FLOOD RESPONSE PRACTICES

DISCLAIMER

These practices are intended as information for the use of emergency planners. They are based on information available to the authors at the time of report preparation. These practices are not based on an exhaustive review of the literature, and are limited by the information available to the authors. Discussion of the practices cannot be considered an endorsement by the authors or sponsoring agencies of any particular technology or product. The authors and sponsoring agencies are not liable for any consequences arising from the use of the information in this document.

Actual methods and practices used will vary depending on site specific conditions.

Existing Dikes

Tips for Existing Dikes

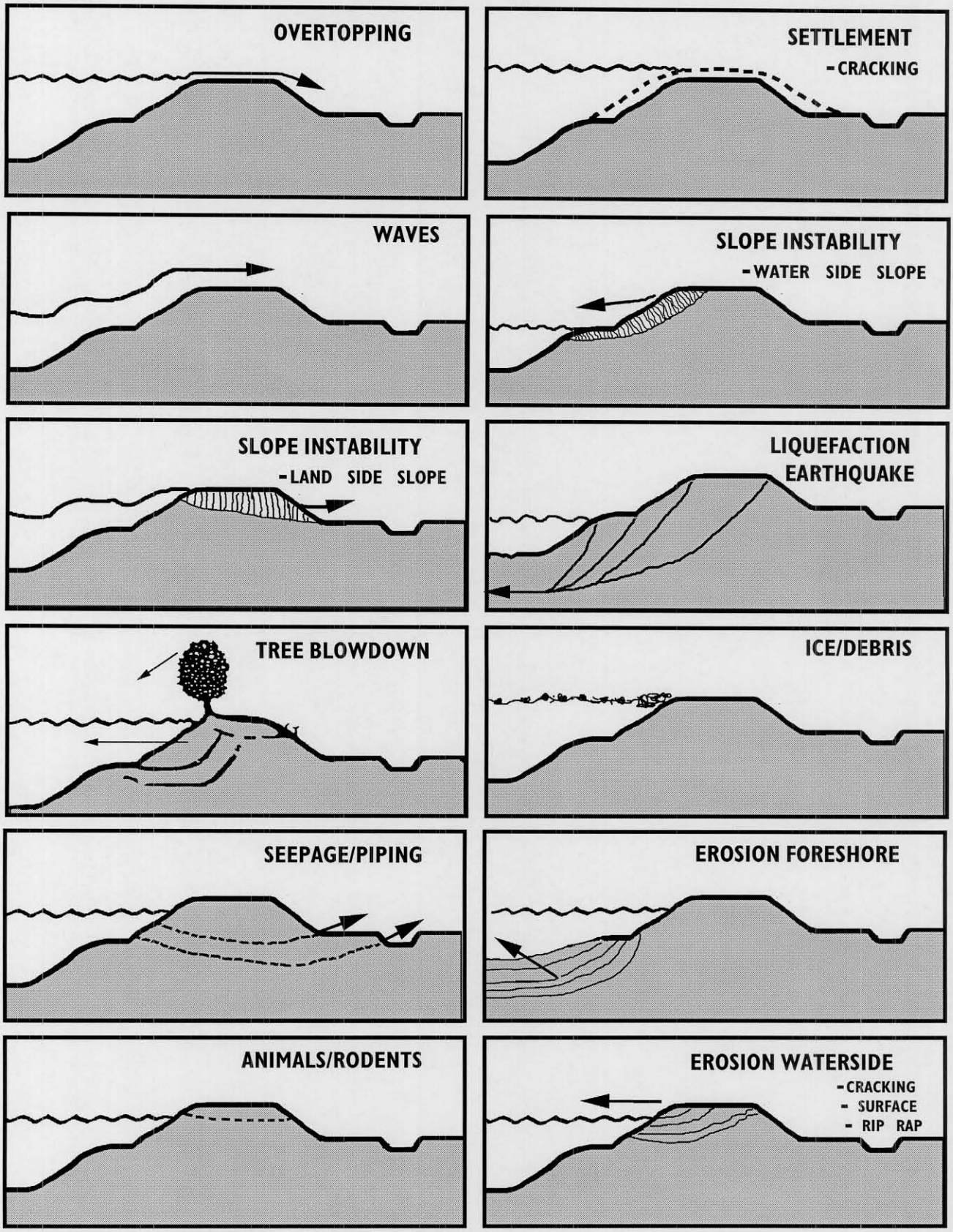
- address remedial repairs prior to them becoming catastrophic
- inspect as necessary to identify failure mechanisms
- understand the dike construction methods
- classify the dikes and identify risks associated with different types (e.g. berms, engineered dikes, soil types, ownership)
- identify methods of response based on risk assessment or a particular form of failure
- consider that risks increase with continuing and successive flood peaks
- consider the rate of draw down and possible affects on dike stability
- consider wind effects on wave height and wave uprush

Failure Mechanisms

Dikes failure can occur in a number of ways and remedial practices are discussed in the following sections. Figure 1 on the next page illustrates the following failure mechanisms:

- overtopping
- waves
- settlement - cracking
- slope instability
  - landside slope
  - water side slope
- liquefaction - earthquake
- tree blowdown
- ice - debris
- seepage - piping
- animals
- erosion
  - foreshore
  - water side

Figure 1 - Failure Mechanisms



Raising Existing Dikes (Local Overtopping)

Sandbagging Tips

- sandbagging may be employed for a number of failure mechanisms not just raising dikes
- filling sandbags in sufficient quantities requires extensive pre-planning (e.g. equipment, manpower, volunteers)
- check quality of bags prior to anticipated flooding
- attempt to identify quantity of sandbags needed
- provide training - demos, videos, on the job
- identify sources of sand
- identify location where sandbagging will take place - at sand source or transport sand
- ensure equipment is available for all aspects of sandbagging - transportation, filling, etc.
- ensure that team leaders manage the installation crews
- Abbotsford installs half round chutes at the back of dump trucks for rapid sandbag filling.

Preparation

- As the prediction of flood profiles is uncertain, and because dikes often have varying freeboard, patrols should be advised to pay close attention to lower than average freeboard.
- Once water flows over the dike crest, fill is usually rapidly washed away creating a breach. This generally increases in size and will not be practical to close until water levels equalize.
- Sandbags are usually considered for raising low sections of dike as shown in Figure 2. However, progress is slow and considerable hand labour is required. Sandbags should normally only be used for raising short sections of dike. Alternatives to sandbags include wire baskets or water dams and Flex-Mac (See Figure 3 and the Flood Response Resource Listing).
- Consider using the Windrow and Plastic Sheet method shown on Figure 4 to raise an existing dike up to 0.4 metres.

- Heavy equipment and trucks can be used to raise a dike provided the work is done well in advance of high river levels, however, heavy equipment is not generally advisable on a dike when the water level is near the crest due to vibration and saturation effects.
- Stripping large diameter vegetation from the dike crest when the water is at or above the freeboard level should be ***avoided if possible*** as you are loosening the very fill material that you are relying on. A better method would be to cut it as close to the crest elevation as possible and then place a thin layer of fill over it to allow access.

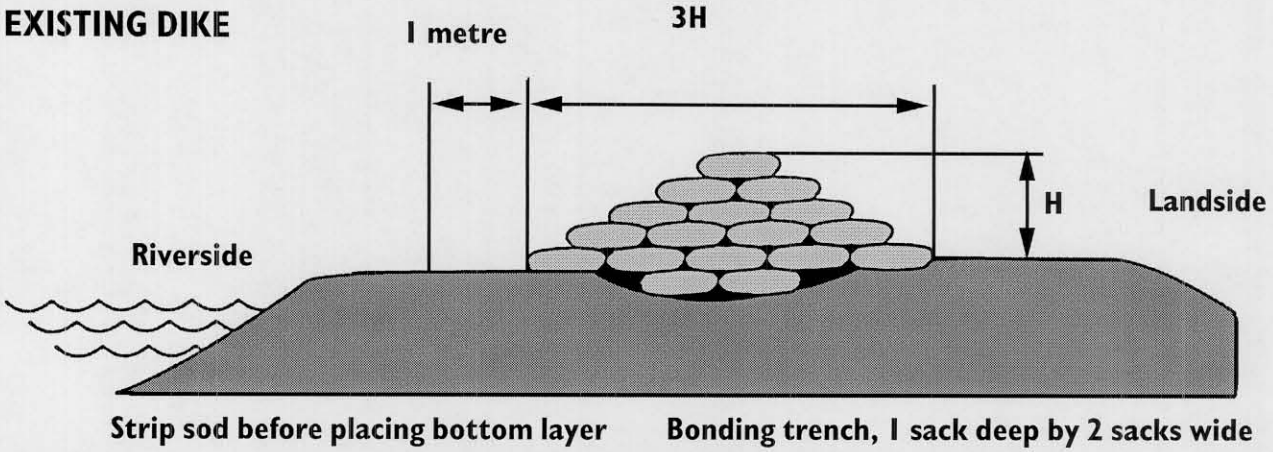
Alternative measures

The Alberta publication *Alternatives to sandbags for temporary flood protection, 1998*, describes other methods that can replace sandbags as temporary flood protection measures.

