HANDBOOK
for
OPERATING FLOOD PROTECTION PROJECTS

pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

INTRODUCTION

Effective, safe and efficient operation of your flood protection project is vital to maximizing the project's performance and to minimizing potential damage during a high water event. Efficient operation, combined with monitoring and maintenance, ensures that the level of protection to your community is maintained.

Addressing project needs through effective monitoring and operations planning will enhance flood protection benefits. Projects kept in a state of readiness will be able to perform properly, when needed, and provide flood protection well beyond the designed service life, an important priority for sponsors.

Through an effective operation and maintenance program, Pennsylvania sponsors are attaining high levels of condition and performance for their projects. As your partner in flood protection, DEP is committed to working with you to keep your project ready to perform. We encourage each of you to continue to make your project the focus of your community as we work together to protect our citizens.

This manual will aid in understanding your project and in planning and responding to high water events, enabling you to continue to provide safe and reliable flood protection to your community.

On behalf of DEP and its Flood Protection program, we would like to acknowledge the U.S. Army Corps of Engineers, the Federal Emergency Management Agency and the New York State Department of Environmental Conservation for providing information used in the development of this manual.

TABLE OF CONTENTS

OPERATING FLOOD PROTECTION PROJECTS

Operations Goal

- The goal for project operations is to ensure that project features are utilized in an effective and efficient manner, providing the design level of protection to the community during a high water event.

Mission

- Effective, safe and efficient operation of a flood protection project is accomplished by a thorough understanding of the project, planned responses to any action that occurs during a flood event and annual exercises to ensure smooth and efficient operation of each element of the plan.

What is an Operations Plan?

- A project operations plan is a course of action in response to a high water event that has been predetermined, practiced and, as part of plan management, documented for the flood protection project. The plan provides a strategy for operations before, during and after a high water event in planning and conducting exercises (before), actions and emergency response actions (during) and recovery (after). The plan defines a chain of command to initiate operations and provides detailed information on how and when specific actions must take place. Elements of a plan include flood threat recognition, warning dissemination, response actions, emergency response actions, post-flood recovery and continued plan management.

Why Plan?

- Development of a plan encourages the process of thinking through a response to a flood scenario. It increases understanding of the project; how it is expected to perform; and how it has performed in the past.

- A plan enables responders to distinguish between normal spring flooding and a “Hurricane Agnes” type of event.

- Without a current and effective operations plan, any unplanned action may not succeed. A course of action is predetermined and documented, reviewed and practiced until it is easily and efficiently executed. Once the threat of flooding has been determined, response actions begin.

- Response actions are reviewed and evaluated for continued plan management. Reactions and responses can be improved based upon experience gained during routine drills or an actual flood event.

- Development of the operations plan establishes a dialogue between the local emergency manager, local officials, citizen volunteers and DEP. Problems are identified and appropriate response strategies are discussed and evaluated.

- Practice sessions, including operation of gates and annual installation of closure structures, enable municipal personnel and citizen volunteers to become familiar with emergency procedures and equipment.

- For the purposes of the National Flood Insurance Program (NFIP), the Federal Emergency Management Agency (FEMA) will recognize only those flood protection systems that meet and continue to meet minimum design, operations and maintenance standards as set forth in 44CFR Parts 55-77, *Regulations for Floodplain Management and Flood Hazard Identification*. Included in the standards is a requirement for the official adoption by the sponsor of a formal plan of operations with provisions for the periodic operation of closure structures and mechanized portions of drainage systems for testing and training at not greater than one-year intervals.

FLOOD WARNING AND OPERATIONS PLAN REQUIREMENTS

This section describes the requirements for plan preparation and maintenance, coordination with the local or County Emergency Management Agency and organization of periodic training exercises.

Flood Threat Recognition

- One of the most important considerations in flood operations planning is the ability to recognize, in advance of the onset of precipitation, that a particular storm is likely to result in a major flood event. Warning time is the time beginning when the potential of a flood event is first recognized, and ending when damage reduction activities and response actions must be completed. The purpose of a flood recognition system is to provide a means of increasing the length and reliability of warning time.

- Rainfall amounts (total precipitation quantities, typically in inches), rainfall intensities (rate of precipitation, typically in inches per hour) and the resulting stream rise associated with historical storms are important to implementing flood warning measures and determining timing of response actions. Comparisons of historical storm data with real time rainfall and rates of rise can be used to determine the amount of time available to complete a response action for that particular event.

- To anticipate potential flooding, each community must know where to obtain rainfall and river forecast information, and must thoroughly understand the flood warning system that will be used to trigger response activities. Rainfall information is available from the National Weather Service (NWS). Flood forecasting is performed by the National Oceanic and Atmospheric Administration (NOAA). Telephone numbers are listed on page 14 of this manual.

    - A *Flood Watch* occurs when high water is possible in the near future, typically when any of the following conditions are predicted: unusually hard rain for several hours or substantial rain over several days; rains in conjunction with a spring thaw; or a hurricane or tropical system affecting the area. A flood watch may occur several days before rainfall begins. The conditions that trigger the watch may or may not occur.

- A *Flood Warning* occurs when the following conditions are beginning or are highly likely to occur: unusually hard rain for several hours or substantial rain over several days; rains in conjunction with a spring thaw; or a hurricane or tropical system affecting the area. Additional observation is appropriate. A warning may be issued hours or even days before rainfall begins. Predicted rainfall intensities, rainfall amounts and flood forecasts must be continually monitored to ascertain the degree of response likely to be required. A significant flood event would require a greater level of monitoring and response effort than a moderate flood event

    - During a moderate flood event:
        - Water levels in streams and ponding areas may reach half of the project height.
        - The capacity of interior stormwater collection systems may be exceeded and flooding of streets and intersections may occur.
        - Drainage outlet structures become submerged.
        - Operation of a single pump in a pumping station may be required.

