start to freeze.
- Thaw or open frozen culverts by using steam, high pressure water, or ice augers.
- Check culvert inlet for erosion and to ensure water is flowing in the pipe and not around it; if some water goes around the culvert it can undermine bedding and the culvert will fail (e.g. “piping”).
- Replace culverts with the same size pipe if it is handling the flow adequately.

Table 4 - CULVERT MAINTENANCE & INSPECTION CHART		
Problem	**Cause**	**Solution**
Scouring/ erosion at the inlet	Ditch graded too steeply Poor location or alignment Clogged pipe	Line the inlet with stone. Properly align the culvert. Clean/flush the culvert.
Scouring/ erosion at the outlet	Pipe sloped too much Pipe too small Improper alignment	Build a stone splash pad. Check size and replace with larger pipe if necessary. Properly align culvert.
Ponded/ puddled water	Invert too high Ditch grade too flat	Reset the pipe to match the invert to the channel bottom. Regrade ditch to maintain correct flow.
Dented/ crushed ends	Traffic/snow plows are hitting the ends	Fix pipe ends; use flared inlets and outlets; mark and protect.
Heavy corrosion	Water flowing through the culvert is acidic	Install a sleeve of PVC in the existing pipe or replace the steel pipe with a noncorrosive material (PVC, polyethylene, aluminum, concrete).
Piping around the outlet	Pipe incorrectly installed, resulting in water flowing outside the pipe	Reinstall pipe with proper bedding and compaction; install a headwall or anti-seep diaphragm.
Sediment build-up	Not enough slope	Reinstall pipe with a slope of at least 1/4 inch per foot.
Objects blocking the pipe	Debris traveling from the ditch to the culvert	Remove blockage; install check dams upstream of the culvert.
Sagging bottom	Foundation material has settled or has low bearing capacity	Reinstall pipe with suitable and properly compacted foundation material.
Crushed top	Not enough cover Soil around walls not compacted Traffic loads too heavy	Add cover. Reinstall pipe deeper and/or with suitable and properly compacted bedding material. Install multiple smaller pipes or pipe with different shape. Replace with stronger or elliptical pipe (“squashed tube”).

5.0 OUTLET STRUCTURES

Insects that are indicators of excellent water quality and provide nutrition for stream trout

Mayfly Nymphs
Flatheaded Mayfly Nymph
Order Ephemeroptera, Family Heptageniidae



- Measures up to 3/4 inch in length
- Nymphs are flattened with sprawling legs and a horizontally oriented head
- Platelike gills are present on abdominal segments
- Abdomen terminates in two or three tails
- Often colored yellow to dark brown, some with banding of yellow and brown on legs.
- Flatheaded mayfly nymphs are common in a variety of aquatic habitats. Stream species are often found clinging to rocks where they graze on algae and other organic material associated with the stream bottom.

Great Lakes Trivia Test (answers on back):

1) Which Great Lake is the only one entirely within the United Sates boundaries?

2) Approximately how many islands are in Lake Huron?
(a) 5,000 (b) 10,000 (c) 30,000

3) What Lake forms the headwaters (or source) of the Great Lakes?

4) When did the glaciers recede leaving the Great Lakes and Michigan shaped as they are today?

GUIDING PRINCIPLES

1. Plan projects. (All projects should be planned!)
2. **Move water off road surfaces as soon as possible.**
3. Direct runoff into vegetated filter areas or rock-lined turnouts.
4. Address road runoff from the top of both approaches.
5. **Avoid directing runoff into surface waters.**
6. Stabilize bare areas.
7. Keep runoff velocities low and avoid concentrating runoff.
8. Minimize areas of disturbance.
9. Revegetate disturbed areas ASAP.
10. Maintain and monitor all practices.

Answers:

1) Lake Michigan
2) (c) over 30,000
3) Lake Superior
4) 10,000 years ago

5.0 OUTLET STRUCTURES

5.1 Description

Outlet structures are used to discharge water from a ditch or culvert. There are a variety of types of outlet structures. Roadside water should not be discharged directly to surface waters.

5.2 Importance to Maintenance & Water Quality

Outlet structures reduce the velocity of water carried by road ditches and culverts, therefore helping to control sedimentation. Water should outlet to areas with moderate slopes and vegetative filter strips before entering surface waters. This type of outlet, often referred to as *daylighting*, will allow for most of the sediments and other pollutants to be removed before runoff enters surface waters.

5.3 Turnouts

Turnouts are extensions of ditches which direct water away from the road edge to filtering or detention/retention areas. They are usually geotextile-reinforced, vegetative chutes. Turnouts will not only protect water quality, but will also save gravel for reuse.

- Use only in areas where the water will flow to a filtering or detention/ retention area, well away from the road and surface waters.

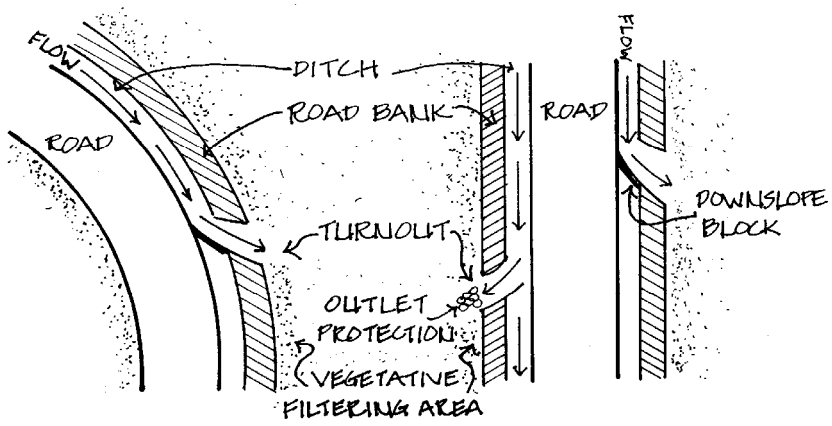


Figure 19—TURNOUTS

5.4 Rock Aprons

Rock aprons are areas lined with riprap used to discharge water from culverts to existing ground. Rock aprons provide culvert outlet protection by reducing water velocity and promoting sheet flow.

- Use only where there is a vegetative filter strip.
- Discharging of culvert to a fill slope will require a conveyance channel (see next section) before the water reaches the rock apron for discharge to existing ground.
- Size and placement of riprap in the apron is dependent on the diameter of the culvert as well as on expected water flow through it.

Table 5 - ROCK APRON SPECIFICATIONS

Culvert Diameter (inches)	Riprap Size - R#	T (inches)	N (feet)	W (feet)	L (feet)
18	D50 - 6 inches	18	4.5	14.5	10.0
24	D50 - 6 inches	18	6.0	20.0	14.0

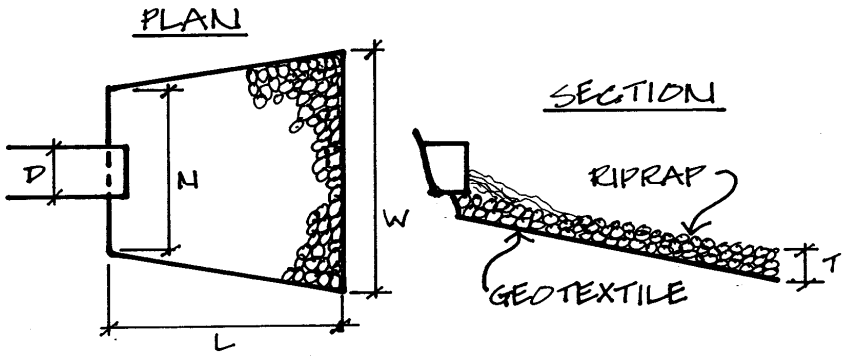


Figure 20—ROCK APRON

5.5 Riprap Conveyance Channel

A riprap channel is used to remove sediments and to keep the channel itself from eroding while carrying runoff from a culvert or ditch. It is used only in areas with steep fill slopes, where erosion would otherwise occur without adequate vegetative filter strips, and where an outlet must go directly into surface waters.

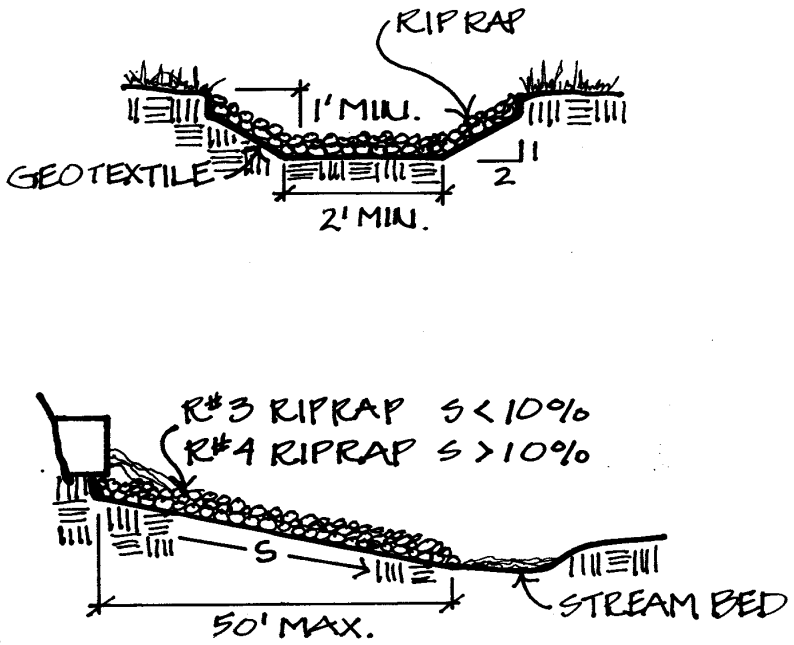


Figure 21—RIPRAP CONVEYANCE CHANNEL

5.6 Splash/Plunge Pools

Splash/plunge pools are riprap basins, located at the outlet of culvert pipes. They are used to remove sediments by absorbing energy from flowing water and allowing sediments to settle out from areas with concentrated flows and areas without adequate vegetative filter strips. They reduce energy and velocity flows by providing storage of runoff and consolidate the sediment for easier removal. They can also allow for ground water recharge.