The publication is essentially a review of available published literature and commercial brochures. Proposed new techniques and methods were critically evaluated based on common professional practice and gathered experiences in flood fighting. The systems can be considered as complementary means in flood protection and control. The use and effectiveness of each method is often situation dependent. Proper planning and preparation is always needed in order to achieve full efficiency

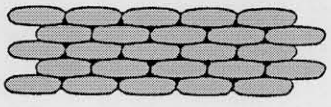
In addition, refer to the Flood Response Resource Listing for source information on using Aqua-Barrier, Aqua Dam, Flex-Mac, Gabions, Lock-Blocks and the Sandbagger for raising existing dikes.

Figure 2 - Method for Sandbag Diking



1. Alternate direction of sacks with bottom layer i.e. bottom layer lengthwise with dike, next layer crosswise.
2. Lap unfilled portion under next sack.
3. Tying or sewing of sacks not necessary.
4. Sacks should be approximately one-half full of clay, silt or sand.
5. Tamp thoroughly in place.

Bags Required for 30 Linear Metres of Dike	
Height Above Dike	Bags Required
1/3 metre	600
2/3 metre	2000
1 metre	3400

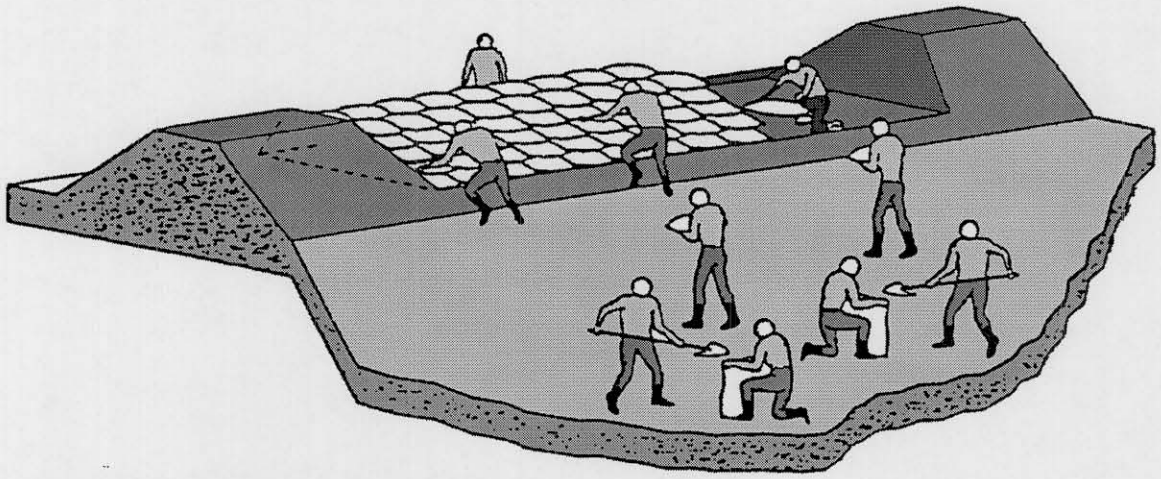


PLAN OF BOTTOM LAYER

METHOD OF LAPPING SACKS

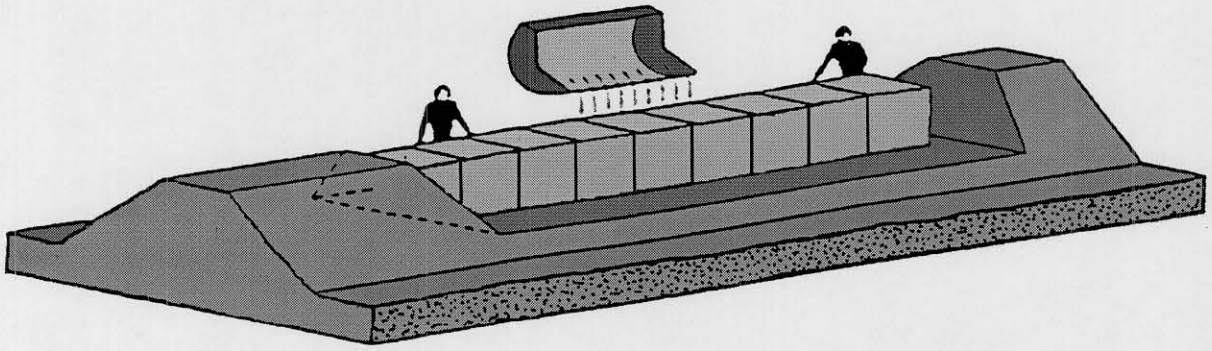
Figure 3 - Emergency Works

Classic Use of Sandbags



- High Labour Requirement (10-15 people)
- Long Time Requirement (approximately 8 hours)

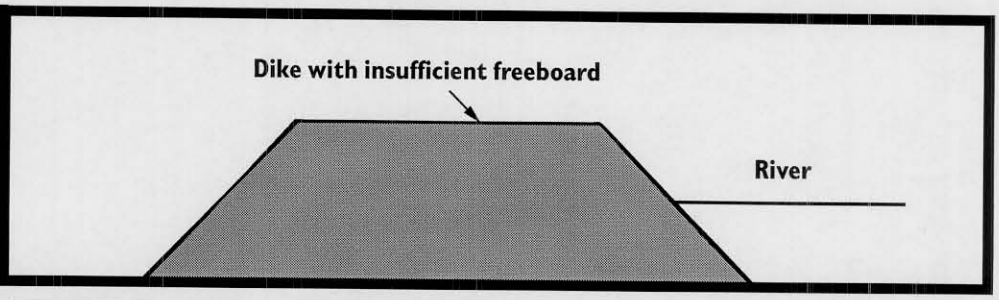
Wire Baskets



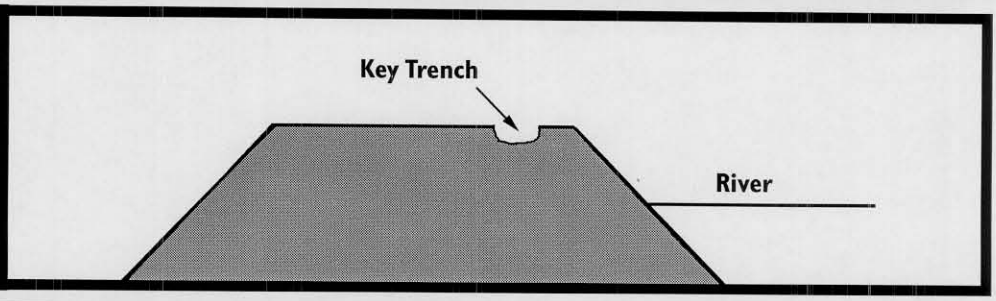
- Minimum Labour Requirement (2-3 people)
- Lowest Time of Installation (approximately 25 minutes)

Figure 4 - Windrow & Plastic Sheet Method

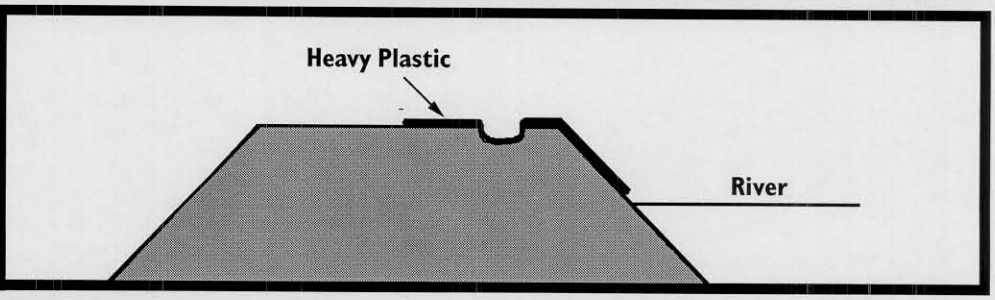
Step 1
Identify extent of problem area.



