Module 9a: Rainfall and Runoff - Introduction

CE 378 Water Resources Engineering

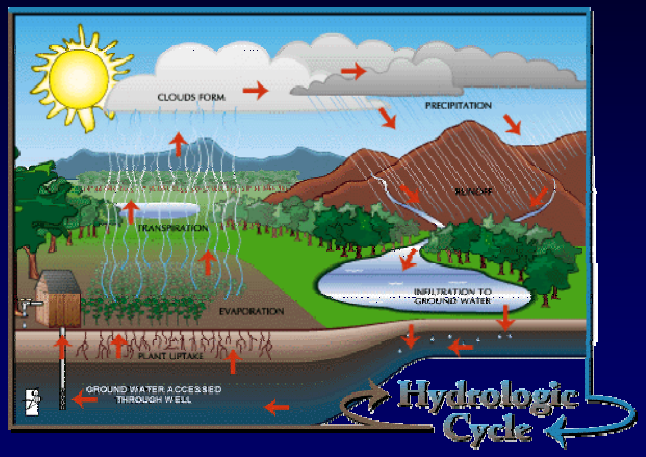
Robert Pitt
University of Alabama

Shirley Clark
Penn State Harrisburg

Hydrology – study of the water of the earth, including:

- Precipitation
- Movement over the land surface
- Movement below the ground surface
- Evaporation and transpiration from land, water and plants
- Condensation and reprecipitation

Water Cycle (a.k.a. Hydrologic Cycle)



Watershed – all land area that drains to a specified outlet during a rainstorm

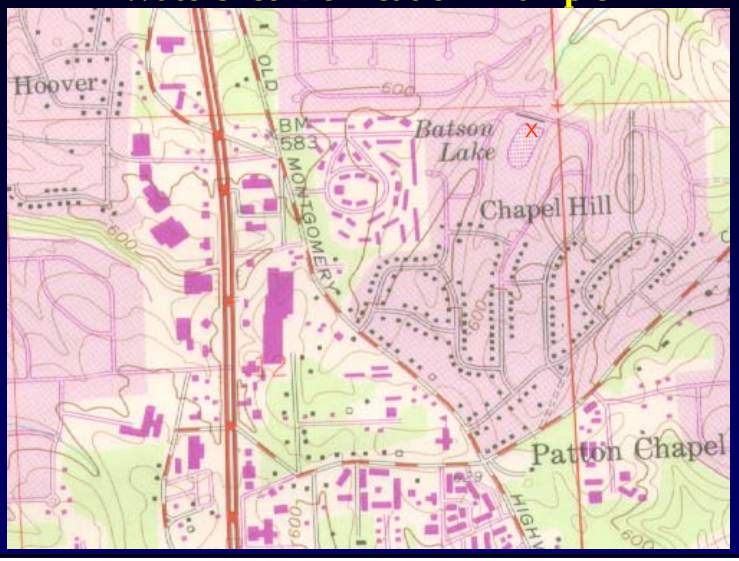
"A watershed is the land area between ridge lines, including the valley, which contributes rainfall runoff to the stream in the valley."

Two basic principles about watersheds:

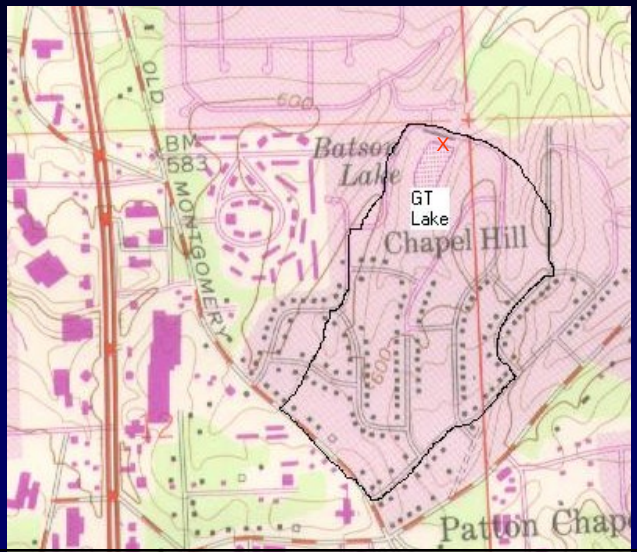
- A watershed's perimeter boundary will be the ridge lines of adjacent terrain.
- Water will run off these ridges, and down into the valley, at 90º to each contour line crossed by the water. This is known as the fall line.