- Limit to areas with less than 10% slope.
- Clean when pool area is one-third filled with sediment.
- Locate to facilitate mechanical cleaning.
- Not recommended for new culvert replacement.
- Useful to correct a perched culvert problem.

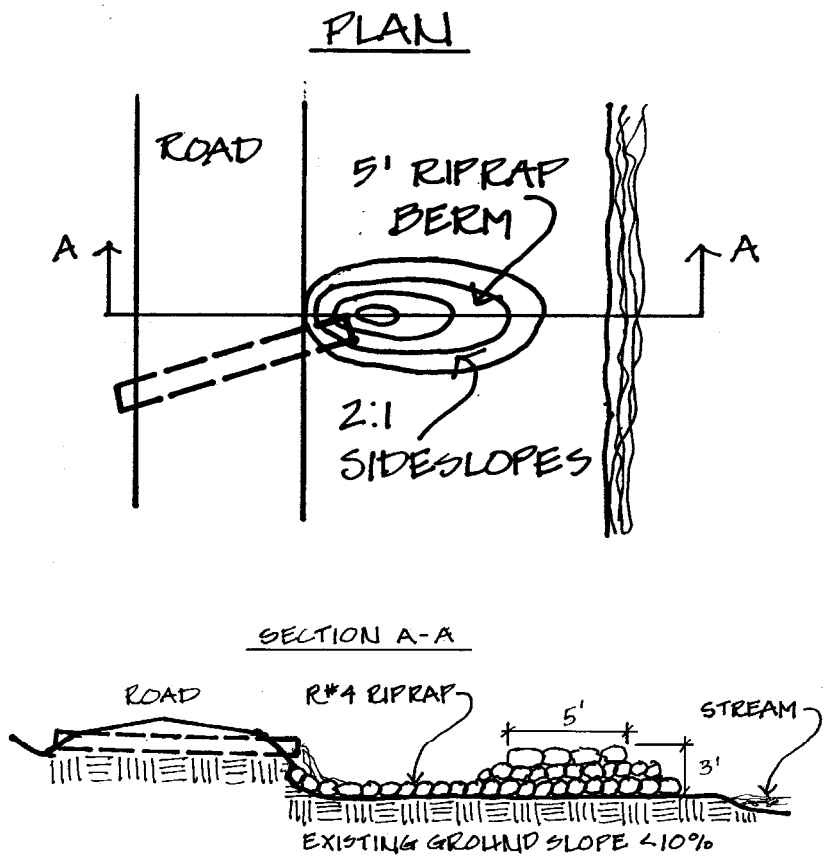
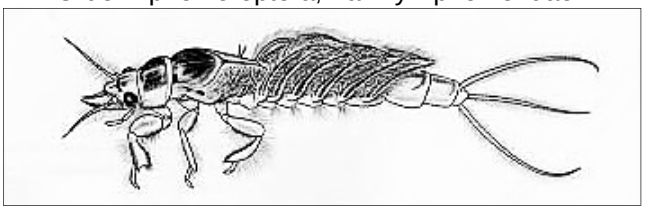


Figure 22—SPLASH/PLUNGE POOL

6.0 BANK STABILIZATION

Insects that are indicators of excellent water quality and provide nutrition for stream trout

Mayfly Nymphs
Burrowing Mayfly Nymph
Order Ephemeroptera, Family Ephemeridae



- ❑ Nymphs measure up to an inch in length
- ❑ Conspicuous dorsal gills on abdominal segments
- ❑ Three tails
- ❑ Possess curved tusks which project from the head
- ❑ Nymphs burrow in silt or sand in rivers, streams, lakes and ponds.
- ❑ Most species are thought to feed on organic particles associated with the substrate.

Great Lakes Trivia Test (answers on back):

1) Name one significant treaty or agreement concerning the Great Lakes.

2) The Great Lakes Charter is an agreement between the Great Lakes Governors for management of the quantity of Great Lakes waters. Under the agreement, a state must consult with the other Great Lakes states on any proposal to do what with Great Lakes water?

3) How many miles do the Great Lakes run from west to east?
(a) 750 miles (b) 1,000 miles (c) 3,000 miles

4) Name two Great Lakes ports starting with the letter "C".

GUIDING PRINCIPLES

1. Plan projects. (All projects should be planned!)
2. Move water off road surfaces as soon as possible.
3. Direct runoff into vegetated filter areas or rock-lined turnouts.
4. Address road runoff from the top of both approaches.
5. Avoid directing runoff into surface waters.
6. **Stabilize bare areas.**
7. Keep runoff velocities low and avoid concentrating runoff.
8. Minimize areas of disturbance.
9. **Revegetate disturbed areas ASAP.**
10. Maintain and monitor all practices.

Answers:

1) Boundary Waters Treaty of 1909, the Great Lakes Charter, the Canada-U.S. Great Lakes Water Quality Agreement, or the Great Lakes Toxic Substances Control Agreement

2) divert Great Lakes waters outside the Basin

3) (a) 750 miles

4) Chicago, Cleveland, Calumet

6.0 BANK STABILIZATION

6.1 Description and Purpose

Bank stabilization is the vegetative or structural means used to prevent erosion or failure of any slope. The terms *erosion* and *bank failure* have different definitions, as well as different causes. Erosion occurs when soil particles at the bank's surface are carried away. It is caused by wind, water, ice, and gravity, which are caused by such things as stream currents and waves, obstacles in a stream, overbank drainage, heavy rainfall on unprotected land, freeze-thaw and dry cycles, seepage, and changes in land use. Bank failure occurs when a section of the bank slides. It is caused by increase of load on top of the bank, swelling of clays due to absorption of water, pressure of ground water from within the bank, minor movements of the soil or creep, and changes in stream channel shape.

Soft bank stabilization practices such as vegetative seeding are

- More natural appearing.
- Able to absorb energy from stream flow.
- Easy to apply.
- Less expensive.

Hard practices such as rock riprap and structures are

- Less natural in appearance.
- Likely to deflect energy of stream flow.
- More difficult to apply.
- More expensive to apply.

6.2 Importance to Maintenance & Water Quality

Stabilization of banks along roads and streams will prevent bank erosion and failure, both of which may contribute considerable amounts of sediment to surface waters. Preventing erosion and failures can also alleviate the need fro expensive road repairs that can be caused by these problems.

6.3 Vegetation - Seeding

Grass and forb seeding is the most efficient and inexpensive method to stabilize a bank and should be used wherever possible. Grass will slow the movement of water, allowing more water to seep into the ground and minimizing the impact of runoff to surface waters. Areas should be seeded **as soon as possible** after disturbance - this may even need to be done on a temporary basis.

Areas with unstable soil and steep banks may require the use of sod as opposed to seeding techniques. If sodding is necessary it should not be laid between June 10 and August 20 without irrigation in northern Michigan and similar latitudes.

- Areas to be seeded should have a maximum 2:1 slope.
- Spread at least 3 inches of topsoil over the area to be seeded and then finish grade.
- Fertilize and lime the area as needed according to the soil condition.
- Harrow or rake fertilizer and lime into the soil to a depth of two inches.
- The surface should be left rough to reduce water velocity, and to help hold seed and much.
- Select a seed mixture appropriate for site soil and drainage ("Conservation Seed Mix" is suitable for most areas).
- Whenever practical use native grasses and forbs.
- Broadcast seed evenly over the prepared area by either had broadcasting or hydroseeding. Hydroseeding is done using a truck with a mounted sprayer.
- After seeding, mulch with straw to a depth of 2 inches - this can be done by blowing it on from a truck or by hand spreading - if no mulch is to be applied, roll, rake or brush to lightly cover the seed.
- Erosion control blankets should be used on steep erodible situations nears surface water. Jute netting (COIR fiber) is preferred over any plastic 'biodegradable' nettings.

Temporary seeding: usually contains small grains, i.e. oats, barley, rye or wheat, and can contain perennial rye. This type of seeding gives a quick cover to prevent erosion during construction.

Dormant seeding: may be made in the late fall for germination in the spring. Dormant seedings must be mulched.

Long term seeding: should be done from May 1 to September 20 and must be mulched. Recommended seed mix is listed in the following table.

It is always wise to check with your local Conservation District for detailed seeding information unique to your area.

Table 6-Conservation Seed Mix
Long Term Vegetative Cover

Seed Type	Lbs/Acre	Lbs/1000 ft^2
Perennial Rye	5	0.15
Tall Fescue	20	0.5
Redtop	1	0.03
Creeping Red Fescue	20	0.5
Kentucky Bluegrass	5	0.2
Ladino Clover	0.5	0.015

6.4 Vegetation - Shrubs and Trees

Native shrubs and trees can be used to stabilize steep slopes and streambanks, create a good vegetative filter strip and create a valuable wildlife habitat. Deeply rooted woody species provide greater protection against slippage problems.

- Identify native plants in the area to determine the most suitable plants to use for stabilization.
- Commonly used stabilization plants include: native willows, dogwood and ninebark.
- Techniques for stabilizing banks with woody plants include:

6.4.1 Live Fascines/Wattles/Bundles

Live fascines, wattles and bundles are long bundles of live branches, 5 to 30 feet in length and 6 to 8 inches in diameter, tied together with growing tips oriented the same direction and tops evenly distributed through length of bundle. They can be used on steep slopes (1:1) and to protect slopes from shallow slides.

- Place in 12- to 18-inch deep trench dug along the contour of the slope, working from the base of the slope upwards.
- Secure with live stakes and dead stout stakes.
- Install bundles the same day as cut during dormant periods (spring, winter, or fall).