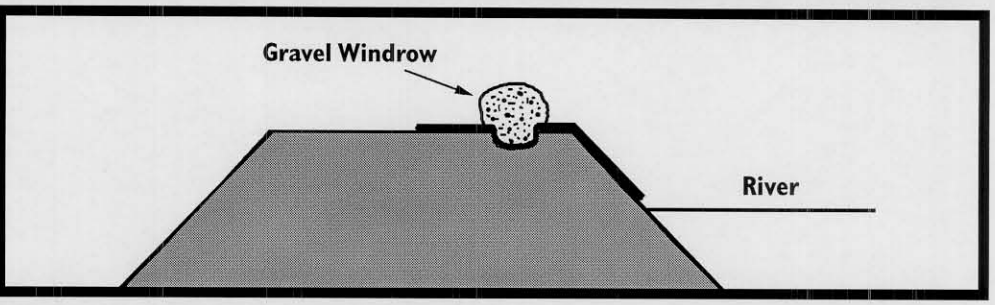
Step 2
Evacuate a shallow (0.15 metres plus) bonding (key) trench.



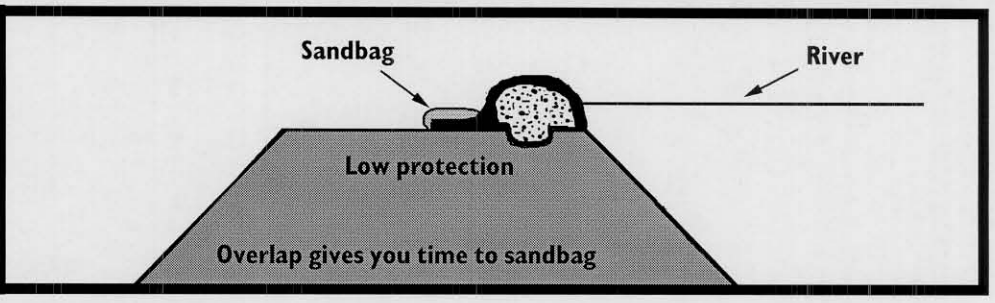
Step 3
Place plastic starting at the downstream end, ensuring that the majority of the sheet width is on the river side of the trench. Overlap roll ends by approximately five metres.



Step 4
Place fill in a windrow to the desired height.



Step 5
Fold the plastic over the windrow and hold it in place with the sandbags or fill.



NOTE: This method is restricted in height by the width of the plastic (usually 2.4 metres) and should therefore be used in places where the freeboard only has to be raised by 0.4 metres and less.

Landside Damage

Tips for Landside Damage

Excessive Slope Seepage

Where seepage on the dike landside slope leads to soggy unstable conditions, free draining fill berms may be needed. The berm should start and end at an appropriate safe distance both upstream and downstream of the seepage area.

Saturation Of Fills

If high water levels are sustained for some time and the dike fill becomes saturated, it may be necessary to restrict traffic on the dike crest road.

Active Boiling

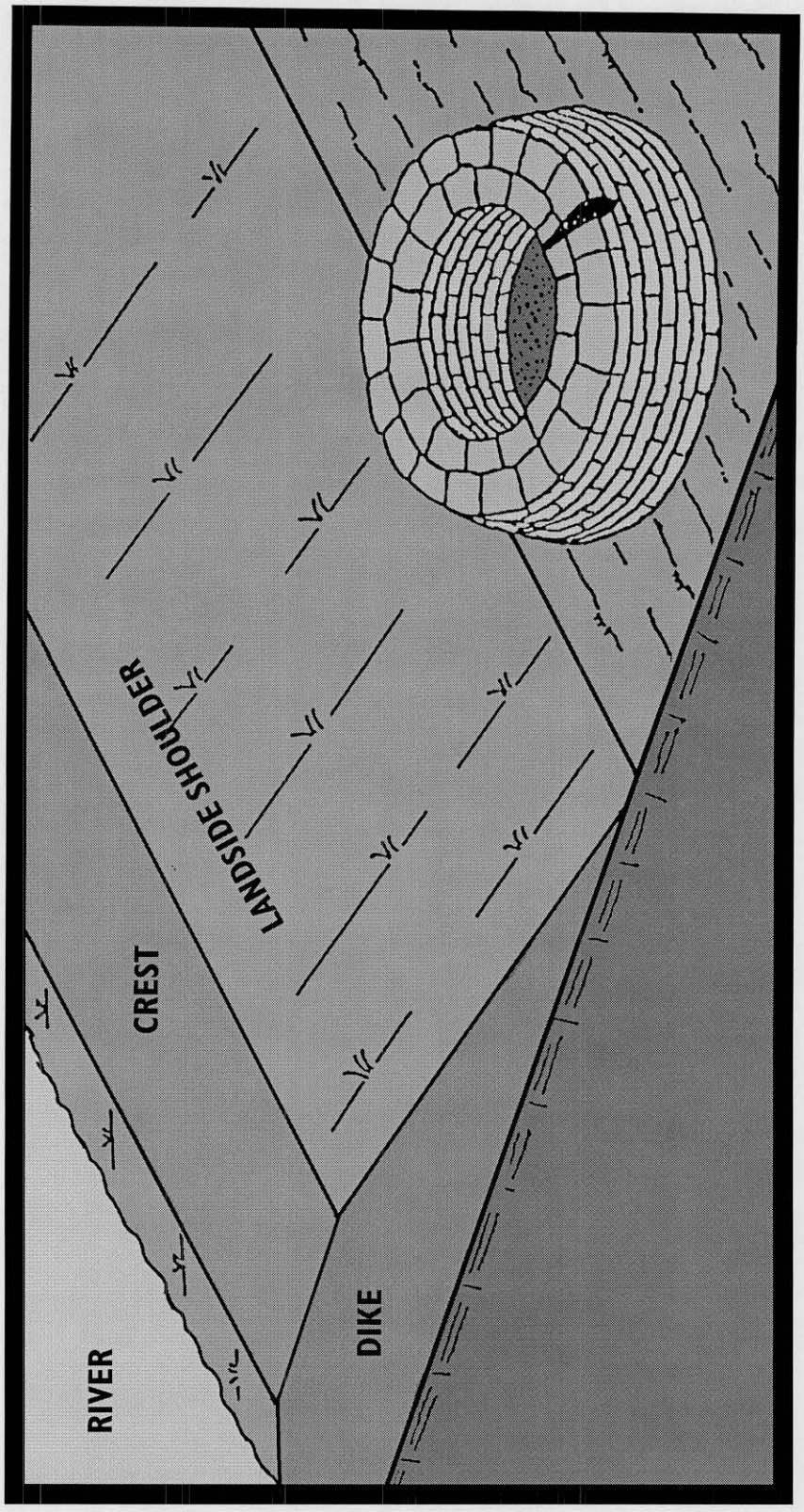
The simplest and most effective method of treating an active boil (one that is carrying sand and silt) is to construct an impervious ring around it of a sufficient height to stop the transportation of solid material. It should not be built to a height which stops the flow of clear water because of the probability of building up an excessive local pressure head, which could cause dike failure or additional boils nearby. Concrete well rings, short pieces of large diameter pipe, earth berms, sheet steep pilings, etc., can all be used, but the most generally accepted method is using sandbag rings.

The recommended method of building a sandbag containment ring is as follows (See Figure 5):

- Scarify the base for the ring (internal diameter of which should be at least 1.5 times the contemplated height) to provide a watertight bond between the natural ground and the sack ring (a very important step).
- Lay sacks in a ring around the boil and surrounding weak ground starting at its outer edge and working towards the center. Joints are staggered and loose earth is used as a mortar.

- When the proper height is reached (when clear water only is being discharged), a V-shaped drain constructed of wood or sheet metal should be inserted near the top of the ring to carry off the water in a more controlled manner in the most desirable direction.
- An alternative method of controlling an active boil is by placing a blanket of pea gravel or other free-draining gravel over it. The thickness of the gravel blanket must be increased until the seepage water runs clean. Note: When soil conditions are such that boils occur, it will probably be impossible or imprudent to bring loaded dump trucks into the area, even the dike may be impossible for heavy vehicles. First consideration should be given to methods which do not impose heavy loads on the ground adjacent to the boils.
- All flowing inactive boils should be flagged and closely monitored throughout the flood period in case they start to transport solids.