"Water will always flow across the contour and downhill, across the shortest and steepest distance, perpendicular to the contour."

Watershed Delineation Example



Watershed Delineation Example



Watershed Delineation Hints

The determination of a watershed's area begins with the analysis of a topographic map of the region. The most downstream point of interest (a potential dam site, a culvert location, the outlet of a stream, where a stream reaches a river, etc.) is located. The area contributing flow to that site is then identified by application of a few simple rules:

- Water flows downhill
- Water tends to flow perpendicularly across the contour lines
- Ridges are indicated by contour "V"s pointing downhill
- Drainages are indicated by contour "V"s pointing upstream.

The Delineation Process

Information Sources

USGS Topographic Maps

- The fundamental source of data for delineating and studying watersheds is the U.S. Geological Survey Quadrangle map. Each "Quad Sheet" map covers 7.5 minutes of longitude and latitude.
- These maps give a wealth of information including topographic contour lines, locations of cities, buildings, roads, road types, railroads, pipelines, water bodies, forested land, stream networks, and USGS stream gauging stations and benchmarks.
- Quad sheet maps typically have a scale of 1:24,000 (i.e. 1 inch on the map = 24,000 inches in
- Depending on the age of the map, elevation data may be in English or Metric units. Typically, here in the Midwest, the contour intervals of the elevation data are 5 feet or 1.5 meter. For watershed delineation, quad sheet maps offer us the best starting point.

Digital Elevation Models

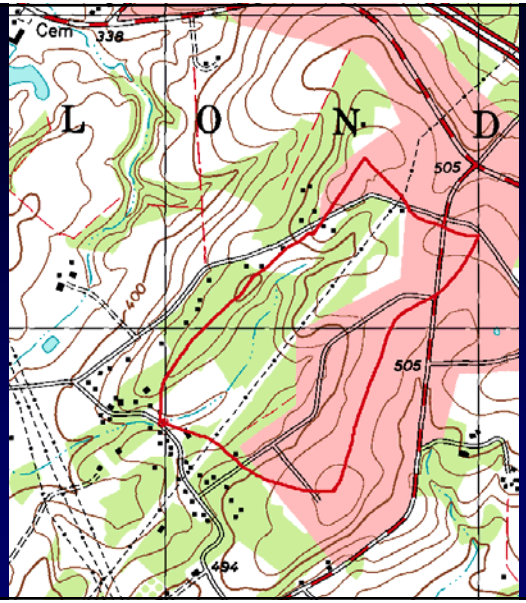
Digital Elevation Models (DEM's) store topographic data in the form of grid cells. Typically, these grid cells have a resolution of 30 meters and elevation intervals of 1 foot or 1 meter.

Using a DEM within a Geographical Information System (GIS), we can perform digital terrain analysis (DTA) such as calculating slopes, flow lengths, and delineate watershed boundaries and stream networks.

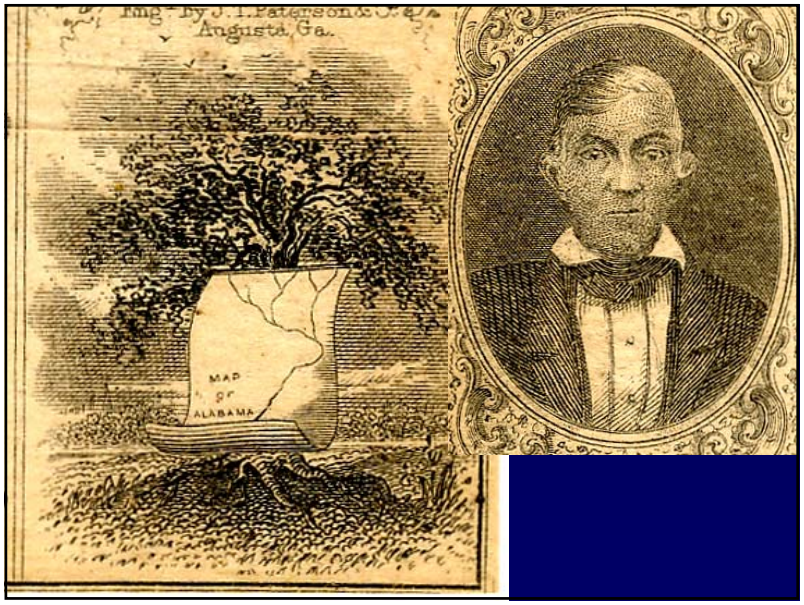
However, there are certain drawbacks to DTA because some algorithms are not very smart, especially in delineating watershed boundaries.