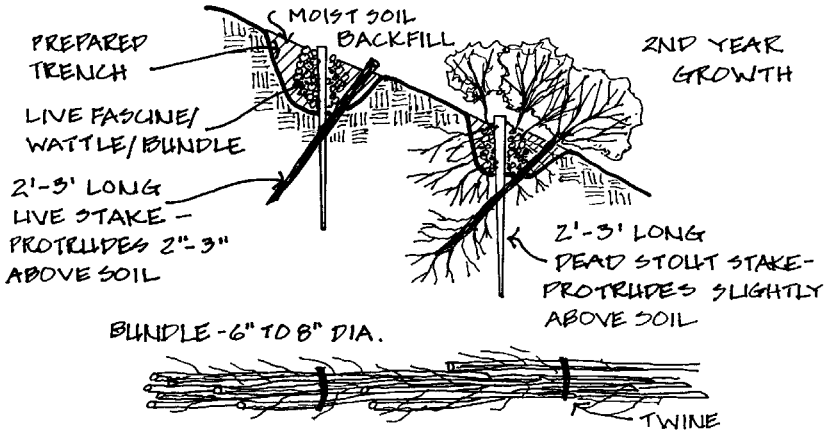


Figure 23—LIVE FASCINES/WATTLES/BUNDLES

6.4.2 Live Stakes

Live stakes are cuttings of live branches usually 1/2 to 1-1/2 inches in diameter and 2 to 3 feet long. They are an inexpensive method that can be used when time is limited and the site is relatively uncomplicated.

- Branches should be cleanly removed from stake and basal end of stake cut at an angle for easy insertion into soil\
- Stakes are tamped into the ground at right angles to the slope along the contour with buds oriented up.
- Plant in alternating grids with 2 to 4 stakes per square yard.
- Plant stakes the same day as cut during dormant periods (spring, winter, or fall).

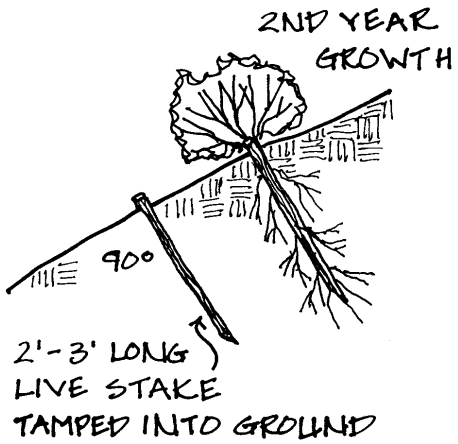


Figure 24—LIVE STAKES

6.4.3 Brushlayering

Brushlayering is the use of live branches, 1/2 to 2 inches in diameter and 3 to 4 feet long, which are placed perpendicular to the slope with growing tips outward. They are used to break up slopes into a series of shorter slopes.

- Small 2 to 3 feet wide benches, angled slightly higher at the outside, are excavated along the contour starting at the toe of the slope and working upward.
- Branch cuttings are placed on the bench in a crisscross or overlapping manner.
- Backfill on top of branches and compact.
- Plant branches the same day as cut during dormant periods (spring, winter, or fall).

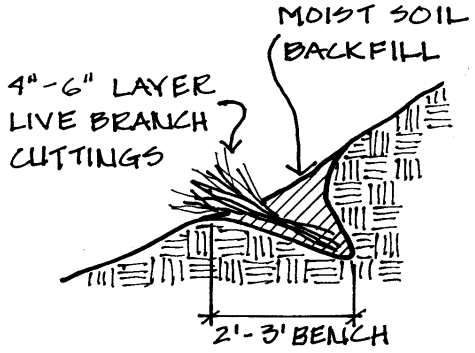


Figure 25—BRUSHLAYERING

6.4.4 Sprigs/Plugs

Sprigs or plugs are individual plant stems with roots. They can be seedlings or rooted cuttings. Rooted shrubs from a nursery may be used and are more reliable, but more expensive. Sprigs/plugs are often used on filled slopes in conjunction with fiber rolls.

- Place in hole that is dug large enough to accommodate the roots and tamp soil down around the plant.
- Plant in alternating grids with plants 1/2 to 1 yard or meter apart.

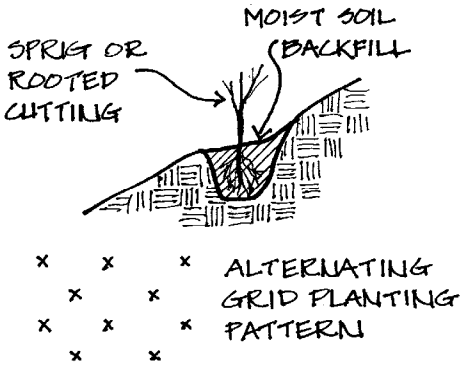


Figure 26—SPRIGS/PLUGS

6.5 Grading Techniques

Banks should be graded to a maximum 2:1 slope.

6.5.1 Terracing

Benches can be constructed on slopes that are excessively steep and long to provide near level areas that intercept and divert water.

- Backslope terrace inwards toward the slope to intercept water and prevent erosion of terrace.

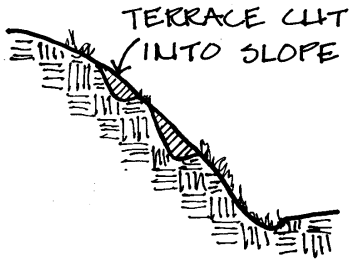


Figure 27—TERRACING

6.5.2 Counterweights

A level bench and stable slope can be added next to a steep failing bank to hold the bank up and prevent continued sliding.

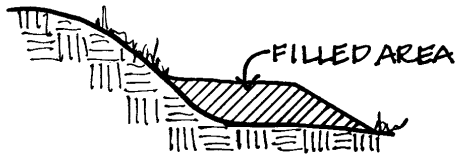


Figure 28—COUNTERWEIGHT

6.5.3 Cut and/or Fill

The removal or addition of soil to the bank to create the desired 2:1 or flatter slope, often times removing less stable soils and replacing them in the process of regrading the slope.

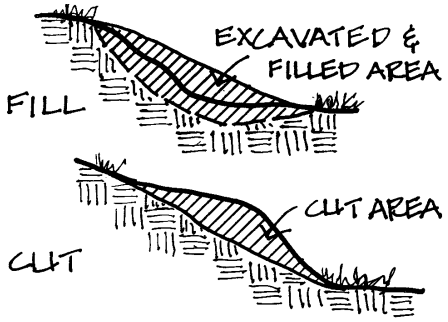


Figure 29—CUT AND/OR FILL

6.5.4 Notching or Keying

A V or trapezoid shaped cut is made in the existing ground to help further stabilize fill added to smooth the slope.

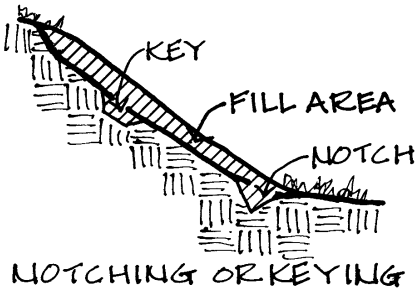


Figure 30—NOTCHING OR KEYING

6.6 Structures - Walls

6.6.1 Gabions

Gabions are wire mesh rectangular boxes filled with stone and used as a retaining wall. Gabions are permeable, allowing water to seep through and aiding in the removal of sediments. They can be stacked or terraced, and can be combined with woody vegetative stabilizers to improve their appearance.

- Gabions can be costly.
- Can be used in unstable flows.
- Live stakes or other **bioengineering** material can be used with them.

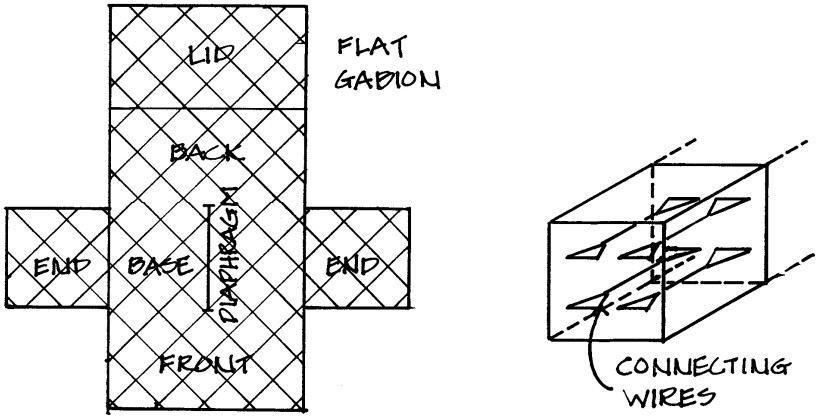


Figure 31—GABIONS

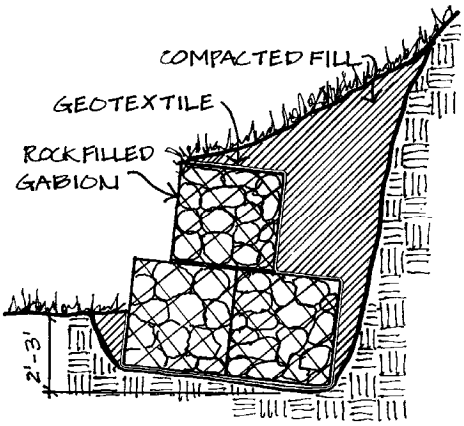


Figure 32—GABION WALL

6.6.2 Log or Timber cribs

Log or timber cribs are made of logs or treated timber filled with soil and used as retaining walls. Live branches can be planted in the crib to assist with stabilization.

