

# Module 317

## Storm Reports

**Engineering  
Hydrology Training Series**

**Module 317—Storm Reports**

National Employee Development Center  
Natural Resources Conservation Service  
United States Department of Agriculture  
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### **Preface**

This module consists of a study guide which describes the methods and procedures for making the two basic types of storm reports—general flood studies and performance studies.

Proceed through this module at your own pace. Be sure you completely understand each section before moving on. If you have questions or need help, please request assistance from your supervisor. If your supervisor cannot clear up your problems, he/she will contact the state-appointed resource person. The resource person is familiar with the material and should be able to answer any questions you may have.

Be sure to write out your answers to the included activities. This will help to reinforce your learning. After completing each activity, compare your answers with the included solution.

### **Acknowledgment**

The design and development of this training module is the result of a concerted effort by practicing engineers in the Natural Resources Conservation Service. The contributions from many technical and procedural reviews have helped make this module one that will provide needed hydrology and hydraulic skills to NRCS employees.



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## Module Description

### Overview

This module presents information associated with watershed studies and storm reports that NRCS personnel need. Types of survey data required for hydrologic and hydraulic studies are covered, including items to include in storm reports. The module explains study techniques for flood management studies.

### Objectives

Upon completion of this module, participants will be able to:

- List references associated with watershed studies.
- Describe procedures for obtaining hydrologic and hydraulic surveys.
- List and explain the hydrologic and hydraulic items needed in storm reports.
- Be able to perform at ASK Level 3 (Perform with Supervision).

### Prerequisites

None

### **Length**

Participants should take as long as necessary to complete the module. Training time for this module is approximately three hours.

### **Who May Take The Module**

This module is for all NRCS personnel who use storm report data in their work.

### **Method of Completion**

This module is self-study, but the state should select a resource person to answer any questions that the participant's supervisor cannot handle.

## **Module 317—Storm Reports**

### **Introduction**



Watershed studies and storm reports are the Natural Resources Conservation Service's (NRCS) method by which to document the effects of major storm events on private and public properties and NRCS installed structures. This module describes methods and procedures to be used in making the two basic types of storm reports—general flood studies and performance studies.

### **Watershed Study References**

Watershed studies and storm reports are as varied as the watersheds they are associated with. They are varied in the size, type, and extent of detail each covers. Consequently, no one specific reference document can cover all the different aspects of watershed studies and storm reports. A partial listing of NRCS documents available and a short description and location of each follows.

#### **National Watershed Manual (NWM)**

This manual sets forth policies and criteria applicable to watershed projects planned and carried out under the Watershed Protection and Flood Prevention Act, Public Law 83-566. It is equally as applicable to the eleven watersheds authorized by the Flood Control Act of 1944, Public Law 78-534. In addition, the manual covers requirements and procedures for Emergency Watershed Protection as authorized by Section 216, Public Law 81-516 and Section 403 of Title IV of Public Law 95-334. Updated copies of this manual can be found in most NRCS state offices.

### **National Planning Manual (NPM)**

This manual provides current NRCS policy for USDA river basin studies, interagency coordination activities and NRCS activities in flood plain management studies and flood insurance studies. Updated copies of this manual can be found in most state offices.

### **National Engineering Handbook (NEH)**

This handbook is intended primarily for NRCS engineers and technicians. The aim of the handbook is to present information on the application of engineering principles to the problems of soil and water conservation. The handbook is divided into sections that cover a variety of topics, to name a few:

- Engineering Practices
- Sedimentation
- Hydrology
- Hydraulics
- Structural Design
- Geology
- Irrigation
- Drainage
- Groundwater
- Snow Survey

Updated copies of this handbook can be found in most state and area offices.

### **National Engineering Manual (NEM)**

This manual establishes policy for NRCS engineering activities. Its purpose is to present engineering policy clearly and completely so that engineering activities can be carried out efficiently and at the appropriate level of quality. Updated copies of this manual can be found in most state and area offices and some field offices.

### **Engineering Field Handbook (EFH)**

This handbook is intended primarily for use at the field office level. Its objective is to provide guidance in the use of basic engineering principles, techniques, and procedures for the planing, design, installation and maintenance of soil and water conservation practices. Updated copies of this handbook can be found in most state, area, and field offices.

### **National Handbook of Conservation Practices (NHCP)**

This handbook establishes official names, definitions, national standards and specifications, or guides to specifications for the practices commonly used in soil and water conservation programs. Updated copies of this handbook can be found in most state, area, and field offices.

### **Technical Releases (TR)**

NRCS has developed a number of technical releases intended primarily for NRCS engineers and technicians. The aim of these releases is to provide technical information on various site specific engineering practices. TR40 is an index of NRCS national engineering technical materials. Updated copies of most Technical Releases can be found in state offices. TR's can be found in area and field offices as well. **TR's are being incorporated into the general manual over time and will not be separate publications in the future.**

### Activity 1



At this time, complete Activity 1 in your Study Guide for review of material you have just covered. When you have finished, compare your answers with the solution provided. When you are sure you understand the material, continue with the Study Guide test.



## Activity 1



List six NRCS reference documents associated with watershed studies and storm reports, and tell what offices they might be found in.

1. \_\_\_\_\_

\_\_\_\_\_

2. \_\_\_\_\_

\_\_\_\_\_

3. \_\_\_\_\_

\_\_\_\_\_

4. \_\_\_\_\_

\_\_\_\_\_

5. \_\_\_\_\_

\_\_\_\_\_

6. \_\_\_\_\_

\_\_\_\_\_

### Hydraulic and Hydrologic Surveys

Hydrology has been defined as the science that deals with the occurrence and behavior of water in the atmosphere, on the earth's surface, and below its surface. Hydraulics has been described as the branch of engineering science dealing primarily with the flow of water or other liquids. In the broadest sense, hydrology deals with the computation of how much water we could expect, and hydraulics deals with the level or elevation this water will attain.

### Methods of Obtaining Hydraulic and Hydrologic Surveys

In order to determine how much water to expect and what level it will attain, hydraulic and hydrologic surveys must first be obtained. There are various methods by which these surveys may be obtained. This module categorizes them into three types:

- manual or field surveys
- A & E contracts
- data bases

#### *Manual surveys*

Typically, when we think of manual surveys we think of surveying or engineering surveys. Chapter 1 of the Engineering Field Manual defines surveying as the science by which line distances, angles, and elevation are established and measured on the earth's surface. Engineering surveys describe the topographic characteristics of a watershed. However, manual surveys encompasses more than just engineering surveys. Data must be collected to describe watershed characteristics other than topographic. Data collected includes soil information, land use and land treatment information, and other data needed to describe the watershed's hydrologic characteristics.

### *A & E contracts*

Engineering surveys are very labor intensive and time consuming. It is sometimes necessary, due to workload demands and time restraints, to contract out engineering surveys. Contracts may also be let to collect data that NRCS does not typically collect within the service, such as water quality data for groundwater and surface water. Contracts may also be let with other government agencies to collect data, such as with the United States Geological Survey to collect streamflow data on ungaged watersheds. Part 505 of the National Engineering Manual sets policy for non-NRCS engineering services.

### *Data bases*

There are numerous data bases both in computer and tabular format that have been developed by NRCS and other organizations. Data bases are as varied as the data they represent. A data base could be a one page tabular stream gage record or thousands of lines of computer records, such as National Resource Inventory data.

### Hydraulic Surveys

Hydraulic surveys are basically topographic in nature and consist mainly of engineering surveys. Chapter 1 of the Engineering Field Manual sets forth basic engineering principles, techniques, and procedures for making engineering surveys. Part 540 of the National Engineering Manual sets policy for making engineering surveys.

Engineering surveys should adequately describe the following data:

- Valley channel cross-sections
- Valley and channel profiles
- Manning's "n" value as described in NEH 5
- Road profiles and bridge and culvert information
- Structure data for grade stabilization structures and floodwater retarding structures.

The data derived from the engineering survey can be evaluated using techniques and procedures found in NEH 5, Hydraulics. More complex watershed systems may require developing water surface profiles using TR-61, WSPZ, Computer Program. Part 534 of NEM sets forth the policy to be used in hydraulic investigations.

### Hydrologic Surveys

Hydrologic surveys are concerned with basic watershed characteristics other than topography. Some watershed characteristics needing data in order to perform adequate hydrologic analyses are:

- Soils
- Land use and land treatment
- Climatological
  - Precipitation
  - Temperature
  - Wind movement
  - Evaporation
- Streamflow
  - Low flows
  - Flood flows
  - Historical flood records
- Groundwater
- Water quality
- Snow surveys

NEH 4 Hydrology presents guidance, techniques, and procedures for using the above watershed characteristics in making hydrological analyses of watersheds. Part 530, NEM, sets forth policy for hydrologic studies.

