# Erosion and Sediment Control and BMP's (Best Management Practices)

# Introduction

- Soil erosion occurs naturally as a result of the dispersive action of rain and the power of water and wind to initiate soil detachment and transport soil particles across the surface.
- The extent of erosion losses will depend on climate, topography, and the ability of soils to resist detachment and infiltrate water, but a good vegetative cover can largely offset the effect of these factors.
- Plant cover and natural vegetative residue protect the soil from the impact of raindrops, slows runoff and enhances infiltration of water.

# Introduction (Cont'd)

- Unfortunately, the substantial benefits of vegetative cover are lost during the process of land development, because trees and plants are removed, natural drainage pathways are altered and stable topsoil aggregates are stripped away as part of the grading process.
- If left uncontrolled, erosion of exposed soils can cause local air quality problems, degradation of aquatic habitats, and damage to downstream recreational areas and infrastructure.
- Monitoring has shown that untreated runoff from construction sites can be up to 30 times greater than that of stabilized residential areas and roughly 90 to 100 times greater than stream concentrations.

# Effects

- Effects on fish may include:
  a) impairment to respiratory functions
  b) lower tolerance to toxicants or disease
  c) increased physiological stress
  d) decreased reproductive success
  e) reduced vision, which inhibits their ability to find food.
- Migrating fish will avoid rivers with high suspended solids concentrations.
- Reduced light transmission caused by increased turbidity can also reduce production of plant growth in streams, which can have important repercussions on community dynamics.
- Spawning and egg incubation periods are particularly sensitive times, because sediment (especially clay and silt) may attach to the adhesive surface of eggs resulting in increased egg mortality.
- Excess sediment discharge to downstream watercourses may also have degradation on water quality, increase stream flooding, elevation levels of in-stream erosion influencing the geomorphic stability/instability of the watercourse channel, and reduce navigation in waterways.

# Controls

- Sediment control measures have been required on construction sites for over a decade. However, even on sites where recommended practices are applied, sediment continues to be discharged at concentrations above those required to protect aquatic life.
- In one Toronto area study, monitoring of a channel reach upstream and downstream of a construction site showed an average increase in suspended solids concentration of 500%. This increase in stream sediment concentration occurred even though runoff volumes from the construction site comprised less than 25% of total stream flow and sediment control practices were in compliance with interim guidelines (Greenland International and TRCA, 2001).
- Subsequent studies of temporary sediment control ponds draining construction sites reported similar results (TRCA and U of G, 2006; Clarifica, 2004).
- During one storm, peak effluent concentrations of suspended solids were over 100 times the target level.
- Numerous guideline documents have been prepared since the 1980s, which emphasized the importance of protecting the natural environment during construction activities.
- Other documents include the technical guidelines produced by the Ministry of Natural Resources (MNR) in 1989.

# Guiding Principle

- The pressures of urban development have large scale impacts to the natural environment and in particular aquatic resources and their natural corridors. Changes to the land use can decrease permeability, increase fine sediment inputs, impact on water quality and increase runoff.
- These changes create an unbalance in the natural processes and lead to increased flood events, reduce base flows, decrease habitat diversity and channel erosion.
- Sedimentation from construction activities is a major contributor to these problems. This added sediment contributes to the destabilization of watercourses that not only has extreme ecological costs, but results in the loss of property, costly infrastructure repairs and stabilization efforts that could take a lifetime to complete.
- It is everyone's responsibility to prevent construction related sediment from impacting aquatic resources and other natural features.

# Erosion / Sedimentation

- **Erosion** - is defined as the physical removal or detachment of soil materials.

- **Sedimentation** - is the subsequent transport and deposition of these detached particles (sediment) from the source location.

The two most common mobile agents:

- Water
- Wind

Factors that influence the type and severity of erosion include:

- vegetation cover
- Topography
- soil erodibility / permeability
- Precipitation

- The best way to prevent sedimentation is to prevent erosion BEFORE it occurs!
- Erosion prevention is the preferred mitigation measure for eliminating and/or reducing the potential for sedimentation.

# Topography

- The larger the project area, the greater the disturbed surface area and consequently, the greater the influence that precipitation and resulting runoff has on a site.
- Topography is one of the factors that directs runoff and increases velocity and erosion rates. Where steep slopes are found within a project boundary, runoff may be accelerated down slope to receiving features such as watercourse, wetlands, swales and woodlots.
- In the absence of surface roughness both through the lack of vegetation or loose permeable surfaces, runoff velocities will be accelerated by gravity and the ability to attenuate storm events will be compromised.
- These conditions make the control of sediment nearly unattainable without significant planning, an effective sediment control strategy, contingencies, exhaustive maintenance, and costly restoration.

STEEPER TOPOGRAPHY = HIGHER EROSION RATES!

HIGHER EROSION RATES = MORE AND LARGER PARTICLES BEING MOVED!

# Natural Waterways

The discharge of high sediment loads to natural watercourses has major effects on receiving waters and aquatic habitat. Some specific examples include:

- Degradation of water quality
- Damage or destruction of fish habitat
- Increased flooding
- Elevated levels of in-stream erosion influencing the geomorphic stability/instability of the watercourse channel (channel width and depth as well as pool characteristics)
- Reduced navigation in waterways

# Turbidity

Silt and sediment deposits and elevated levels of turbidity can cause a variety of harmful impacts to fish and fish habitat *by contributing to the following:*

- Reducing the diversity and abundance of bottom-dwelling organisms that fish feed upon
- Blanketing spawning substrates such that they may not be suitable for spawning or food production
- Reducing the survival of fish eggs by smothering the spawning beds and preventing the escape of hatching fry
- Destroying aquatic vegetation that is buried by sediments
- Clogging fish gills and damaging gill membranes
- Reducing the ability of fish to feed by sight.

