FLOOD RESPONSE MANUAL

US Army Corps of Engineers

2023

TABLE OF CONTENTS

CHAPTER 1: INTRODUCTION

1-1 Objective

One of the missions of the United States Army Corps of Engineers (USACE) is to prevent, reduce, and mitigate the risk of damages associated with flooding. Floods can happen at any time and for various reasons. During flood emergencies, the full capabilities, and authorities of USACE will be utilized in accordance with underlying USACE policies. The primary objective of this manual is to provide emergency organizations and their members with information that may increase their understanding of the full capabilities and authorities of USACE so that they may better prepare and be ready to respond to flood emergencies.

Figure 1: Photo of February 2019 flood response efforts in USACE Vicksburg District

1-2 Purpose

The purpose of this manual is to:

- Provide information on the types of USACE assistance available prior to, during, and after a flood emergency.
- Describe different types of failure modes that a levee can experience during high-water events.
- Describe warning signs of various modes of failure a levee can experience during high-water events.
- Describe standard practices for successfully preventing various types of levee failure during flood response operations.

1-3 Scope

This manual provides information on emergency responsibilities, field report formats, and general operational procedures of USACE to facilitate effective and coordinated flood emergency response activities, as authorized by Public Law 84-99, in support of State, Local, Tribal, or Territorial officials.

This manual does not cover every flood response scenario and this manual is not intended to restrict flood response personnel to a set of rigid rules or standard techniques. Levees provide a significant amount of flood risk management benefits in the U.S., so they receive much of the focus of this manual. Dangerous conditions not covered in the manual may arise that will require in depth knowledge, initiative, and independent action on the part of flood response personnel. Under normal conditions, the procedures outlined in this manual should be followed.

CHAPTER 2: AUTHORITIES

2-1 General.

The authority to supplement the resources of local interests in times of flood, to repair or restore flood risk management projects damaged or destroyed by floods, and to initiate the construction of temporary emergency measures is delegated to the Chief of Engineers pursuant to the authority of Public Law (PL) 84-99. The USACE implementing guidelines and publications for PL 84-99 are Engineer Publication (EP) 500-1-1 and Engineer Regulation (ER) 500-1-1.

Figure 2: Federal flood life-cycle risk management and programs

2-2 Emergency Authorities

PUBLIC LAW 84-99

USACE may provide emergency assistance under PL 84-99 to save lives and protect improved properties (e.g. public facilities/services and residential/commercial developments) during or following a flood event. USACE emergency assistance will be undertaken only to supplement state, tribal, county, and local efforts. State, tribal, and local interests must commit all available resources, e.g., work force, supplies, equipment, funds, National Guard assets, etc., as a general condition of USACE assistance.

USACE can provide either technical assistance or direct assistance during flood response operations. Technical assistance consists of providing review and recommendations in support of state and local efforts and helping determine feasible solutions to uncommon situations. The following are examples of technical assistance:

1. Guidance in flood response techniques.
2. Inspection of an existing flood risk management project.
3. Providing hydraulic and hydrologic analysis of the area.
4. Geotechnical evaluations of existing flood risk management projects.

Direct assistance under PL 84-99 may include furnishing flood response materiel, e.g., sandbags, polyethylene sheeting, lumber, pumps, and riprap to stabilize eroding embankments; contract hiring of equipment and operators for flood response operations or construction of temporary emergency measures; removal of log or debris jams that are blocking stream flow and causing flooding of communities, etc. Direct assistance under PL 84-99 is limited to flood related emergencies only.

Local entities and non-federal sponsors desiring assistance from USACE for flood response should first go to their emergency disaster agency or other state/tribal agencies who are authorized to act for the governor/tribal chairman in times of natural disaster. The governor/tribal chairman, or an authorized representative, will request assistance for the applicable program from USACE. Assistance under PL 84-99 cannot be provided directly to individuals.

For further information on USACE assistance or eligibility for assistance during flood emergencies, contact the Readiness Branch of your local USACE District Office. To find an address or telephone number for your local USACE office, visit the USACEHQ website (https://www.usace.army.mil/) and look for the contact page, which includes a USACE office locator. Contact info can also be found by using internet search engines, include your state name and “USACE District” to find your local office.

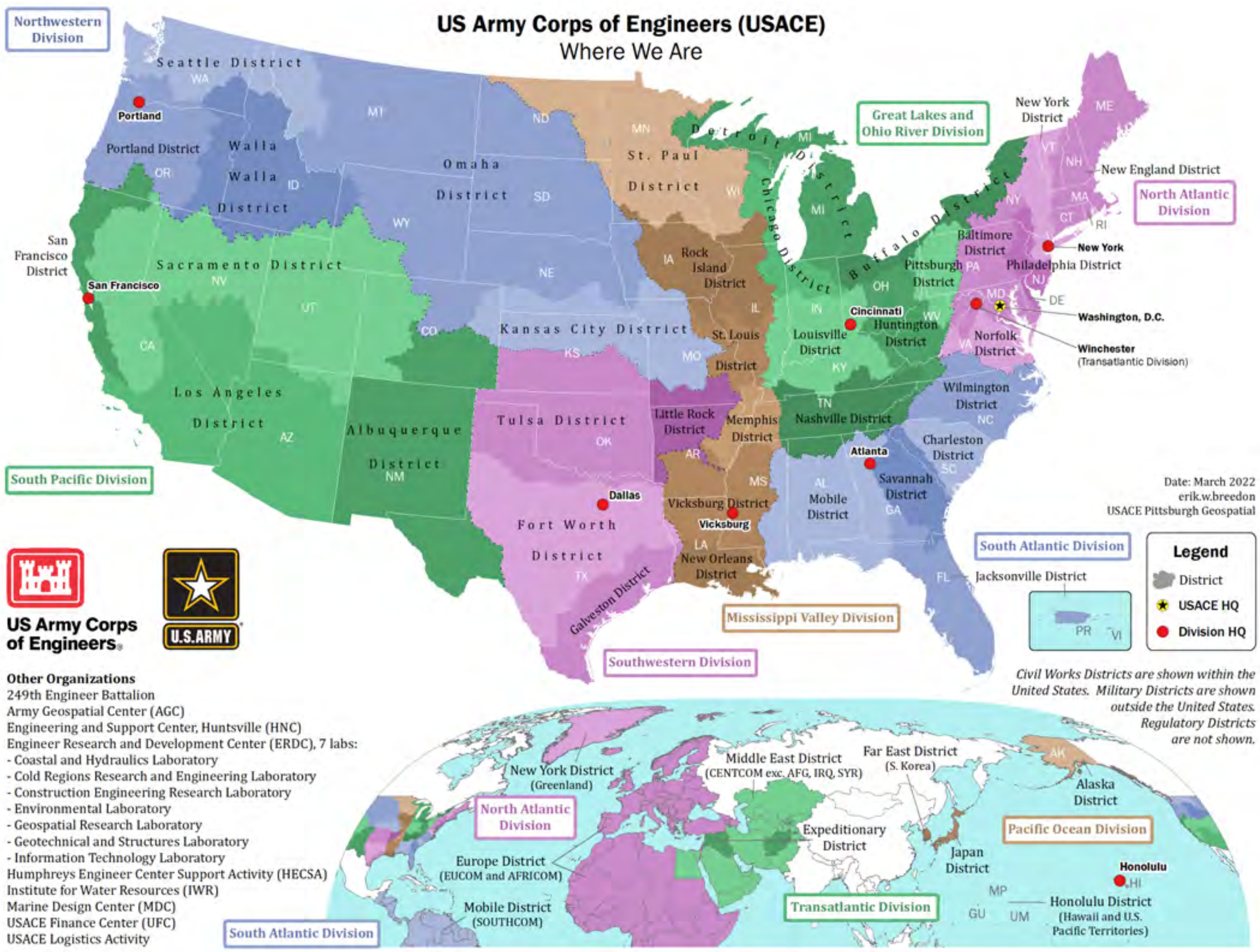


Figure 3: USACE Division delineation and District location map

PUBLIC LAW 93-288 (Also known as the Stafford Act)

In declared major disasters, the Federal Emergency Management Agency is authorized to direct Federal Agencies to utilize their resources to provide specific types of relief assistance. For floods this can include FEMA tasking USACE to do post-watershed assessments, debris basin cleanups, and other missions that aren’t covered under the PL 84-99 authority.

Army Regulation (AR) 500-60

The Department of the Army regulation involving the USACE’s participation in natural disaster relief activities. This regulation provides, in part, that in disasters of such imminent seriousness and in the absence of specific statutory authority, action will be taken as necessitated to save human life, prevent human suffering, or mitigate major property damage or destruction. Except as authorized under Public Law 84-99, contractors must be engaged by non-Federal public entities, unless and until there has been a FEMA declaration of PL 93-288 authority.

33 USC 408 (Also known as Section 408)

Section 408 authorizes proposed alterations by private, public, tribal, or other federal agencies to any USACE federally authorized Civil Works project. Proposed alterations must not be injurious to the public interest or impair the usefulness of the USACE project. Emergency alterations or emergency activities performed by USACE under PL 84-99 authority do not require Section 408 permission. Alterations by others that are considered an emergency and/or urgent, which may include interim risk reduction measures, but not implemented under PL 84-99, may require Section 408 permission and Engineering Circular (EC) 1165-2-220 would apply. Districts will consider if the alteration meets other criteria defined under paragraph 9. If this EC applies, districts may reprioritize and expedite reviews as appropriate given the urgency required for each specific situation.

2-3 Other Flood Support Programs

Silver Jackets

Figure 4: Silver Jackets Logo

State-based Silver Jackets teams collaboratively address flood risk management priorities based on state priorities, including enhancing mitigation, preparedness, and recovery efforts. Common team participants include state and federal agencies with mission areas of floodplain, emergency and/or natural resources management, and hazard mitigation.

Planning Assistance to States

The Planning Assistance to States program provides technical expertise to support state, territorial, and tribal preparation of comprehensive water and related land resources development plans, which is generally the State Water Plan or efforts that support the State Water Plan. Additionally, USACE may provide technical assistance, including providing and integrating hydrologic, economic, and environmental data and analysis in support of state-wide plans. USACE technical assistance in support of the Planning Assistance to States program is at the planning level of detail and does not include detailed design for construction. Typical studies include water supply, flood risk management, and environmental restoration. Assistance is given within the limits of available appropriations and is cost-shared on a 50% federal, 50% non-federal basis. Work-in-kind is allowed for comprehensive plans, but not for technical assistance. Non-federal entities may voluntarily contribute funds more than the cost-share.

Floodplain Management Services

USACE can provide technical and planning assistance through the Floodplain Management Services program. Its objective is to foster public understanding of the options for dealing with flood hazards and to promote prudent use and management of the nation's floodplains. Upon request and within program funding limits or through voluntary contributions, program services may be provided to tribal, state, regional, and local governments as well as other non-federal public agencies without charge. Program services are also offered to non-water-resource federal agencies and to the private sector on a 100% cost-recovery basis. Most studies under this program include flood hazard evaluation, flood warning/ preparedness, flood-proofing, and flood risk management plans.

CHAPTER 3: GETTING READY FOR THE FLOOD

3-1 General

This chapter outlines flood preparedness activities that non-federal sponsors and USACE should accomplish before high-water flood events. These activities can be adjusted to address special situations. For example, some levees may be in areas that experience coastal storms, and response activities will need to be adjusted according to flooding sources. An emergency plan should guide how, when, and where these activities are performed.

3-2 Pre-Flood Preparedness Activities

Pre-flood preparedness activities are a very important element of flood response operations that require continuous investments in time and effort to be effective. This section describes the activities associated with preparedness. Preparedness refers to actions taken before a flood event to assess and anticipate levee performance based on a risk assessment. A risk assessment is a systematic process for describing the nature, likelihood, and magnitude of risk associated with some situation, action, or event, including consideration of relevant uncertainties. By looking at hazards, levee performance, and consequences, risk assessments better inform risk management activities, to include understanding operational roles performed by team members during a flood event and knowing when to initiate necessary emergency procedures. Preparedness activities also include planning, training, communication, and management.

Flood Forecasts and the National Weather Service (NWS)

USACE works in cooperation with the United States Geologic Survey and other agencies to operate and maintain hydrologic data collection stations across the United States. These data collection stations are commonly referred to as "river gages." These river gages provide up-to-date information for each location to aid in forecasting, project regulation, and flood response. USACE makes the information from these gages available on its public access website.

NWS is the official water-level forecasting agency. River forecasts are issued twice daily (and may be issued more often during high-water events) and can be found at http://water.weather.gov/ahps/forecasts.php.

These forecasts typically account for precipitation over the next 24 hours (some events are up to 72 hours). The rivergages.com website also shows the NWS forecasts for gages where a forecast has been developed.

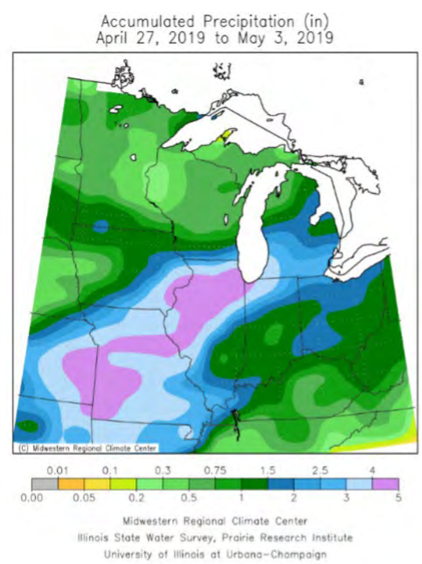


Figure 5: NWS developed rain accumulation diagram from 2019 Midwest spring flooding.

USACE Responsibilities

1. USACE districts maintain flood response plans that typically include:
    a. Rosters of personnel ready to provide technical and/or direct assistance during a flood response.
    b. Contact lists of local and state Emergency Management (EM) offices for quick reference.
    c. Inventory, maintenance and augmentation of sandbags and other special purpose flood emergency items.
    d. A list of emergency contracts that can be used during a flood response or for rehabilitation after a flood.
    e. If a levee system is operated and maintained by USACE, USACE districts will need to maintain an Emergency Action Plan (EAP) for the levee system in accordance with EC 1110-2-6075. These systems may also have inundation mapping which is distributed to other agencies via the procedures outlined in EC 1110-2-6075.

2. USACE Divisions are responsible for ensuring that subordinate Districts execute Flood Response Operations in accordance with current laws, guidance, and regulations to lessen the flooding effects upon people and property. Divisions may have shared responsibilities with the district when flood events are anticipated to or become region-wide events which can occur in the following cases:
    a. Involves more than one District per basin.
    b. District flood response requires resources beyond the Division's organic capabilities.

   c. The flood event involves foreign countries.
   d. The Division Commander determines the event is significant enough to warrant regional oversight.

3. USACE aids both before and during flood emergencies as required and justified to save human life, to prevent immediate human suffering, and to mitigate major property damage or destruction. This phase of the program is authorized under PL 84-99 and is further augmented by the AR 500-60 and includes:
   a. Aid in the development of community emergency plans, training, and exercises.
   b. Aid in the development of emergency response training for non-federal sponsors and community disaster response personnel.
   c. Provide floodplain and flood hazard analysis and data to assist the non-federal sponsor and community to understand their flood hazard.
   d. Field reconnaissance as required to obtain and evaluate flood potential data for submission to higher authority and the subsequent determination of specific expenditure of funds and warranted action for flood response.
   e. Continuing liaison with other Federal, State, and local agencies and the participation in ad-hoc meetings dealing with the flood threat.
   f. Technical advice on State and local measures for adequate preparedness to act, including operational planning.
   g. Intensification of inspection of flood risk management projects and potential flood hazards, the determination of deficiencies, and the recommendation of required corrective action by the responsible authorities.
   h. Attainment of maximum preparedness on the part of the District Emergency Operations Center (EOC) to provide flood response assistance, which includes, but is not limited to, the augmentation and pre-positioning of strategic material and equipment in threatened areas of immediate flood potential and the preparation of contingency plans providing for program support by employment of specific resources available to all USACE elements.

Figure 6: Photo of USACE EOC members engaged in an emergency exercise

i. Provision of supplementary assistance to State and local authorities in the performance of protective work required to cope with forecasted flood potential. This supplementary assistance will be predicated on the lack of adequate capability of the locally responsible authorities and may be extended to include the loan of needed equipment and supplies, emergency measures by either sand- bagging or other more expedient temporary means, or the clearance of channels as required to remove obstructions to expected flood flows. All supplementary assistance of emergency protective work is to be terminated upon the cessation of the current flood potential.
j. Conduct levee inspections and risk assessments of non-federal sponsor's levee systems. Levee inspections serves as an important source of information about the levee's condition and expected performance during a flood. Risk assessments use levee inspection information along other with other factors such as flood hazards and contents of the leveed area to identify the most critical areas for a levee. Non-federal sponsors are encouraged to participate in levee inspections and risk assessments. USACE will work with non-federal sponsors to summarize the results of these activities, prioritize actions, and share valuable information with stakeholders to promote awareness and flood preparedness.
k. National Flood Fight Materiels Center (NFFMC). The NFFMC centrally manages USACE-level flood response materiel assets, oversees the Regional Flood Fight Materiel Centers (RFFMCs), executes Indefinite Delivery/Indefinite Quantity (IDIQ) contracts, maintains the USACE-level inventory of flood response supplies and equipment, and delivers flood response materiel assistance upon district request before, during, and after a flood event. RFFMC's maintain limited stocks of emplaceable flood response materiel in general support of USACE flood response efforts within pre- established state boundaries.

Non-Federal Sponsor Recommended Procedures

1. Planning. Upon receipt of official forecasting information from NWS of imminent high water, the non-federal sponsor prepares for and immediately alerts all personnel identified in its emergency plan. If the non-federal sponsor is responsible for many miles of a levee system, specific sections of the levee should be assigned to individual section leaders/supervisors. During planning activities, the non-federal sponsor should:

   a. Review emergency action plans and recent inspection/risk assessment information to identify critical areas that may need flood response assistance or close monitoring.
   b. Verify that personnel have access to all gate keys, current rosters, and maps of important features (e.g., road and culvert closings, pumps, access points, sandbag/stop log storage locations, radios, safety gear, and other critical items).
   c. Review assignments for patrols, closings, etc.
   d. Obtain lists of all construction equipment, motorboats, vehicles, earthmoving equipment, and trucks that can be made available.
   e. Assess needed support (e.g., vehicles, radios).
   f. Close the flood risk management project to the public and remove livestock as necessary.
   g. Review and understand the trigger elevations for closures and pump operations for both phases of the response.
   h. Notify other entities of restrictions to access, such as highways, railroads, or navigation (US Coast Guard).
   i. Secure any active construction sites on or adjacent the levee.
   j. Assess supplies, such as sandbags and sand, and obtain additional supplies if needed, such as by requesting assistance from USACE.

2. Sharing Information

   a. The non-federal sponsor should establish procedures to share flood risk information, and thereby improve community understanding of flood risk and promote actions to reduce and manage flood risk at all levels of government, the private sector, and individuals.

3. Conduct Pre-flood Inspection of Levees

   a. As soon as they have been notified that high water is forecasted, non-federal sponsors should immediately conduct a thorough inspection of their entire levee system, omitting nothing from this pre-flood inspection regardless of the levee's performance during past flood events. This may require coordination among non-federal sponsors if there are more than one for a levee system.
   b. Special attention should be given to the following items during this pre-flood inspection.

      i. For large levee systems, ensure that the dividing lines between levee system sections with different assigned personnel and responsible section leaders are clearly defined and marked.

ii. Review the condition of any recent repairs to the levee.
iii. Observe water conditions and any accumulation of trash, debris, or ice on the embankment, culverts, pump station intakes, and other closure structures.
iv. Observe the condition of transportation, including roads, rail, and water access points, on and around the levee system. Road closure and detour signs should be verified as in place.
v. Identify the location, quantity, and conditions of all necessary tools and materials (e.g., sacks, sandbags, lumber, lights) and distribute and store them at points where maintenance is anticipated, or materials are needed to support successful closures or flood response activities.
vi. Monitor drainage structures that are situated to convey interior drainage from low points of the leveed area through the levee by gravity flow. Because of their location, these drainage structures are generally subject to inundation at lower stages than other features and potentially will not be accessible later during the flood event.

4. Perform Pre-flood Operation and Maintenance of Levees

   a. Once the pre-flood inspection has been completed, the non-federal sponsor should organize its labor force to take care of any pressing maintenance issues before the water rises further.
   b. Some closure structures in levee systems may take significant time, labor, and extensive coordination to close properly. Coordination prior to the flood and preparation of materials needed to close the structure will avoid last minute or incomplete closures which can be dangerous and reduce the protection provided by the levee system. Early coordination will ensure closures are complete at pre-determined river elevation trigger points or earlier in anticipation of high river elevations.
   c. Manually check all flap gates that are critical or in questionable repair to ensure that the gates will function appropriately during the flood event.
   d. Perform necessary maintenance on sluice gates before the outlet end of the structure becomes submerged.
   e. Remove any trash, debris, or other potential obstructions from culvert inlets and outlets, closure gates, pump station trash racks, and inlets.
   f. If, for any reason, the gate system on a drainage structure fails to operate and cannot be repaired because of high water, immediate consideration should be given to blocking the structure opening by other means. If stream stages permit, the outlet end of the structure should be blocked using timber, metal plates, tarps, sandbags, or by other means. If the efforts to plug the outlet structure fail, immediate action should be taken to build a sandbag or earth ring around the inlet structure. Note, if a closure structure is constructed on the landside, this area should be closely monitored due to the pipe being fully loaded and creating a new loading condition within the levee. While the primary concern in blocking the structures is to prevent high stages of the river from flowing into the leveed area, closures that are installed should be able to be readily removed after the river recedes.
   g. Attention should be given to the grade line or profile of the levee system. Personnel should fill any holes, gullies, and washes in the levee crown, embankment side slopes, and land-side berms with compacted fill material whenever possible, or sandbags if compacted fill cannot be placed. Avoid taking material for these repairs from the area adjacent to the levee, particularly in the area around a seepage berm.
   h. Perform repairs to gate sills and components as necessary to ensure closures can be exercised during flood operations.
   i. Examine all drainage ditches on the landside of the levee and remove any obstructions.

5. Begin Incident Reporting

   a. It is necessary for non-federal sponsors to develop and initiate an incident reporting procedure that can efficiently collect and report areas of distress/damage occurring on the levee during the flood event to others who need to know such as community leaders within the leveed area, county emergency managers, the state emergency operations center, and the local USACE district’s emergency operations center.
   b. The incident reporting procedures should identify critical information regarding flood stage elevations, established trigger points for reporting flood response operations such as levee gate closures, transportation road closures, public warnings, and evacuation notices.

CHAPTER 4: RESPONDING TO THE FLOOD

4-1 General

Levee projects are a common flood risk management solution because they can be dependable, materials are readily available, and they are relatively cheap to construct when compared with other structural options. Regardless of how well a levee system is designed and constructed, every levee system should be inspected on a regular basis and monitored prior to the flood season to ensure that problems, which could threaten the structural integrity of the system, are identified far enough in advance so that corrective action can be taken to prevent a failure. Proper maintenance of a levee system is extremely important because the consequences of a levee failure can, in some cases, be more damaging than the flood itself.

This chapter presents a discussion of activities and general practices, which have been used successfully during high water conditions to maintain and prevent levee failure. The methods described herein have been developed during many years of experience dealing with the problems caused by high water. Conditions and problems may arise which are not completely covered by the suggestions provided. If problems do arise that are not adequately covered in the document presented herein or there is doubt as to the proper procedure to be taken, the sponsor should immediately consult the local USACE District Office for advice and assistance as necessary.

An earthen embankment is in potential danger whenever there is water against it. The danger increases with the height of water, the duration of the flood stage and the intensity of either the current or wave action against the embankment face. Potential failures due to sand boils, subsidence, slides or sloughing may be prevented if prompt action is taken and proper methods of treatment are employed.

Some states consider the landside toe of the levee as part of the floodway. Capping or raising a levee may cause the entity that placed materiel within the floodway to be fined by the regulating agency. All temporary barrier alignments should be kept outside of any identified floodway and allow as much area to the river as possible while allowing for monitoring and construction equipment access.

Note: Under certain circumstances, temporary raising of levees can cause floodwaters in rivers and channels to rise higher than they otherwise would have as the temporary rise prevents floodwaters from draining into the protected area. A temporary levee raising may protect one area, but the resulting raising of the flood waters could cause additional flooding in another. Temporary levee raises can also stress the levee beyond its intended design and, if overwhelmed, result in catastrophic failure and damages than if the levee was allowed to overtop. Additionally, individual states may have their own laws or regulations and associated approvals prior to temporary levee raising. Be aware of these regional limitations as well as potential transfer of flood risk to other communities before considering temporary levee raising.

A glossary of terms used in this manual is presented in Appendix K.

4-2 Flood Response Activities

USACE Activities

USACE performs a vital mission by providing supplementary technical and direct assistance to State, Local, Tribal, or Territorial governments during flood response operations. These activities include engineering, emergency management, and levee safety expertise concerning flood risk management projects. USACE may also be mission assigned by FEMA for flood response operations support.

Below is a list of activities often accomplished by USACE during a flood:

1. Issuance of a Declaration of Flood Emergency to implement flood response operations.
2. Coordination of funding for USACE technical and/or direct assistance.
3. Coordination with other Federal, State, Local, Tribal, or Territorial agencies when accomplishing USACE flood response activities.
4. Performing inspection and field reconnaissance of flood risk management projects and potential flood hazards and providing technical recommendations and/or contingency planning support.

5. Documenting, classifying, and reporting issues in accordance with applicable USACE guidance (ex. ER/EP 500-1-1 and EC 1110-2-6075). Where applicable, the National Levee Database (NLD), is used to identify vulnerable locations and to record pertinent levee performance data.

6. When authorized, providing supplementary flood response assistance which may include, but is not limited to, the provision of flood response material and equipment. Issuance of supplies and equipment to non-Federal interests is permitted only in emergencies officially declared by the District Commander.

   All issued USACE supplies, and equipment are hand receipted to the receiving agency on ENG Form 4900, which can be found in Appendix D. The hand receipt will contain an agency billing address, and a statement like the following: "I understand that my agency will be required to return loaned equipment and reimburse the US Army Corps of Engineers for expended supplies. Reimbursement may be in the form of (a) replacement in kind with an equivalent quality to those issued; (b) paying the cost for the Corps of Engineers to replace the supplies with those of an equivalent quality; or (c) returning in good, usable condition those supplies not used; or (d) any combination of the above. I understand that my agency will be billed for supplies not replaced and agree to remit payment within 30 days of the bill date. All unused stocks loaned to local interests will be returned to USACE when the operation is complete.

7. When authorized, constructing temporary emergency measures to reduce flood risk using contract or hired labor resources. Emergency measures are temporary and designed to address the immediate flood threat. Removal of temporary emergency measures are a local responsibility.

8. Activation of an Emergency Operations Center (EOC). The EOC ensures the following:

   a. Space for coordinating emergency operations.
   b. Monitoring various sources for flooding information. Examples include the District's Water Management data, the National Weather Service sites for specific states, USGS, etc.
   c. Preparing daily reports on flood conditions. USACE employees will report their flood situation daily in accordance with the battle rhythm set by the respective District EOC. A sample of a District EOC battle rhythm can be found in Appendix C.
   d. Housing and deploying expedient flood response product (Gabion Baskets, flood barriers, jumbo sandbags etc.). More information on these products can be found in Chapter 4.
   e. Preparing the necessary Cooperation Agreements (CA) required whenever direct assistance is requested. The CA format is provided in Appendix D.
   f. In parallel with activation, the EOC will also begin planning for deactivation and follow-up activities once the event has concluded. This includes data collection for after-action reporting (AAR) and potential improvements for future event response by using a continuous improvement program.

Non-Federal Sponsor Recommended Activities

1. Operation of Flood Risk Management Projects

   a. Install levee system closures and gates based on the emergency plan and established procedures and trigger points. Coordination for closures should occur prior to the flood if feasible.
   b. Staff and operate pumping stations. Ensure staffing to operate continuously (24/7) throughout the flood response.
   c. Trained operators should be on duty during pump station operation. Operators should understand how the pumping station was designed to operate and be capable of manual operation should automated equipment or sensors fail.
   d. Monitor debris basins, trash racks, closure structures, drainage and pump station inlets, and riverside project fencing for sediment and accumulated debris. As debris and sediment continue to be deposited in the basin, debris loads will substantially block racks and sediment deposits will block the entrance to the basin, forcing the flow against the sides. Any large accumulation of debris on racks or flow directed on the sides of basins will cause local erosion and scour. Embankments and concrete structures that are part of the debris basin facility will need to be monitored closely to ensure good performance.

2. Accomplishing Crisis Communication

   a. Communication changes to informative or directive communications that is intended to update stakeholders of the current situation and provide direction of specific actions that should be taken to respond to changing flood conditions.

b. Incident reporting procedures should be expanded to include levee system distress that could lead to life loss, significant damage, and other critical performance concerns with the levee system. These critical incidents can include projected levee system overtopping or critical damages that impact the integrity or performance of the levee system. Additional critical reporting information should include levee system personnel safety incidents and incidents impacting the public's safety.
c. Monitor, coordinate, or accomplish flood alerts, warnings, and emergency notifications as required.

3. Conduct Flood Response Operations

   a. Flood response operations consist of the actions that should be taken when the flood waters have exceeded bank-full condition and are loading the levee system. The following is a summary of actions that should be taken during flood response:
      i. Establish an EOC to oversee the emergency response, manage communications and coordination, and conduct incident reporting. This operations center should be staffed 24-hours daily until the flood emergency is over.
      ii. Increase frequency and duration of levee patrols to continuous (24/7) coverage or as the situation requires.
      iii. Monitor the inventory of flood response equipment, material, and supplies as they are used. Replenish supplies and material as required.
      iv. Repair any erosion, seepage, or stability problems identified by patrols as quickly as possible.
      v. Use portable pumps to pump water over the levee if water is ponding in undesirable areas or is rising too quickly in ponding areas within the leveed area.
      vi. Remove debris from debris basins, trash racks, closure structures, drainage and pump station inlets, and river-side project fencing.
   b. Potential performance issues may arise as the water loading increases. This loading can lead to specific damages that may require emergency actions to prevent further levee damage or activation of emergency evacuation plans. The four primary conditions that may impact the performance of the levee system are: Erosion, Seepage, Stability, and Overtopping.

4. Coordination of Volunteer Assistance.

   a. When using volunteer assistance during the emergency response, several actions can be taken to organize volunteer support and are summarized below.
      i. Establish primary and alternate assembly areas with adequate parking for volunteers.
      ii. Arrange transportation, subsistence, and shelter for workers as appropriate.
      iii. Contact media to request that volunteers report to the designated assembly area.
      iv. Instruct volunteers to bring flashlights, work gloves, rain gear, shovel, snacks, and water.
      v. Maintain a sign-in roster at the assembly area to account for volunteers and personnel (e.g., name, phone number, e-mail address, address, work group assignment).
      vi. Establish staging areas away from the work site but as close to the flood response locations as possible and with good access to clear roads. Separate areas in the staging site should be established for sandbag filling, carrying, and loading, materials stockpiles, rest, and breaks, and first aid.
      vii. Establish traffic patterns that will be used to move the sandbags from the staging area to the work site. If conditions permit, one-way traffic patterns should be established on the levee system if trucks are being used to transport the filled sandbags.
      viii. Be certain that the people laying sandbags are well supervised by a trained individual who knows how to properly place and stack the sandbags.
      ix. Volunteers may be exposed to strenuous activities accompanied by extreme weather conditions that include the full range between excessive heat and extreme cold. Supervisors of volunteer workers must be trained to notice signs of heat stress or exhaustion, frostbite, general fatigue, dehydration, and other physical distress. Proper techniques for lifting and placing the sandbags should also be observed to prevent injury.

5. Evacuation

   a. Non-federal sponsors need to be prepared to implement or support evacuation plans when necessary and should also consider the following.
      i. Immediately coordinate evacuation with police, the fire department, and other first responders.
      ii. Follow the pre-determined plan for evacuation.
      iii. Meet in pre-determined locations and immediately verify the safety of all personnel.
      iv. If the Emergency Operations Center requires evacuation, collect, and bring contact information, sign-in registers, and other critical information to the center.

4-3 Assessing the Situation

At the beginning of every flood season, it is essential for individuals living in areas prone to flooding to establish an organization responsible for actions prior to and during flood emergencies. This organization should assign individuals directly responsible for various tasks during flood emergencies. The various tasks during a flood emergency will depend on site-specific conditions but generally individuals should be assigned the following tasks:

1. **Flood Occurrences:** One or more individuals should be assigned to research and be aware of river stages, precipitation forecasts, snow-melt runoff potential, and the potential for flooding.

2. **Inspections:** Inspections should be conducted at the beginning of every flood season and during flood events. The purpose of the inspection conducted at the beginning of every flood season is to determine the existing condition of the levee and to repair areas that have been damaged or degraded in past floods to ensure the functional ability of the levee system. To minimize damage and to prevent the levee system from breaching during a flood response, any problems must be detected early and treated appropriately. The entire levee system should be patrolled continuously during a flood. For safety and efficiency, patrols should be conducted by teams rather than by individuals. Where access to the levee has been compromised, consideration should be given to the use of Unmanned Aerial Systems (UAS) or working with local law enforcement or the National Guard to utilize helicopters to make patrols. During each patrol, levee performance concerns should be documented using photographs and other automated inspection tools that can identify the location and condition of the levee performance concern. Special attention should be made to all drainage ditches, closures, drainage structures, flap gates and slide gates to ensure that all are functional and in good working condition. In areas that do not have a levee system, this inspection should be conducted to determine where a temporary embankment structure would be constructed, where the upstream and downstream tie-off points would be, to locate borrow areas or sources of material, and to make sure that the alignment area is clear of trees and other obstructions that would prevent the quick construction of a temporary embankment during a flood emergency. The purpose of the inspection conducted during a flood event is to determine if problem areas are developing within a levee system or a temporary system which requires remedial measures such as a sandbag barrier, mud box levee, or flashboard system.

   Many of the tasks typically accomplished during flood inspections and patrols are listed in Table 4-1. Any significant or unusual conditions identified should be reported in accordance with the non-federal sponsor's incident reporting procedures.

Table 4.1

Levee System Component	Recommended Patrolling Observations
General System	• Record gage readings (hourly or per frequencies established as part of emergency planning). • Inspect fences on riverside of levee to make sure they are free from debris. • Inspect ponding areas. • Verify that all necessary access roads and ramps along the levee system are usable and in satisfactory condition. • Document the location and take photographs of all observed issues.
Levees	• Look for sand boils or unusual wet areas in the vicinity of the levee (approximately 200 feet from the landward levee toe), including in ditches and low areas. • Look for slides or sloughs in embankment side slopes. • Look for wave wash or scouring of the riverside levee slope. • Look for low areas in levee crown. • Monitor relief wells and associated instruments such as piezometers. • (Are the wells flowing or not? If so, measure and document the flow rate. Record the water level in the piezometers.) • Check flap/sluice gates for proper closure. • Check that trash racks are free of debris • Check closures (e.g., stop logs, sandbags, swing gates).
Floodwalls	• Look for saturated areas or sand boils landward of the floodwall. • Look for settlement or misalignment of the floodwall. • Look for bank caving which may affect the structural stability of the floodwall. • Inspect toe drain risers (discharging/non-discharging). • Inspect the land-side of floodwall for leakage, especially around the monolith joints. • Inspect for wet areas, soft areas, seeps, sand boils, and sink holes (soil collapse) landward of the toe of the floodwall. • Check gap or gate closures (e.g., stop logs, sandbags, swing gates) and monitor for leakage.
Pump Stations	• Verify proper ventilation (e.g., turn fans on, open vents) of the pumping plant, to prevent overheating of pump motors and carbon monoxide poisoning of operators. • Monitor sump area for sandboils as water levels decrease and adjust pumping if needed. • Be aware of past seepage issues that may require adjustments to pumping operations. • Look for sink holes or wet areas or sand boils around the perimeter of the pumping plant, and/or settlement of the pump house, all of which could potentially be the result of separation in the conduits. If this condition is suspected, the pumps and motors should be shut down until an engineering review can be conducted to analyze the condition. • Verify that pump stations are adequately staffed per operating/emergency plan. Pump stations must be staffed during times pumps are in operation. Ensure pump stations are adequately stocked with food and water to support the necessary staff. • Test the back-up power supply. • Verify that the trash racks are free of debris.
Necessary Patrol Equipment	• Portable radio or cell phone (NOTE: cell service can be unreliable during storm events). • Watch. • Equipment log book. • Patrolling instructions. • Plan of action for patrolling. • Plan drawings of the flood risk management system. • Operation and maintenance manual for the levee system. • Weather gear. • Flashlights and extra batteries. • Record log for documenting conditions. • Life jackets. • Probing rod. • Short wooden stakes and neon flagging (pink and orange have the highest visibility). • 40 feet of ½-inch nylon safety line to connect team members. • Camera (GPS cameras are preferred since they show the location of each photo). • Evacuation plan. • Emergency contact list.
Performance Data Collection	• River hydrograph with stage readings and frequencies and/or high water marks (i.e. debris line). • Written observations of performance issues by stationing along with GPS coordinates where applicable. • Photographs of all performance issues. • Maps showing all observation points collected. • Instrumentation readings and evaluations. • Any levee system breach dimensions (width, scour depth) if applicable. • Plot of breach development over time if available. • Photographs of areas of inundation if applicable. • Estimated area and depth of inundation if applicable. • Collection of photographs or public accounts on social media. • The National Levee Database is the repository of all levee performance data collected during emergency flood operations. Data collected from any devices or methods other than the Levee Inspection System should be uploaded to the National Levee Database.

3. **<u>Inspection Methods</u>**: The levee system alignment should be broken up into segments with boundaries well defined. Usually, boundaries are established at landmarks such as bridges or drainage structures. This inspection should be conducted early in the spring before substantial vegetative growth occurs. Vegetation can, in some cases, hide the true condition of the levee and adjacent area. In areas that have temporary barriers acting as levees, the individuals in charge of each levee section should conduct the preliminary inspection. Inspectors should be given a large- scale map and a profile of his/her section. If profiles are not available, the necessary surveys should be conducted to determine the existing profile of the levee. Inspectors should walk the entire length of his/her section, making detailed notes on the map. There is no better way for one not familiar with the territory assigned than to walk over the line as often as possible, studying the maps, and making careful notes. An individual should be assigned the responsibility of inspecting each segment of the levee system alignment. Aerial inspections can provide an understanding of the source and magnitude of flooding. Inspection checklists are provided on Plate Nos. 1, 2, & 3 in Appendix G to assist the inspector. All completed checklists and inspection documentation should be maintained in a file for future reference.

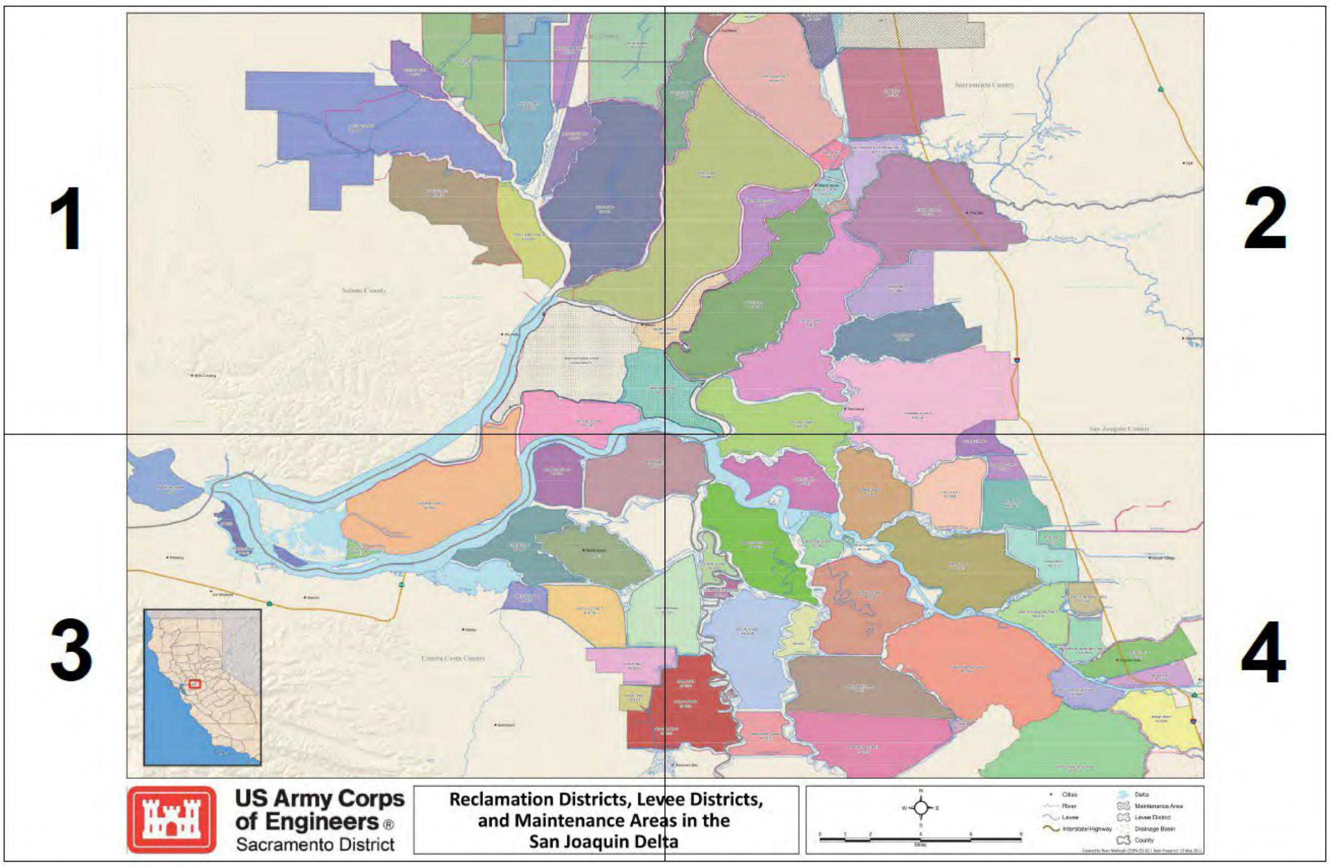


Figure 9: Sample of levee district delineation within the San Joaquin Delta

a. Failure Modes Indicators. It is very important that the individuals responsible for inspections during flood events be familiar with the signs that occur prior to each failure mode. The different levee failure modes and signs, that indicate which failure mode is occurring are discussed later in this chapter. Identifying which failure mode is occurring is important because the failure mode dictates which technique or techniques would be used in a flood response.

b. Inspection Areas. Specific areas to inspect include the following:

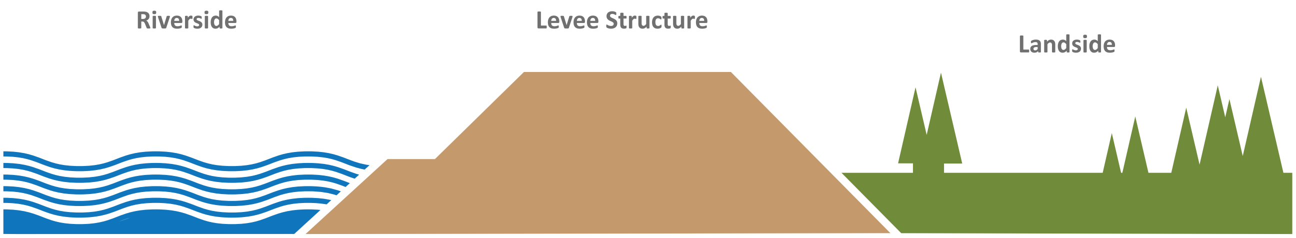


Figure 10: Areas for inspection.

Levee Structure

i. Type of cross section, such as, trapezoidal, berm, etc.
ii. Condition of sod and growth of weeds.
iii. Debris on levee slopes
iv. Local damage, such as wave-wash, rain-wash, and work down ramps, etc.
v. Evidence of previous high-water work, such as capping, earth blanketing, and ringing of sand boils, etc.
vi. Condition of existing seep drains on the landside slope.
vii. Damage to landslide slope, such as where the toe of levee has been damaged by farm equipment or other machinery.
viii. Obstructions and crossing, such as siphons, pipelines, cables, railroads, power lines, and fences, etc.
ix. Local depressions, such as old slides and depressions caused by subsidence.
x. Type and condition of existing wave-wash protection.
xi. Condition of levee markers.
xii. Uncompleted levees.
xiii. Condition of protective bulkheads, etc., around ends of levees.
xiv. Condition of drainage structures including flap-gates, slide-gates, and inlet and outlet channels.
xv. Condition of closures and associated materials.

Riverside of Levee

i. Growth of trees and brush.
ii. Existing abandoned levees that may serve as wave-wash protection or as a source of material necessary for capping or blanketing.
iii. Spur levees – height and condition.
iv. Current scour and points, angles, and through openings that have been cut in abandoned levees.
v. Landings and structures, etc.
vi. Caving banks.
vii. Condition of outfall drainage ditches.
viii. Secondary levees that may cause erosive velocities when overtopped, should be noted, and monitored during flooding.

Landside of Levee

i. Drainage ditch at landside toe – its condition and extent.
ii. Condition of culverts under roads adjacent to levee.
iii. Condition of drainage ditches.
iv. Condition of natural drainage, ponded areas, and where drainage ditches connect with these areas.
v. Local depressions near the levee where seepage water might be impounded.
vi. Sand boil areas.
vii. Possible landside borrow-pit areas for material necessary for sandbagging or capping.
viii. Condition of landward drainage ditches.

Inspection checklists like those in Appendix G (Plate Nos. 1, 2, & 3) provide an excellent means to ensure an adequate inspection and proper documentation of results.

4. **Instrumentation:** If instrumentation devices are present on a levee system, a team should be assigned the responsibility of data acquisition and evaluation. A properly designed, installed and maintained instrumentation program is a vital asset in the evaluation of the performance of a levee system both prior to and during a flood response. Instrumentation such as survey points and piezometers at drains and relief wells provide key insight into the evaluation of a levee structure. More extensive instrumentation requirements for USACE owned and maintained levees can be found in EM 1110-2-1908. Details of various instrumentation devices are presented on Plate Nos. 4, 5, & 6 in Appendix G. Typical data recording formats are presented on Plate Nos. 7, 8, & 9 in Appendix G.

5. **Flood Response:** A team of individuals should be assigned the responsibility of providing field flood technical assistance. These individuals should be fully aware of the techniques described in this manual.

6. **Evacuation:** One or more individuals should be involved with executing the evacuation plan if a levee failure becomes imminent. An evacuation plan should be developed prior to the beginning of a flood season and reviewed at the beginning of every flood season thereafter. The evacuation plan should be coordinated and communicated with the appropriate state and local authorities that can order an evacuation to ensure compliance with state and local laws.

7. **Rescue:** A search and rescue team should be assigned if a levee failure occurs or if personal injury is experienced during a flood response operation.

Availability of Labor, Equipment, Materials, and Communications

It is very important that the availability of labor, equipment, materials, and communication equipment be known prior to a flood emergency. It is very difficult to determine availability of these items in an emergency. Contacts should be made with responsible individuals to ensure quick and easy access to these items during an emergency. The following is a checklist of items that should be evaluated prior to each flood season:

1. Types and conditions of roads near and on the levee.
2. Accessibility by roads to main arteries of traffic.
3. Buildings that may be used as supply depots.
4. Telephone, telegraph, and radio communications.
5. Sources of emergency materials, supplies and labor.
6. Types, locations, and general condition of levee building equipment.
7. Types, locations, and general condition of motorboats that may be available for high-water service.
8. Fuel supply stations and maintenance facilities.

Reports

Following inspections, a complete report should be made from the notes taken in the field and submitted to the individuals in charge of flood response activities. The report should be comprehensive and in sufficient detail to provide an accurate picture of existing conditions in the field. An executive summary is useful to highlight immediate flood risk management efforts.

Preliminary Work

Prior to a flood season and after the preliminary inspection is completed, the following work should be performed as identified in the preliminary inspection report.

Evacuation Plans

Every community within an area that experiences flooding should develop an evacuation plan. An evacuation plan should also be developed for areas surrounded by levees or other flood reduction projects, such as dams. Designated shelters, which are located above potential floodwater, should be a major component of the evacuation plan if they are available. Arrangements with the local fire departments, Army Reserve, National Guard, and/or Coast Guard to obtain rescue equipment are also an important component of the evacuation plan. Responsible entities or procedures for evacuations should be identified in Emergency Action Plans in accordance with EC 1110-2-6075.

4-4 Flood Response Equipment and Materials

General

Due to the potential scarcity of labor for flood response duties, the use of machinery is critical. For instance, the large volume of labor necessary for sandbagging operations can be substantially reduced using small trenching machines which dig the material and discharge it to the side. A backhoe or small dragline and a combination hopper-belt conveyor can be used to fill sandbags directly on trucks, with the use of very little labor. The utilization of electric saws and air hammers, etc., in the mass production of such articles as cribs and board sections of movable barriers that reduced wave-wash erosion will result in a great savings in labor and expedition of work.

Expedient temporary barriers can generally be grouped on how they redirect floodwaters, and specifically, what method they use to keep the barriers in place. Those methods are soil- (sand) filled temporary barriers (e.g., sandbags, gabion baskets), freestanding temporary barriers that use flood waters as a weight, water filled bladder temporary barriers, and freestanding temporary barriers (e.g., Portadam).

Many manufacturers produce variants of these expedient barriers in several heights, widths, and lengths. Local conditions may allow or rule out the ability to use certain barriers. If a manufactured temporary barrier will be installed, requesting the presence of a technical representative of the company will ensure the product is installed per manufacturer's specifications. During a flood, stocks of product may not be available. If an area is in risk of flooding, planning a temporary barrier alignment prior to the event is recommended to ensure the foundation and alignment can use a manufactured barrier.

Figure 11: Sandbagging machine being utilized in Georgetown, SC

Sandbags

Sacks or bags filled with earth/material (sandbags) can be used in almost every phase of an emergency high-water event. Deploying sandbags is time intensive due to the labor associated with filling them. They can also be expensive, from the standpoint both of original cost and cost of filling and handling sandbags. While sandbags are a dependable method, more efficient and expedient methods should be used whenever possible.

Figure 12: Sandbags placed into a temporary dike

1. **Filling Sandbags:** Sandbag barrier construction consists of bags made from different materials, including burlap and plastic. Coarse sand is the ideal fill material for sandbags, as finer materials like clay and silt will pass through fabric of the sandbags. Desired sand, when tossed into a bucket of water and mixed, will result in the water staying clear or transparent.

   Most measure approximately 14” wide by 26” long, however, larger bags are available. Properly filled sandbags are filled one-half to two-thirds full and do not need to be tied. When a tie is needed (e.g., moving by heavy equipment), it is best placed loosely at the top of the bag. Properly filled bags (Figure 13) should weigh no more than 35 to 40 pounds to limit fatigue for persons who fill and place the bags.

   Ordinarily, filling sandbags is a two or three-person operation. One member of the team should place the bottom of the empty bag on the ground slightly in front of wide-spread feet with arms extended. This person may also want to kneel or sit to avoid back strain from bending. The throat of the bag is folded outward about 1½” to form a collar and held in that position to allow a second team member to empty a shovelful of material into the open end, until the bag is ½ to 2/3 full. The third team member stacks and stockpiles the filled sandbags. Gloves should be used to avoid injury, and safety goggles are desirable during dry and windy days.

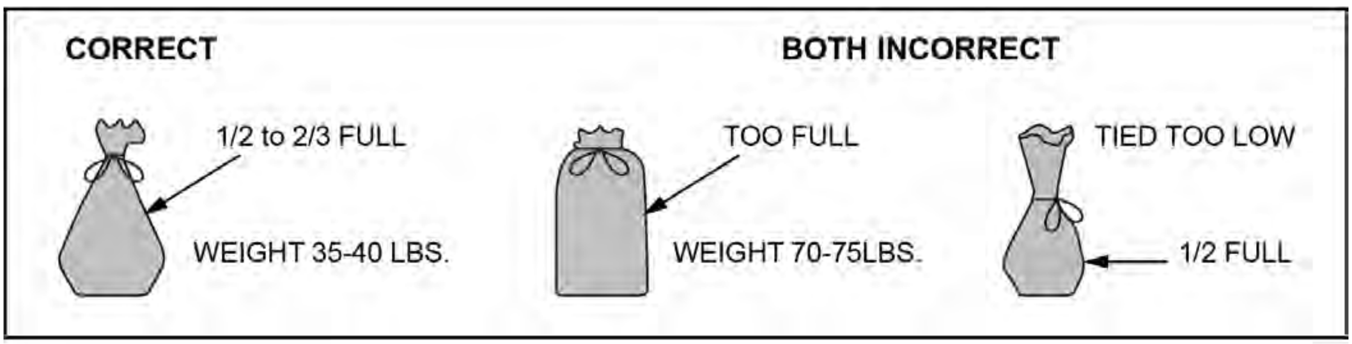


Figure 13. Correct and Incorrect Sandbag Preparation

   For larger operations, sand-bagging machines might be available in the state (see county Emergency Management Agency) or from a USACE District, which can be used to expedite the filling operation. Other options such as bag-holding racks or funnels on the back of dump trucks, can be found online.