The main end product from hydrologic studies is the determination of peak discharges for various points throughout the watersheds being evaluated. NRCS usually uses four levels of peak discharge estimating procedures. The choice for a specific use should be based on the size and complexity of the watershed, the importance of the use, the potential for adverse affects, and the knowledge and skills of the user. The four most widely used NRCS handbook methods for estimating peak discharge are listed below:

<b>Level</b>	<b>Method</b>	<b>Application</b>
1.	EFM, Chapter 2	On farm engineering practices
2.	TR-55, Chapter 4 (Graphical Method)	Small urban or rural engineering practices
3.	TR-55, Chapter 5 (Tabular Hydrograph Method)	Small urban or rural practices in complex watersheds
4.	TR-20	Evaluation of measures in complex watersheds

### Sources of Hydraulic and Hydrologic Data

Hydraulic and hydrologic studies require large amounts of raw data for adequate analyses. Fortunately, a considerable amount of this data is available through NRCS and outside sources. Some sources and types of data they can supply are:

<b>Source</b>	<b>Data and Data Type</b>
Natural Resources Conservation Service	Engineering surveys <ul style="list-style-type: none"><li>• Original survey data</li><li>• As-built construction plans</li></ul> Soil surveys National Resource Inventory data Snow surveys
U.S. Department of Army—COE	Streamflow data Flood study data
National Weather Service	Climatological <ul style="list-style-type: none"><li>• Precipitation</li><li>• Temperature</li><li>• Wind movement</li><li>• Evaporation</li></ul>
Federal Emergency Management Agency	Flood study
Tennessee Valley Authority	Streamflow data
United States Geological Survey	Streamflow data Groundwater data Water quality data Engineering survey data
Agricultural Research Service	Streamflow data Groundwater data Water quality data Climatological data
State and local agencies	Streamflow data Groundwater data Water quality data
Individuals	Climatological data Streamflow data
Public libraries	Climatological data and newspapers Streamflow data

### Activity 2



At this time complete Activity 2 in your Study Guide to review the material you just covered. After finishing the Activity, compare your answers with the solution provided. When you are satisfied that you understand the material, continue with the Study Guide text.

## Activity 2



1. List three methods of obtaining hydraulic and hydrologic surveys.

a. \_\_\_\_\_

b. \_\_\_\_\_

c. \_\_\_\_\_

2. List five types of topographic data needed to adequately analyze the hydraulics of a watershed.

a. \_\_\_\_\_

b. \_\_\_\_\_

c. \_\_\_\_\_

d. \_\_\_\_\_

e. \_\_\_\_\_

3. List seven watershed characteristics that data will be needed for in order to perform an adequate hydrologic analysis of a watershed.

a. \_\_\_\_\_

b. \_\_\_\_\_

c. \_\_\_\_\_

d. \_\_\_\_\_

e. \_\_\_\_\_

f. \_\_\_\_\_

g. \_\_\_\_\_

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4. List ten sources of hydraulic and hydrologic data.

a. \_\_\_\_\_

b. \_\_\_\_\_

c. \_\_\_\_\_

d. \_\_\_\_\_

e. \_\_\_\_\_

f. \_\_\_\_\_

g. \_\_\_\_\_

h. \_\_\_\_\_

i. \_\_\_\_\_

j. \_\_\_\_\_

### **Storm Reports**

Storm reports are assembled to document the effects of major storm events. Data constituting a major storm event varies from region to region, depending on climatic conditions. Basically, a major storm event would be an event that has a relatively low frequency of occurrence and that causes significant damages to private and public properties.

Storm reports generally fall within two categories—general flood studies and performance studies. General flood studies document the effects of major storm events on private and public properties. Performance studies document how NRCS installed structures operate during major storm events.

### General flood studies

General flood studies should be made as soon after the occurrence of a major storm event as practical. The studies and subsequent reports should consider and document the information listed below as well as other pertinent information:

- Dates, amounts, intensity, and duration of rainfall
- Stages of flow and volume of discharge
- Streamflow data—peaks and volume
- Delineate the storm and flooded area
- Determination of the extent and kinds of damage
- Effectiveness of applied measures
- Notation of any particular feature of event such as ice or log jam that influenced flooding
- High water marks
- Analysis of the interrelationship of rainfall, runoff, soils, cover erosion, sediment production, and other climatic and watershed factor
- Evaluation of the operation of installed works of improvement
- Photographs of post-storm conditions.

An example of a general flood study is contained in appendix A. The example shows how some of the pertinent information above can be displayed in a document. The example should be used as a guideline only, not as official format.

### Performance Studies

Thousands of emergency spillways have been installed since 1954 when NRCS began using the present procedure for design. Several hundred more are installed each year. Major spillway flows can be expected at several structures each year.

Current emergency spillway criteria are determined by research results, procedural analyses, and the judgment from experience gained over the years. However, most research and field evaluations to date have been on structures with drainage areas less than 10 square miles.

Further research is needed, but laboratory model studies are not always directly applicable and large field models or prototype studies have not yet been undertaken. An alternative is to make field studies of the operation of existing structures.

Part 504 of the NEM sets policy and criteria to be followed in making performance studies.

States are responsible for gathering data, making analyses, and preparing reports on spillway flows meeting the requirements of Part 504 of the NEM. The following is a guide to the supporting activities of the State staff.

A study is to be made of any earth, rock (except massive, unweathered rock), or vegetated spillway built since 1954 when any of the following situations occur:

- The water surface in the reservoir has reached an elevation above the crest of the spillway of 3 feet or more.
- The spillway has suffered severe damage, has approached breaching, or has breached to any degree.
- The spillway has sustained continuous discharge for 7 days or more.

A performance study is to be made as soon after the occurrence as practical. The study and the report are to consider and document the information listed below and any other pertinent information.

- Name of watershed.
- Name or number of structure and inventory number.
- Location (State and latitude and longitude to nearest degree and minute).
- Date built.
- Drainage area in square miles.
- Height of dam.
- Plan and profile along spillway center line from entrance to streambed.
- Cross sections at control section and at selected points in the exit channel showing the depth and width of the constructed spillway.

- Geologic map and profiles of the control section and the exit channel.
- Statement regarding the condition of the spillway before the flood event including the density and type of any vegetation.
- A copy of the last maintenance and inspection report before the storm.
- Photographs, if available, of prestorm spillway conditions.
- Date of flood.
- Rainfall—depths for various durations according to either official rain gages or a “bucket survey”, and the related frequency for each duration.
- Runoff—if a stream gage is available, USGS “provisional” data should be included.
- Observed or reconstructed inflow and outflow hydrographs at the structure, including maximum reservoir stage and duration of emergency spillway flow.
- Physical factors of drainage area related to a weighted “curve number”, including antecedent moisture and vegetative cover conditions immediately preceding the storm.
- Description of condition on damage in the emergency spillway, including location, depth, and severity of erosion.
- Photographs of post-storm conditions in spillway and downstream.
- Estimate of volume of soil and rock eroded from various sections of the spillway.
- An estimate of the cost to repair the spillway.

An example of a performance study is contained in appendix B. The example shows how some of the pertinent information above can be displayed in a document. The example should be used as a guideline only, not as official format.

### Activity 3



At this time, complete Activity 3 in your Study Guide to review the material just covered. When you have finished, compare your answers with the solution provided. When you are sure you understand the material, continue with the Study Guide text.

**Activity 3**



1. Name the two basic categories of storm reports.

a. \_\_\_\_\_

b. \_\_\_\_\_

2. List 11 items to be considered in making general flood studies.

a. \_\_\_\_\_

b. \_\_\_\_\_

c. \_\_\_\_\_

d. \_\_\_\_\_

e. \_\_\_\_\_

f. \_\_\_\_\_

g. \_\_\_\_\_

h. \_\_\_\_\_

i. \_\_\_\_\_

j. \_\_\_\_\_

k. \_\_\_\_\_

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3. List 21 items to be considered in making performance studies.

a. \_\_\_\_\_

b. \_\_\_\_\_

c. \_\_\_\_\_

d. \_\_\_\_\_

e. \_\_\_\_\_

f. \_\_\_\_\_

g. \_\_\_\_\_

h. \_\_\_\_\_

i. \_\_\_\_\_

j. \_\_\_\_\_

k. \_\_\_\_\_

l. \_\_\_\_\_

m. \_\_\_\_\_

n. \_\_\_\_\_

o. \_\_\_\_\_

p. \_\_\_\_\_

q. \_\_\_\_\_

r. \_\_\_\_\_

s. \_\_\_\_\_

t. \_\_\_\_\_

u. \_\_\_\_\_

### Summary

Upon completion of this module you should be able to describe the two basic categories of storm reports, general flood studies and performance reports. You should have a good working knowledge of what hydraulic and hydrologic data is needed to prepare the two different types of storm reports. You should also be able to describe the three basic methods of obtaining hydraulic and hydrologic surveys needed for the preparation of storm reports; manual surveys, A & E contracts and data bases. You should be familiar with sources of existing hydraulic and hydrologic surveys and what types of data each can provide. You should also be able to describe the available NRCS reference documents used in watershed studies and storm reports and know where they can be found.

Retain this Study Guide as a reference until you are satisfied that you have successfully mastered all the methods covered. It will provide an easy review at any time if you should encounter a problem.

If you have had problems understanding the module or if you would like to take additional, related modules, contact your supervisor.

When you are satisfied that you have completed this module, remove the Certification of Completion sheet (last page of the Study Guide), fill it out, and give it to your supervisor to submit, through channels, to your state Training Officer.



### Test



1. Match the following NRCS documents with their description:
  - a. National Watershed Manual      \_\_\_ Establishes policy for NRCS engineering activities
  - b. National Planning Manual      \_\_\_ Provides technical information on site specific engineering practices
  - c. National Engineering Handbook      \_\_\_ Sets forth policies for PL-83-566 and PL-78-534 watersheds
  - d. National Engineering Manual      \_\_\_ Establishes official names, definitions, standards and specifications for soil and water conservation practices
  - e. Engineering Field Manual      \_\_\_ Provides guidance in the use of engineering principles, techniques and procedures for the planning, design, installation, and maintenance of soil and water conservation practices
  - f. National Handbook of Conservation Practices      \_\_\_ Provides current NRCS planning policy
  - g. Technical Releases      \_\_\_ Presents information on the application of engineering principles

2. What branch of science deals with the occurrence and behavior of water in the atmosphere, on the earth's surface, and below its surface?