Figure 5 - Active Boiling



Flood Barrier Construction

Tips for Flood Barrier Construction

The construction of dikes can provide temporary protection against flooding. The construction of the barriers takes time; thus it is necessary to have an accurate flood forecast to prevent unnecessary expenditure of resources and to ensure that the barrier is constructed in time.

To obtain the most effective use of flood barriers, it is best to consider the following factors prior to construction.

1. Select the shortest practical route - saves time and resources.
2. Provide maximum protection. The dike location should offer protection to the greatest number of structures.
3. Take advantage of high ground.
4. Avoid sharp bends, unstable river banks.
5. Utilize the available floodplain mapping to determine the areas that are threatened, the shortest route, high ground, and the evacuation routes.
6. Keep trees and brush between dike and river. The trees and brush provide protection to the dikes from debris and ice.
7. Leave at least 2.5 metres between dike and buildings which will allow access to the dikes from the landward side.
8. Keep as far away from the river as possible.
9. If possible, discuss alignment with local floodplain management officials.

The following poor construction practice may also result in a dike failure: (1) joining a dike with a solid wall; (2) structures, trees or debris projecting from the riverside of the dike; (3) a pipe through the fill.

Sandbag Dike Construction

Sandbags may be used where a low short barrier is acceptable and earth fill is not practical. The construction of sandbag dikes are time consuming, expensive, and require a significant amount of manual labor. The following steps are recommended for the construction of a sandbag barrier (See Figure 6):

1. Remove all ice and snow, sod, down to bare ground, if possible.
2. Dig a bonding trench 2 sacks wide, 1 sack deep (0.6 m wide, 0.3 m deep). (If on a roadway this may have to be omitted.)
3. Lay a polyethylene seepage barrier across trench, there should be enough to cover the riverside of the sandbag. The riverward slope is covered with the polyethylene seepage barrier, protected with 1 layer of sandbags. Polyethylene should have slack to allow outer side bags to be tapped into place and to avoid puncture. Anchor excess poly at top of dike using sandbags. Poly is not used on landward slope.
4. Fill trench with sandbags perpendicular to flood, bottom of bags toward the flood, unfilled portions toward building.
5. The bottom layer of sandbags is laid parallel to flow, with subsequent layers alternating (i.e., perpendicular, parallel, etc.) The base of the barrier should be about three times the height. It is advisable to not exceed 0.9 metre high.

When filling and placing the sandbags, the following suggestions should be used:

1. The sandbags should be filled with sand or sand and gravel.
2. Bags should be half (1/2) full.
3. Overlap unfilled portions with filled bag.
4. Tamp bags into place.
5. Need not tie bags.

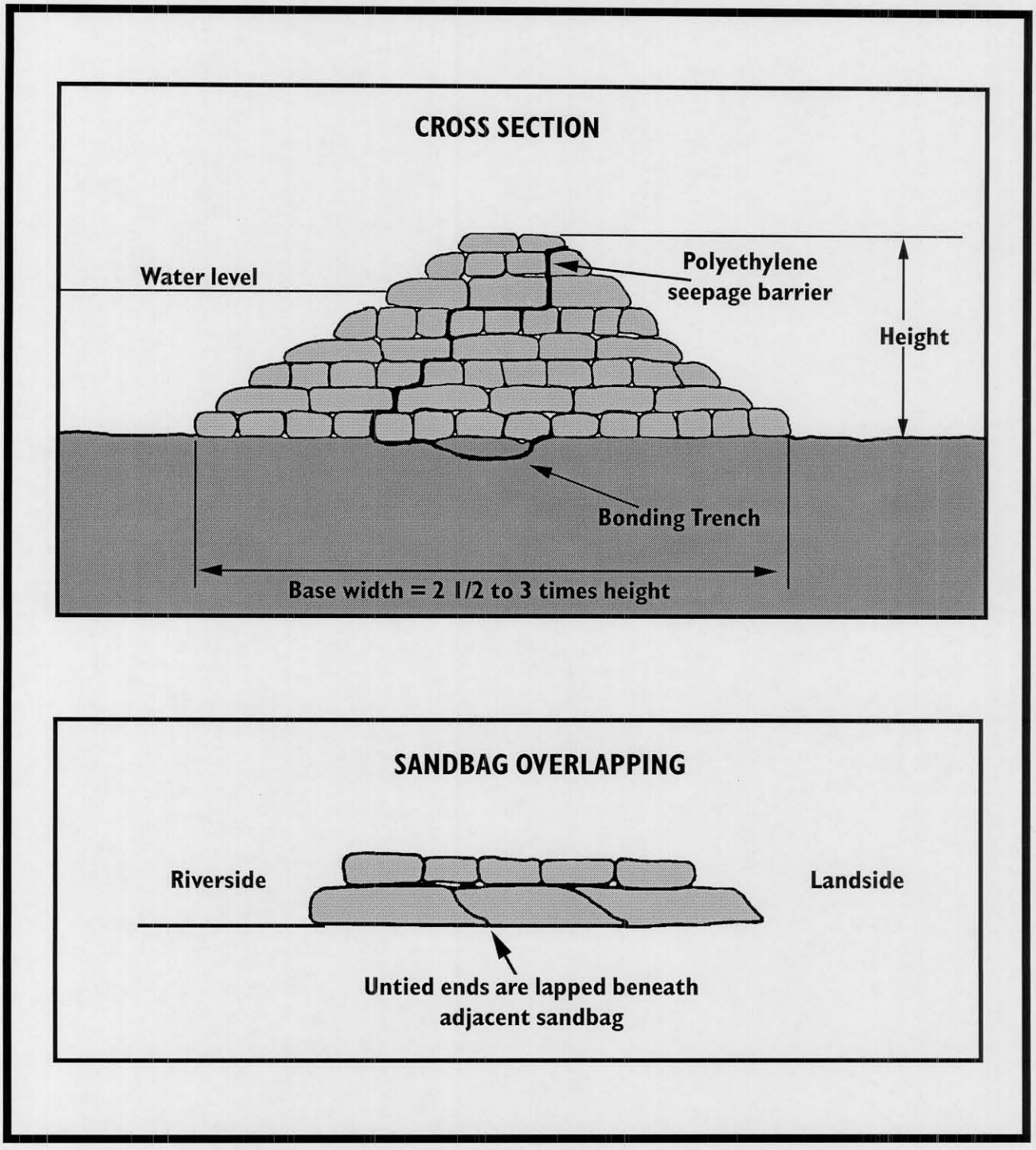
Approximate materials needed for the construction of 30 lineal metres of dike:

Height	Bags	Sand (Cubic Metres)	Polyethylene Sheeting
0.3 metre	800	6	1.3 metres/m
0.6 metre	2000	16	1.5 metres/m
*1.0 metre	3400	28	1.8 metres/m

*Sandbag walls not recommended over 0.9 metres high.

Reference:
Michigan Flood Hazard Mitigation Handbook, 1988

Figure 6 - Sandbag Dike Construction



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Slope Protection Of Earth Fill Dikes

The construction of dikes for flood protection may subject the slopes to scour, debris damage, seepage, and possibly wave action. Thus it is necessary to provide protection to the slope to prevent a failure of the dike. Under emergency conditions it is generally not possible to provide permanent slope protection. The use of a combination of polyethylene and sandbags has proven to be an effective protection method, provided the placement is done correctly.

Anchorage of the Polyethylene (Poly)

For the polyethylene to provide adequate protection of the slope, it must be properly anchored at the toe and on the slope. To anchor the toe of the polyethylene there are several methods that could be used:

1. Excavate a trench and place the poly in the trench and backfill.
2. Poly may be placed away from the toe, and stabilized with fill.
3. Place the poly away from the toe and stabilize with sandbags. Poly is not really necessary on clay embankments if stream velocities are less than two feet per second.

The poly should be started at the downstream end and placed with at least 0.6 metre of overlap. The poly is held down by sandbags. A solid blanket of sandbags should be used when high velocities, heavy debris, or ice may occur; if not anticipated, a grid system can be used. The grid system can include sandbags, 2"x4" lumber and sandbags, or rope and sandbags.

The critical areas of an embankment should receive priority when placing poly. Poly should not be placed on the landward side of the embankment. If done, seepage may be forced elsewhere and result in failure.