# Costs and Impacts

The costs associated with the impacts of erosion and sedimentation include, but are not limited to:

- Removal of sediment
- Repair and stabilization of slopes and channels
- Construction delays and stop-work orders
- Charges and fines
- Construction of new ecosystem habitat.

# Non-Compliance

The costs associated with the impacts of erosion and sedimentation include, but are not limited to:

- Increased regulatory scrutiny
- Tarnished professional reputations
- Construction shutdowns
- Costs of additional assessments/restoration
- Substantial legal costs
- Monetary fines
- Relinquished work permits
- Imprisonment – in some cases.

# Environmental Management

Environmental management is the product of the planning and design of an undertaking related to the mitigation of environmental effect.

Components of this environmental management are visible in various forms including permits, approvals, tender documents, design drawings, operational standards and restoration plans which are interwoven into the project.

An important function of environmental management is to translate all the operational constraints, mitigation, compensation and restoration measures detailed in the approvals package to the construction operations.

Environmental management can include specific elements including:

- Erosion and Sediment Control (ESC) Plans
- Worksite isolation plans for in-stream construction
- Spill Control and Response Plans

The plans should encompass all elements of an undertaking and provide a substantial measure of diligence if the site-specific details have been incorporated.

# Developing an Effective ESC Plan

Designing and implementing an effective Erosion and Sediment Control (ESC) Plan is essential for minimizing the potentially adverse environmental effects originating from a construction site.

A well designed ESC Plan includes appropriate locations of selected control measures, scheduling information for the installation of ESC practices, and details of the assigned responsibilities for implementation, operation, modification, inspection and maintenance.

# Developing an Effective E&SC Plan

The following principles will assist in creating an effective ESC Plan:

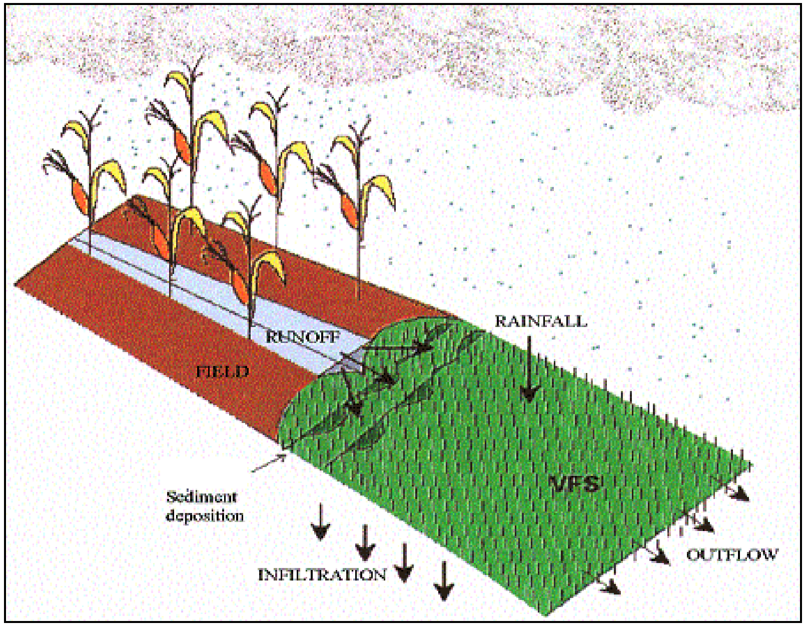
- Adopt a multi-barrier approach to provide erosion and sediment control through erosion controls first;
- Retain existing vegetation and stabilize exposed soils with vegetation where possible, erosion prevention is key in reducing sediment to downstream aquatic habitat;
- Limit the duration of soil exposure and phase construction when possible;
- Limit the size of disturbed areas by minimizing non-essential clearing and grading;
- Minimize slope length and gradient of disturbed areas;
- Maintain overland sheet flow and avoid concentrated flows;
- Store/stockpile soil away (e.g. greater than 15 metres) from watercourses, drainage features and top of steep slopes;
- Ensure contractors and all involved in ESC practices are trained in ESC Plan, implementation, inspections, maintenance, and repairs;
- Adjust ESC Plan at construction site to adapt to site features; and
- Assess all ESC practices before and after all rainfall and significant snowmelt events.

# BMP's

- **Vegetative Filter Strips (VFS)**
- **Mechanical Seeding**
- **Terraseeding®**
- **Hydroseeding**
- **Blankets, mats, Nets**
- **Scarification**
- Edge Saver System®
- **Silt Fence**
- **SiltSoxx® / Straw Wattle**
- **Diversion Swales**
- **Mud Mats**
- Vehicle Washing Systems
- Channel Soxx®
- **Sediment Traps**
- **Rock Check Dams**
- Ditch Chexx®
- Filter Berms
- **Straw Bales**
- **Sediment Control Ponds**
- **Outfall Protection**
- **Storm Drain Inlet Protection**
- Inletsoxx® for Inlet Protection
- **Sediment Bags**
- Filter Bags
- **Sediment / Turbidity Curtain**
- Temporary Stream Crossing
- **Cofferdams**
- Temporary Stream By-Pass
- De-watering and Water Diversions

# Vegetative Filter Strips

- Making use of existing vegetation to filter out sediment is an effective, low cost measure for protecting the ground surface from erosion, enforcing sediment control, and improving the infiltration capacity of the soil.
- Thick and matted existing grass and vegetation is the most effective type of vegetative filter.
- Vegetative filter strips are located immediately adjacent to a watercourse and act as living sediment filters that intercept and detain stormwater runoff from up-gradient disturbed areas.
- They reduce the flow and velocity of surface runoff, promote infiltration, and reduce pollutant discharge by capturing and holding sediments and other pollutants carried in the runoff water.
- Filter strips are fairly level and treat sheet flow across them.