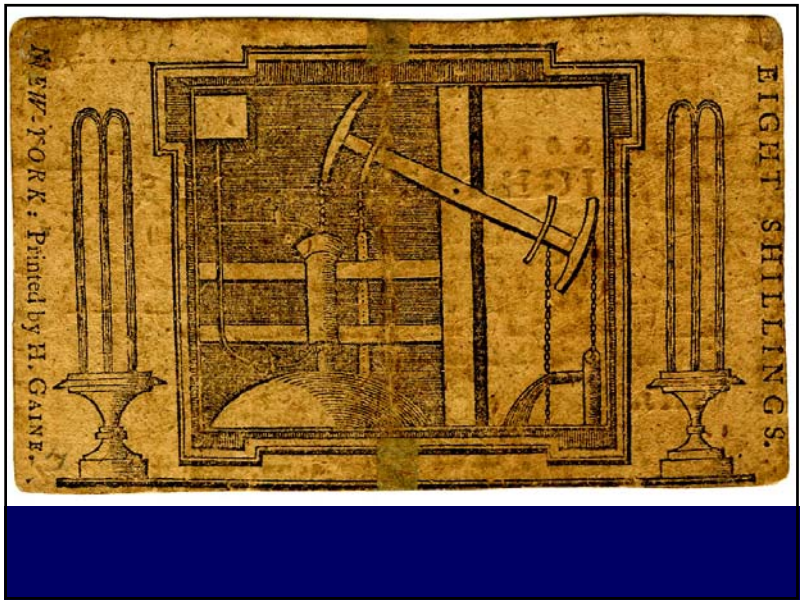
The Delineation Process

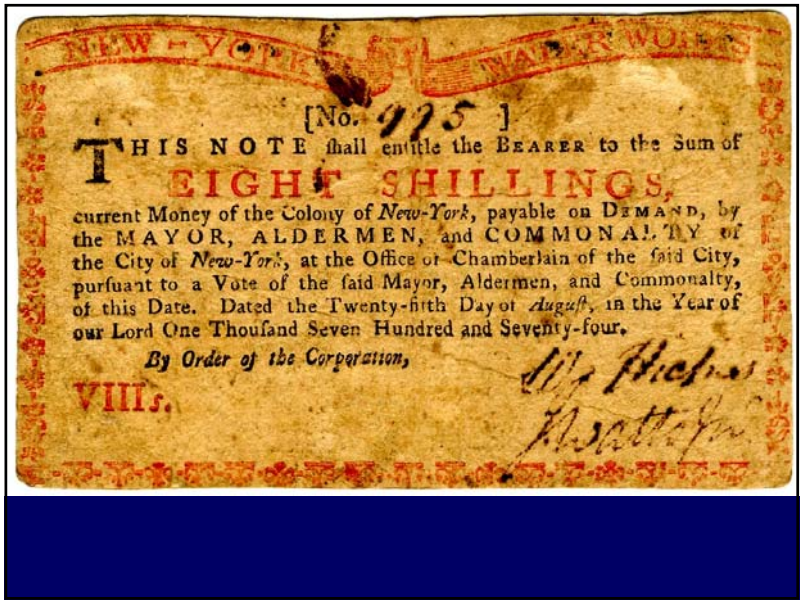
- There are two basic steps to follow in watershed delineation.
- Step 1:
  - Choose the point of the watershed outlet. This is generally our point of interest for designing a structure or monitoring location.
- Step 2:
  - Delineate the watershed boundary by drawing perpendicular lines across the elevation contour lines for land that drains to the point of interest.
- Note - There are a few things to remember when you are working with topographic maps.
  - A watershed boundary always runs perpendicular to the contour lines.
  - "Arrows" that point upstream are valleys.
  - "Arrows" that point downstream are hills.