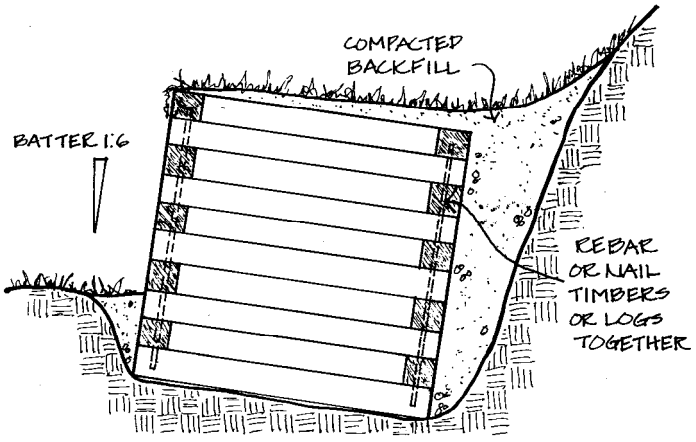


Figure 33—LOG OR TIMBER CRIB

6.7 Structures - Revetment Systems

6.7.1 Riprap

Riprap can be carefully placed on bank slopes and stream edges where vegetation does not adequately prevent soil loss to reduce erosion and filter sediment. It is used on very steep slopes, at sharp turns in streams, and where a bridge or culvert restricts water flow.

- Size of riprap is dependent on quantity and velocity of water flow.
- Riprap should be placed at an elevation equal to the 10-year storm elevation, or the annual high water line, or the top of slope.
- Use graded riprap so that smaller stones will fill in the gaps between the larger stones.
- Place appropriate geotextile properly with <u>all</u> edges 'toed in' so that water does not flow under the geotextile.

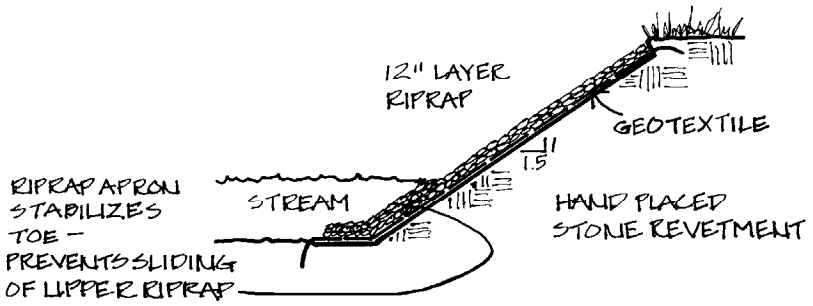


Figure 34—RIPRAP REVETMENT

6.7.2 Full Tree Revetment

Tree revetments are used in place of, or in conjunction with, rock riprap to reduce the amount of rock needed and for economic purposes. In remote areas not readily accessible to heavy equipment, tree revetment use is desirable. Often trees are available near streambanks where rock or access to equipment and rock are not.

- Install trees as parallel as possible to the bank.
- Optimal stabilization is accomplished with lush coniferous trees having total heights ranging from 12' to 20', and crown widths of 5' to 8'. Red or white pine will be used.
- Trees should be staggered and overlapped 30-50%.
- Galvanized cable of 3/16 inch diameter should be utilized to anchor trees.
- All cable should be taut and concealed.
- Earth anchors should be driven to a minimum depth of 4' below existing grade.
- Follow manufacturer's recommendations for setting anchors and cable.

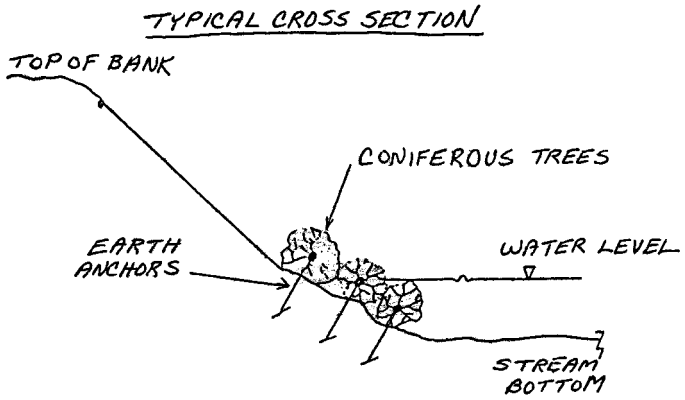


Figure 35—FULL TREE REVETMENT

6.8 Combinations

Also called bioengineering, vegetative and structural components can be combined to form a system used to stabilize steep banks. They are used when one component will not provide the necessary slope protection and stabilization. Combination or bioengineering techniques include:

6.8.1 Rock Riprap

Rock Riprap placed around cribwalls or gabions held to secure in less stable flow conditions; they also improve wildlife habitat.

6.8.2 Live Cribwalls

A log or timber crib is combined with live branches, as used in brushlayering. Timbers provide structural support while plants take root, but use half as much wood as in a timber or log crib, making it less expensive. They may also be constructed in a step fashion, creating planting areas. Use at the base of a slope where a low wall, not higher than 6 feet, is required.

- Place logs or timbers in an alternating manner leaving space for live branch cuttings.
- Branch cuttings should be long enough to reach the undisturbed soil at the back of the crib.
- Cover each layer of branches with a layer of compacted soil.

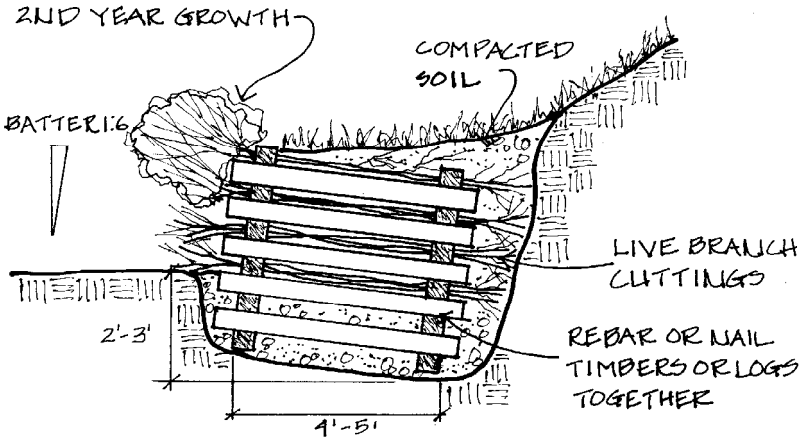


Figure 36—LIVE CRIBWALL

6.8.3 Vegetated Gabion

A gabion wall is combined with live branches, as used in brushlayering. Live branches root into gabions and slope, binding the gabions to the slope, and provide aesthetic enhancement to the gabion wall. Use at the base of a slope where a low wall, not higher than 5 feet is required.

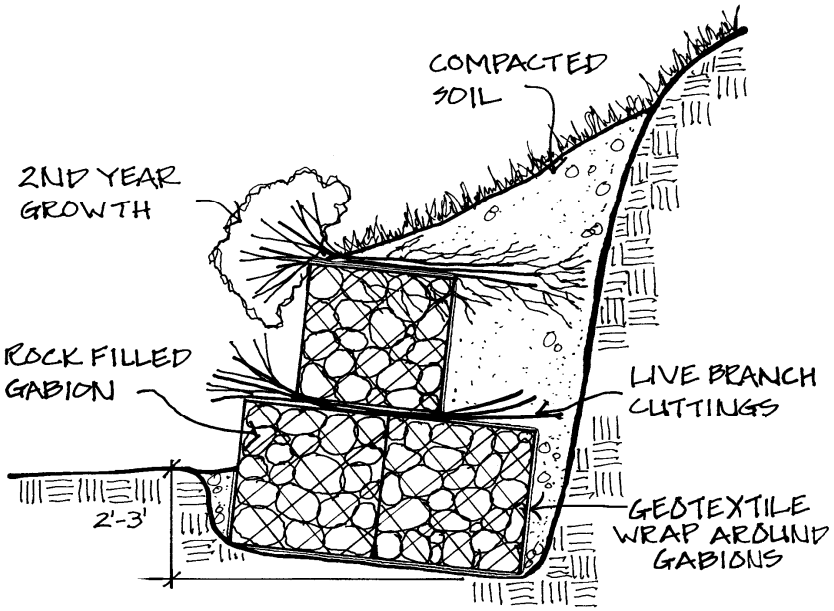


Figure 37—VEGETATED GABION WALL

6.8.4 Vegetated Rock Wall

A combination of rocks and live branches, as used in brush layering. It provides a well drained base for the wall. Use at the base of a slope where a low wall, not higher than 5 feet, is required.

- Excavate a minimum amount of slope behind the wall.
- Place rocks with long axis slanting inward toward the slope.
- Backfill between each layer of rocks and place live branch cuttings on backfill.
- Cover with soil and compact.

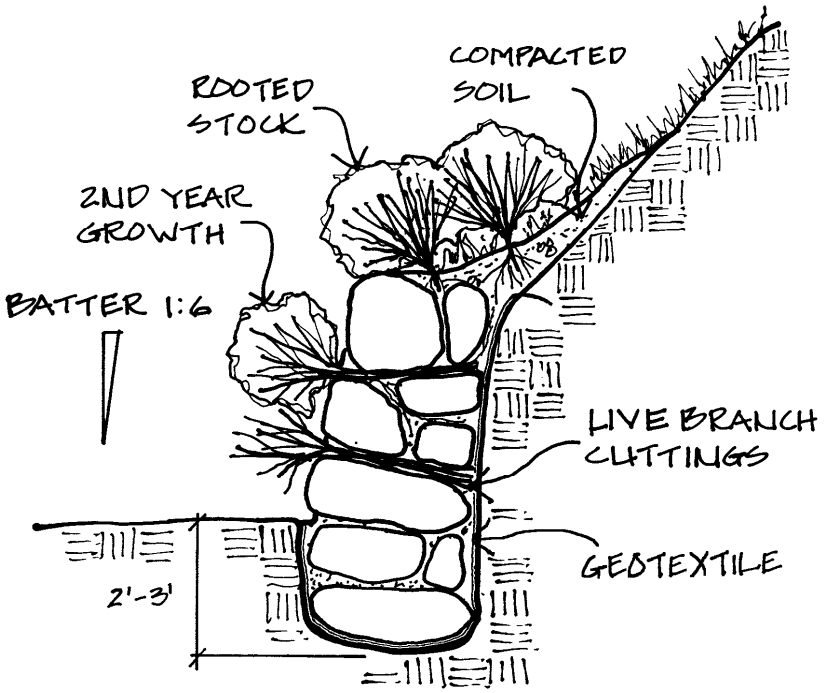


Figure 38—VEGETATED ROCK WALL

6.8.5 Vegetated Riprap/Joint Planting

Combines riprap revetment with the tamping of live stakes between the joints or open spaces in the rocks. Roots improve drainage and create a mat that binds and reinforces the soil, preventing washouts and loss of fines between and below the rocks.