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3. What method of obtaining hydraulic and hydrologic surveys would engineering surveys be most typically associated with?

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4. What NRCS document sets forth policy for non-NRCS engineering services?

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5. A farmer keeps rainfall records for a rain gage on his farm in a notebook. Is this a data base?

---

6. Match the following statements with the type of survey they are associated with:

a. Basically topographic in nature and consists mainly of engineering surveys      \_\_\_\_Hydraulic Surveys

b. Concerned with the basic watershed characteristics other than topography      \_\_\_\_Hydrologic Surveys

7. What is the main end product from a hydrologic study?

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8. What type of data would you think the following organization might be able to supply you with?

National Weather Service

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United States Geological Survey

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9. Describe a major storm event.

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10. Match the following statement with the type of storm report it is associated with.

a. Documents how NRCS installed structures operate during major storm events      \_\_\_ General flood study

b. Documents the effects of major storm events on private and public properties.      \_\_\_ Performance studies

11. What three situations require a performance study to be made?

a. \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

b. \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

c. \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_



## **Activity & Test Solutions**

### Activity 1

List six NRCS reference documents associated with watershed studies and storm reports, and tell what offices they might be found in.

1. *National Watershed Manual; State office*
2. *National Basin and Area Planning Manual; State office*
3. *National Engineering Handbook; State and area offices*
4. *National Engineering Manual; State, area, and field offices*
5. *Engineering Field Handbook; State, area, and field offices*
6. *National Handbook of Conservation Practices; State, area, and field offices*

### Activity 2

1. List three methods of obtaining hydraulic and hydrologic surveys.
  - a. *Manual surveys*
  - b. *A & E contracts*
  - c. *Data bases*
2. List five types of topographic data needed to adequately analyze the hydraulics of a watershed.
  - a. *Valley and channel cross-sections*
  - b. *Valley and channel profiles*
  - c. *Manning's "n" value*
  - d. *Road profiles and bridge and culvert data*
  - e. *Structure data*

3. List seven watershed characteristics that data will be needed for in order to perform an adequate hydrologic analysis of a watershed.
  - a. *Soils*
  - b. *Land use and land treatment*
  - c. *Climatological data*
  - d. *Streamflow*
  - e. *Groundwater*
  - f. *Water quality*
  - g. *Snow surveys*
  
4. List ten sources of hydraulic and hydrologic data.
  - a. *Natural Resources Conservation Service*
  - b. *U.S. Department of Army—COE*
  - c. *National Weather Service*
  - d. *Federal Emergency Management Agency*
  - e. *Tennessee Valley Authority*
  - f. *United States Geological Survey*
  - g. *Agricultural Research Service*
  - h. *State and local agencies*
  - i. *Individuals*
  - j. *Public libraries and newspapers*

### Activity 3

1. Name the two basic categories of storm reports.
  - a. *General flood studies*
  - b. *Performance studies*
  
2. List 11 items to be considered in making general flood studies.
  - a. *Rainfall data*
  - b. *Stages of flow and volume of discharge*
  - c. *Streamflow data*
  - d. *Delineate the storm and flooded area*
  - e. *Extent and kinds of damage*
  - f. *Effectiveness of applied measures*
  - g. *Notation of any particular feature of event such as ice or log jam that influenced flooding*
  - h. *High water marks*
  - i. *Analysis of the interrelationship of rainfall, runoff, soils, cover erosion, sediment production, and other climatic and watershed factor*
  - j. *Evaluation of the operation of installed works of improvement*
  - k. *Photographs*

3. List 21 items to be considered in making performance studies.
  - a. *Name of watershed*
  - b. *Name and number of structure and inventory number*
  - c. *Location*
  - d. *Date built*
  - e. *Drainage area*
  - f. *Height of dam*
  - g. *Plan and profile along spillway center line*
  - h. *Cross-sections at control section*
  - I. *Geologic profiles at control section and in the exit channel*
  - j. *Statement regarding the condition of the spillway before storm event*
  - k. *Last maintenance and inspection report*
  - l. *Photographs of prestorm conditions*
  - m. *Date of flood*
  - n. *Rainfall*
  - o. *Runoff*
  - p. *Observed or reconstructed inflow and outflow hydrographs*
  - q. *Physical factors of the watershed related to curve numbers, antecedent moisture condition, vegetative cover*
  - r. *Description of damage in emergency spillway*
  - s. *Photographs of post-storm conditions*
  - t. *Estimate of volume of soil eroded*
  - u. *Repair cost estimate*

### Test

1. Match the following NRCS documents with their description:
  - a. National Watershed Manual
  - b. National Planning Manual
  - c. National Engineering Handbook
  - d. National Engineering Manual
  - e. Engineering Field Manual
  - f. National Handbook of Conservation Practices
  - g. Technical Releases
  - d. Establishes policy for NRCS engineering activities
  - g. Provides technical information on site specific engineering practices
  - a. Sets forth policies for PL-83-566 and PL-78-534 watersheds
  - f. Establishes official names, definitions, standards and specifications for soil and water conservation practices
  - e. Provides guidance in the use of engineering principles, techniques and procedures for the planning, design, installation, and maintenance of soil and water conservation practices
  - b. Provides current NRCS planning policy
  - c. Presents information on the application of engineering principles

2. What branch of science deals with the occurrence and behavior of water in the atmosphere, on the earth's surface, and below its surface?

*Hydrology*

3. What method of obtaining hydraulic and hydrologic surveys would engineering surveys be most typically associated with?

*Manual surveys*

4. What NRCS document sets forth policy for non-NRCS engineering services?

*Part 505 of the National Engineering Manual*

5. A farmer keeps rainfall records for a rain gage on his farm in a notebook. Is this a data base?

*Yes*

6. Match the following statements with the type of survey they are associated with:

a. Basically topographic in nature and consists mainly of engineering surveys

a. Hydraulic Surveys

b. Concerned with the basic watershed characteristics other than topography

b. Hydrologic Surveys

7. What is the main end product from a hydrologic study?

*Peak discharge*

8. What type of data would you think the following organization might be able to supply you with?

National Weather Service

*Climatological*

United States Geological Survey

*Streamflow*

*Groundwater*

*Water quality*

*Engineering survey*

9. Describe a major storm event.

*A storm event that has a relatively low frequency of occurrence and causes significant damages to private and public properties*

10. Match the following statement with the type of storm report it is associated with.

a. Documents how NRCS installed structures operate during major storm events

b. General flood study

b. Documents the effects of major storm events on private and public properties.

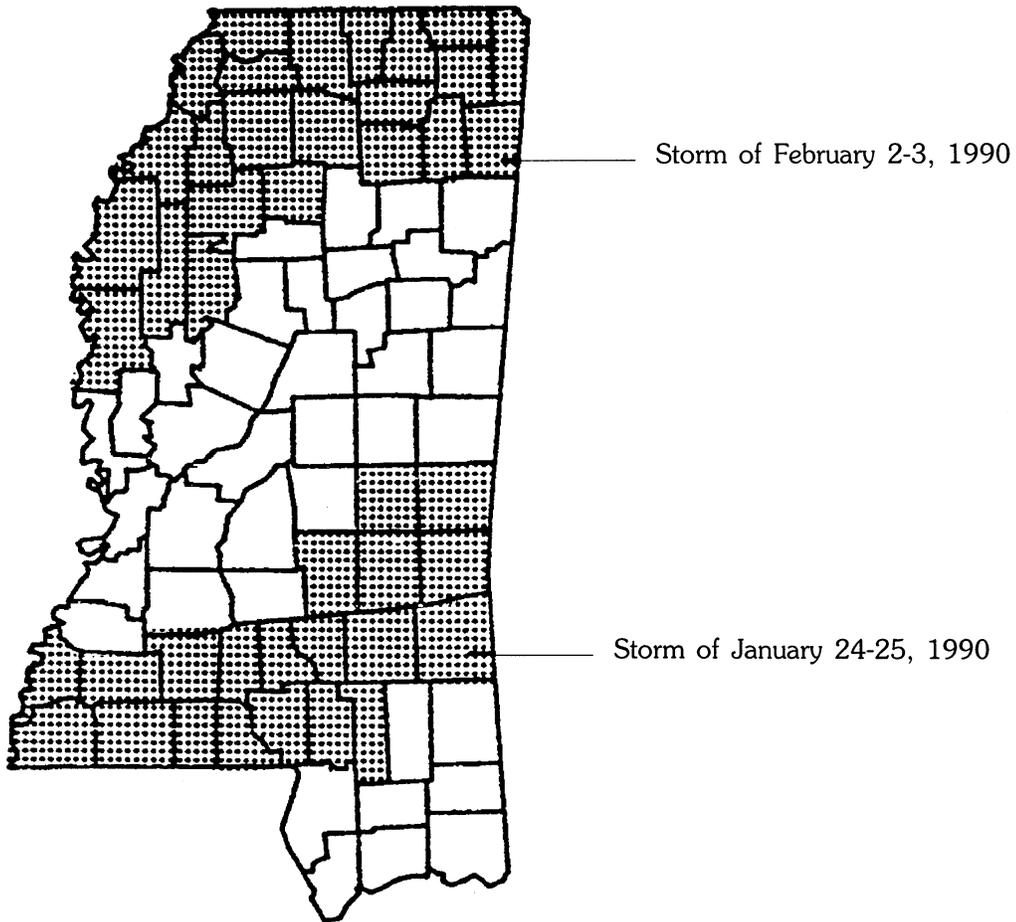
a. Performance studies

11. What three situations require a performance study to be made?
- a. *The water surface in the reservoir has reached an elevation above the crest of the spillway of 3 feet or more;*
  - b. *The spillway has suffered severe damage, has approached breaching, or has breached to any degree; or*
  - c. *The spillway has sustained continuous discharge for 7 days or more.*



**Appendix A**  
**Example Storm Report**

## Special Storm Report for Storms of January 24-25, 1990 and February 2-3, 1990



U. S. Department of Agriculture  
Jackson, Mississippi

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### Summary

On January 24-25, 1990 a 4 to 11 inch rain fell over a twenty county area in South Mississippi. On February 2-3, 1990, a 5 to 10 inch rain fell over a twenty-three county area in North Mississippi.