    - During a significant flood event:
        - Water levels may approach the top of levees, floodwalls and channels.
        - Culverts may become obstructed by debris.
        - Power outages and some interior flooding are likely to occur.
        - Partial or complete inundation of roads leading to the community may occur.
        - Installation of closure systems across roads and railroads may be required.
        - Some damage to the flood protection system may occur.

Warning Dissemination

- Flood warning dissemination is a key element of any flood warning preparedness program. Warning dissemination is the mechanism for local officials to be notified when a flood threat condition exists; when weather forecasts are changed; or when actual conditions differ from anticipated conditions. Methods of initially warning key personnel may include audio alarms,

voice dial-out systems to call key officials or pager systems or simply reading a staff gage and placing a telephone call.

- Each community should have a specific plan to notify key officials. This may be based upon the level of response anticipated. For example, government officials at higher levels may be notified only if a significant flood is forecast or occurring.

Chain of Command

- Names, telephone numbers and responsibilities of key officials should be maintained. It should be clear who is responsible for each element in the operations plan. At a minimum, the following items should be clearly and specifically addressed in an operations plan:

    - The individual in charge during an emergency should be identified by name or title;
    - The role of citizen volunteers, including monitoring and sandbagging teams, should be established. A means of contact for mobilization during an emergency should be clearly identified. Information on establishing a monitoring team is contained in the *Handbook for Monitoring Flood Protection Projects*;
    - The procedure for recording and interpreting information gathered by monitoring teams, such as rainfall amounts and intensities, rate of rise and time of peak should be documented;
    - The individual to whom problems are reported should be identified by name or title; and
    - The individual responsible for seeking technical assistance when problems occur should be identified by name or title.

Emergency Operations Plan

- An Emergency Operations Plan (EOP) is a plan of action taken to reduce the potential for loss of life and property in the event of a natural or manmade disaster, and is typically prepared by a state, county or local emergency management agency. The county or local emergency management agency should be familiar with the flood protection project and the EOP should reference or include a copy of the community's project operations plan. High water may restrict access to the entire community or to specific areas within the community,

complicating responses to other emergencies, such as fires, health emergencies and chemical spills that may occur during floods.

- Should the storm exceed the capacity of the flood protection system, or the flood protection system fail to perform, evacuation of all or part of the community may become necessary. The EOP should clearly identify when to order a relocation based upon the amount of time required to evacuate all or part of the community, the location of the emergency shelter(s) and potential evacuation routes.

- The EOP should also identify those structures that warrant additional protection against flood damage, such as hospitals, nursing homes and historical buildings. Measures should be established to protect the structures or the occupants if overtopping of the flood protection system occurs.

Emergency Equipment

- It is imperative that emergency and flood-fighting equipment be in good condition and readily available to the community during high water.

- At a minimum, emergency lighting, sand and sandbags, shovels, weather gear and emergency communications equipment must be maintained within the community.

- Sources of additional equipment may be available within the community. Businesses and industries, schools and emergency response organizations may be sources of emergency equipment such as trucks, lighting and generators. A current listing of such equipment and operators should be maintained, with a notation in the listing of whether high water levels limit equipment access.

Exercises

- Annual drills or exercises must be conducted so that individuals and organizations that would be involved in an actual high water event become familiar with emergency procedures and equipment. Careful planning is necessary to establish the scope and objectives of the exercises. At a minimum, exercises should include monitoring and operation of project features. The exercises can also include other emergencies that may take place during a flood, such as

vehicle collisions or fuel spills occurring when interior streets are flooded or flooded evacuation routes. The exercises should be tailored to the community. Representatives from agencies or organizations who would actually be called upon, such as medical personnel, public works, the mayor's office and DEP, should be involved in planning the exercises.

- Exercises should be sequenced to simulate the development of a significant high water event and include implementation of the appropriate response actions. Exercises should include:
    - Operation of specific project features, including sluice gates, pumping stations and closure structures;
    - Notification of emergency response personnel;
    - Testing of communications/backup communications system;
    - Mobilization of monitoring teams and monitoring of project features;
    - Coordination and control; and
    - Dissemination of information to the public.
- Documentation of the exercise is important to identify where any shortfalls exist in planning and coordination, training, personnel, equipment and facilities. Debriefing sessions held with all participants can provide valuable feedback on the effectiveness of policies and procedures, identification of areas of improvement and suggestions to correct deficiencies. Lessons learned during the exercise should be incorporated into the project operations plan and local emergency operations plan.

Continued Plan Management

- The plan must be reviewed annually and after each event where flood levels reach half of the levee or wall height or where an unusual or unexpected incident has occurred.
- Annual plan updates should include:
    - Verification that sources of emergency equipment, contact names and telephone numbers are current;
    - Review of evacuation routes and emergency shelter locations; and
    - Incorporation of knowledge gained during exercises or in response to an actual event into the plan.
- Updated information should be forwarded to DEP.

OPERATIONS PLAN IMPLEMENTATION

This section describes when and how to put the plan into action and appropriate response actions for a flood emergency.

Flood Threat Response

- Preparedness planning identifies what must be done and who must do it. The warning or lead-time available, the accuracy and the reliability of the forecast and warning systems dictate the types of response actions that take place. Response actions should be keyed into stages and time required to complete the response action based on an assumed rate of rise. The assumed rate of rise, taken from the design flood, is compared to the actual rate of rise. Times to implement response actions are adjusted according to these factors.

Response Actions

Before a flood occurs, a flood watch or warning may be issued.

- Flood Watch

  A flood watch means that high water is possible in the near future. The National Weather Service may issue a flood watch or conditions that typically precede a flood may be predicted, such as unusually hard rain for several hours, substantial rain over several days, rains in conjunction with a spring thaw or a hurricane or tropical system affecting the area. During a flood watch:

  - Begin checking current weather predictions and flood forecasts;
  - Continually monitor anticipated rainfall intensities and amounts; and
  - Notify key officials and monitoring teams of the developing potential flood situation.