- Live stakes must be long enough to extend well into soil below rock surface.

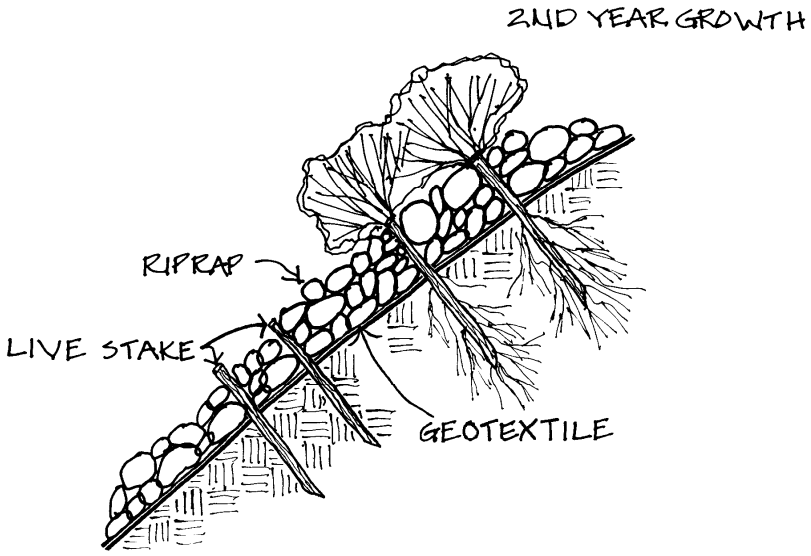


Figure 39—VEGETATED RIPRAP

6.9 Mats & Blankets

Mats and blankets are used to prevent erosion on a temporary basis on steep slopes, in ditches with high water velocities, and other areas prone to erosion. Types of mats and blankets include:

6.9.1 Jute Matting

is a strong, natural fiber woven into an open 1-inch square weave mesh.

- Spread over seeded and mulched areas to hold in place.
- Bury up-slope end of each section in a 6-inch vertical slot, backfill and tamp.
- Overlap each down-slope section with 12 inches of mat.
- Overlap side-by-side sections by 4 inches.
- Securely anchor mat with stakes and staples.
- Jute matting is generally preferred over other types of mats and blankets.

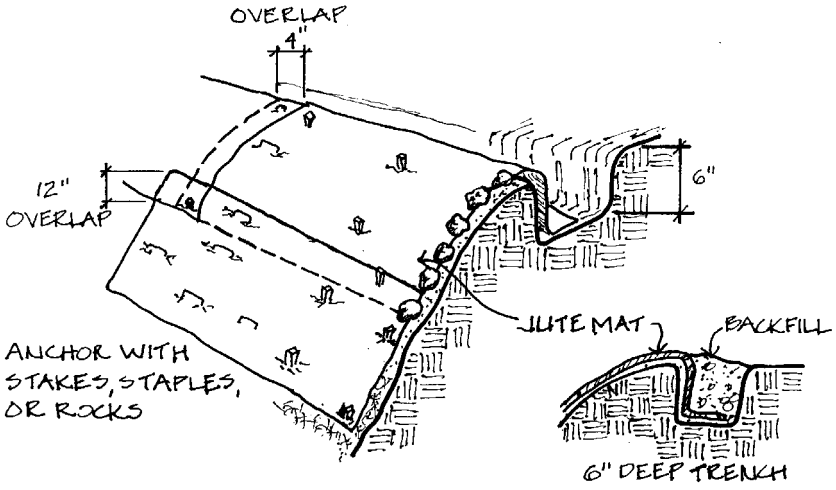


Figure 40—JUTE MATTING

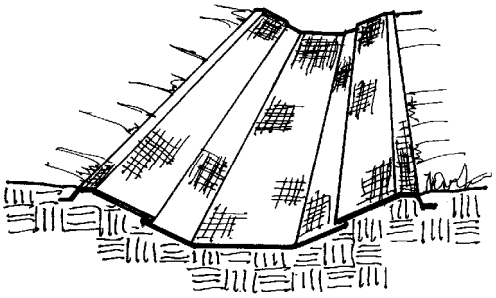


Figure 41—DITCH INSTALLATION

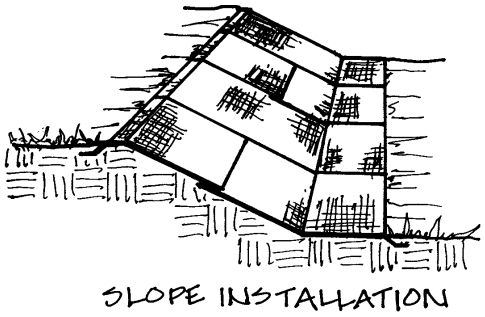


Figure 42—SLOPE INSTALLATION

6.9.2 Wood Excelsior Blanket

Wood excelsior blanket is a machine produced mat of 6-inch long curled wood excelsior entwined with a photodegradable plastic mesh.

- Ends of sections should be tightly butted but not overlapped.
- No need to mulch when using a wood excelsior blanket.
- Installation is otherwise similar to jute mat.

6.9.3 Mulch Blanket

Straw, coconut, or wood fibers sandwiched between photodegradable plastic. Use in areas where it is difficult to hold mulch in place and there is erosion potential until vegetation is established.

- Place after area has been seeded.
- Place lengthwise along direction of the slope and secure with staples.

6.10 Geotextiles

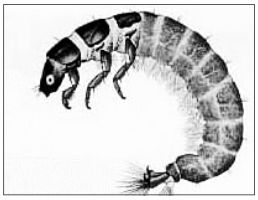
Geotextiles are permeable natural or synthetic materials used for silt fences, channel linings, road base stabilizers, and prior to the placement of riprap or aggregate. They help to prevent the migration of finer soil particles and are used to trap sediments.

- Installation technique is dependent upon use.

7.0 OTHER TOOLS

Insects that are indicators of excellent water quality and provide nutrition for stream trout

Caddis Larvae
Net-spinning Caddis Larva
Order Trichoptera, Family Hydropsychidae



- ❑ Larvae measure up to 3/4 inch in length.
- ❑ Three pairs of legs.
- ❑ Body is caterpillar-like and strongly curved.
- ❑ Antennae reduced and inconspicuous.
- ❑ Color varies from bright green to dark brown.
- ❑ Gill tufts on lower half of body.
- ❑ 3 hard plates on dorsal thorax (adjacent to legs).
- ❑ Brush of hairs at tip of prologs (found at the posterior end of the abdomen).
- ❑ Net-spinning caddisfly larvae are widespread and may be abundant in poor quality streams.
- ❑ As their name suggests, netspinners construct a silken mesh net which they use to filter organic particles from the water column.

Great Lakes Trivia Test (answers on back):

1) Name two toxic substances of concern in Great Lakes fish.

2) What is the greatest source of human exposure to Great Lakes toxic substances? (a) swimming (b) drinking water (c) eating fish

3) How many U.S. citizens live in the Great Lakes basin?
(a) 27 million (b) 36 million (c) 43 million

4) Name a glacial lake plain area.

5) Name the process whereby toxic substances accumulate throughout the food chain.

GUIDING PRINCIPLES

1. Plan projects. (All projects should be planned!)
2. Move water off road surfaces as soon as possible.
3. Direct runoff into vegetated filter areas or rock-lined turnouts.
4. Address road runoff from the top of both approaches.
5. **Avoid directing runoff into surface waters.**
6. Stabilize bare areas.
7. **Keep runoff velocities low and avoid concentrating runoff.**
8. Minimize areas of disturbance.
9. Revegetate disturbed areas ASAP.
10. Maintain and monitor all practices.

Answers:

1) PCBs (polychlorinated biphenyls), mercury, dioxin, PAHs (polycyclic aromatic hydrocargons), PBBs (polybrominated biphenyls), or chlordane

2) (c) eating fish

3) (b) 36 million

4) Saginaw Bay or Detroit (area north and west of Lake Erie)

5) biomagnifications (or bioaccumulation)

7.0 OTHER TOOLS

7.1 Grade Stabilization Structures

Grade Stabilization Structures are permanent structures that stabilize grades in natural or artificial channels by carrying runoff from on e grade to another. These structures include vertical drop structures, chutes, pipe drop structures, and downdrains. They may be made of rock riprap, concrete, metal, wood, and/or heavy plastic.

In natural streams, every effort should be made to reduce stormwater inputs which may increase stream velocities.

Grade stabilization structures are designed to prevent banks from slumping, reduce the velocity with which water runs off the land, and prevent erosion of a channel that results from excessive grade in the channel bed. Proper grade stabilization, combined with adequately protected outlet structures, can reduce the likelihood that soil will be detached and transported to surface water.