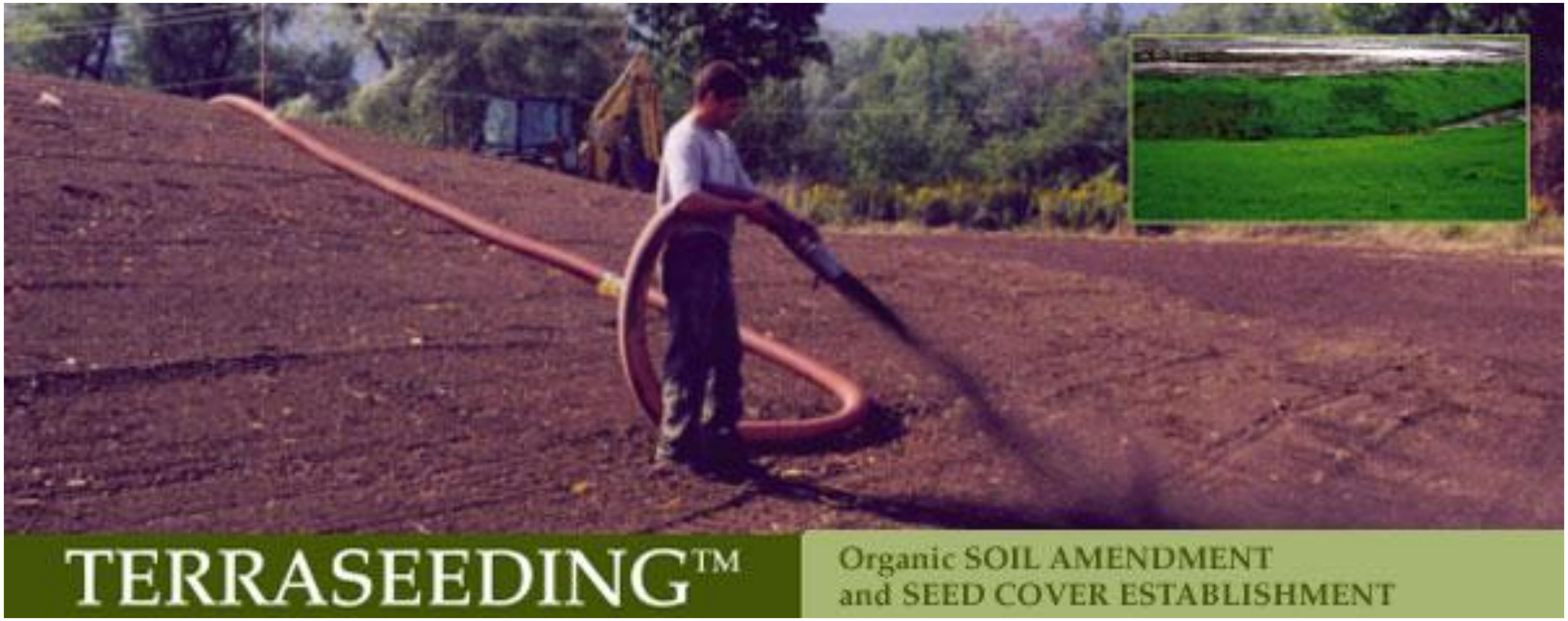


# Mechanical Seeding

- The establishment of vegetative cover achieved by seeding disturbed areas with the use of machinery.
- An effective, long term, relatively inexpensive measure. Vegetative cover is one of the most effective methods of stabilizing exposed soil and reducing erosion due to rainfall and runoff.
- Should be applied to any disturbed surface that is to be left exposed for 30 days or greater and for areas that are at final grade.
- Seeding can be applied to stabilize floodplain and valley bank surfaces, and stormwater pond embankments.
- Typically installed on 3:1 slopes or flatter

# Terraseeding

- Terraseeding™ is the computer calibrated injection of seed into a non-slurried mulch, compost, fibre, or growth media during the application process by an Express Blower™ truck.
- This measure protects the soil surface from direct rainfall impact, reduces the velocity of overland runoff, and fosters the growth of vegetation by conserving moisture and preventing the washing away of seed.
- Applied for the stabilization of exposed soil surfaces and the rapid establishment of both temporary and permanent vegetation.
- Terraseeding provides the establishment of vegetation quicker than hydroseeding.



# Hydroseeding

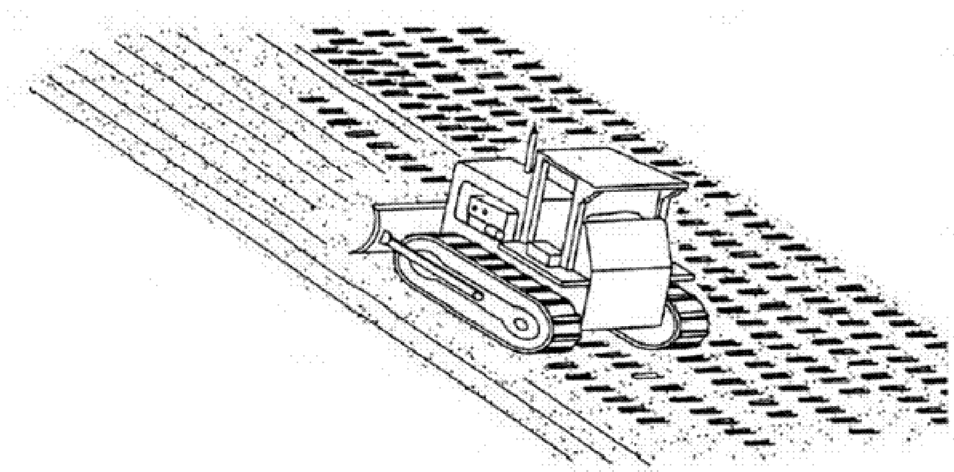
- Hydroseeding is a process of mixing seed, fertilizer, paper mulch with dye and water inside a tank, then spraying the mixture onto exposed surfaces.
- It is not an erosion control method unless a bonded fibre matrix is applied with the material or a straw, wood fibre, coconut fibre mat or equivalent, blanket is applied overtop and secured into place by staples.
- Applied on-top of freshly prepared, cultivated soil. Application for the stabilization of exposed soil surfaces and the rapid establishment of both temporary and permanent vegetation.