2. **Passing Sandbags**
   To avoid injuries and maximize productivity emergency responders can be organized into a sandbag passing line or “chain.”
   a. The line is formed by standing facing the next person and slightly off set.
   b. The bags are passed diagonally down the center of the chain.
   c. Do not throw bags.
   d. If a bag gets dropped do not pick it up until a break allows time.

Figure 14: Photo of Sandbag Passing Line

3. **Transportation of Sandbags**
On the job site, when motorized equipment cannot be used, sandbags may be transported in wheelbarrows or on a person's shoulders. Wheelbarrows are preferable, as two filled sandbags constitute a load for one wheelbarrow that can be handled by one person if smooth-run planks and a suitable grade are provided. When necessary, filled sandbags are transported on a person's shoulders, one sack per person, or in handbarrows carried by two people. The handbarrows have the advantage over carriage on the shoulder if the sandbags are to be transported over a relatively long distance.

Under certain situations, consideration should be given to filling bags or sacks offsite and transporting them to the problem area by trucks, perhaps on pads flown to the spot by cargo-type helicopters, or by boat to the impacted area.

In instances where vehicles must be sent over roads that are impassable due to mud or sand, their safe passage may be provided using a plank road constructed as shown on Plate No. 44, Appendix G. When travel or other satisfactory means of communication cannot be maintained, walkie-talkie type radio or telephone communication should be provided along dangerous stretches of levee.

Large Sandbags (Bulk Bags, Big Bag or Supersacks)

Large Sandbags are industrial containers made of flexible fabric that are designed for holding materials, including sand. These bags are usually constructed of thick woven polyethylene or polypropylene and may be coated to reduce seepage. The bags typically measure 3' by 3' at the base and range from 3- 4' tall. The bags may come individually or as a connected set, typically 15' or longer. Types and configurations of Large Sandbags are shown in Figure 16. When stacking higher than one tall, they should be stacked in a pyramid type configuration. Stacking vertically without other support may lead to inundation of the leveed area.

Large sandbags have the advantage of filling a large sized gap without the excessive labor requirements of traditional sandbagging (One 15-foot-long section can replace 750 traditional sandbags). The bags conform to uneven surfaces and work well with curved alignments.

Figure 15: Super sandbag being delivered by helicopter

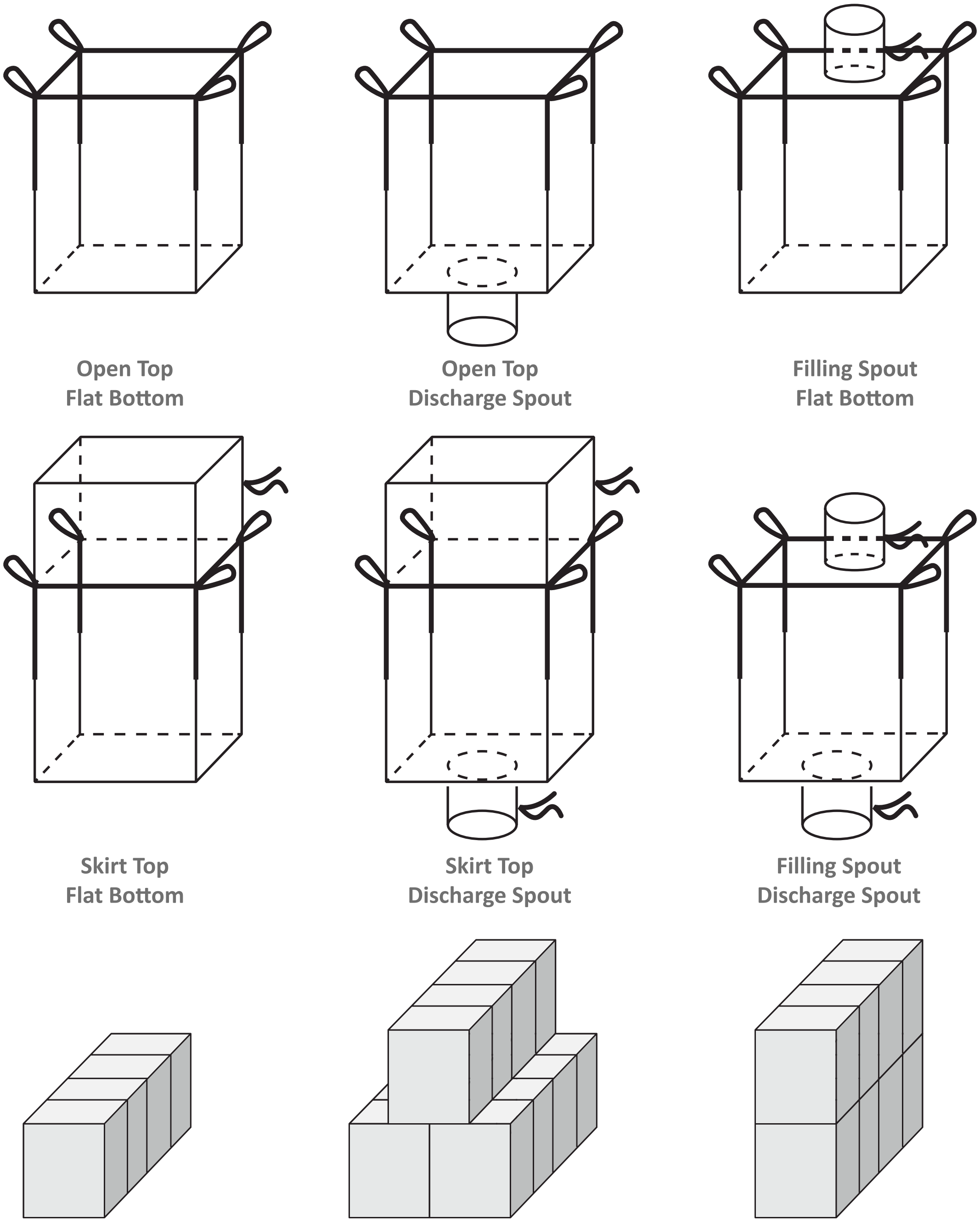


Figure 16. Types of Large Sandbags and Stacking Configuration for Large Sandbags and Gabion Baskets. Foundations of temporary barriers may require a wider cross-section depending on the alignment's soil stability or pavement types.

Transporting and loading is done on either pallets or by lifting the bags from the loops. Bags are made with one, two or four lifting loops. The single loop bag is suitable for use by one operator with a loader as there is no need for a second person to put the loops on the loader hook. Emptying is made easy by a special opening in the bottom such as a discharge spout, of which there are several options, or by simply cutting it open. (Warning: Do not cut bags while they are being lifted or while they are suspended; cut them while they are on the ground, before they are lifted, and stand clear when lifting.)

Seepage can be expected with the installation of the large bags. The placement of plastic sheeting or poly, using the same techniques as with traditional sandbags, should be used if the bags are not treated. Liners may also be used in each bag; however, seepage between bags may still be possible. Some bags are designed for underwater placement if they are equipped with a method for closing the top of the bag. When closed, this type of large bag may withstand overtopping of the bags. Large sandbags may be used to stop an overtopping event or breach.

Plastic Sheeting (Poly)

Made of polyethylene, these 100’x20’x6mil rolls are sometimes referred to as visquine and are used for erosion control. A photo of a way it is used is shown in Figure 17.

Figure 17: Poly sheets used for levee armoring

Gabion Baskets

Gabion Baskets, developed by Hesco Bastion Inc., are container units that are granular-filled, permeable membrane lined wired baskets that pin together to form a continuous structure (See Figure 18). The containers are 3’ or 4’ high x 3’ wide x 15’ long and are shipped flat-packed on pallets. Each pallet contains 10 containers per pallet or 150 lineal feet of flood wall.

Below are general construction considerations for HESCO barriers. Review manufacturer construction guidance documentation prior to construction. When USACE districts are installing these or other manufacturer specific barriers, send a request to the NFFMC for a manufacture technical representation to be present at the installation site.

- Units require firm level foundations, irregularities in foundation should be grubbed and graded. Insufficient foundations may require additional foundation improvement.
- Appropriate fill units must be laid out, line and level checked. They will need to be correctly joined with proper tucking of geotextile flaps.
- Stacking of HESCO units has additional construction and foundation requirements that must be considered. Improper stacking of units can cause the barrier to fail.
- Good fill materials (well graded sands and gravels) must be properly placed (proper layer thickness and compaction) for good structural integrity. Review HESCO documentation on placement of materials and use of other fill materials.
- The use of polyethylene (poly) sheeting may be secured at the riverside tow of the sheeting by using sandbag weights or laying the poly sheeting under the riverside edge of the gabion baskets. Poly sheeting secured under the riverside face of the gabion basket should extend to a maximum of 6” to avoid a significant loss in sliding friction.
- Adequate drainage for the structure.

Figure 18. HESCO Bastion Gabion Baskets

Portadam

Portadam consists of an impermeable membrane liner that is supported by a steel frame that pins together to form a continuous structure. The system consists of two main components: a welded tubular steel framework support and a flexible waterproof membrane. The welded tubular steel framework support is packaged 20 per bundle, and the flexible waterproof membrane comes in 50 or 100 lineal feet. Also included is the hardware (clamps, bolts, braces, and ties) required in setup of the product. The hardware and installation instructions are containerized in pallets and will cover 100 lineal feet of Portadam. To construct a 100 -foot Portadam, 76 welded tubular steel framework supports are required, as well as 100 lineal feet of flexible waterproof membrane. See Figure 19.

Figure 19. Portadam

Lumber

When available, rough, common pine lumber is the most suitable structural material for use in high-water construction. Rough lumber of all structural grades is cut to full size, approximately one-quarter inch being removed from each dimension in dressing. Therefore, rough lumber has greater strength than dressed lumber of the same theoretical dimensions and should be used whenever possible. Rough lumber is also ordinarily cheaper in cost than dressed lumber. The principal consideration in obtaining lumber, as well as all other materials for use in high-water construction, is its availability. Material that can be placed on the site of operations, in the desired quantity, in the least possible time is what should be used.

Figure 20: Lumber and poly sheets used in the construction of flashboard

Emergency Lighting

Flood-response operations will continue through the night. It is strongly recommended to find emergency lighting that would be readily available for use during flood responses.

Communications System

A reliable communication system is extremely important for coordinating flood response efforts and for calling for assistance when needed. Cell phones work very well but are limited in their capacity for communicating with multiple people at one time, which can be important during emergencies. Workers may also experience dead spots or non-availability of service if the phone traffic is very heavy. Because of these problems, two-way radios are preferable as they are extremely reliable for short distances and have the capability to broadcast to several people at once.

Riprap for Erosion

It is recommended to develop plans to address erosion that may occur during a flood emergency. It might not always be necessary to stockpile riprap, but know the location and emergency telephone numbers of local quarries capable of supplying riprap if it's needed. Some levee districts choose to keep a supply of gravel on hand so they can maintain the levee access routes during an emergency.

Flotation Vests

The safety of workers and volunteers should always be the highest priority during a flood response. Floatation coats or vests (PFD) are recommended and should be always worn when working near the riverward crest of the levee, on the riverward side slope, or near fast-moving water. Floodwaters can quickly sweep a person downstream, and hypothermia can set in quickly in cold water conditions.

Pumps

Like sandbags, pumps are also a critical part of any flood response effort. Pumps are used to control interior drainage and seepage through the levee. Those communities that experience frequent flooding should consider purchasing one or more high-capacity pumps. If additional pumps are needed during a flood response, contact the State, because the USACE District office may have pumps available, but the State may need to coordinate and prioritize these requests before passing them to the USACE.

Sources of Borrow Material

Sources of borrow material should be located prior to a flood event. Several borrow areas should be identified in advance, because wet or sloppy weather could unexpectedly limit access to some sites. Carefully consider the access points to the levee when choosing the sites for the borrow material.

Sponsor Agreement for Materials

USACE policy (set forth in 33 CFR Part 203 and ER 500-1-1) requires Districts to obtain a Cooperation Agreement with the non-federal sponsor, which agrees to provide lands, easements, rights-of-way, relocations, borrow material, and dredged or excavated material disposal areas (LERRDs), to hold and save the Government free from damages, and to operate and maintain the temporary emergency measures.

In using any of these products, the Non-federal sponsor shall:
1. Provide labor to assemble, operate, and disassemble and repackage material issued.
2. Provide necessary equipment and fill material to assemble the flood response product.
3. Sign hand receipt for responsibility of issued products.

Guide to Equipment and Personnel Requirements

Certain flood response materials by nature require substantial amounts of labor and hand tools and equipment to deploy. Consequently, to assist field personnel in determining these requirements, five tables giving basic figures are provided in Appendix H of this manual.

The figures given indicate the type and number of tools, plus the number of personnel required to construct 1,000 linear feet per day of the structure without the use of modern mechanical or motorized equipment. These tables are to be used only as “maximums” since the introduction of power tools and equipment, labor-saving methods, and the ingenuity of the individual in charge can drastically reduce the given labor figures.

4-5 Flooding Issues and Remedial Measures

General

This section presents a description of various modes of levee failure that could be encountered prior to and/or during a flood event, additional potential flooding issues that could occur, and recommended remedial measures. These sections are not comprehensive and do not cover mechanical failures, pipe intrusion collapse, or other structural element (i.e., floodwall) related failures. Remediation of these and other types of failures may require unique engineering guidance. Figure 21 shows typical failure modes of a levee embankment.

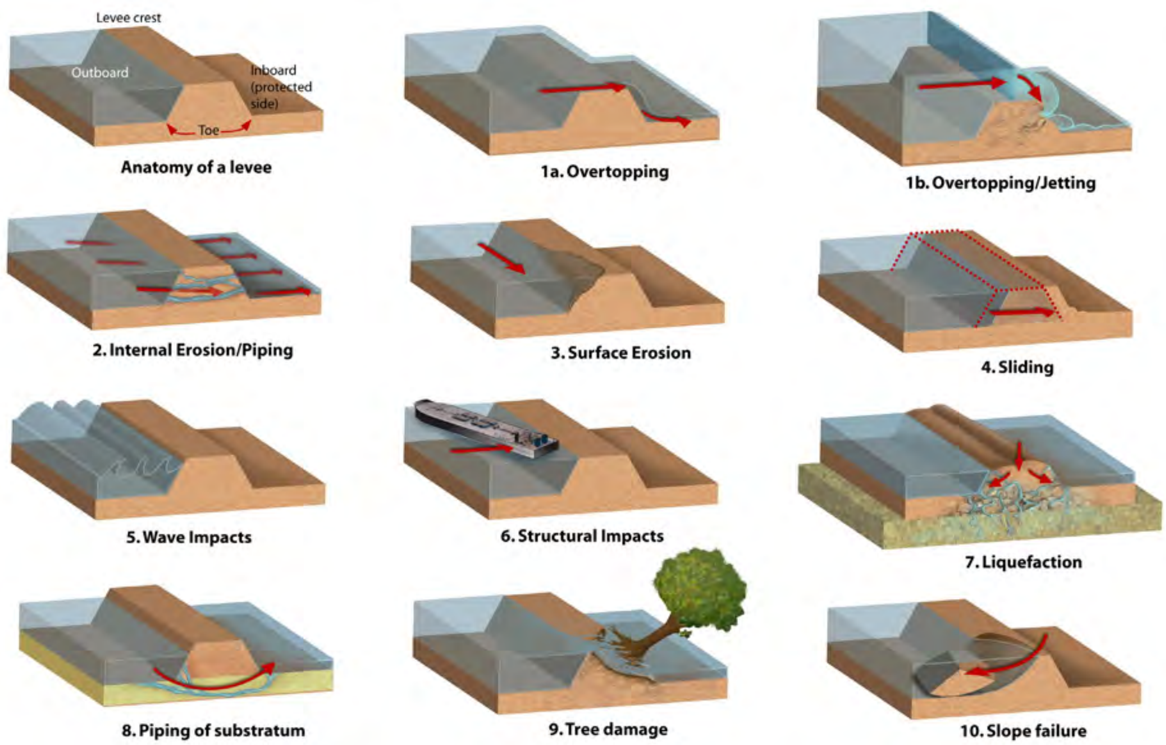


Figure 21: Typical levee failure modes (Zina Deretsky, National Science Foundation)

Overtopping

1. Description

Overtopping of a levee is the flowing of water over the levee crown. Overtopping may occur along an entire levee line or over local depressions in the crown. The quantity and velocity of flow may be high enough to cause erosion of a levee embankment crown or landside slope, washing material from the embankment. Overtopping of a structure can result in scour of the landside foundation. Overtopping over a long period can cause enough erosion to create a breach, or crevasse, in the levee line. Once a breach has occurred in the levee it is very difficult, and sometimes impossible, to close.

Figure 22: Overhead photo of levee overtopping

The overtopping location can be estimated where there is (1) a designated overtopping location or (2) accurate topographic surveys of the levee combined with hydraulic modeling (e.g. river or coastal hydraulic profiles). Obstructions in the river, changes to the levee, and variability of inflow from tributaries can make predicting the overtopping difficult. Since most levee systems have a potential to be overtopped, a plan to address a levee overtopping scenario should be made in advance during pre-flood preparedness activities. These plans should include identification of where overtopping is likely to occur and remedial measures that may be taken. The areas where overtopping occur first should be identified and those areas should be monitored closely during a flood event; however, structures in the river such a bridges or culverts may become blocked by ice or debris and result in an increase upstream of those structures.

A plan to address a levee overtopping scenario should evaluate potential remedial measures and their impacts. Initiating response activities without a proper understanding of potential impacts to the levee and within the watershed, as well as safe response techniques can result in dangerous situations and increase damages. This plan should be coordinated with USACE (for USACE design and constructed levees), other governmental agencies with responsibility to enforce local laws and regulations regarding activity in the floodplain, and those who may be impacted (by a levee raise if planned). In some states, increasing the height of levees is illegal without state permits or an emergency declaration suspending regulations.

Because of the danger posed to a levee system by overtopping, flood fighting overtopping through levee raises is a common response. Increasing the height of the levee may have negative impacts within the floodplain. Levees restrict flows in a watercourse, thereby increasing flood heights for a given flow rate. Levee raises have the potential to further increase flood heights in the floodplain, which can increase the duration and/or height of loadings on other flood risk management infrastructure and increase inundation heights for areas without flood risk management infrastructure. These potential impacts should be considered and coordinated with others who may be impacted prior to the initiation of any levee raises. Another approach to flood fighting overtopping is the use of armoring of the landside slope. This approach avoids negative impacts within the floodplain but are limited in their application.

Raising a levee beyond its original intended design height may also increase the hydraulic loading to greater amounts than it was originally designed to withstand. This increased stress on the infrastructure can lead to catastrophic failure and greatly increase the risk to people and property behind the levee, as well as increase damages to the levee during its failure. Similarly, measures to prevent overtopping must be implemented in a structurally safe manner. The following sections provide good practices for typical levee raise activities (commonly called capping or topping) to reduce the likelihood of failure of the raise due to weaknesses in its construction.

2. Designated Overtopping Locations

Earthen embankments are often constructed with vegetation covering or engineered armoring on the crests and landside slopes to reduce the potential for breach during overtopping. However, the cost to armor an entire levee sufficiently to prevent erosion during overtopping is typically prohibitive. A good way to manage the risk of erosion associated with overtopping is with designated overtopping locations which are designed to be resilient to erosive forces. This is most practical in riverine settings where there is a predictable distribution of hydraulic loading throughout the levee system for a given event and a singular location for initial overtopping can be designed. Additional information on the design of Designated Overtopping Locations can be found in Engineering Manual (EM) 1110-2-1913.

Isolating the initial overtopping of a levee to a predictable and planned location can reduce damages to the levee caused by overtopping and reduce the magnitude of inundation within the leveed area, thereby reducing potential damages to property and harm to people. The predictable and managed overtopping improves the ability to notify people who would be impacted by an overtopping event and manage evacuations, if necessary. It is critical that emergency response operations are developed and carried out to ensure no flood fighting occurs which would obstruct flow when the controlled overtopping is intended to occur. This can lead to uncontrolled overtopping at unplanned locations, increasing the risk to people and property.

3. Remedial Measures

The practice of increasing the height of a levee by placing material on the crown to prevent overtopping is called capping or topping. In any high-water situation, sound practice requires that immediate consideration be given to the levee grade line. Although grade lines or profiles should be kept current, a new line of levels (survey) should be run over any reach that appears to be below the predicted flood crest to confirm the locations where overtopping will occur. If the intention is to prevent overtopping, a good practice is for capping to be constructed to attain a grade line approximately two feet above the predicted crest height of the flood event. 24-hour inspections should begin once floodwaters approach this cap, if safe to do so.

Field supervisors should use a certain amount of judgment in determining the type and extent of capping. For example, if the profile shows that a stretch of levee requires less than ½ foot of capping to provide the desired 2 feet of freeboard, the capping may be temporarily omitted. In general, allowing for a tolerance of ½ foot above or below the targeted grade is a good practice.

Since capping should be as nearly watertight as possible, care should be taken in preparing the portion of the crown of the levee upon which capping rests. All depressions, such as paths or ramps, should be restored to the design levee grade, with adequate cross section. Sandbags are frequently used to bring low ramps up to grade as shown on Plate No. 10 in Appendix I. The levee crown should be thoroughly scarified to a minimum depth of 2 inches by scraping, or other similar means, to obtain a watertight bond between the capping and the levee crown (levee surface).

There are generally five types of capping as follows:

a. Earth-fill.
b. Sandbag.
c. Flashboard.
d. Mud-box or box levee.
e. Manufactured temporary barriers.

The type of capping required is governed by local conditions. Earth-fill capping is the simplest type and quickest to construct. Soil from the levee prims, levee toe or seepage berms should never be used. Earth-filled capping can be used to a height of approximately 1½ feet for a 10-foot-wide crown; however, greater heights can be achieved, depending on wave action, current velocities, borrow type, and crown width. Sandbags or flashboards are typically used where the height capping exceeds 1½ feet, and is less than 3 feet, or where wave action is anticipated. Capping more than 3 feet in height usually requires manufactured temporary barriers or mud-box or box-levee construction, depending on the width of the levee crown and the nature of the material used for capping.

Capping may increase the likelihood of catastrophic levee failure. Mandatory Evacuation of the leveed area should be considered and discussed with local officials.

The construction methods for each type of capping will be described in the order mentioned above.

Levees designed and constructed by the USACE were constructed to a design profile in accordance with legislative authority. Capping is considered temporary and should be removed as soon as possible after the flood event has subsided. A Section 408 Alteration Request that includes an evaluation of impacts to the floodplain is required to keep the material in place.

a. Earth-fill Capping

Earth-fill capping consists of a small embankment constructed on the crown of the existing levee. After all local depressions have been prepared as described previously, the crown of the levee is thoroughly scarified by scraping the top layer of grass, or other method which overturns the earth to a minimum depth of 2 inches. An earth-fill is then constructed to the required height with its riverside edge 1½ feet from the riverside edge of the crown. The crown of the fill should be level transversely, and the side slopes should not be steeper than the natural slope of the angle of repose of the material used. The 1½ feet on the riverside edge of the crown is reserved for placing earth-filled sacks for wave-wash reduction when necessary. Wave-wash reduction may also be fulfilled but utilizing polyethylene sheeting kept in place by sandbags and sandbags tied together on each side of the crown.

The method of placing material in the earth-fill varies with the locality and circumstance. Speed is essential, and the more use that can be made of machinery, with a corresponding savings in hand labor, the more quickly the job will be completed. The use of lumber fences and/or boxes will greatly reduce the amount of earth required.

The material may be placed by hand from wheelbarrows or tractor-drawn scrapers; trucks, clamshell, or dragline machines may be used to place material in the cap. Where the crown of the levee is more than 15 feet in width, the material can be rapidly and economically bladed from the landside edge of the crown into the fill by means of a road grader. Where the crown width is less than 15 feet, usually the material can be readily and relatively cheaply placed by a long reach trackhoe obtaining material from borrow pits located landward of the levee. Ordinarily, materials shall not be taken from within 350 feet of the landside toe of the levee, however the appropriate distance from which to take borrow materials can vary based on the levee height and shape. More than one lift may be required before the required height of fill is obtained. For bringing capping material up from the landside of the levee, tractor-drawn scrapers or trucks are probably the fastest and the most satisfactory method of transportation if conditions are such that this sort of equipment can operate. Trucks are fast but can operate only when the levee is dry and when well-constructed ramps are available. Tractor-drawn scrapers can operate under more adverse conditions than trucks but are not satisfactory for extremely wet and soggy levees. For extremely bad conditions, the relatively slow and expensive method of bringing the material up the land slope of the levee in wheelbarrows must be used. The earth-fill type of capping is ordinarily recommended only for levees having a crown 10 feet or more in width.

Listed below are two methods of placing materials for an earth-filled cap:

i. <u>Capping (Topping) With Hauling Equipment.</u> This method should receive first consideration in raising long low stretches of levee known to have insufficient freeboard to safely withstand predicted stages, provided the work is done well in advance of high stages. No heavy equipment should be allowed on the levee without engineer approval when the water is near the top as the vibration might cause a failure, especially to structures and foundations comprised of sandy soils. An ideal outfit for this work consists of a long reach trackhoe or dragline capable of transportation by heavy-duty trailer, a fleet of trucks, and a bulldozer. The material dumped on the levee crown should be spread in layers not exceeding 1 foot in thickness and thoroughly rolled by bulldozer. Loaded trucks should be run over the topping as the work progresses to give additional compaction. Great care must be exercised in traveling up and down landside slopes to avoid damage to the slope or sod and in no case may be done when the levee has commenced to seep.

ii. Cut Crown Topping. This form of topping, which consists of shifting material from the landside edge to the riverside edge of the levee crown, should never be used except as a last resort when material cannot be secured from other sources. When this method is used, care must be taken to disturb as little of the sod as possible and to excavate in such a manner that through seepage does not become a problem. Trackhoe or small draglines may be used on a wide levee crown.

Earth-fills used to increase the level of protection for a levee are very susceptible to wave and runoff erosion. They are also very limited to the height they can be constructed to, therefore, the degree of protection they can be expected to provide is limited.

b. Sandbag Capping

Sandbag capping as shown on Plate No. 11 in Appendix I is a dependable method and has been used over the years. However, an excessive amount of labor is required, and progress is relatively slow. Due to the increasing scarcity of labor, flood response teams should use faster, more efficient methods whenever possible such as other manufactured temporary barriers.

The base area available limits the height of a sandbag capping; therefore, a levee can usually be raised only a few feet by this method. In general, the base width of a sandbag levee cap should be three times the height of the cap.

Figure 23: Sandbag capping (Credit: 139th Airlift Wing)

The following is a description of the proper steps required to construct a sandbag levee:

i. The foundation where sandbags are to be placed should be scarified. This will provide for a good bound between the ground surface and the sandbags and reduce the amount of seepage that could occur between the ground surface and the first row of sandbags.
ii. A key trench should be dug in the center of the proposed sandbag alignment. This trench should be approximately 2 bags wide and 1 bag deep.
iii. Before placing sandbags in the key trench, plastic sheeting should be placed in the bottom of the trench. This will reduce the amount of seepage that would occur between the ground surface and the first row of sandbags.
iv. Sandbags should be filled one-half to two-thirds full.
v. If the bags are filled at the site of placement, then the bags should not be tied. If the bags are to be filled off site and transported to the placement site, then tying the bags will prevent losses due to spillage.
vi. Start placing sandbags in the key trench on the plastic sheeting.
vii. Place the filled bags lengthwise and parallel to the direction of flow. Lay the unfilled portion of the bag flat on the ground.
viii. Place the succeeding bags on the unfilled or tied portion of the previously laid bag and stamp into place to eliminate voids and form a tight seal.
ix. Stagger the joint connections when multiple layers are necessary and stack the sandbags in pyramid fashion.
x. A good rule of thumb is to construct the sandbag levee base width three times the sandbag levee height.

c. Flashboard and Mud Box Capping

Flashboards and mud boxes are similar in that they are both constructed of wood and are usually reinforced with some type of earth-fill. The use of flashboards and mud boxes in connection with earth-filled caps serves several purposes. They protect against wave-wash, reduce the amount of topping material required, provide for greater heights with lesser base widths, make the topping material more impervious and generally provide a more stable structure. Typical flash board capping is illustrated on Plate Nos. 12 through 16 in Appendix I.

Figure 24: Flashboard installed along levee crest

Flashboards are generally used for heights up to 3 feet. For heights over 3 feet, it is probably more economical to construct a mud box instead of a flashboard.

Flashboard Capping. If the capping required exceeds 1½ feet, and is less than 3 feet, or if the capping is likely to be exposed to wave action, flashboard capping is used. This work consists of a board fence built about 1½ feet from the riverside edge of the levee crown with an earth-fill placed on the levee crown landward of the board fence. Flashboard capping is usually divided into two classes: two-board and three-board. The two-board levee capping is used in situations that require less than 2 feet of capping but require protection for the capping against wave action. The three-board levee capping is used in situations that require more than 2 feet, but not to exceed 3 feet of capping. The method of construction for both classes is fundamentally the same. The accepted method and sequence of operations in constructing this type of capping are as follows:

i. A furrow is plowed or dug into the levee crown about 1½ feet from the riverside edge. The earth dug from the furrow should be deposited landward of the furrow so that the bottom board will fit flush against its riverside edge. The furrow should be as straight as practicable, avoiding abrupt turns, and should not be less than 2 inches deep. The bottom of the furrow should be as level as practicable to provide a secure and even seat for the bottom board of the fence.
ii. The next step is to place the bottom l-inch-by-12-inch boards on edge in the plowed furrow, placing them end-to-end.
iii. The 2-inch-by-4-inch posts are then driven to a penetration of about 24 inches on the landside of the 1-inch-by-12-inch boards, wedging the boards against the riverside edge of the plowed furrow. The 2-inch-by-4-inch posts should be placed at intervals of approximately 5 feet so that the ends of the boards will lap on a post, the length of the boards usually determining the intervals between posts. In general, the posts used in flashboard capping should extend at least 1 foot above the top of the proposed upper flashboard, to provide for the placing of an additional board in case of necessity. Tops of posts should be roughly chamfered before driving.
iv. After the bottom boards have been nailed to the posts, the furrow is backfilled with loose material that is thoroughly tamped against the bottom boards on both sides.

v. Additional boards are then placed and nailed to the posts. Care should be taken to break the joints on the posts. If necessary, additional posts may be driven to take the laps of additional boards. It is practicable to build this type of capping up to three boards in height.
vi. The levee crown landside of the capping is scarified by plowing or other methods that overturn the earth to a minimum depth of 2 inches. This is very important to provide a good bond between the levee crown and the new earth-fill.
vii. Burlap, plastic sheeting, tar paper, or other type material is then placed on the landside of the flashboards to prevent the loose earth-fill from being washed out through the cracks between the boards.
viii. Earth-fill is placed on the landside of the flashboards to the desired height.
ix. If three-board capping is used on a narrow crown levee and the toe of the slope of repose of the earth-fill would fall beyond the landside edge of the levee crown, it is necessary to add a board fence near the landside edge of the levee crown. The landside fence is constructed in the same manner as described for the riverside fence. The posts are placed on the landside of the boards and are tied to the posts of the riverside fence by 2-inch-by-4-inch braces. Generally, the height of the landside fence is one or two boards less than that of the riverside fence.
x. An alternate method of constructing flashboard capping is to place the 2-inch-by-4-inch posts on the riverside of the 1-inch-by-12-inch boards. The first described method is preferable since the bottom boards are wedged tightly against the riverside edge of the plowed furrow and permits less seepage than does the alternate method. However, an advantage in placing the 2-inch-by-4-inch posts on the riverside of the 1-inch-by-12-inch boards is that the pressure of the earth-fill is transmitted directly from the boards to the posts. Also, with this method, flashboard capping can be converted into a box levee, if necessary. If the alternate method is used, it is very important that the loose earth on the riverside of the 1-inch-by-12-inch boards be thoroughly tamped against the boards.

<u>Mud Box Capping.</u> In capping to a height greater than 3 feet, or in capping a narrow crown levee, the mud box levee type of capping is used as illustrated on Plate Nos. 17 and 18 in Appendix I.

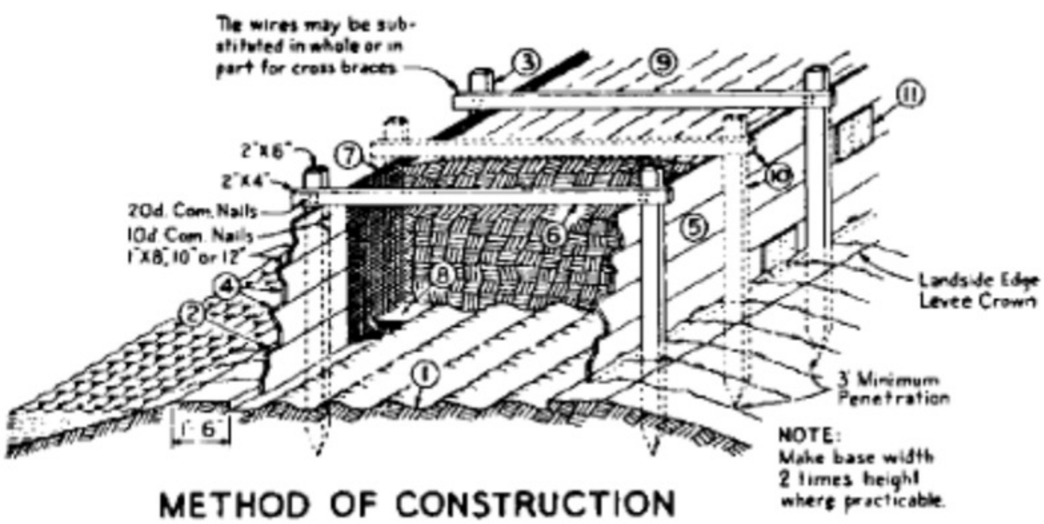


Figure 25: Mudbox diagram

The work consists of building board fences near both the riverside and landside edges of the levee crown and placing earth-fill between the two fences. This fill should be well tamped and should never be earth-filled sacks. Where possible, the width of mud box levee capping should be twice the height of the earth-fill. An accepted method of constructing a box levee is as follows:

i. A furrow is plowed along the levee crown, about 1½ feet from its riverside edge, as described above.
ii. The bottom boards are placed on edge in the plowed furrow, end to end, along the levee.
iii. The 2-inch-by-6-inch or larger posts are then driven to a penetration of about 3 feet on the riverside of the bottom boards. The posts should be spaced at intervals of approximately 5 feet so that the ends of the boards overlap on the posts. Tops of posts should be roughly chamfered before driving.
iv. After the bottom boards have been nailed to the posts, loose earth is thoroughly tamped against the bottom boards on both sides.
v. Additional boards are than placed and nailed to the posts, joints being broken on the posts.
vi. Plowing, or some other method, which provides a good bond between it and the fresh fill, scarifies the levee crown.
vii. The landside fence is constructed in the same manner, except that the posts are placed on the landside of the boards.
viii. The posts of both fences are then tied together with 2-inch-by-4-inch horizontal braces.
ix. Burlap, plastic sheeting, tar paper, or similar material is placed on the landside of the riverside fence.
x. Earth-fill is placed between the fences.
xi. If the height of the earth-fill is to exceed 4 feet, the box levee should be reinforced by driving additional posts to support the fences.
xii. In constructing a mud-box or box levee across an old slide, depression, or on levees having a narrow crown where it may be impossible to obtain the standard height-width ratio (1 to 2), the box levee should be strengthened with additional bracing. The strength of the members used for bracing and their disposition depend entirely upon local conditions. If possible, the additional braces are placed outside the mud-box or box levee, bracing it to the landside slope of the levee. If outside braces are impracticable, the mud-box or box levee is bolstered by braces within the box, placed diagonally from the top of the riverside fence to the bottom of the landside fence.

d. Capping Material

Sources. The usual sources of earth-fill for capping are from the farm fields landside of the levee, from the banks of drainage ditches, or from the landside edge of the crown when the levee has a crown more than 15 feet in width. Clays are typically better capping materials than silts or sands, but availability of materials may limit options. In taking material from cultivable fields, care should be exercised not to damage them any more than is necessary. It is customary to take a cut only about one spade deep over a relatively large area. USACE does not recommend or endorse using material from the levee landside slope to increase levee height. Decreasing the levee cross-section may lead to an increase in through seepage, weakens the structural integrity of the levee and increases the risk of failure.

Placing. The method of placing material for capping is important to minimize the amount of seepage through the capping. The material adjacent to the flashboards should be free from sods and stubble and should be thoroughly tamped. All additional material should be compacted as well as conditions permit.

e. Conduct Of Work

The supervisors in charge of capping should organize crews so that the work will proceed in a regular order, each crew executing a particular phase of the work, such as preparing and distributing lumber, plowing, setting posts, nailing boards, placing burlap or other materials, and placing the earth-fill. If long stretches of levee are to be capped to a given height in the face of a rapidly rising river, it is well to set the posts to the required height and place the bottom boards only. Succeeding boards and fill are placed after the first boards have been placed throughout. Capping work should be laid out so that the low places are concentrated on, and a uniform freeboard provided, parallel to the anticipated flow line, throughout the entire length of the job. The exact method of conducting this kind of work depends upon local conditions and upon the best judgment of those in charge of the work.

These methods of capping are labor intensive and costly. They are also very susceptible to erosion from river velocities and waves if the waves break at the intersection of the flashboard and the levee. If this case arises, measures to reduce erosion should be executed to ensure that the capping is not placed in vain. Measures for reducing wave erosion are discussed later in this Chapter.

Reducing Levee Erosion

1. Description

   River velocities and wave-wash can cause erosion of the soil slope by wave action. Waves can be caused by winds, storms, or a passing boat. In any case, erosion may seriously damage a levee, particularly if the erosion surface is near the levee crown, or if the levee is newly constructed, or constructed of sandy soil.

   If the slope is well vegetated, a storm of short duration should cause very little damage. Individuals responsible for inspections should determine beforehand as to the possibility of wave-wash. In all such reaches that can be determined in advance, filled sandbags and other material should be kept available for an emergency. During periods of high wind and waves, flood response personnel should stand by, and experienced watchmen should observe by sounding the submerged slope with a long pole where the washouts are beginning.

   Monitor weather forecast for winds speeds and direction. If the wind direction is in an alignment where the flood waters have an opening to a levee reach with a long wind fetch, it may be prudent to place plastic sheeting or riprap. While placing erosion reduction materials is often an emergency operation, a severe storm of a general nature may cause serious damage to the levee line and may require installation of the capped area of a levee or any temporary barrier. Construction of such erosion works as are reasonably justified especially when a peak of several days is forecasted. Local officials should be in constant readiness to meet emergencies as signs of erosion appear.

2. Remedial Measure

   Ways to reduce wave-wash erosion depend upon local conditions; whether the levee is exposed to severe wave-wash; the materials of which the levee is constructed; and the type, quantity, and heights of vegetation along the riverside toe of the levee, which may be expected at the existing and predicted stages of the river. The types of wave-wash protection generally used are vertical board revetment, horizontal board revetment, earth-filled sack revetment, and plastic sheeting. Each of these types is described below. Sometimes, icy conditions are such that protection provided by the methods outlined above will not be totally effective. A boom of logs, driftwood, or any available timber fastened together, strung along the levee slope, and anchored about 15 feet from the water's edge has proven particularly effective against ice attack.

   a. Polyethylene and Sandbags

      A combination of polyethylene (poly) and sandbags has proven to be one of the most expedient, effective, and economical methods of combating slope erosion on earth fill levees.

      Anchoring the poly along the riverward toe is important for a successful job. Anchoring methods for poly on sandbag levees, described in Section K Construction of Sandbag Levees further in this chapter, should be used for earth fill levees as well.

      Ideally, poly and sandbag protection should be placed before water has reached the toe of the levee. However, wet placement may be required due to rising river levels or to replace or maintain damaged poly or poly displaced by the action of the current. Placement of poly on earth fill levees is the same as placement on sandbag levees, as described in Section K Construction of Sandbag Levees further in this chapter.

      It is mandatory that poly placed on levee slopes be held down by weights. Unless extremely high velocities, heavy debris, or a large amount of ice is anticipated, an effective method of weighting poly is a grid system of sandbags, as shown on Plate 25 and Figure 26. A grid system can be constructed faster and requires fewer bags and much less labor than a total covering. Grid systems may include vertical rows of lapped bags or 2x4 boards held down by attached bags.

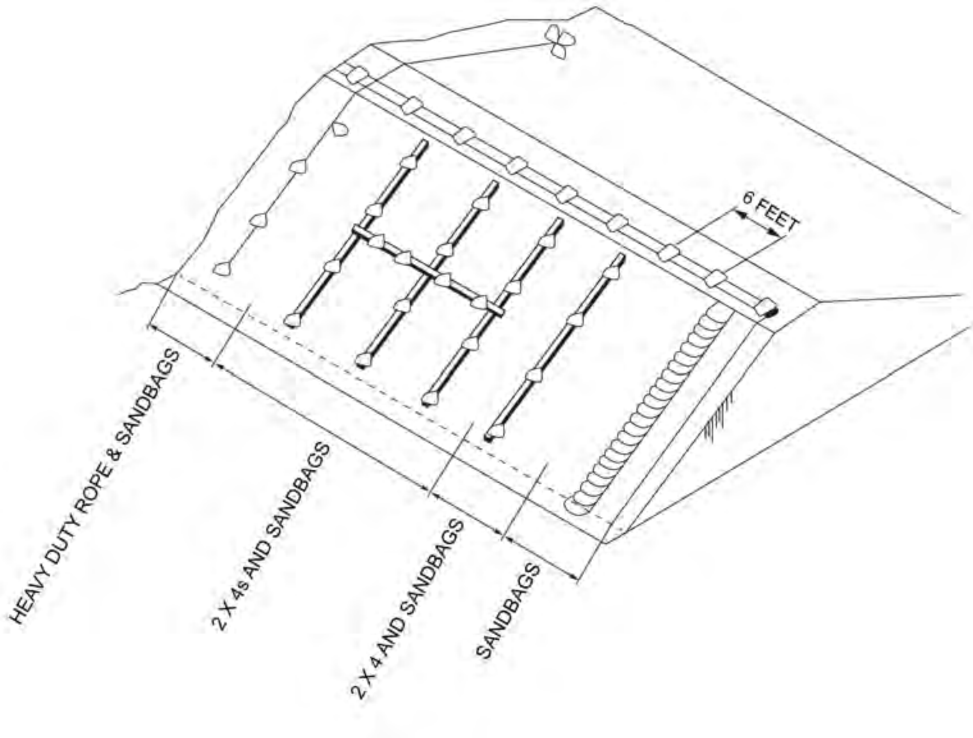


Figure 26: Recommended method for placement of polyethylene sheeting on temporary levees (when placed in dry)

A grid system of counterweights is more suitable for placement under wet conditions. Counterweights consisting of two or more sandbags connected by a length of quarter-inch rope are saddled over the levee crown with a bag on each slope. The number and spacing of counterweights will depend on the uniformity of the levee slope and current velocity. For the more extreme conditions mentioned previously, a solid blanket of bags over the poly should be used. Sandbag anchors can also be formed at the bottom edge of the poly by bunching the poly around a fistful of sand or rock and tying a sandbag to each fist-sized ball. This counterweight method is shown on Plate 24 and Figure 27.

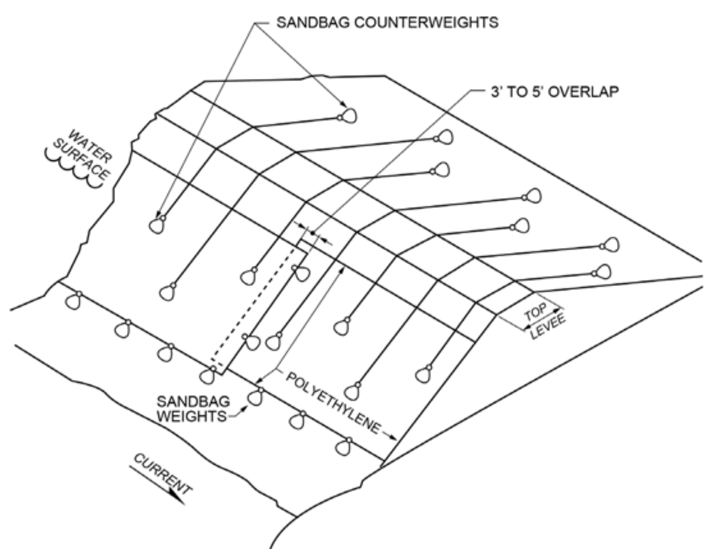


Figure 27: Recommended method for placement of polyethylene sheeting on temporary levees (when placed in the wet)

If the counterweight method is used, efficient placement of the poly requires that enough rope and sandbag counterweights be prepared prior to the placement of each poly sheet. Placement consists of first casting out the poly sheet from the top of the levee with the bottom weights in place, and then adding counterweights to slowly sink the poly sheet into place. In most cases the poly will continue to move down slope until the bottom edge reaches the toe of the slope. Sufficient counterweights should be added quickly to ensure that no air voids exist between the poly and the levee face and to keep the poly from flapping or being carried away in the current.

For extreme conditions such as high velocity, excess seepage, ice or debris in the water or wave action, a solid blanket of bags over the poly should be used.

b. Vertical Board Revetment

The vertical board type of wave-wash protection is preferred in all localities where the wave action is, or is expected to be, severe. On higher levees, however, this method is impracticable, as the length of boards and the length of braces, etc., would be prohibitive, both in cost and time of construction. The toe of the vertical board revetment generally should be placed in about 1 foot of water and the top should extend about 2 feet above the predicted high-water stage. The accepted method of constructing this type of revetment is described as follows: (See Plate No. 19, Appendix I.)

i. Posts that are 2inches by 6inches or larger are driven to a minimum penetration of 3 feet, 6 inches and battered to a slope of about 6 vertical on 1 horizontal. They are usually placed on 7-foot centers. Tops of posts should be roughly chamfered before driving.
ii. Braces 2-inches-by-6-inches or larger are fastened to the posts as indicated.
iii. Braces are then secured by anchors constructed of 2-inch-by-4-inch lumber.
iv. A 2-inch-by-6-inch top whaler is placed as indicated in the detail. A bottom rail of the same size is placed just above the existing water level and secured to the posts.
v. Next, 1-inch-by-12-inch boards are driven to a minimum penetration of 2 feet and are securely attached to the top and bottom rails by 16d common nails. The boards are driven close together so that the width of cracks is kept to a minimum.
vi. If the height of the 1-inch-by-12-inch boards above the ground surface exceeds 10 feet, a third 2-inch-by-6-inch whaler is placed between the top and bottom whalers.

c. Horizontal Board Revetment

The horizontal board types of wave-wash protection are used in cases where it is necessary to provide a minimum of protection for levees that are not directly exposed to attack and are partially protected by timber growth. This type is suitable for use on levees where the levee is not exposed to sustained wave action over extended periods. This type of protection can be placed with a relatively small crew and is suitable in case of an emergency along a long levee line, even if some of it later requires replacement with a sturdier type of protection work. The accepted method of constructing the horizontal board revetment is as follows: (See Plate No. 20, Appendix I for details).

i. Posts of 2-inch by 4-inch lumber, or larger, are driven at the water's edge to a minimum penetration of 2½ feet, being battered on a slope of about 6 vertical on I horizontal. The posts are placed at intervals of approximately 5 feet so that the ends of the boards will overlap on the posts, the lengths of the boards determining the intervals between posts. Tops of posts should be roughly chamfered before driving.
ii. Braces of 2-inch-by-4-inch lumber are fastened to the posts as indicated.
iii. The braces are secured by at least three 2-inch-by-4-inch anchor stakes, which are driven to a minimum penetration of 2 feet. The anchor stakes are fastened to the braces.
iv. Boards of 1-inch-by-12-inch material are placed on the riverside of the 2-inch by 4-inch posts and are nailed securely. The bottom boards are embedded in the levee slope as well as practicable before additional boards are placed. Additional boards are placed to approximately I foot above the predicted water level.
v. Earth-filled sacks are used to fill local scour holes under the bottom boards. One or more rows of sacks are placed against the landward side of the bottom boards to prevent undermining at the base.

d. Sack Revetment

Sacked earth material should be used only as a means of minor wave-wash protection, or to fill local holes that are washed in the levee by wave action. The sacks should be placed close together beginning about 2 feet under the water surface. Each succeeding row of sacks should overlap the preceding row like shingles on a roof. Care should be taken to stagger the joints. All sacks should be tamped or mauled into place so that the wave action will not readily wash the sacks away.

Sacking for wave-wash cannot be placed effectively in advance in the face of a rising river since the cutting action is at the water surface. Before the sacked zone can be made effective, the water level will rise above and overtop the upper sacking.

The accepted method of constructing a sack revetment is shown on Plate No. 21 in Appendix I.

e. Riprap Revetment

Rock riprap is a very popular method to prevent wave-wash erosion and current scour. Depending on the haul distance, this method can, however, be very costly.

Although not covered in this manual, if site conditions and time permits, the use of filter fabric and / or bedding and spalls placed prior to riprap should be considered to prevent soil material from being pulled through the riprap layer.

Other Methods. Straw bales wrapped with polyethylene sheeting on the waterside can be used to provide some wave-wash protection as shown on Plate Nos. 23 through 25 in Appendix I. Sandbags should be used to weigh the bales down, so they don't float away.

f. Steel Piling Revetment

Under certain conditions, it may be necessary to construct a steel-piling revetment. This method is shown on Plate No. 26 in Appendix I.

g. Blankets

In the event the levee shows definite indications of sloughing, it will become necessary to blanket the riverside slope. Plastic sheeting can be used to retard erosion and seepage. Sandbags are used to anchor the plastic sheeting. For underwater placement, sandbags are tied to the corners of the sheet and at intervals in between to hold the sheet tight against the slope. Sandbags are then placed into the water allowing them to sink to the toe of the levee.

Current Scour

1. Description

Current scour is the erosion of the riverside slope of the levee, the berm, and/or the adjacent borrow pit by high water velocities. Physical conditions that cause current scour are outside angles in the levee, waterway gaps that have been cut through abandoned levees, secondary levees, river structures, large obstructions (fallen trees) that direct flow toward the levee, and topographical features which may create relatively deep channels adjacent to the levee during high water.

Scours are particularly dangerous due to the treacherous way they develop and the difficulty of detection until almost irreparable damage has been done. The chief danger, of course, is that the scour will work into the levee slope. This type of scour resembles the caving bank of a river in action and appearance, in that it erodes under water and has a vertical caving face. When the water is near the top of the levee, and by the time the vertical caving face appears above the water surface, a large portion of the levee is gone.

Flood-response personnel must make careful observations of the riverside of the levee in the borrow pits in all reaches where an unusually fast current is apparent. Levee projects that have been designed using a hydraulic model, careful observations of the riverside of the levee should be made where the profiles show a steep high-water slope. Turbulence in areas where the water is shallow is a pretty good sign of no scour but should be watched. If the turbulence unexpectedly becomes quiet, scour may be suspected, and soundings should be made immediately. Conversely, in deep water, scour mat be indicated by turbulence and eddies. Field personnel should be particularly watchful for such conditions. If erosion is evident, immediate steps should be taken to protect the levee.

Figure 28: Image of levee scour

2. Remedial Measures

The methods to be used in protecting a levee against current scour depend entirely upon local conditions. In some cases, the current attack is so severe, and the scour is of such serious nature, that it requires specially designed structures that cannot be constructed with the ordinary high-water equipment and personnel. Ordinarily, however, current scour can be prevented or stopped by relatively simple techniques. The methods which can be used to prevent current scour are widening of waterway gaps in abandoned levees, hardening the riverside slope of the levee with riprap or wave-wash fences, the construction of brush dikes, or placing plastic sheeting on the slope prior to the event or “rolling” plastic sheeting using sandbags during the flood event, each of which is discussed below. If the measures mentioned above are not effective in preventing current scour, the U.S. Army Corps of Engineers may be able to aid upon request.

a. Widening of Waterway Gaps

Widening the gaps and degrading abandoned levees to the extent necessary can reduce high current velocities against a levee, caused by narrow waterway gaps through abandoned levees. Waterway cuts at both the upper and lower ends of old levees should be widened sufficiently, to reduce the current velocity to that which will not cause erosion. This operation can be accomplished during high water only by floating equipment, such as trackhoes, dragline, or clamshell machines on barges or by trackhoe on land if access allows.

b. Brush Dikes

In cases where other protective methods will not obtain the desired results and where it becomes necessary to deflect the current away from the levee or to reduce the flow adjacent to the levee, it becomes necessary to construct brush dikes as current deflectors. In any instance, local conditions will determine the position, specific location and design of the brush dike. Several dikes may be required to stop scour. The first dike should be constructed below the scour, working upstream into and above the scour with additional dikes.