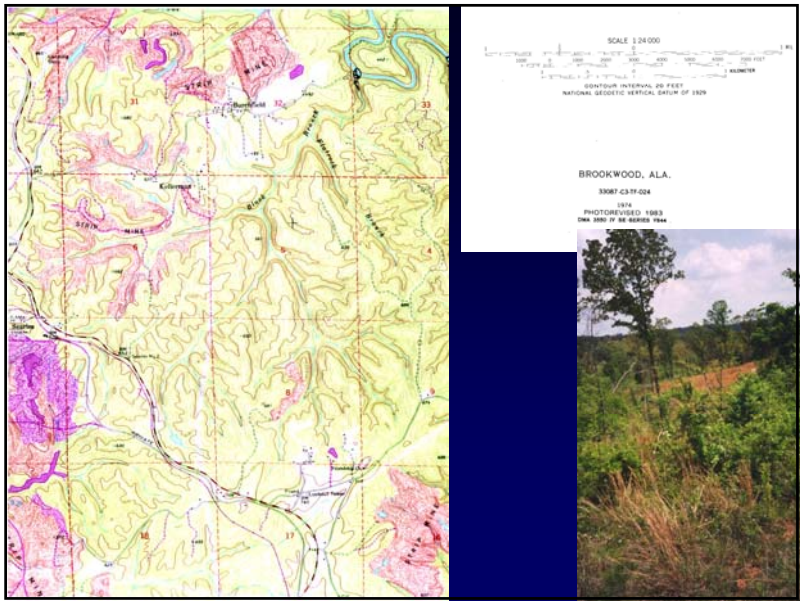


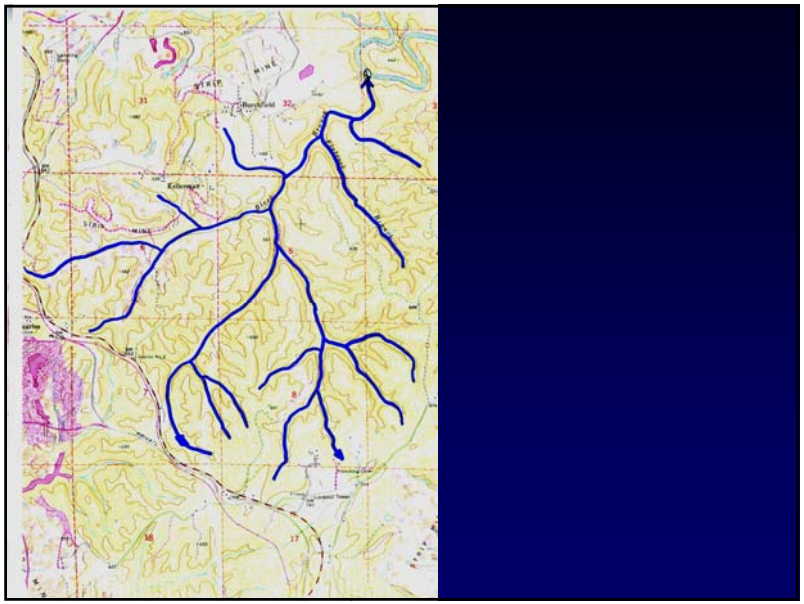

ONE
RECEIVABLE IN PAYMENT OF ALL PUBLIC DUES.
STATE OF ALABAMA
WILL PAY TO BEARER
ONE DOLLAR
REDEEMABLE IN TREASURY NOTES AT THE STATE
TO CONFEDERATE STATES WHEN PRESENTED
TREASURY
IN SUMS OF TWENTY DOLLARS AND REWARDS
Montgomery, Ala.
January 1863
Jno. Gill Shorter
GOVERNOR
ONE