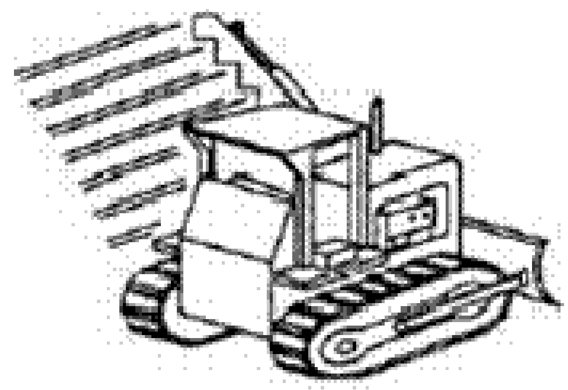
# Blankets, Mats, Nets

- Erosion control blankets, mats or nets, are prefabricated layers of material, generally biodegradable, which are laid on a soil surface to prevent erosion and promote seed growth.
- Nets consist of degradable material tightly woven into a photodegradable mesh. Blankets are simply fibres woven within a photodegradable netting to form a thick fibre blanket.
- Mats may consist of hardy materials such as coconut husk fibres, wood shavings or synthetic fibres that form a stronger/heavier material layer or “mat”.
- Erosion control blankets, mats or nets should be applied to un-vegetated conveyance systems including swales and ditches as these systems receive concentrated flows.
- They should also be applied to all exposed slopes with greater than 2H:1V and are subject to rainfall and runoff.


# Surface Roughening (Scarification)

- Provides for a rough soil surface with the horizontal depressions created by operating suitable equipment on the contour, or by leaving slopes in a roughened condition without fine grading.
- This measure aids in seed bed preparation and establishment of vegetative cover, reduces runoff velocity and quantity, increases infiltration and provides some sediment trapping.
- Can be applied to any disturbed surface that is to be left temporarily exposed (i.e. less than 30 days).





# Silt Fence

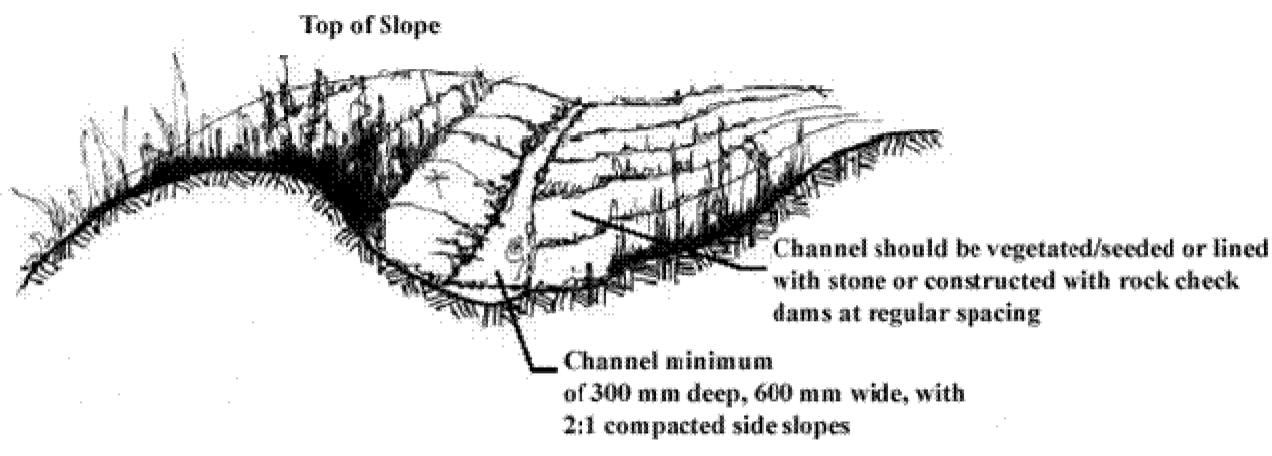
- Consists of a non-woven synthetic fabric material (geotextile) stretched across and attached to supporting post and wire fence. The non-woven geotextile must be entrenched.
- Does NOT filter runoff, but acts as a linear barrier creating upstream ponding which allows soil particles to settle out thereby reducing the amount of soil leaving a disturbed area.
- Decreases the velocity of sheet flow and low to moderate level concentrated flows.
- Should be implemented along the perimeter of sensitive areas, stream and river corridors, and at the base of moderate slopes.
- Used to treat moderate sheet flow; NOT suitable to treat concentrated flows, or substantial amounts of overland flow.
- May be utilized to delineate between work areas and sensitive areas.

# Siltsoxx ™ / Straw Wattles

- Siltsoxx ™ is a sediment-trapping device using filtermedia materials applied with a pneumatic blower device or equivalent.
- Traps sediment by filtering the water passing through the media allowing water to pond, creating a settling of solids.
- Apply to areas of high sheet erosion, on steep slopes up to and exceeding a 2:1 slope, and in other disturbed areas of construction sites requiring sediment control.
- May also be used in sensitive environmental areas.
- Also has the ability to bind various contaminants contained in runoff.