There are two types of deflection dikes, Type “A” (Plate No. 27, Appendix I) and Type “B” (Plate No. 28, Appendix I). Both dikes are constructed in the same manner, except that Type “A” requires the use of wire mesh to retain the riprap stone in place when used instead of sacked earth or sacked gravel. In general, a simple brush dike is constructed in the following manner.

i. A double line of 4-inch-by-4-inch or 3-inch-by-6-inch posts are driven on 4-foot centers, the lines of posts being about 4 feet apart and at the designated angle to the levee. The posts should be driven to the maximum practicable penetration, with their tops approximately 2 feet above the anticipated high-water surface.
ii. ii. Each pair of posts is braced laterally with 2-inch-by-6-inch or larger cross-braces placed so that a runway may be constructed on top of the braces. In deep water, additional diagonal braces should be placed on the downstream side of the dike, bracing the downstream line of posts to the ground. Such braces should be of 2-inch-by-6-inch material and should be driven at a 45-degree angle with the posts, to a minimum penetration of 3 feet. The dike may be strengthened by driving an additional row of posts on the downstream side of the dike, bracing them to the dike with 2-inch material.
iii. The brush dike frame is filled with alternate layers of willows, or some other suitable brush. Sacked earth, sacked gravel, riprap stone, or concrete is used to hold the brush in place. Heavy lumber should be used for braces and walkway to support the movement of materials. The first layer of filler should consist of earth-filled sacks, being so placed as to level out the irregularities in the bottom and to provide a smooth base for the brush filler. The brush filler should consist of bundles of brush and poles, laid to form a solid mat. The brush should be rammed tightly into place. Each layer of brush should be about 2 feet in thickness and should be weighted down with one or two layers of sacked earth. The brush and sack filler should extend about I foot above the anticipated elevation of the high water.
iv. A mat of earth-filled sacks to retard scour is placed at the outer end of the dike.
v. Unless a floating plant is available, the driving of posts should be commenced at the inshore end of the dike and carried progressively to the outer end of the dike. The posts may be driven with mauls or by means of a “dolly” (See Plate 14, Appendix I). As each pair of posts is driven and braced, the driving crew moves forward by means of 2-inch-by-12-inch plank runway placed on the horizontal braces, and the next pair of posts is driven. Tops of posts should be roughly chamfered before driving.
vi. The placing of brush and sacked earth filler should be undertaken along the full length of the dike simultaneously. The filler should be placed in approximately horizontal layers beginning at the deepest water and progressing upward to the required height of the dike. In localities where trees of suitable dimensions are readily available, round timbers may be substituted for the square posts and braces described above.

c. Stone Cribs

For control of scour along the levee slope or in the borrow pits near the levee, the use of stone or riprap cribs as shown on Plate No. 29 in Appendix I and as described in the next paragraph, is very effective. The cribs should be placed in the scour hole with the concentration of load in the direction of the levee to ensure that further scour development will be away from, rather than toward, the levee. The cribs can be constructed at the site on the levee or bank and pushed where needed by bulldozers.

Cribs are usually 14 feet by 14 feet by 18 inches outside dimension constructed of double thickness 1-inch-by-4-inch-by-14-foot lumber, equivalent to 2-inch-by-4-inch pieces, lapped rail fashion at all corners and intersections. The cribs are divided into four compartments by two cross walls constructed in the same manner as the sidewalls. The floors and covers of the cribs are built up of double 1-inch-by-4-inch boards spaced about 9 inches center to center. Under the floor, and perpendicular to the direction of the floorboards, are five equally spaced pairs of 1-inch-by-4-inch boards about 2½ feet center to center. On top of the cover, perpendicular to the direction of cover boards, are three pairs of top boards, placed over each sidewall and the partition wall. The covers can be built directly on the crib, or separately, and placed on the crib. In either case, the cover is placed after the crib is filled with rock. All intersections are nailed with one 20d nail and each intersection of walls or fabricated crib is securely fastened by a loop of ⅜-inch strand, tightly twisted. The wire loop is put in place loosely before filling with rock and twisted into place to include the top after it is in place.

The 14-foot-by-14-foot-by-18-inch crib will hold approximately 5 tons of stone. The weight can be adjusted as desired to meet existing conditions by increasing or decreasing the depth of crib.

If stone is not available, the cribs may be filled with sacked earth or gravel, broken concrete, or other suitable material.

In launching the cribs, it is sometimes advisable to tie them together to keep them from separating and so they will help pull each other off the bank.

The use of stone-filled cribs has been very effective in retarding the caving of banks. The size of the crib is not necessarily standard. It may be necessary to make heavier or smaller cribs to accomplish the mission. Each condition of emergency must, of course, govern the plan of operation.

After construction of the stone-filled cribs, launching or placing them properly becomes critical. To be most effective, the cribs or whatever substitute has been devised must be fastened to each other with a cable in a sort of string-out.

If the caving bank is not inundated, the construction, assembly, and launching of the cribs can be accomplished from the top of the bank. Power tools and other equipment, such as cranes and bulldozers, would be used in this case. Where the caving is entirely under water, a floating plant will be needed for the operation. The number of cribs in a string-out must be governed by factors such as working room, time, rate of caving, and possibly other conditions peculiar to the location.

d. Rip Rap

The use of riprap is a positive means of reducing erosive forces and has been used in a few cases where those forces (caused by current, waves, or debris) were too large to effectively control by other means. Objections to using riprap for flood response are: (1) the relatively high cost, (2) a large amount may be necessary to protect a given area, (3) limited availability, and (4) little control over placement, particularly in wet conditions.

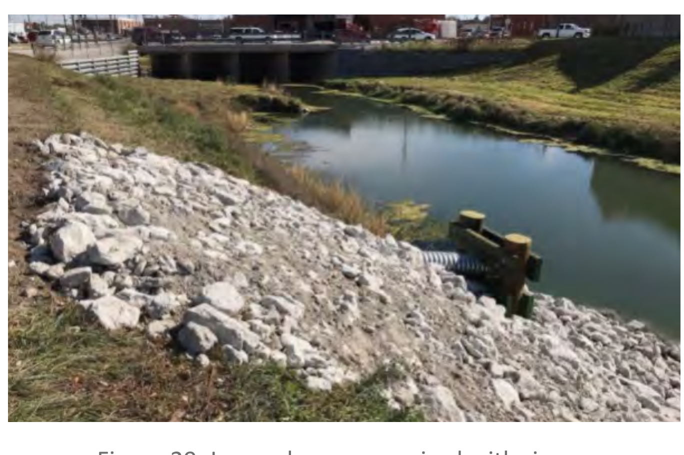


Figure 29: Levee damage repaired with rip rap

e. Small Groins

Groins extending 10 feet or more into the channel can be effective in deflecting current away from the levees. Groins can be constructed using sandbags, snow fence, rock, compacted earth, or any other substantial materials available. Preferably, groins should be placed in the dry and at locations where severe scour may be anticipated. Consideration of the hydraulic aspects of placing groins should be given because haphazard placement may be detrimental. Hydraulic technical assistance should be sought if doubts arise in the use of groins. Construction of groins during high water will be very difficult and results will generally be minimal. If something other than compacted fill is used, some form of anchorage or bonding should be provided; generally, snow fence anchored to a tree beyond the toe of the levee is used, but junk car bodies can be tied together to act as anchors.

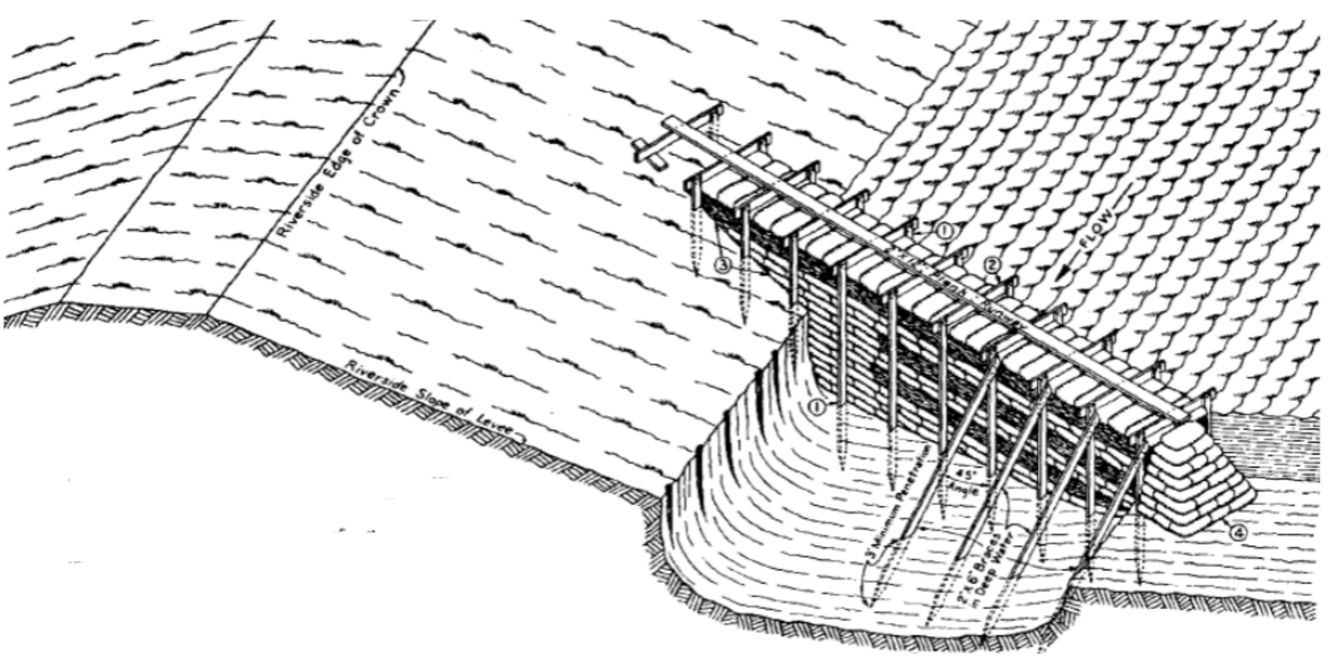


Figure 30: Groin/deflection dike routing flow away from erosion

f. Log Booms

Log booms have been used to protect levee slopes from debris or ice attack. Logs are cabled together and anchored in the levee with a device referred to as a “dead man,” often consisting of a concrete block with reinforcing bar, or another heavy anchor. The anchor should be of sufficient size and weight to hold the log boom in place. The log boom is floated out into the current and, depending on the log size, will deflect floating objects and protect the levee.

Through seepage

1. Description

Through seepage is the percolation of water through the levee structure and the seepage may decrease the stability of the levee by saturating the soil causing instability of the landside slope. Through seepage usually appears in the drainage ditch at the landside toe of the levee. As the water rises against the levee, the seepage flow increases. If the wetted area is relatively small, no action, other than keeping the water drained away from the levee by means of small seep drains in the landside slope, will be necessary. If the levee becomes saturated over a relatively large area, it may become necessary to take other precautions to prevent sloughing. Blanketing with an acceptable filter is the most satisfactory treatment, although this may be combined with the construction of buttress work on the landside, or the installation of drainage wells, if such action appears necessary.

Seepage through a levee system can also occur along drainage structures or result from improperly adjusted or damaged drainage structure gates.

Leakage caused by improperly adjusted or damaged gates should be identified in the preliminary inspections prior to every flood season and corrective actions taken. Leakage through drainage structures because of improperly adjusted or damaged gates will probably not fail the levee system. In many cases, time will be better spent accomplishing flood response activities in areas where a levee failure could occur.

2. Remedial Measures

   a. Seep Drains

   Drainage of the landside slope of the levee is one of the most important high-water maintenance operations. Consequently, the function must be fully understood and appreciated. Drainage of the adjacent terrain is also highly important.

   The methodology utilized in draining the slope is to concentrate the flow of seepage into directed channels that carry it rapidly down the slope and away from the levee. The result is that the slope will often become dry and firm between the drains. The drains themselves sometime never stop flowing. Drainage alone sometimes will not stabilize a wet slope and the slope could become unstable. If this happens, watch the slope carefully for signs of sliding or sloughing and be prepared to construct a mattress immediately.

   Water seeping through a levee may first appear as a wet spot on the slope. As the seepage increases, the wet spot spreads in size until the whole slope is wet and the seep water slowly flows down in a sheet. Continued exposure will cause the slope to become more and more saturated and soggy until it is liable to slide or even flow out resulting in a levee failure or requiring extreme measures to prevent a failure.

   To prevent sloughing of the levee where the slope is steep and saturated, small “V”-shaped seep drains should be cut in the landside slope to remove the seepage water. These drains may be cut diagonally down the levee slope and should not be more than 4 inches in depth. Several diagonal drains may be led into one drain running straight down the levee as shown on Plate No. 30 in Appendix I. Horizontal drains should not be used, and extreme care should be taken not to disturb the sod unnecessarily outside of the seep drains.

   The work consists of opening and clearing the various ditches so that seep water or rainwater will have a free flow from the levee into drainage ditches which convey the water to the drainage structures through the levee. If drainage is perfected prior to high water, the effectiveness of the drainage system will be far greater than if the work is attempted after the ground has become saturated. During flood events, the gates on the drainage structures should be closed to prevent floodwaters from inundating the protected area landward of the levee. This condition may cause runoff water to pond behind the levee until the floodwaters recede. If the water behind the levee begins to cause damages, it should be pumped across the levee to the riverward side.

   The first drains should be cut 12 feet to 15 feet apart, V-shaped, no more than 4 inches deep. The drains should originate at the upper or highest limit of seepage and run straight down the slope and lead across the landside berm into a drainage system. To secure better coverage of the seeping area, additional drains spaced 4 feet to 6 feet should be cut between the first drains.

   The above-described method of drainage is applicable to clay, loam, and sandy loam levees only. It should not be used as a means of drainage on sand levees, or where the foundation supporting the levee consists of sand. On sand levees, the seep drains should be omitted, and the seepage allowed to “trickle” down the landside slope to the drainage ditch paralleling the levee toe. If seepage through a sand levee is excessive, a blanket of loamy material should be placed on the riverside slope.

   If additional excavation is necessary to provide adequate drainage, the general plan described in the above paragraph, should be followed as closely as practicable. The material excavated from the seepage ditches should be deposited on the side away from the levee, and material excavated from the off-take ditches should be deposited in such a manner that it can later be used as material for capping, if necessary.

   In no case should an attempt be made to cut slope drains until seepage appears. All traffic, animals and personnel should be kept off seeping side slopes.

   For levees constructed of sand, a long peak may cause erosion on the landside slopes. Once the crevices are more than 6 inches, back dragging the slopes with a bulldozer will allow the surface to be repaired and increases the density of the sand. Ensure clay is not mixed into the coarse sand.

b. Sloughs And Slides

Where seepage appearing high on the levee slope cannot be controlled by seep drains as outlined in the preceding paragraph, and the condition grows progressively worse, there is danger that a slough or slide may develop. A slough is a condition in which the slope is excessively wet and soggy and is inclined to flow or fall away from the slope and heave or pile up at the toe. A slide is more apt to occur on steep slopes even when the soil does not appear to be extremely wet. In a slide, the slope breaks away in a clearly defined crack or cleavage plane and moves outward taking the toe of the embankment.

Figure 31:Image of levee embankment slide

If slope failure is likely or has occurred, the recommended treatment is reinforcement in the form of a buttress on the berm below the slide, tapering up over the failure. A brush or board mattress is always placed under the buttress and constructed in such a manner that it will permit drainage, provide a stable but flexible base for distribution of uniform pressure, bridge the failure, and anchor it against further movement.

Plate Nos. 31, 32, and 33 in Appendix I illustrate methods of construction of a brush mattress and two types of board mattress.

<u>Brush Mattresses</u>. After slope drains have been cut as shown on Plate No. 31 in Appendix I, place a single layer of standard willow brush or several inches of small trees or limbs with butts up the slope and tops down and perpendicular to centerline of levee. The brush should extend onto the dry slope several feet above the soft area and far enough onto the berm landward of the levee to provide a base for the buttress. A second layer of poles or brush is cross-laid over the first layer to help distribute the load and to prevent sacks from falling through. In preparing brush for a mattress, all leaves and small twigs must be removed to prevent stoppage of drains.

The mattress is then loaded with sand-filled or gravel-filled sacks or riprap in the form of a buttress as required to hold the failure, having the heaviest part of the load on the berm, not more than one layer near the top and no load at the very top.

Great care should be taken when placing the second and third layers of sandbags because placing these layers too far up the slope can add load to the slide area causing additional movement.

<u>Board Mattress – Standard Type</u>. When brush is not available or impracticable to obtain, a board mattress may be constructed instead of the brush mattress as shown on Plate No. 32, Appendix I. Any width of 1-inch lumber may be used, but either 6-inch or 8-inch widths will probably be more available than other sizes.

To construct a standard board mattress, begin by first draining the levee slope and berm, as described above, making the slope ditches 3 to 6 feet on centers. Lay a board over each drainage ditch up and down the levee slope and as far across the berm at right angles to the levee as considered necessary to hold the slope mattress in place. Fill in between the first boards with parallel boards up the slope and across the berm leaving about 1-inch cracks between boards.

Place the top layer of boards across the bottom layer and parallel to the levee leaving about 2-inch cracks beginning at the toe of levee and working up and down. The top boards should be randomly nailed to the bottom boards with at least two nails to each board. On levee slopes of 1 vertical on 3 horizontal and steeper, 2-by-4s should be placed about every 3 feet in the top layer to prevent the sacks from slipping down.

The mattress is then loaded in the same manner as the brush mattress.

Board Mattress – Stringer Type. For a condition known as "dry slide" in which the landside levee slope breaks away and moves out but is not excessively wet or soggy and simple reinforcement or buttressing is indicated, the stringer-type board mattress can be used effectively as shown on Plate No. 33 in Appendix I.

The method of construction is like the other board mattress except 2-inch-by-4-inch lumber is used for the bottom layer instead of 1-inch lumber. Drain the slope as in the other method with ditches 2 feet on centers. Then lay one 2-inch-by-4-inch, 4-inch side down, between each drain running up the levee slope to a point several feet above the slide and well out onto the berm. Lay the 1-inch lumber across the 2-by-4s, nailing as required to hold in place.

The mattress is then loaded in the same manner as the brush mattress.

Blankets. See **Reducing Levee Erosion**, pg 33.

Seepage that occurs along a drainage structure can be stopped most effectively by placing plastic sheeting around the outlet of the structure that is located on the riverside of the levee on the upstream and downstream levee slopes from the drainage structure.

If it becomes necessary to prevent leakage through a levee system as a result of improperly adjusted or damaged gates, the outlet on the riverside of the levee should be covered with a row of sandbags or earth filled bags, and plastic sheeting. If the water level on the riverside of the levee prevents this, it may be necessary to plug the inlet to the drainage structure on the landward side of the levee. This is much more difficult than plugging the outlet on the riverside of the levee. Any measure used on the landward side of the levee will probably leak and it may become necessary to pump the water back over the levee once it collects in the drainage ditches on the landward side of the levee.

Under seepage

1. Description

Under seepage is seepage water flowing through the foundation, usually near the landside toe of the levee or appearing as a spring or sand boil in ditches, borrow pits, or other depressions landside of the levee. Water that issues from sand boils flows through pervious strata under the levee and then breaks through the surface cover, washing with it material from beneath the levee base. A sand boil may gradually undermine a levee and result in a failure by causing sudden subsidence of the levee.

It is difficult to evaluate the seriousness of sand boils. Consequently, all sand boils should be watched closely. Any boil that enlarges and increases its discharge of material, especially if located within 200 feet of the levee toe, is considered a threat to the levee and should be controlled. Treatment of boils, however, is not limited to those within 200 feet of the levee toe. Incipient boils should be marked conspicuously with flagging on a stick so that patrols can locate them without difficulty and observe changes in their conditions. A boil which discharges clear water in a steady flow usually is not a serious menace to the safety of the levee. The only action necessary in this case is to make careful frequent observations of the boil and to drain the excess water off to prevent its impoundment near the levee. However, if the flow increases and in addition carries a material load of sand and silt, corrective action should be taken immediately to prevent levee failure.

2. Remedial Measures

The following is a discussion of methods to treat sand boils. Piping is an extreme condition caused by excessive under seepage in which foundation materials (soil) are transported from beneath the levee. Unless corrective actions are taken, a solution channel or "pipe" may develop and enlarge to the point where the levee could fail. Early treatment of sand boils found to be transporting soil materials is the best insurance against a piping condition from developing.

i. Lower Pool Level. The most effective method of controlling a sand boil is to reduce the head of water on the riverside of levee as shown on Plate No. 34 in Appendix I. This method, however, is not normally practical because it would take construction of a setback levee to eliminate or lower the river elevation.

ii. Sacking of Sand Boils. The most widely accepted emergency method of treating a sand boil is to construct a ring of sacked earth/sand around the boil, building up a head of water within the ring sufficient to reduce the velocity of flow that prevents further erosion of sand and silt. This method is illustrated on Plate Nos. 35 through 39 in Appendix I. The ring should not be built to a height that stops the flow of water because of the probability of building up an excessive local pressure head, increasing the risk of additional issues such as additional boils nearby.

iii. Method of Ringing Sand Boils. The accepted method of ringing or sacking a sand boil is described below and shown on Plate No. 35 in Appendix I.

- The base of the sack ring is prepared by clearing the adjacent ground of debris, vegetation, or other objectionable material, to a width sufficient for the base of the ring. The base should then be thoroughly scarified to provide a watertight bond between the natural ground and the sack ring (a very important step).
- A rule of thumb is to create a ring about three times the width of the boil, or a minimum inside diameter of 3 feet.
- The sacks are laid in a general ring around the boil, with joints staggered and with loose earth as mortar between all sacks. In general, it has been found that the best results can be obtained by commencing construction of the sack ring at its outer edge and working toward the center.
- The ring is carried to a sufficient height to stop the flow of soil from the boil. Work is stopped when clear water only is being discharged.
- A V-shaped drain constructed of two boards, a piece of sheet metal, or plastic sheeting should be inserted near the top of the ring to carry off the water. A spillway made of sandbags can also be used to discharge water from the sandbag ring.
- The water level in the ring will have to be adjusted as flood water rise. The goal is clear discharge water out of the spillway. Raising the water level too high may result in the boil moving to another location.

iv. Dimensions of Sack Ring. It is impossible to establish exact dimensions for a sack ring. Field conditions in each situation will govern. The diameter of the ring, as well as its height, depends upon the size of the boil and the flow of water from it. Field forces should determine the size of the ring upon consideration of the following:

- The sack ring should have sufficient base width to prevent side failure. The width should be determined by the contemplated height of the ring and should be not less than 1½ times the height.
- The enclosed basin should be of sufficient size to permit the sacking operations to keep ahead of the flow of water. If ground weakness is indicated close to the sand boil, it is well to include the weak ground within the ring, thereby avoiding the possibility of a breakthrough later.

v. Sacking Methods Versus Sand Boil Location. Sand boils at the toe of the levee are sacked in the same manner as those away from the levee, using the levee slope as one side of the enclosure as shown on Plate Nos. 38 and 39 in Appendix I. The seep drains on the levee slope should be constructed to drain the water from the sack ring.

If several sand boils appear within a relatively small radius, it is better to enclose the entire group in a sub-levee or single sack ring.

If sand boils break out in very low ground or deep ditches, it may be necessary to step down the head of water within the enclosure in two or three steps, by means of outside concentric rings, to avoid a "blowout" near the ring.

vi. Inverted Filter. An inverted filter as shown on Plate 40 in Appendix I is an expedient and economical means to control excessive seepage such as sand boils. A fine sand and/or filter fabric is normally placed over the seepage area with successively larger granular material placed on top. The section will allow the seepage water to be safely removed while holding down or trapping the fine soil material preventing the development of a piping situation.

vii. Corrugated Sheet-Steel Piling. An alternate method of ringing sand boils is using corrugated sheet-steel piling as shown on Plate No. 41 in Appendix I.

Using sheet-steel piling accomplishes the same task faster than sandbagging but is limited in use by the availability of material, equipment and location of boils. Care should be taken to ensure the water levels inside the ring are adjustable. However, as previously stated throughout this manual, circumstances will dictate the system or method most applicable.

Sudden Draw Down

1. Description

   Distress due to sudden draw down results in the sloughing or sliding of the riverward side-slope of a levee after the flood waters recede. This condition develops in levee systems constructed of impervious material, such as clay, which become saturated during a flood and the floodwater recedes faster than the levee can drain. During the period that the flood water is receding, the riverward side slope should be inspected closely for cracks and slides to determine if corrective actions should be taken.

2. Remedial Measures

   In the event of a sudden draw down failure, loading the toe of the levee like the techniques described for through-seepage control can be used. If under water placement becomes a problem, a temporary earth-filled setback levee may be the only solution.

Burrowing Animals

1. Description

   Burrowing animals can severely threaten the integrity of a levee system and these animals need to be controlled. Animals of particular concern are the pocket gopher, ground squirrel, badger and fox. The most common is the gopher, which pursues activities mainly underground and is seldom seen on the surface.

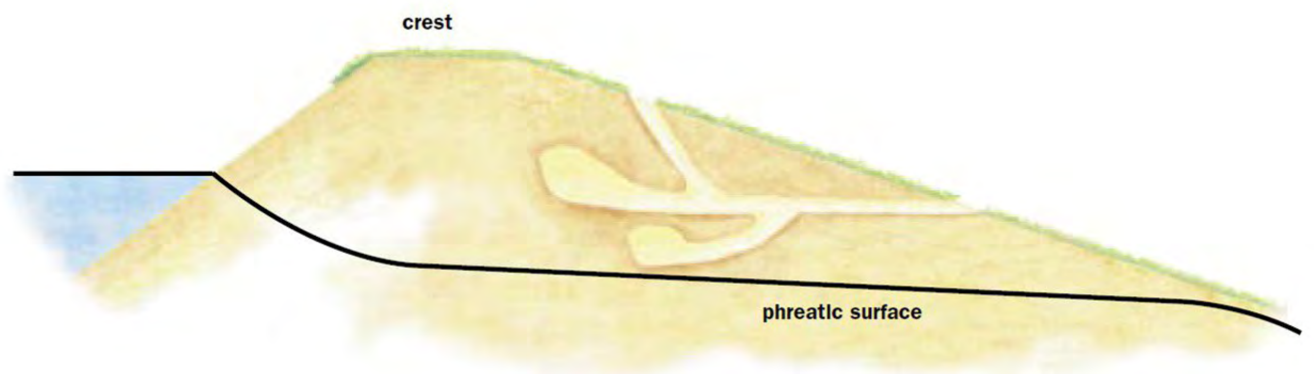


Figure 32: Embankment cross section with gopher burrows (FEMA Technical Manual)

   The burrow openings, created by most of the animals observed on the levee, are approximately 3 inches in diameter and are evidenced by a mound of fresh earth 1 to 2 feet across. The opening is always filled with a few inches of loose earth. The burrow is a system of runways, side branches, food storage, and nesting chambers, with numerous openings to the surface spaced very close together. The chambers or burrows may have a depth of several feet.

   During periods of flood, the river water and the seep water drive the animals to the levee from the adjacent low areas. The animals immediately burrow into the levee and overnight may honeycomb the levee with runs. As the water rises, new runs are opened higher on the levee and the old ones are left open for water to enter. When a run or system of runs below the water elevation happens to connect from landside to riverside, the water literally pours through the levee.

2. Remedial Measures

   There are generally two methods used to control levee failure caused by water flowing through holes in the levee created by burrowing animals:

   a. Ring the landside opening with sacks the same as for a sand boil.
   b. Plug the opening on the riverside with sandbags or plastic sheeting.

When a leaking burrow is first observed, effort should be made to first stop the flow from the riverside by spreading a tarpaulin or plastic sheeting on the riverside slope and weighting it down with sandbags. A single sack over the riverside opening of the burrow may stop the burrow from leaking if the opening can be found, but the tarpaulin or plastic sheeting has the advantage of covering a larger area since the intake opening might not necessarily be exactly opposite the discharge opening. The tarpaulin or plastic sheet would probably be more impervious than a sandbag and would therefore provide a better seal.

If the burrow hole is high up on the landside slope with minimal hydraulic head, sacks tamped directly into the outlet will effectively stop the flow. It would be necessary to cut a small notch or bench at the opening to seat the sacks into place.

Landside treatment, which may be required if the riverside opening cannot immediately be stopped, is to build a sack ring like a boil ring around the landside opening with a sufficient base width to support a ring to a height sufficient to stop the flow of water. This ring differs from a boil ring in that it is required to stop the flow of water. The time, material, and labor required for a ring emphasizes the importance of first attempting to stop the flow from the riverside of the levee structure.

Levee Breach

1. Description

   If the levee were to breach due to the failure modes shown in Figure 21 the following remedial measures are recommended.

2. Remedial Measures

   Where it is practical and desirable to do so, closure of a breach in a levee will reduce the period of inundation of the property inside of the levee, prevent the breach from widening, and reduce the damage caused by subsequent rises that may occur before the levee can be repaired. For Federally constructed projects, the U.S. Army Corps of Engineers, District Engineer will make determination if a breach should be closed.

   Generally, a breach closure should not be attempted on a rising river stage or on an extremely high stage. Conditions could develop such that it would become impossible to accomplish the closure. The time to attempt a closure is on a falling river stage when the velocity and turbulence of the flow through the breach has decreased sufficiently to assure complete success of the effort.

   There are undoubtedly several acceptable methods of making a closure. However, each closure must be considered as a special case depending on the general location, size, river stage, economics, and the health and safety of the general public.

   Seepage through and under a levee may be controlled to prevent a levee failure from occurring, however, a significant quantity of water may pond on the landward side of the levee with no place to drain to. In this situation, pumping may be used to prevent damages caused by seep water.

   a. Structure and Plan for Closing a Levee Breach

      One levee closure plan, which has been developed and successfully used by USACE, is detailed in the following paragraphs. It should be considered for use, only under specific situations where the plan and general conditions are complementary and not as a standard procedure for all closures. The structure is composed of two parts:

      i. A timber trestle filled with sandbags to shut off the free flow of water
      ii. An earth-filled mud box landward of the trestle to reinforce and make the structure watertight, constructed in that order as shown on Plate No. 42 in Appendix I.

   A scour hole usually forms in the breach slightly landward and enlarges to the landside. The closure structure should be located far enough away from the edge to allow for enlargement of the scour hole and the structure may be placed either on the landside or the riverside of the crevasse depending on which has the shallower water and the least number of obstructions. The ends of the structure should join the existing levee well back from the edges of the breach to allow for caving while the closure is being built. Trees should be cut off just above the water surface to prevent any movement of sandbags caused by trees swaying in the wind.

The closure should never be started until all required labor and material are available at the site so that closure can be made without interruption. The delay of a few minutes at a critical time may mean the loss of the closure.

Closing a levee breach entails considerable danger to personnel working on the closure. Handrails should be installed where needed, the project should be well-lighted, and employees should wear life vests when working near water. At least two boats equipped with oars and ring buoys with handlines and always manned by experienced operators should be anchored just below the levee breach. An experienced first-aid team equipped with first-aid equipment should be always available.

In areas where soil material and earthmoving equipment are available, the levee closure can be constructed of earth.

b. Timber Trestle

The components of the timber trestle and mud box levee closure are described below:

i. Drive four 4-inch-by-4-inch upright posts. The mud box post is lower than the trestle posts; it should be about 6 inches above the water.
ii. Nail a 2-inch by 6-inch crosspiece on each side of the three trestle posts at the top and one 2-inch by 6-inch crosspiece from the center post to the mud box just above the waterline.
iii. There should be four runways, two along the top of the mud box and two along the top of the sack trestle. Each runway consists of two 2-inch by 10-inch boards laid side by side. The runway boards are projected beyond the last bent so men can stand side by side to drive the posts of the next bent. Bents are spaced 4 feet on centers.
iv. Five stringers are placed. One each under the cross-piece on the landside posts, center posts, and riverside posts, and one each just above the waterline on the center posts and the riverside posts.
v. Hog wire netting is strung along the riverside of the center posts and nailed to the lower stringer by 40d nails; the lower edge of wire is extended across the bottom of the trestle so it will be held down by sacks when they are dropped on it.
vi. One-quarter inch wire strand braces are placed on the trestle part of each bent, as shown on the plan, but not on the mud box posts.
vii. Sufficient filled sacks should be stockpiled to complete the closure; because once this operation is started, it must not be stopped until completed. The first sacks are distributed across the bottom and banked against the hog wire. The dam is then brought up on a level grade so that the flow of water is distributed evenly over the entire length. The crest can be brought above the water surface first against the hog wire netting and then widened on the riverside until the dam is brought to the desired grade and cross section.

c. Mud Box

After the sandbags in the trestle cut off the free flow and as soon as the backwater will permit, the mud box can be completed in the following order:

i. Clear and grub the base, removing all debris.
ii. Nail a 2-inch-by-6-inch stringer along the inside of the landside row of posts just above the ground.
iii. One-quarter inch wire strand braces are placed at each bent as shown on the plan.
iv. 12-inch sheeting is driven along the inside of the wall and nailed to the stringers.
v. Earth is dumped and tamped into the box until it slopes from the crest of the sack dam to the top edge of the mud box wall.

Closures

Closures can consist of gaps, culverts, or pipes in the flood barrier system that are to be left open until flood stage reaches a critical elevation, at which point they are closed with a barrier (gates, stop logs, sandbags, HESCO barriers, etc.) and become part of the larger flood barrier system. The critical flood elevation must be based on the time required to activate the work crew, get materials to the site, and complete the construction. The speed of the water rising must be considered. Closures can be performed using flood barrier methods described in this manual (e.g., sandbag dikes), however many closure structures have predetermined materials such as stoplogs that can be slotted into the structure. Refer to O&M Manuals and site-specific closure processes before determining proper closure method.

Typical examples of closure structures include gap closures, floodgates, and flap gates. Gap closures are gaps in the levee or floodwall where roadways and railroad tracks are allowed to continue to cross the flood barrier until the water level reaches an elevation where the risk of flooding becomes unacceptable. Some gap closures are concrete structures that have slots for stoplogs or other structures such as large movable gates to be placed in to act as a barrier. Wider gap closures without specified structures may require the construction of sandbag dikes or HESCO barriers to properly close.

Figure 33: Installation of wooden stoplogs being slotted into place at gap closure

Certain closing methods may require significant coordination and training due to the time to construct as well as the agencies who may use the roads and railways regularly. Roadway and railway closure timing should be well understood by other agencies as modification of rail schedules can be difficult and roads may be used as evacuation routes prior to closure. Railroad closures that are not well communicated can lead to dangerous situations if the rail is still active when the closure barrier is being constructed or already in place. Situations can also arise where people or equipment may be stuck on the waterside of the structure if not evacuated or moved on time.

Floodgate closures are pipes, culverts, or similar structures that are typically manually closed with a gate to prevent floodwaters from flooding the protected area. Inspections of gates and gate operators should be performed on a regular basis to ensure both the gate and the mechanisms for operating the gates are full functional leading into flood events. Gate closing operations on active pipes can potentially have significant impacts to the organizations that use them for operations other than flood response.

Although the means of blocking closures can typically be implemented quickly if proper preparations are taken, unanticipated problems occurring at a critical time when closure activities are underway could result in resources being reallocated elsewhere. This may result in a slower time for closure. If water rises faster than expected, sealing gap closures and closing gates may not be finished and the flood barrier system may not function as intended.

Flap gates are hinged gates at the end of pipes that allow water flow out of the pipe in one direction. Flap gates are typically automated and will open when there is sufficient water pressure in the pipe to push the gate open. They will close when there is little to no water in the pipe or flood water rises above the outside of the pipe. These gates need to be inspected and tested regularly. Flap gates that are not regularly used can rust shut or not open fully when the required pressure is applied to them, which can be an issue especially for pump systems that are dependent on flap gates to be fully open to remove water from flooded areas.

Closures should be monitored when loaded, especially those constructed with temporary measures such as HESCO barriers and sandbags. These structures can fail if improperly installed, poorly maintained, or experience higher than anticipated loading.

Construction of Sandbag Levees

1. Site Selection and Preparation

   When selecting the location for a levee, consider the ground elevation, ground condition, obstructions, and alignment. For stability, the levee should be kept as short and low as possible. Avoid any obstructions that would weaken the levee, and do not build the levee against a building wall unless the wall has been designed to retain floodwaters. If possible, plan to leave at least 8 feet between the landward toe / base of the levee and any building or obstructions to allow for future levee raises, levee monitoring, construction equipment and vehicles, and to prevent damage to building walls and foundations.

   Remove all ice and snow from a strip of land at least as wide as the base of the levee. If the levee will be more than 2-3 feet high, remove a strip of sod to create a bonding trench along the center line of the alignment to better anchor the levee in place, as shown in Figure 34.

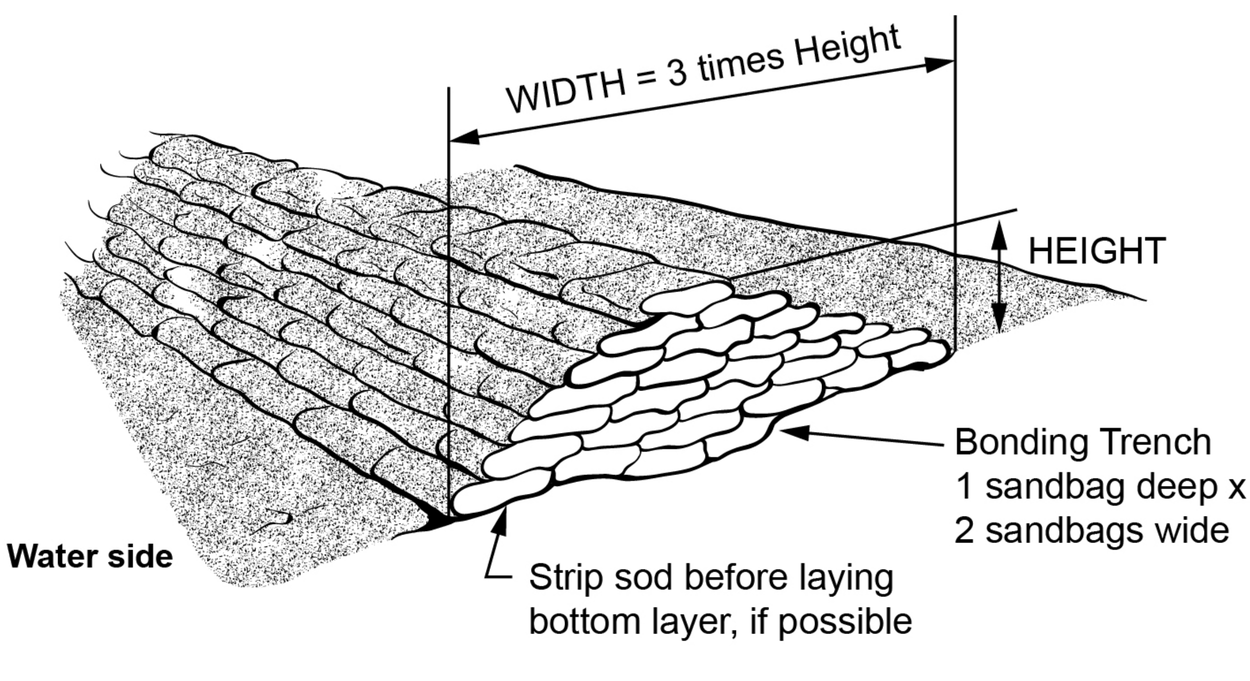


Figure 34: Proportions of sandbag levee showing bonding trench at base.

2. Stacking Sandbags to Form a Levee

Overlap the sandbags as shown in Figure 35, placing the first layer of bags lengthwise along the levee and lapping the bags so the filled portion of one bag lies on the unfilled portion of the previous bag.

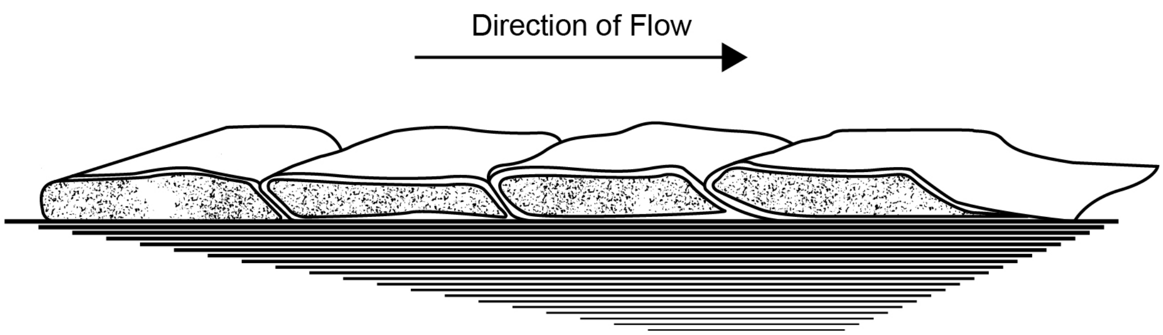


Figure 35: Sandbag placement

The bags should be placed lengthwise and overlapped parallel to the direction of the river flow. The bonding trench shown in Figure 35 should be filled with a layer that is two sandbags wide by one sandbag high; the first full layer is then placed over this bonding trench. The base of the levee should be three times as wide as the levee is high.

The second layer of bags should be staggered perpendicular to the first layer and placed over the seams of the previous layer, with additional layers laid in alternating directions to the top of the levee, as shown in the "Correct" example in Figure 36. By alternating placement directions, the gaps and seams along the edges and corners in each layer below will be covered and filled in by a sandbag in the next overlying layer. Plate 1 in Appendix J of this manual illustrates additional details of sandbag placement.

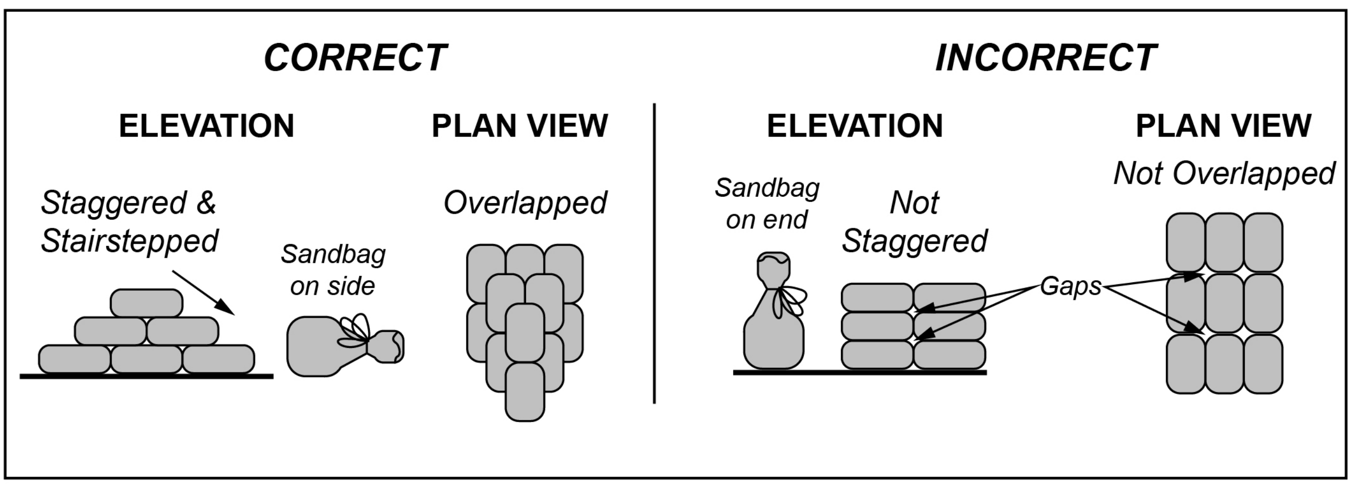


Figure 36: Correct and incorrect placement of staggered sandbag layers.

3. Sealing the Levee

The finished levee can be sealed with a sheet of polyethylene plastic (poly) to improve water tightness. The poly sheeting should be about 6 mils thick and is generally available in 20-foot-wide-by-100-foot-long rolls from construction supply firms, lumberyards, and farm stores.

a. Anchoring

The poly must always be anchored at the bottom edge and weighted along the top and slope to be effective. Three methods are recommended to anchor the poly on the riverward face of a sandbag levee.

The most successful anchoring method is to place the poly flat on the ground surface extending away from the bottom row of sandbags, and then place one or more rows of sandbags over the flap. The poly should then be unrolled over the anchoring row of sandbags, anchored again, and then up the slope and over the top of the sandbag levee, far enough to allow for anchoring with additional sandbags. This method is illustrated in Figure 37 and shown on ***Plate 2*** in Appendix J of this manual.

An alternate method to anchor poly is to spread a layer of dirt or sand one inch deep and about one foot wide along the base of the levee on the water side, to create a uniform surface to anchor the poly. Lay the poly sheeting so the bottom edge extends one to two feet beyond the bottom edge of the sandbags over the loose dirt, and then place sandbags over the edge of the poly to anchor. This method is illustrated in Figure 38 and included on ***Plate 2*** in Appendix J of this manual.

A third method to anchor the poly is to excavate a 6-inch or deeper trench along the toe of the levee, place poly in the trench, and backfill the trench, compacting the backfill material or placing a row of sandbags over the trench to prevent loss of the backfill material. This method, illustrated in Figure 39, will be unsuitable if water levels have reached the sandbags at the toe of the levee.

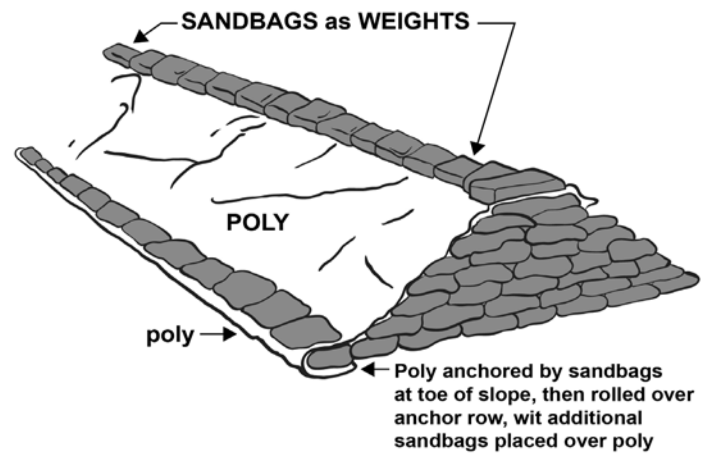


Figure 37: Preferred method of tucking and anchoring poly with two rows of sandbags.

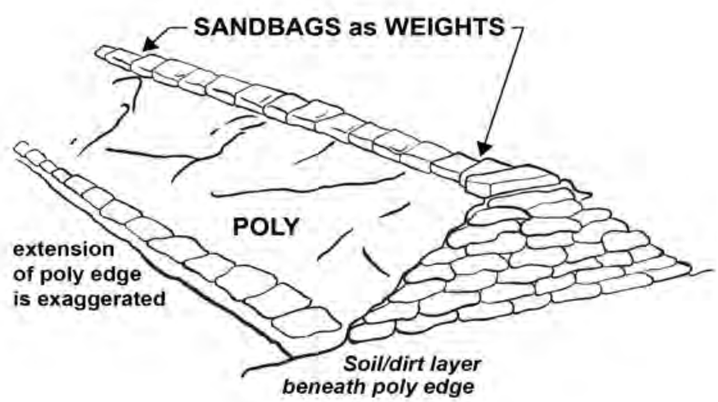


Figure 38: Poly edge placed over dirt and anchored with a row of sandbags.

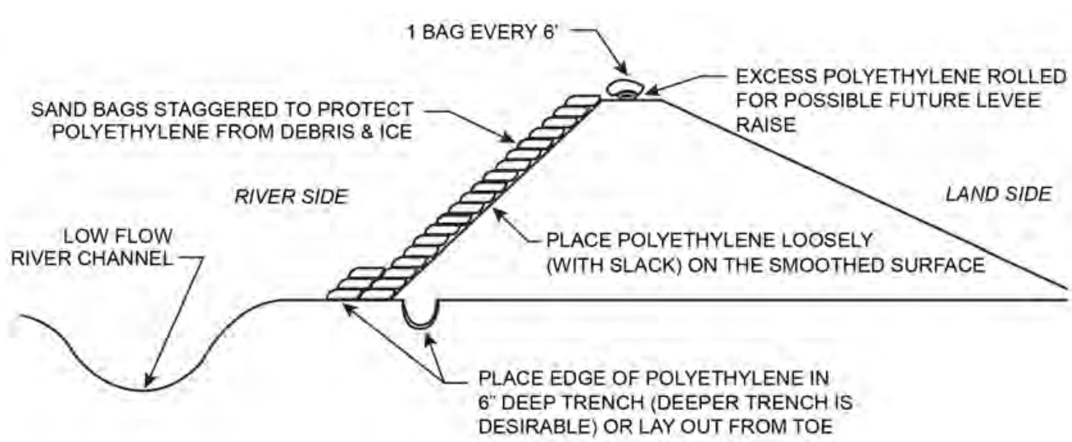


Figure 39: Poly anchored within a trench (placed under dry conditions).

b. Placement

Poly should be placed from downstream to upstream along the slopes and the next sheet upstream overlapped by at least 3 feet, as shown on Figure 40. Overlapping in this direction prevents the current from flowing under the overlap and tearing the poly loose. After the poly is anchored in place, it should be unrolled up the slope and over the top. Lay the poly sheeting down very loosely, as the pressure of the water will make the poly conform easily to the sandbag surface if the poly is loose. If the poly is stretched too tightly the force of the water could puncture the poly.

c. Weighting

Once the poly is anchored and unrolled, additional sandbags, boards, and/or loose dirt should be used as weights along the top of the levee to keep the poly in place and prevent the wind or river current from disturbing it. These weights are not shown on the illustration. Avoid puncturing the poly with sharp objects or by walking on it.

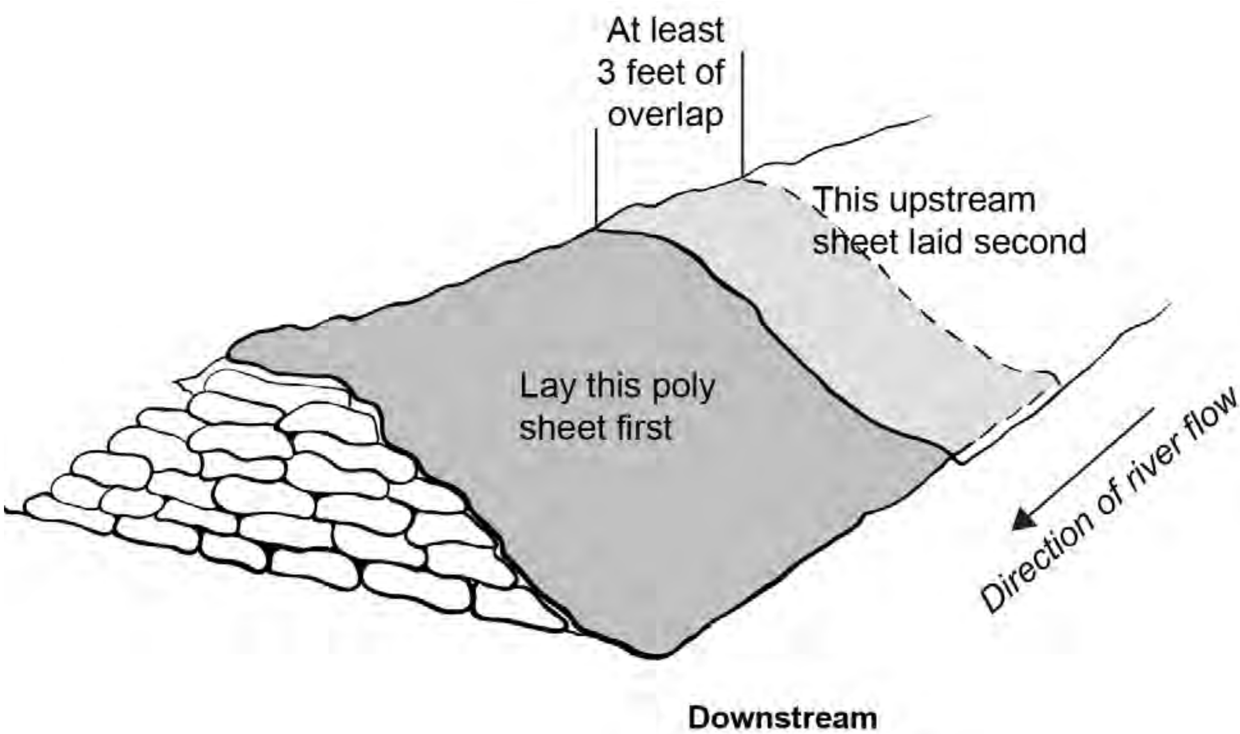


Figure 40: Poly placement from downstream to upstream with overlap shown.