The total damages to roads, bridges, culverts, channels, levees, cemeteries, homes, and water and sewer facilities are estimated at \$7,739,000.

This report was prepared on March 5, 1990, by the USDA Soil Conservation Service.

### Counties Affected in North and South Mississippi

#### South Storm

##### *Date*

This report describes the effects of the storm of January 24-25, 1990, on the southern half of the State of Mississippi.

##### *Location*

The storm event of January 24-25, 1990, covered all of those counties lying south of the thirty-third parallel and east of the Big Black River. These thirty-eight counties account for approximately 24,000 square miles or 50 percent of the total land area of the State of Mississippi. The major drainage basins within the area are the Pascagoula River Basins and the Pearl River Basin. Also included in this area are a number of independent streams and their tributaries that flow directly into the Mississippi River and a number of coastal streams and their tributaries that flow directly into the Gulf of Mexico.

Within the thirty-eight county area covered by the storm event, twenty counties sustained significant storm damages. The twenty counties that sustained significant storm damages accounted for approximately 11,475 square miles or twenty-five percent of the total land area of the State of Mississippi.

##### *Rainfall*

Reports from official National Oceanic and Atmospheric Administration rainfall gauging stations show that on the dates of January 24-25, 1990, from 1 to 11 inches of rainfall fell within a 24-hour time span over the entire southern half of the State of Mississippi. Approximately eighty percent of the total area sustaining significant storm damage had four inches or more of rainfall, forty percent had six inches or more, ten percent had eight inches or more, and two and one-half percent had ten inches or more. The City of Woodville in Wilkinson County, Mississippi, had the highest rainfall event recorded at 11.07 inches.

A storm event producing four inches of rainfall over a 24-hour period is expected to occur once a year on the average, or a 100 percent chance in any one particular year. A six inch rainfall is expected to occur once every five years or a twenty percent chance in any one particular year. An eight inch rainfall event is expected to occur once every twenty-five years or a four percent chance in any one particular year. A ten inch rainfall is expected to occur once every 100 years or a one percent chance in any one particular year.

The rainfall pattern for the storm of January 24-25, 1990, is shown on the following map of the southern half of the State of Mississippi.





### **North Storm**

#### *Date*

The report also describes the effects of the storm of February 2-3, 1990, on the northern half of the State of Mississippi.

#### *Location*

The storm event of February 2-3, 1990, covered all of those counties lying north of the thirty-third parallel. These thirty-nine counties account for approximately 21,075 square miles or 45 percent of the total land area of the State of Mississippi. The major drainage basins within the area are the Yazoo River Basin, the Tombigbee River Basin, the Big Black River Basin, the Tennessee River Basin, and the upper portion of the Pearl River Basin. Also included in this area are a number of independent streams and their tributaries that flow north into Tennessee.

Within the thirty-nine county area covered by the storm event, twenty-three counties sustained significant storm damages. The twenty-three counties that sustained significant storm damages accounted for approximately 12,650 square miles of twenty-five percent of the total land area of the State of Mississippi.

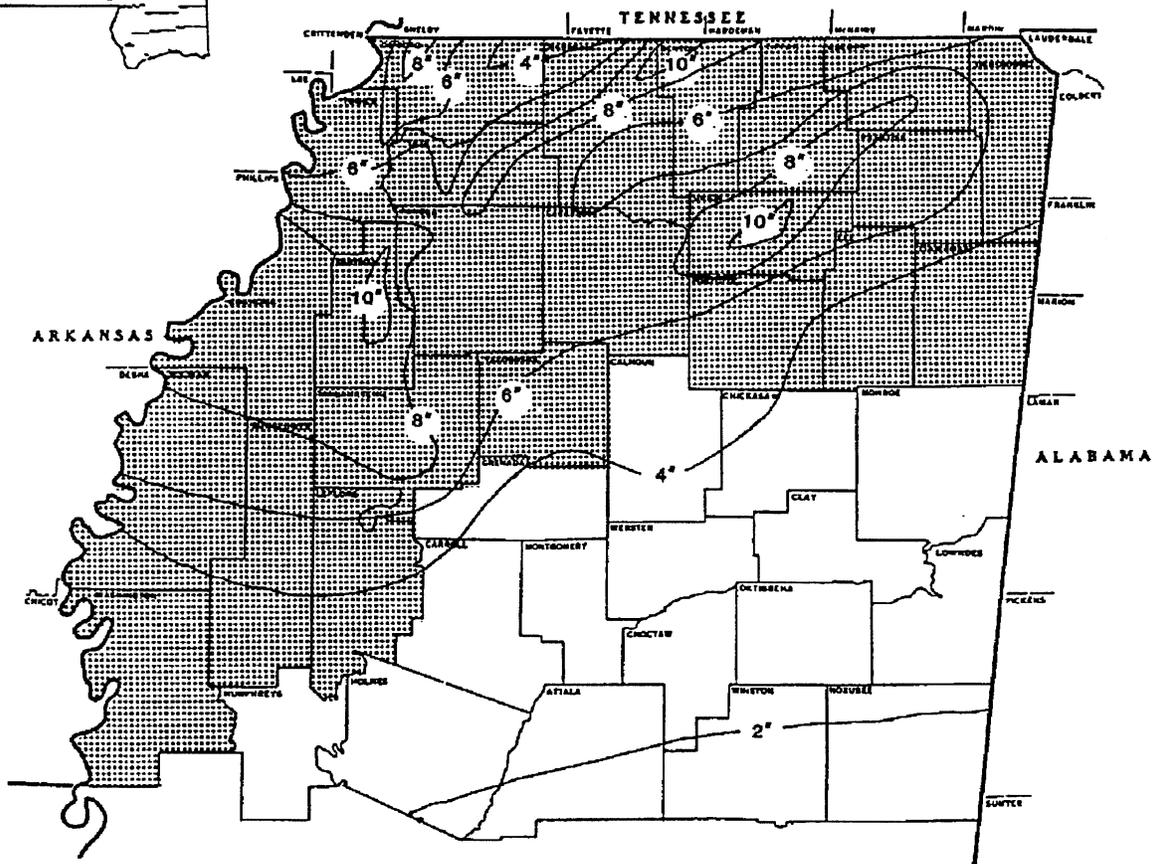
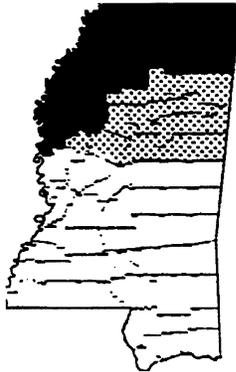
#### *Rainfall*

Data of official gauging stations along with gage readings from farmers throughout the area were used to develop amounts, duration, and intensity of the rainfall over most of north Mississippi. One to two inches had already fallen over the entire area early Friday morning February 2, 1990. This rain, along with the above average rainfall for January had the soil of the area completely saturated. Heavy rains began around 12:30 a.m. on Saturday, February 3, 1990, and continued until 4 to 5 p.m. that afternoon. During this 16 hour period 5 to 9 inches of rainfall fell over most of the area. As much as 10.5 inches of rainfall fell on part of Benton, Marshall, Quitman, and Union Counties. In addition, intensities as high as 0.5 inches in 5 minutes were recorded one or more times on official recording gages in Lafayette and Tate Counties. Rainfall amounts approached or exceeded the 100 year frequency storm event over approximately 50 percent of the geographic areas.

The rainfall pattern for the storm of February 2-3, 1990, is shown on the following map of the northern half of the State of Mississippi.