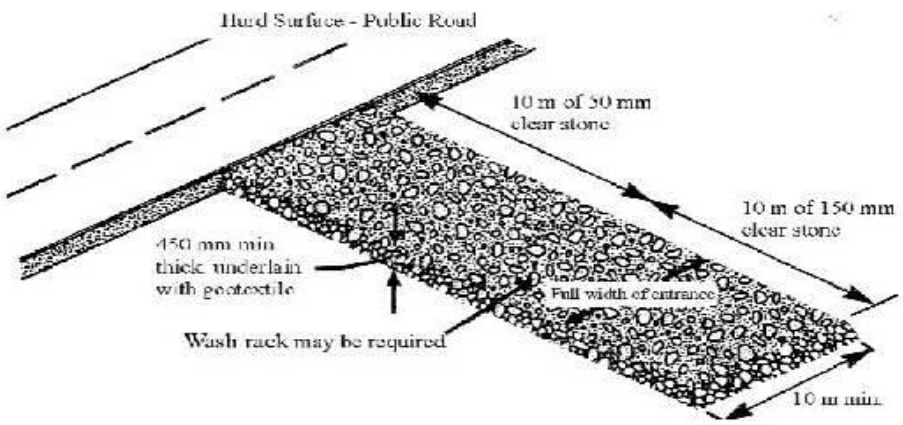
# Diversion Swales and Dykes

- The use of temporary grading of conveyance systems to collect and convey runoff away from unprotected/disturbed slopes, as well as convey runoff from disturbed slopes to a downstream sediment trap or basin/pond.
- Diversion swales/dykes reduce erosion on slopes to allow re-vegetation to proceed and slopes to stabilize.
- Can be applied to intercept surface water runoff from undisturbed or disturbed slopes and convey flows to the appropriate discharge or treatment location.
- Intended to convey small flows along low-gradient channels.
- Should be considered along all toe of slopes and adjacent to valley and stream corridors.



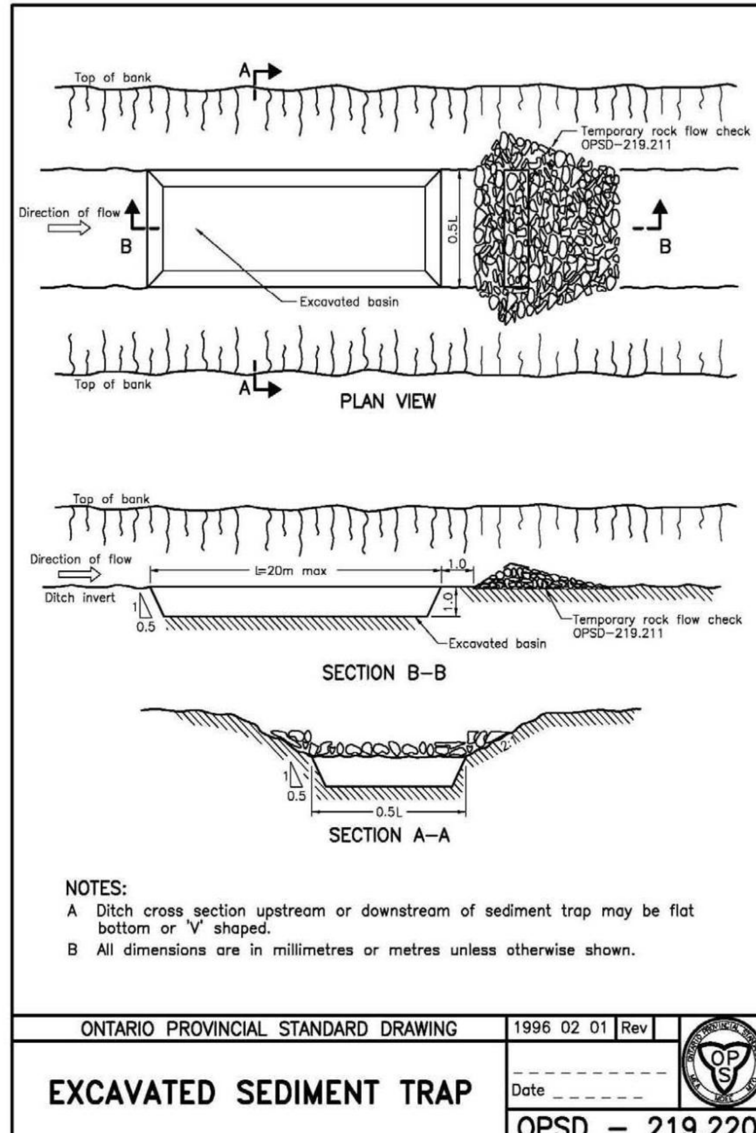
# Mud Mats

- A stabilized vehicle access and egress point constructed of coarse granular material, to reduce the transport of debris.
- Should be built at the entranceway of construction site.
- Stone pad must be a minimum of 20 metres in length and the full width of the entrance.
- Pad should be a minimum of 300 mm thick, but 450mm thickness is recommended.
- Pad should be underlain with a geotextile and consist of 50 mm diameter clear stone for the first 10 metres, and 150 mm diameter clear stone for the last 10 metres.