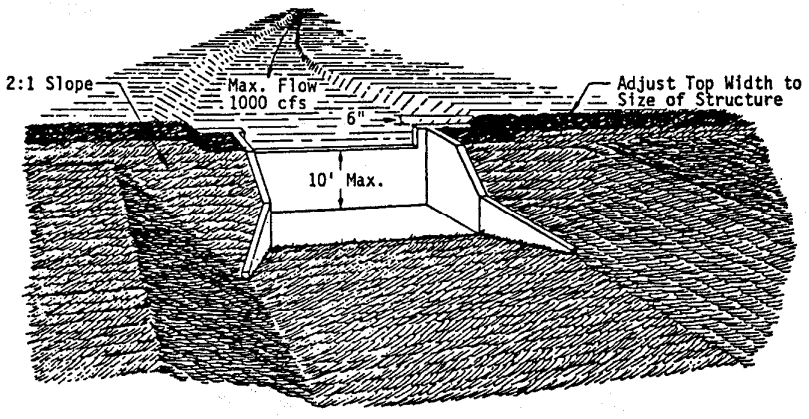


Figure 43—GRADE STABILIZATION STRUCTURE

7.2 Sediment Controls & Traps

Sediment controls and traps are erosion controls used for the removal of sediments. Types of sediment controls and traps include:

7.2.1 Silt Fence-Short Term

Used to removed sediments from sheet flows and often used at the toe of a slope.

- Short term

7.2.2 Straw Bales-Short Term

Used to remove sediments from sheet flows and often used at the toe of a slope. They can be used at culvert outlet or around drains to remove sediments.

- Replace after heavy rains or every 3 months.
- For more information see Velocity Controls & Energy Dissipaters, Section 3.6.

7.2.3 Rock Filters/Check Dams-Long Term

Used in conveyance channels to remove sediments.

- Long term
- Need to remove and replace if filter becomes clogged
- For more information see Velocity Controls & Energy Dissipaters, Section 3.6.

7.2.4 Sediment Traps-Long Term

Small temporary excavations or embankments designed to intercept, trap, and retain sediment from runoff during construction. They handle flows larger than other controls. Sediment traps are also a useful tool for stream rehabilitation.

- Should be at least twice as long as it is wide.
- No maintenance - capacity is equal to volume of sediment for life of structure if used on short term projects.
- Not a substitute for handling on-site erosion.
- Requires appropriate technical guidance and permits.

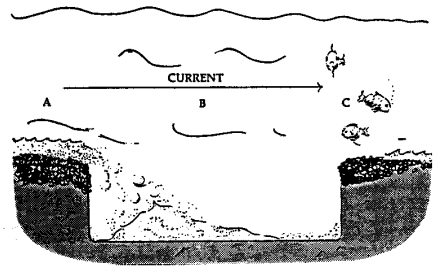


Figure 44—SEDIMENT TRAP PROFILE

7.3 Storage & Borrow Areas

Areas where soil for use in road construction or maintenance is either kept for future use or taken from, as in a sand pit.

- Develop an erosion and sediment control plan for the specific site.
- Divert runoff from the face of exposed slopes.
- Only leave areas in current use unvegetated.
- Stabilize exposed areas immediately after use.
- Locate storage areas on the uphill side of a disturbed area so they can act as a diversion for runoff.
- Control any sediment from storage and borrow areas with previously described temporary controls.

7.4 Level Spreaders

Bermed trench used to intercept and discharge water flow over a wide linear area. They prevent gullies by discharging over a wide linear area and are generally used at the toe of a slope.

- Construct a long, level, bermed trench - water will discharge evenly over berm when trench is full.

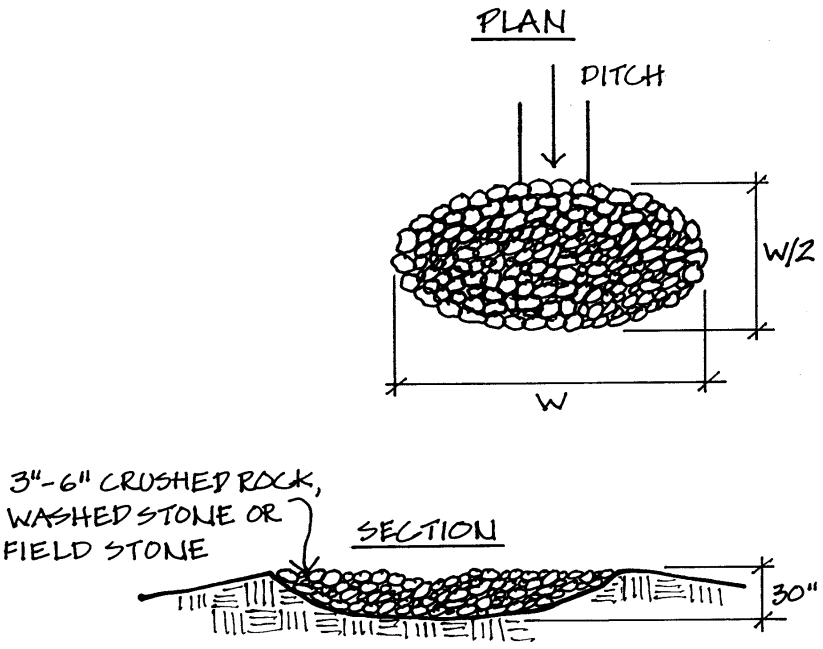


Figure 45—LEVEL SPREADER

7.5 Water Bars

Berm or open culvert constructed across road used to divert water flowing down the road. Use only on very low traffic volume roads. They prevent gullies in the road and eliminate concentrated sediment deposits.

- Construct low enough for traffic to pass over and angle across road to direct runoff flow off the road.
- Spacing of berms is dependent upon road slope.
- Need to be rebuilt periodically.
- Inexpensive means for controlling and diverting water.
- Refer to Outlets (especially for concentrated flows).

Table 7 - SPACING FOR WATER BARS

Road Grade (percent)	Distance Between Water Bars (feet)
2	250
5	135
10	80
15	60
20	45
30	35

- Proper spacing between water bars can be determined from the above table.
- Installation should be at an angle of 30 or more degrees down slope or to turn surface water off the road or trail.
- A shallow trench, 12 to 18 inches below the surface of the road or trail would extend beyond both sides.
- The uphill end of the bar extends beyond the side ditch line of the road and ties into the bank to fully intercept any ditch flows.

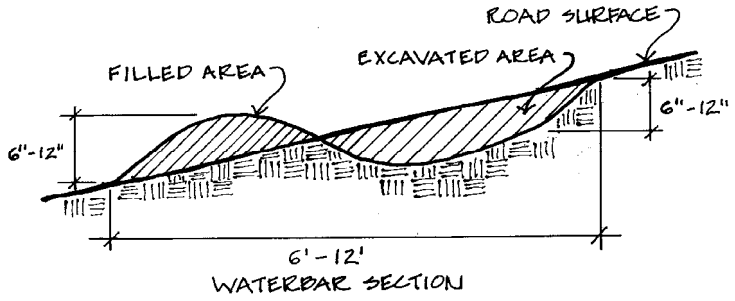


Figure 46—WATER BAR SECTION

7.6 Broad-based Dip

Provides cross drainage on backroads and logging or timber operation haul roads to prevent buildup of excessive surface runoff and subsequent erosion. Broad-based dips can be used on haul roads and heavily used skid trails having a gradient of 12% or less. They are not used for cross draining spring seeps, intermittent or permanent streams. This practice may be substituted for other surface water cross drain practices such as pipe or box culverts. An inherent problem in construction of a broad-based dip is to recognize that this roadbed consists of two planes rather than one unbroken plane. One plane is the 15 to 20 foot reverse grade toward the uphill grade and outlet. The second plan is the long grade from the top of a hump or start of a down grade and ends at the outlet of the dip. Neither the dip nor the hump should have a sharp angular break, but be rounded, allowing a smooth flow of traffic. Only the dip itself should be outsloped since the dip provides sufficient break in grade to turn the water.

The “broad-based dip” removes water from the backroad and allows flow onto natural forest floor (from Kochenderfer 1970).

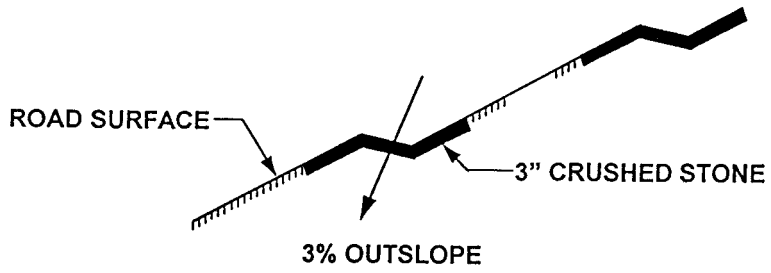


Figure 47—BROAD-BASED DIP

Specification for Broad-based Dips

- Installation takes place following basic roadbed construction.
- 1 20-foot long, 3% reverse grade is constructed into the existing roadbed by cutting from upgrade of the dip location and using cut material to build up the mound for the reverse grade.

Table 8 - SPACING FOR BROAD-BASED DIPS

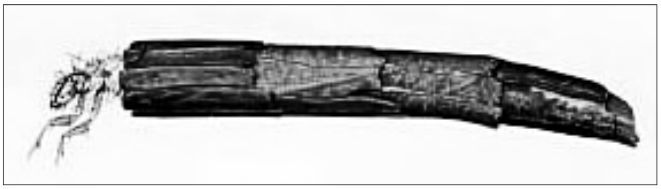
Road Grade (percent)	Spacing Between Dips (feet)
2	300
3	235
4	200
5	180
6	165
7	155
8	150
9	145
10	140
12	100

- Cross drain must slope to a controlled discharge at no more than a 30% slope.
- An energy dissipater should be installed at the outfall of the dip to dissipate water velocity assuring no erosion of cast fill.
- The dip and reverse grade section may require a surface of at least 3 inches of crushed stone, in some soils, to avoid rutting of the road surface.

8.0 OTHER CONSIDERATIONS

Insects that are indicators of excellent water quality and provide nutrition for stream trout

Caddisfly Larvae
Case-making Caddisfly Larva
Order Trichoptera, various families



- Up to one inch in length
- Build distinctive cases made of sticks, rocks, sand, plant material and/or other debris
- Three pairs of legs
- Antennae reduced and inconspicuous

Great Lakes Trivia Test (answers on back):

1) Is spring earlier or later along the shores of Lake Michigan, and what effect does this have on the fruit trees?