## Storm Event of February 2 & 3, 1990

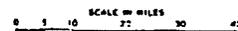
(Rainfall in Inches)



Legend

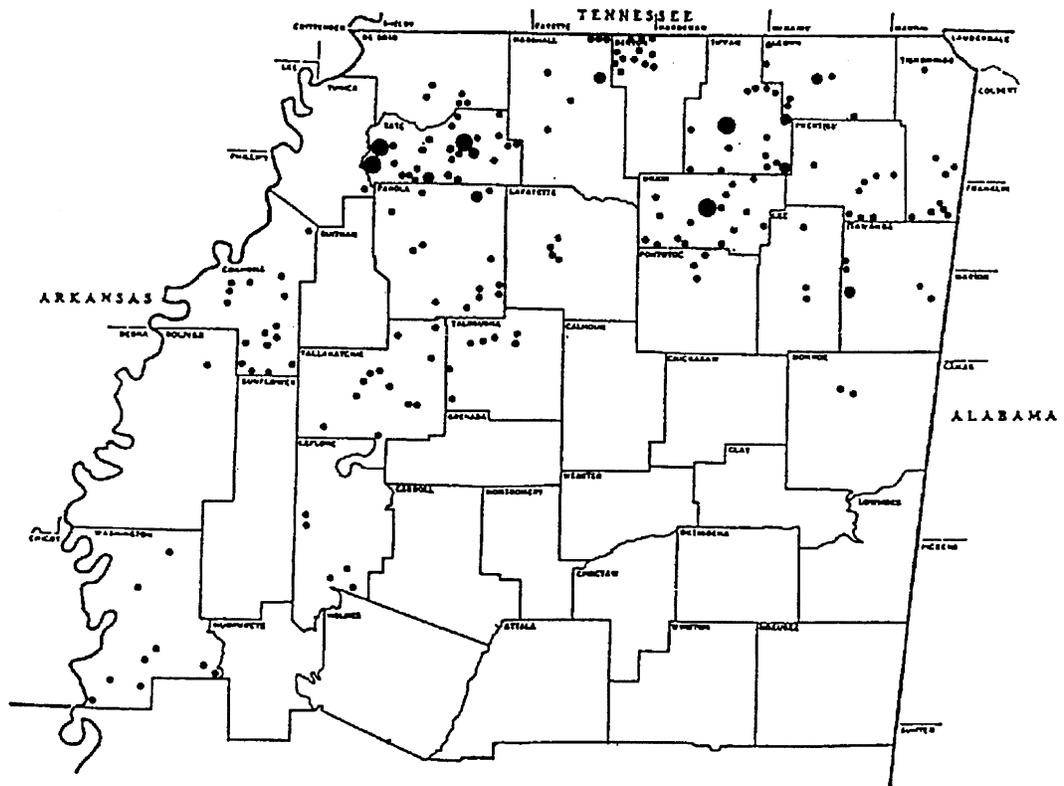


Area sustaining significant storm damage



# Storm Event of February 2 & 3, 1990

(Damage Site Location)



Legend

- Damage Site Location (1 Site)
- Damage Site Location (3 Sites)
- Damage Site Location (4 or More Sites)

SCALE IN MILES  
0 5 10 15 20 25

### Total Damages by County

<b>County</b>	<b>Damage Amount</b>
Marshall County .....	\$235,000.00
Benton County.....	280,000.00
Panola County .....	400,000.00
Pontotoc County .....	35,000.00
Lafayette County .....	50,000.00
Tallahatchie County .....	685,000.00
Yalobusha County .....	186,000.00
Tippah County .....	262,000.00
Tate County.....	823,000.00
DeSoto County .....	75,000.00
Union County .....	596,000.00
Itawamba County .....	151,000.00
Prentiss County .....	160,000.00
Alcorn County.....	268,000.00
Tishomingo County .....	200,000.00
Lee County .....	150,000.00
Monroe County .....	50,000.00
Wilkinson County .....	450,000.00
Adams County .....	880,000.00
Lincoln County.....	300,000.00
Walthall County.....	45,000.00
Covington County .....	26,000.00
Smith County .....	87,000.00
Forrest County .....	190,000.00
Perry County—Damaged by a prior storm .....	55,000.00
George County—Damaged by a prior storm .....	150,000.00
Newton County .....	57,000.00
Washington County .....	132,000.00
Bolivar County .....	31,000.00
Coahoma County .....	385,000.00

Leflore County .....	305,000.00
Tunica County .....	40,000.00
Sunflower County .....	No damage
Quitman County .....	No damage
Franklin County .....	No damage
Amite County .....	No damage
Pike County .....	No damage
Lawrence County .....	No damage
Jeff Davis County .....	No damage
Jasper County .....	No damage
Clarke County .....	No damage
Lauderdale County .....	No damage
Wayne County .....	No damage
Jones County .....	No damage
Lamar County .....	No damage
Marion County .....	No damage
Total Dollars Needed .....	7,739,000.00

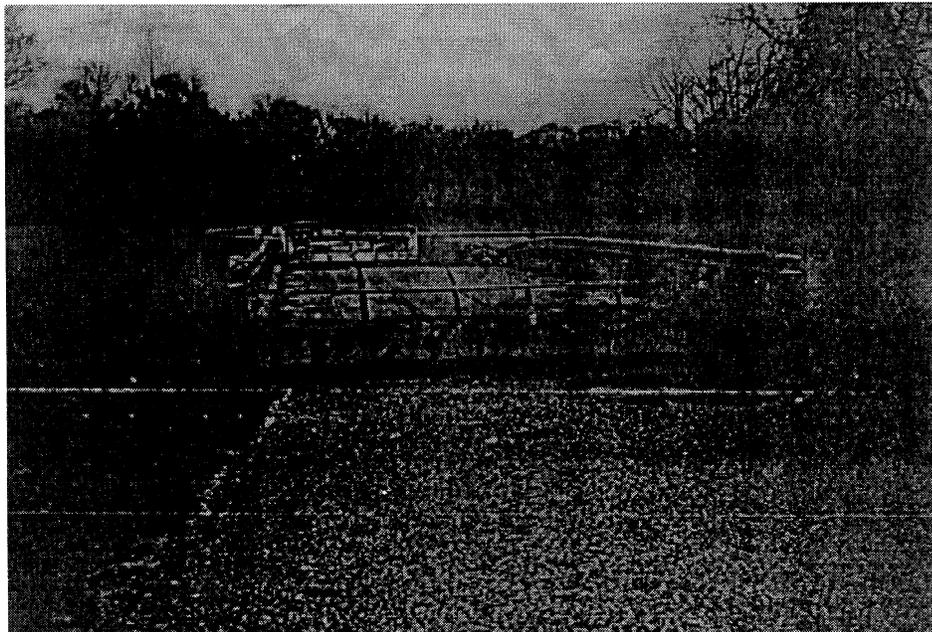
### Description of Damage by Site and County

(All of the damage descriptions are not included in this example.)

Description of Site	Type of Damage	Apparent Work Needed	Cost Estimate
Wilkinson County—County Code 157			
157-1	Damage to bridge both ends, upstream and downstream	Stabilize ends of bridge with rock. County to repair bridge.	70,000
157-4	Two road slides washed into Percy Creek.	Backfill and stabilize with rock riprap.	50,000
157-5	Portion of road has washed into the creek.	Backfill and stabilize with rock riprap.	20,000
157-6	Loosing road due to slide.	Backfill and stabilize with rock riprap.	60,000
157-9	Damage to bridge both ends, upstream and downstream.	Stabilize ends of bridge with rock. County to repair bridge.	50,000
157-10	Damage to concrete spillway on Lake Mary.	Stabilize spillway area.	200,000
Adams County—County Code 001			
001-4	Erosion is endangering road and box culvert.	Backfill eroded area and construct concrete spillway.	250,000
001-5	Erosion causing road slide.	Backfill and stabilize with rock riprap.	40,000
001-6	Bank slide is threatening four homes.	Backfill and stabilize with rock riprap.	40,000
001-7	Erosion is endangering grave sites.	Install drop pipe, backfill and protect with rock riprap.	100,000
001-8	Erosion is endangering High School Track.	Install drop pipe, backfill and protect with rock riprap.	40,000
001-9	Bank slide is threatening homes and businesses.	Backfill and stabilize with rock riprap.	60,000

**Photographs Showing Storm Damage**

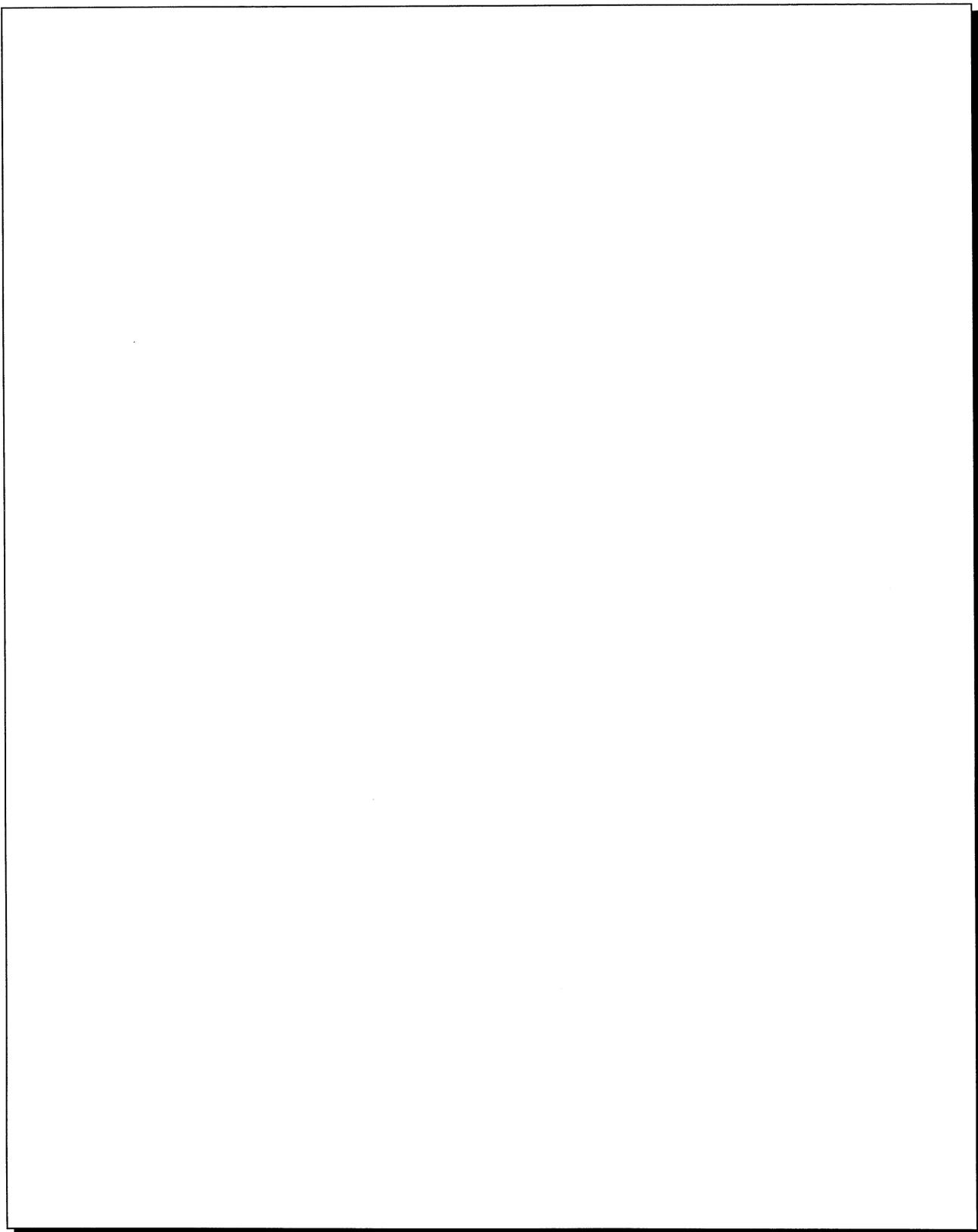
(All of the photographs showing storm damage are not included in this example.)