4. Number of Sandbags Needed

The information in Table 1 indicates the approximate number of sandbags that are needed for levees of various heights and lengths. Note that 5 feet high is the practical limit of a sandbag levee. If a higher sandbag levee is needed, alternative means of construction should be considered. The preferred height limit is 3 feet.

Estimated Number of Sandbags Per Linear Foot of Levee	
Height in Feet	Bags Required
1	6
2	21
3	45
4	78
5	120

LEVEE HEIGHT	Number of Sandbags Required or Length of Levee									
	50 FT	100 FT	175 FT	200 FT	250 FT	300 FT	350 FT	400 FT	450 FT	500 FT
1 Foot	300	600	1,050	1,200	1,500	1,800	2,100	2,400	2,700	3,000
2 Feet	1,050	2,100	3,675	4,200	5,250	6,300	7,350	8,400	9,450	10,500
3 Feet	2,250	4,500	7,875	9,000	11,250	13,500	15,750	18,000	20,250	22,500
4 Feet	3,900	7,800	13,650	15,600	19,500	23,400	27,300	31,200	35,100	39,000
5 Feet	6,000	12,000	21,000	24,000	30,000	36,000	42,000	48,000	54,000	60,000

Construction of Earthen Embankments

Earth fill levees rather than sandbag levees are the preferred type of emergency flood barrier for large scale flood responses, and their construction should be directed by experienced flood response workers.

a. Foundation Preparation

Prepare the levee footprint as follows prior to placing fill:

i. Remove snow from the ground surface and place snow on riverside of levee to eliminate ponding of water behind levee when snow melts.
ii. Trees should be cut, and the stumps removed.
iii. All obstructions above the ground surface should be removed, if possible. This will include brush, structures, snags, and similar debris.
iv. The foundation should then be stripped of topsoil and surface humus, if possible. Any material removed should be pushed landward of the toe of levee and windrowed.
v. Stripping may be impossible if the ground is frozen; in this case, the foundation should be ripped or scarified, if possible, to provide a tough surface for bond with the embankment.

NOTE: Clearing and grubbing, structure removal and stripping should be performed only if time permits.

Every effort should be made to remove all ice or frozen ground. Frost or frozen ground can give a false sense of security in the early stages of a flood response. It can act as a rigid boundary and support the levee; however, on thawing, soil strength may be reduced sufficiently for cracking or development of slides. It also forms an impervious barrier to prevent seepage. This may result in a considerable build up in pressure under the soils landward of the levee, and, upon thawing, pressure may be sufficient to cause sudden failure of the foundation material resulting in piping, slides, and boils. If the ground is frozen, it must be monitored, and one must be prepared to act quickly if sliding or boiling starts.

b. Levee Fill

Earth fill materials for emergency levees will come from local borrow areas. An attempt should be made to use materials that are compatible with the foundation materials as explained below. However, due to time limitations, any local materials may be used if reasonable construction procedures are followed. The materials should not contain large frozen pieces of earth.

i. **Clay Fill:** Most earth fill levees erected in recent floods consisted of clay or predominantly clay materials. Clay is preferred because the cross-section width can be made smaller with steeper side slopes. Clay is also relatively impervious and has a relatively high resistance to erosion in a compacted state. A disadvantage in using clay is that adequate compaction is difficult to obtain without proper equipment. Another disadvantage is that if the clay is wet, subfreezing temperatures may cause the material to freeze in the borrow pit and in the hauling equipment. Cold and wet weather could cause delays and should be considered in the overall construction effort.
ii. **Sand Fill:** If sand is used, the cross-section of the levee should comply as closely as possible with recommendations described in the following design section. Flat slopes are important. Steep slopes, without poly coverage, will allow seepage through the levee, creating high outflow on the landward slope and may cause slumping of the slope and eventual failure.
iii. **Silt:** Material that is primarily silt should be avoided. If it must be used, poly sheeting must always be applied to the river slope. When silt gets wet, it tends to collapse under its own weight and is very susceptible to erosion.

c. Levee Design Section

The dimensions of the levee design section are generally dictated by the foundation soils and the materials available for construction. Therefore, even under emergency conditions, an attempt should be made to make the embankment compatible with the foundation. Information on foundation soils should be requested and considered, if available from local officials or engineers. The three foundation conditions and the levee design sections described below are classical and idealized, and assume a sand foundation, a clay foundation, or a thin clay layer over sand foundation. Actual field conditions generally depart from the ideals to various degrees. However, the described levee design sections for each foundation should be used as a guide to reduce the likelihood of serious flood response problems during high water.

In determining the top width of any type of section, consideration should be given to whether a revised flood level forecast will require additional fill to be placed. A top width adequate for construction equipment will facilitate raising the levee. Finally, actual levee construction will, in many cases, depend on available time, materials, and right-of-way access.

i. Sand Foundation – Pervious and permeable (readily allowing water to pass through).

- ***Sand Section:*** Use a ratio of 1V (V=Vertical) to 3H (H=Horizontal) on the riverside slopes, and a ratio of 1V to 5H on the landward slope, with a 10-foot top width.
- ***Clay Section:*** Use a ratio of 1V to 21/2H for both the riverside and landside slopes. The bottom width of the levee section should comply with creep ratio criterion, i.e., L (across bottom) should be equal to C x H; where C=9 for fine gravel and 15 for fine sand in the foundation, and H is levee height. This criterion can be met by using berms consisting of material placed on either the landward or riverward side of a levee that extends beyond the normal levee footprint. These berms are placed to control or relieve uplift pressures and lengthen the seepage path, although they will not significantly reduce the volume of seepage. Berms are not as high as the levee itself and thickness should be 3 feet or greater.

ii. Clay Foundations – Impervious (does not allow water to pass through)

- ***Sand Section:*** Same as paragraph in the first bullet in section i. above.
- ***Clay Section:*** Use a ratio of 1V to 2½H for both the riverside and landside slopes.

iii. Clay Layer over Sand Foundation

- ***Sand Section.*** Use the same design as paragraph in the first bullet in section i. above. Additionally, a landside berm of sufficient thickness may be necessary to prevent rupture of the clay layer. The berm may be composed of sand, gravel, or clay material. Standard design of berms requires considerable information and detailed analysis of soil conditions. However, prior technical assistance may reduce berm construction requirements in any emergency.
- ***Clay Section.*** Use the same design as paragraph in the second bullet in section i. above. A berm to prevent rupture may also be necessary as described in paragraph 3.a.

Proper compaction of the emergency levee is critical to stability. Use of standard compaction equipment such as a sheepsfoot roller, may not be feasible during emergency operations because of time constraints or limited equipment availability. It is expected that in most cases the only compaction available will be from hauling and spreading equipment, such as dump trucks and dozers.

d. Erosion Protection for Emergency Levees

Erosion protection may be required for earth fill levees. Factors that influence whether additional erosion protection is required include levee material (clay levees tend to be much more resistant to erosion than sand levees), channel velocities, presence of ice and/or debris in channel, wave action, and seepage. Methods of protecting levee slopes are numerous and varied. However, during a flood emergency, time, availability of materials, cost, and construction capability may limit the use of certain accepted methods of permanent slope protection.

Structure Protection

1. Description

The main causes of damage to structures, homes, and property during heavy rains or flood flows are:

a. Flood water from overwhelmed storm drains and urban diversions, particularly on sloping streets.
b. Flood flows onto property through driveway openings and low spots in curbs.
c. Debris flow from hillsides that have been cleared of vegetation by fire or development.

The flood response methods described in the following sections have proved effective in combating floodwaters and debris flows.

2. Remedial Measures

a. Diverting Water or Debris Flows Away from Structures

Homes and structures can be protected from floodwater or debris flows by redirecting the flow as shown in Figure 41. Sandbag barriers must be long enough to divert the flows away from all structures. Barriers constructed of sandbags and lumber as well as RDFW, HESCO Bastion, and Portadams can also be used to channel mud and debris away from property improvements.

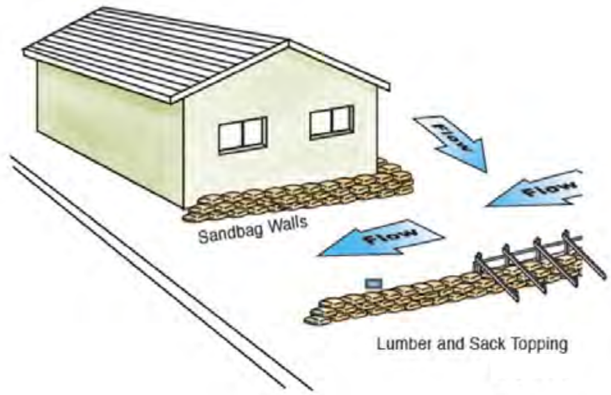


Figure 41: To divert mud, debris, and water, use sandbag walls or lumber and sack topping (California Natural Resources Agency Department of Water Resources)

b. Structure Protection

The following method is used for protection of buildings and other structures along lake shores and in similar situations where water is rising with little or no current. Lay plastic sheeting on the ground and up the building walls to a point at least 1 foot above the predicted water elevation. Place sandbags on the plastic sheeting in the form of a half pyramid against the structure (see Figure 42). Secure plywood over doors and vents. Overlap plastic sheeting and sandbags at corners of buildings. Manufactured temporary barriers may also be used for structure protection.

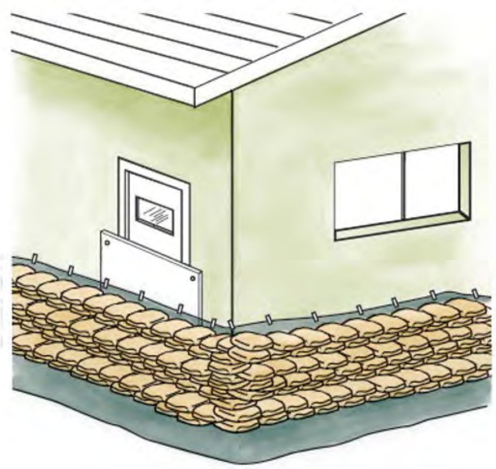


Figure 42: Structure protection. (California Natural Resources Agency Department of Water Resources)

c. Wet Flood Proofing Requirements for Structures Located Within Special Flood Hazard Area

National Flood Insurance Program regulations require that buildings on extended wall foundations or that have enclosures below the base flood elevation must have foundation or enclosure wall openings. These openings prevent the foundation or enclosure walls from weakening or collapsing under pressure from hydrostatic forces during a 100-year flood event. The openings allow flood waters to reach equal levels on both sides of the foundation or enclosure wall and minimize the potential for damage from hydrostatic pressure.

THESE OPENINGS MUST NOT BE BLOCKED IF THE BUILDING IS LOCATED WITHIN A SPECIAL FLOOD HAZARD AREA.

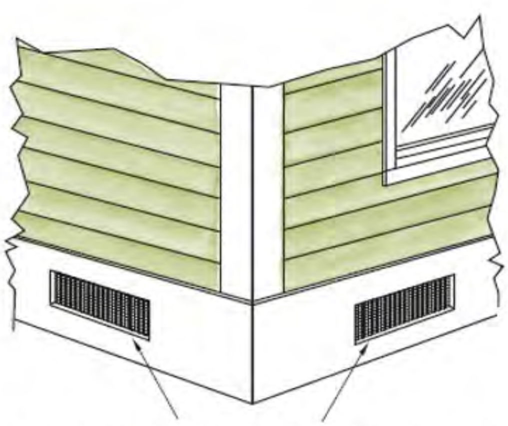


Figure 43: Foundation and wall openings in structures (California Natural Resources Agency Department of Water Resources)

For details refer to FEMA Technical Bulletins TB1-93 and TB-7. These bulletins may be obtained from the FEMA web site at: http://www.fema.gov.

d. Water / Storm Drain Protection

Flows through storm water or sewer systems can be reduced by placing a large pipe such as corrugated metal pipe (CMP) or concrete pipe over the utility hole (See Figure 44) and keeping floodwaters out of an area with a temporary barrier installed. Lay plastic sheeting up the walls of the CMP and place sandbags in the form of a half pyramid around the CMP to seal it to the pavement. This method will prevent mud and debris from entering the system and also act as a surge chamber. Alternately, expanding foam sealant can be used reduce flow underneath concrete pipes. These methods may result in a higher pressure inside the sewer system than designed.

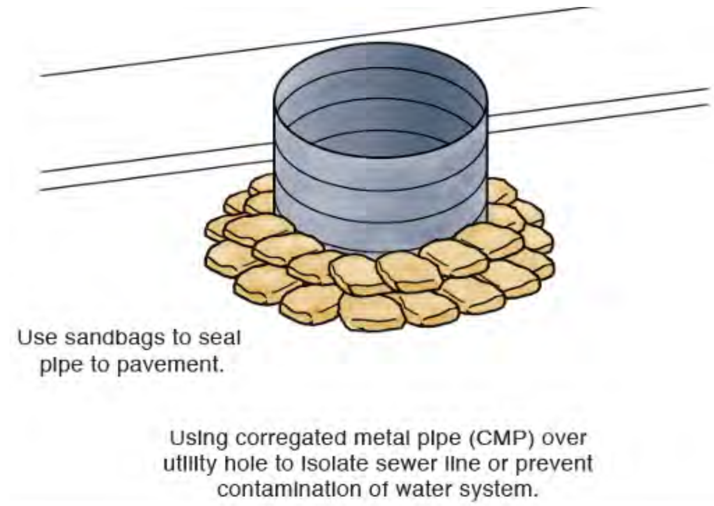


Figure 44: Reducing interior flooding of area within a temporary barrier. (California Natural Resources Agency Department of Water Resources)

Interior Drainage Issues

1. Description

High river stages often disrupt the normal drainage processes. Storm sewer and sanitary sewage treatment plants can become inoperative, which cause floodwater and other fluids to flow backward within the system into homes and businesses, and eventually into the river. When the river recedes, some of the sewage and natural storm water runoff may be trapped in low-lying pockets behind the constructed levees, causing the ponded area and soils to become contaminated.

Quickly constructed flood barriers intended to keep out river waters may also seal off normal outlet channels for local runoff, creating large ponds on the landward side of the barrier. As the ponded runoff level increases, the levee now becomes vulnerable from both sides, increasing saturation of the levees and nullifying the benefits provided even if the dike is not overtopped. In these cases, the ponded runoff will need to be pumped over the barrier to the river side. Closing storm water and/or sanitary sewers will need to be included in a Flood Response Plan to ensure impact areas are free of floodwater.

2. Preliminary Work

To arrive at a reasonable plan for interior drainage treatment, several items of information must be obtained by field personnel. These include:

- Size of drainage area (most city blocks are about 2.5 acres).
- Pumping capacity and/or ponding required if data is not available. This can be estimated in section 3.e., or by working with a local public works, engineering consultant, or technical assistance from the USACE.
- Basic plan for treatment.
- Storm and sanitary sewer and water line maps, if available, with sizes, especially those close to the flood waters.
- Location of sewer outfalls (abandoned or in use).
- Inventory of available local pumping facilities and pumping equipment providers.
- Probable location to set up pumping equipment close to the water source.
- Whether larger drainage channels/pipes are necessary to drain surface runoff to ponding and/or pump locations to increase discharge capacity to ensure enough water is directed toward the pumps.
- Location of septic tanks and drain fields (abandoned or in use).

3. Pumps -Types, Sizes and Capacities

Temporary pumps should be obtained wherever they are available. When public property is being impacted, the County, State, or Federal Government might have them available.

However, local businesses might have them available for rent or for free if those pumps help keep their business dry. All pumps are generally supplied with two to three lengths of 50-foot butyl rubber hose or similar hose type. Care must be taken to prevent damage to the hose. Irrigation pipe, culverts, or PVC pipe with a ring clamp can serve as to lengthen the discharge pipe. Too long of a discharge pipe will reduce output due to friction loss in the pipe. If needed, a hose end may be cut off if it needs to be extended. Replacement cost will be determined in the future by the owner of the hose; removing ponded water can be more critical if significant damage is occurring by interior ponded water.

On 12' or larger lines, substantial anchorage is required to ensure the pipes do not move. Care should be taken to extend pump discharge lines riverward far enough to not cause erosion of the levee. Any sustained discharge on soil can cause an erosion spot that can reduce or severely impact the integrity of the levee. Discharge should be made on concrete, large riprap, sheets of plywood, large sheets of poly, or metal (all secured to not float away). One local solution was to extend the discharge end of the pipe into water using an extension ladder on stilts.

a. Diesel Powered Pumps

Diesel powered self-priming pumps excel at pumping out of manholes. These pumps may also be used for ponded water. Table 2 shows sizes and capacities of diesel trailer mounted pumps.

		Discharge at RPM in Gallons Per Minute (GPM)				
Pump Size	Load in lbs	1400 RPM	1800 RPM (Advised RPM)	2000 RPM	2200 RPM (Max)	Fuel Consumption in GPH
6”	3250	1500	1900	2150	2370	0.8-3.5
8”	5250	2500	3000	3200	3350	1.5-5.2

Table 3: Typical Performance Data for Trailer Mounted Diesel Powered Self Priming Pumps

To use diesel pumps effectively:

- Ensure pump is level using jack stands or cribbing.
- Make sure all hose joints are connected and supported.
- Allow engine to warm up and cool down.
- Raise and lower engine speed gradually.
- Open drain values after shutting down.
- Keep fuel going to the engine as the fuel delivery system will have to be bled to restart engine if the lines run dry.

b. Tractor Powered Pumps

3 shows sizes and capacities of tractor Power-Take-Off (PTO) agricultural-type pumps which are useful in large ponding areas. PTO pumps should not be operated on slopes greater than 20 degrees from horizontal.

**Adapters may be found locally if PTO splines are not compatible.

For heads over 20', a high-head impeller will have greater efficiency; however, these are not stocked with standard pumps

8” pump is 1,685 lbs; 12” pump is 1,685 lbs; 16” pump is 2,220 lbs

Size	GPM	PTO RPM	Gas or Diesel
15” Head			
4”	700	540	10
6”	1600	540	20
8”	2250	540	25
12”	3500	540	30
16”	8600	540	75
20” Head			
4”	600	540	10
6”	1250	540	20
8”	1750	540	25
12”	3000	540	30
16”	7000	540	75

Table 4: PTO Driven Crisafulli Pumps at 540 RPM

PTO pump hoses are for low differences in elevation between the pump and highest location of the pipe. Keeping that difference, or head, less than 25’ will ensure the hoses do not burst. Putting together a hose used for a PTO pump is a two-person job. Starting with the outlet to the pump, place the hose end with the softer ring onto the pump outlet. That ring needs to be pushed past the raised bump on the hose outlet. The metal ring clamp needs to go between the softer ring and the metal bump. Continue with the next section of hose.

Connecting the next pipe can be tricky. Take the hose from the pump and place it over the end of the next hose section that has a hard ring embedded within the pipe. Ensure the soft bump on hose 1 is over the hard ring bump by at least 1 inch. Take the loose metal ring toward that gap between the hard ring bump and the other bump (Figure 45). Dish soap and water can make this process easier. If the weather is cold, a heat gun can make the hose more pliable. Ensure you do not ruin the hose.

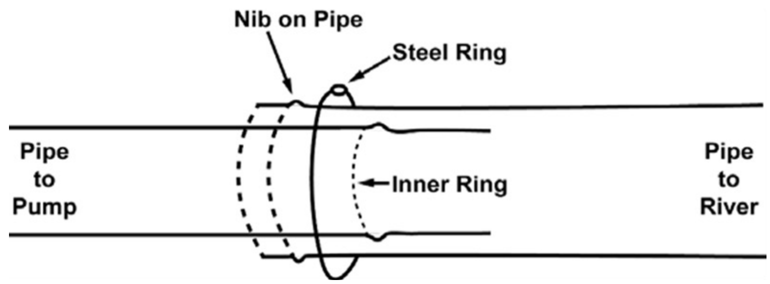


Figure 45: Cross-section of a Connected PTO Pump Hose (typical)

c. Fire Engine Pumps.

The ordinary fire pumper has a 4-inch suction connection and a limited pumping capacity of about 750 gpm. Use only if necessary. Damage to this critical equipment may take it out of service for an indeterminate timeframe and may result in more damages from fire than damages saved from flood waters.

Additional Pump Types

Table 5 indicates the size of pump needed to handle the full flow discharge from sewer pipes up to 24 inches in diameter. Table 6 shows sizes and capacities of agricultural type pumps that may be useful in ponding areas or in low areas adjacent to the flood barrier where a sump hole could be excavated. Table 7 lists full flow discharge capacities for clay sewer pipes laid on slopes of 0.001 and 0.005 feet per foot. Generally, the smaller pipes are laid on steeper slopes than are the larger pipes. Table 8 and Table 9 show sizes and capacities of Crisafulli and Flygt centrifugal pumps, respectively.

Sewer Pipe Diameter	Probable Required Pump Size
6-inch	2-inch
8-inch	2- to 3 -inch
10-inch	3- to 4 -inch
12-inch	4- to 6 -inch
15-inch	6- to 8 -inch
18-inch	6- to 10 -inch
21-inch	8- to 10 -inch
24-inch	10- to 12 -inch

Table 5: Matching Sewer Pipe Size to Pump Size

16-inch Regular Pump @ 540 rpm		
Dynamic in Feet	**Total Head Capacity Gallons per Minute**	**Brake Horsepower**
0	13,500	100
5	12,000	95
10	10,600	91
15	8,900	85
20	7,100	78
25	5,300	70
30	3,300	60
35	1,400	47
38.3	0	36.5
12-inch Regular Pump @ 540 rpm		
Total Dynamic Head in Feet	**Capacity Gallons per Minute**	**Brake Horsepower**
0	5,525	42
5	5,100	40
10	4,600	38
15	3,900	35
20	2,900	30
24.8	0	15.6

Table 6: Typical Pump Discharge Capacities for Agricultural Pumps used in ponded areas.

Pipe Diameter	|---- S = 0.001 ----|		|---- S = 0.005 ----|	
	cfs	gpm	cfs	pm
6-inch	0.19	85	0.35	156
8-inch	0.35	156	0.76	340
10-inch	0.65	292	1.60	720
12-inch	1.20	540	2.50	1,120
15-inch	2.1	945	4.5	2,020
18-inch	3.4	1,520	7.3	3,260
21-inch	5.0	2,230	11.2	5,000
24-inch	8.2	3,660	15.2	6,800

Table 7: Flow Capacity of Clay Sewer Pipe on two different slopes (S)

|-------------------------------- 10-foot Head --------------------------------|			
Pump Size	**gpm**	**Elec. HP**	**Gas or Diesel HP**
2-inch	150	1	
4-inch	500	7.5	15
6-inch	1,000	10	20
8-inch	3,000	15	25
12-inch	5,000	25	40
16-inch	9,500	40	65
24-inch	25,000	75	140
|-------------------------------- 20-foot Head --------------------------------|			
Pump Size	**gpm**	**Elec. HP**	**Gas or Diesel HP**
2-inch	130	1	
4-inch	490	10	20
6-inch	850	15	25
8-inch	2,450	20	35
12-inch	3,750	30	50
16-inch	8,000	45	85
24-inch	19,000	100	190
|-------------------------------- 30-foot Head --------------------------------|			
Pump Size	**gpm**	**Elec. HP**	**Gas or Diesel HP**
2-inch	120	1	
4-inch	475	12	25
6-inch	795	20	35
8-inch	2,150	25	45
12-inch	3,450	35	70
16-inch	7,100	60	125
24-inch	16,600	125	250
NOTE: Use high head pumps for heads over 20 feet.			

Table 8: Crisafulli Pumps -- Model CP 2-inch to 24-inch Tractor driven

Pump Size	Capacity*	Horsepower
3-inch	90 - 150 gpm	1.3 - 2.0 HP
4-inch	100 - 250 gpm	2.7 - 3.5 HP
6-inch	1,150 gpm	30.0 HP
8-inch	2,300 gpm	29.0 HP
10-inch	3,300 gpm	62.0 HP
** (at 25-foot head)*		

Table 9: Flygt Centrifugal Pumps (Submersible)

d. Pump Discharge Piping

The Crisafulli pumps are generally supplied with 50-foot lengths of butyl rubber hose. Care should be taken to prevent damage to the hose. Irrigation pipe or small diameter culverts can also serve as discharge piping. The outlet of a pump discharge line should extend riverward far enough off the toe of the levee so that discharges do not erode the levee slope. The discharge end should be tied down or otherwise fixed to prevent its movement. These pumps must not be operated on slopes greater than 20 degrees from horizontal.

e. Sanitary Sewage Pumping

During high water, increased infiltration into sanitary sewers may necessitate increased pumping at the sewage treatment plant or at manholes at various locations to keep the system functioning. To estimate the quantity of sewage, allow 100 gallons per capita per day for sanitary sewage and an infiltration allowance of 15,000 gallons per mile of sewer per day. In some cases, it will be necessary to pump the entire amount of sewage, and in other cases only the added infiltration will have to be pumped to keep a system in operation.

Example: Estimate pumping capacity required at an emergency pumping station to be set up at the first manhole above the sewage treatment plant for a city of 5,000 population and approximately 30 miles of sewer (estimated from map of City). In this case, it is assumed that the treatment plant will not operate at all.

Computation:

Sewage: $$\frac{500 \text{ persons} \times 100 \text{ gal / person / day}}{24 \text{ hrs / day} \times 60 \text{ minutes / hr}} = 347 \text{ gpm}$$

Infiltration: $$\frac{1500 \text{ gal / minute / day} \times 30 \text{ min}}{24 \text{ hrs / day} \times 60 \text{ minutes / hr}} = 312 \text{ gpm}$$

Required pumping capacity is the Sewage Inflow + Infiltration Inflow = 347 GPM + 312 GPM = 665 GPM. From Table 2, a 6-inch diesel pump or its equivalent may handle the flow. If using a Flygt centrifugal pump from Table 9, use one 6-inch or three 4-inch pumps.

4. Determination of Pumping Requirements

Precipitation from storm water runoff may the biggest pumping requirement. Other considerations to include are the expected duration of the flooding. If the flooding source is a large river, slow draining river, or a lake, pumping provided should be above the minimum pumping capacities determined above.

Seek additional assistance. Likewise, if the foundation of flood barrier is relatively pervious (sandy), a seepage allowance of 1 to 2 GPM per linear foot of levee should be added to the pumping rate determined from the above formula. If the foundation consists of a thick clay layer, under seepage can be ignored; however, it should be added if poly is not part of the temporary structures.

One equation that can be used to determine storm water runoff is:

Where:

Pumping rate (GPM) = **K*A*M**.

K = constant. Values for the northern middle portion of the US are a minimum value of 30 (0.5 to 0.7” in 6 hours) to a more desired value of 90-100 (1.5 to 2.0” in 6 hours).

A = the contributing drainage area (acres).

M = a reduction factor if one or more substantial ponding areas are available. To determine the value of M, calculate X using the following formula:

X = (Ponding area in acres * Average Depth of Ponding area (Feet) x 100) / Drainage Area to the Ponding Area in Acres

Once you have calculated the value for X, use Table 10 to determine the value of M.

Value X	Value M
0-10	1.0
10-20	0.9
20-25	0.8
25-30	0.7
30-35	0.6
35-40	0.5
40-45	0.4
45-50	0.3
50-55	0.2
55-60	0.1
Greater than	0.0

Table 10: Values of M for Adjustment to Pumping Rate

Example: Local civil defense officials are considering the emergency construction of approximately 3,000 linear feet of levee, which will seal off the natural outlet for approximately

200 acres of local runoff from a small, non-storm-sewered city where historic floodwaters exceeded flood stage for 15 days. It is estimated that 20 acres of ponding area with a maximum depth of 4 feet will be available. What pumping capacities can be recommended for the removal of surface runoff with around 2” of rain in the forecast (Case A)? With light rain in the forecast and a quicker river fall (Case B)?

Steps:

1. Assuming the average depth of the ponding area is ½ of the maximum depth:
   a. Average depth = ½ x 4.0 = 2.0’

2. Calculate M
   a. $X = \frac{\text{Ponding Area x Ave Depth x 100}}{\text{Total Drainage Area}}$ *or* $X = \frac{\text{20 acres x 2 feet x 100}}{\text{200 acres}} = 3$

2. Select M from Table 3.3
   a. M = 0.9

4. Determine Desired runoff pumping rate for Case A
   a. Pumping Capacity = K*A*M = 90*200 acres*0.9= 16,200 GPM
   b. If seepage is a concern (see above), the seepage rate = 3,000 linear feet x 1 gallon per minute per linear feet = 3,000 GPM
   c. Total Pumping capacity = 16,200 GPM + 3,000 GPM = 19,200 GPM.

5. Determine runoff pumping rate for Case B
   a. Pumping Capacity = K*A*M = 30*200 acres*0.9= 5,400 GPM
   b. If seepage is a concern (see above), the seepage rate = 3,000 linear feet x 1 gallon per minute per linear feet = 3,000 GPM
   c. Total Pumping capacity = 5,400 GPM + 3,000 GPM = 8,400 GPM

6. Determine Pump required
   a. Diesel Pumps
   b. Case A: 5 to 6 – 12” PTO Driven Crisafulli Pumps at 540 RPM from Table 3 or 8” Diesel pumps from Table 2
   c. Case B: 3 – 12” PTO Driven Crisafulli Pumps at 540 RPM from Table 3 or 8” Diesel pumps from Table 2

4-6 Safety

General

By nature, several of the high-water emergency construction methods described herein pose a certain degree of danger to personnel and equipment. Furthermore, during flood emergencies, the loss of key personnel or a piece of urgently needed equipment could be much more serious than in normal operations. Therefore, planning, training, mobilization, and operations of flood emergencies should include all basic accident prevention concepts.

These hazards are manageable if identification and communication occur on an ongoing basis. Personal safety requires a conscious effort that every flood responder must consider in their various duties and activities. Safety regulations, safe procedures and methods should be followed to the extent compatible with the situation.

Site Safety and Health Plan (SSHP)

It is highly recommended that a Site Safety and Health Plan (SHHP) be developed prior to a flood event for use in a flood event.

Hazards

Numerous potential hazards exist during flood events.

1. Patrolling Hazards

    a. The members of the levee patrol team should walk with one person on the waterside of the levee near the water surface and one person at the top of the levee. During this patrol, the team should monitor for warning signs such as a break in a riverside tree line beyond the levee toe, a change in water currents, muddy water at the edge of the slope, edges of existing riprap, or cracking of the embankment slope above the water line. Patrol team members should also be wearing life jackets with high visibility reflective tape that allows them to be seen in all light conditions, including low light. For the return patrol, one person should inspect the crest while the other person inspects the area near the land-side levee toe. If at any time water currents or other conditions become hazardous that puts the patrol team at personal risk, the patrolling should be discontinued.

    b. The person walking closest to the water should be especially observant of floating objects. The limbs and roots of a floating tree that has been uprooted can extend above the water surface and strike anyone walking along the water's edge. To increase the chance of seeing floating objects, it is best to walk in an upstream direction when patrolling the water side of the levee.

    c. When patrolling floodwalls, the patrol should not attempt to walk the top of the wall but should concentrate on potential problem areas on the landside (inside) of the wall. Where the wall is more than five feet above the land-side ground level, it is recommended that observation points be selected every 100 yards or so, and ladders used to observe the water side of the floodwall.

    d. Each person on the patrol should be thoroughly familiar with the community evacuation plan and signals. If evacuation is necessary, the patrol should move to a pre-determined location and keep the team intact.

    e. If the area is evacuated, be aware when returning to the levees and floodwalls that the physical conditions may be considerably different from those observed prior to the evacuation, especially if the levee was overtopped. If overtopping occurs during darkness, it is recommended that the patrols not resume until daylight.

    f. Patrols should also keep an eye out for anyone who seems out of place or who is acting suspiciously. Any suspicious activities observed by the patrol should be reported immediately to the local law enforcement agency.

2. Changing Weather Patterns

    This occurrence can affect existing conditions and create more serious situations. Always know the forecast and how it affects vulnerable areas, workers, and the public.

3. Changing Water Patterns

The rise and fall of water can occur gradually or very quickly. Knowledge of high water and how it relates to levees, communities, and workers is essential. Continuous monitoring and communication of water level influences (e.g., reservoir releases, tides, and drainage inflow) are very important. Always know your area and the flood history around you.

4. Swift Water

High velocities of water are common during flooding events. Extreme caution should be used when anyone is exposed to high water. Workers should have flotation devices, throw ropes, and lifelines in the immediate area. Swift water rescue teams may be available. Use common sense and sound judgement around swift water. Know your resources and how to activate them prior to the event.

5. Temperature-related Illness

During a flood, weather patterns can change constantly. Changes in temperature present the potential for hypothermia and heat exhaustion/stroke. Flood fighters should know the signs of distress for these types of illnesses and how to treat them. During cold, wet weather it is recommended that workers layer clothing to stay warm and dry. A dry blanket and warm clear fluids should be on the work site for emergency use. In warm, hot weather lightweight clothing is recommended. If skin is exposed, a sun block agent may need to be applied. Plenty of drinking water should be on site and consumed regularly. Headgear is recommended in both hot and cold situations.

6. Insect/Animal Exposure

Flooded areas force a variety of animals to evacuate to high ground. Workers in these areas should be aware of these animals and not handle them. If animal removal is needed, contact a local professional. Stinging and biting insects are prominent in certain flood-prone areas. Chemical repellents can be useful as a deterrent. A complete first aid kit should be on site.

7. Vegetation

Noxious plants such as star thistle, stinging nettle, and poison oak are commonly found along rivers, streams, and levees. Avoid direct contact with this type of vegetation to prevent itching and rash. Consult medical personnel if symptoms persist.

8. Sandpile Safety

When shovels are used for filling bags a safe distance for workers is essential. Sandbags and sand may contain contaminates. Have disinfectant available. Safety glasses or goggles are recommended for protection from blowing sand particles.

9. Contamination

Flooded areas can potentially carry high levels of contaminants. Common contaminants include fuel, sewage, and pesticides. Local Haz-Mat teams should be contacted if needed. Always wear protective clothing to help limit contact with water. Carry antibiotic hand soap and wash thoroughly after working around floodwater.

10. Exhaustion

Stress combined with long, physically demanding hours can have an adverse effect on the flood worker. It is very important to recognize exhaustion or sleep deprivation and treat them immediately. Operation of vehicles, machinery, or equipment should be avoided. A shift rotation of personnel will help eliminate fatigue factors.

11. Body Mechanics

Proper body mechanics while working on floods is very important. The body is expected to work long, physical hours during the event. Everyone must make a conscious effort to use safe lifting and weight distribution techniques. Watch your footing;

surfaces can be slippery and cluttered with tripping hazards.

12. Construction Equipment

There are times when equipment and people will occupy the same work area. Workers should wear safety vests and hard hats and be aware of their surroundings. Safety warning devices (i.e., backup alarms and lights) should be in-tact and working on all equipment. Communication and alertness are vital! All operators must be certified for their equipment.

13. Boat Travel

Materials and/or personnel will sometimes need to be transported to work sites by boat. Operators of the watercraft must be certified. Flotation devices must be available for every passenger. Extreme care should be taken while loading and off-loading.

14. Vehicle Placement

Vehicles in work areas along the levee should remain parked on high ground. This is usually the crown roadway. Vehicles should also be parked facing their access point. An escape plan should be communicated to all flood workers.

CHAPTER 5: POST FLOOD (RECOVERY)

This section describes activities that take place after a flood event. As the response requirements for a flood diminish, recovery activities become the focus of effort. The goal of recovery is to return the levee system to its pre-flood condition and to document lessons learned about levee system performance to aid in future preparedness, response, recovery, and mitigation. Recovery begins right after the flood event, although some recovery activities may overlap with response and mitigation efforts. Although recovery is primarily a responsibility of the non-federal sponsor, USACE may be able to provide some assistance. For levee systems with multiple non-federal sponsors, coordination between sponsors during the recovery phase is important. Flood recovery is unique to each levee system, depending on the severity and extent of damage caused by the flood, resources available for recovery, and the level of effort needed to document what happened during the flood event. Anticipated recovery actions have been divided into short-term and long-term activities.

Figure 46: USACE and partners inspect flood-damaged infrastructure

USACE Responsibilities

1. USACE recovery operations following a flood pursuant to PL 84-99 is limited to the repair, restoration and rehabilitation of authorized flood control structures.

    a. Public Law 84-99 (PL 84-99).

        i. Recovery of USACE Material. Upon cessation of the flood emergency, every effort will be made to ensure the return of USACE-loaned equipment and supplies. Unused sandbags will be returned to area office warehouses and final inventory report furnished to the District Emergency Manager.

        ii. PL 84-99 Rehabilitation Program Assistance. Federal or non-federal Flood risk management projects may be repaired, restored, or rehabilitated in accordance with the authority and scope of Chapter 5 of ER/EP 500-1-1.

b. If the flooding was significant, the levee sponsor may receive a letter informing them that USACE is accepting rehabilitation assistance requests. Generally, the timeframe for submission of rehabilitation assistance requests is not more than 30 days after the flood waters have receded to normal levels. Upon receipt of a request, USACE will determine whether the requested repairs are eligible for rehabilitation assistance.
c. If program qualifications are met, USACE will coordinate repair alternatives with the levee sponsor and prepare an appropriate cooperation agreement depending on whether the system is federally or non-federally authorized. The cooperation agreement clarifies details of the rehabilitation effort, including the specific work to be done and sponsor requirements of cost sharing and local cooperation. The cooperation agreement must be signed by both the levee sponsor and the District Engineer before rehabilitation construction can begin. To prevent additional costs, the cooperation agreement should be signed within 30 days after it has been prepared.
d. The cooperation agreement outlines the cost breakdown for the work to be accomplished. The following sections outline the types of items that will typically be paid for by the federal government, the items that may be cost shared, and the items the levee sponsor would typically be responsible for at 100% local cost. This is not a complete list and certain details have been omitted for brevity. Specific details concerning the cooperation agreement can be found in EP 500-1-1.
    i. Rehabilitation components typically covered at 100% federal cost.
        - Preparation and approval of preliminary investigation reports; and
        - Engineering and design costs.
    ii. Items that may be cost-shared. If the levee system is federally authorized, the following items are covered at 100% federal cost, but if it is non-federally authorized, they are typically cost-shared at 80% federal cost and 20% local cost:
        - Cost of construction.
        - Contingency costs for construction.
        - Supervision and administration costs.
    iii. Items the levee sponsor is responsible for at 100% local cost:
        - Land, easements, and rights-of-way.
        - Borrow material.
        - Improvements requested by the levee sponsor.
        - Utilities and other relocations.
        - Deliberate levee cuts.
        - Repairs beyond the least cost alternative.

2. Relief operations under PL 93-288. FEMA issues USACE response and recovery missions under the National Response Framework (NRF) for Civil Emergency/Response (any response to the urgent needs of civilians and/or state/local governments) and Civil Disaster (any formally declared emergency involving civilians and/or civil governments). USACE is the lead federal agency for the planning and execution of Emergency Support Function (ESF) #3 within the NRF, with the primary goal of restoring essential public services and facilities. The authority conferred by PL 93-288 and any funds provided there under are supplementary to and not limiting upon or in substitution for any other law. The types of assistance that the Corps may be called upon to render when specifically authorized by FEMA are:

    a. Participation in pre-disaster activities including pre-positioning and other advance elements.
    b. Participation in field/damage assessments.
    c. Contracting to support health and safety, temporary housing, temporary emergency power, and others as required.
    d. Removal/management of debris from public streets and roads.
    e. Temporary repair and/or replacement of emergency access routes as necessary for life sustaining operations.
    f. Emergency restoration of critical facilities including temporary restoration of water and wastewater treatment systems.
    g. Emergency demolition or stabilization of damaged structures and facilities designated by state or local governments as immediate hazards to the public health and safety, or as necessary to facilitate the accomplishment of lifesaving operations.
    h. Emergency clearance of debris from highways, roads and bridges.
    i. Technical assistance, i.e., structural inspections, construction management, real estate support, as required.
    j. Assist in the preparation of Preliminary Damage Assessments (PDA) and Damage Survey Reports (DSR)
    k. Support to other ESFs as outlined in the NRF

3. The National Disaster Recovery Framework (NDRF) is a companion to the NRF, and is influenced by response activities conducted by the ESFs that implement all aspects of early recovery. The NDRF does not address response activities with respect to life sustaining, property protection, and other measures intended to neutralize the immediate threats and stabilize the community. These activities, however, influence recovery efforts, necessitating the need for their incorporation into short term recovery planning. The NDRF establishes a coordinating structure that includes six recovery support functions (RSFs), one of which is the Infrastructure Systems RSF (IS-RSF) for which the USACE serves as the coordinating agency.

4. The EOC will prepare Disaster Recovery SITREPs on flood conditions for transmittal to higher authority as often as conditions warrant (daily, weekly, etc). Example of flood inspection reports can be found in Appendix C.

5. The District commander will issue a Notice to Public Sponsors immediately after significant flood events to alert non-federal sponsors of Active projects that a submittal deadline is in effect for USACE assistance to repair damaged FCW under PL 84-99. The notice format is provided in Appendix E. Issuance of a Notice to Public Sponsors will be noted in the next SITREP submitted. For further information on providing rehabilitation assistance under PL 84-99, see ER/EP 500-1-1 Chapter 5.

6. Deactivation will be an orderly return to normal operations with particular attention to completeness of records, salvage of materials and supplies, return of accountable items of property, and release of equipment. The EOC will complete the Deactivation Checklist found in Appendix F.

7. The District EOC will provide After Action Report (AAR) worksheets and online surveys from the Emergency Management Continuous Improvement Program (EMcip) to the Division EOC Representatives. The Division EOC Representatives will collect and summarize comments from their respective personnel who have been involved with the flood threat. The Division EOC will conduct a formal AAR and will ask for the summaries electronically. AAR templates are available in Appendix D. All AAR documents will also be provided to EMcip within the Readiness Support Center (RSC).

Figure 47: EMcip logo

Non-Federal Sponsor Recommended Procedures

1. Short-Term Post-Flood Activities

    a. Post-flood operation
        i. Purpose. The purpose of short-term post-flood operation is to reestablish the condition of levee features (e.g., gap closures, culvert gates) that were not damaged during the flood event. This activity should not be initiated until the water has subsided and it is not predicted to rise again. Short-term post-flood operation activities may occur in conjunction with immediate repairs and interim risk reduction measures depending on the extent of damage to the levee system.
        ii. Basic Procedures
            - Re-open gates and closures.
            - Remove temporary flood response measures such as sandbags.
            - Remove material placed during temporary levee raises.
            - Clean debris from trash racks and/or other openings such as culverts.
            - Properly clean all components.
            - Inventory items, return borrowed equipment, and determine what can be re-used.
            - Salvage and store any materials and supplies.
    b. Assess levee condition and performance
        i. Purpose. Once flood waters have receded to an adequate elevation, it is important to assess how the levee performed during the event and its post-flood condition. This allows for effective assessment of damages, determination of immediate and long-term repair needs, and development of lessons learned.
        ii. Basic Procedures
            - Post-flood inspection. USACE refers to post-flood inspections as Special Inspections and will coordinate and conduct these inspections with levee sponsors. Inspect the entire system, noting locations of damage and the extent of damage at each location. Consider use of UAS to observe potentially inaccessible

- locations. Take photographs to document the conditions observed. Document the event and keep a map record of the levee system, indicating areas that were in distress during the event. This is useful for making repairs or improvements and for use as a guide to focus attention on these areas during the next flood. For future planning, locate and keep records of the flood's high-water marks. Keep these records, along with any rainfall and river data that was gathered.
- Performance assessment. Levee sponsors should work with USACE to evaluate how the levee performed during the flood event. The evaluation should consider the following information that is typically collected during the response phase when available.
  – River hydrograph (with stage readings and frequencies) and/or high-water marks.
  – Written observations of performance issues by stationing along with GPS coordinates where applicable.
  – Photographs of all performance issues.
  – Maps showing all observation points collected.
  – Instrumentation readings and evaluations.
  – Final breach dimensions (width, scour depth) if applicable.
  – Plot of breach development over time if applicable
  – Levee material and surface protection description
  – Estimated number of houses/businesses flooded if applicable.
- Damage assessment. Based on the post-flood inspection and review of the performance assessment, a damage assessment can be accomplished to determine locations and extent of damages to levee features (e.g., embankment erosion, seepage, floodwall displacement). This damage assessment should be used to identify immediate repair needs and inform future long-term mitigation actions necessary to manage and reduce flood risk. Levee sponsors are encouraged to evaluate and document the flood damages prevented in order to reflect the contributions of the levee system to the community.
  – Determine and implement immediate repair needs. Priority repairs should be made as soon as possible.
  – Develop interim risk reduction measures. These are actions to reduce risk associated with the levee while more long-term and comprehensive risk reduction and management solutions are pursued.

2. Long-Term Post-Flood Activities

   a. Develop long-term risk reduction measures. Utilizing the information gathered through the short-term activities, levee sponsors in collaboration with USACE, should generate a tentative list of long-term risk reduction measures beyond those taken to address immediate needs of the levee system. Some of these measures may be related directly to needed levee improvements while others will result from an understanding of emergency response activities during the event. For example, levee sponsors should work with local and state emergency management agencies as appropriate to update local emergency plans to account for lessons learned, levee system operation issues, and evacuation effectiveness.
   b. Documenting lessons learned and updating risk information.
      i. Purpose. Documentation of levee condition, performance, damages, and short-term actions taken on the levee can be very helpful for future preparedness, response, and mitigation efforts.
      ii. Basic Procedure.
         - Soon after the event, the sponsor should meet with key personnel, volunteer representatives, and community partners to de-brief, share remaining concerns, and discuss lessons learned during the event.
         - Consider documenting the following information in addition to the information evaluated in the short-term activities (performance assessment), if applicable:
           – Estimated population impacted.
           – Estimated area and depth of inundation.
           – Information regarding evacuation procedures, including effectiveness of warnings related to percentage of population taking action.
           – Time of incident notification to evacuation authorizing agency.
           – Time of evacuation warning.

General Investigations: Under the General Investigations program, the U.S. Army Corps of Engineers (Corps) can partner with a non-federal sponsor to develop large scale projects that address complex water resource issues, such as basin-wide flood risk reduction. The Corps must obtain authorization and appropriations from Congress to conduct a general investigation.

CAP 205: The U.S. Army Corps of Engineers (Corps) can partner with a nonfederal sponsor (sponsor) to plan and construct small flood damage reduction projects that have not previously been specifically authorized by Congress and are not part of a larger project. Projects may be structural (i.e., levees, flood walls, diversion channels, pumping plants and bridge modifications) or non-structural (i.e., floodproofing, relocation of structures and flood warning systems). Authority is provided by Section 205 of the Flood Control Act of 1948 (P.L. 80-858), as amended, also referred to as Section 205 under the Continuing Authorities Program.

CAP 14: The U.S. Army Corps of Engineers (Corps) can partner with a non-federal sponsor to plan and construct emergency streambank- and shoreline-protection projects to reduce risk to public and non-profit organizations' facilities. Authority is provided by Section 14 of the Flood Control Act of 1946 (P.L. 79-526), as amended, also referred to as Section 14 under the Continuing Authorities Program. Facilities eligible under this authority may include at-risk highways, highway bridge approaches, public water and sewer lines, churches, public and private non-profit schools, and hospitals, and known historic properties.

CAP 103: The U.S. Army Corps of Engineers (Corps) can partner with a nonfederal sponsor (sponsor) to modify existing Corps projects to study, design, and construct small coastal storm damage reduction projects. Authority is provided by Section 103 of the Rivers and Harbors Act of 1962, as amended, also referred to as Section 103 under the Continuing Authorities Program. This authority allows USACE to assist in the protection of public infrastructure on small beaches against erosion and damages caused by natural storm driven waves and currents. Typical projects include protecting utilities, roadways, and other public infrastructure systems. Beach nourishment (structural) and floodproofing (non-structural) are examples of storm damage reduction projects constructed utilizing the Section 103 authority.

CAP 1135: The U.S. Army Corps of Engineers (Corps) can partner with a nonfederal sponsor (sponsor) to modify existing Corps projects to restore the environment or construct new projects to restore areas where a Corps project has contributed to environmental degradation. Environmental improvements cannot conflict with authorized Corps project purposes. Typical projects have included setting back levees, restoring degraded habitat and improving fish passage. Authority is provided by Section 1135 of the Water Resources Development Act of 1986 (P.L. 99-662), as amended, also referred to as Section 1135 under the Continuing Authorities Program.

TPP: Section 203 of the Water Resources Development Act of 2000, provides authority for the Corps in cooperation with Indian tribes and heads of other federal agencies to study and determine the feasibility of carrying out projects that will substantially benefit Indian tribes. The Tribal Partnership Program provides an opportunity to assist with water resources projects that address economic, environmental, and cultural resource needs through studies that may include flood damage reduction, environmental restoration, and protection and preservation of natural and cultural resources. Upon request, the Corps will cooperate with tribes to study water resources projects and such other projects as determined appropriate, primarily located within tribal lands

APPENDIX A - FLOOD RESPONDER PACKING LIST

Personal gear:

- ◻ Government Travel Credit Card
- ◻ Pocket utility knife
- ◻ Bottled water and snacks
- ◻ Cellular phone
- ◻ Pre-packed 5 days of personal clothing, gear, and supplies, to keep at work, ready for mobilization.
- ◻ Digital cameras to record significant events.
- ◻ EOC jacket, shirt, and hat when reasonably appropriate, even meetings.
- ◻ Vehicles available from Flood Lead or Flood Response Coordinator(s). Get keys and parking garage key. Note when purchasing gas with credit card you must put mileage and government vehicle license plate into the pump.
- ◻ Foul weather gear (personal rainsuits, boots, extra socks)
- ◻ Calculator
- ◻ Writing Instruments
- ◻ Optical measuring devices if available
- ◻ GPS Location Device (ensure proper datum is used)
- ◻ Road and topographic maps

Gear bags (If provided by the EOC) - Contents:

- ◻ Flashlight (40 min. life) UK 1200
- ◻ Flashlight SL4/SL6
- ◻ 25 ft. Measuring tape
- ◻ Rainsuit or poncho
- ◻ Overboots
- ◻ Waterproof field notebook
- ◻ Abney level or hand level (checkout)
- ◻ Several instances of Replacement Batteries for each device requiring batteries.
- ◻ Compass
- ◻ First aid kit
- ◻ Duct Tape
- ◻ Straight Edge

Personal Protective Equipment (PPE):

- ◻ Hardhat
- ◻ Safety glasses
- ◻ Safety vest
- ◻ Steel toe boots

APPENDIX B - SAMPLE DECLARATION OF EMERGENCY

CEXXX-CO-E 28 June 20xx

MEMORANDUM FOR See Distribution

SUBJECT: Declaration of Emergency: June 20xx Flood, Xxxxx District, Elizabeth River and Tributaries

1. In accordance with ER 500-1-1, a Declaration of Emergency has been declared to exist in the Xxxxx District as of 1200 hours 28 June 20xx.

2. Level of Activation. The Emergency Operations Center is activated at Level II effective 281200Jun20xx. The EOC will be manned daily from 0600 - 1800 IAW District OPLAN 2001-01 by all Level II-designated personnel. During unmanned periods, telephone messages will be received by the duty officer via the 24-hour emergency number (899) 555-1234. The Crisis Management Team's initial meeting is set for 0900 hours 29 June in the EOC.

3. Expenses incurred as a result of this Emergency will be those involved with the flood operation, i.e., EOC operations, issuance or transportation of sandbags, forecasting, flood sector engineers, or flood reconnaissance. No charges will be made prior to the date of this declaration. Costs relating to Dam or Lake observation must be charged to O&M work items.