- Flood Warning

  A flood warning means high water is highly likely to occur in the near future. The National Weather Service may issue a flood warning or conditions that precede a flood may be imminent or occurring. During a flood warning:

- Conduct an inspection of the entire project and include the following:
  - Inspect condition of all drainage structures, including operation of all gates. Gated outlets may be submerged with only a moderate rise in river stage, so it is imperative that the gates are inspected and necessary servicing is performed before any rise in the river occurs. Sluice gates along levee systems should be in the full "open" position. Flapgates and sluice gates should be inspected to ensure that they are operational and can be securely closed. Objects and debris that might prevent the closure of the gate should be removed.
  - Inspect any trashracks and remove floatable debris. This must be done before a rise in the stream occurs.
- As soon as precipitation begins, monitor rainfall amounts and intensities, water levels and rate of rise in streams and ponding areas.
- If a significant flood event is predicted, the following actions must also be completed:
  - Inspect condition of levees and floodwalls, including any recent repairs. Fill any holes or washes found in the levee with compacted soil material that includes some clay. Repair gaps where road crossings have worn down the levee crown or other locations where the levee is below grade;
  - Locate any right-of-way encroachment that could impede access and efficient operation and take the necessary action to remove it;
  - Locate transportation resources, including available trucks and equipment;
  - Obtain necessary tools and materials, such as sacks, sandbags, brush, snow fence, lumber and lights for distribution at points where active maintenance is anticipated;
  - Secure emergency communications equipment, telephones, police and radio systems;
  - Verify the location of relief agencies; and

- Notify local officials responsible for warning dissemination and emergency response plan actions.

During a flood, begin project monitoring, high water and emergency operations.

Flood Monitoring

- As soon as precipitation begins, mobilize monitoring teams and initiate emergency monitoring efforts. Monitoring patrols should be continually maintained until waters recede. Information on establishing and training flood protection monitoring teams is contained in the *Handbook for Monitoring Flood Protection Projects*.
    - Observations of the following should be recorded:
        - Incremental or cumulative rainfall amounts; water levels in streams, rivers, ponding areas and pumping stations; and the rate of rise or fall in streams, rivers and ponding areas at regular intervals;
        - Conditions of project features that may indicate that the project is not properly operating; the structural integrity of the project is in jeopardy; or that the capacity of the project may be exceeded; and
        - Conditions in pumping stations, including the number of pumps in operation at pumping stations, the accumulation of debris on trashracks (remove if safe to do so), excess noise, cycling of pumps and the ability of pumps to keep pace with inflow.

High Water Operations

- When water levels begin to rise, the various features of the project must be placed in service. If precipitation is more intense than in the design flood, stream levels are likely to rise at a much faster rate. To allow adequate time for the operation of project features, the timing of response actions should be adjusted based on changing storm conditions or precipitation intensities.

- All preliminary inspections and notifications of impending closures at roads and railroads must be completed in advance to permit time for the closure to be completely installed before water reaches the bottom of the closure.
- Typical project features and operational requirements are listed below:
    - Levees, floodwalls, channels and conduits have no special operational requirements, but should be continuously monitored during a high water event. Measures should be taken to prevent the formation of ice or debris jams. Large objects that become lodged against the bank should be removed.
    - Drainage Structures – Automatic gates such as flapgates should be closely observed to ensure proper function. Sluice gates on the land side of a levee or channel are a backup system for the automatic gates and should remain in the full open position unless closure is required to prevent the inflow of flood water. **If any sluice gate is closed during a high water event, it should be opened after the water level on the river side of the levee has receded to 3 inches below the pond level on the protected side.**
    - Closure Structures – Closure structures should be completely installed before water reaches the bottom of the closure. Detailed information regarding the proper installation of the closure structure should be included in the project operations manual. Closure structures should be inspected frequently during flood periods to ascertain that no undue leakage is occurring. **Closure structures should remain closed until the water has receded below the bottom of the closure, and current flood forecast information indicates continued water level recession.**
    - Pumping Stations – During flood periods, competent operators should be on duty whenever it appears that operation is imminent, even when station operation has been automated. Operators should thoroughly understand the manner in which the pumping station was designed to operate and be capable of manual station operation, should

automated equipment or sensors fail. DEP should be contacted for technical assistance when conditions differ significantly from expected conditions.

- Ponding Areas – Ponding areas have no specific operational requirements during high water events other than those associated with the operation of their drainage structures. A portable pump may be used to pump water over the levee, if ponding occurs in undesirable areas or if water is rising too quickly in ponding areas. Ponding areas should be continually patrolled during high water.
- Debris Dams/Trashracks – Monitor debris basins and trashracks for sediment deposits and accumulating debris. As debris and sediment continue to be deposited into the basin, debris loads will substantially block racks and sediment deposits will block the entrance to the basin forcing flow to be directed along the sides of the basin. Any large accumulations of debris on racks or flow directed along the sides of the basins will cause local erosion and scour. Levees and concrete structures that are part of the debris basin facility will need to be closely monitored to ensure performance. Debris should be raked from trash racks at pumping stations periodically when the station is in operation.

Emergency Operations

- An emergency operations plan covers preparation for and responses to project emergency conditions. Recognition of potentially damaging conditions is addressed in the *Handbook for Monitoring Flood Protection Projects*. The project operations plan must address how to respond to project emergencies, methods of emergency communications, the chain of responsibility and telephone numbers of local, state and federal emergency response agencies. Emergency conditions and appropriate responses are detailed in Appendix 1 (page 16).

After a flood, recovery actions must be initiated.

Post Flood Recovery

- Post flood recovery includes actions that must be taken after the flood to begin preparing for the next high water event. Any sluice gates that were placed in the closed position must be opened. Removing debris, locating high water marks and inspecting the condition of the project must be done at this time. Any damage to the project should be reported to the U.S. Army Corps of Engineers and DEP. The Corps of Engineers and DEP can provide technical assistance for damage repair. Financial assistance is also available through the Corps of Engineers for non-federal local flood protection projects that are satisfactorily maintained and have sustained damage during a high water event. Post flood maintenance is addressed in the *Handbook for Maintaining Flood Protection Projects*.