Wilkinson County—Site #1  
Damage to bridge on Foster Creek at Rosetta.



Wilkinson County—Site #4  
Road slide on Percy Creek at Sand Road.



## **Appendix B**

### **Example Performance Report**

The Emergency Spillway Flow Study Task Group, ESFSTG, prepared this report with considerable assistance from the Engineering Staff in West Virginia; Thomas O. Purkey, Hydraulic Engineer, Water Resources Planning Staff, West Virginia; the Soil Mechanics Laboratory, Lincoln, Nebraska; Donald E. Woodward, Head, Technology Development and Support Staff (TDSS), Engineering Division; and Kerry K. Cato, former Engineering Geologist, Engineering Division. The ESFSTG members contributing to this report are John A. Brevard, Civil Engineer, TDSS, Engineering Division and John S. Moore, Engineering Geologist, Northeast National Technical Center.

# West Virginia, November, 1985 Spillway Performance Report

### Introduction

West Virginia experienced a major rainfall during the period of November 1-5, 1985. The officially measured rainfall ranged up to 11.3 inches. However, local residents estimated the maximum rainfall to be 13 inches or more. The resulting runoff caused emergency spillway flow at several PL-534 watershed project dams. The flows caused erosion at the sites varying from slight to moderate, in relation to the volume of material remaining in the spillway. At some sites, the flows eroded large volumes of soil and rock from the emergency spillway outlets; but the erosion did not threaten spillway integrity.

The storm produced the largest spillway flows at dam sites in the South Fork of the South Branch of the Potomac River. This report details the investigation and the analysis for sites 10, 14, 17, and 19 of the subject watershed. Site 10 has a hazard classification of Class (b); and sites 14, 17, and 19 are Class (c).

### Storm Conditions

#### Prior to Storm

The rainfall in October 1985 was above normal in the Potomac Basin. Rain associated with Hurricane Juan began to fall on November 1, and periodic rainfall continued through the next several days culminating with an intense storm on November 5. When the November 5th rainfall occurred, the watershed soils were saturated and the reservoirs of the dams were partly filled.

#### November 1985 Storm

The rainfall of 8 to 11 inches on the eastern mountains of West Virginia during November 1-5, 1985 was much above normal. The storm return period was in excess of 200 years. During this same period, the rainfall to the east and south in Virginia ranged as high as 16 to 19 inches.

SCS made a rainfall "bucket survey" in the immediate vicinity of the watershed shortly after the storm. This survey was supplemented with daily precipitation information from the nearest National Climatic Data Center gauging stations to develop an isohyetal map representative of this storm. See figure 1.

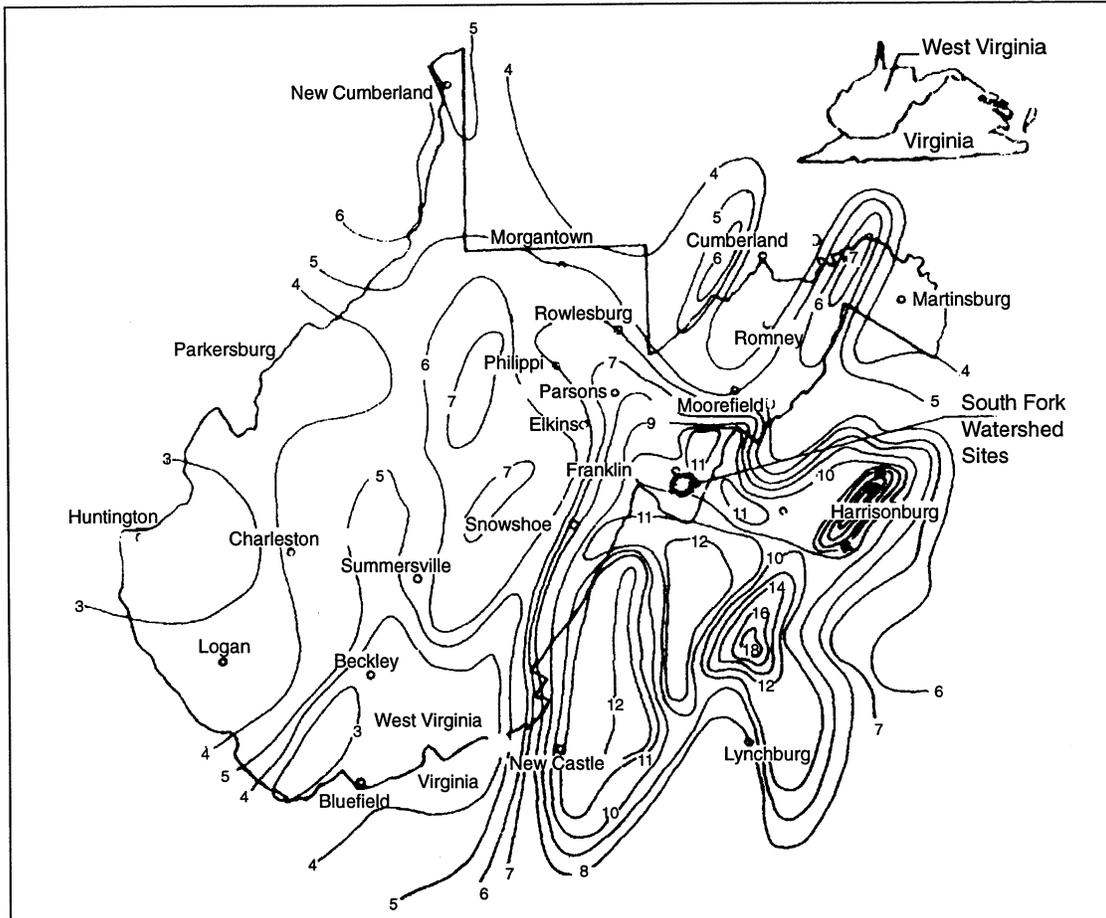


Figure 1. Isohyetal Map—West Virginia Storm, November 1-5, 1985. Developed from National Weather Service gage data and SCS "bucket survey".

## Storm Effects at Dam Sites

### Emergency Spillway Flow

The measured maximum reservoir water surface above the emergency spillway crest,  $h_p$ , for the sites varied from 2.0 to 3.6 feet. The emergency spillway flow durations ranged from about one day to nearly two days. See table 1 and table 2 for the computed emergency spillway flow parameters.

Size	Drainage Area (Sq. Mi.)	Class	Emergency Spillway Layout				Values Associated with November Storm				
			Width (Ft)	Max Exit Channel Slope (%)	Level Section Length (Ft)	Exit* Channel Length (Ft)	Measured	Synthesized		0. /b AF Ft	$\Sigma V^2 \Delta T$ Ft <sup>2</sup> Hrs Sec <sup>2</sup>
							$H_p$ (Ft)	Em. Spwy. Maximum Discharge (CFS)	Em. Spwy. Flow Duration (Hrs)		
SF#10	2.68	B	100	19.0	20	255	2.2	990	38	6.7	1960
SF#14	5.55	C	205	2.2	30	290	2.5	2200	26	7.1	550
SF#17	17.27	C	300	2.1	30	575	2.0**	5000	28	11.0	770
SF#19	15.15	C	213	1.9	30	420	3.6	4340	41	16.4	1050

\* Length measured on center line.

\*\*The synthesized  $H_p = 3.4$  feet. With other values in the development of the synthesized inflow hydrograph held within reasonable bounds, this is the minimum value of  $H_p$  obtainable. The accuracy of the measured  $H_p$  value is suspect.

Table 1. Site, emergency spillway, and emergency spillway flow information.