2) Name three benefits of Great Lakes wetlands.

3) How many species are there of Great Lakes fish?
(a) 65 (b) 145 (c) 180

4) What percentage of the U.S. population lives in the Great Lakes basin? Of the Canadian population?

5) Where do all the waters of the Great Lakes end up?

GUIDING PRINCIPLES

1. Plan projects. (All projects should be planned!)
2. Move water off road surfaces as soon as possible.
3. Direct runoff into vegetated filter areas or rock-lined turnouts.
4. Address road runoff from the top of both approaches.
5. Avoid directing runoff into surface waters.
6. Stabilize bare areas.
7. Keep runoff velocities low and avoid concentrating runoff.
8. **Minimize areas of disturbance.**
9. **Revegetate disturbed areas ASAP.**
10. **Maintain and monitor all practices.**

Answers:

1) Spring is delayed several weeks making it a cooler spring which protects the fruit trees from being vulnerable to damaging frost. This improves Michigan's harvest of fruit.

2) They reduce flooding by storing water; provide habitat for plants, animals, and fish; improve water quality fy filtering out sediments, nutrients, and contaminants; and reduce shoreline erosion by providing a buffer between the water and the shoreline.

3) (c) 180

4) U.S. is 20 percent, or 36 million people; Canadian is 60 percent or 6 million people

5) the Atlantic Ocean or through the Chicago diversion down the Mississippi River and into the Gulf of Mexico

8.0 OTHER CONSIDERATIONS

8.1 Aesthetics/Vegetative Management

Good maintenance and erosion control practices create more attractive backroads and make the public happy about the care their roads are receiving. This in turn improves public support for the needs of the road crew in maintaining roads properly. Tree canopies over backroads are one of the area's important scenic resources for residents and visitors alike; but there are times when aesthetics and good road maintenance and erosion control practices may seem to conflict, as in creating proper ditches. The road crew has the important job of balancing the need for the proper road maintenance and erosion control that will keep sedimentation from reaching surface waters with the need to maintain the wonderful aesthetic qualities of scenic backroads.

- Removal of large, healthy trees along the road should only be done when absolutely necessary.
- Grading too close to trees, closer to the trunk than the drip line of the leaf canopy, will harm the tree and may eventually kill the tree.
- Grading that exposes roots, especially on slopes or along deep ditches may cause a hazard by making trees more easily uprooted, as well as look unsightly.
- Cover exposed tree roots as quickly as possible to avoid damaging the tree.
- Prune any tree limbs broken during maintenance back close to the main trunk or branch.
- Replant areas where trees are removed for construction purposes to provide for a new canopy and revegetation.
- Rebuild any stonewalls that must be removed for road construction or ditching.
- Stone culvert headers are aesthetically pleasing and in keeping with the rural character of backroads.
- Use natural fieldstone for riprap as opposed to quarry limestone for a more aesthetic appearance.

8.2 Beavers

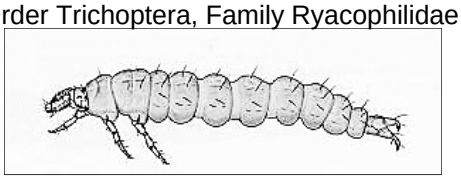
Cute as they are, beavers can create problems for road crews by building dams that block culverts and impounding water that can be released during a flood, washing out roads and bridges. Beavers, particularly, like to build dams at culverts because the stream flow is narrowed and the road makes up the rest of the dam. This creates a recurring problem for road crews since beavers have a tendency to keep rebuilding dam after dam in the same spot. However, beavers also create significant wildlife habitats and scenic areas. In recent years, many inventive people have developed methods to deal with the beavers other than constantly dismantling dams or extermination. Some of these ideas include:

- Use deep repellent to keep beavers away temporarily.
- Hang a 36-inch x 36-inch white flag attached to two poles when beavers start to construct a new dam - the color and motion causes the beaver to leave and not return.
- Weld an elbow that aims downward at a 90 degree angle onto the culvert, allowing water through the pipe and preventing the beavers from plugging the culvert.
- Install a perforated pipe that inserts into the larger culvert pipe and goes through the beaver dam extending into the pond about 15 feet - this drains the pond causing beavers to move to better accommodations.
- Install two small perforated pipes, each with an elbow extension creating 4 arms going into the pond, on the outside of the culvert. Known as a “beaver reliever”, this device also drains the beaver pond.
- Install a beaver pipe and a metal fence around the culvert that prevents the beavers from blocking the culvert with debris - the two pipes going from the pond through the fence and beaver dam allow the water to flow into the culvert.
- In isolated instances, it may become necessary to control beavers by animal control means such as trapping and removal. Follow the applicable trapping regulations in your area. This method should only be used if all other methods fail.

9.0 RESOURCE LIST

Insects that are indicators of excellent water quality and provide nutrition for stream trout

Caddisfly Larvae
Free-living Caddis Larva
Order Trichoptera, Family Ryacophilidae



- Measure up to 3/4 inch, occasionally 1 inch in length
- Abdomen usually has deep constrictions between segments
- Often whitish to green in color
- Found in cool, clean streams
- Most species are active predators.

Great Lakes Trivia Test (answers on back):

1) The Locks at Sault Ste. Marie are the first, third or eighth busiest in the world?

2) Which is the shortest shipping distance to Europe by freighter: Buffalo, New York, or Baltimore, Maryland?

3) What is the acronym most commonly used to remember the names of all of the Great Lakes?

4) What canal moved settlers from New York City and the Hudson River over to the Great Lakes?

5) Name the largest waterfall in the Great Lakes system.

Answers:

1) third
2) Buffalo, New York
3) HOMES (Huron, Ontario, Michigan, Erie, and Superior
4) the Erie Barge Canal
5) the Niagara Falls

9.0 RESOURCE LIST

The following organizations, in Michigan, may be able to provide assistance with road maintenance, erosion control and sedimentation problems. For projects in other states, consult the appropriate agencies in those areas.

Michigan Department of Environmental Quality (517) 373-1170
Land and Water Management Division
PO Box 30458
Lansing, MI 48909

Michigan Department of Environmental Quality (517) 241-1300
Water Bureau
PO Box 30273
Lansing, MI 48909

Michigan Department of Transportation (517) 373-2090
State Transportation Building
425 W. Ottawa St.
PO Box 30050
Lansing, MI 48909

Michigan Department of Natural Resources (517) 373-1275
Forest, Mineral and Fire Management Division
PO Box 30452
Lansing, MI 48909

Michigan Department of Natural Resources (517) 373-1280
Fisheries Division
PO Box 30446
Lansing, MI 48909

USDA Natural Resources Conservation Service (517) 324-5270
Michigan State Office
3001 Coolidge Rd., Suite 250
East Lansing, MI 48823

U.S. Fish & Wildlife Service (517) 351-2555
Ecological Services Field Office
2651 Coolidge Rd., Suite 101
East Lansing, MI 48823

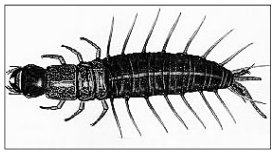
USDA Forest Service
Huron-Manistee National Forests
Supervisor's Office
1755 S. Mitchell St.
Cadillac, MI 49601

(231) 775-2421

10.0 PERMITS

Insects that are indicators of excellent water quality and provide nutrition for stream trout

Dobsonfly
Order Megaloptera, Family Corydalidae



- ❑ Commonly called Hellgrammites.
- ❑ Measure 3/4—4 inches in length.
- ❑ Body is elongate and somewhat flattened.
- ❑ Large pinching jaws.
- ❑ Lateral appendages along the length of the abdomen.
- ❑ Cotton-like gill tufts on underside of abdomen.
- ❑ Abdomen terminates in two small prologs, each bearing two claws.
- ❑ Short inconspicuous antennae.
- ❑ Feed on other aquatic insects.
- ❑ Hellgrammites are usually found on the underside of large rocks in cool, slow-moving streams.
- ❑ Handle hellgrammites, carefully, larger individuals may deliver a painful pinch!

Great Lakes Trivia Test (answers on back):

1) What fish were introduced to the Great Lakes in the late 1960's and the 1970's that revitalized the sport fishing industry?

2) What is the name of the canal that allows ocean-going vessels to pass around the Niagara Falls?

3) What Lake is most susceptible to "seiches" or winds that pile water up as high as eight feet at one end?

4) Name four ways people play along the Great Lakes.

Answers:

1) Salmon (primarily Coho and King)

2) the Welland Canal (part of the St. Lawrence Seaway)

3) Lake Erie because it is shallow, long, and narrow

4) walking, swimming, boating, fishing, building sandcastles, collecting rocks, wading, windsurfing

10.0 PERMITS

The following permits are required under Michigan law. For projects in other states, contact your state resource agency responsible for permitting.

Inland Lakes and Stream - Part 301 of Act 451
A permit is required to dredge, fill, or place a structure below the ordinary high water mark of an inland lake or stream in Michigan. Common activities requiring a permit under this program are: seawalls or riprap, dredging or filling, and bridge or culvert placement.

Great Lakes - Part 325 Act 451
A permit is required for work or structures below the ordinary high water mark of the Great Lakes.

Also, a permit may be needed under Section 404 of the Federal Clean Water Act for Army Corps of Engineers jurisdictional waters (mostly Great Lakes).

Wetlands Protection Act, Part 303 of Act 451
A permit is required for dredging, draining, filing or maintained use of a wetland. The Act applies to wetlands that are connected to or are near a lake, pond, river, or stream. Isolated wetlands greater than five (5) acres are also protected in counties with populations greater than 100,000.

Flood Plain Control Act, Part 31 of Act 451
A permit is required for structures or to fill in the 100 year floodplain (0.1% chance of occurring each year). The purpose of this Act is to control encroachments into floodways for flows including a one percent probability. This would include bridges and culverts, fills and stream modifications for roads, etc.