- If a significant event has occurred, forward a copy of monitoring information to DEP.

- After a flood, closely examine the events and actions that occurred prior to and during the flood to determine whether the actions taken were effective and efficient. Because floods may occur decades apart, it is important that information be recorded for use in future planning efforts. Debriefing sessions, with all participants represented, provide valuable feedback on the lessons learned. Note which actions worked well, and identify the reason for their success. Note which actions could be improved upon and solicit suggestions to correct the problems. Collect data on the response effort, such as material, equipment and man-hour estimates, weather reports and bulletins and monitoring reports. Compare the planned responses with the actions taken and incorporate the information learned into the plan.

CONTACTS

Pennsylvania Department of Environmental Protection

Bureau of Waterways Engineering
Division of Project Inspection
P.O. Box 8460
400 Market St.
Harrisburg, PA 17105-8460
(717) 787-7432 (7:30 a.m. to 4:30 p.m.)

After office hours, contact DEP's Statewide Emergency Response **AND** PEMA's State Emergency Operations Center. Clearly identify that the emergency involves a flood protection project and request that the Bureau of Waterways Engineering, Division of Project Inspection be contacted.

DEP Statewide Emergency Response
800-541-2050
717-787-4343

Pennsylvania Emergency Management Agency

State Emergency Operations Center
800-424-7362
717-651-2001

U.S. Army Corps of Engineers. Contact DEP and the U.S. Army Corps of Engineers for an immediate inspection when your project is damaged by a high water event. Flood damage assistance is available if your project was initially certified by the Corps and was rated acceptable or minimally acceptable condition from the last annual inspection.

Office	Phone Number
Baltimore District	410-962-4223
Philadelphia District	215-656-6757
Pittsburgh District	412-395-7145

National Weather Service

Office	Phone Number
Binghamton, NY	607-729-1597
State College, PA	814-234-9417
Philadelphia, PA	609-261-6600
Pittsburgh, PA	412-262-1591

Mid-Atlantic River Forecast Center

River System	Office	Phone Number
Susquehanna River – upstream from Wilkes-Barre, PA	Binghamton, NY	607-729-1597
Delaware River – upstream from Belvidere, NJ	Binghamton, NY	607-729-1597
Susquehanna River - downstream from Wilkes-Barre, PA	State College, PA	888-881-7555
Lehigh River	Mount Holly, NJ	609-261-6600
Schuylkill River	Mount Holly, NJ	609-261-6600
Delaware River – downstream from Belvidere, NJ	Mount Holly, NJ	609-261-6600
Potomac River	Sterling, VA	703-260-0305
Ohio River	Wilmington, OH	937-383-0031

Sandboils

A sandboil is muddy or flowing water observed within or near the levee toe on the landward side of the levee. Sandboils discharging solids indicate that material is eroding from under the levee foundation during high water events. Damage to the levee can be localized by constructing a sandbag ring around the boil, as shown in Plate 1 (page 19). The ring should be constructed completely around the boil, outside of the defective area. The ring should be constructed to a height that water entering the ring is clear, indicating erosion of material from beneath the levee has stopped. No attempt should be made to completely stop the flow of water, as other boils may occur outside the ringed area. If several sandboils occur in the same vicinity, a single ring may be built around all of them. The sandboil ring should discharge on the landward side of the levee through an overflow section at the top of the ring. Overflow should be directed away from the levee structure. If the sandboil is clear, little danger of undermining the levee exists, and the sandboil need not be ringed. However, it is still important to direct flow away from the toe of the levee. Observation of areas in and around the ring should continue.

Seeps or Unusual Wetness on the Land Side of the Levee

If seeps are observed, adverse effects can be minimized by cutting shallow V—shaped seep drains into the levee on the land side slope to provide an outlet for drainage as shown on Plate 2 (page 19). The drains should be shallow, with the depth not exceeding 6 inches, and should be cut down the levee slope. Collected flow should be diverted from the toe of the levee to the main drainage ditch or storm drain. Areas of seeps should be closely monitored for increased seepage, particles of earth in the seepage or longitudinal cracks in the slope or crown, as they may be precursors to sloughs or slides.

Sloughs or Slides

If sloughs develop in the levee, seep drains should be cut to drain any soft areas. Picket snow fence or a single layer of trees or limbs with the butts up and the tops down should be placed over the affected area, as shown in Plate 3 (page 20). Sacks or weights should be placed over the brush or fence in sufficient quantity to hold the fence down, but should not be placed higher than 2/3 of the distance from the toe of the slope to slough. Lattice or chain link fencing or porous geotextile fabrics may be substituted for snow fence. Areas of sloughs should be closely monitored for indication of increasing damage.

Significant slides or sloughs in the levee, or any bridge abutments adjoining the levee, may indicate impending structural failure. Begin evacuation of affected areas and call DEP immediately for technical assistance.

Wave Washing or Scouring

If any signs of scour are observed, soundings should be taken to determine the extent of scour and to monitor its progress. Scour action may be decreased by constructing deflection berms, as shown in Plate 4 (page 20). The berms should be constructed by driving stakes into the levee, wiring the stakes together, then filling the area between the stakes with brush, tree-tops, lumber or sacks of stone. Another method of combating scouring is placing polyethylene sheeting anchored with sandbags, as shown in Plate 4.

Low Reaches of the Levee

If a low area or depression is observed in the levee, sandbagging is the preferred method of raising the levee, as shown in Plate 5 (page 21). Sandbagging is a dependable method of levee raising, but is very labor intensive and slow to construct. A sandbagging device, as shown in Plate 6 (page 21), may be constructed to aid in filling the sandbags. Alternative methods to raise the levee are constructing an earthen embankment of polyethylene sheeting and earth or sand, as shown in Plate 7 (page 22), or placing a double row of New Jersey Barricades on a level surface and filling the center with earth, sand or clay as shown in Plate 8 (page 22).