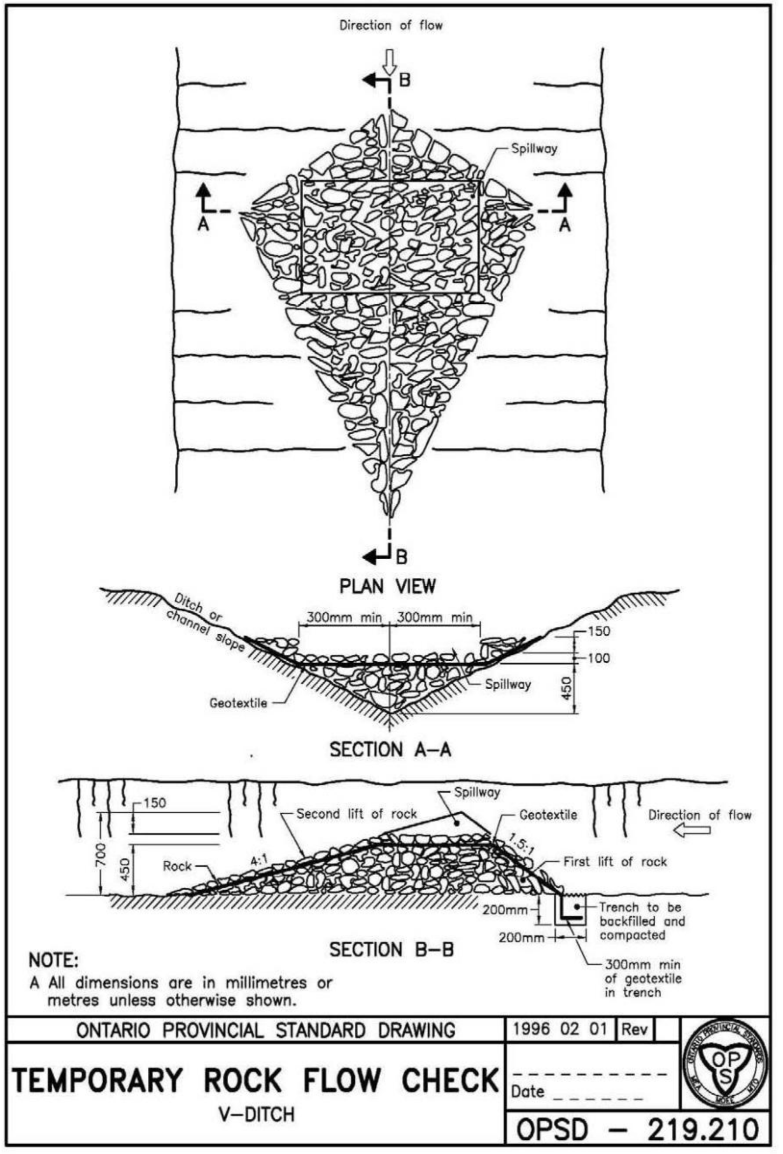

# Sediment Trap

- A depression area allowing runoff to pond.
- Formed by constructing an earth embankment across a drainage ditch, or by excavating a depression below original grade.
- Used to detain runoff from disturbed areas for a long enough period of time to allow for a majority of the coarser suspended soil particles in the runoff to settle out.



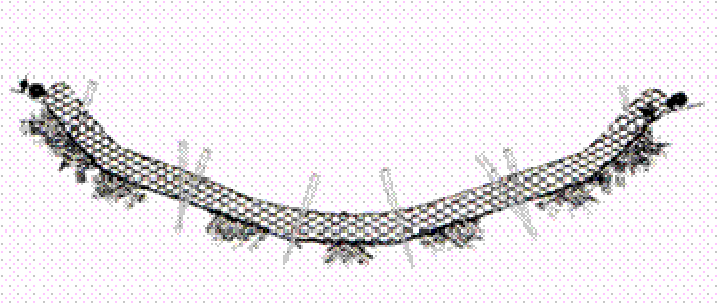
# Rock Check Dams

- A rock check dam consists of granular material placed temporarily across a ditch, minor stream or drainage way. Its purpose is to reduce the velocity of runoff to reduce the erosion of ditch and drainage way inverts.
- Rock check dams allow for little ponding and is therefore not very effective in settling out sediment, particularly fine soil particles.
- Rock check dams are applied across intermittent and low flow swales, ditches, and diversion channels.
- Additional sediment control measures should also be incorporated with rock check dams.



# Straw Bales

- Permeable barriers consisting of a line of organic material, implemented along the contours of mild slopes (< 5 %) to assist in reducing flow and increase the interception of suspended sediments.
- Can be oriented end to end and in multiple layers to form a consistent and continuous permeable barrier to flow.
- Can be applied across constructed conveyance systems and along the contours of mild to gentle slopes.
- Should not be used alone, but should be used in combination with other controls for effective performance.
- Should be firmly butted together and staked with wooden stakes or T-bars.



# Sediment Control Ponds / Basins

- A runoff storage area formed by constructing a compacted earth embankment or by excavating a depression across or at the end of a drainage path.
- Uses an outlet structure to control the stormwater release rate.
- Its purpose is to detain runoff long enough to allow the majority of soil particles to settle out of suspension.
- Sediment ponds/basins typically serve as an "end of pipe" control, which receive flows from other ESC controls and overland flow during extensive grading operations.
- Used on sites with disturbed drainage areas exceeding two (2) hectares.
- Sediment basins are typically capable of removing sediment as small as 4 microns.
- Sediment ponds should have two components:

<u>Active Storage Volume</u>:

a) Should be designed with a minimum of 125 m3/hectare contributing drainage area with a minimum 48 hour drawdown time (minimum 75mm diameter orifice), and a minimum 4:1 L:W ratio of the pond; and