For the above, contact:
Michigan Department of Environmental Quality (517) 373-1170
Land and Water Management Division
PO Box 30458
Lansing, MI 48909

Applications: www.mi.gov/jointpermit

Soil Erosion and Sedimentation Control Act, Part 91 of Act 451
This provides for the control of soil erosion and protects the waters of the state from sedimentation. The Act is applicable to all earth changes of one acre or greater or to any earth change within 500 feet of a lake or stream. Contact your county building and zoning department.

For the above, contact your county building and zoning department.

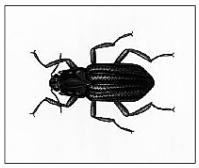
Natural Rivers Act, Part 305 of Act 451
This Act establishes a system of outstanding rivers in Michigan for the preservation, protection and enhancement of them. This Act applies to a selected list of Michigan's rivers and their tributaries.

For the above, contact:
Michigan Department of Natural Resources (517) 373-1280
Fisheries Division
530 W. Allegan St.
PO Box 30046
Lansing, MI 48909

11.0 BIBLIOGRAPHY

Insects that are indicators of excellent water quality and provide nutrition for stream trout

Riffle Beetle
Order Coleoptera, Family Elmidae



- Riffle beetles measure approximately 1/16 to 1/4 inch in length
- Body small, usually oval
- Legs are long
- Antennae are usually slender
- Riffle beetles walk slowly underwater, they do not swim on the surface.

Great Lakes Trivia Test (answers on back):

1) What historic and recreation resource is protected by Great Lakes Bottomland Preserves?

2) Great Lakes water levels fluctuate—go up and down—naturally. What is the most significant cause of these changes in water levels from year to year?

3) What is the percentage of Michigan's land area that drains into the Great Lakes? (a) 75 (b) 95 (c) 100

Answers:

1) shipwrecks
2) precipitation rates (rainfall)
3) (c) 100

11.0 BIBLIOGRAPHY

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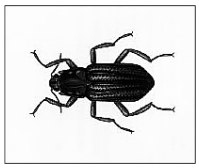
Riffle Beetle
Order Coleoptera, Family Elmidae



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HATCH CHART

Michigan Trout Streams Emergence Schedule - Compiled by John J.P. Long for The Challenge Chapter of Trout Unlimited - “X” Denotes Peak Period

NAME	SIZE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV
Allocapnia granulata or vivipara Tiny Early Winter Black Stonefly	18/20	****	****	****								
Nemouridae and Leuctridae Tiny Late Winter Black Stonefly	16/20			* ****	****							
Taeniopteryx nivalis Early Black Stonefly	10/14			* ****	****							
Brachyptera fasciata Early Brown Stonefly	12/14			**	****	*						
Baetis vagans Blue Wing Olive Mayfly	18/20				***	X***	*XX*	****	***			
Paraleptophlebia adoptiva Slate Wing Mahogony Mayfly	16/18				**	XX**	****					
Ephemerella subvaria Dark Hendrickson Mayfly	12/14				**	XX*						
Chimarra aterrima Little Black Caddis	16/18				**	XX**	****	****	****			
Leptophlebia cupida Borcher's Drake Mayfly	12/14				*	****	****	****	**			
Brachycentrus americanus Grannom Caddis	14/16				*	****	****	****				
Pteronarcys dorsata Midwestern Salmon Fly Stonefly	2/8				*	****	****	**				
Rhyacophilidae fenestra Green Rock Worm Caddis	10/18					****	****					
Perlodidae Isogenus and Isoperla Medium Brown Stonefly	8/14					****	****	****				
Siphloplecton basale Great Speckled Olive Mayfly	10/14					*XX	****	**				
Hydropsyche bronta and simulans Net Building Caddis	14/20					***	****	****	****	****	****	
Ephemerella dorothea Sulphur Dun Mayfly	16/18					**	XXX*	*				
Alloperla caudata and imbecilla Little Yellow and Little Green Stonefly	14/18					**	****	****	****	****	****	
Nectopsyche White Miller Caddis	14/16					**	****	****	****	****	****	
Baetis cingulatus Blue Wing Olive Mayfly	20/22					**	****	****	****			
Ephemerella invaria True Hendrickson Mayfly	14/16					*X	X***	***				
NAME	SIZE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV

NAME	SIZE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV
Ephemerella rotunda Light Hendrickson Mayfly	14/16					**	***					
Stenonema vicarium American March Brown Mayfly	10/12					**	****	**				
Stenonema fuscum Sand Drake Mayfly	12/14					*	XX**	**				
Siphlonurus rapidus Early Gray Drake Mayfly	12/14					*	X**					
Ephemera simulans Brown Drake Mayfly	10/12					*	XX**	*				
Phryganlidae ptilostomis Great Orange Sedge Caddis	8/10						****	****				
Green Oak Worm/Greenie Worm Caterpiller	8/12						*XX*	*				
Diptera Midges	20/28						****	****	****	****	****	
Isonychia sadleri Mahogany Dun Mayfly	10/12						**X	XX**				
Hexagenia limbata Great Olive Winged Drake Mayfly	6/8						**X	X**				
Isonycha bicolor White Gloved Howdy Mayfly	10/12						***	****	****	***		
Stenonema canadense Light Cahill Mayfly	12/14						**	****	*			
Sephlonurus alternatus Late Gray Drake Mayfly	10/12						**	XX**				
Ephemera varia Golden Drake Mayfly	10/12						**	****	*			
Paragentina media Big Golden Stonefly	6/8						*	****	*			
Ephemerella lata Slate Winged Olive Mayfly	14/18						*	****	***			
Pseudocloen anoka Tiny Blue Winged Olive Mayfly	22/24						*	****	****	****		
Ephemerella simplex Dark Slate Wing Olive Mayfly	18/20						*	****	****	****		
Terrestrials Ants/Grasshoppers/Beetles/Jasids	8/24						*	****	****	****	****	
Tricorythodes stygiatus Tiny White Wing Black Mayfly	24/26							***	****	****	****	
Paraleptophlebia debilis Small Slate Mahogany Dun Mayfly	16/18							*	****	****	****	
Mystocides sepulchralis Black Dancer Caddisfly	18/20								****	****		
Baetis pygmalus Little Medium Olive Mayfly	22/24								***	****		
Ephoron album White Fly Mayfly	12/14								**	****		
Baetis heimalis Slate Wing Brown Mayfly	14/16									****	****	
NAME	SIZE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV

The following chart was taken from the Michigan Department of Natural Resources, Fisheries Division, *2006-2008 Michigan Fishing Guide*.

Minimum Entry Lengths/Weights and Current State Records

Catch and Release Entries must meet minimum length
Catch and Keep Entries must meet minimum weight

Species	Minimum Entry Length (inches)	Minimum Entry Weight (lbs. -oz.)	Current State Record (lbs.-oz.)	Species	Minimum Entry Length (inches)	Minimum Entry Weight (lbs. -oz.)	Current State Record (lbs.-oz.)
American Eel	32"	3-0	7-7	Musky, Tiger	42"	20-0	51-3
Bass, Largemouth	22"	6-0	11-15	Northern Pike	40"	18-0	39-0
Bass, Rock	11"	1-0	3-10	Perch, White	10"	0-8	1-14
Bass, Smallmouth	21"	5-0	9-4	Perch, Yellow	14"	1-13	3-12
Bass, Warmouth	9"	1-0	1-6	Salmon, Atlantic	33"	12-0	32-10
Bass, White	16"	2-0	6-7	Salmon, Chinook	41"	27-0	46-1
Bluegill	10"	1-0	2-12	Salmon, Coho	32"	12-0	30-9
Buffalo, Big Mouth	32"	20-0	----	Salmon, Pink	21"	3-0	8-9
Buffalo, Black	26"	10-0	33-4	Smelt***	10"	None	12"
Bullhead, Black	14"	1-4	3-7	Splake	25"	6-0	17-8
Bullhead, Brown	14"	1-8	3-10	Sucker, Longnose	17"	2-0	6-14
Bullhead, Yellow	14"	1-8	3-9.6	Sucker, N. Hog	13"	1-8	2-8
Bowfin	27"	7-0	14-0	Sucker, Redhorse	22"	4-0	12-14.2
Burbot	26"	5-0	18-4	Sucker, White	20"	3-0	7-3
Carp	30"	20-0	61-8*	Sunfish, Green	9"	0-12	1-8
			45-0**	Sunfish, P.Seed	9"	0-12	1-5.6
Carpsucker	19"	3-0	8-0	Sunfish, Redear	10"	1-0	1-15.5
Catfish, Channel	27"	8-0	40-0	Trout, Brook	17"	2-0	9-8
Catfish, Flathead	29"	10-0	47-8	Trout, Brown	33"	16-0	34-10
Crappie, Black	14"	1-12	4-2	Trout, Lake	34"	18-0	61-8
Crappie, White	14"	1-12	3-6	Trout, Rainbow			
Freshwater Drum	21"	7-0	26-0	(Steelhead)	34"	17-0	26-8
Gizzard Shad	16"	1-8	4-2	Walleye	29"	11-0	17-3
Lake Herring	16"	2-8	5-6	Whitefish, Lake	23"	6-0	14-4.5
Lake Sturgeon	50"	70-0	193-0	Menominee	15"	1-0	4-0
Longnose Gar	32"	5-0	18-0				
Musky, Great Lks.	42"	20-0	48-0				
Musky, Northern	42"	20-0	49-12				

*State Record Carp; **Largest hook and line caught Carp; ***The minimum entry requirement for Smelt is 10" for both catch and keep and catch and release entries. The Smelt State Record is by length rather than weight.

Length Measurement Directions: Measure fish from tip of nose (or lower jaw) to tip of tail in a straight line (DO NOT measure in a curve around the body from nose to tail). Measure to the closest 1/8th inch. Tail and jaw should be pinched together.

Our Great Lakes