Leakage at Drainage Gates or Piping Penetrations

All drainage structures in levees should be inspected frequently during floods to determine if seepage is taking place along their lines of contact with the embankment. The ponding of water at the inlet end of a pipe does not necessarily indicate serious leakage, as the ponding may be caused by local runoff. Leakage at the gates or piping can be confirmed through close observation of the direction of flow at the end of the pipe. Muddy water is indicative of material eroding from within the levee along the pipe during high water events. If seepage is occurring, it should be treated as a sandboil by constructing a sandbag ring around it. The ring should be constructed completely around the boil, outside of the affected area and to a height that the flow of water is stopped.

Animal Burrows

Animal burrows can provide an easy conduit for water through flood control structures. Burrows can be easily plugged if they are located above the water line. Flooded burrows can be sealed off by dropping weighted sheets of plastic on the water side of the levee as shown on Plate 9 (page 23). Another method of plugging flooded animal burrows is placing a mixture of manure and straw or dry hay into the water near the flow vortex at the burrow entrance.

Unusual Movement of the Levee

Significant localized subsidence or unusual vertical or horizontal movement of a levee or floodwall may indicate impending structural failure. Continue monitoring and begin evacuation of affected areas. Contact DEP immediately for technical assistance.

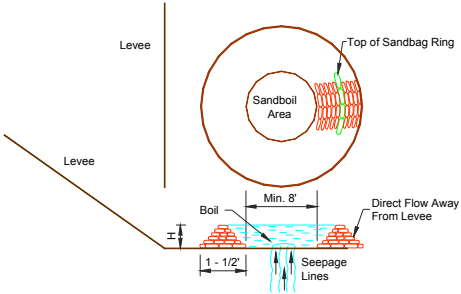
Concrete Channels and Floodwalls

Patrols should monitor leakage at construction joints, seepage at points of transition between levees and channels or floodwalls or seepage beneath floodwalls. Any condition which endangers the stability of the walls must be corrected. Contact DEP immediately for technical assistance.

Overtopping of a Debris Dam, Levee or Floodwall

Although the likelihood of overtopping is remote, the potential does exist. Overtopping of a dam or levee may erode material and create a breach or crevasse in the works. Once a breach is opened, it is extremely difficult, if not impossible, to close. Overtopping should be prevented whenever possible by building up low areas or short levee reaches that may be subject to backwater at bridges as described above. If a flood stage exceeding the levee or floodwall height is predicted, evacuation of the community is required, even if levee raising is contemplated. Careful consideration should be given before initiating a large-scale flood fighting effort. The first priority in flood-fighting is the protection of human life. Raising long levee reaches is expensive, time consuming, labor-intensive and may endanger personnel engaged in flood fighting efforts. Materials to mount a large-scale flood fight may not be readily available, or in very large events, at all.

SANDBOIL CONTAINMENT

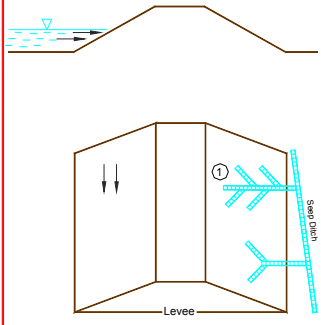


Build Sandbag Ring to stop movement of soil until the ponded water clears.

DO NOT ATTEMPT TO STOP THE WATER FLOW!

PLATE 1

SEEPAGE - METHODS OF DRAINING LEVEE SLOPE



1. Cut shallow V - shaped ditches on the land side of the levee. Depth should not exceed 6 in.
2. Herringbone-type drainage ditches should be used for very heavy seepage. (1)
3. DO NOT cut drains horizontally across levee slopes.
4. Collected flow should be diverted from the levee toe by ditching to the main drainage ditch or nearest storm drain facility.

PLATE 2

SLIDE/SLOUGH MEASURES

1. Cut seep drains to drain soft areas.
2. Place a layer of fencing porous geotextile fabric or a single layer of brush (butts up, top down) on the slope.
3. Weight the levee toe with a sandbag buttress.
4. Place no weight other than what is necessary to hold the brush in place higher than 2/3 of the distance from the toe to the slough.

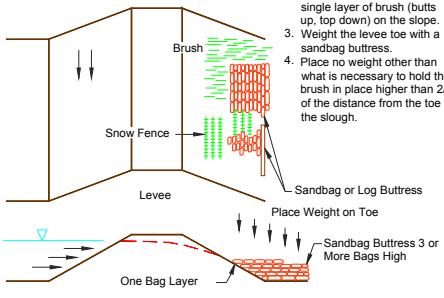
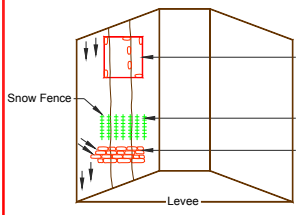


PLATE 3

SCOUR OR EROSION PROTECTION

Protect area by placing snow fence, porous geotextile fabric, plastic or cotton bagging over scour area, stake and weight with sandbags. Use only the minimum number of sandbags to weigh down the fence.

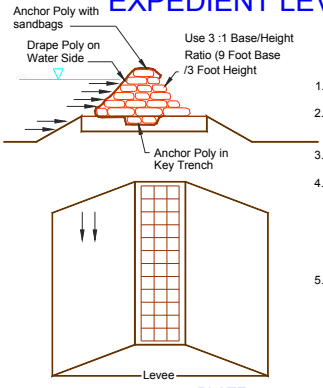


or

Build Deflection Dike Use Sandbags, Rocks, Lumber Bulkhead

PLATE 4

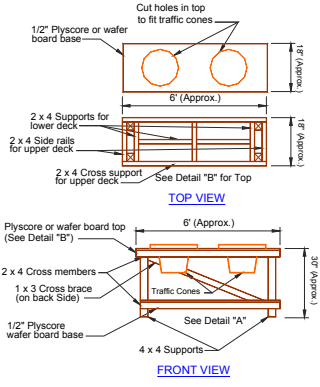
SANDBAG EXPEDIENT LEVEE

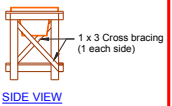


1. Dig key trench approximately 6" deep and 18" wide.
2. Line key trench with polyethylene sheeting on the water side
3. Anchor poly in key trench with sandbags.
4. Place sandbags in alternating rows, staggering joints between rows and the open end of the bag facing downstream and anchored by the next bag placed on top and tamped into place.
5. When the appropriate height is reached, drape poly over sandbag line. Anchor poly with additional sandbags.