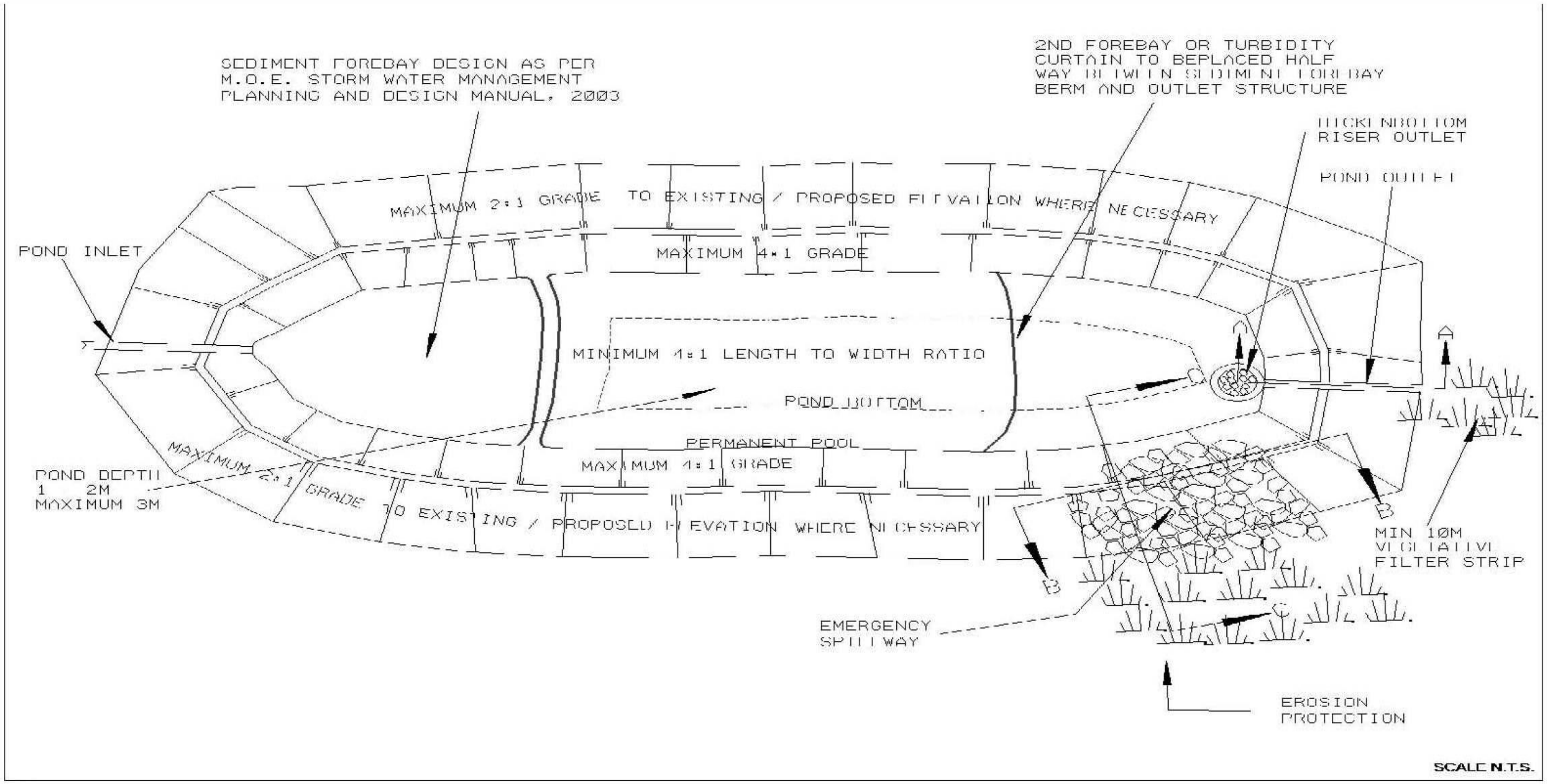
<u>Permanent Pool Volume</u>:

a) Minimum 125 m3 storage volume/hectare drainage; or

b) Minimum 185 m3 storage volume/hectare drainage area if L:W ratio is less than 4:1 or the drawdown time for active storage is less than 48 hours.

# Sediment Control Ponds / Basins

Plan View of Sediment Control Pond

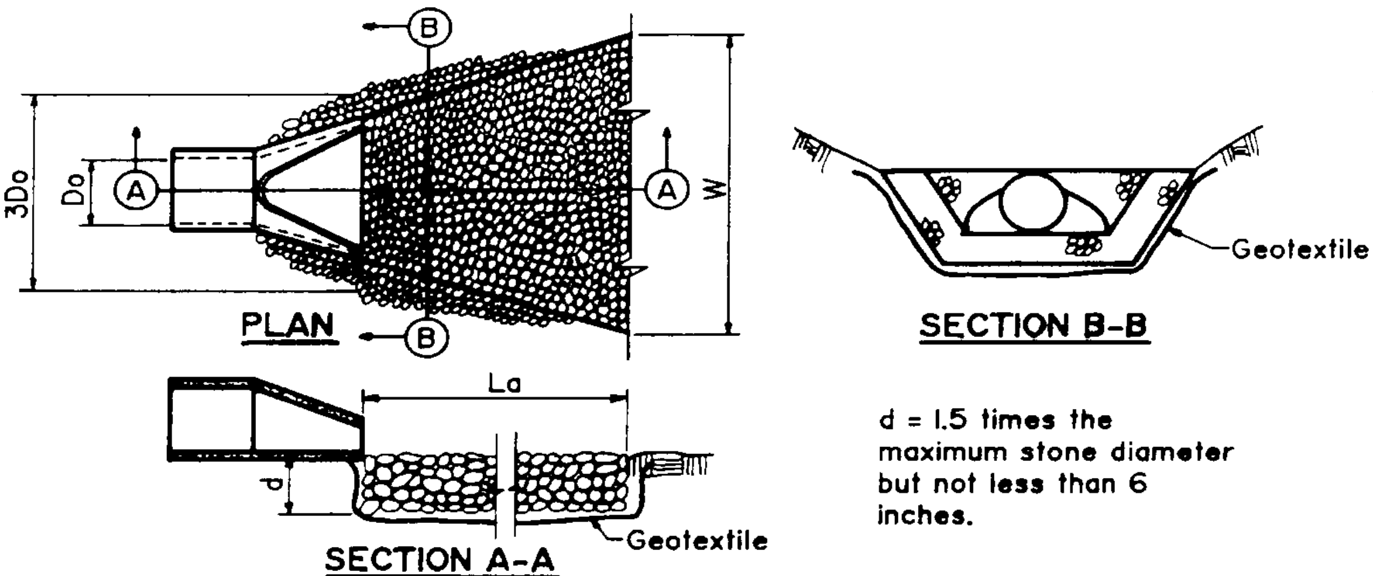



Notes:

1. ***Pond side slopes to be stablized immediately***;
2. Minimum 48 Hour drawdown time with minimum 75mm diameter orifice;
3. Active Storage Volume:
   Should be designed with a minimum of 125 $m^3$/hectare contributing drainage area with a minimum 48 hour drawdown time (minimum 75mm diameter orifice) and minimum 4:1 L:W pond ratio; and,
4. Permanent Pool Volume:
   i. Minimum 125 $m^3$/hectare drainage area; or
   ii. Minimum 185 $m^3$/hectare drainage area if L:W ratio is less than 4:1 or the drawdown time for the active storage is less than 48 hours.