LOCATION	CATEGORY CODE / CATEGORY ELEMENT / WORK ITEM		
Elizabeth River & Tribs	021000	BBA00	002LSL

4. Paid overtime is authorized under the following criteria:

   a. All personnel, regardless of grade, engaged in flood emergency operations may be paid overtime.

   b. Earning of GS employees exempt from FLSA are subject to limitation contained in 5 USC 6547. Earnings under the provision of FLSA are not subject to the aforementioned limitation.

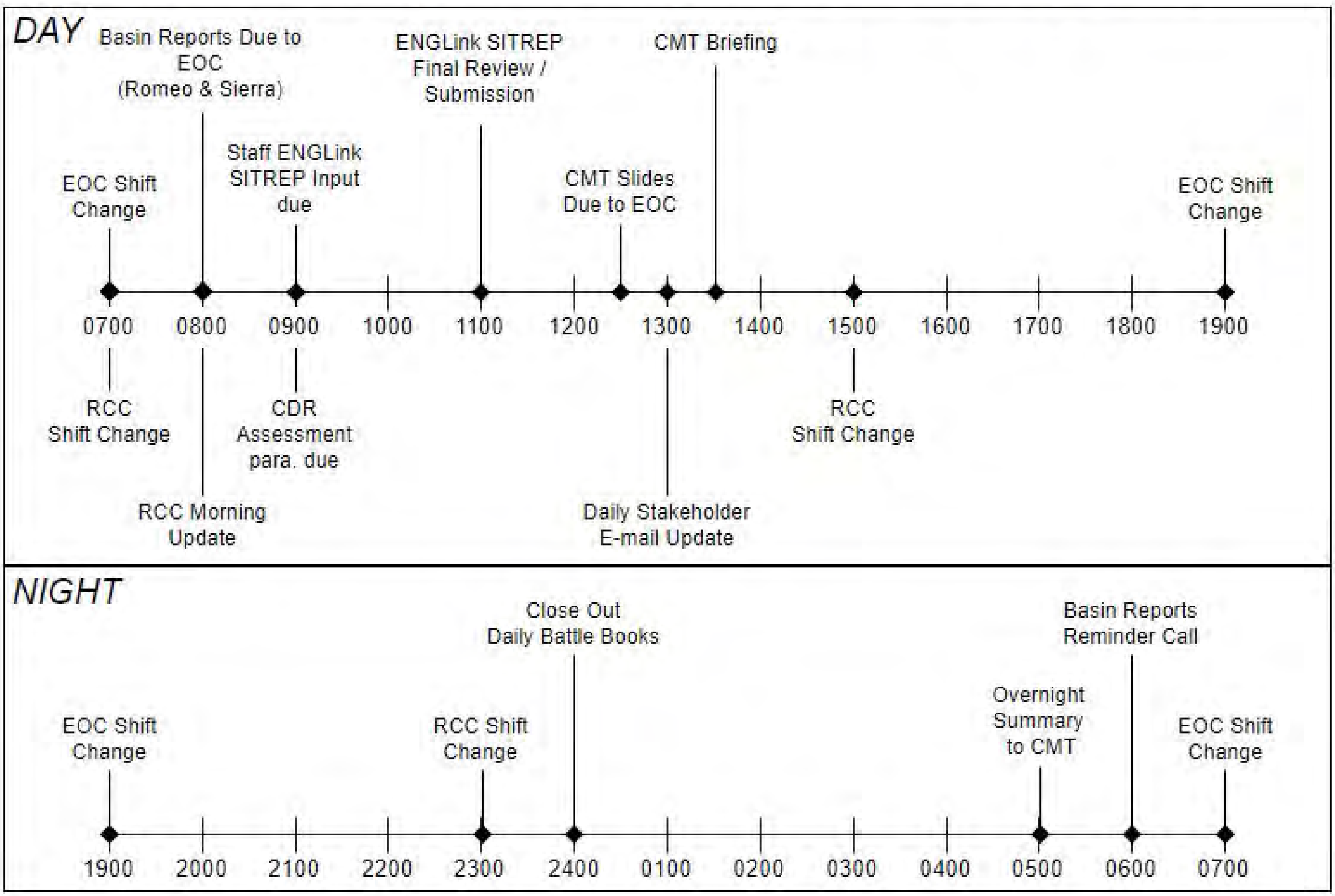
   c. A copy of this order, attached to DA Form 5172-R, Overtime Request and Authorization, overrides the requirements outlined in Xxxxx District Regulation 690-1-600, paragraph 4, dated 1 May 1999.

GEORGE H. GABION
Colonel, EN Commanding

DISTRIBUTION:
as required

APPENDIX C – SAMPLE BATTLE RHYTHM AND REPORTS FOR AN USACE DISTRICT EOC

Flood Fight Daily Battle Rhythm



Flood Briefing Template and Sample Language

Personnel in Field Today: *List field personnel and role*

Personnel in Field Tomorrow: *List field personnel and role*

LOCATION #1: *Levee Segment 8, between the South St. Bridge and the North St. Bridge, City of Bedford, Kansas*

a. ISSUE: *With the forecast crest of 94.5', the river will be approx. 1.3' – 1.5' below the top of the lower wall as seen in Photo 1. The actual flood protection T-wall has been demolished as part of the on-going construction to raise the level of protection. The excavation for the foundation of the T-wall is lower than the top of the lower wall.*

b. ONGOING ACTIONS: *The City has backfilled the construction area where the T-wall has been demolished. The City has set up HESCO's blocking the stairway through the lower wall in order to prevent possible scour in the construction area. The City is following their high water action plan, and in the event that the river forecast rises, the City has enough HESCOs to form a line of protection spanning from the South St. Bridge and the North St. Bridge.*

c. POSSIBLE IMPACTS: *At the current river forecast, it does not appear that homes or business will be affected.*

d. EOC SUPPORT NEEDED: *The EOC should determine whether we want field personnel on site near the crest to keep an eye on this area.*

e. POC(s): *List local POC and include their title. If a USACE team member will be on set daily, list them here.*

LOCATION #2:

a. ISSUE:

b. ONGOING ACTIONS:

c. POSSIBLE IMPACTS:

d. EOC SUPPORT NEEDED:

e. POC(s):

LOCATION #3:
Keep repeating for each location

ACTIONS FOR THE NEXT 24 HOURS: *This will be where you address increases or decreases of personnel that you anticipate, and an overview of the team's plan for the next 24 hours.*

STAKEHOLDER ENGAGEMENTS: *Meetings that you or your team will be attending, meeting with Mayors, Governors, media, etc.*

Photo 1: Levee Segment 8 – Looking US at the North St. Bridge

APPENDIX D - COOPERATION AGREEMENT FORMAT, ENG FORM 4900, AND AAR TEMPLATE

COOPERATION AGREEMENT
BETWEEN THE UNITED STATES OF AMERICA
and
____
for
EMERGENCY ASSISTANCE (FLOOD or COASTAL STORM)

THIS AGREEMENT, entered into this ____ day of _______________, 20___, by and between THE DEPARTMENT OF THE ARMY (hereinafter referred to as the "Government") acting by and through the District Engineer, ______________ District, U.S. Army Corps of Engineers, and the ____ [PUBLIC SPONSOR], (hereinafter referred to as the "Public Sponsor"), acting by and through ___________________________ [TITLE OF PERSON SIGNING THIS AGREEMENT].

WITNESSETH THAT:

WHEREAS, 33 USC 701n authorizes the Chief of Engineers to flood response and perform rescue operations.

WHEREAS, the Public Sponsor has requested assistance under 33 USC 701n, and the Public Sponsor qualifies for such assistance in accordance with the established policies of the U.S. Army Corps of Engineers.

WHEREAS, the Public Sponsor hereby represents that it has the authority and legal capability to furnish the non-Federal cooperation hereinafter set forth and is willing to participate with the terms of this agreement.

NOW, THEREFORE, the parties agree as follows:

1. The Government will perform the work described in its scope of work (attached) that is made part of this agreement.

2. The Public Sponsor will:

a. Provide without cost to the Government all lands, easements, rights-of-ways, relocations, and borrow and dredged or excavated material disposal areas necessary for the work.

b. Hold and save the Government free from damages arising from construction, operation, maintenance, repair, replacement, and rehabilitation of the work, except damages due to the fault or negligence of the Government or its contractors.

c. Operate, maintain, repair, replace, and rehabilitate the completed work in a manner satisfactory to the Government.

d. Remove, at no cost to the Government, all temporary work constructed by the Government.

3. (Add others as applicable)

4. ATTACHMENTS:

a. Exhibit A - Government Scope of Work.

b. (Add others as applicable)

IN WITNESS WHEREOF, the parties hereto have executed this agreement of the day and year first above written.

THE DEPARTMENT OF THE ARMY

BY: __________________________
[SIGNATURE]
[TYPED NAME]
[TITLE IN FULL]
ADDRESS:

THE [NAME OF PUBLIC SPONSOR]

BY: ___________________________
[SIGNATURE]
[TYPED NAME]
[TITLE IN FULL]
ADDRESS:

Figure 46. Cooperation Agreement for Emergency Assistance

COOPERATION AGREEMENT BETWEEN THE
UNITED STATES OF AMERICA
and
____for
POST FLOOD RESPONSE ASSISTANCE (FLOOD or COASTAL STORM)

THIS AGREEMENT, entered into this ____ day of ________________, 20___, by and between THE DEPARTMENT OF THE ARMY (hereinafter referred to as the "Government") represented by the District Engineer, _________________________ District, U.S. Army Corps of Engineers, and the ___________________ _________________________________ [PUBLIC SPONSOR], (hereinafter referred to as the "Public Sponsor"), represented by [TITLE OF PERSON SIGNING THIS AGREEMENT] acting in accordance with the request of the Governor of the State.

WITNESSETH THAT:

WHEREAS, pursuant to 33 USC 701n, in any case in which the Chief of Engineers is otherwise performing work in an area for which the Governor of the affected State has requested a determination that an emergency exists or a declaration that a major disaster exists under The Robert T. Stafford Disaster Relief and Emergency Assistance Act (42 U.S.C. 5121 et seq.), the Chief of Engineers is authorized to perform on public and private lands and waters for a period of ten days following the Governor's request any emergency work made necessary by such emergency or disaster which is essential for the preservation of life and property, including, but not limited to, channel clearance, emergency shore protection, clearance and removal of debris and wreckage endangering public health and safety, and temporary restoration of essential public facilities and services; and,

WHEREAS, the Governor has requested the Government to undertake authorized Post Flood Response activities in accordance with 33 U.S.C. 701n, and established policies of the U.S. Army Corps of Engineers; and,

WHEREAS, the Public Sponsor hereby represents that it has the authority and legal capability to furnish the non-Federal cooperation hereinafter set forth and is willing to participate in accordance with the terms of this Agreement;

NOW, THEREFORE, the parties agree as follows:

1. The Government will perform the work described in its scope of work (attached) that is made part of this agreement.

2. The Public Sponsor will:

a. Provide without cost to the Government all lands, easements, rights-of-ways, relocations, and borrow and dredged or excavated material disposal areas necessary for the work.

b. Hold and save the Government free from damages arising from construction, operation, maintenance, repair, replacement, and rehabilitation of the work, except damages due to the fault or negligence of the Government or its contractors.

c. Operate, maintain, repair, replace, and rehabilitate the completed work in a manner satisfactory to the Government.

d. Remove, at no cost to the Government, all temporary work constructed by the Government.

3. (Add others as applicable)

4. ATTACHMENTS:

THE DEPARTMENT OF THE ARMY

BY: ___________________________

[SIGNATURE] [TYPED NAME] [TITLE IN FULL]

ADDRESS:

THE [NAME OF PUBLIC SPONSOR]

BY: ___________________________

[SIGNATURE] [TYPED NAME] [TITLE IN FULL]

ADDRESS:

Figure 47. Cooperation Agreement for Post Flood Response Assistance

For examples of rehabilitation Cooperation Agreements, see EP 500-1-1, Appendix C:

- rehabilitation of non-Federal flood risk management projects (Figure C-1.),
- rehabilitation of Federal flood risk management projects (Figure C-2.), and rehabilitation of HSPP's (Figure C-3.)

Print Form | Save As | E-mail

U.S. Army Corps of Engineers

PROPERTY CONTROL RECEIPT

For use of this form, see Engineer Regulation 700-1-1; the proponent agency is CELD-MS-S.

FEDERAL CONDITION CODES (CC)

Supply condition codes are used to classify materiel in terms of readiness for issue and use or to identify action underway to change the status of materiel. Supply Condition Code A through H and S will be utilized to reflect materiel condition prior to turn-in to DRMO. The two types of condition codes are Supply and Disposal. The Hand Receipt Holder (HRH) turning in excess items to the Property Disposal Office (PDO) assigns the Supply Code; it is always the first position of the Federal condition code. The PDO assigns the Disposal code after inspection of the item, which provides additional information for screening purposes.

SUPPLY CODE

A - Serviceable (*Issuable without Qualification*) New, used, repaired, or recondition materiel which is serviceable and issuable to all customers without limitation or restriction.

B - Serviceable (*Issuable with Qualification*) New, used, repaired, or reconditioned materiel which is serviceable and issuable for its intended purpose but which is restricted from issue to specific units, activities, or geographical areas by reason of its limited usefulness or short service life expectancy.

C - Serviceable (*Priority Issue*) Items which are serviceable and issuable to customers, but which must be issued before Supply Condition Codes A and B materiel to avoid loss as a usable asset. Includes materiel with less than 3 months of shelf life remaining.

D - Serviceable (*Test/Modification*) Serviceable materiel which requires test, alteration, modification, technical data marking, conversion, or disassembly. This does not include items that must be inspected or tested immediately prior to use.

E - Unserviceable (*Limited Restoration*) Materiel which involves only limited expense or effort to restore to serviceable condition and which is accomplished in the area where the stock is located. May be issued to support ammunition requisitions coded to indicate acceptability of usable condition E stock.

F - Unserviceable (*Reparable*) Economically reparable materiel which requires repair, overhaul, or reconditioning; includes reparable items which are radioactively contaminated.

G - Unserviceable (*Incomplete*) Materiel requiring additional parts, or components to complete the end item prior to issue.

H - Unserviceable (*Condemned*) Materiel which has been determined to be unserviceable and does not meet repair criteria; includes condemned items which are radioactively contaminated; Type I shelf-life materiel that has passed the expiration date; and Type II shelf-life materiel that has passed expiration date and cannot be extended.

S - Unserviceable (*Scrap*) Materiel that has no value except for its basic materiel content. No stock will be recorded as on hand in Supply Condition Code S. This code is used only on transactions involving shipments to DRMOs. Materiel will not be transferred to Supply Condition Code S prior to turn-in to DRMOs if materiel is recorded in Supply Condition Codes A through H at the time materiel is determined excess. Materiel identified by NSN will not be identified by this supply condition code.

DISPOSAL CODES:

1 - Excellent: Property that is in new condition or unused condition and can be used immediately without modification or repairs.
4 - Usable: Property that shows some wear, but can be used without significant repair.
7 - Repairable: Property that is unusable in its current condition, but can be economically repaired.
X - Salvage: Property that has some value in excess of its basic material content, but repair or rehabilitation is impractical and/or uneconomical.
S - Scrap: Property that has no value except for basic material content.

SECTION I - ACTION TO BE TAKEN

Issue/Turn-In | Transfer | Temporary Loan | Excess | F | O | I | In Repair

SECTION II - PROPERTY TRANSFER

1. losing Agency Name:	8. Gaining Agency Name:
2. HRH Number: 3. Phone:	9. HRH Number: 10. Phone:
4. Email Address:	11. Email Address:
5. Losing Property Book Officer Name:	12. Gaining Property Book Officer Name:
6. Department of Defense A___ A___ C___ /Unit Identification Code (UIC):	13. Department of Defense A___ A___ C___ /Unit Identification Code (UIC):
7. Address (*Pick-Up*):	14. Address (*Ship-To*):

ENG FORM 4900, FEB 2015 REPLACES ENG FORMS 4900-R, SEPT 2012; 4900-1, Dec 1992; and 4900-2, Dec 2000, WHICH ARE OBSOLETE. Page 1 of 2

Print Form | Save As | E-mail

SECTION III - PROPERTY DESCRIPTION

+	Item No.	Bar Tag No.	Serial No.	National Stock No.	Nomenclature (*Description of Item*)	Price	Cond. Code
X							
X							
X							
X							
X							
X							
X							
X							
X							
X							
X							

SECTION IV - AUTHENTICATION

1. Print Name Losing Agency	2. Date	3. Losing Signature
4. Print Name Gaining Agency	5. Date	6. Gaining Signature

ENG FORM 4900, FEB 2015 Page 2 of 2

After Action Report Template

A-1. After Action Report Template. This template is provided as a resource for supported District and MSC use to develop After Action Reports. This template may be further modified at District/MSC discretion to fit the circumstances of a particular event.

Table of Contents.

Executive Summary. Provide a succinct snapshot of the event and the response, as well as any major overarching enterprise lessons learned, if applicable.

Chapter 1. Background Chronology

a. Weather. Tell the story of the event: Provide a high-level chronology of the event, including description of the event, antecedent conditions, weather, pool stages, river conditions, snowpack, etc. Place voluminous tabular data, maps, etc., in an appendix. This chapter should be prepared in sufficient detail so that a historical researcher, years in the future, will be able to understand what happened.

b. Impacted Area. Describe the impacted area, basin topography, and provide an overview of any applicable flood risk management systems, particularly reservoirs. Break this section down into States or Territories, as appropriate and logical.

Chapter 2. Emergency operations of the Corps element(s) involved. Either a straight chronological approach, or chronological for each division/District involved, may be used. This chapter should also include appropriate reference to FEMA operations. Divide into sections if necessary, or for larger events, feel free to break individual missions into separate chapters.

Chapters 3. - X. As needed.

Appendices.

Appendix A. Cost information. Cost summary and cost breakdowns for the event will be provided. The first figure or table presented will be a one page summary of all costs (e.g., FCCE, FEMA, O&M Gen, etc.) of the event's operations. The second and third figures/tables will be separate summaries of FCCE costs (by category/class) and ESF 3 costs (by mission), respectively, with explanatory remarks. For FCCE costs, costs to undertake major (i.e., costing more than $1,000,000) Advance Measures or rehabilitation projects will be shown separately. These cost figures will also be further broken down by state. Other figures, charts, and tables will be presented as needed.

Appendix B. PL 84-99: Projects and major activities. Each separate project and major activity (e.g., a significant flood fight) within Categories 200-500 will be addressed in narrative format. This may be either in a single appendix for a small event or in individual tabs to the appendix when large numbers of projects/efforts are involved.

Appendix C. FEMA Mission Assignments (if applicable). Provide an overview and listing of all FEMA Mission Assignments relevant to the supported District and/or MSC. Include, whenever possible, the ESF #3 Mission Summary Report from all applicable ESF #3 Permanent Subject Matter Experts.

Other Appendices. Include other appendices as needed, if applicable.

Appendix D [*or subsequent letter in the alphabet, if additional appendices were included*]. Lessons Learned. Include any additional comments and observations obtained through any and all applicable methods of progressive data collection that were utilized during the event. Include validated outcomes of the After Action Review.

Quick Look Report Template

B-1. Quick Look Report Template. This template is provided as a resource for supported District and MSC use to develop Quick Look Reports. A QLR is a time-sensitive document that may precede a full AAR or replace a full AAR for smaller events that do not meet the formal AAR triggers and highlights major findings or high-priority issues from an after-action review that require attention. Generally, a QLR does not contain analysis with as much detail as what would be found in an AAR. This template may be further modified at District/MSC discretion to fit the circumstances of a particular event.

Event Name. Name of the event, and District or MSC responsible for the QLR.

Event Overview. Provide a brief event overview.

Data Collection Method. Provide a description of the methodology and scope of data collection and analysis.

Preliminary Findings and Recommendations. Provide preliminary findings and observations (or findings and observations, if a QLR is replacing a full AAR for a smaller event that does not meet the formal AAR triggers) based on the data analysis, as well as recommendations for each finding and observation.

Conclusion. Provide a conclusion wrapping up the QLR. Include any potential next steps, if applicable.

APPENDIX E - PUBLIC NOTICE TO SPONSORS EXAMPLE

NOTICE TO PUBLIC SPONSORS

US ARMY CORPS OF ENGINEERS

REPLY TO:
CORPS OF ENGINEERS, ____ DISTRICT
Emergency Management Division
Street Address
City, State, Zip

DATE: 1 June 20__

APPLICATION PERIOD EXPIRES 1 JULY 20__

REHABILITATION ASSISTANCE FOR FLOOD-DAMAGED FLOOD CONTROL PROJECTS

Public Sponsors of flood control projects that sustained damages due to flooding during the period 17 May 20____ to 31 May 20____, have until 1 July 20____ to apply for Public Law 84-99 Rehabilitation Assistance from the US Army Corps of Engineers, _________________ District.

The Corps of Engineers has authority under Public Law 84-99 to supplement local efforts in the repair of both Federal (Corps-constructed, locally operated and maintained) and non-Federal (constructed by non-Federal interests or by the Work Projects Administration (WPA)) flood control projects damaged by flood.

a. For a non-Federal flood control project to be eligible for Rehabilitation Assistance, it must have been inspected, evaluated, and accepted into the Corps Rehabilitation and Inspection Program (i.e., granted Active status) *prior to* the onset of the flood, and still be Active (based on the latest Continuing Eligibility Inspection) at the time of the flood.

b. For a Federal flood control project to be eligible for Rehabilitation Assistance, it must be in an Active status by having passed its last Inspection of Completed Works inspection.

c. Rehabilitation Assistance will be provided by the Corps only when the work is economically justifiable, the damage was sustained during the recent flood event, and the cost of repairs is more than $15,000.

d. Rehabilitation Assistance for a non-Federal project is cost shared between the Public Sponsor and the Corps of Engineers. The Public Sponsor must provide 20 percent of the cost of the Rehabilitation Assistance.

All requests for assistance made to the Corps will be coordinated with the Federal Emergency Management Agency (FEMA) and the Natural Resources Conservation Service (NRCS) to prevent duplication of benefits.

If the Public Sponsor believes that its project may qualify for Rehabilitation Assistance, a written request must be submitted to the Corps of Engineers at the address above. The request must be signed by an officer or responsible official of the Public Sponsor, and must include:

- Name and telephone number of the Public Sponsor's point of contact;
- Legal name of the flood control project;
- Date and results of the last inspection by the Corps of Engineers;
- Location of the flood control project by township, section, range, city, and county;
- Location(s) of the damaged section(s), and extent of the damage at each location; and
- Waterway causing the flood.

Upon receipt of the Public Sponsor's request, the Corps of Engineers will schedule an inspection with the Public Sponsor. If you have any questions, contact the Corps of Engineers at *phone number* for assistance.

[SIGNATURE BLOCK OF DISTRICT ENGINEER]

APPENDIX F - EOC ACTIVATION AND DEACTIVATION CHECKLIST

	DATE	Time
1. Commander Issues Emergency Declaration	______________	______________
2. Activation Funds Requested	______________	______________
3. EOC Activation Message to SPD	______________	______________
4. CMT Notification Completed	______________	______________
5. Schedule Initial CMT Briefing	______________	______________
6. Event Created in ENGLink	______________	______________
7. Overtime HVAC Service Requested	______________	______________
8. EOC Staffed and Operational	______________	______________
9. RSOI Process Initiated	______________	______________

Figure 48. District EOC Activation Checklist Example

	DATE	Time
1. The District EM will recommend to the District Commander or Deputy District Commander that the emergency declaration no longer exists. The Commander or designated alternate will declare an end to the emergency.	______________	______________
2. The District EM will notify the CMT and external stakeholders of the end of the emergency and return the EOC back to Level IV (Normal Operations).	______________	______________
3. The District EM will submit a final SITREP to higher headquarters in ENGLink.	______________	______________
4. The District EM will begin recalling non-expendable resources that supplemented state and local response operations.	______________	______________
5. The District EM may remain open to facilitate other phases of a recovery mission. This will be determined during the deactivation process.	______________	______________

Figure 49: District EOC Deactivation Checklist Example

EMERGENCY LEVEE INSPECTION CHECKLIST					
Project: **Date/Time:**					**Date/Time:**
Specific Item	**YES**	**NO**	**N/A**	**A**	**Comments/Notes**
1. Access:					
a. Project Accessible (General Location)?					
b. Levee ramp and crest accessible and usable?					
c. Landward side of levee accessible?					
2. Levee Embankment					
a. Any low areas in danger of being overtopped?					
b. Evidence of seepage on landward slope, toe, or around pipes? (e.g., Boils, soft saturated areas, seeps, etc.)					
c. Any indications of slides or sloughs developing (misalignments, cracking, bulging, etc.)?					
d. Any erosion from wave wash, scouring, or overtopping?					
e. Any areas were riprap revetment work has been displaced?					
f. Whirlpools observed riverward of levee?					
g. Any evidence of bank caving or erosion riverward of the embankment?					
h. Other?					

SHEET 1 of 2

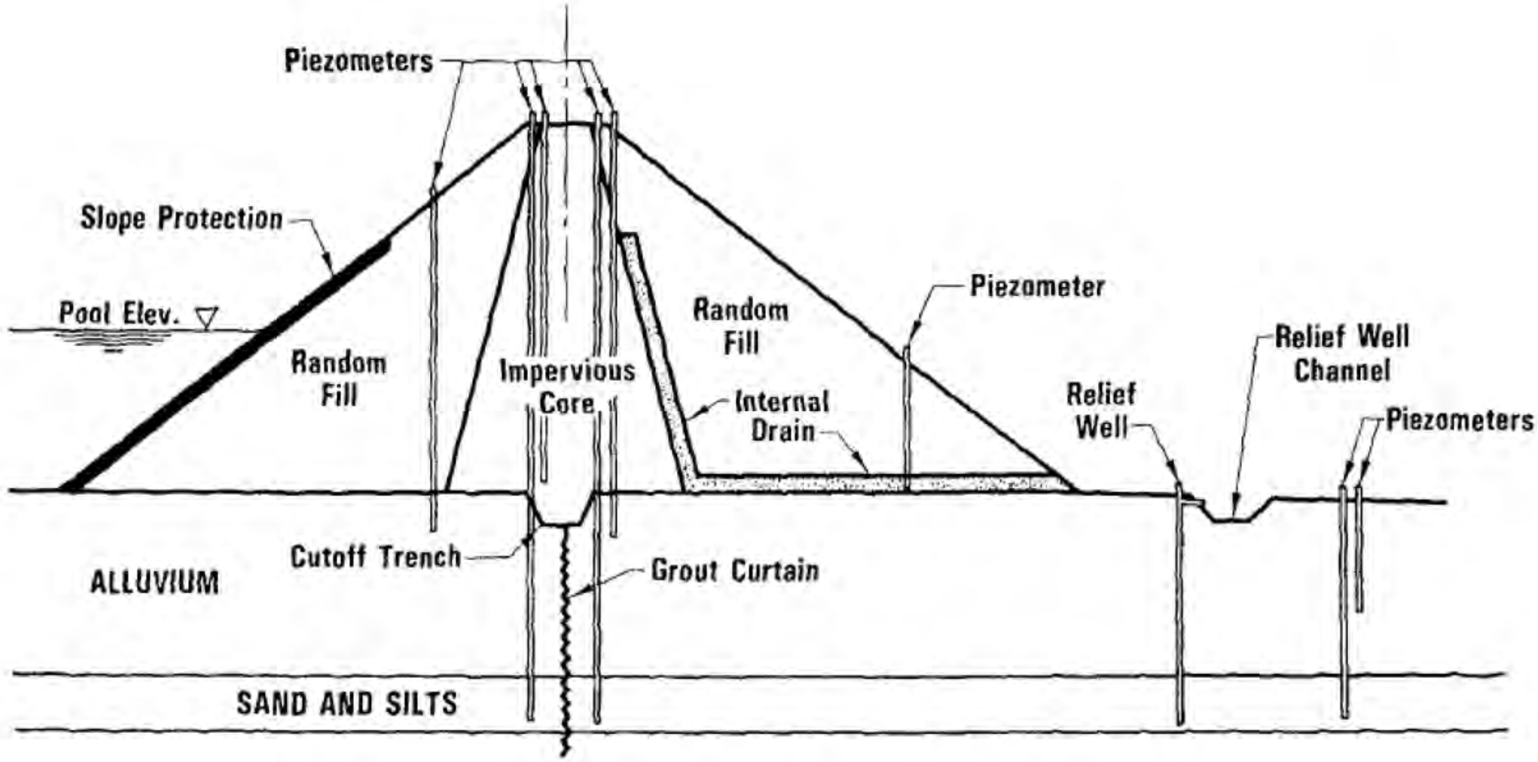
PLATE NO. 1

EMERGENCY LEVEE INSPECTION CHECKLIST					
Project: **Date/Time:**					**Date/Time:**
Specific Item	**YES**	**NO**	**N/A**	**A**	**Comments/Notes**
3. Drainage Structures/Floodwalls:					
a. Any evidence of seepage around, through, or adjacent to this structure which might affect its or the embankments stability?					
b. Any signs of settlement that may affect the stability or water-tightness of the structure?					
c. Has the structure deteriorated (e.g. cracked, rusted, etc.) to a point where the structure's stability or water-tightness may be affected?					
d. Any debris or trash accumulated adjacent to inlets, outlets, or other critical areas?					
e. Are flap-gates, slide-gates, or other control structures operational?					
f. Has riprap around structures been displaced?					
g. Other?					
4. Miscellaneous Items:					
a. Are relief wells flowing (record well numbers and flow rates as required)?					
b. Are inlet and outlet channels clear of growth and debris?					
c. Are tributary channels clear of debris that might jeopardize the project (e.g., debris at bridges)?					
d. Any obvious signs of distress at pumping plants, closure structures, or other structures?					
e. Are closure structures in place?					
f. Can closure be made promptly if necessary?					
g. Are closure structures leaking or in poor condition?					
h. Are appropriate flood response materials readily available to implement flood response operations?					
i. Other?					
Weather Conditions:					**Water Level:**
Name & Signature of Inspector:					

N/A = Not Applicable A = Action Item

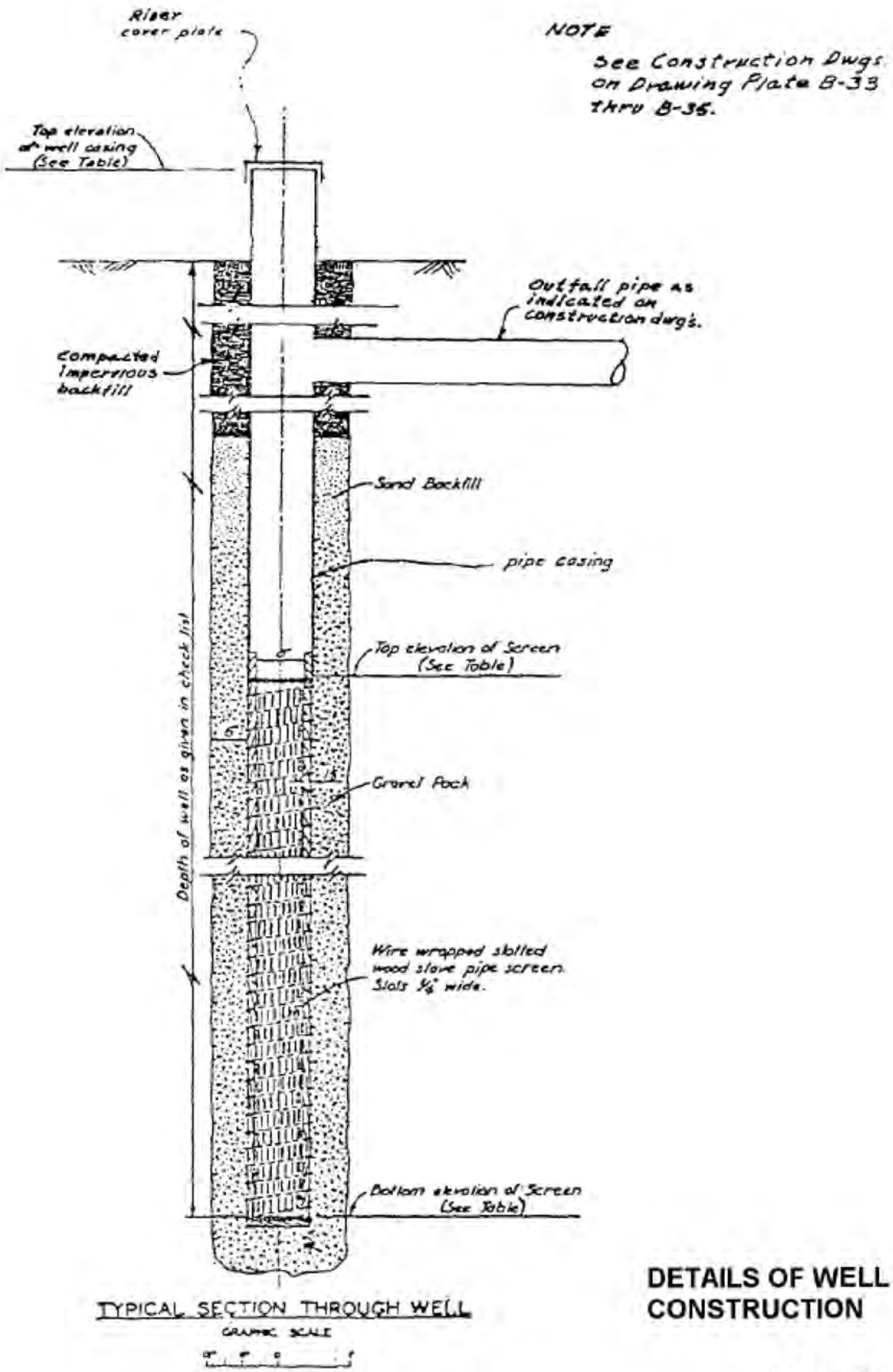
SHEET 2 of 2

PLATE NO. 2



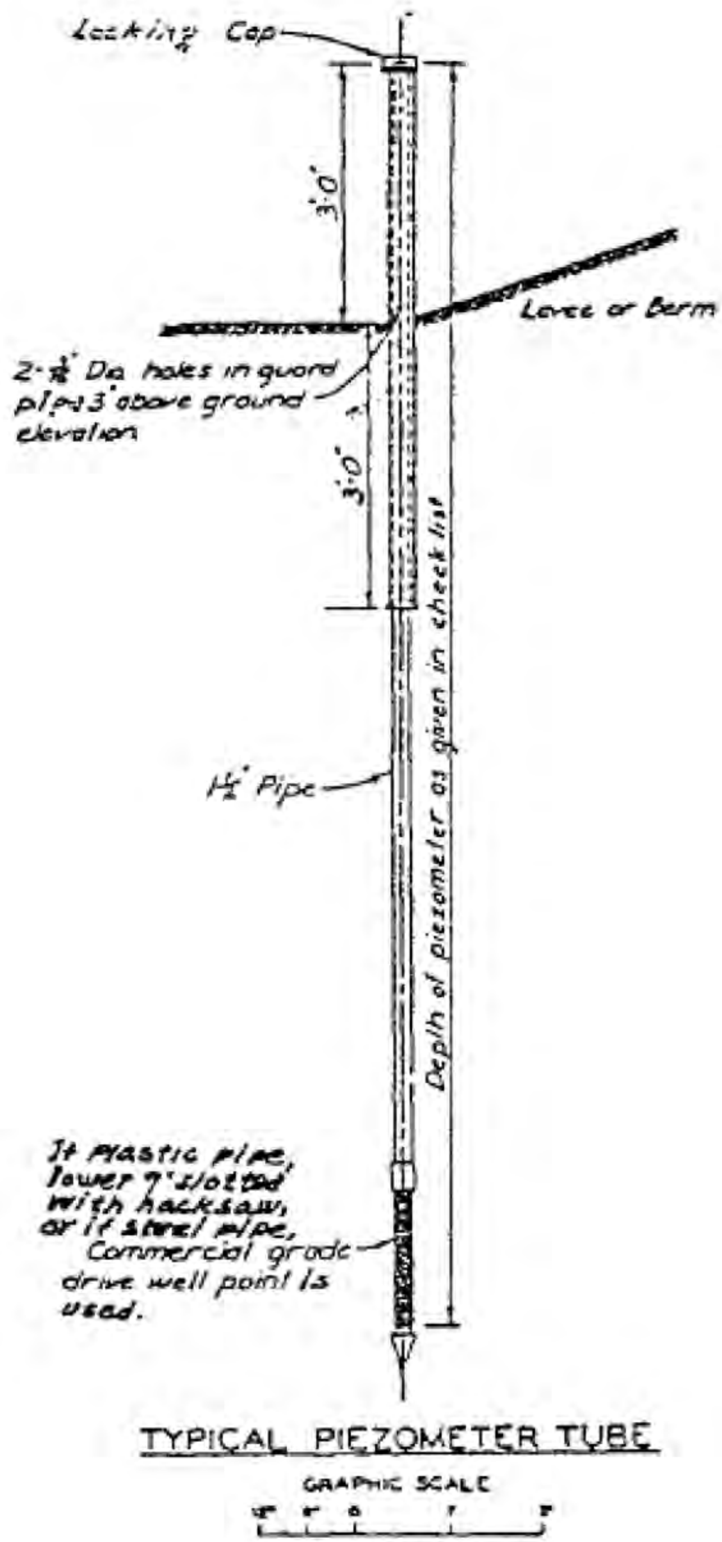
EMBANKMENT AND UNDERSEEPAGE CONTROL

PLATE NO. 4



DETAILS OF WELL CONSTRUCTION

PLATE NO. 5



DETAILS OF PIEZOMETER TUBE CONSTRUCTION

PLATE NO. 6

EMERGENCY LEVEE INSPECTIONS
PIEZOMETER WATER LEVEL DATA SHEET

Project: **Date:**

Instrument No.	Depth to Water (Time:)	Depth to Water (Time:)	Depth to Water (Time:)	Notes

Inspector Name & Signature

PLATE NO. 7

EMERGENCY LEVEE INSPECTIONS
RELIEF WELL DATA SHEET

Project: | **Date:**

Instrument No.	Depth to Water (Time:)	Depth to Water (Time:)	Depth to Water (Time:)	Notes

Inspector Name & Signature

PLATE NO. 8

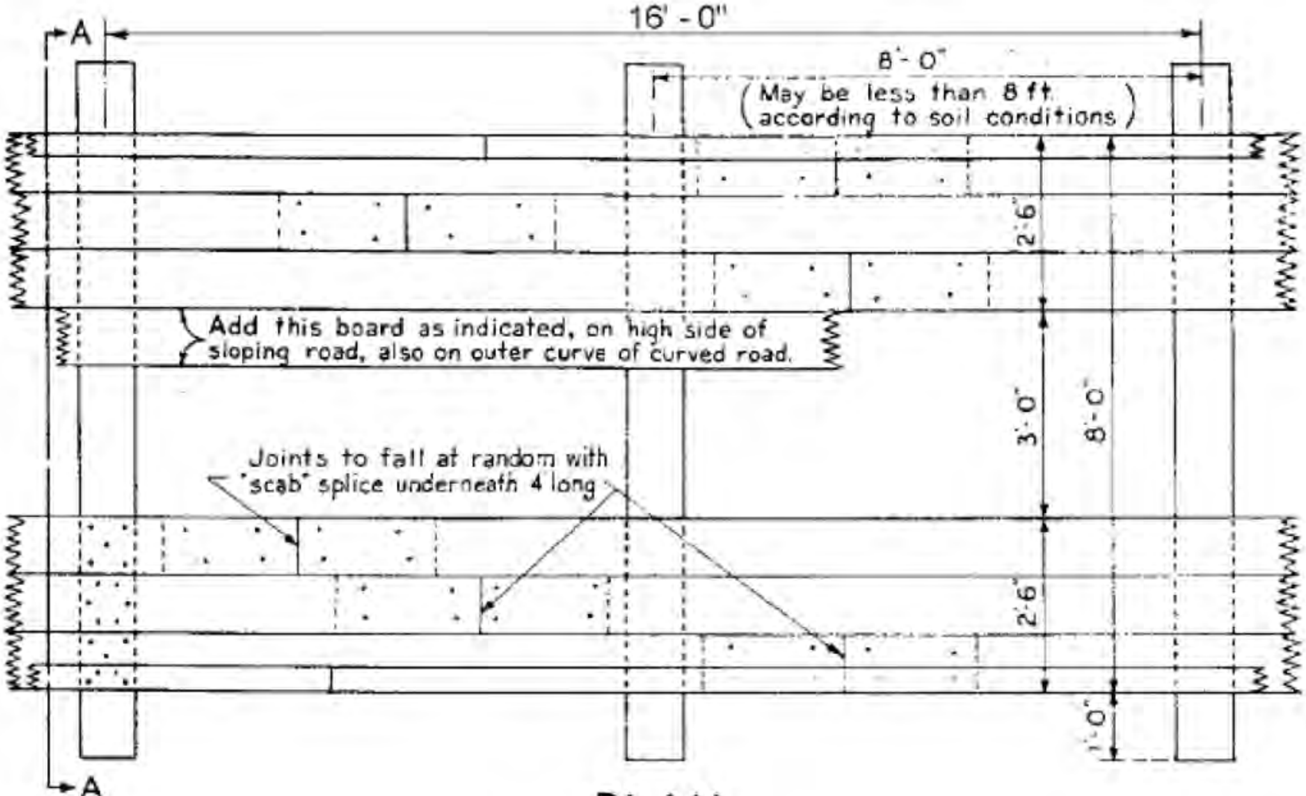
EMERGENCY LEVEE INSPECTIONS
RIVER STAGE DATA SHEET

Project: | **Date:**

Measurement Location	Time	Notes

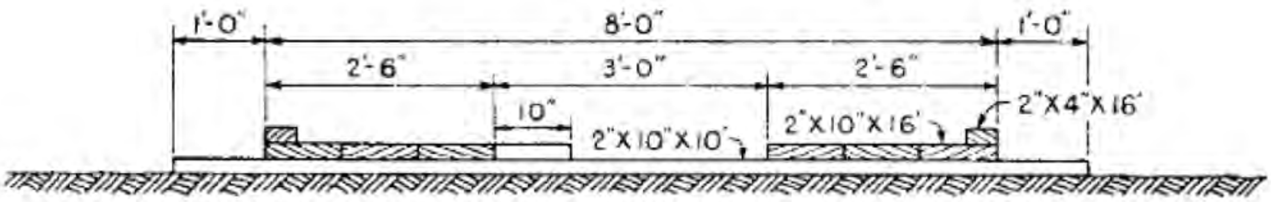
Inspector Name & Signature

PLATE NO. 9



PLAN

Scale $\frac{3}{8}$" = 1'-0"



SECTION A-A

Scale $\frac{1}{2}$" = 1'-0"

BILL OF MATERIALS FOR 100 LINEAR FEET OF ROADWAY

Cross Members	13 Pcs. 2"X10"X10' =	217 Bd. Ft.
Road Bed	38 Pcs. 2"X10"X16'* =	1014 Bd. Ft.
Guard Rail	13 Pcs. 2"X4"X16'* =	139 Bd. Ft.
	Total	1370 Bd. Ft.

18 Lbs. 30d. Common Nails

10 Lbs. 60d. Common Nails

Kind of Lumber: Hardwood, Rough.

Actual quantities. No allowance made for waste.

NOTE:

Where foundation is very soft, 12 ft. flooring should be used with cross members at 6 ft. centers. In this case add approximately $33\frac{1}{3}$% or $\frac{1}{3}$ to Bill of Materials at left, for 100 ft. of roadway.

* Random not less than 12'

EMERGENCY FLOOD FIGHTING

PLANK ROAD

U.S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS
OMAHA, NEBRASKA

PLATE NO. 44

Seepage and Sand Boil Descriptions

Seepage Description	
Impounded Water	Area covered in water but unable to determine source.
No seepage	No evidence of saturated areas.
Very Light Underseepage	Saturated area only with no flow
Light Underseepage	Ground surface is saturated with seepage flowing slowly out of the ground surface such as a uniform thin sheet seepage flow.
Medium Underseepage	Seepage over large areas flowing into collecting streams on the surface (no sand boils). Small, concentrated seeps may be observed that are not transporting foundation material.
Heavy Underseepage	Seepage over large areas flowing into collecting streams with sand boil activity.

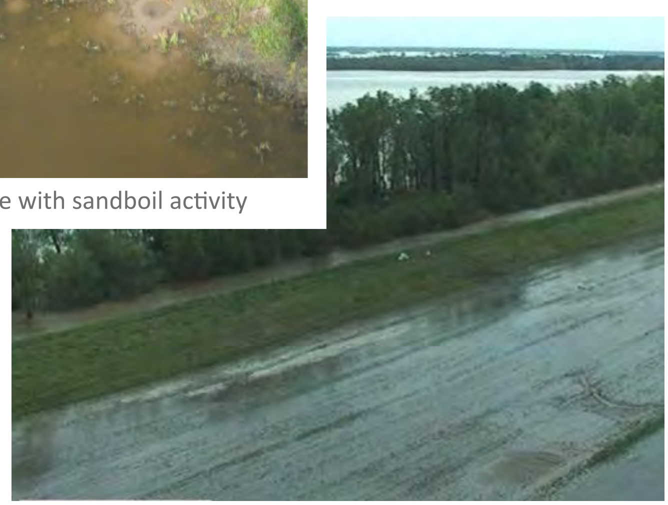
Examples of Underseepage Magnitude

a: None or Very Light Underseepage

b: Light Underseepage

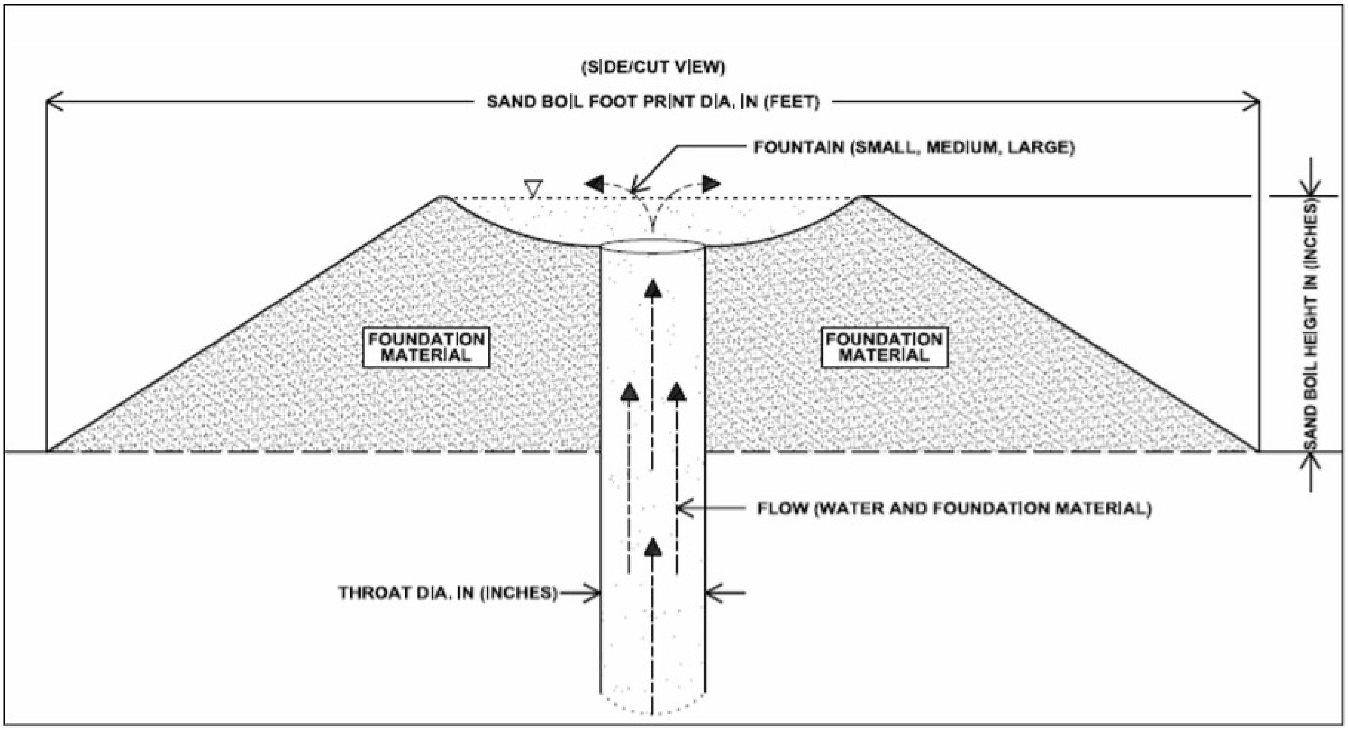
e: Heavy underseepage with sandboil activity

c: Medium Underseepage



d: Heavy Underseepage

Sand Boil Geometry



Sand Boil Size Description	
Pin Boil	Throat size less than ½ inch in diameter (less than 1 finger width wide)
Small	Throat size between ½ inch to 2 inches in diameter (up to 3 finger widths)
Medium	Throat size between 2 inch to 4 inches in diameter (3 fingers to Fist)
Large	Throat size between 4 inch to 6 inches in diameter (Fist and extended thumb)
Very Large	Throat size greater than 6-inches in diameter (Larger than fist and extended thumb)

Sand Boil Activity Description	
Low Activity	No or very little sand observed around the throat of the sand boil and seepage discharge was clear.
Moderate Activity	Cone of sand accumulated around the sand boil less than 6 cubic feet (6 cubic feet is roughly equivalent to one wheelbarrow full of material) or seepage discharge is slightly cloudy.
High Activity	Cone of sand accumulated around the sand boil is greater than 6 cubic feet of material but less than 1 cubic yard, or seepage discharge is very cloudy.
Very High Activity	Greater than one cubic yard (27 cubic feet) of material accumulated around the sand boil. (One cubic yard is roughly equivalent to the outside dimensions of a standard refrigerator/freezer), or seepage discharge is extremely cloudy.

Examples of Various Sand Boil Size and Activity

a: Pin Boils

b: Small Boil, Moderate Activity

c: Med Boil, Moderate Activity

d: Very Large, Very High Activity, Concentrated Leak under floodwall

e: Very Large Boil, Very High Activity

APPENDIX H - GUIDE TO EQUIPMENT AND PERSONNEL REQUIREMENTS

Table I

TWO-BOARD CAPPING

The following is a list of personnel and equipment required to construct approximately 1,000 linear feet of two-board capping per day. It is presented as a guide only; to be used in situations where modern earthmoving equipment cannot be used or is not available for accomplishing the work.

Personnel

- 1 Foreman
- 6 Sub foremen (skilled laborers)
- 2 Timekeepers
- 116 Laborers

Tools and Equipment

- 4 Axes
- 6 Claw hammers
- 4 Mauls (post)
- 110 Shovels (long-handled, round-pointed)
- 100 Wheelbarrows
- 1 Chain saw, with 5 gallons of fuel (minimum)
- 2 Saws (crosscut, hand)
- I Saw set tool (hand crosscut)
- 6 Files (saw)
- 1 Plow and team
- * Lighting equipment

  * Lighting equipment is to consist of the following (quantities to be determined at time of mobilization):
  - Lanterns
    - ☐ High candlepower
    - ☐ Air pressure light, with fuel Generator Sets, with floodlights and fuel

Earth-fill

400 Cubic yards

Table II

THREE-BOARD CAPPING

The following is a list of personnel and equipment required to construct approximately 1,000 linear feet of three-board capping per day. It is presented as a guide only; to be used in situations where modern earthmoving equipment cannot be used or is not available for accomplishing the work.

Personnel

- I Foreman
- 6 Sub foreman (skilled laborers)
- 3 Timekeepers
- 190 Laborers

Tools and Equipment

- 4 Axes
- 8 Claw hammers
- 4 Mauls (post)
- 175 Shovels (long-handled, round-pointed)
- 165 Wheelbarrows
- 1 Chain saw, with 5 gallons of fuel (minimum)
- 4 Saws (crosscut, hand)
- 1 Saw set tool (hand crosscut)
- 6 Files (saw)
- 1 Plow and team
- * Lighting equipment

  * Lighting equipment is to consist of the following (quantities to be determined at time of mobilization):
    - Lanterns
      - ☐ High candlepower
      - ☐ Air pressure light, with fuel Generator Sets, with floodlights and fuel

Earth-fill

575 Cubic yards

Table III

MUD BOX LEVEE, 3 FEET-6 INCHES AVERAGE HEIGHT

The following is a list of personnel and equipment required to construct approximately 1,000 linear feet of mud box levee (3 feet-6 inches average height) per day. It is presented as a guide only; to be used in situations where modern earthmoving equipment cannot be used or is not available for accomplishing the work.