PLATE 5

SANDBAG FILLING STATION



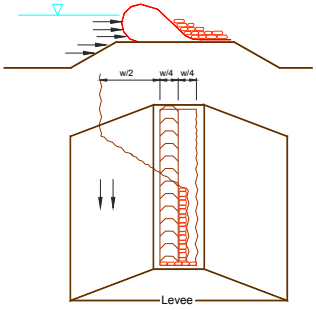


Construction Notes:

1. Dimensions given are approximate and may be field modified to suit local materials and needs.
2. The distance between the bottom of the traffic cone and the bottom deck should be equal to ¾ of the bag height
3. For added strength, lag screws may be used to attach 2 X 4's to 4 X 4 posts.
4. To reduce lifting heights, bottom deck should be as high as possible.

PLATE 6

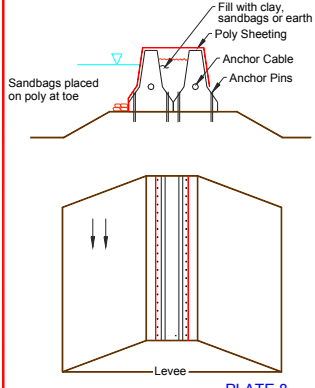
EARTHEN EMBANKMENT
EXPEDIENT LEVEE



1. Place polyethylene sheeting on the levee top. Embank earth or sand on
2. one-quarter to one-third of the polyethylene sheeting. Fold the polyethylene sheeting over, placing
3. sandbags on the flap to anchor.

PLATE 7

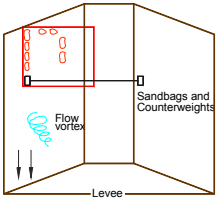
JERSEY BARRIER FLOOD WORKS



1. Place first row of barriers on sound footing.
2. Attach barriers together with cable.
3. Securely anchor barriers with pins to ground.
4. Position the second row of barriers on sound footing.
5. Attach the second row of barriers together with cable.
6. Securely anchor the second row of barriers with pins to ground.
7. Fill and tamp the space between barriers with fill.
8. Place polyethylene sheeting on water side and anchor with sandbags.
9. Drape poly over barriers.

PLATE 8

EMERGENCY REPAIR OF ANIMAL BURROWS



Above the water line:
Fill the burrow with cement, grout, or other slurry-type material such as mud. Cover with polyethylene sheeting, stake and weight with sandbags.

Below the water line:
Cover the burrow with polyethylene sheeting, stake and weight with sandbags or counter weights.
OR
Place a mixture of manure and straw or dry hay into the water at the flow vortex near the burrow entrance to fill and seal the burrow.

PLATE 9

APPENDIX 2 - DEFINITIONS

Access - The approach or entrance and exit to the top of a levee or along a channel; an access ramp or access road.

Alignment - The location or arrangement of a reference line locating a structure or feature of a project, often identified as the centerline of a levee or channel.

Base Flood - A flood with a one percent chance of being equaled or exceeded in any given year (also called the 100-year flood). (1)

Boil - An upward lifting and eruption in the surface of the ground caused by water escaping under pressure from under a levee, floodwall or dam which can result in soil particles being removed from the foundation in the form of muddy water.

Breach - An opening or a breakthrough of a levee or dam sometimes caused by rapid flowing water and erosion or scour of a section of the earthen embankment.

Bureau of Waterways Engineering - An organizational level of DEP responsible for flood protection, dam safety and stream improvements programs.

Chain of Command - A hierarchy of command structures utilized in emergency operations centers for the purpose of defining a structure for the resolution of emergencies. (2)

Channel - A natural or artificial waterway that periodically or continuously contains moving water or forms a connecting link between two bodies of water. It has a definite bed and banks which confine the water. The deep portion of a river or waterway where the main current flows. (1)

Channel Capacity - The maximum rate of flow that may occur in a channel without causing overbank flooding.

Cracking - The opening in the soil or fissure found at the top of a levee or dam caused by earth slopes that are unstable; an indication that the slope is failing or will fail.

Dam - A barrier built across a watercourse for the purpose of impounding, controlling or diverting the flow of water. (2)

Dam Failure - The uncontrolled release of impounded water resulting in downstream flooding. (2)

Danger Stage - Along flood control project levees, flow is greater than maximum design capacity. [1]

Department of Environmental Protection (DEP) - An agency of the Commonwealth of Pennsylvania responsible, in part, for the flood protection program including the planning, design, construction inspection, project inspection and outreach program for sponsors and their completed projects.

Depression - A low or sunken area along the top of a levee or dam sometimes caused by poor compaction of the soil and resulting in settlement at the location of a pipe or by loss of soil particles through the joints of a pipe.

Design Flood - The flood magnitude for which a specific project was designed. New hydrologic data could change a design flood for a specific project. [1]

Detention Dam/Basin - Used to impound water temporarily. [1]

Discharge - The rate of flow or volume of water flowing past a specific point within a given period of time. Generally expressed in cubic feet per second. [1]

Drainage Structure - A structure, such as a pipe or culvert, to convey excess rainfall to a stream or channel. For flood protection systems, typically a pipe through a levee, floodwall or culvert with a flapgate mounted at the outlet and sometimes a sluice gate mounted at the inlet, or a twin-celled drop inlet with grating at the inlet cell and a flapgate in the outlet cell.