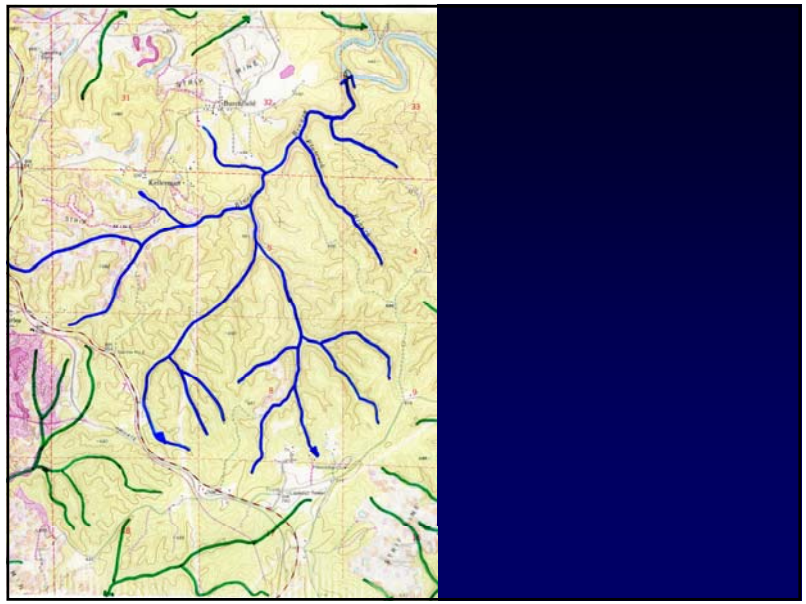

Augusta, Ga.
MAP OF ALABAMA

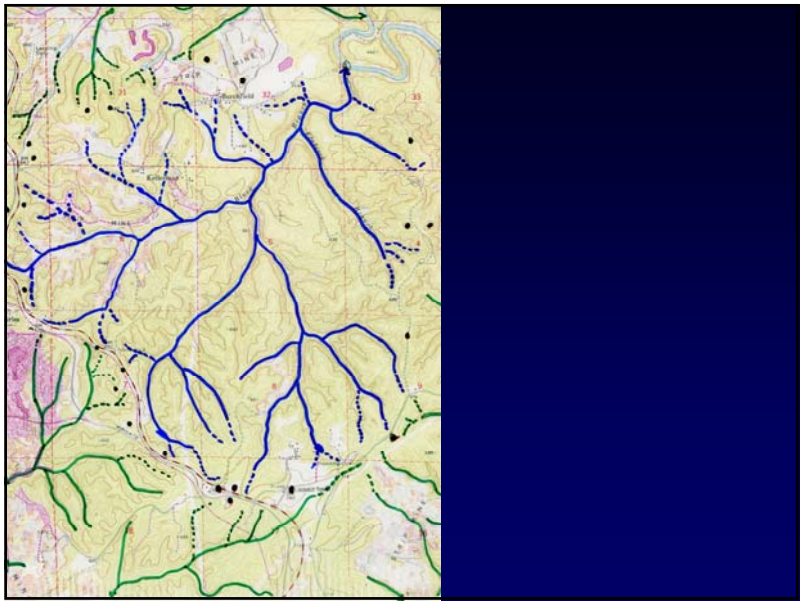

NEW-YORK: Printed by H. GAINE.
EIGHT SHILLINGS.