Personnel

- 2 Foremen
- 6 Sub foreman (skilled laborers)
- 4 Timekeepers
- 210 Laborers

Tools and Equipment

- 5 Axes
- 10 Claw hammers
- 4 Mauls (post)
- 200 Shovels (long-handled, round-pointed)
- 180 Wheelbarrows
- 1 Chain saw, with 5 gallons of fuel (minimum)
- 4 Saws (crosscut, hand)
- 1 Saw set tool (hand crosscut)
- 6 Files (saw)
- 1 Plow and team
- * Lighting equipment

  * Lighting equipment is to consist of the following (quantities to be determined at time of mobilization):
    - Lanterns
      - □ High candlepower
      - □ Air pressure light, with fuel Generator Sets, with floodlights and fuel

Earth-fill

925 Cubic yards

Table IV

VERTICAL BOARD WAVE-WASH REVETMENT

(Height above ground surface approximately 8 feet)

The following is a list of personnel and equipment required to construct approximately 1,000 linear feet of vertical board wave-wash revetment per day. It is presented as, a guide only; to be used in situations where modern earthmoving equipment cannot be used or is not available for accomplishing the work.

Personnel

- I Foreman
- 3 Sub foremen (skilled laborers)
- 2 Timekeepers
- 100 Laborers

Tools and Equipment

- 4 Axes
- 2 Hatchets
- 8 Claw hammers
- 2 Post drivers
- 4 Mauls (post)
- 2 Dollies
- 10 Shovels (long-handled, round-pointed)
- 1 Chain saw, with 5 gallons of fuel (minimum)
- 4 Saws (crosscut, hand)
- 1 Saw set tool (hand crosscut)
- * Lighting equipment

  * Lighting equipment is to consist of the following (quantities to be determined at time of mobilization):
    - Lanterns
      - □ High candlepower
      - □ Air pressure light, with fuel Generator Sets, with floodlights and fuel

Table V

HORIZONTAL BOARD WAVE-WASH REVETMENT

(Height above shelf surface, 2.5 feet)

The following is a list of personnel and equipment required to construct approximately 1,000 linear feet of horizontal board wave-wash revetment per day. It is presented as a guide only; to be used in situations where modern earthmoving equipment cannot be used or is not available for accomplishing the work.

Personnel

- 1 Foreman
- 3 Sub foremen (skilled laborers) 1 Timekeeper
- 30 Laborers

Tools and Equipment

- 4 Axes
- 10 Claw hammers
- 2 Post drivers
- 2 Mauls I Dolly
- 2 Shovels (long-handled, round-pointed)
- 1 Chain saw, with 5 gallons of fuel (minimum)
- 4 Saws (crosscut, hand)
- I Saw set tool (hand crosscut)
- 6 Files (saw)
- 2 Skiffs, with outboard motors and 20 gallons of fuel
- * Lighting equipment

  * Lighting equipment is to consist of the following (quantities to be determined at time of mobilization):
  - Lanterns
    - High candlepower
    - Air pressure light, with fuel Generator Sets, with floodlights and fuel

Table VI

SAMPLE SPECIFICATIONS FOR TYPICAL SANDBAGS AND SHIPPING CONTAINERS

PART 2 PRODUCTS

2.1 SANDBAGS

Sandbags shall be constructed in accordance with the following specifications.

2.1.1 Sandbag Dimensions.

The sandbags shall be constructed with the nominal dimensions of 26 (± ½”) inches long by 14 (± ½”) inches wide.

2.1.2 Sandbag Material.

The sandbags shall be constructed from coated polypropylene fabric. The sandbags shall be constructed with a minimum denier of 700 and be a minimum of 10x10 woven pattern.

2.1.3 Sandbag Tie String.

The length of the tie string shall not be less than 24 inches. The ends of the tie string shall be heat-sealed or knotted to prevent unraveling. The tie string shall be located on one side of the bag (at seam or folded bag edge), not less than 4 inches nor more than 5 inches from the top edge of the bag. Tie strings shall be located on the outside of the bag.

2.1.4 Sandbag Color.

The sandbags shall be white in color.

2.1.5 Sandbags UV Resistance Coating

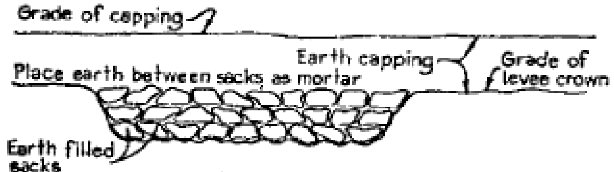
The sandbags shall contain ultraviolet resistance to retain 70% strength after 200 hours of exposure to accelerated weathering testing.

2.1.6 Quantity of bundles

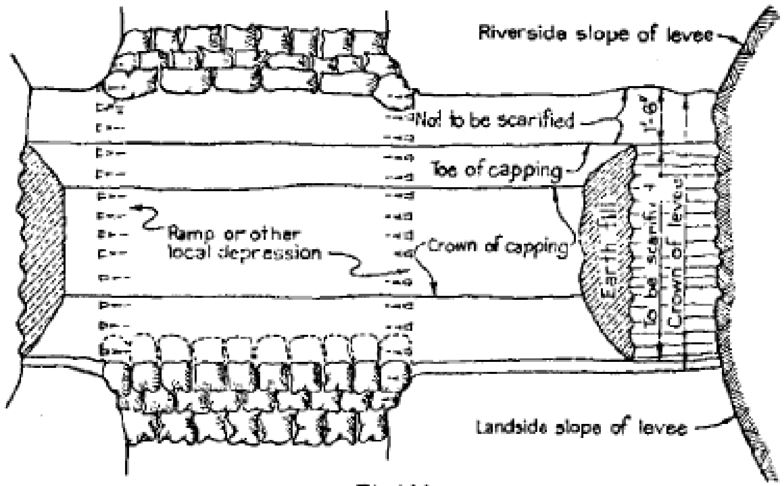
per Shipping Container:
- 25 bundles per 4 ft. long, 4 ft. wide, and 4 ft. high container
- 12,500 sandbags per shipping container

per pallet:
- 16 bundles per 4 ft. long, 4 ft. wide pallet
- 16,000 sandbags per pallet

A bundle shall contain 500 sandbags per shipping container or 1,000 sandbags per pallet. Sandbags shall be stacked flat-wise, compressed and banded.



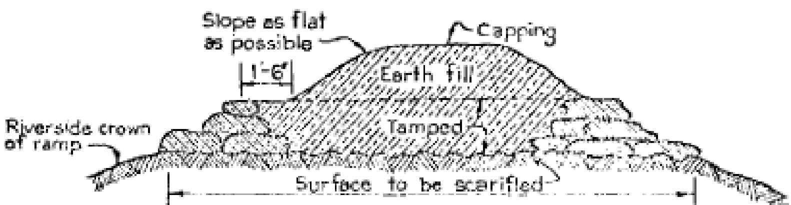
ELEVATION



PLAN

TYPICAL SECTION LEVEE CAPPING

NOTE: This type of capping not to be used on levees with crown less than 10' wide or on levees exposed to wave wash.



TYPICAL SECTION AT RAMP OR OTHER DEPRESSION

EMERGENCY FLOOD FIGHTING

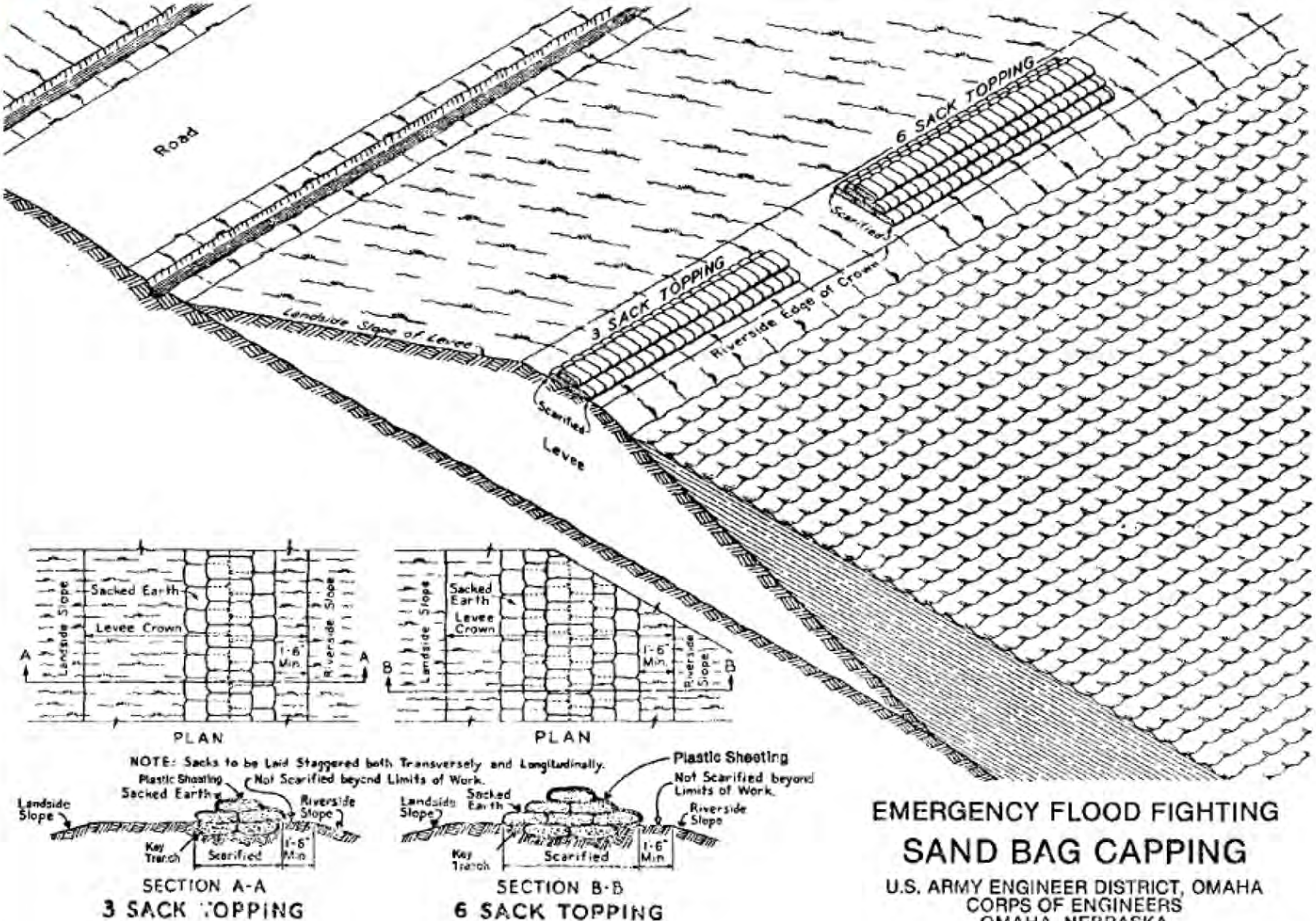
EARTH CAPPING

FOR RAISING DEPRESSIONS AND LEVEE CAPPING

(THIS DESIGN IS ADEQUATE FOR HEIGHTS UP TO 1½')

U.S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS
OMAHA, NEBRASKA

PLATE NO. 10



EMERGENCY FLOOD FIGHTING

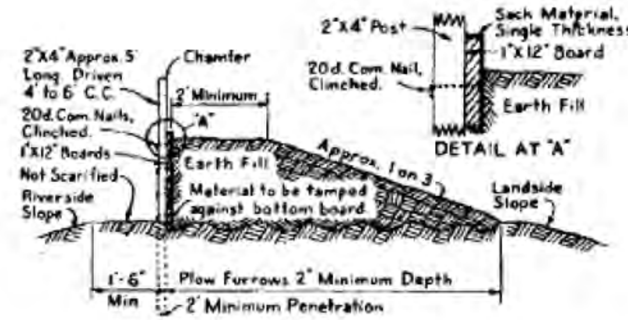
SAND BAG CAPPING

U.S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS
OMAHA, NEBRASKA

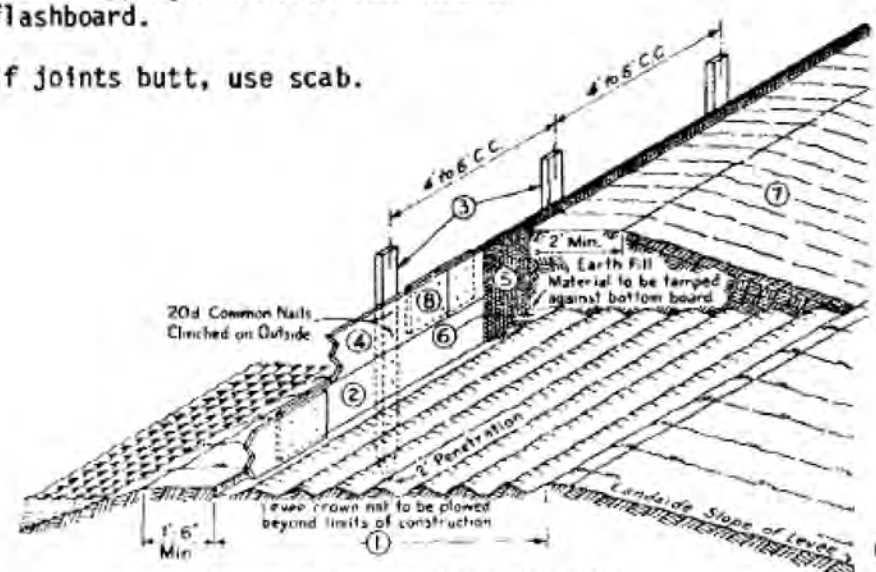
PLATE NO. 11

SEQUENCE OF OPERATIONS

1. Plow crown of levee (2" minimum depth) beginning 1'-6" from riverside edge.
2. Place bottom flashboards on edge of plowed furrow, break joints any place.
3. Place and drive 2"x4" posts from 4' to 6' C.C., nail flashboards to posts.
4. Place top flashboards and nail; break joints any place.
5. Place and nail Visqueen or other material.
6. Refill plowed furrow and tamp on both sides of bottom boards.
7. Place capping material, landside of flashboard.
8. If joints butt, use scab.



SECTION



METHOD OF CONSTRUCTION

TWO BOARD LEVEE CAPPING
BILL OF MATERIALS FOR 1000 LINEAR FEET

201 Posts	2" x 4" x 5'-0"	=	670 bd.ft.
	Boards 1" x 12" x 2000 L.F.	=	2000 bd.ft.
			2670 bd.ft.
50 lbs.	20d Common Nails	=	1450 Nails
Visqueen	2-1/2' x 1000'	=	2500 sq.ft.

Actual quantities. No allowance made for waste.

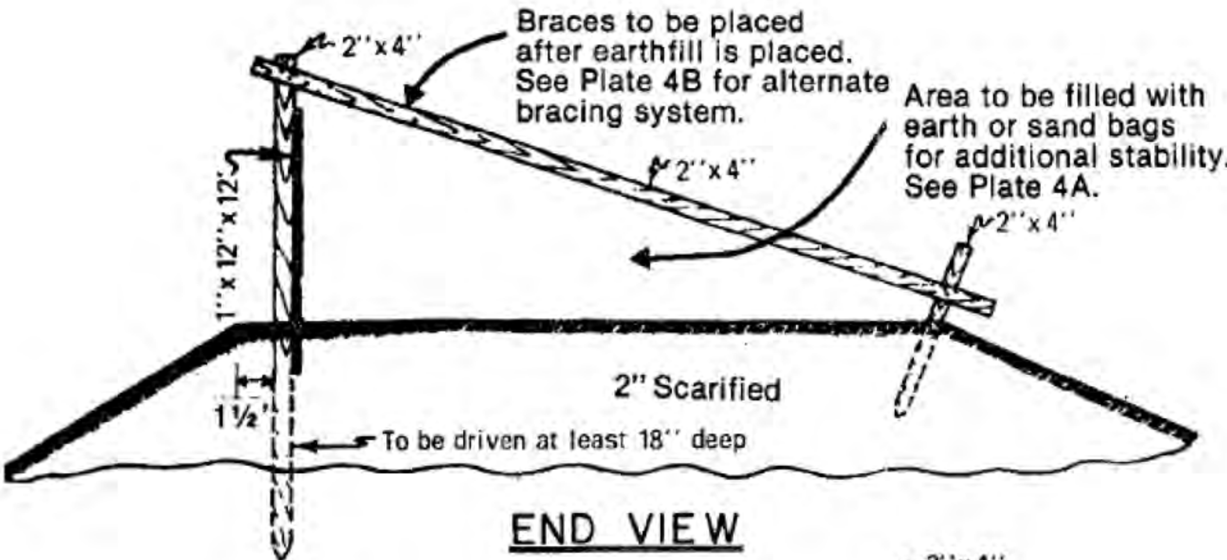
*NOTE: Dimensions based on rough cut lumber.

EMERGENCY FLOOD FIGHTING
FLASHBOARD LEVEE CAPPING TWO BOARD TYPE

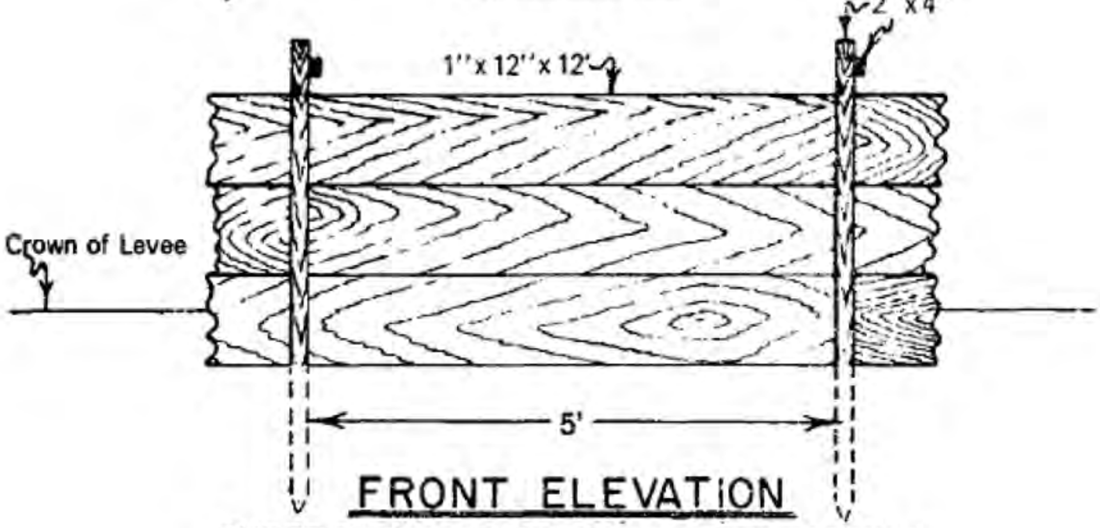
(THIS DESIGN IS ADEQUATE FOR HEIGHTS UP TO 2')

U.S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS
OMAHA, NEBRASKA

PLATE NO. 12



END VIEW



FRONT ELEVATION

THREE BOARD FLASHBOARD LEVEE CAPPING
BILL OF MATERIAL TO CONSTRUCT 100'

Boards	1"X12"X 300 L.F.	=	300 Bd.Ft.
17 Posts	2"X4"X 6'-0"	=	68 Bd.Ft.
17 Braces	2"X4"X10'-0"	=	114 Bd.Ft.
17 Anchors	2"X4"X2'-0"	=	23 Bd.Ft.
	TOTAL		505 Bd.Ft.

Dimensions based on rough cut lumber.
5 lbs. 10d Common Nails

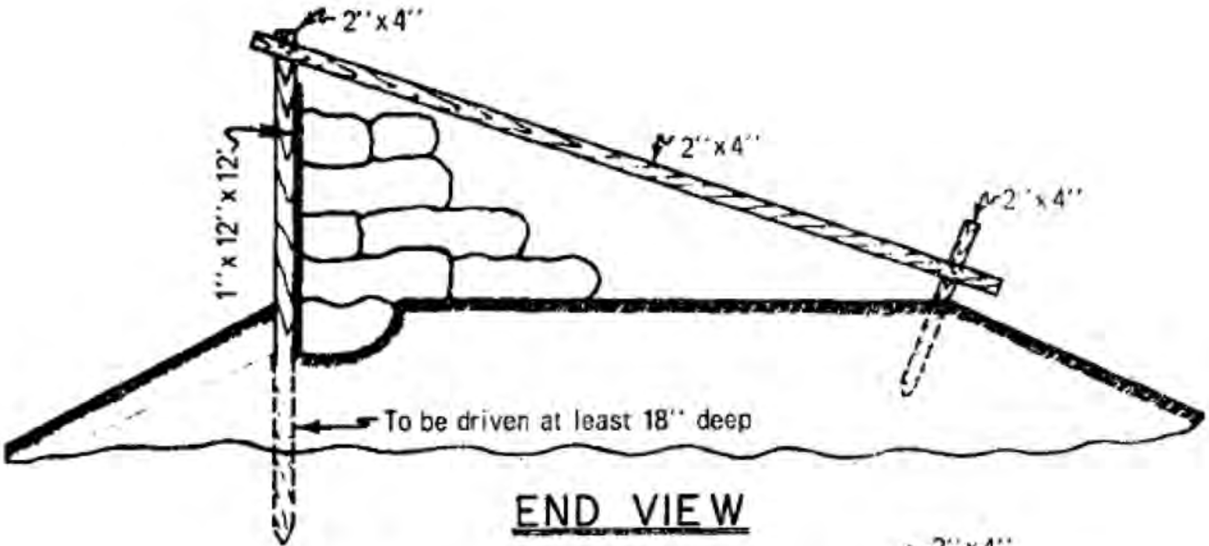
EMERGENCY FLOOD FIGHTING

FLASHBOARD LEVEE CAPPING THREE BOARD TYPE

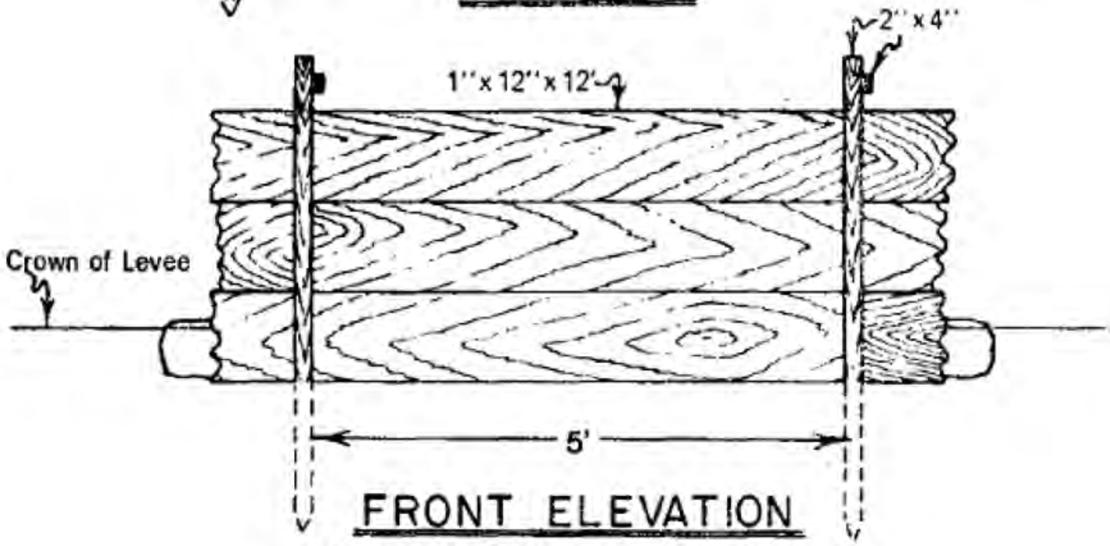
(THIS DESIGN IS ADEQUATE FOR HEIGHTS UP TO 3')

U.S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS
OMAHA, NEBRASKA

PLATE NO. 13



END VIEW



FRONT ELEVATION

THREE BOARD LUMBER AND SACK TOPPING
BILL OF MATERIAL TO CONSTRUCT 100'

Boards	1"X12"X 300 L.F.	=	300 Bd.Ft.
17 Posts	2"X4"X 6'-0"	=	68 Bd.Ft.
17 Braces	2"X4"X10'-0"	=	114 Bd.Ft.
17 Anchors	2"X4"X2'-0"	=	23 Bd.Ft.
	TOTAL		505 Bd.Ft.

Dimensions based on rough cut lumber.
5 lbs. 10d Common Nails
6 - 8 bags/L.F.
800 bags

EMERGENCY FLOOD FIGHTING

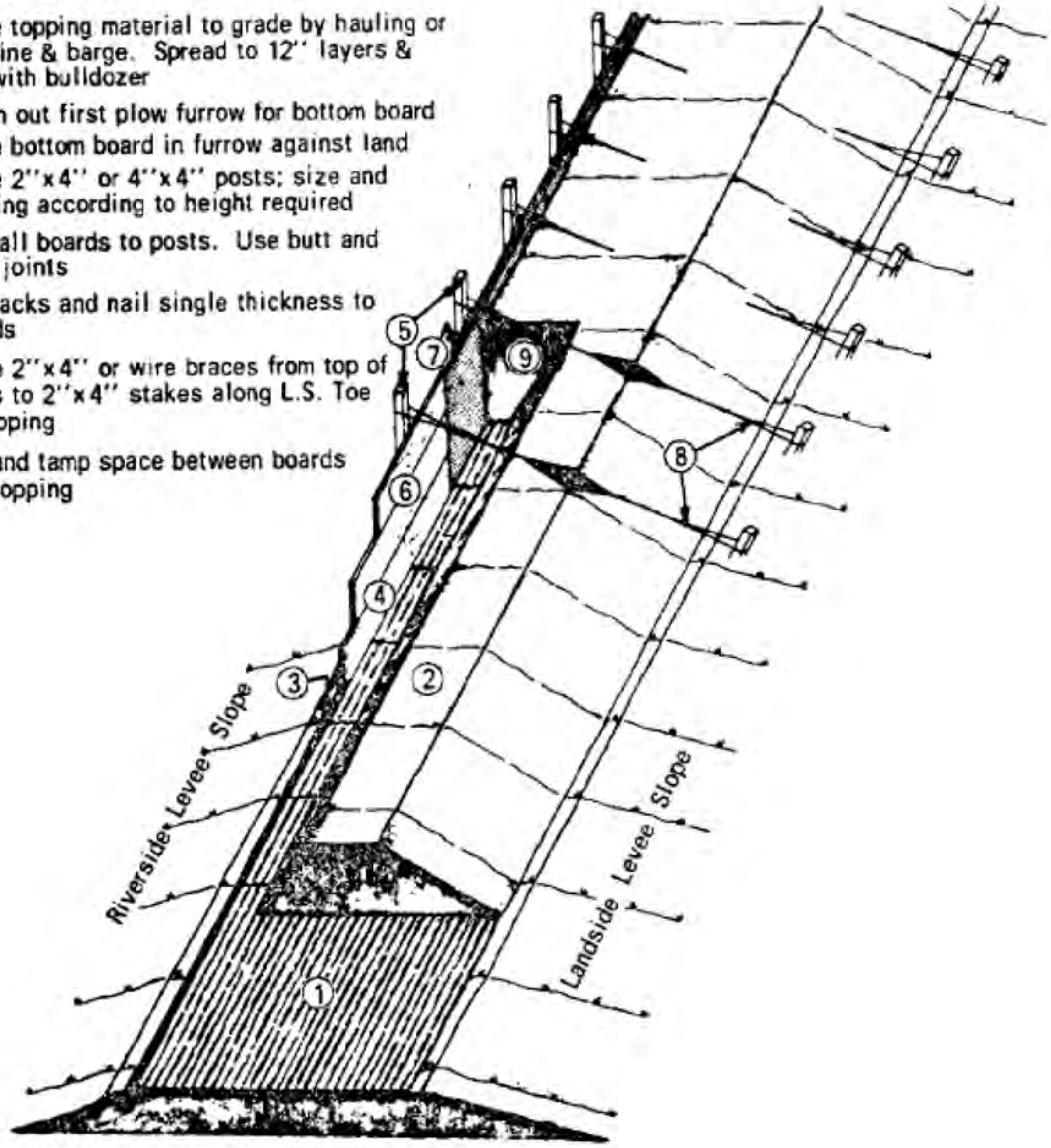
LUMBER AND SACK TOPPING

U.S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS
OMAHA, NEBRASKA

PLATE NO. 14

SEQUENCE OF OPERATIONS

1. Plow crown of levee
2. Place topping material to grade by hauling or dragline & barge. Spread to 12" layers & roll with bulldozer
3. Clean out first plow furrow for bottom board
4. Place bottom board in furrow against land
5. Drive 2"x4" or 4"x4" posts; size and spacing according to height required
6. Nail all boards to posts. Use butt and scab joints
7. Rip sacks and nail single thickness to boards
8. Place 2"x4" or wire braces from top of posts to 2"x4" stakes along L.S. Toe of topping
9. Fill and tamp space between boards and topping



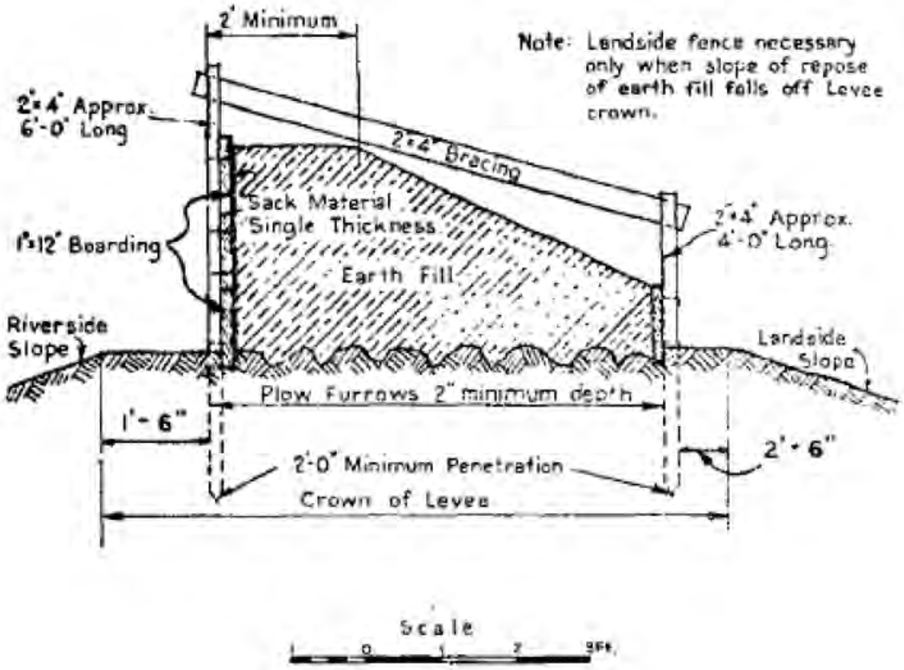
MATERIAL REQ. FOR 100' X 3'H

Posts - 17 pc's 2"x4"x12' Spaced 3' = 136 b.f.
or 13 pc's 4"x4"x12' Spaced 4' = 208 b.f.
Boards - 300 FBM 1"x12" x Any Length = 300 b.f.
3' Brace Stakes - 8 pc's 2"x4"x12' = 64 b.f.
300 Sq.Ft. Visqueen
5 lbs. 16d Common Nails
Braces - 1000 ft. (121 lbs.) 1/4" Strand

EMERGENCY FLOOD FIGHTING
BOARD & EARTH TOPPING MECHANICAL METHOD

U.S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS
OMAHA, NEBRASKA

PLATE NO. 15



BILL OF MATERIALS FOR 1000 LINEAR FEET
OF THREE BOARD CAPPING FOR NARROW
CROWN LEVEE (MAX. 3' HIGH)

201 Posts 2"X4" X 6'-0" = 804 Bd.Ft.
201 Posts 2"X4" X 4'-0" = 536 Bd.Ft.
*201 Braces 2"X4" X 14"=0" = 943 Bd.Ft.
Boards 1"X12" X 2000 L.F. = 4000 Bd.Ft.

Dimensions based on rough cut lumber

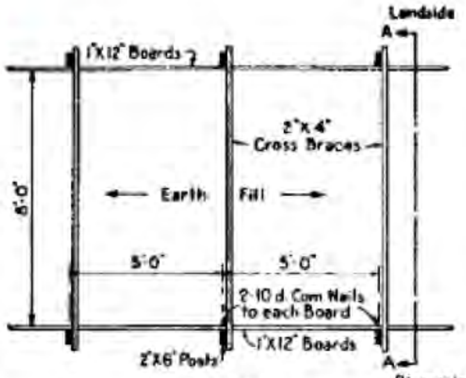
50 lbs. 8d. Common Nails
30 lbs. 20d. Common Nails

*NOTE: Should get two braces from each board.

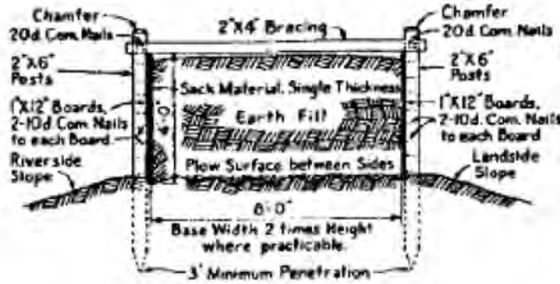
EMERGENCY FLOOD FIGHTING
FLASHBOARD LEVEE CAPPING THREE BOARD TYPE
(THIS DESIGN IS ADEQUATE FOR HEIGHTS UP TO 3')

U.S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS
OMAHA, NEBRASKA

PLATE NO. 16



PLAN



SECTION A-A

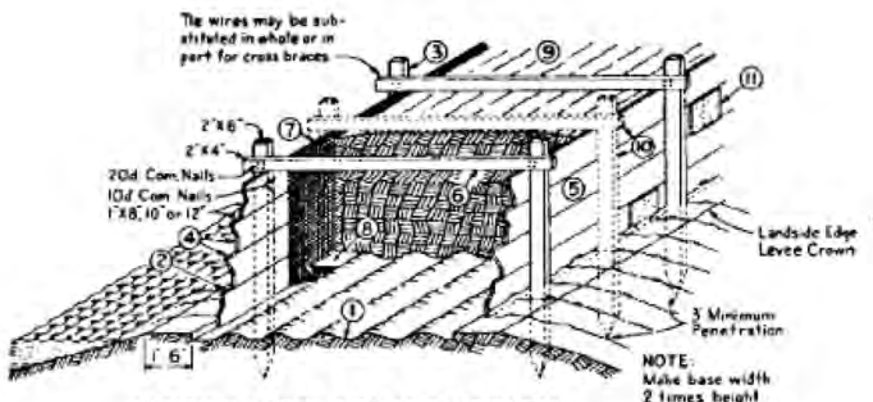
MUD BOX LEVEE CAPPING — 4 FEET HIGH
BILL OF MATERIALS FOR 1000 LINEAR FEET

402	Posts	2"X6"X8'-0"	=	3215 Bd. Ft
201	Ties	2"X4"X10'-0"	=	1340 Bd. Ft
	Boards	1"X12"X8000 L.F.	=	8000 Bd. Ft.
		Total		12,556 Bd. Ft.

100 Lbs. 10d Common Nails
80 Lbs. 20d Common Nails
1700 Sacks
Actual quantities. No allowance made for waste

4500 Sq.Ft. Visqueen 2-1/2' X 1000'

*NOTE: Dimensions based on rough cut lumber.



METHOD OF CONSTRUCTION

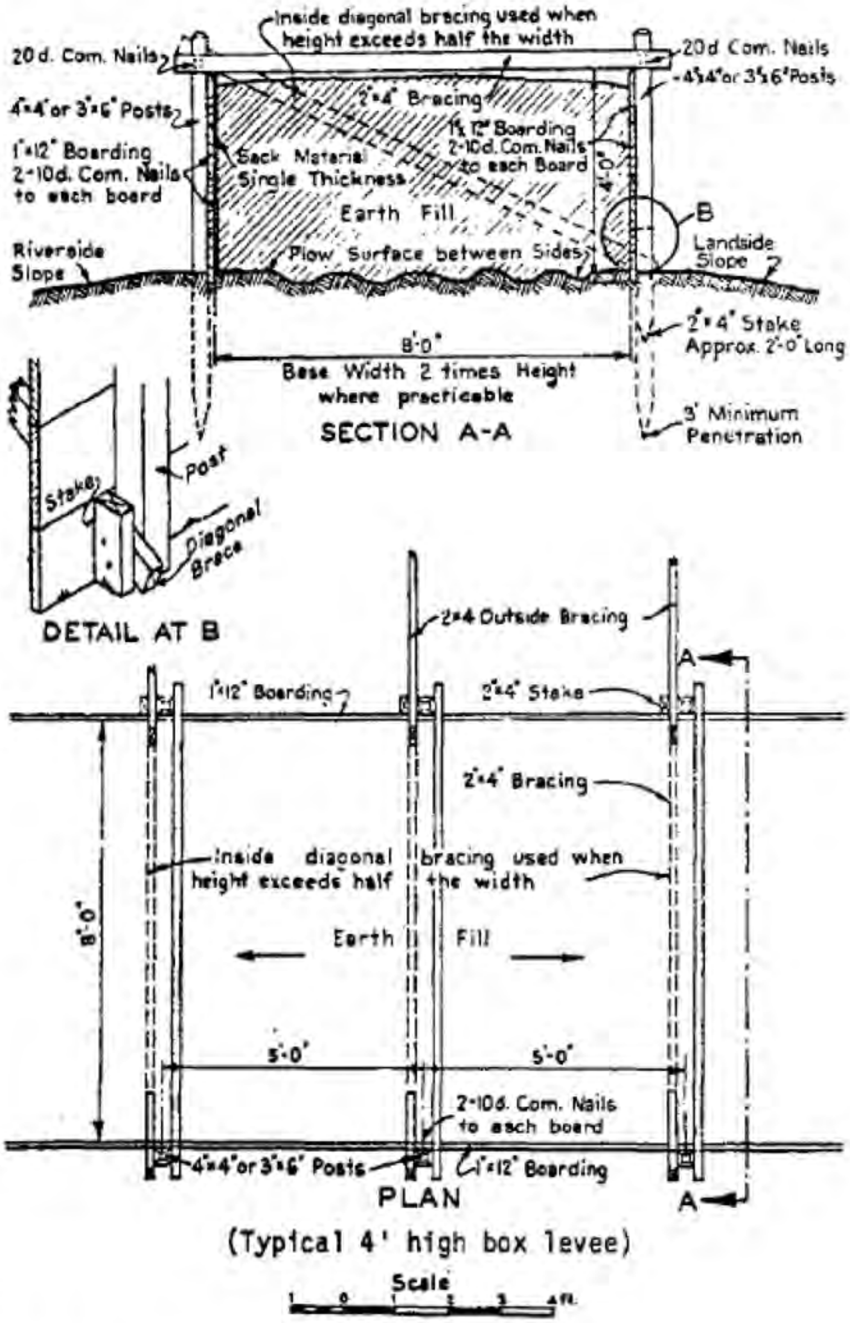
SEQUENCE OF OPERATIONS

1. Plow crown of levee (2" minimum depth) beginning 1'-6" from riverside edge.
2. Place bottom board.
3. Place and drive posts at 4' to 8' C.C. so ends of boards will meet on posts.
4. Place additional boards and nail.
5. Construct landside fence.
6. Brace fences together
7. Place and nail sack material
8. Refill furrow and tamp on both sides of bottom board.
9. Place earth fill between fences.
10. Drive and brace additional posts if earth fill exceeds 3 ft. in height
11. Break joints any place. If joints butt, use scab

EMERGENCY FLOOD FIGHTING
MUD BOX LEVEE CAPPING
(FOR CAPPING IN EXCESS OF 3' IN HEIGHT OF NARROW CROWN LEVEE CAPPING)

U.S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS
OMAHA, NEBRASKA

PLATE NO. 17



BILL OF MATERIALS FOR 1000 LINEAR FEET FOR BOX LEVEE WITH DIAGONAL BRACING

201 Stakes 2"X4"X2'-0"	= 268 Bd.Ft.
201 Diagonal Braces 2"X4"X10'	= 1340 Bd.Ft.
402 Posts 4"X4"X8'	= 4288 Bd.Ft.
201 Bracing 2"X4"X8'	= 1072 Bd.Ft.
Boarding 1"X12"X8000'	= 8000 Bd.Ft.
	14,968 Bd.Ft.

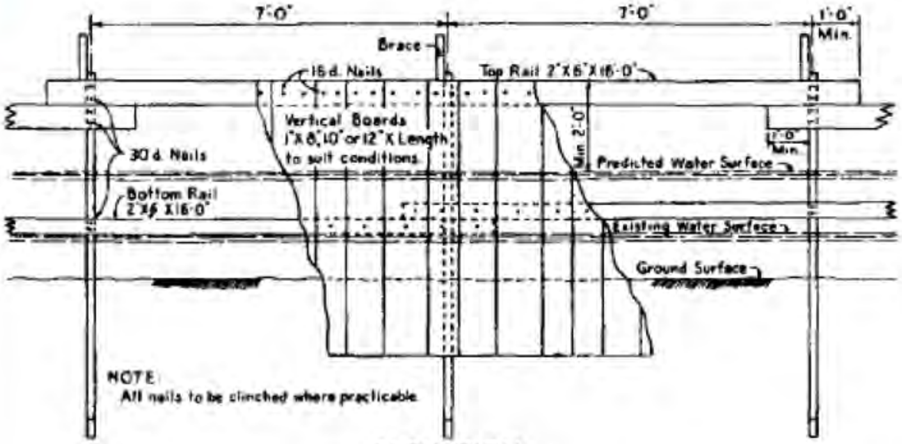
Dimensions based on rough cut lumber.
60 lb. 20d. Common Nails
60 lb. 10d. Common Nails

EMERGENCY FLOOD FIGHTING

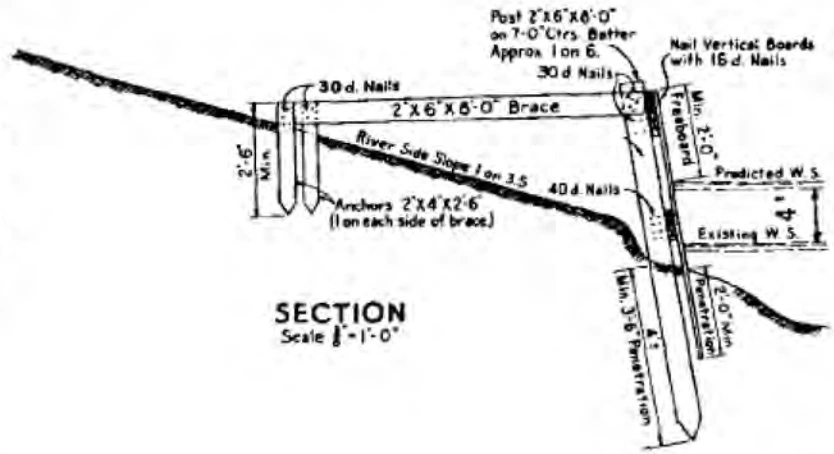
MUD BOX LEVEE WITH DIAGONAL BRACING

U.S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS
OMAHA, NEBRASKA

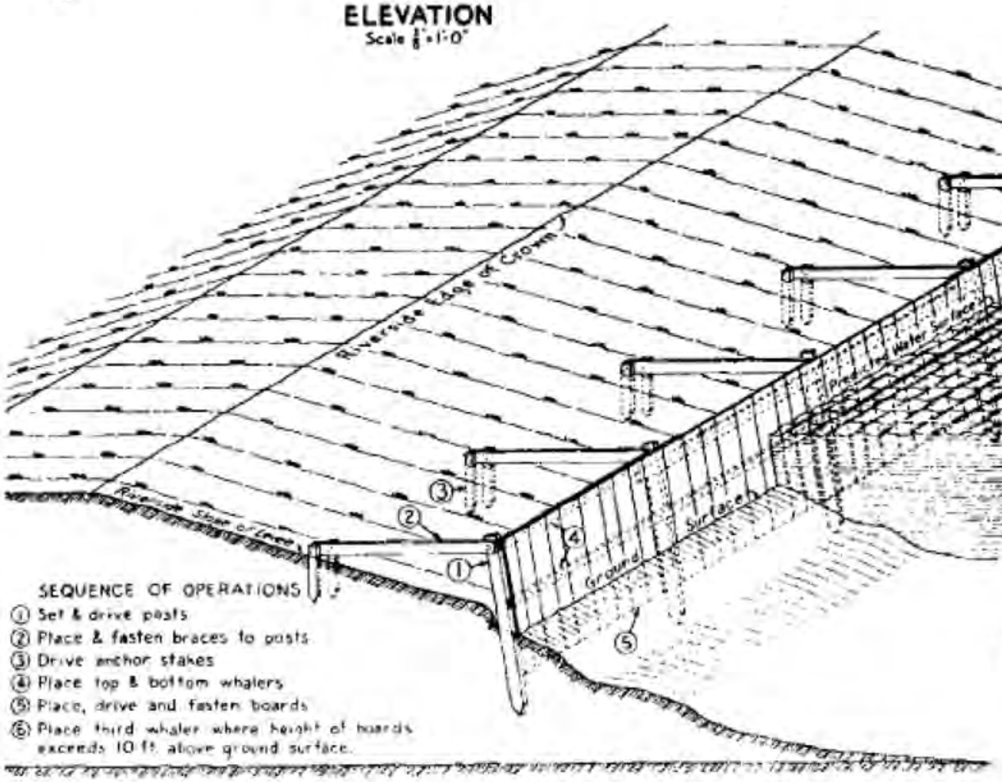
PLATE NO. 18



ELEVATION
Scale 1/8"=1'-0"



SECTION
Scale 1/8"=1'-0"



BILL OF MATERIALS FOR 100 LINEAR FEET OF REVETMENT WITH BRACES ON 7'-0" CENTERS
(Using Boards 6 Feet Long)

14.5	Posts	2"X6"X8'-0"	= 116 Bd. Ft.
14.5	Braces	2"X6"X8'-0"	= 116 Bd. Ft.
29	Anchors	2"X4"X2'-6"	= 49 Bd. Ft.
7	Rails	2"X6"X16'-0"	= 112 Bd. Ft.
7	Rails	2"X4"X16'-0"	= 75 Bd. Ft.
	Vertical Boards	1"X8", 10" or 12"X6'-0"	= 600 Bd. Ft.
		Total	1068 Bd. Ft. (Net)

6 Lbs. 30d. Common Nails
6 Lbs. 16d. Common Nails
Actual quantities. No allowance made for waste.

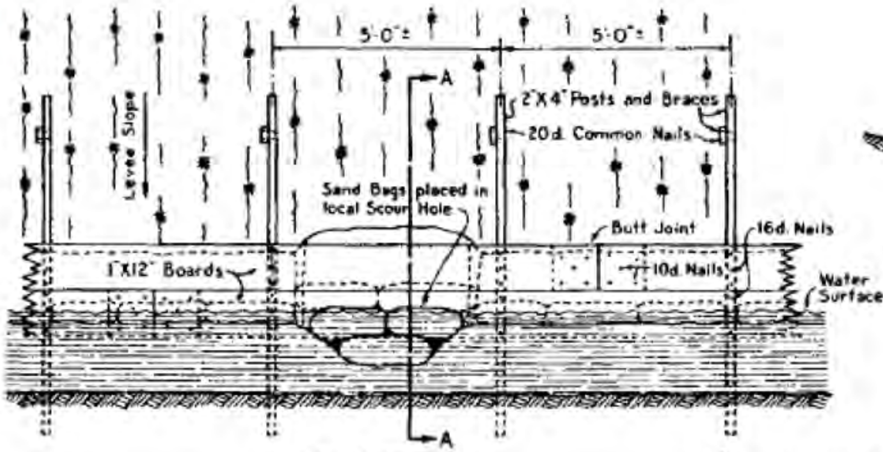
Dimensions based on rough cut lumber

NOTE: When horizontal brace span is greater than 10' diagonal bracing and strongback is required. (Plate 7A)

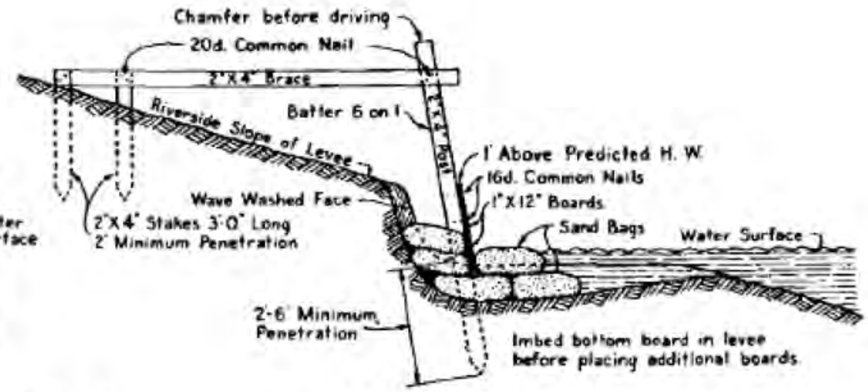
EMERGENCY FLOOD FIGHTING
VERTICAL BOARD REVETMENT

U.S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS
OMAHA, NEBRASKA

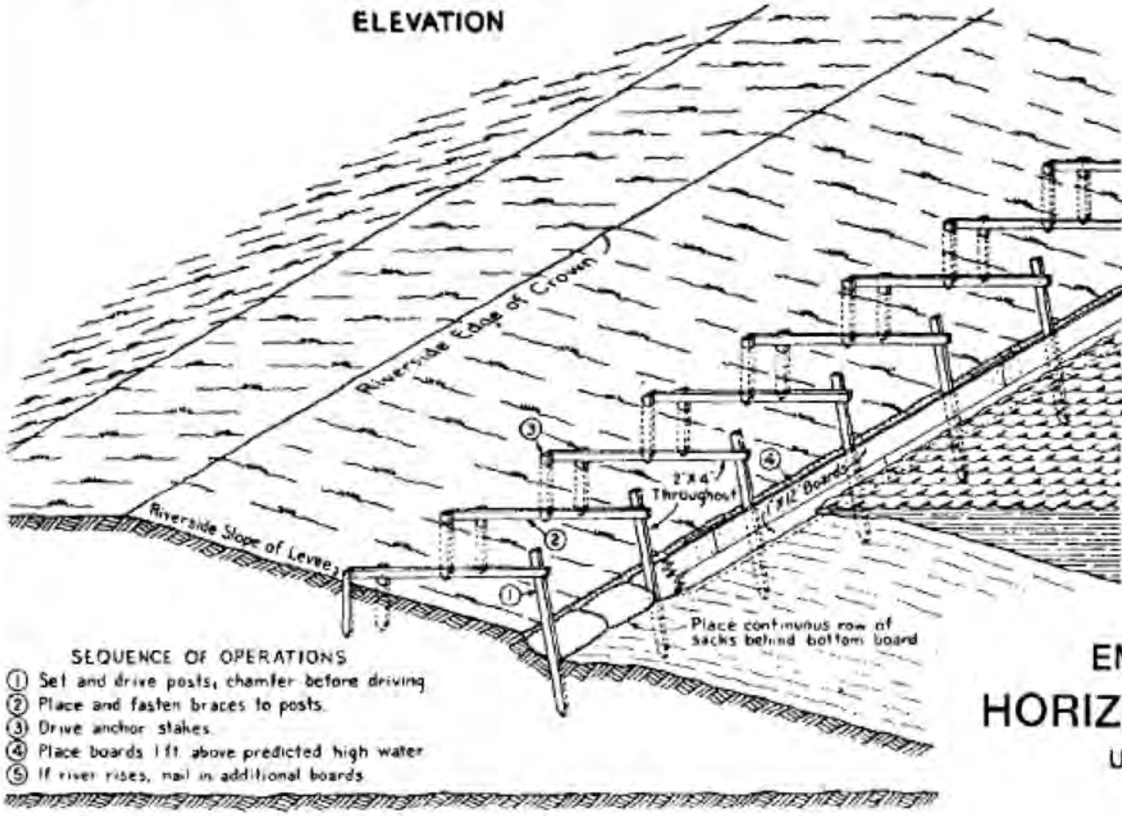
PLATE NO. 19



ELEVATION



SECTION A-A



SEQUENCE OF OPERATIONS

① Set and drive posts, chamfer before driving
② Place and fasten braces to posts.
③ Drive anchor stakes.
④ Place boards 1 ft. above predicted high water.
⑤ If river rises, nail in additional boards.

BILL OF MATERIALS FOR 100 LINEAR FEET OF REVETMENT WITH BRACES ON 5'-0" CENTERS
(Using Posts 8 Feet Long) ★

21 Posts	2"X 4"X 8'-0"	= 112 Bd. Ft.
21 Braces	2"X 4"X 9'-0"	= 126 Bd. Ft.
42 Anchors	2"X 4"X 3'-0"	= 84 Bd. Ft.
Horizontal Boards	1"X12"X240 Lin. Ft.	= 240 Bd. Ft.
		* Total 562 Bd. Ft.