Size	Drainage Area (Sq. Mi.)	Class	Emergency Spillway Layout				Values Associated with November Storm				
			Width (Ft)	Max Exit Channel Slope (%)	Level Section Length (Ft)	Exit* Channel Length (Ft)	Measured	Synthesized		0 /b AF Ft	$\Sigma V \Delta T$ Ft Hrs Sec
							$H_p$ (Ft)	Em. Spwy. Maximum Discharge (CFS)	Em. Spwy. Flow Duration (Hrs)		
SF#10	2.68	B	100	19.0	20	255	2.2	990	38	6.7	1960
SF#14	5.55	C	205	2.2	30	290	2.5	2200	26	7.1	550
SF#17	17.27	C	300	2.1	30	575	2.0**	5000	28	11.0	770
SF#19	15.15	C	213	1.9	30	420	3.6	4340	41	16.4	1050

\* Length measured on center line.

\*\*The synthesized  $H_p = 3.4$  feet. With other values in the development of the synthesized inflow hydrograph held within reasonable bounds, this is the minimum value of  $H_p$  obtainable. The accuracy of the measured  $H_p$  value is suspect.

Table 2. Design parameters vs. flood parameters.

**Erosion**

The flow at some of the sites eroded large quantities of soil and rock. See figure 2 for plan views of eroded areas. The head-cut erosion at each site began downstream of the emergency spillway exit channel with the deepest gullies occurring in waste material placed in ravines, during construction, to smooth the grade. At some sites, the flow formed shallow gullies in the spillways which removed topsoil.

Although these spillways required maintenance after the flows, they functioned as designed, and the erosion posed no threat to the safety of the dams.

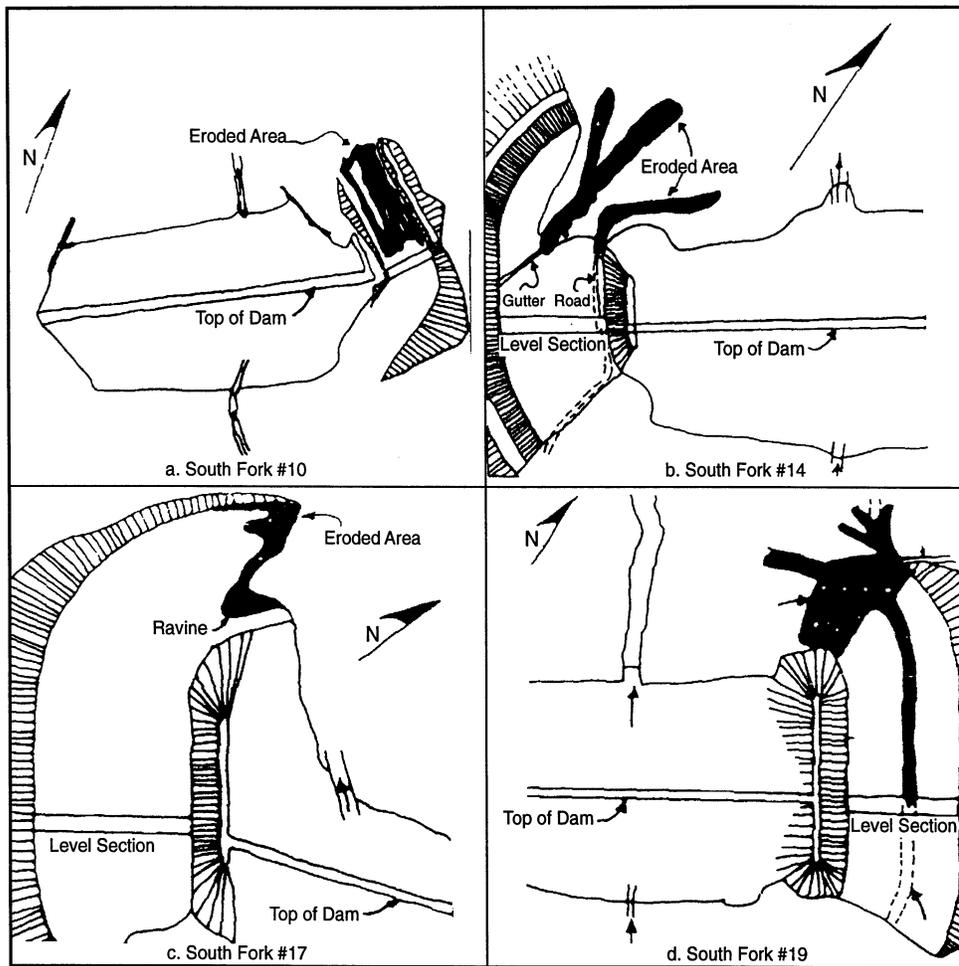


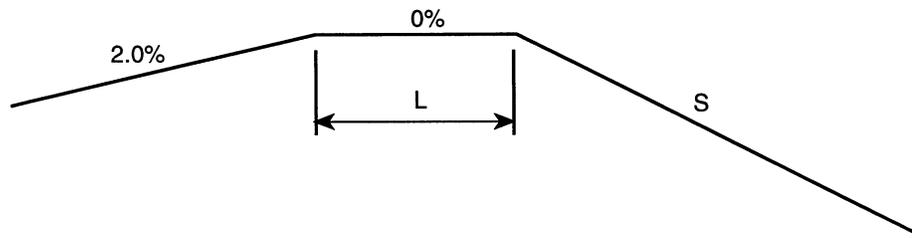
Figure 2. Plan view of eroded areas at the sites.

### Study of Emergency Spillway Performance

See tables 1 and 2 for significant factors and parameters about the four studied sites.

#### Spillway Layout

The following sketch shows the emergency spillway profiles for the sites.



where:

$l$  is either 20 or 30 feet

$S$  varies from 1.9% to 19%

The exit channel slope of site 10 is very steep (19%) to the floodplain; however, the other three sites have mild (1.9 to 2.2%) exit channel slopes which end at steep natural escarpments. See tables 3, 4, 5a-5d.

#### Synthesis of Hydrographs

Official rainfall information, both amount and distribution, was meager for the watershed. Local residents provided some additional information on storm duration, rainfall amount, and durations of emergency spillway flows.

The SCS Engineering Staff in West Virginia furnished the information about the dams and associated structures. They also estimated Manning's  $n$  values at the time of flow in the forbays and exit sections of the emergency spillways.

The inflow and outflow hydrographs for the sites were synthesized using the March 1, 1984 version of the SCS DAMS2 "Structure Site Analysis" computer program. The synthesis assumes that at the beginning of the storm an antecedent moisture condition of III existed and the water surface in the reservoir was at the principal spillway crest. For South Fork #14, see Appendix B, figure B2 for a plot of time versus exit channel velocity.

### *Inflow Hydrograph*

The inflow Hydrographs were developed using rainfall information from the developed isohyetal map and the National Climatic Data Center, National Oceanic and Atmospheric Administration, U.S. Department of Commerce. This information gave rainfall totals and rainfall distributions with time at locations in the vicinity of the watershed. The rainfall data recorded at the Mustoe Virginia precipitation gage, which is approximately thirty miles from the sites, provided the storm distribution used in the simulation for all the sites. No reliable rainfall or stream gage data from within the watershed was available.

### *Outflow Hydrograph*

To determine the outflow hydrograph, the rainfall amount was adjusted, within reasonable limits, until the  $H_p$  value from the DAMS2 routing matched the measured storm  $H_p$ . The synthesized outflow hydrograph provides emergency spillway flow parameters such as the maximum spillway discharge and flow duration and permits the calculation of parameters such as the total volume of emergency spillway flow divided by the emergency spillway bottom width,  $O_e/b$ , and maximum exit channel velocity. See tables 1 and 2 for these computed values.

### **Geology**

The spillways were excavated into siltstone and shale, covered with topsoil, and vegetated. The rock at the sites is class III, for erosion resistance, by Technical Release No. 71 (TR-71) and CDCC or CCCC by the Unified Rock Classification System (URCS). See table 3, Geologic Data. The thin bedding of the rock units makes the material class III; otherwise, the material would have been class II by TR-71. Although three dominant rock fracture orientations exist, the fracture spacing is large and the fractures are closed or very tight. The rock strike is primarily transverse to the flow and the rock units dip upstream. These rock mass properties increase the erosion resistance of the rock. The topsoil is SM, ML, and CL by the Unified Soil Classification System (URCS) with plasticity indices of 8 to 11.

The factors constraining or accentuating erosion at each site are shown in tables 5a-5d. Where appropriate, the factors are referenced to the current guidelines in TR-71 or NENTC Technical Note No. 4 (TN-4), "Excavated Rock Spillway Classification and Layout". See Appendix A, "Engineering Geology Report on the Flow Performance of Four Emergency Spillways," for a detailed description of the individual site geology and erosion effects.

### **Summary of Data**

Table 1 is a tabulation of information about the sites, the emergency spillways, and the emergency spillway flows associated with the November 1985 storm.

Table 2 contains information about reservoir retarding storage, designed frequency of emergency spillway use, dam crest design values, and measured and synthesized values associated with the emergency spillway flow at these sites.

Table 3 shows information on erosion, geology, selected soil parameters, and emergency spillway flow at the sites.

Table 4 is a tabulation of the damage data for each site.

Tables 5a-d shows information on the erosional effect of the geology, layout, and maintenance at each site.