Easement - A right to use the land, or part of the land, of another for a particular or limited purpose. [2]

Embankment - A structure made of soil or stone to hold back water or support a roadway; refers to levee and/or dam. [1]

Emergency Operations Plan (EOP) - A plan of action to be taken to reduce the potential for loss of life and property in the event of a natural or manmade disaster. An EOP is typically prepared by a state, county or local emergency management agency. It identifies authorities, relationships and the actions to be taken by whom, what, when and where, based on predetermined assumptions, objectives and existing capabilities. [1,2]

Emergency Shelter - A shelter provided for the communal care of individuals or families forced from their homes by a major disaster or an emergency. (2)

Encroachment - Advance or infringement of uses, plant growth, fill, excavation, buildings, permanent structures or development into a floodplain, on the lands of a flood protection project or within the designated rights-of-way of a flood protection project.

Erosion - The loss or wear of the levee or channel slopes and stream/channel bottoms caused by the velocity of flowing water that removes grass/sod and soil that leaves a denuded surface or void.

Evacuation - Organized, phased and supervised dispersal of people from dangerous or potentially dangerous areas to safe areas, including reception and care in safety areas. As used, evacuation refers to population removal for a short period (not more than a few days). Relocation refers to removal for more than a few days. (2)

Evacuation Area - The total area encompassed by the reception area necessary to receive evacuees from a risk area or group of closely related risk areas. (2)

Evacuees - People removed or moving from areas threatened or struck by a disaster. (2)

Exercise - A supervised instruction session which develops, tests and / or maintains a specific emergency response capability. An exercise or drill conducted and evaluated by a person(s) trained in the control and evaluation of drills, involving decision-making and actions by participating personnel to simulated emergency conditions, utilizing a limited-scope scenario to identify simulated conditions and be followed by a documented critique to identify areas for improvement/correction. (2)

Federal Emergency Management Agency (FEMA) - An executive agency of the federal government that serves as a single point of contact within the federal government for emergency management activities--including planning, activities for preparedness, response, recovery and mitigation. (2)

Fence - A safety barrier, 4 feet in height, built of posts, rails and chain link fabric located on top of concrete channel walls and retaining walls.

Flapgate - A hinged cover and frame made of cast iron over the opening of a pipe at the outlet of a drainage structure that prevents the backflow of water from the stream into the pipe when the stream is at flood stage.

Flash Flood - Sudden flooding resulting from heavy localized rainfall. Follows a situation in which rainfall is so intense and severe and runoff so rapid that it precludes recording and relating it to stream stages and other information in time to forecast a flood condition. [2]

Flood - A general and temporary condition of partial or complete inundation of normally dry land areas from the overflow of waters or the unusual and rapid accumulation or runoff of surface waters from any source.

Flood Capacity - The flow carried by a stream or floodway at bankful water level. Also the storage capacity of the flood pool at a reservoir. [1]

Flood Crest - The maximum stage of elevation reached by waters of a flood at a given location. [1]

Flood Protection System - A structure or work used to separate flood waters from a protected community.

Floodplain/Flood-Prone Area - Any land area susceptible to being inundated by water from any source (see definition of flood). [2]

Floodwall - A reinforced concrete structure constructed as a wall and footing/slab and used to separate flood waters from the protected community.

Flood Warning - Flooding is imminent or already occurring for a particular watershed.

Flood Watch - Conditions are such that flooding is likely to occur for a particular watershed.

Freeboard - The vertical distance between the design water level, 100-year flood or design flood, and the top of the levee, floodwall, channel wall or channel bank. An additional height of protection provided at flood protection structures to account for waterway blockage caused by debris and sediment and for the inaccuracy in stream modeling.

Gage - Device to measure water level in a channel, reservoir or ponding area. A gage may consist of markings on a road or bridge or provide automated measurement of water levels.

Impoundment - The collection or confinement of water, as in a lake. [1]

Inlet Channel - The upstream ditch, swale or waterway leading to a drainage structure or concrete channel.

Inlet Structure - The entrance waterway to a drainage structure or concrete channel.

Inlet Structure Grating/Metalwork - The opening to a twin-celled concrete channel drainage inlet composed of a cast iron or steel inlet grate and frame.

Inundation Area - The area that would be covered by water in the event of a dam or levee failure. (2)

Joints - A formed break in concrete wall and slab sections. Contraction joints are normally spaced at 30 feet and are painted with bituminous paint to prevent bonding. Expansion joints are normally spaced at 90 feet and are filled with preformed sponge rubber material. Construction joints have through steel reinforcing bars and are located between separate sections of walls for the convenience of placing concrete.

Levee - A trapezoidal-shaped rolled earth embankment generally composed of an impervious mixture of clay, silt, sand and gravel. Levees are engineered flood protection structures used to separate floodwaters from the protected community.

Level of Protection - The amount of protection that a flood control measure is designed to provide, as determined by engineering feasibility, economic criteria, and social, environmental, and other considerations. (1)

Local Emergency Operations Plan - The local EOP focuses on essential measures for protecting the public, to include warning, emergency public information, evacuation, and shelter. To be included in a local EOP should be a mechanism for emergency responders and managers to notify and activate State resources. (2)

Local Government - Any county, city, town, district, or political subdivision of any state or any Indian tribe or authorized tribal organization. (2)

Municipality - The terms "municipality" or "municipal government" is defined as referring, singularly or collectively, to cities, townships and incorporated towns within a state. (2)

National Flood Insurance Program (NFIP) - Created by Congress in 1968, the program's purpose is to reduce loss of life and property and rising disaster relief costs. It is administered by the Federal Emergency Management Agency and provides insurance coverage for property within a flood hazard area. NFIP also requires replacement

buildings in a flood hazard area to be constructed to resist future flood damages and discourages future construction in flood hazard areas. [1]

Obstructions - A blockage of a channel, culvert and bridge caused by sediment, debris, trees, trash and other materials that would restrict normal and flood flows by reducing the waterway of the structure.