3 Lbs. 10d. Common Nails
3 Lbs. 16d. Common Nails
5 Lbs. 20d. Common Nails

Actual quantities. No allowance made for waste.

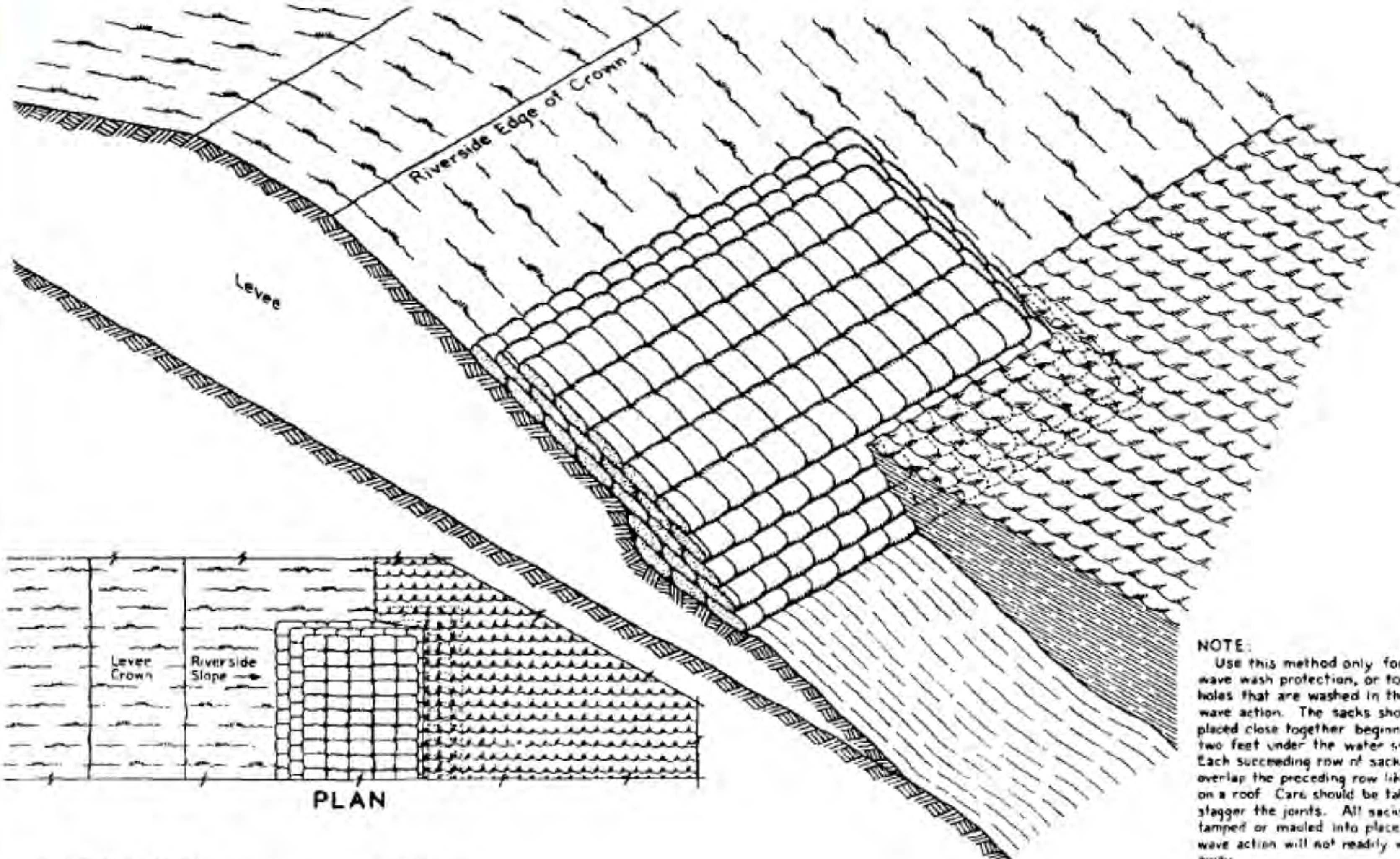
NOTE:
Use this method only in localities subject to light attack. Use vertical board fence for all other cases.

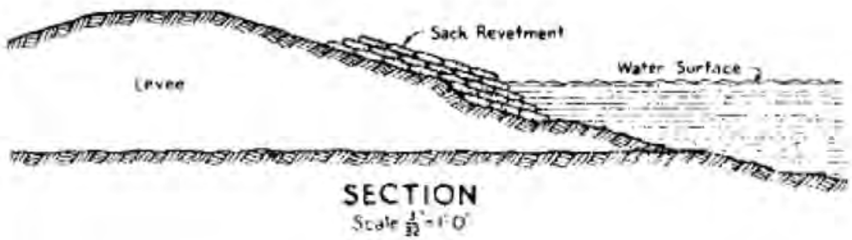
*Dimensions based on rough cut lumber

EMERGENCY FLOOD FIGHTING
HORIZONTAL BOARD REVETMENT

U.S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS
OMAHA, NEBRASKA

PLATE NO. 20





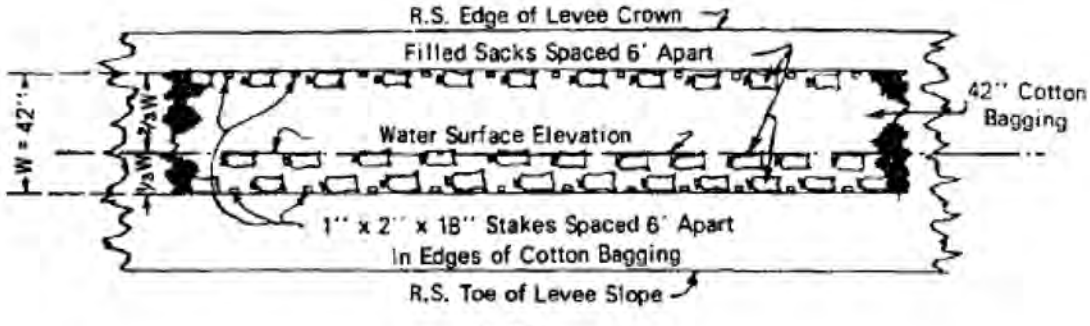
NOTE:
Use this method only for minor wave wash protection, or to fill local holes that are washed in the levee by wave action. The sacks should be placed close together beginning about two feet under the water surface. Each succeeding row of sacks should overlap the preceding row like shingles on a roof. Care should be taken to stagger the joints. All sacks should be tamped or mauled into place so that wave action will not readily wash them away.

EMERGENCY FLOOD FIGHTING

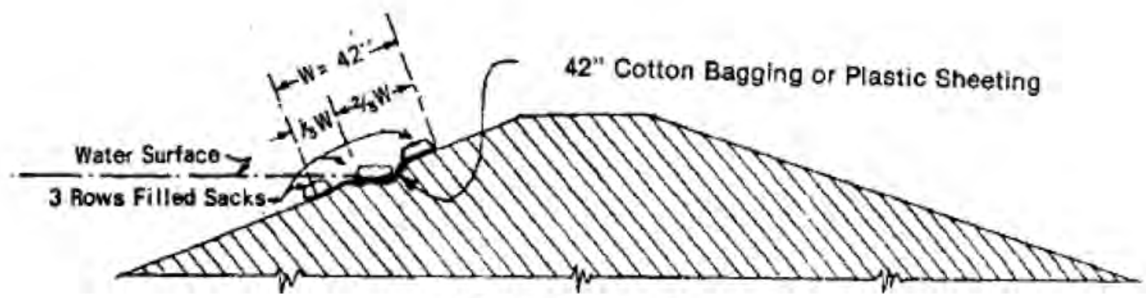
SACK REVETMENT

U.S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS
OMAHA, NEBRASKA

PLATE NO. 21



PLAN



CROSS SECTION

BILL OF MATERIAL
TO CONSTRUCT 180 FT.

1 Roll Jute Cotton Bagging 42'' x 180'
90 Filled Sacks
60 Stakes 1'' x 2'' x 18'' = 15 Bd. Ft.

INSTRUCTIONS

Lay 42" cotton bagging (Jute) longitudinally along riverside slope of levee with approximate 2/3 width above water surface.

Weight bagging along edges and at water surface with filled sacks spaced approximately 6' apart. Drive stakes alternately between sacks along both edges of bagging.

If additional width is required, lace two or more widths of bagging together and lay as desired.

EMERGENCY FLOOD FIGHTING

TYPE OF WAVEWASH PROTECTION

U.S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS
OMAHA, NEBRASKA

PLATE NO. 23

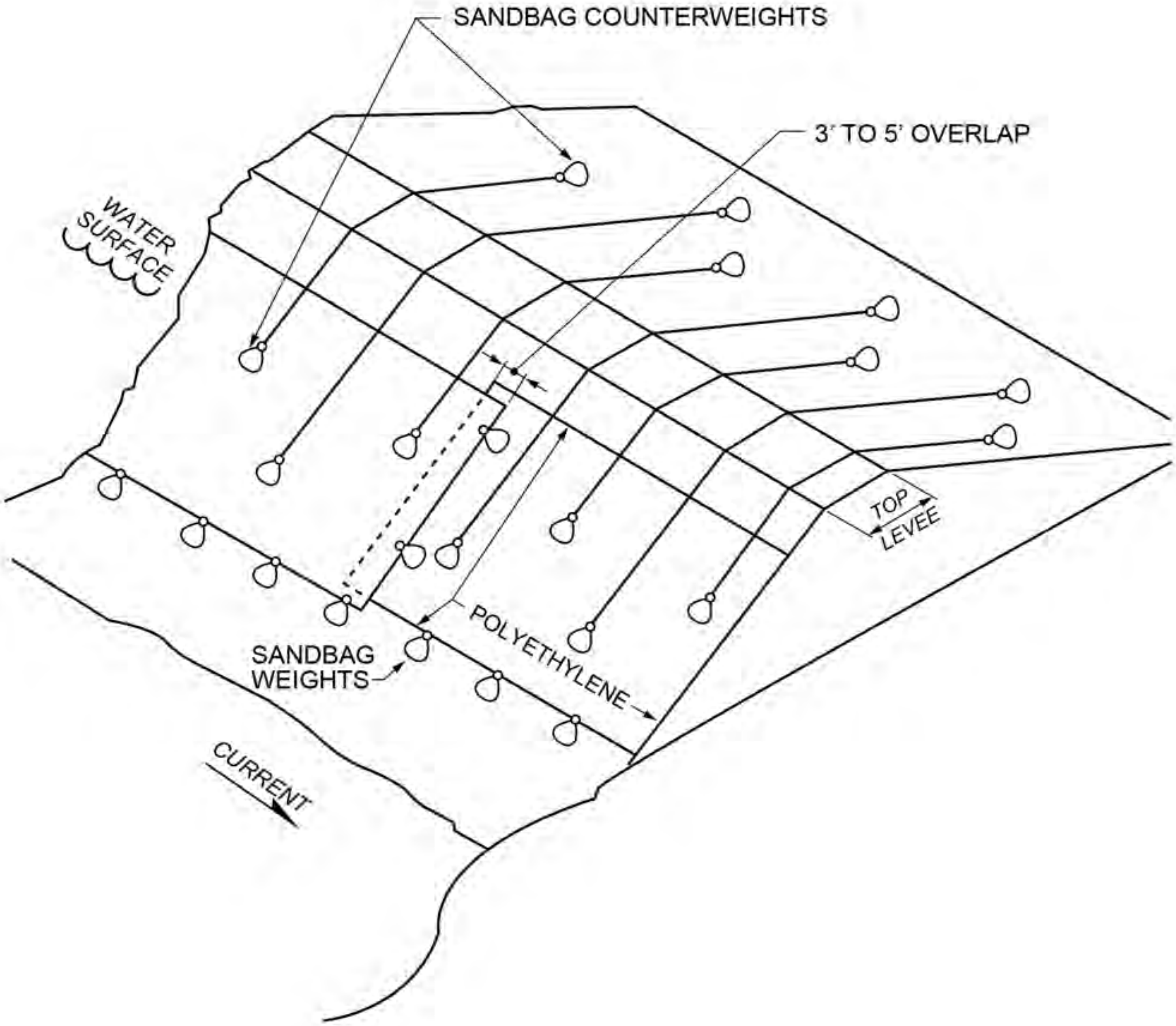
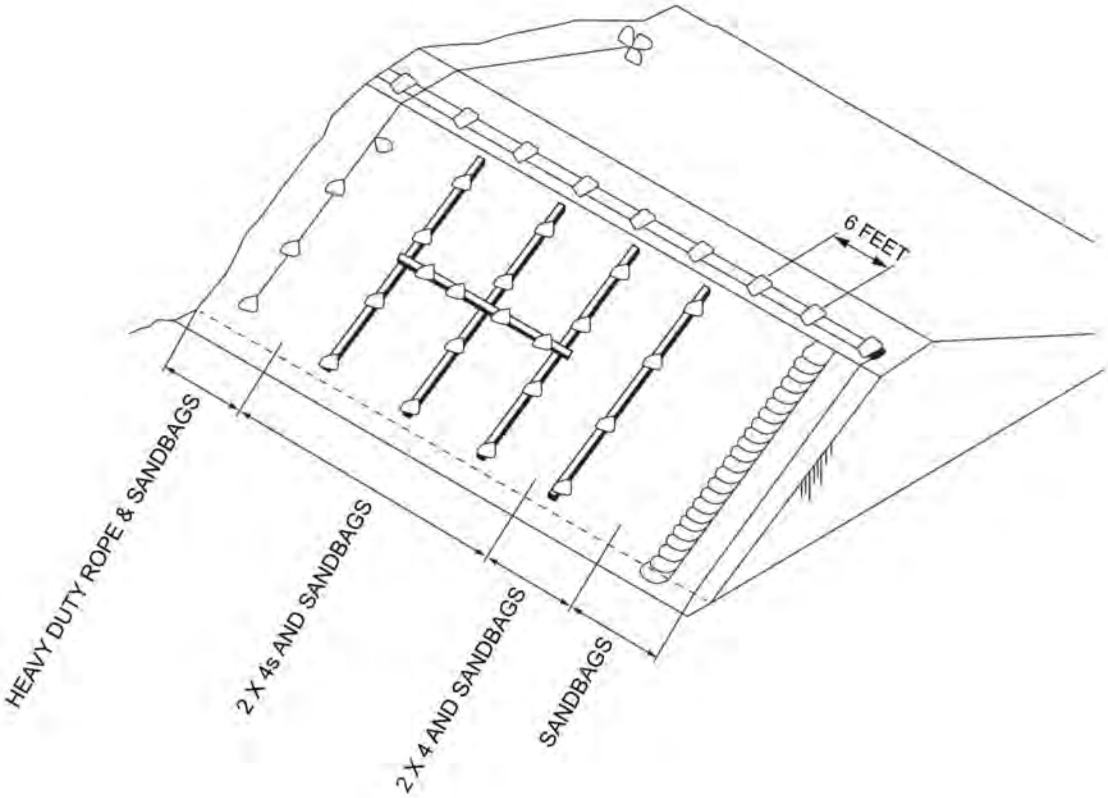
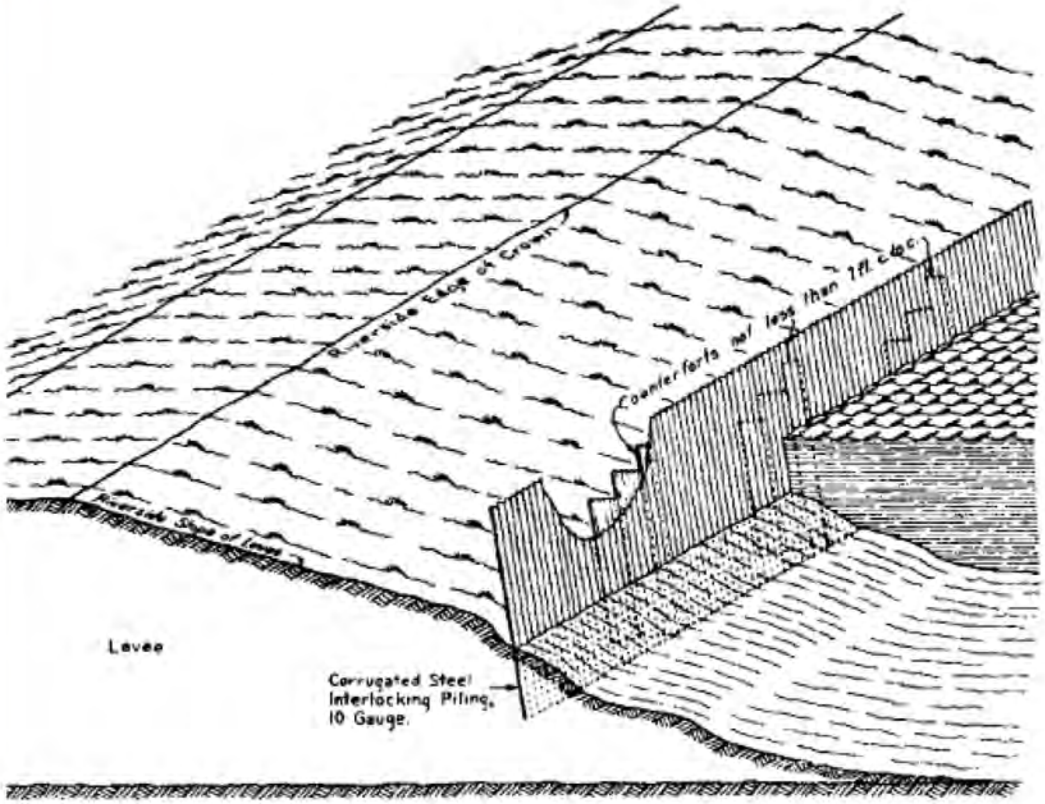

SANDBAG COUNTERWEIGHTS
3' TO 5' OVERLAP
WATER SURFACE
TOP LEVEE
SANDBAG WEIGHTS
POLYETHYLENE
CURRENT

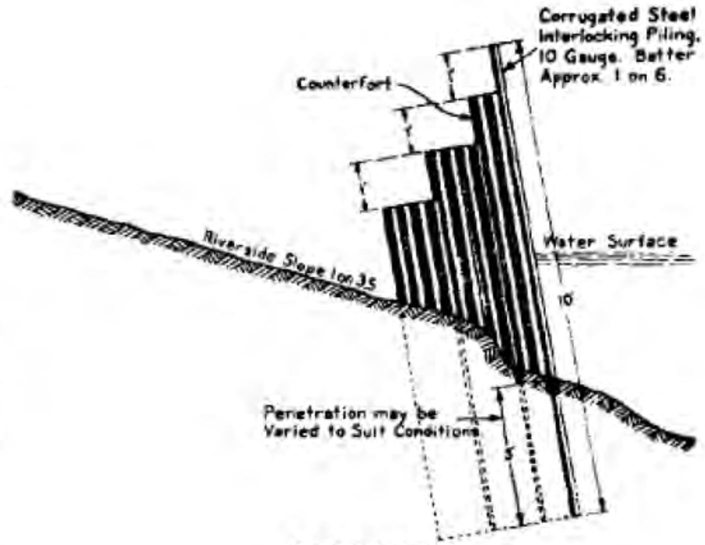
PLATE NO. 24



RECOMMENDED POLYETHYLENE		
1st	-	6 MIL BLACK
2nd	-	6 MIL CLEAR
3rd	-	4 MIL BLACK
4th	-	4 MIL CLEAR
5th	-	2 MIL BLACK OR CLEAR (USE AS A LAST RESORT)

PLATE NO. 25





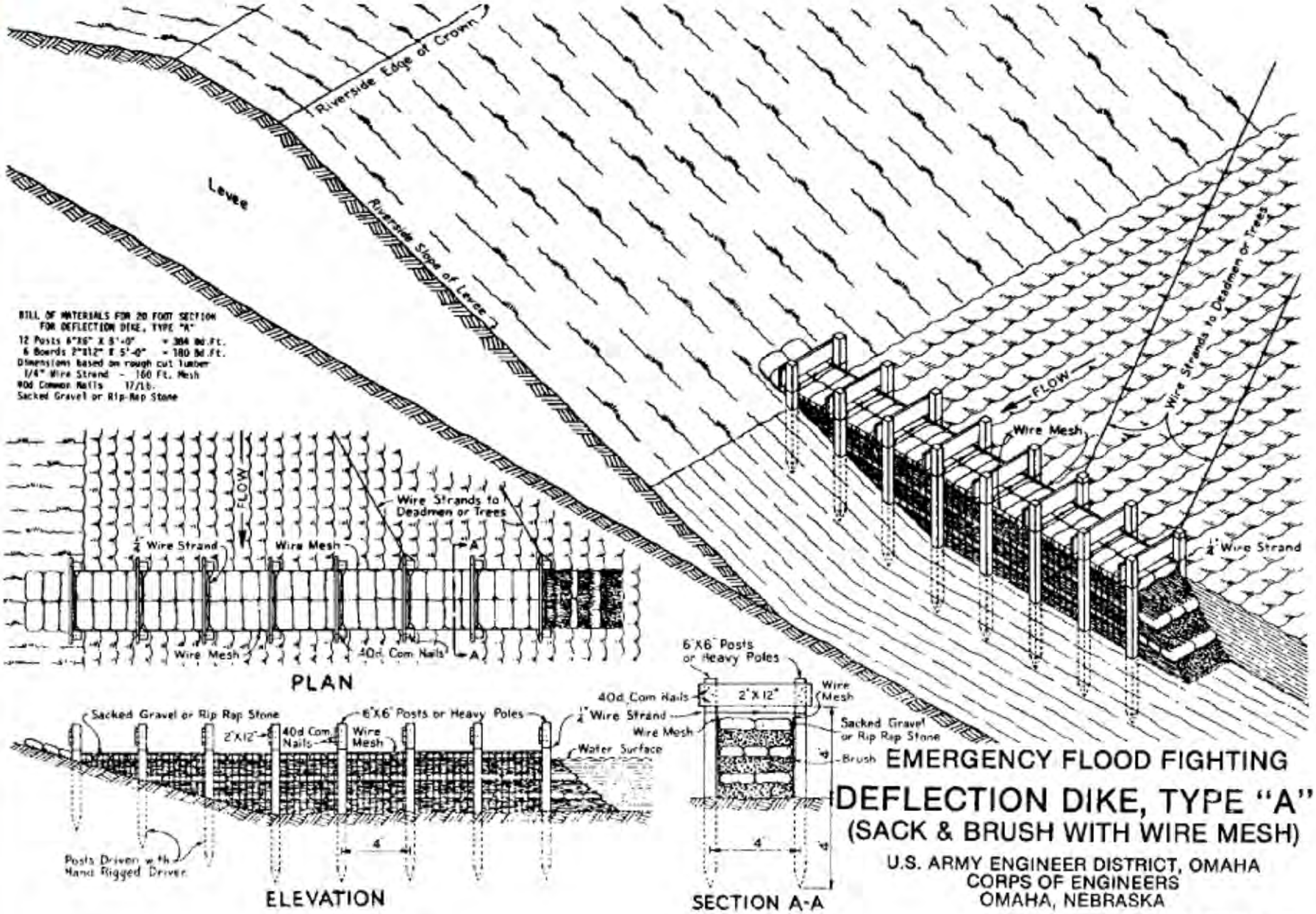
SECTION

EMERGENCY FLOOD FIGHTING

STEEL PILING REVETMENT

U.S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS
OMAHA, NEBRASKA

PLATE NO. 26



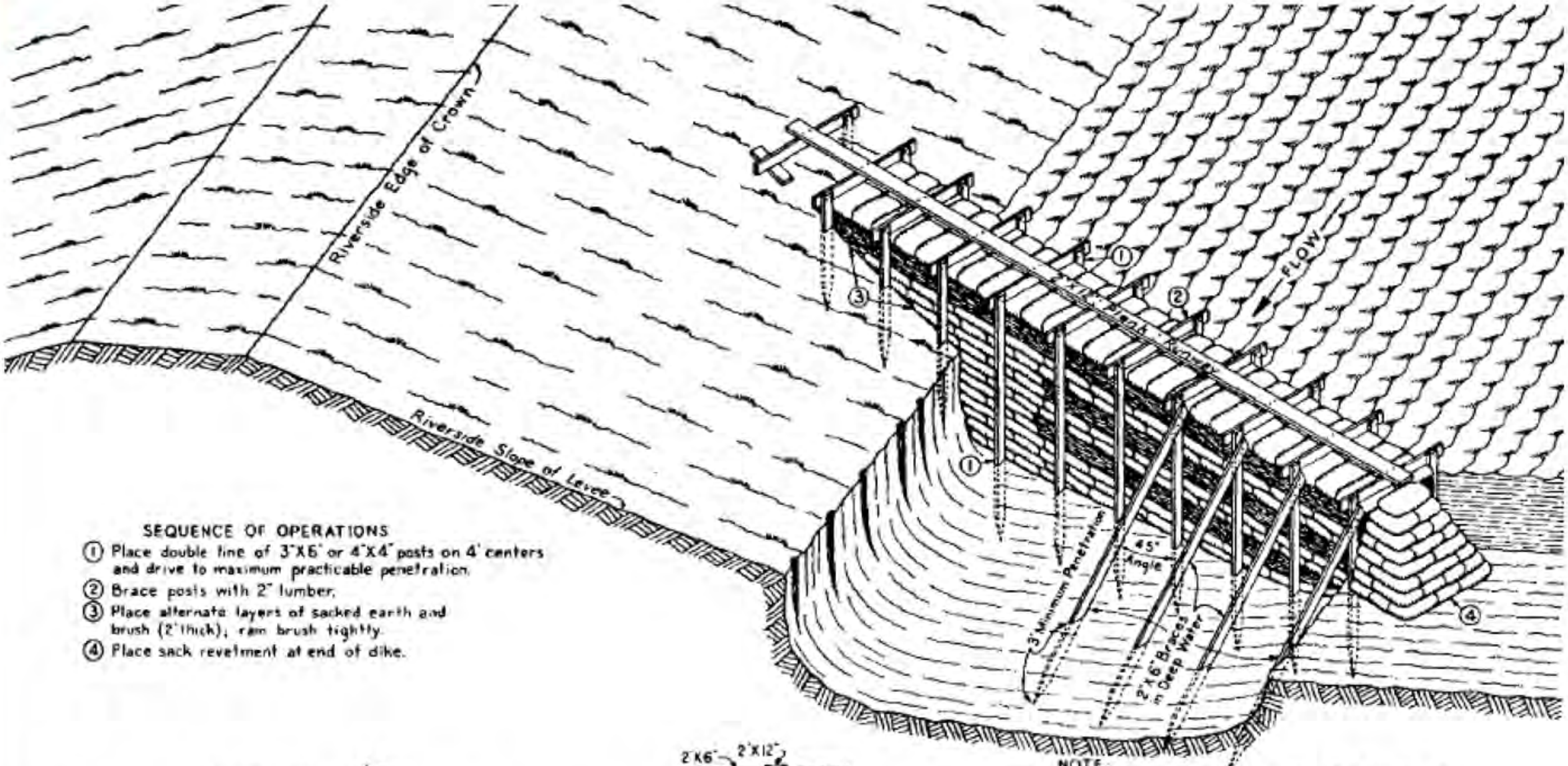
EMERGENCY FLOOD FIGHTING

DEFLECTION DIKE, TYPE "A"

(SACK & BRUSH WITH WIRE MESH)

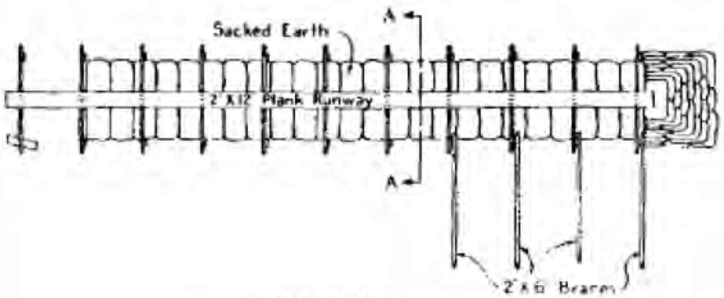
U.S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS
OMAHA, NEBRASKA

PLATE NO. 27

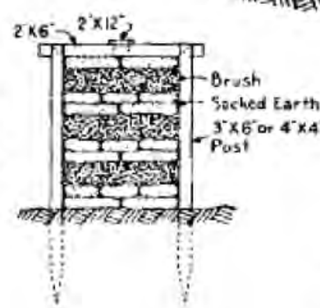


SEQUENCE OF OPERATIONS

1. Place double line of 3"X6" or 4"X4" posts on 4' centers and drive to maximum practicable penetration.
2. Brace posts with 2" lumber.
3. Place alternate layers of sacked earth and brush (2' thick); ram brush tightly.
4. Place sack revetment at end of dike.



PLAN



SECTION A-A

NOTE:
Commence at inshore edge unless floating plant is available and carry progressively to outer end. Placing of brush and sacked earth filler should be undertaken along the full length of dike simultaneously in horizontal layers to an elevation of 1' above anticipated high water.

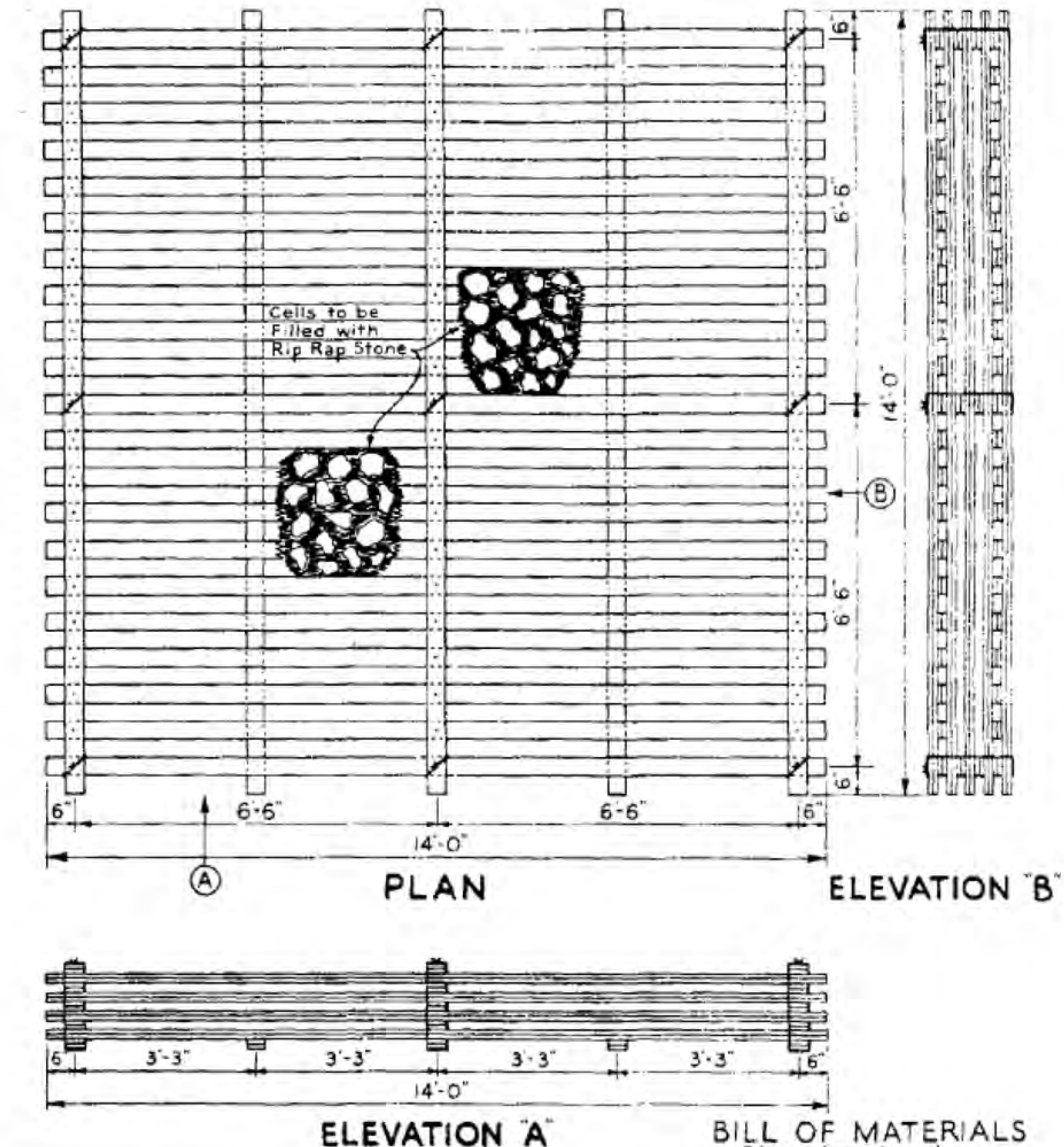
EMERGENCY FLOOD FIGHTING

DEFLECTION DIKE, TYPE "B"

(SACK & BRUSH)

U.S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS
OMAHA, NEBRASKA

PLATE NO. 28



BILL OF MATERIALS
Dimensions based on rough cut lumber

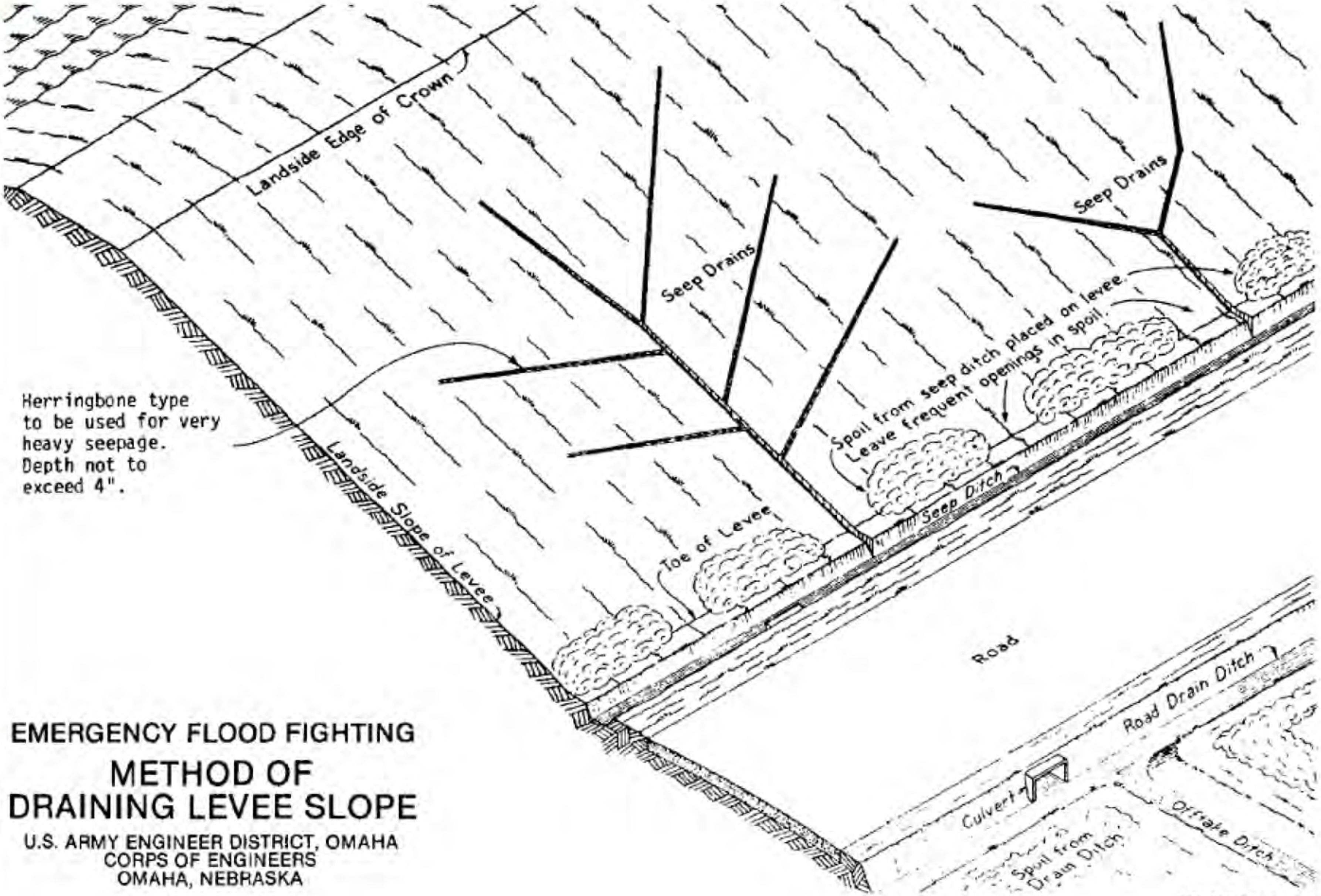
140 Pcs. 1"X 4"X 14' = 653 Bd. Ft.
12 Lbs. 20d. Common Nails
60 Ft. ¼" Strand
1½ Cu. Yds. Rip Rap Stone
Actual quantities. No allowance for waste

NOTE:
Cribs constructed of double thicknesses of 1"X 4"X 14' lumber. Nail all intersections with 1-20d. nail. Each intersection of walls securely fastened by a loop of ¼" strand, tightly twisted. If rock or concrete blocks are unobtainable, sacks filled with gravel or soil cement may be used.

EMERGENCY FLOOD FIGHTING
STONE CRIB
CAVING BANK PROTECTION

U.S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS
OMAHA, NEBRASKA

PLATE NO. 29

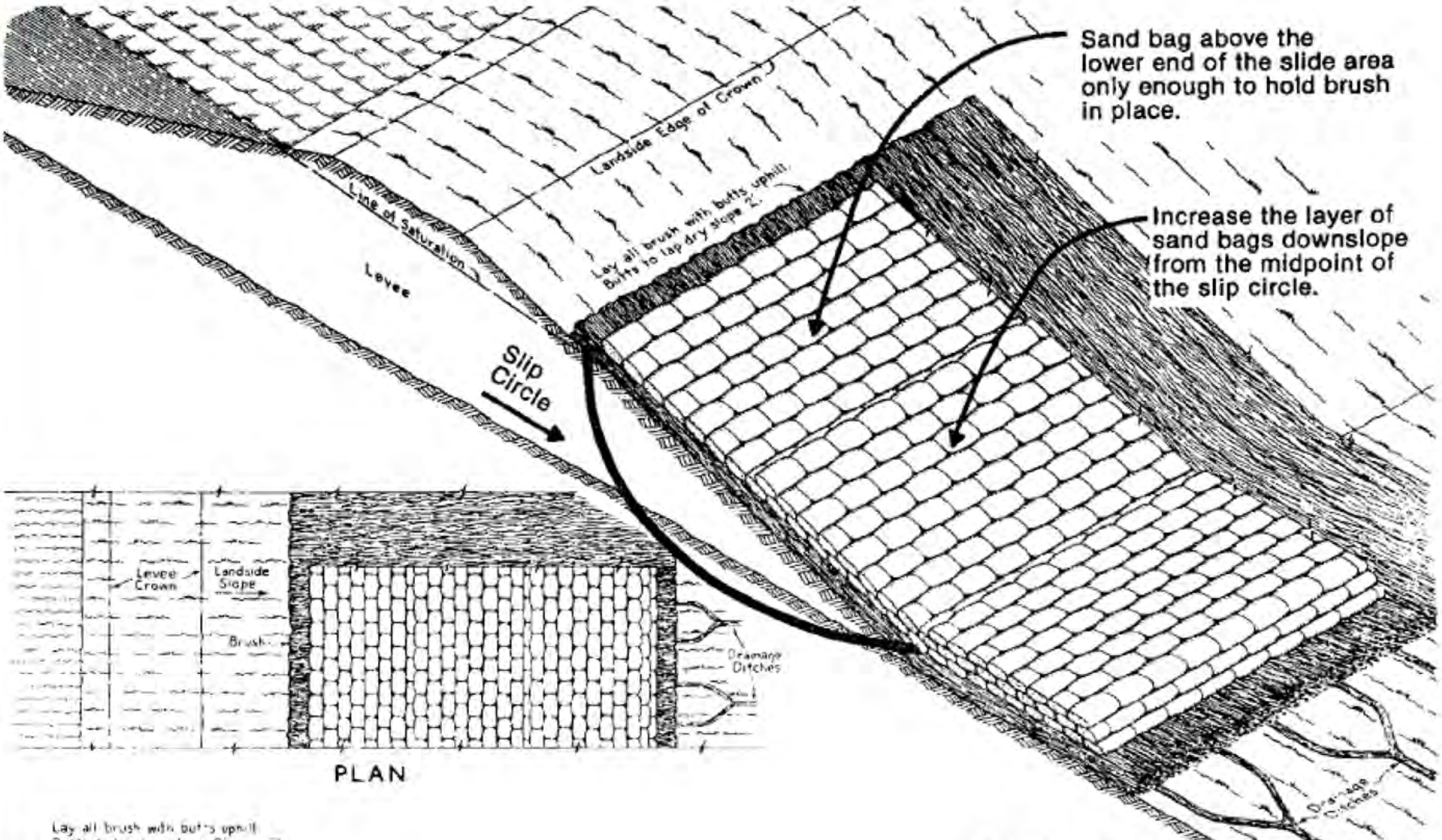


EMERGENCY FLOOD FIGHTING

METHOD OF DRAINING LEVEE SLOPE

U.S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS
OMAHA, NEBRASKA

PLATE NO. 30



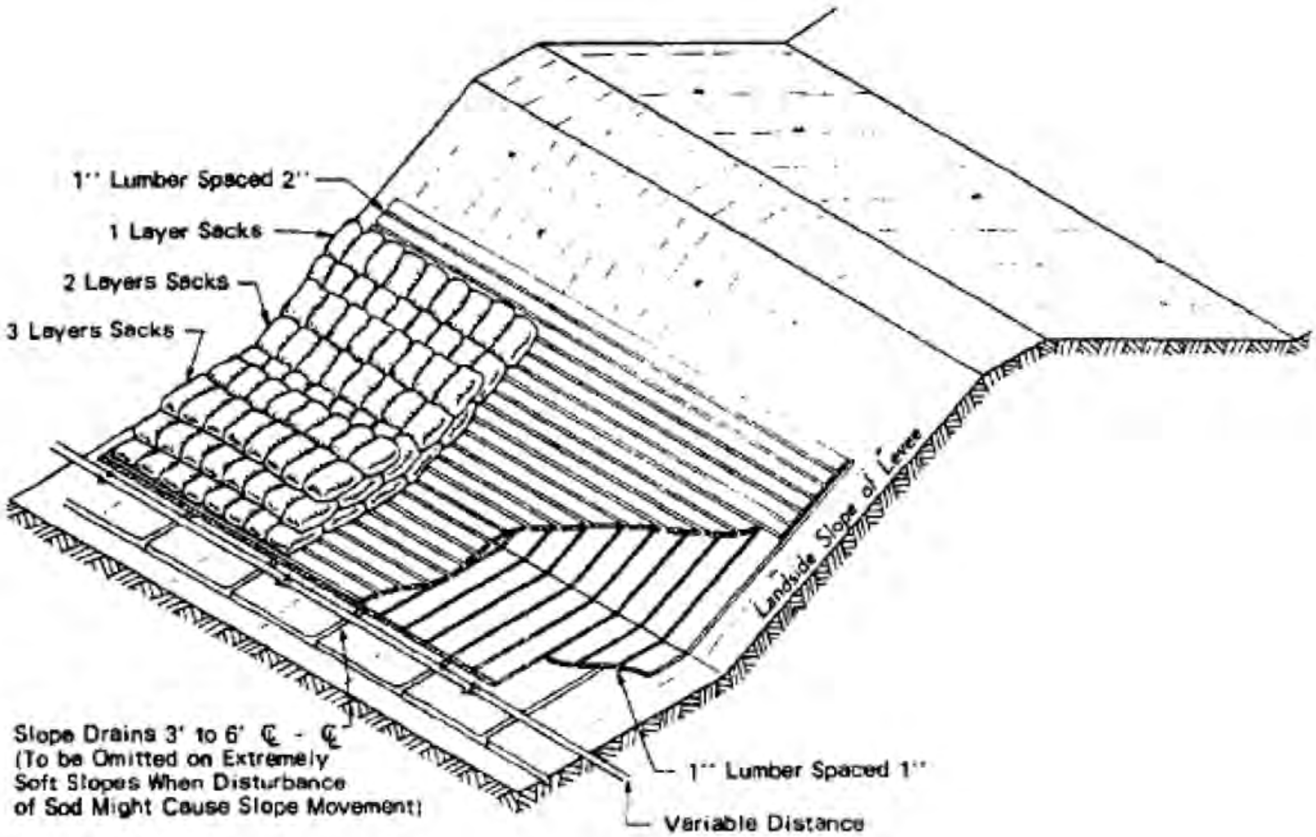
EMERGENCY FLOOD FIGHTING

BRUSH MATTRESS

(FOR TREATMENT OF LEVEE SLOUGHS)

U.S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS
OMAHA, NEBRASKA

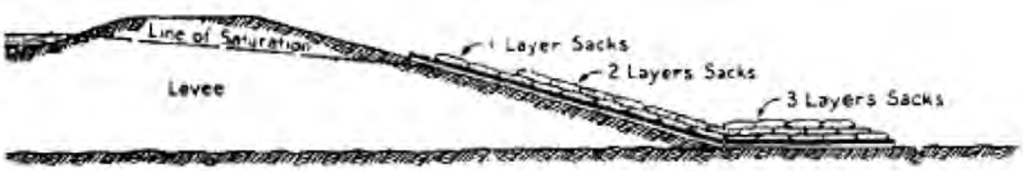
PLATE NO. 31



PLAN

Material Required for 100 Sq. Ft.
180 F.B.M. 1'' x 6'' or 1'' x 8'' Lumber
1 Lb. 8d Common Nails

Dimensions based on rough cut lumber



SECTION

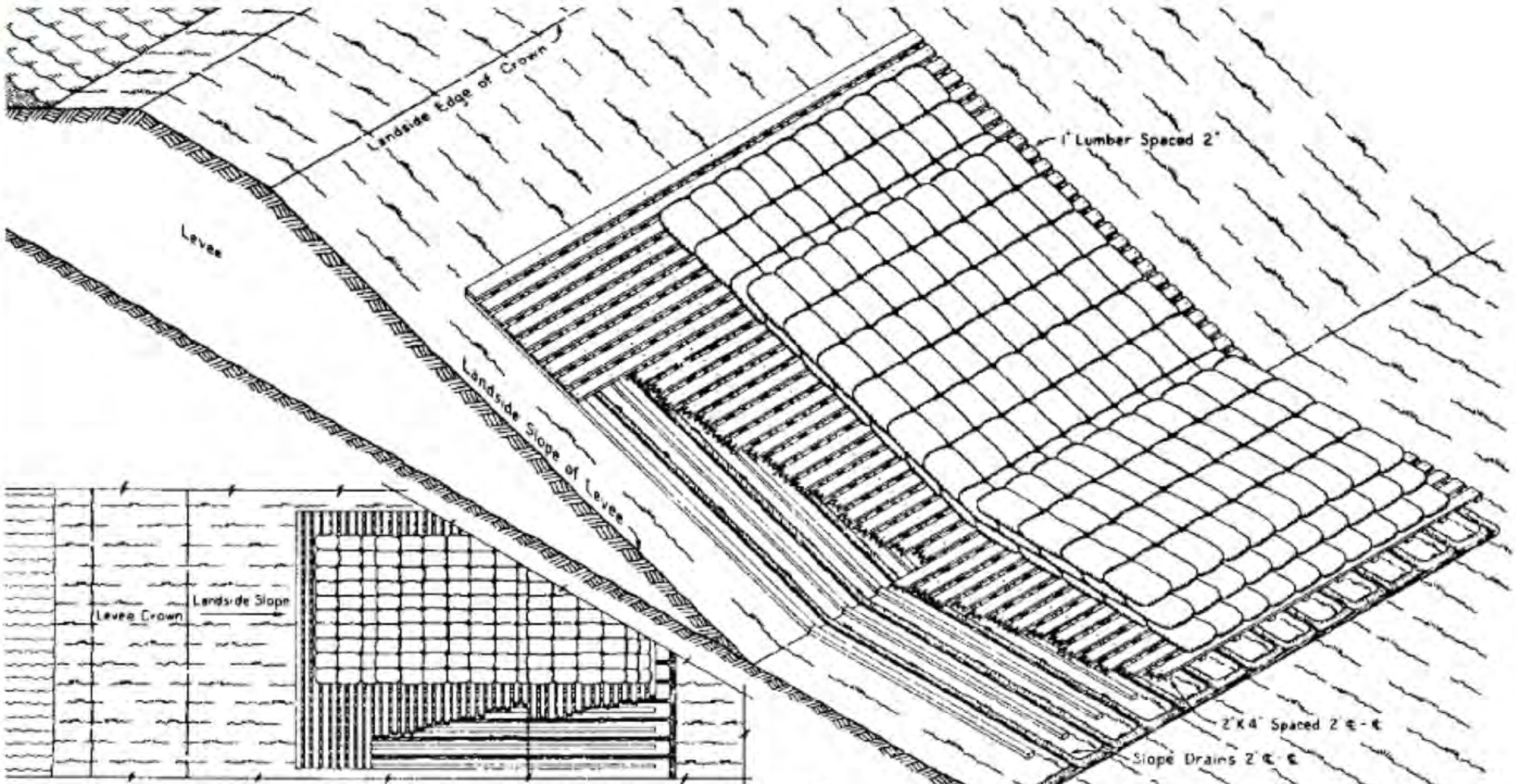
EMERGENCY FLOOD FIGHTING

BOARD MATTRESS-STANDARD TYPE

(FOR TREATMENT OF LEVEE SLOUGHS)

U.S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS
OMAHA, NEBRASKA

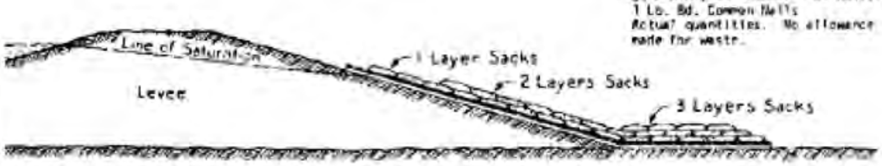
PLATE NO. 32



PLAN

MATERIAL REQUIRED FOR 100 SQ.FT.

Dimensions based on rough cut lumber
90 F B M 1"X6" or 1"X8" Lumber = 60 Bd.Ft.
36 F B M 2"X4" Lumber = 24 Bd.Ft.
1 Lb. 8d. Common Nails
Actual quantities. No allowance made for waste.