Riprap may be used to control high erosive or impact forces. However, this is a very costly method which requires a large amount of material that may not be readily available.

Other forms of slope protection include groins to deflect the current, log booms to deflect debris, and straw bales to reduce wave action.

Flashboard Dike

A flashboard dike is constructed using lumber and earth fill. 2"x4" posts are driven at least 0.6 metres into the ground, located on about 1.3 m to 1.8 m centers. 1"x12" boards are placed horizontal between the post. An earth berm is placed landward of the flashboards, and is tamped against the bottom board. The berm has a minimum 0.6 m top width, and a 1 on 2 slope on the landward side of the berm (See Figure 7).

Box Dike

A box dike consists of two rows of 2"x2" (or 4"x4") posts driven at least 0.6 metres into the ground, located on about 1.3 m to 1.8 m centers parallel to flow. The parallel rows of posts are driven on a spacing of about 2 times the height of the box. (If box is 1.3 metres high, the rows of post are driven 2.6 metres apart). 1"x12" boarding is placed horizontally inside of the posts to contain the earth fill, and 2"x4" bracing is provided to hold posts in place (See Figure 8).

These types of dikes are very costly and require a considerable amount of time to construct. Thus, they are generally not used, unless the area is very restrictive and earth fill dikes will not work

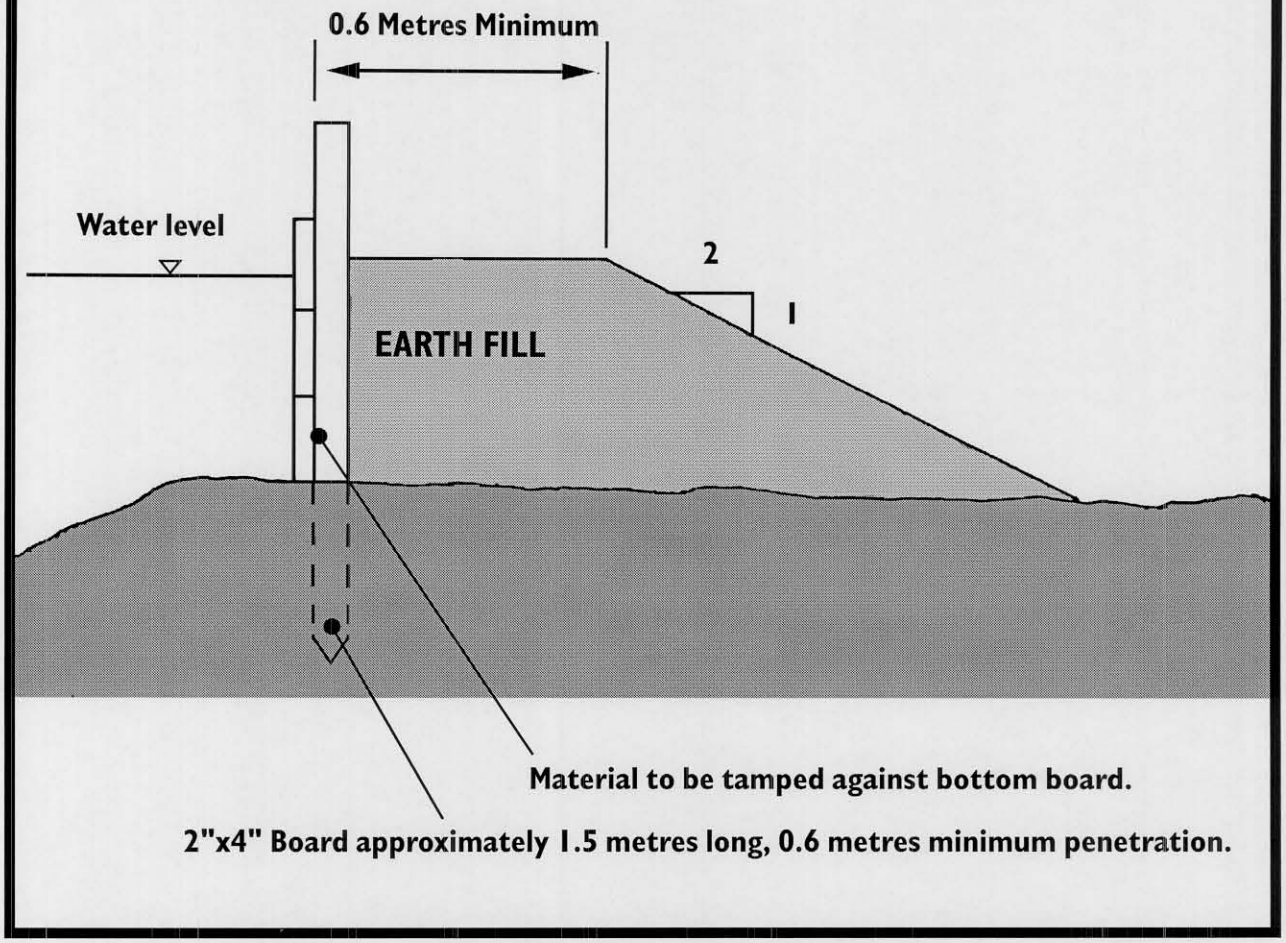
Other Flood Barrier Construction Methods

Reference: Michigan Flood Hazard Mitigation Handbook, 1988

Refer to the Flood Response Resource Listing for source information on using Aqua-Barrier, Aqua Dam, Flex-Mac, Gabions, Lock-Blocks and the Sandbagger for constructing flood barriers.

Figure 7 - Flashboard Dike

A flashboard dike is constructed using lumber and earth fill. 2"x4" posts are driven at least 0.6 metres into the ground, located on about 1.2 metre to 1.8 metre centers. 1"x12" boards are placed horizontal between the posts. An earth berm is placed landward of the flashboards and is tamped against the bottom board. The berm has a minimum 0.6 metre top width, and a one on two slope on the landward side of the berm.



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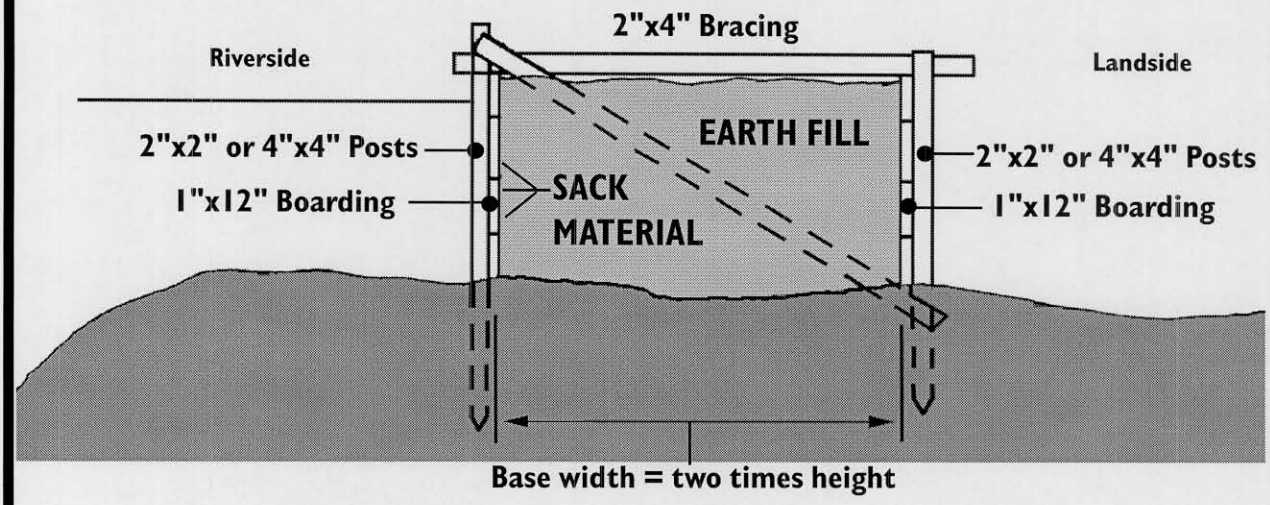


Riverside Damage

Tips for Riverside Erosion

- identify problem areas
- use soundings to determine 'condition' of toes of slopes (Fraser River)
- assemble stockpiles of armor material
- 'as builts' for structures
- consider restriction/speed limits for boat traffic
- follow MELP/DFO guidelines for works/maintenance - instream works - response protective flood work
- where river currents are eroding the face of the dike or nearby overbank, additional large rock riprap should be placed with an excavator or end dumped provided the site is accessible and safe for heavy equipment to operate
- in some circumstances (access is hampered or the available material is too small to be placed directly into the water) placing the fill in a setback arrangement may have advantages

Emergency Placement of Riprap

Effective placement of riprap during flood response conditions is one of the most difficult construction tasks you can encounter. Methods depend to a great extent on site specific conditions. However, there are usually two factors that weave a common thread. They are:

1. riprap is usually considered when the erosion is already causing problems
2. riprap delivery rate is, at least initially, never fast enough.