# Engineering Hydrology Training Series

Site	SF #10	SF #14	SF #17	SF #19
Drainage Area (Sq. Mi.)	2.68	5.55	17.27	15.15
Flow Duration (Hrs.)	38	26	28	41
Spillway Width (Ft.)	100	205	300	213
Spillway Exit Channel				
Slope (%)	19.0	2.2	2.1	1.9
Velocity, Maximum (FPS)	14.0	7.7	9.1	9.5
Erosion	Yes	Yes	Yes	Yes
Downstream from Exit Channel				
Slope (%)	2 (floodplain)	51	41	29
Velocity, Maximum (FPS)	7	18	21	20
Erosion	Yes	Yes	Yes	Yes
$O_e/b$ , Actual (AF/Ft)	6.7	7.1	11.0	16.4
$O_e/b$ , Current Criteria (AF/Ft)	25-40	40-50	40-50	40-50
Surface Soil (0 to 1 Ft.)*				
USCS Lab Classification	No sample	ML	CL	SM
Plasticity Index	—	11	8	8
Rock Material				
Unified Rock Class. System	Shale & Siltstone	Shale & Siltstone	Shale & Siltstone	Shale & Siltstone
Technical Release No. 71 Class.	CDCC	CDCC	CCCC	CDCC
Outflow Direction & Rock Strike and Dip**	III	III	III	III
Natural Fractures				
Spacing (Ft)	4	Not exposed	2-30	1-12
Width (Inches)	1/8 - Closed	—	Clay Filled	Clay Filled
Strike/Dip	N80W/90 N55W/90 N25E/90	—	N40W/90 N85W/90 N70E/90	N45W/90 N80W/90 EW/90
Rock Spillway Classification				
NENTC T.N. 25	III	III	III	III

\* Sample taken at head of most upstream gully.

\*\*Outflow direction varies from flow direction at level section to flow direction at end of constructed channel.

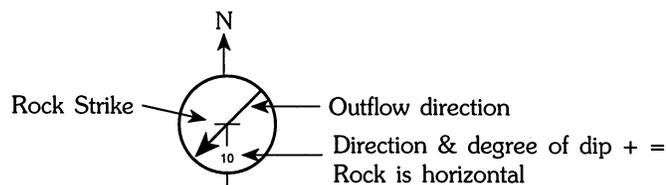


Table 3.

Site	Damage					Erosion Accentuating Features
	Emergency Spillway			Downstream End of Exit Ch.	Downstream Flood Plain	
	Volume Eroded (Cu. Yds.)	Volume Eroded* Surf. Area Exit Ch. (Cu.Yds./Sq.Yds.)	Est. Cost to Repair (\$)			
S. Fork #10	1710	0.60	26,000	Severe	Severe	Steep exit channel slope; SC and GC material at end of exit channel
S. Fork #14	2180	0.33	18,000	Severe	Severe	Road and drainage ditch in exit channel; steep slope and waste material downstream of spillway
S. Fork #17	11,290	0.59	96,000	Severe	Severe	Steep slope and waste material downstream of spillway
S. Fork #19	550	0.06	54,000	Severe	Severe	Road in spillway; ravine across downstream end; steep natural slope downstream of spillway

\*Volume of material eroded from the spillway (Cu. Yds.) divided by spillway exit channel surface area (Sq. Yds.) (spillway bottom width multiplied by exit channel length measured on center line).

Table 4. Site damage and erosion accentuating features.

## South Fork—Site 10

Factors Influencing Erosion	Effect on Erosion	Remarks
<b>Geometry</b>		
Exit channel slope Slope = 19%	Increased erosion	Erosive forces were very large.
Exit channel-flood plain intersection Large decrease in slope	Increased erosion	Hydraulic jump will occur if tailwater is below break in grade.
<b>Surface Condition</b>		
Vegetal cover Good	Erosion resistant	
Top Soil Compaction not controlled PI is low	Erodible Easily erodible	
Mass Properties Thickness—one foot	Slight	Thickness prevented rafting from rock surface which has occurred with thicknesses less than or equal to 6".
<b>Subsurface Condition</b>		
Alluvial soil and terrace deposit Material properties Normally consolidated SC and GC materials (USCS)	Easily erodible	Located at downstream end of exit channel where hydraulic jump may occur.
Siltstone and Shale (CDCC-URCS) Mass properties Unit attitude Dip is upstream and toward outside of exit channel	Erosion resistant  Dip limited erosion; guided flow away from dam	TR-71—Class I rock must dip upstream or be horizontal. NENTC TN-4—Dip to the outside is preferred.
Bedding thickness Thinly bedded (4")	Slight	TR-71—Class I rock must have thickness greater than 1', and rock with a thickness of less than 3" is Class III.
Joint separations Tight (closed to <1/8")	Constrained erosion	TR-71—Class I rock must have 95% or more of joints cemented or <1/8" wide.
Joint spacing Spacing averaged 4'	Constrained erosion	Joint spacing >2' limits erosion.

Table 5a. South Fork Site 10.

South Fork—Site 14

Factors Influencing Erosion	Effect on Erosion	Remarks
<b>Geometry</b>		
Exit channel		
Drainage ditch produced uneven channel floor	Increased erosion	Ditch located on erodible ravine fill and concentrated flow to produce erosion.
Road paralleling flow	Increased erosion	Concentrated flow removed top soil back to level section.
Downstream end of exit channel		
Slope = 51%	Increased erosion	Increased velocities and initiated gullying.
<b>Surface Condition</b>		
Vegetal cover		
Good	Erosion resistant	
Top Soil		
Material properties		
Compaction not controlled	Erodible	
PI is low (ML-USCS)	Easily erodible	
Mass Properties		
Thickness—one foot	Slight	Thickness prevented rafting.
<b>Subsurface Condition</b>		
Waste material—ravine fill	Easily erodible	Uncompacted small angular fragments to platy boulders of siltstone and shale easily eroded on the steep slope.
Siltstone and Shale (CDCC-URCS)		
Mass properties		
Unit attitude		
Dip is upstream and toward inside of exit channel	Dip limited erosion	TR-71—Class I rock must dip upstream or be horizontal. NENTC TN-4—Dip to outside is preferred.
Bedding thickness		
Thinly bedded (4")	Slight	TR-71—Class I rock must have thickness greater than 1', and rock with a thickness of less than 3" is Class III.
Joints not exposed at this site		

Table 5b. South Fork Site 14.

## South Fork—Site 17

Factors Influencing Erosion	Effect on Erosion	Remarks
<b>Geometry</b>		
Downstream end of exit channel Slope = 41%	Increased erosion	Increased velocities exceeded erodibility.
<b>Surface Condition</b>		
Vegetal cover Good	Erosion resistant	
Top Soil		
Material properties	Erodible	
Compaction not controlled	Easily erodible	
PI is low (CL-USCS)		
Mass Properties		
Thickness—one to two feet	Slight	Thickness prevented rafting.
<b>Subsurface Condition</b>		
Waste material—ravine fill	Easily erodible	Uncompacted siltstone and shale fragments and boulders easily eroded on steep slopes.
Siltstone and Shale (CDCC-URCS)	Erosion resistant	
Mass properties		
Unit attitude		
Dip is upstream for most of channel length; at downstream end rock dips toward dam	Dip limited erosion	TR-71—Class I rock must dip upstream or be horizontal. NENTC TN-4—Dip away from dam is preferred.
Bedding thickness		
Thinly bedded (4")	Slight	TR-71—Class I rock must have thickness greater than 1', and rock with a thickness of less than 3" is Class III.
Joint separations		
Clay filled	Constrained erosion	TR-71—Class I rock must have 95% or more of joints cemented or <1/8" wide.
Joint spacing		
Spacing ranged from 2-30'	Constrained erosion	Joint spacing >2' limits erosion.

Table 5c. South Fork Site 17.

South Fork—Site 19

Factors Influencing Erosion	Effect on Erosion	Remarks
<b>Geometry</b>		
Exit channel		
Road parallel to flow	Increased erosion	Uneven channel floor concentrated flow which removed top soil back to level section.
Downstream end of exit channel		
Slope = 51%	Increased erosion	Increased velocity initiated erosion.
Ravine cuts across downstream end	Increased erosion	Ravine concentrated flow and contained erodible materials.
<b>Surface Condition</b>		
Vegetal cover		
Good	Erosion resistant	
Top Soil		
Material properties		
Compaction not controlled	Erodible	
PI is low (SM-USCS)	Easily erodible	
Mass Properties		
Thickness—one to two feet	Slight	Thickness prevented rafting.
<b>Subsurface Condition</b>		
Siltstone and Shale (CDCC-URCS)	Erosion resistant	
Mass properties		
Unit attitude		
Dip is upstream	Dip limited erosion	TR-71—Class I rock must dip upstream or be horizontal. NENTC TN-4—Dip to outside is preferred.
Bedding thickness		
Thinly bedded (4")	Slight	TR-71—Class I rock must have thickness greater than 1', and rock with a thickness of less than 3" is Class III.
Joint separations		
Clay filled	Constrained erosion	TR-71—Class I rock must have 95% or more of joints cemented or <1/8" wide.
Joint spacing		
Spacing ranged from 1-12'	Constrained erosion	Joint spacing >2' limits erosion.

Table 5d. South Fork Site 19.



Hydrology Training Series  
Module 317—Storm Reports

Certificate of Completion

This is to certify that

\_\_\_\_\_ has completed Hydrology Training Series  
Module 317—Storm Reports  
on \_\_\_\_\_ and should be credited with three hours of training.

Signed \_\_\_\_\_ Supervisor/Trainer \_\_\_\_\_ Participant

Completion of Hydrology Training Series  
Module 317—Storm Reports

is acknowledged and documented in the above-named employee's record.

Signed \_\_\_\_\_ Date \_\_\_\_\_  
Training Officer