One Hundred Year (100-year) Flood - The flood magnitude expected to be equaled or exceeded on the average of once in 100 years or the flood magnitude with a 1 percent chance of being exceeded in any given year. Also called the base flood.

Operator - The geared mechanism used to manually raise and lower a sluice gate using a handwheel, handcrank or motor/gas driven power unit.

Outlet Channel - The downstream ditch, swale or waterway leading away from the drainage structure or concrete channel.

Outlet Structure - The exit waterway from a drainage structure or concrete channel.

Pipe - A circular conduit capable of conveying local drainage through a levee or dam normally made of precast reinforced concrete and corrugated metal.

Pipe Lining - A pipe placed inside another pipe usually at a drainage structure where a plastic pipe is grouted in place to preserve the barrel of the corrugated metal pipe.

Precipitation Intensity - The rate of precipitation per unit of time, typically expressed as rainfall in inches per hour.

Precipitation Quantity - Total amount of precipitation.

Preparedness - Those activities, programs and systems that exist prior to an emergency that are used to support and enhance response to an emergency or disaster [2].

Protective Measures - Measures taken during an emergency for the purpose of preventing or minimizing hazards that are likely to develop if the actions were not taken[2].

Project Operations Plan - For flood protection systems, a specific course of action to place project features into use during a high water event. The plan provides a strategy for planning and conducting exercises before a flood event, actions and emergency response

actions to take place during a flood event and post flood recovery actions. The plan defines a chain of command to initiate operations and provides detailed information on how and when specific actions must take place.

Rate of Rise (or Fall) - Change in height of water surface in river, stream or ponding area, typically expressed in feet per hour.

Reach - A length, distance or leg of a channel or other water course. [1]

Reservoir - A pond, lake, tank, basin or other space, either natural or created in whole or in part by the building of a structure such as a dam, which is used for storage, regulation and control of water for power, navigation and recreation. [1]

Response - Those activities and programs designed to address the immediate and short-term effects of the onset of an emergency or disaster. The efforts to minimize the risks created in an emergency by protecting the people, the environment and property, and the efforts to return the scene to normal pre-emergency conditions. [2]

Riprap - A well-graded stone placed on a channel or levee slope that protects the slope from erosion and scour. A layer, facing or protective mound of stones placed to prevent erosion, scour or sloughing of a structure or embankment. [1]

Riverine - Relating to, formed by or resembling a river (including tributaries), stream, brook, etc. [1]

Sandbags/Sand - Plastic woven bags, filled with sand, that are used for building sandbag rings around boils, for closure barriers across roads and railroads and other flood fighting operations.

Saturated Areas - Soft spongy ground areas that may have standing water and are found along the land side toe of the levee, floodwall or dam. Water may bubble or percolate from the area under pressure from flood stages on the stream.

Scour - Erosion or loss of levee or channel slopes and stream or channel bottoms by flowing water.

Sedimentation - Suspended sands and gravels deposited along the channel by flowing water.

Seepage - Water under pressure from flood stages on the stream moving through or under the levee, floodwall or dam.

Settlement - Poor compaction of the soil causing a depression usually observed at the top of a levee, dam or on the land side of a floodwall.

Shelter - A facility to house, feed and care for persons evacuated from a risk area for periods of one to nine days. [2]

Slide/Slough - The failure and movement of an earthen slope towards the toe of a channel, levee or dam usually caused by poor soils or compaction or saturated areas.

Slope Stability - The ability of the slope of a channel, levee or dam to restrict movement and sliding.

Sluice Gate - A gate mounted on an inlet structure on the land side of a drainage structure that opens and closes vertically with the use of an operator that is normally kept in the full open position.

Sponsor - The Borough/Township/County responsible for acquiring lands, relocating utilities and operating and maintaining the flood protection project after construction as defined by its Agreement with DEP.

Stage - The elevation of the water surface above or below an arbitrary point. [1]

Stoplogs - A barrier constructed of aluminum beams individually stacked between concrete abutments used to close off levees at roads and railroads.

Toe of Levee - The intersection of the constructed slope with the natural ground and the lowest portion of the levee.

Top of Levee - The highest portion/elevation of the levee.

Top Width - The width at the highest portion/elevation of the levee or dam, normally 10 feet for levees.

Trashrack - A structure formed by piling spaced at regular intervals to trap debris and trees, normally at the entrance to a concrete channel. Sloped bars closely spaced at the entrance to the sump of a pumping station to prevent trash and debris from entering the station.

Tributary - A stream or other waterbody that contributes its water to another stream or waterbody. [1]

Warning (meteorological) - An advisory issued by the National Weather Service, whenever a severe weather phenomenon is deemed to be imminent or has been sighted or has been confirmed by other means, such as radar. [2]

Watch (meteorological) - An advisory issued by the National Weather Service, whenever meteorological and other data indicate the potential for a destructive weather phenomenon to occur. [2]

Watershed - The whole surface drainage area that contributes water to a collecting river, lake or other waterbody. [1]

Water Surface Elevation - The elevation at a point, frequently referred to as stage, at which the water level stands in reference to a fixed datum, such as mean sea level. [1]

[1] Definitions are from 44CFR Parts 59-76, National Flood Insurance Program, Regulations for Floodplain Management and Flood Hazard Identification.

[2] Definitions are from Emergency Management Glossary And Acronyms, Compiled By Dean R. Larson Ph.D. CSP CEM, Captain USNR (Ret)

For more information, contact:

Pennsylvania Department of Environmental Protection
Bureau of Waterways Engineering
Division of Project Inspection
P.O. Box 8460
400 Market St.
Harrisburg, PA 17105-8460
717-787-7432 (7:30 a.m. to 4:30 p.m.)

For more information,
visit DEP's Web site at www.depweb.state.pa.us,
keyword: Flood Protection.

An Equal Opportunity Employer

3100-BK-DEP2735 Rev. 1/2008