Riprap placement should always be done with a hydraulic excavator of sufficient size (preferably equipped with a hydraulic thumb) to handle the largest riprap that can be delivered. Dumping straight from the tandem into the water, is usually a waste of valuable resources. The rock not only tends to segregate itself into sizes in the dumping process, but the buoyancy effect of the water often leads to the rock being carried downstream. Once it does reach bottom the current can continue to carry it great distances. I have seen I metre diameter rock carried several metres before it

even touches the stream bed. The advantage of the hydraulic excavator is that it can hold the rock till it reaches the stream bed or in cases where the depth exceeds the combined reach of the boom and slick, at least a much lower elevation is achieved before the rock is released (thus reducing the distance traveled).

When starting an emergency riprap job, the first thing to do is look for a hard point or any area that due to the present bank alignment or position of natural obstacles such as roots or stumps, offers a pocket of slower current. Riprap placed here has the best chance of remaining. This foothold, can often be added to, both upstream and downstream. If no such pocket exists, another method of establishing a foothold must be found. Near Hixon, a car body was held submerged by the excavator till rock was placed in the area of reduced water velocity immediately downstream. From this established hard point riprap was then added both upstream and downstream. I have heard of concrete pipeline anchors being used in a similar manner.

Once a hard point has been established it is often worth considering extending it out into the current to act as a short groyne, deflecting some of the current away from the bank. However, an onsite decision must be made to determine if the rock lost to the current in its construction, would not provide more benefit if placed lineally along the bank.

Another danger to look out for is outflanking. Your hard point will become useless if the ground upstream of it is eroding . For this reason, we recommend that one of the first things to be done is the digging of a key trench, This is simply a 45 degree (facing downstream) trench dug down into the bank as far as possible (remember the ground will the saturated) . Its width depends on the height of the trench but is never less that 4 metres wide and is filled with the biggest rock you can obtain. If the bank continues to erode upstream of this trench, its angle tends to defect the current back to the river.

As mentioned above, it is often the case of too little too late that causes most of the problems. We have taken the view that in riprapped areas that have a history of being damaged during flooding, riprap stockpiling goes a long way to lessen the danger. The advantages are great. Only one machine, the excavator is needed freeing other equipment to work on other sites. The erosion area can quickly be repaired before it becomes a major problem. No more agonizing hours of waiting for the rock to arrive, watching the situation deteriorate.

Ice Jams

Tips on Ice Jam Flooding

Ice jam flooding is usually sudden, generally unpredictable, and sometimes severe. It can happen in most of British Columbia except for the lower mainland and Vancouver Island and during freeze-up and winter and spring breakups.

Certain locations on certain streams have a history of ice jamming, and these locations, if populated, deserve special precautionary measures, and, perhaps, post-event actions by local flood response agencies if ice jamming potential is high or ice jams occur.

Some of the possible mitigative actions, both pre- and post-event, may have adverse environmental or human impacts so controversial courses of action must be clearly understood and risks accepted by decision makers.

Ice jams are dangerous to work on or around due to their temporary nature. Safety of personnel overrides need to remove a jam in nearly all instances.

Possible pre-jam steps to reduce jamming potential damage:

- Stay in daily contact with area heavy construction firms and know whereabouts of all useful equipment, particularly excavators, and transport trucks. Have 24-hour means of contact with primary and secondary staff of each firm and MOTH staff, if local.
- Consider ice cover weakening techniques such as cutting, blasting, machine removal or breaking of ice, surface treatment (this is either dusting with dark substance or pumping bed material onto ice cover from streambed in silt or sand bed rivers) and removal of snow cover on ice cover to hasten melting. These techniques must be done at the right time to be effective (and safe).
- Use empirical methods to forecast the onset of potentially severe breakups or freeze-ups.
- Have one or more upstream observers report breakup or severe freeze-up conditions at their locations as soon as it occurs.

- Theoretically, aerial bombing could be used, but this has huge liability risks in populated areas, particularly on small streams, and the nearest air force base is in Edmonton.
- Another possible beneficial measure on regulated rivers is to manipulate storage releases during critical breakup or freeze-up periods.
- When the potential for ice jam flooding is high, media should be kept updated as the situation develops. People should be warned to remove personal possessions, including pets and farm animals, from low-lying areas in threatened reaches.

Possible post-jam steps to mitigate damage:

- Monitor upstream river situation for river flow, other jams (and what actions upstream communities may be taking to release them), and concentrations of running ice.
- Get best weather forecast information available and closely monitor jam water levels.
- Consider blasting or mechanical removal of jammed ice in light of environmental and human hazards both at the site and downstream. If removal is successful, you do not want to cause an even bigger problem downstream if the surge of ice worsens a jam downstream.
- Blasting and mechanical removal will usually only be successful if done soon after jam forms and there is open water downstream for the jammed ice to get away; otherwise, you may simply thicken the jam causing even higher water levels.
- Blasting also requires that there is a good flow of water beneath the jam and that there is a lookout upstream with reliable instant communication device to warn blasters on the ice in case of jam movement. The same lookout is required if equipment working in the channel itself.
- The *New Brunswick River Ice Manual (Section 6.1.5)* advises that "Blasting ice jams is rarely effective and is dangerous to the blasting crew and neighbouring property. The placement of an explosive charge is dangerous work that must only be performed by trained personnel. Adequate safety, rescue and first aid measures should be in place before the commencement of work."

River Ice Investigation Report

File: 76855-08\Ice Jams

BACKGROUND

Date: _____ Time: _____

River / Creek Name: _____

❑ Regular Inspection

Or. . .

❑ Complaint By: Name: _____

Address: _____

Location: _____

_____ GPS: N_____ W_____

GENERAL COMMENTS

Ambient Temperature: _____ Degrees C / F

Water Temperature: _____ Degrees C / F

Evaluation (re: Bank height) _____ metres / feet

Existing Water Elevation: _____ metres / feet

Est. backwater Elevation: _____ metres / feet

Open Channel Flow: Y / N Estimated Velocity:_____ metres per second / feet per second

ICE CONDITIONS

❑ Frazil Ice

❑ Shelf Ice

❑ Anchor Ice

❑ Pack Ice Shear Lines: Y / N

Ice Movement: Y / N

Comments: _____

_____

Report: Written By: _____ Date Written: _____

Debris Flows

Tips On Debris Flows And Mudflows

Debris flows and mudflows usually strike without warning. The force of rocks, soil, or other debris moving down a slope can devastate anything in its path. Take the following steps to be ready:

Before

Get a ground assessment of your property.

Your local planning department may have specific information on areas vulnerable to debris flows. Consult a professional geotechnical expert for opinions and advice on debris flow problems and on corrective measures you can take.

Minimize home hazards:

- Plant ground cover on slopes and build retaining walls.
- In mudflow areas, build channels or deflection walls to direct the flow around buildings.
- Remember: If you build walls to divert debris flows and the flow lands on a neighbour's property, you may be liable for damages.
- The ground slopes downward in one specific direction and may begin shifting in that direction under your feet.

Make evacuation plans.

Plan at least two evacuation routes since roads may become blocked or closed.

Develop an emergency communication plan.

In case family members are separated from one another during a debris flow or mudflow (this is a real possibility during the day when adults are at work and children are at school), have a plan for getting back together.

Ask an out-of-province relative or friend to serve as the "family contact." After a disaster, it's often easier to call long distance. Make sure everyone knows the name, address, and phone number of the contact person.

During

If inside a building:

- Stay inside.
- Take cover under a desk, table, or other piece of sturdy furniture.

If outdoors:

- Try to get out of the path of the debris flow or mudflow.
- Run to the nearest high ground in a direction away from the path.
- If rocks and other debris are approaching, run for the nearest shelter such as a group of trees or a building.
- If escape is not possible, curl into a tight ball and protect your head.