# Storm Drain Outfall Protection

- Energy dissipating devices placed at the base of pipe or channel outlets.
- Prevents scour and minimizes erosion by reducing the velocity of concentrated flows.
- Should be applied at the base of any stormwater outfall structure.
- Applied to areas with concentrated flows.
- Encouraged to blend in with the environment by using natural materials if possible.
- Usually requires minimal amount of riprap stone to prevent downstream scour.
- Riprap stone must be underlain with a geotextile.
- Typically the minimum diameter of riprap stone should be 300 mm.
- Velocities greater than 3.0 m/s may require structural stilling basins, chute blocks or other structural measures to reduce velocities and erosion/scour impacts.
- The typical threshold velocity before a well-grassed channel begins to erode is 1.2 m/s.



# Storm Drain Outfall Protection (Examples)


# Storm Drain Inlet Protection

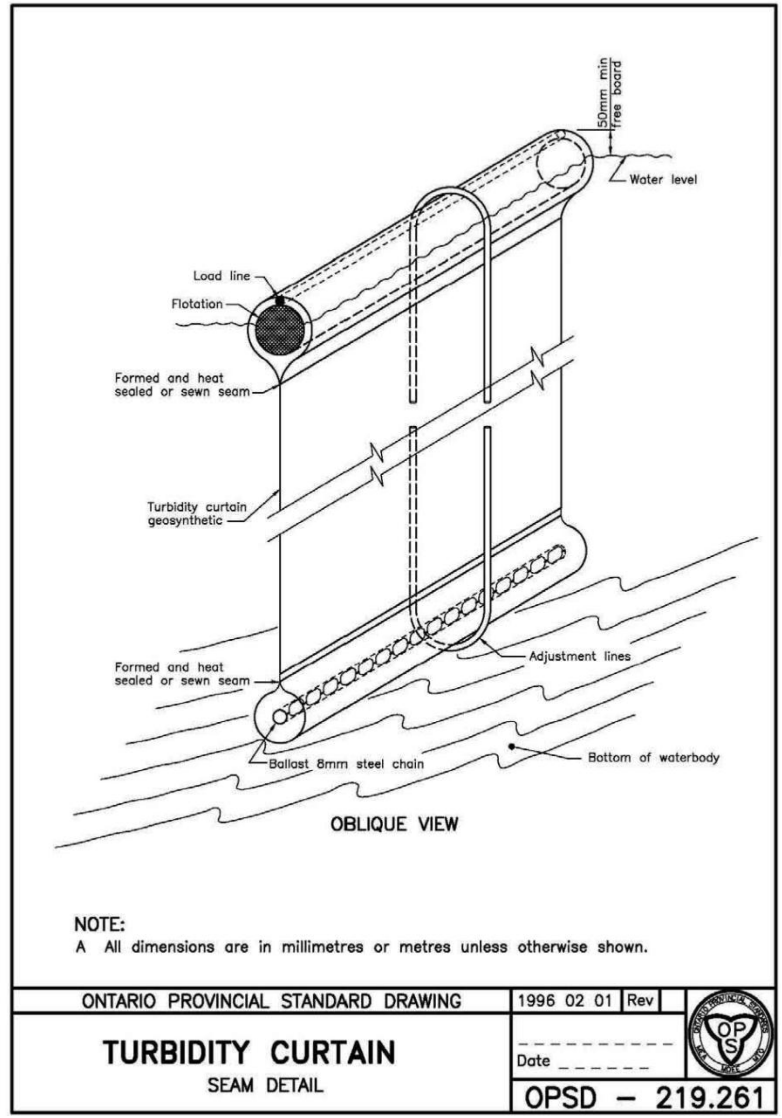
- Consists of a sediment control barrier either around or in the catchbasin inlet.
- The inlet protection filters runoff before it is released to the sewer system.
- Drain/sewer inlet protection reduces the amount of sediment entering the storm drainage system prior to the permanent stabilization of disturbed areas.
- Storm drain inlet controls are implemented to existing frame and grate catchbasins.

# Sediment Bags

- Sediment bags consist of UV stabilized, geotextile material sewn into a rectangular bag structure.
- Used to filter out suspended sediment from dewatering discharge.
- For smaller sites, sediment bags are often a more economic and effective method of filtering sediment laden waters than sediment basins or ponds.
- Only sediment laden water should be pumped to the sediment bag.
- Sediment bags are manufactured in various sizes (typically with a standard width and varying length) and are pre-sealed on all sides except for a small opening on one end, adequately sized for a dewatering hose.
- Sediment bag should be located on a grassed area.

# Sediment / Turbidity Curtian

- Consists of geotextile material that is vertically suspended in water to enclose an in-water work area.
- Allows for sediment transport containment to a limited area within the disturbed water body.
- Usually implemented around construction activities requiring in-water works such as dredging or filling activities undertaken without site isolation and dewatering.
- Applied to isolate and protect an important or sensitive in-water feature.
- Sediment/turbidity curtains are not appropriate for use perpendicular to flowing water, margins of large rivers and on lakes/ponds.



# Cofferdams

- A cofferdam consists of a temporary dam used to isolate areas adjacent to or sections of a watercourse channel.
- The isolated area is to be dewatered which allows for construction to be conducted in dry conditions.
- The height of the cofferdam should be sufficient to prevent overtopping by a minimum of the 5 Year storm.

Figure illustrating coffer dams from Keeping Soil on Construction sites (HRCA & HCA, 1994).