SECTION

EMERGENCY FLOOD FIGHTING

BOARD MATTRESS-STRINGER TYPE

(FOR TREATMENT OF LEVEE SLOUGHS)

U.S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS
OMAHA, NEBRASKA

PLATE NO. 33

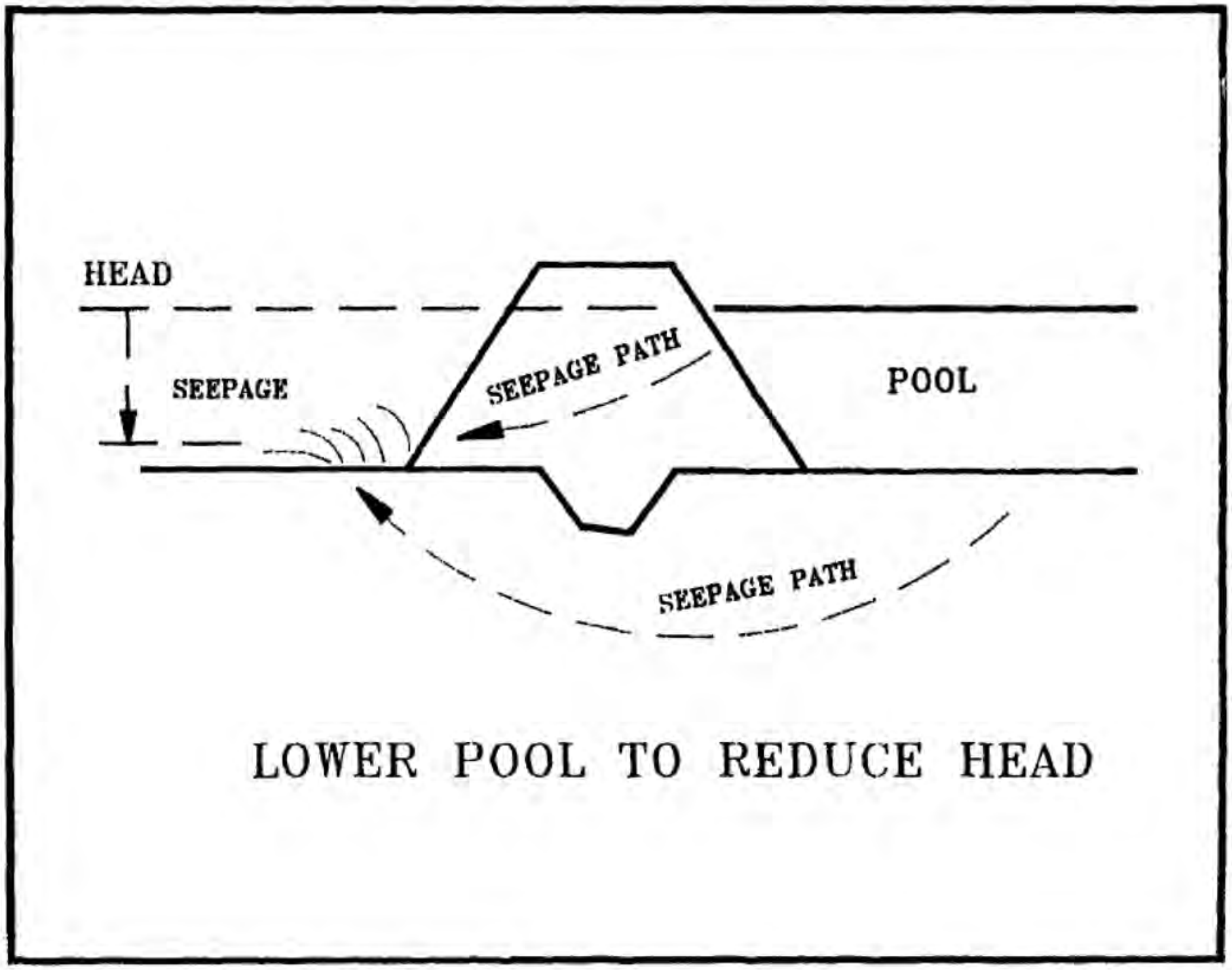
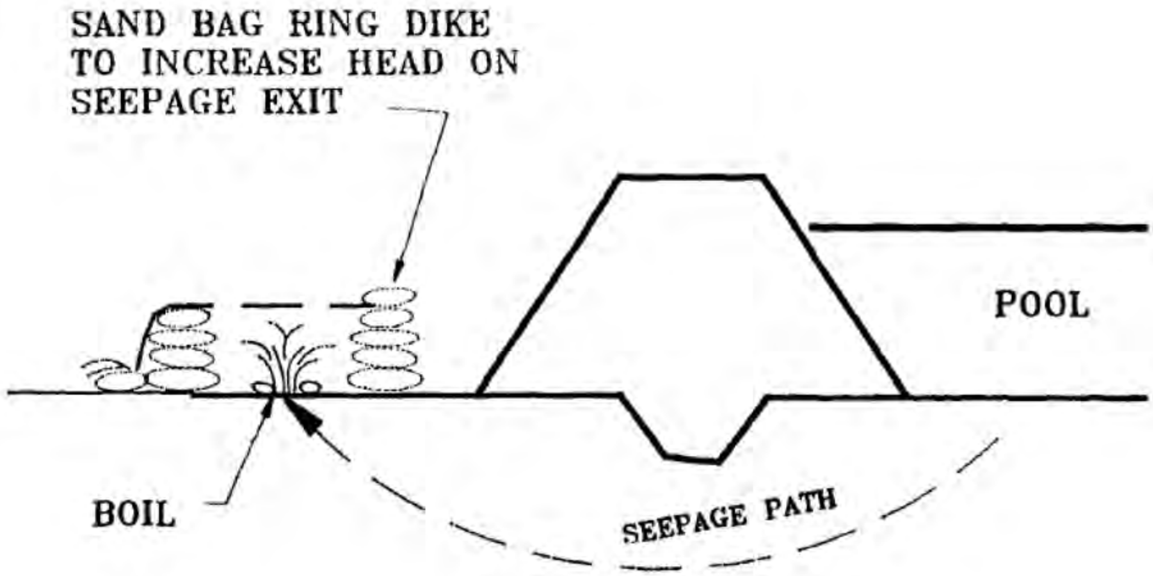
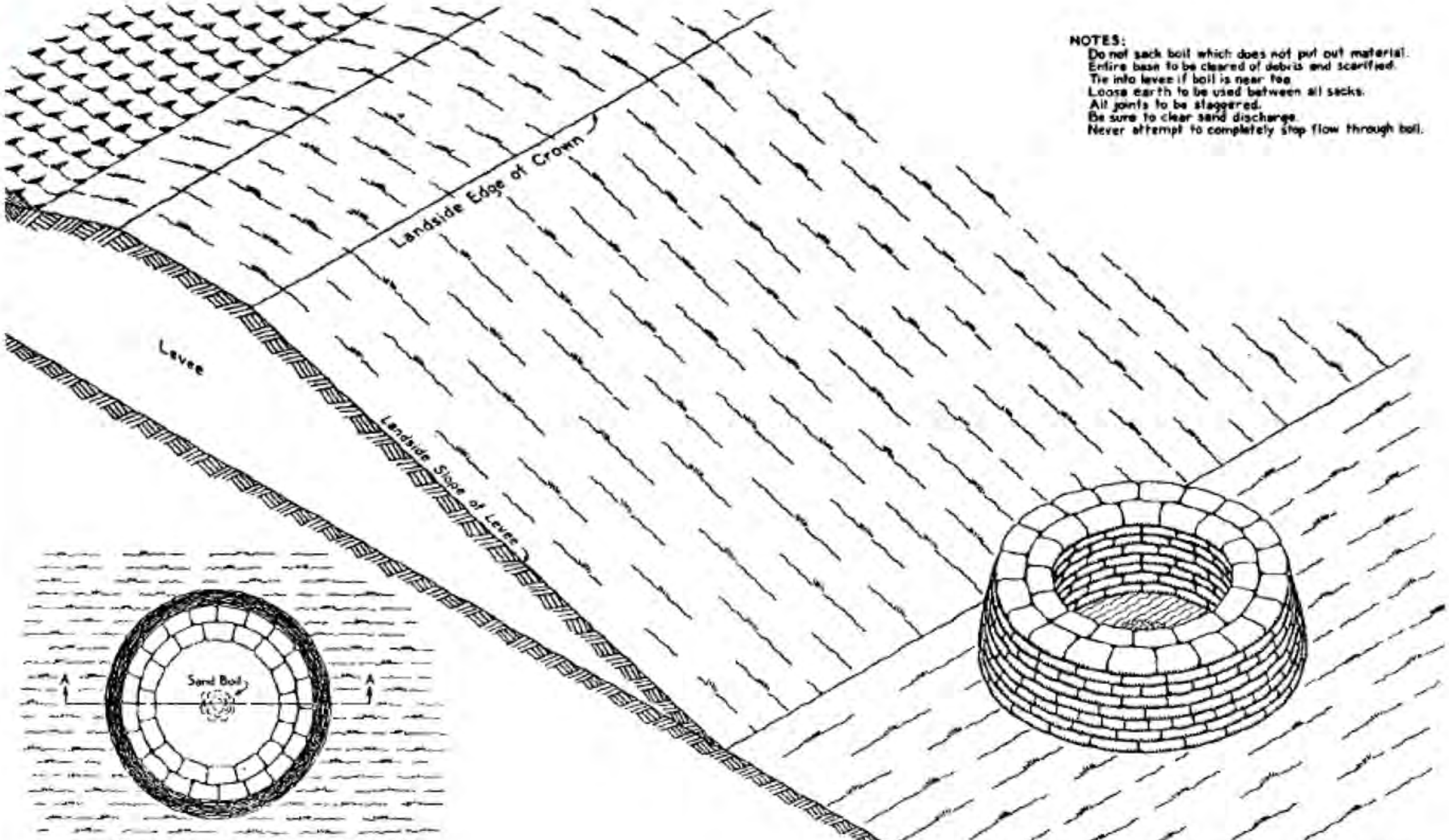

HEAD
SEEPAGE
SEEPAGE PATH
POOL
SEEPAGE PATH
LOWER POOL TO REDUCE HEAD

PLATE NO. 34



SAND BAG RING DIKE

PLATE NO. 35



PLAN

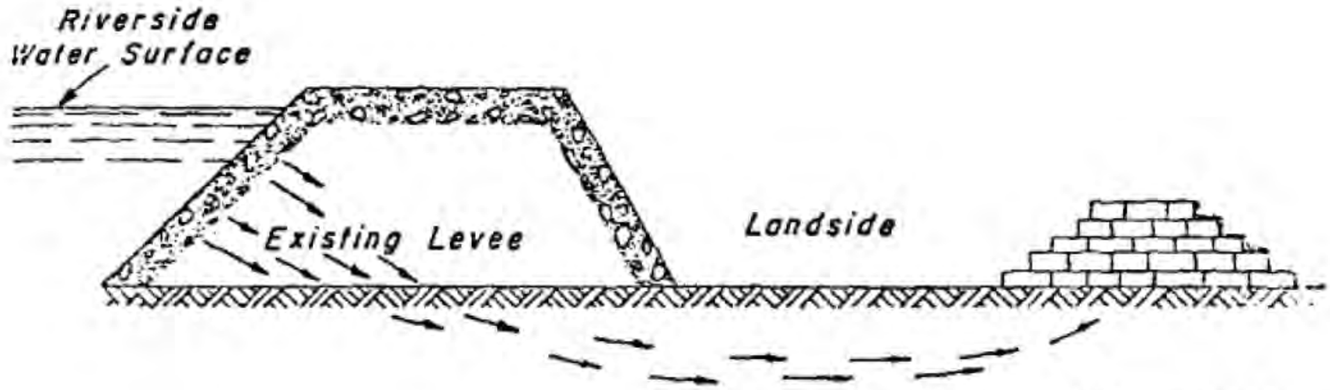
SECTION A-A

EMERGENCY FLOOD FIGHTING

RINGING SAND BOILS WITH SACKED EARTH

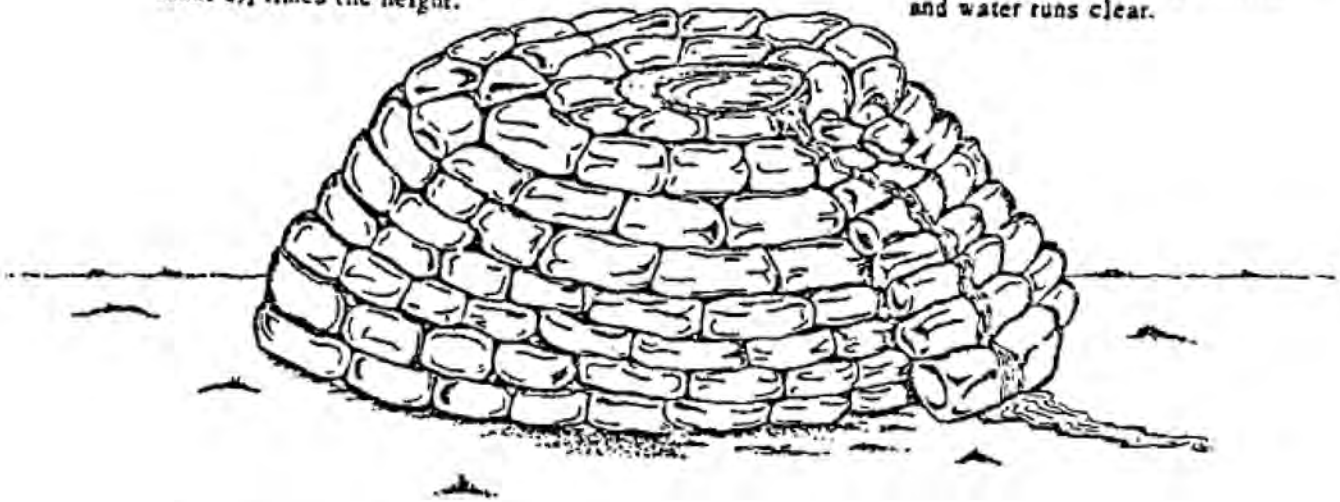
U.S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS
OMAHA, NEBRASKA

PLATE NO. 36



NEVER completely stop the flow from a sand boil. This may cause the boil to "break out" in an adjacent area.
ALWAYS control the boil to the point it ceases to carry material and water runs clear.

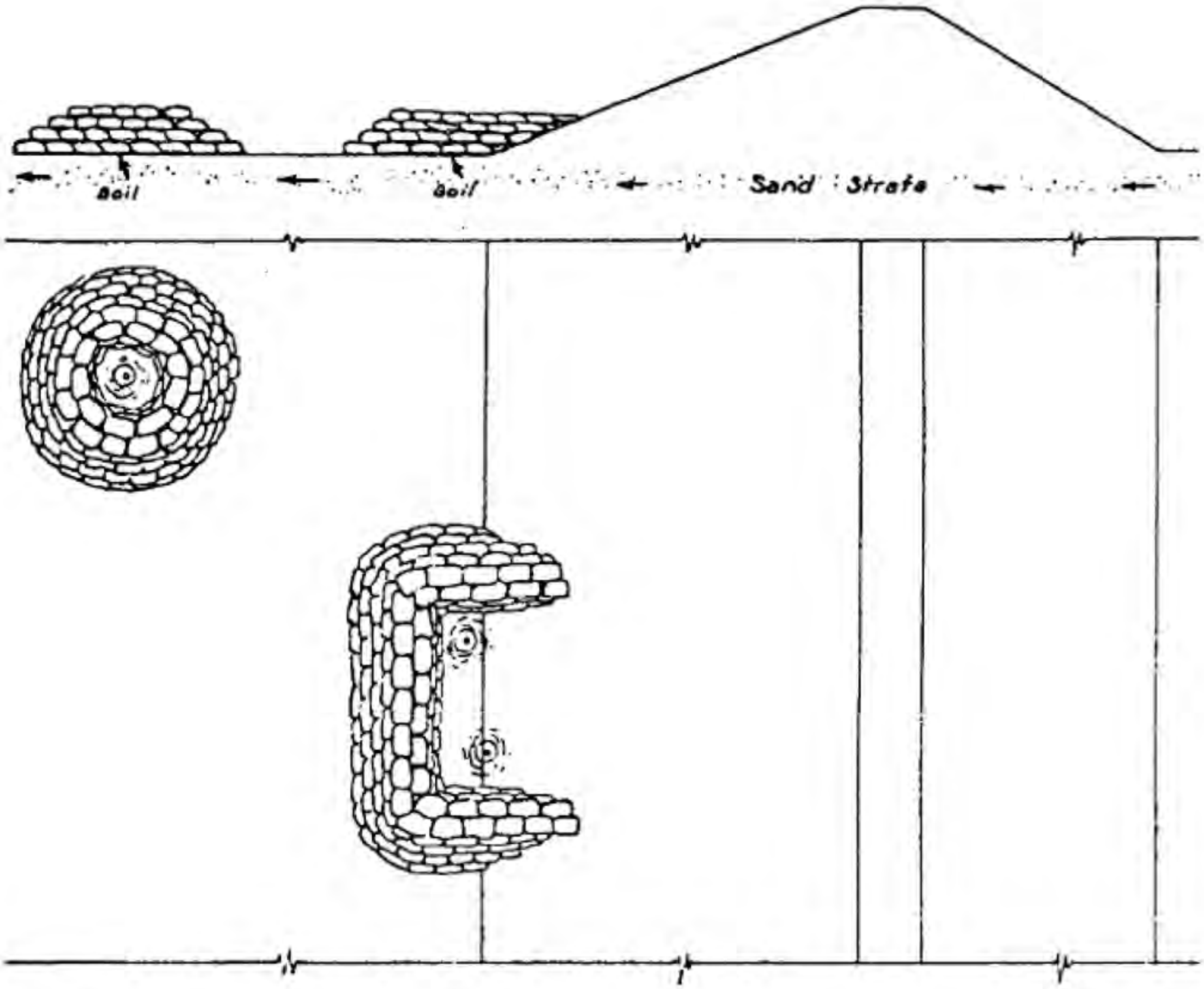
Bottom width should be at least 1½ times the height.



Do not sack boils not carrying material but maintain surveilance during flood periods.

EMERGENCY FLOOD FIGHTING
CONTROL OF SAND BOILS
(AWAY FROM LEVEE)
U.S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS
OMAHA, NEBRASKA

PLATE NO. 37



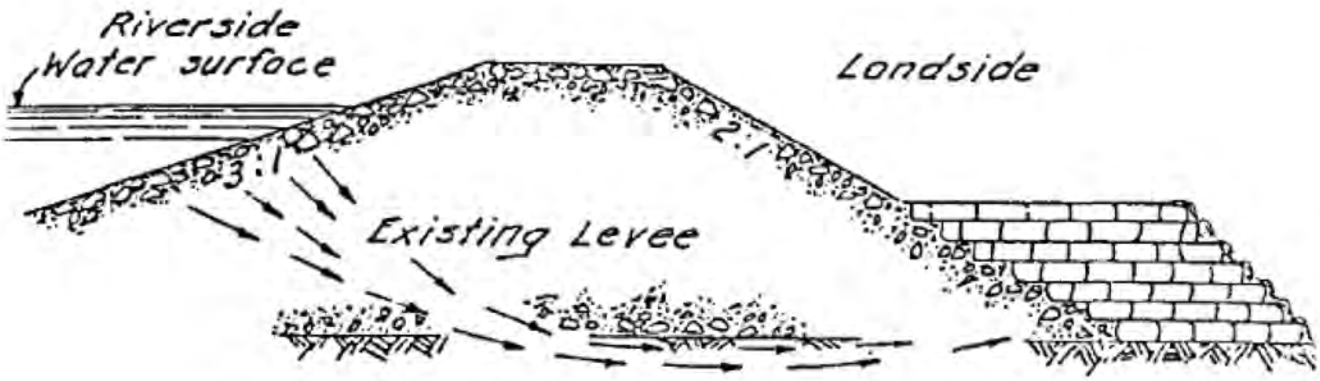
Notes:
Do not stop flow of clear water.
Build ring to height only suficient to stop discharge of material.
Leave a low place in top of ring for a spillway – on side nearest to natural drainage.
Leave sufficient room around boil to allow for caving and to get sacks on solid material to prevent seepage.

EMERGENCY FLOOD FIGHTING

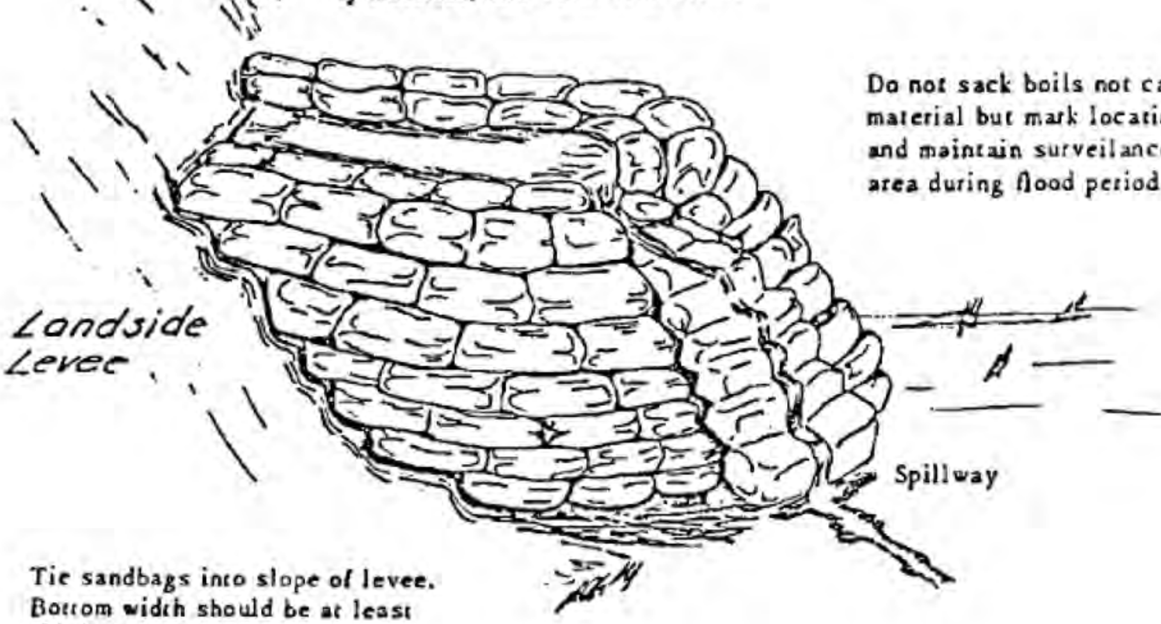
METHODS OF SACKING SAND BOILS

U.S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS
OMAHA, NEBRASKA

PLATE NO. 38



NEVER completely stop the flow from a sand boil. This may cause the boil to "break out" in an adjacent area. ALWAYS control the boil to the point it ceases to carry material, and water runs clear.



Do not sack boils not carrying material but mark location well and maintain surveilance of this area during flood period.

Tie sandbags into slope of levee. Bottom width should be at least 1½ times height.

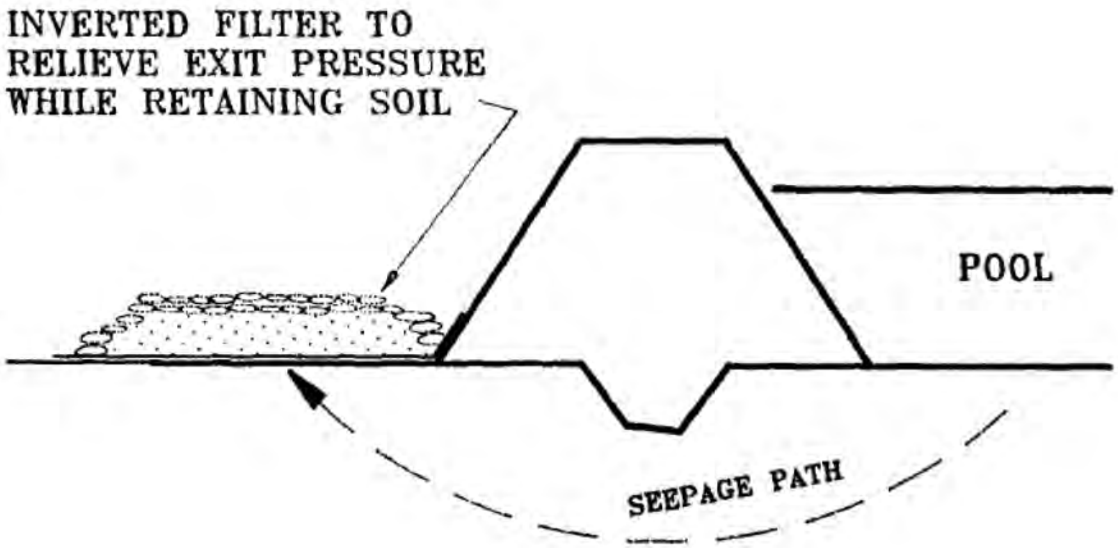
EMERGENCY FLOOD FIGHTING

CONTROL OF SAND BOILS

(NEAR LEVEE)

U.S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS
OMAHA, NEBRASKA

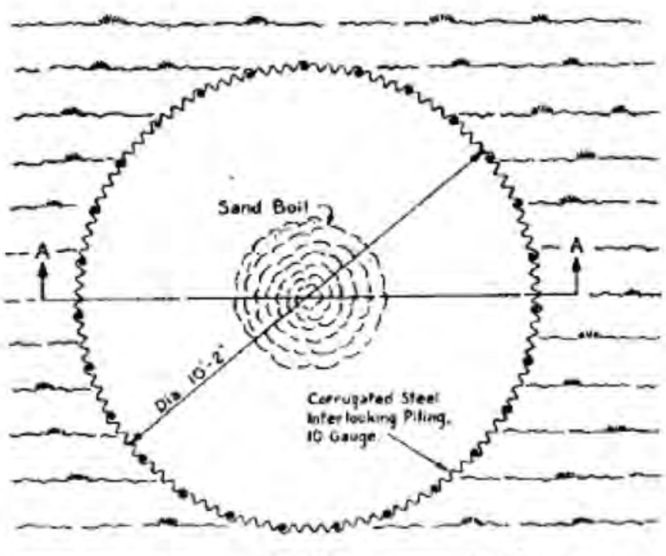
PLATE NO. 39



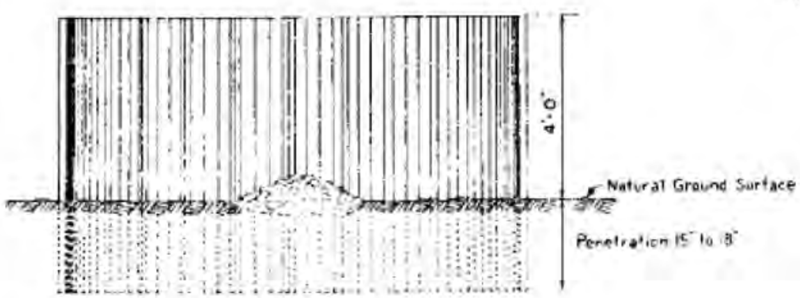
INVERTED FILTER

PLATE NO. 40

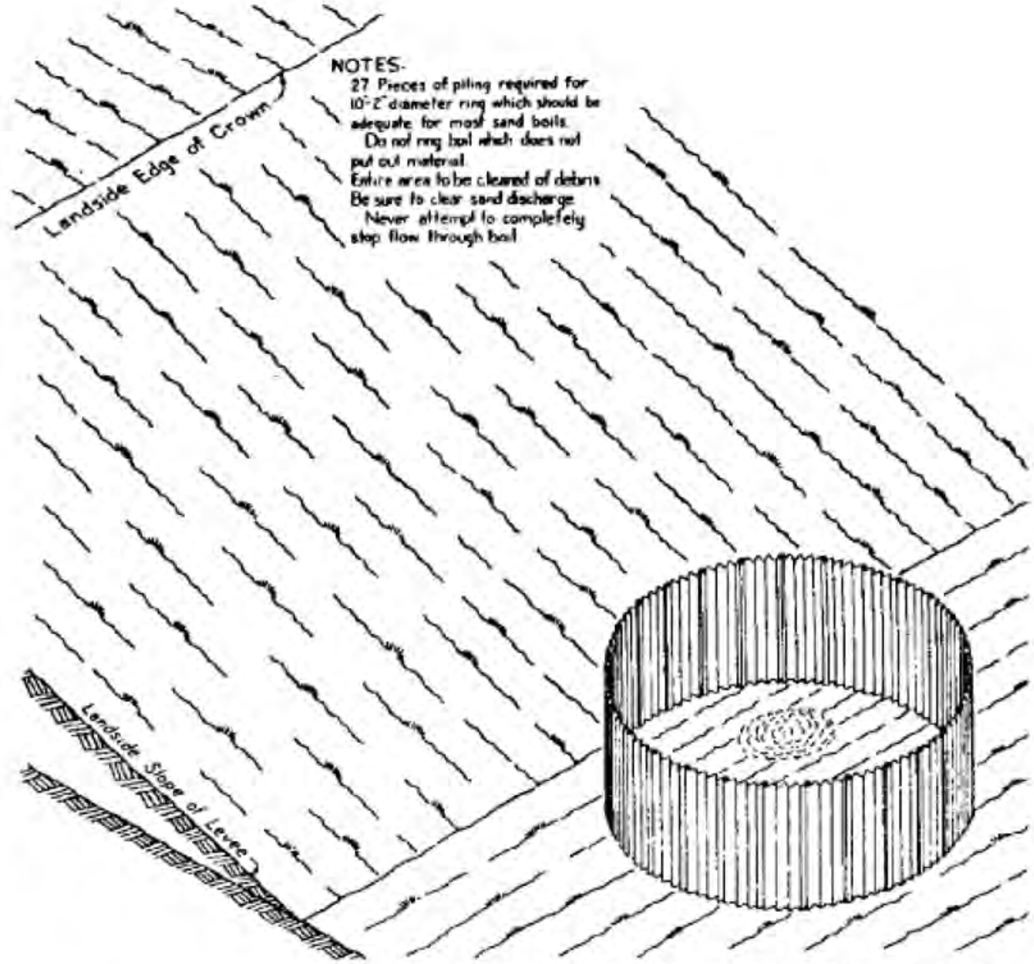
NOTE:
Driving caps will be used. Driving may be effected either by mechanical or hand method.



PLAN



SECTION A-A



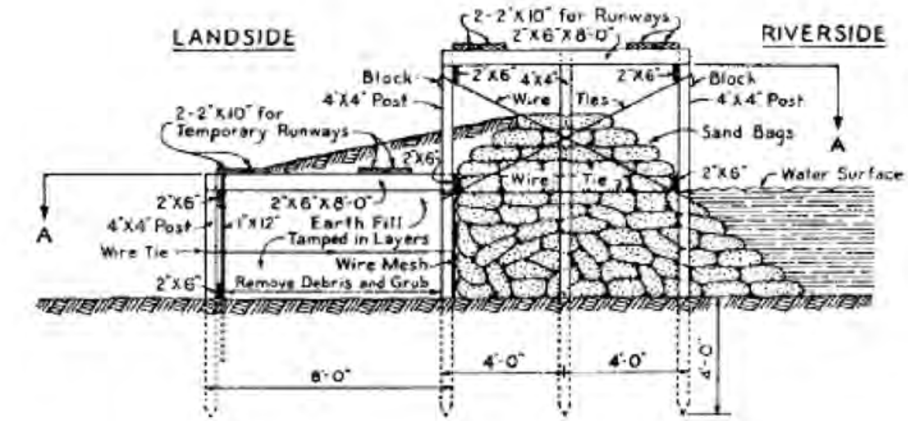
NOTES:
27 Pieces of piling required for 10'-2" diameter ring which should be adequate for most sand boils.
Do not ring boil which does not put out material.
Entire area to be cleared of debris.
Be sure to clear sand discharge.
Never attempt to completely stop flow through boil.

EMERGENCY FLOOD FIGHTING

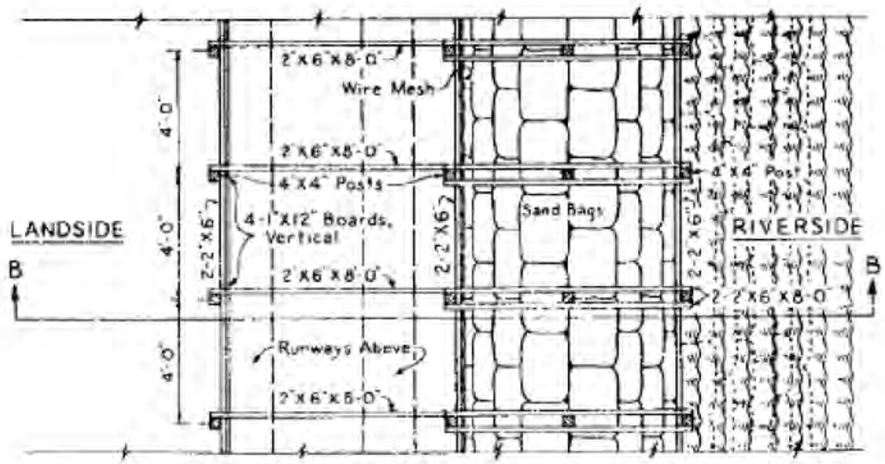
RINGING SAND BOILS WITH STEEL PILING

U.S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS
OMAHA, NEBRASKA

PLATE NO. 41



SECTION B-B

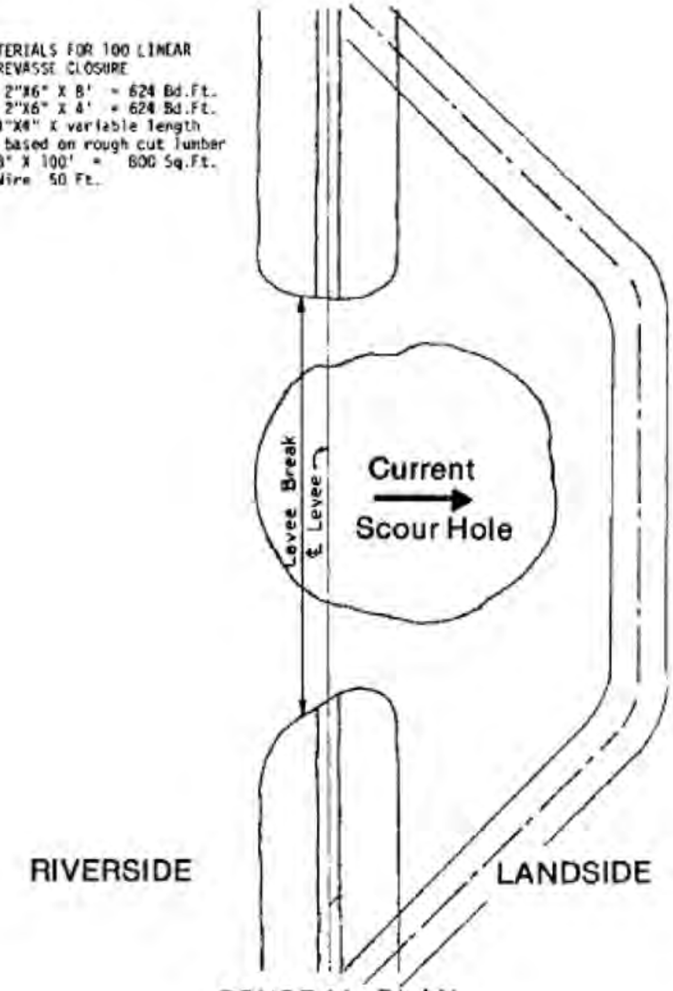


PLAN AT A-A

NOTE:
2 x 4" Braces may be used instead of wire ties.

BILL OF MATERIALS FOR 100 LINEAR FEET CREVASSE CLOSURE

78 Boards 2"X6" X 8' = 624 Bd.Ft.
156 Boards 2"X6" X 4' = 624 Bd.Ft.
104 Posts 4"X4" X variable length
Dimensions based on rough cut lumber
Wire Mesh 8" X 100' = 800 Sq.Ft.
4 Rolls Wire 50 Ft.



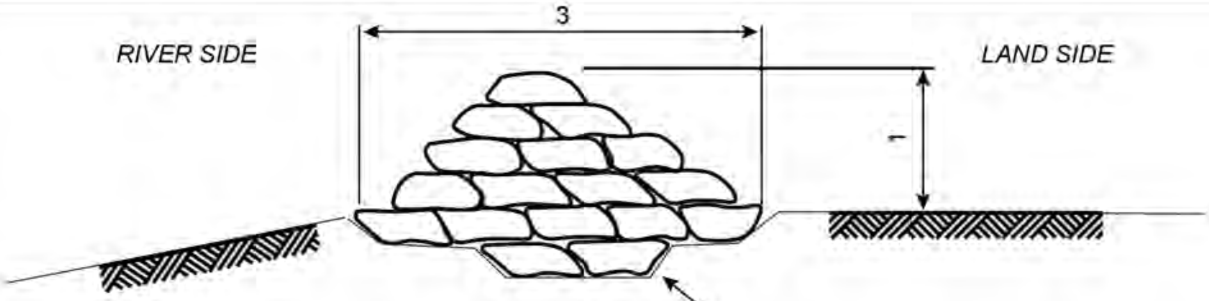
GENERAL PLAN

EMERGENCY FLOOD FIGHTING

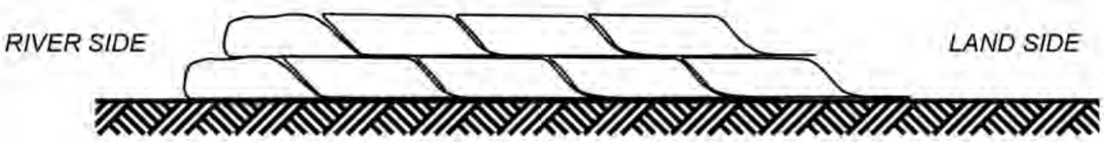
CREVASSE CLOSURE

U.S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS
OMAHA, NEBRASKA

PLATE NO. 42



LEVEE SECTION



METHOD OF LAPPING SACKS

LEVEE HEIGHT	NUMBER OF SAND BAGS REQUIRED FOR LENGTH OF LEVEE									
	50 FT	100 FT	175 FT	200 FT	250 FT	300 FT	350 FT	400 FT	450 FT	500 FT
1 Foot	300	600	1,050	1,200	1,500	1,800	2,100	2,400	2,700	3,000
2 Feet	1,050	2,100	3,675	4,200	5,250	6,300	7,350	8,400	9,450	10,500
3 Feet	2,250	4,500	7,875	9,000	11,250	13,500	15,750	18,000	20,250	22,500
4 Feet	3,900	7,800	13,650	15,600	19,500	23,400	27,300	31,200	35,100	39,000
5 Feet	6,000	12,000	21,000	24,000	30,000	36,000	42,000	48,000	54,000	60,000

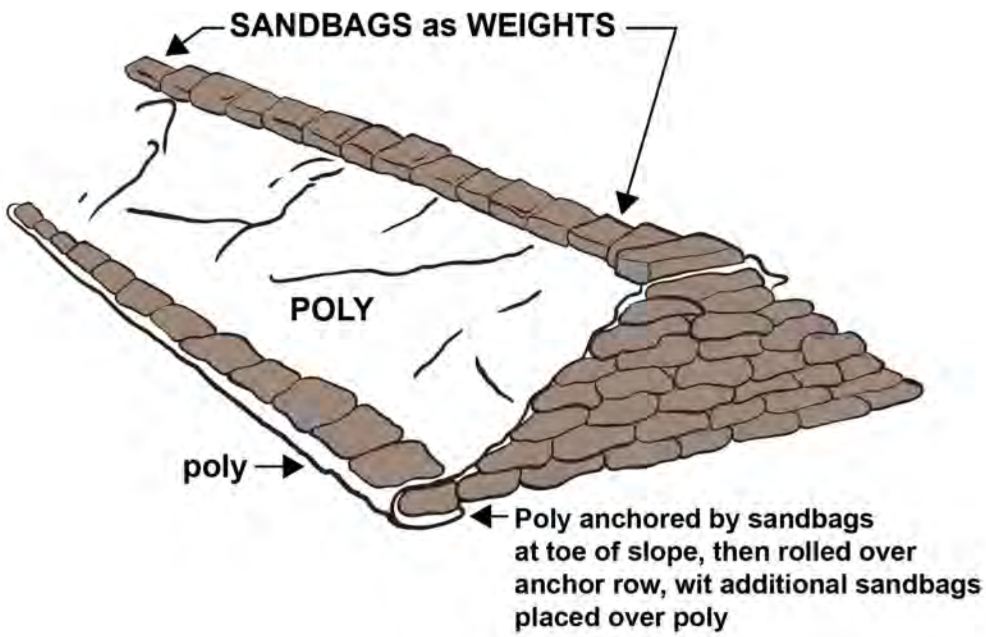
NOTES:

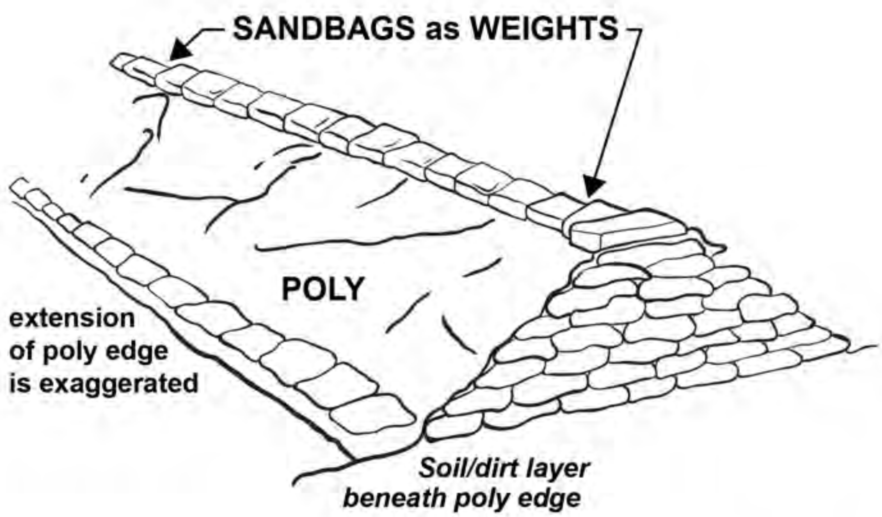
1. START UPSTREAM.
2. STRIP SOD BEFORE LAYING.
3. ALTERNATE DIRECTION OF SACKS WITH BOTTOM LAYER PARALLEL TO FLOW.
4. NEXT LAYER PERPENDICULAR TO FLOW WITH OPEN END AWAY FROM WET SIDE
5. LAP UNFILLED PORTION UNDER NEXT SACK.
6. TYING OR SEWING SACKS NOT NECESSARY.
7. TAMP THOROUGHLY IN PLACE, SACKS SHOULD BE APPROXIMATELY ½-FULL OF SAND.

US Army Corps of Engineers®
St. Paul District

PLATE 1

RECOMMENDED METHOD FOR SANDBAG LEVEE CONSTRUCTION





US Army Corps of Engineers®
St. Paul District

PLATE 2

RECOMMENDED METHODS FOR ANCHORING POLYETHYLENE SHEETING AT THE LEVEE TOE

APPENDIX K - GLOSSARY

Acre-foot
An area of 1 acre covered with water to a depth of 1 foot. One acre-foot is 43,560 cubic feet or 325,851 gallons.

Agricultural levee
A levee that protects agricultural areas where the degree of protection is usually less than that of an urban levee.

Authorization
House and Senate Public Works Committee resolutions or specific legislation which provide the legal basis for conducting studies or constructing projects. The funding necessary for accomplishing the work is not a part of the authorization but must come from an appropriation by Congress.

Bank and channel stabilization
The process of preventing bank erosion and channel degradation.

Basin
Drainage area of a lake or stream as.

Benefits (attributed to a levee system)
A qualitative or quantitative description of the positive contributions the levee system has or can provide to the community in the leveed area. This can include reduction in potential flood damages to residential structures and businesses; potential for the reduction of loss of life; prevention of damages to community services such as schools, hospitals, water treatment plants and other municipal services; prevention of damages to roadways; and providing critical time for the population to get out of harm's way during a flood event.

Breach
The formation of a gap in the levee system through which water may flow uncontrolled onto the adjacent leveed area. A breach in the levee system may occur prior to or after overtopping.

Closure Structures (Gap Closure, Floodgates)
Gap Closure - A constructed gap in a levee or floodwall such as a street, railroad, or access point that is closed off when river stages rise to prevent floodwaters from flooding the area protected by the levee or flood wall.
Floodgates – A pipe, culvert, or similar structure that is closed with a gate to prevent floodwaters from flooding the protected area.

Community
Any state or area or political subdivision thereof, or any Indian tribe or authorized tribal organization, or Alaska Native village, or authorized native organization that has the authority to adopt and enforce regulations for the areas within its jurisdiction.

Confluence
An area where streams meet.

Consequences (of flooding)
The effect, result, or outcome of inundation as reflected in the potential loss of life, economic losses, and adverse environmental impacts.

Cooperation Agreement
An agreement entered by a District Commander (acting as the agent for the Department of the Army on behalf of the United States Government) and the public sponsor for the purpose of identifying each party's rights and obligations concerning the expenditure of federal funds under authority of PL 84-99.

Dam
An artificial barrier, including appurtenant works, constructed for the purpose of storage, control, or diversion of water.

Damages Prevented
The difference between damages occurring without the project and the damages with the project in place.

Degree of protection
The amount of protection that a flood control measure is designed for, as determined by engineering feasibility, economic criteria, social, environmental, and other considerations.

Dike
An embankment to confine or control water, and/or soil.

Draft
The vertical distance from the waterline to the bottom of a floating vessel.

Dredged material
The material removed in excavating or dredging in accessing canals, boat or navigation channels, drainage ditches, and lakes.

Economic risk
The measure of the probability (or likelihood) of direct and indirect economic losses within a leveed area.

Emergency action plan
A formal document that identifies potential emergency conditions at a levee and specifies pre- planned actions to be followed to reduce consequences of the emergency.

Environmental risk
Risk associated with the likelihood of direct and indirect impacts on environmental, cultural, and historic resources within the leveed area that cannot be measured in monetary terms.

Federally authorized and locally operated and maintained
Congressionally authorized levees that are operated and maintained by a local public sponsor through a project agreement with USACE. This category includes levees constructed by USACE and those constructed by others and federally authorized.

Federally authorized and USACE operated or maintained levees
Congressionally authorized levees that USACE has full or partial responsibility to operate or maintain as well as to rehabilitate and modify, as appropriate, under existing authorities.

Flood
An overflow of water that submerges land which is normally dry.

Flood capacity
The flow carried by a stream or floodway at bank-full water level. Also, the storage capacity of the flood pool at a reservoir.

Flood crest
The highest or peak elevation of the water level during a flood in a stream.

Flood plain
Valley land along the course of a stream which is subject to inundation during periods of high water that exceed normal bankfull elevation.

Flood risk (or residual risk)
The risk of flooding in a leveed area that remains at any point in time after accounting for the flood risk reduction contributed by the levee system.

Floodwall
Wall, usually built of reinforced concrete, to confine streamflow to prevent flooding.

Freeboard
(1) Vertical distance between the normal maximum level of the surface of the liquid in a conduit, reservoir, tank, canal, etc., and the top of the sides of the conduit, reservoir, canal, etc. (2) An allowance in protection above the design water surface level.

Gravity drainage outlets
(1) Outlets for gravity drains such as tiles, perforated conduits, etc., servicing an agricultural area and discharging into drainage ditch. (2) Pipe, culvert, etc., used for dewatering pounded water by gravity.

Hazard
An event that causes the potential for an adverse consequence.

Headwaters
(1) The upper reaches of a stream near its source. (2) The region where groundwaters emerge to form a surface stream. (3) The water upstream from a structure.

Incident
An event occurring at a levee system that could potentially result in a levee safety issue.

Interim risk reduction measures
An action to reduce levee risk while more long-term and comprehensive risk reduction and management solutions are being pursued.

Interior drainage
Natural or modified outflow of streams within a levee area for the conveyance of run-off. Interior drainage systems are not components of flood risk management projects.

Inundation
In the context of this document, this refers to flooding in a leveed area.

Inundation scenario (for a levee system)
A scenario which could result in flooding in a leveed area. The four inundation scenarios for a levee system are: breach prior to overtopping; overtopping with breach; component malfunction/mis-operation; and overtopping without breach.

LERRD
Lands, easements, rights-of-way, relocations, and borrow and dredged or excavated materials disposal areas.

Left or right bank of river
The left-hand or right-hand bank of a stream when the observer faces downstream.

Levee
A man-made barrier along a watercourse with the principal function of excluding flood waters from a limited range of flood events from a portion of the floodplain (referred to as "leveed area").

Levee accreditation
The process in which a levee system is evaluated to determine how it will be mapped by the Federal Emergency Management Agency for the purposes of the National Flood Insurance Program.

Levee feature
A structure that is critical to the functioning of a levee system. Examples include embankments, floodwalls, pipes and associated drainage features, closures, pumping stations, floodways, and designed channels.

Levee Inspection System
The electronic tool used by USACE to document levee inspections.

Levee risk (or incremental risk)
The risk of inundation posed by a levee system for the following three inundation scenarios: prior to overtopping; overtopping with breach; and component malfunction/mis-operation.

Levee Safety Program Manager
Person selected by appointment to lead the coordination and implementation of the USACE Levee Safety Program at a particular level in USACE.

Levee safety
The art, science, and practice of managing flood risks posed by levee systems.

Levee Screening Tool
The electronic tool used by USACE to complete all screening risk assessments.

Levee segment
A levee segment is a discrete portion of a levee system that is operated and maintained by a single entity. A levee segment may be composed of one or more levee features.

Levee system (or levee)
Composed of one or more levee segments and other features that are collectively integral to excluding flood water from the leveed area. The term "levee segment" is used to identify a discrete portion of a levee system that is operated and maintained by a single non-federal sponsor.

Leveed area
The lands from which flood water is excluded by the levee system.

Life safety risk
A measure of the probability and severity of loss of life resulting from inundation of a leveed area.

Mitigation
Actions taken that reduce potential loss of life and property by lessening the impacts of flood.

Mouth of river
The exit or point of discharge of a stream into another stream, a lake, or the sea.

Non-breach risk
The risk associated with the scenario when the still-water level and/or associated waves, wind runup, or surge exceeds the top of the levee system, but does not result in a breach of the levee system.

Non-federally authorized and locally operated and maintained levee
Levee that is locally constructed, operated, and maintained.

Non-federal sponsor
A public entity that has responsibility for operation and maintenance for all or a certain portion of a levee system. Within this document, non-federal sponsor refers to entities who operate and maintain federally authorized levees through a project agreement with USACE.

Non-project segment
A segment of man-made high ground which a levee system/segment ties into and whose existence and performance is necessary for excluding flood waters from the leveed area. Some examples of these are roadways, railroads, canals, and other levee embankments. Non-project segments are inventoried, inspected, and assessed if they make up part of the levee alignment and are necessary for the proper functioning of the levee system.

Overtopping
A condition that occurs when the elevation of the still-water level and/or associated waves, wind runup, or surge exceeds the top of the levee system. This may or may not result in a breach of the levee system.

Oxbow lake
A lake formed in the meander of a stream, resulting from the abandonment of the meandering course due to the formation of a new channel course.

Performance
How the levee system has functioned or is anticipated to function during specified hazards.

Ponding area
An area reserved for collecting excess runoff preparatory to being discharged whether by gravity or by pumping.

Pool
A small and rather deep body of quiet water as: water behind a dam.

Potential failure mode
A structured way to describe a chain of events that leads to a levee breach.

Preparedness
Actions taken before a possible future flood event, including planning, training, communication, and anticipation of how the levee will perform based on operation and maintenance, inspections, and assessments.

Project agreement (project cooperation or project partnership agreement)
Legally binding agreement between the government and a non-federal sponsor (state, municipal government, flood control district, port authority, etc.) for construction or operation and maintenance of a water resources project. It describes the project and the responsibilities of the government and the non-federal sponsor.

Reach
A length, distance, or leg of a channel or other watercourse.

Recovery
Actions taken after a flood, including those directed toward a return to normalcy.

Rehabilitation
A major repair. Usually involves considerable reconstruction of already existing structures.

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, recreation, etc.

Resilience
The ability to avoid, minimize, withstand, and recover from the effects of adversity, whether natural or man-made, under all circumstances of use.

Response
Actions taken during a flood, including those to save lives and prevent damage.

Revetment
(1) A facing of stone, concrete, sandbags, etc., to protect a bank of earth from erosion. (2) A retaining wall.

Riprap
A layer, facing, or protective mound of randomly placed stones to prevent erosion, scour, or sloughing of a structure or embankment. The stone so used for this purpose is also called riprap.

Risk assessment
A systematic, evidence-based approach for quantifying and describing the nature, likelihood, and magnitude of risk. Risk assessments are a tool to determine the most likely ways a levee might breach or overtop, how likely those scenarios are to occur, and the potential impacts within a community.

Risk communication
An iterative, open exchange of data, advice, and opinions among individuals, groups, and institutions about levees, the benefits they provide, known risks or areas of concern, and options available to manage that risk.

Risk management
The process of problem finding and initiating action to identify, evaluate, select, implement, monitor, and modify associated risks.

Risk
The measure of the probability (or likelihood) and consequence of uncertain future events.

River basin
A water resource basin is a portion of a water resource region defined by a hydrological boundary which is usually the drainage area of one of the lesser streams in the region.

Sediment load
The total sediment composed of suspended load and bed load transported by a stream. The suspended load is composed of fine sediment transported in suspension while bed load is composed of relatively coarse material transported along or near the bottom.

Seepage
Percolation of water through the levee structure (through seepage) or through the foundation (underseepage).

Semi-quantitative risk assessment
A risk assessment that uses a combination of limited numerical estimates with qualitative descriptions that result in risk estimates based on orders of magnitude.

Sensitive information
Information that could pose a security risk or aid those intending to do harm to a levee system.

Spillway
A waterway or a dam or other hydraulic structure used to discharge excess water to avoid overtopping of a dam.

Stage
The elevation of the water surface above or below an arbitrary datum.

Stakeholder(s)
An individual or group of individuals who are responsible, interested, and/or affected by a levee system. An individual stakeholder may belong to more than one group of stakeholders.

Standard project flood
A flood that may be expected from the most severe combination of meteorologic and hydrologic conditions that are reasonably characteristic of the geographic region involved, excluding extremely rare combinations.

Tributary
A stream or other body of water that contributes its water to another stream or body of water.

Uncontrolled spillway
An overflow spillway having no control gates.

Water shed
The whole surface drainage area that contributes water to a collecting river or lake.