After

Stay away from the slide area.
There may be danger of additional slides.

Check for injured and trapped persons near the slide area.
Give first aid if trained.

Remember to help your neighbors who may require special assistance - infants, elderly people, and people with disabilities.

Listen to a battery-operated radio or television for the latest emergency information.
Remember that flooding may occur after a mudflow or a debris flow.

Check for damaged utility lines.
Report any damage to the utility company.

Check the building foundation, chimney, and surrounding land for damage.

Reference: (US) Federal Emergency Management Agency

Replant damaged ground as soon as possible since erosion caused by loss of ground cover can lead to flash flooding.

Seek the advice of a geotechnical expert for evaluating debris flow hazards or designing corrective techniques to reduce debris flow risk.

Tsunamis

Tips on Tsunamis

A tsunami is a series of waves that may be dangerous and destructive. When you hear a tsunami warning, move at once to higher ground and stay there until local authorities say it is safe to return home.

Before

Find out if your home is in a danger area. Know the height of your street above sea level and the distance of your street from the coast. Evacuation orders may be based on these numbers.

Be familiar with the tsunami warning signs. Because tsunamis can be caused by an underwater disturbance or an earthquake, people living along the coast should consider an earthquake or a sizable ground rumbling as a warning signal. A noticeable rapid rise or fall in coastal waters is also a sign that a tsunami is approaching.

Make sure all family members know how to respond to tsunami.

Make evacuation plans. Pick an inland location that is elevated. After an earthquake or other natural disaster, roads in and out of the vicinity may be blocked, so pick more than one evacuation route.

Teach family members how and when to turn off gas, electricity, and water.

Teach children how and when to call 9-1-1, police or fire department, and which radio station to listen to for official information.

Have disaster supplies on hand.

- Flashlight and extra batteries
- Portable, batter-operated radio and extra batteries
- First aid kit and manual
- Emergency food and water
- Nonelectric can opener
- Essential medicines
- Cash and credit cards
- Sturdy shoes

Develop an emergency communication plan. In case family members are separated from one another during a tsunami (a real possibility during the day when adults are at work and children are at school), have a plan for getting back together.

Ask an out-of-province relative or friend to serve as the "family contact." After a disaster, it's often easier to call long distance. Make sure everyone knows the name, address, and phone number of the contact person.

During

Listen to a radio or television to get the latest emergency information, and be ready to evacuate if asked to do so.

If you hear an official tsunami warning or detect signs of a tsunami, evacuate at once. Climb to higher ground. A tsunami warning is issued when authorities are certain that a tsunami threat exists.

Stay away from the beach.

Never go down to the beach to watch a tsunami come in. If you can see the wave, you are too close to escape it.

Return home only after authorities advise it is safe to do so.

A tsunami is a series of waves. Do not assume that one wave means that the danger is over. The next wave may be larger than the first one. Stay out of the area.

After

Stay tuned to a battery-operated radio for the latest emergency information.

Help injured or trapped persons.

Give first aid where appropriate. Do not move seriously injured persons unless they are in immediate danger of further injury. Call for help.

Remember to help your neighbors who may require special assistance - infants, elderly people, and people with disabilities.

Stay out of damaged buildings. Return home only when authorities say it is safe.

Enter home with caution.

Use a flashlight when entering damaged buildings. Check for electrical shorts and live wires. Do not use any appliances or lights until an electrician has checked the electrical system.

Open windows and doors to help dry the building.

Shovel mud while it is still moist to give walls and floors an opportunity to dry.

Check food supplies and test drinking water.

Fresh food that has come in contact with flood waters may be contaminated and should be thrown out. Have tap water tested by the local health department.

Inspecting Utilities in a Damaged Home

Check for gas leaks - If you smell gas or hear a blowing or hissing noise, open a window and quickly leave the building. Turn off the gas at the outside main valve if you can call the gas company from a neighbor's home. If you turn off the gas for any reason, it must be turned back on by a professional.

Look for electrical system damage - If you see sparks, broken or frayed wires, or if you smell hot insulation, turn off the electricity at the main fuse box or circuit breaker. If you have to step in water to get to the fuse box or circuit breaker, call an electrician first for advice.

Check for sewage and water line damage - If you suspect sewage lines are damaged, avoid using the toilets and call a plumber. If water pipes are damaged, contact the water company and avoid using water from the tap. You can obtain safe water by melting ice cubes.

Reference: (US) Federal Emergency Management Agency

Dam Safety

Tips on Dam Safety

- identify all dams which could impact the Local Authority/Diking Authority area
- identify dam owners and ensure that they have developed a Dam Safety Program
- integrate these Dam Safety Programs into the Local Authority/ Diking Authority flood response plan

What is a Dam?

Simply stated, a dam is a man made barrier constructed for the purpose of storing water.

The two most common types of dams constructed around the world are embankment dams and concrete dams. The majority of the approximately 2600 dams constructed in British Columbia are earthfill embankment dams.

A dam consists of a variety of different components, each having its own unique potential problem area and inspection requirement. The main components that make up a dam include: earth or concrete barrier, abutments, foundation, outlet, spillway and gates.

Why should a Dam Owner have a Dam Safety Program?

Dams, by their very nature, create risks. Although these risks may be minimal they can increase substantially without proper maintenance. Many subtle signs which can be symptomatic of larger problems may go undetected for a variety of reasons.

Sooner or later these problems will become apparent even to the untrained eye. However, by the time a problem has progressed to this point, potential risk has greatly increased and repairs can become complex and extremely expensive. In most situations a Dam Safety Program that includes regular preventative maintenance, routine visual inspections, and the identification of problems in their early stages will ensure that the dam remains in good operating condition.

By having a Dam Safety Program, for even the smallest dams, the owner benefits by:

- protecting his/her investment
- being able to recognize problems in their early stages and eliminate them before they become complex and expensive
- minimizing risks to others and potential liability in case of failure
- having a secure source of water
- conserving a valuable resource, namely water

Who is Responsible for Dam Safety?

In all cases, dam owners are clearly responsible for the safe operation and maintenance of their dams. English common law, on which our legal system is based, considers dams to be inherently dangerous structures and those who own dams are liable for any damages that are caused by them.

The *Water Act* of British Columbia requires that a water licence be issued if water is to be stored and works constructed. The registered licensee, be it a private individual or a corporation thus becomes the 'dam owner'. Section 21 (1) of the *Water Act* states:

> "A licensee, holder of an approval or person who makes a change in and about a stream in accordance with the regulations must
>
> (a) exercise reasonable care to avoid damaging land, works, trees or other property, and
>
> (b) make full compensation to the owners for damage or loss resulting from construction, maintenance, use, operation or failure of the works."

Or in other words, the dam owner is responsible for ensuring that their dam and appurtenant works are structurally sound, operated safely and maintained adequately to prevent loss of life, damage to the environment, or adverse social impact such as loss of communal water supply or infrastructure from a dam failure.

What is Expected of the Dam Owner?

The dam owner's expected actions include:

- thorough visual inspections, accurate monitoring when required;
- recording and interpreting information gained from inspection and monitoring;
- regularly scheduled routine maintenance;
- making required repairs in a timely manner;
- preparing Operation, Maintenance & Surveillance plans and manual when required;
- preparing Emergency Preparedness plans when required; and
- operating the dam in a way that will give the greatest assurance of safety.

Reference: MELP Dam Safety Guidelines, 1998

The required intensity of effort will vary in relation to the loss that would be experienced in terms of loss of life, the downstream development, and the value of the structure itself.

Internal Drainage

Internal Drainage Tips

Temporary pumping may be required to remove the accumulation of snowmelt, rainfall, or seepage behind the barriers. Since the amount of pumping required is site specific it is not possible to give a rule of thumb. The pump size is dependent upon:

1. The drainage area being "cut-off" by the barrier
2. The amount of seepage through and beneath the barriers
3. Amount of storm sewer infiltration and back-up
4. The amount of ponding allowed before damage will occur.

It may be necessary to pump the sewer system to keep it functioning. For sanitary sewage pumping, the pump size needed could be estimated by allowing 100 gallons per day, per person, and infiltration of 15,000 gallons per mile of sewer, per day. For a town with 4000 people and 25 miles of sewer, the pump capacity would be estimated by:

4000 people x 100 gallon/person/day=	400,000	gallon/day
15,000 gallons/mile/day x 25=	375,000	gallon/day
Total Pump Capacity=	775,000	gallon/day or
	538	gallon/minute

Suggest using one 4-inch centrifugal pump or equivalent

Storm And Sanitary Sewers Tips

If pumps are not able (or not available) to keep up with the overflow of manholes it is possible to ring the manhole with sandbags. Due to the high pressures that could result, it is not recommended to build the ring dike above the river elevation. It is suggested that the round be built part way and dispose of the leakage. As an alternative to sandbags, concrete "ring dikes" may be used. Manhole covers should ***not*** be attempted to be weighted down by sandbags, if high heads may occur.

Prevention Of Sewer Backup

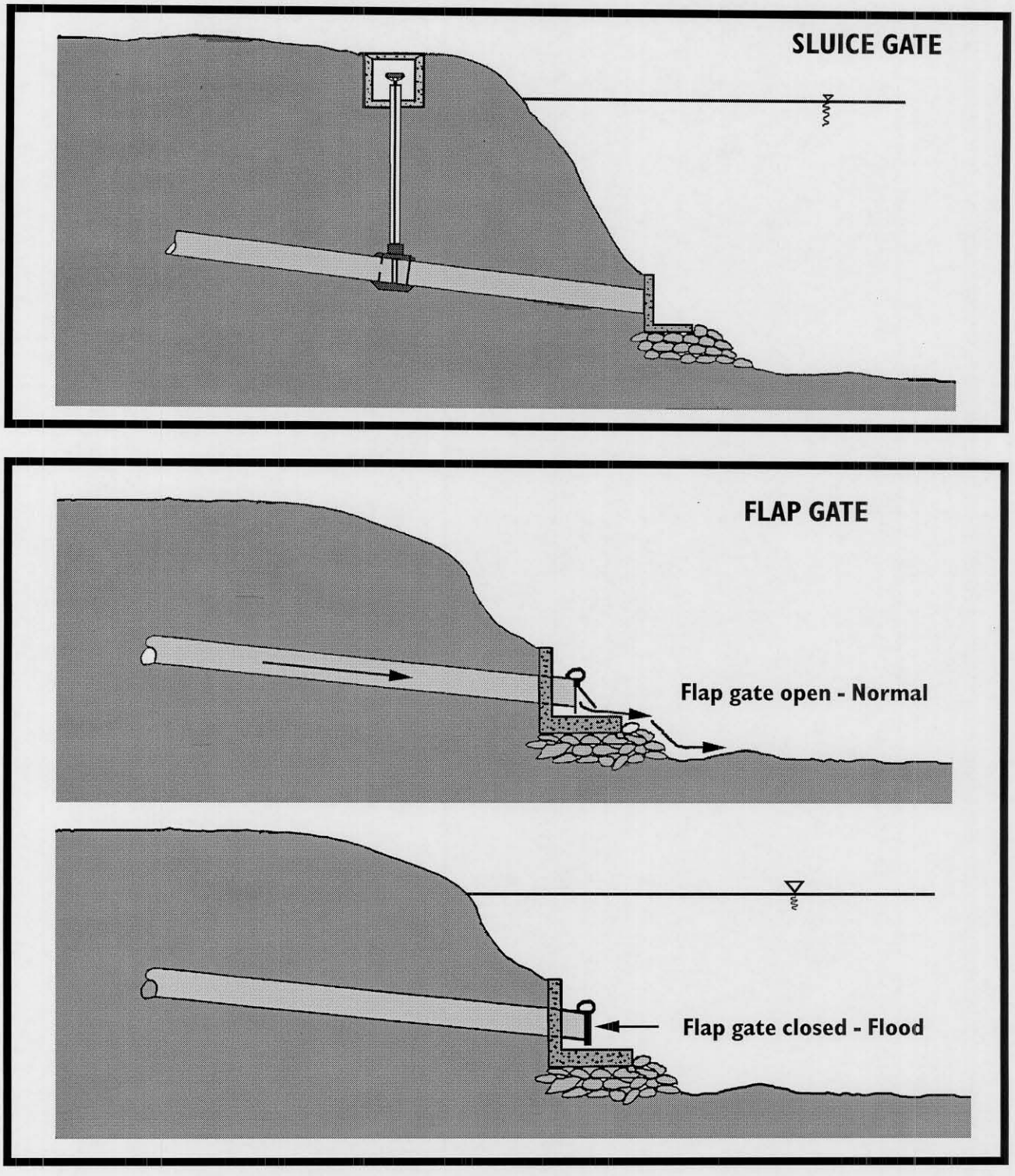
During flood stages, water may "back up" through the sewer outfalls and cause flooding of basements and low lying areas.

The methods of preventing sewer back up include (See Figure 9):

1. Sluice gates are generally closed manually, and are less likely to be blocked by debris than flap gates.
2. Flap gates close automatically if the river stage exceeds the stage on the sewer system. There is a potential problem that the gate may be propped open or blocked by debris.
3. Plugs are available which are inserted into the sewer pipe. Under emergency conditions, lumber, sandbags, and polyethylene can be used as a seal, placed on the outfall pipe. There are also manufactured pipe stoppers available.

Reference:
Michigan Flood Hazard Mitigation Handbook, 1988

Figure 9 - Methods of Preventing Storm Sewer Backup



Roads and Bridges

Tips on Roads and Bridges

- identify and map vulnerable roads and bridges
- identify possible/historical erosion areas
- identify evacuation/disaster routes and the protection of key routes
- monitor changing conditions within the watershed
- carry out pre flood inspections

References

Emergency Response Plan - 1992
Ministry of Transportation and Highways
Describes emergency services delivered by MOTH personnel.

Round IV (1995-6) Maintenance Services Manual
Standards for Road and Bridge maintenance Services
(Maintenance Standards)
August 31, 1995
Ministry of Transportation and Highways
Describes emergency services delivered by MOTH maintenance contractors.

Flood Response Resource Listing

The following is a listing of resources that are known to the authors and has been included for information and possible inclusion in the local flood response plan at the discretion of the Local Authority/Diking Authority.

Inclusion here is not an endorsement of services or products.

The references listed below will have to be contacted to determine the availability and cost of the resources. The resources will have to be arranged well in advance of expected flooding since availability, delivery and possibly training must be considered.

Please add other resources that come to your attention to the listing and advise us by forwarding the Write Us! sheet found in PART 1 - FLOOD PLANNING, so that we may share the information with other Local Authorities and Diking Authorities.

Resources Listing

Diking and Flood Barrier Information

Aqua-Barrier™ Inc.
Phone: 800-245-0199
Sales Information: sales@aquabarrier.com
Flood Barriers, Spill Containment and Construction Dewatering.

Aqua Barrier Flood Fighting System
Geodesign AB
Teknikringen 1
583 30 LinkOping
Sweden
Phone: +46 13 211955 Fax: +46 13 211958
Email: Kullberg@geodesign.se
A water barrier using standard pallets, a metal support and a waterproof geomembrane.

Aqua Dam and Diversion Ltd.
6970 - 10th Avenue S. E.
Salmon Arm, BC V1E 4M3
Phone/Fax: 250-832-1332
A water barrier using portable water filled tubes.

Flex-Mac®
Maccaferri Gabions Of Canada Ltd.
736 Granville Street
Vancouver, BC V6Z 1G3
Phone: 604-683-4824 Fax: 604-683-7089
The Multicellular Structure for Emergency Works.

Gabions
Maccaferri Gabions Of Canada Ltd.
736 Granville Street
Vancouver, BC V6Z 1G3
Phone: 604-683-4824 Fax: 604-683-7089
Wire baskets filled with granular material.

Lock-Blocks
Innomech Manufacturing Ltd.
12600 Mitchell Road
Richmond, BC V6V 1M8
Phone: 604-325-9161
Pre-cast Concrete Retaining Wall Systems.

The Sandbagger Company of Canada Inc.
Box 500, No, 11 PR 241
St. Eustache, Manitoba, Canada R0H 1H0
Phone: 204-353-2540 Fax: 204-353-2733
Manufacturer and Distributor of Sandbag Filling Equipment.

Sanilogical Projects
2001 River Drive
New Westminster, BC V3M 4V8
Phone: 604-524-3458 Fax: 604-524-4058
Ideas for alternative flood barrier construction methods.

Pump Information

ITT Flygt Canada
74 Glacier Road
Coquitlam, B.C. V3K 5Y9
Phone: 604 941-6664 Fax: 604 941-365

Notes