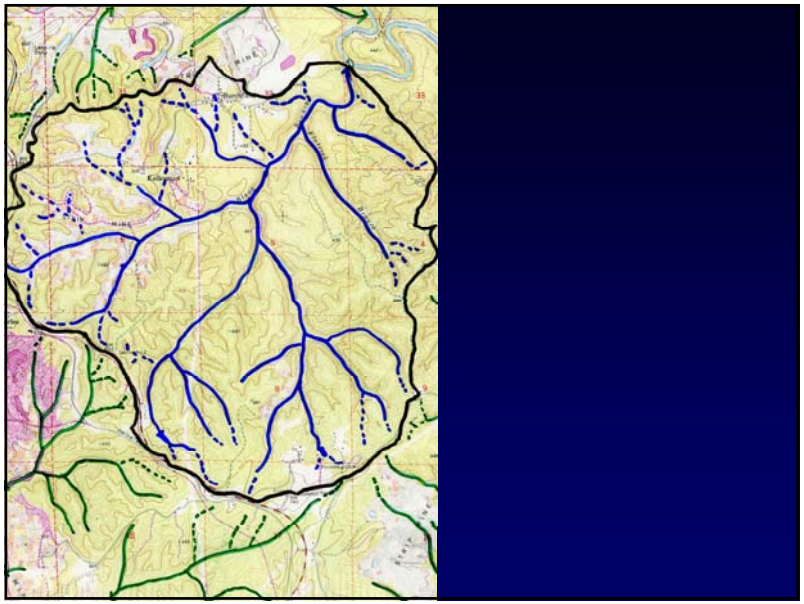

NEW-YORK WATER WORKS
[No. 925]
THIS NOTE shall entitle the BEARER to the Sum of
EIGHT SHILLINGS,
current Money of the Colony of New-York, payable on DEMAND, by the MAYOR, ALDERMEN, and COMMONALTY of the City of New-York, at the Office of Chamberlain of the said City, pursuant to a Vote of the said Mayor, Aldermen, and Commonalty, of this Date. Dated the Twenty-fifth Day of August, in the Year of our Lord One Thousand Seven Hundred and Seventy-four.
By Order of the Corporation,
VIIIs.


SCALE 1:24 000
CONTOUR INTERVAL 20 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929
BROOKWOOD, ALA.
33087-C3-TF-024
1974
PHOTOREVISED 1983









Important Watershed Characteristics

Other Important Watershed Factors

- Land Cover and Use
- Surface Roughness
- Soil Characteristics
  - Texture
  - Soil Structure
  - Soil Moisture
  - Hydrologic Soil Groups

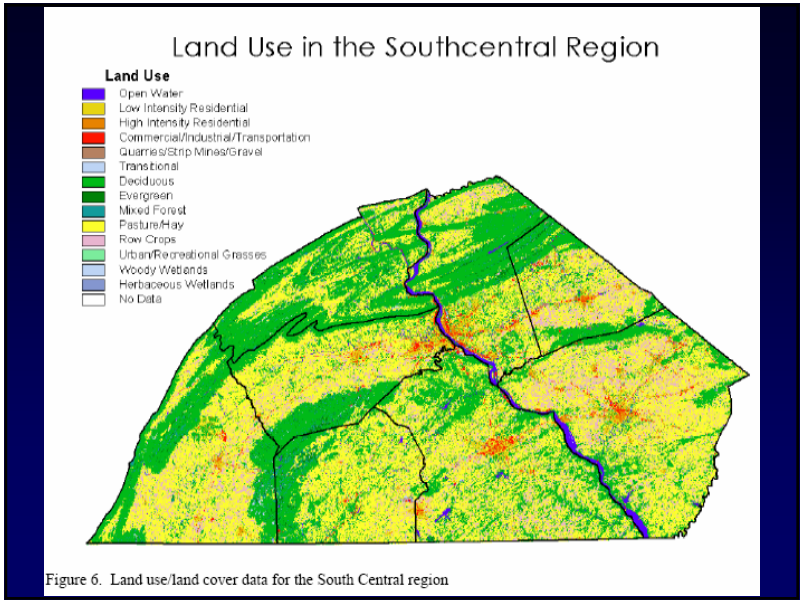


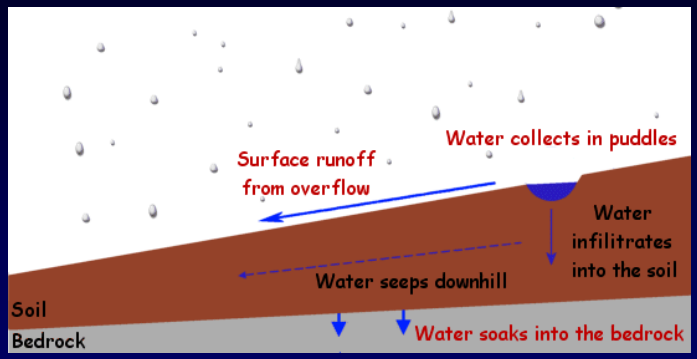
Figure 6. Land use/land cover data for the South Central region

Topographic Map Photo-updated 1978

Aerial Photograph Taken 1999 www.terraserver.com

Rainfall-Runoff Processes

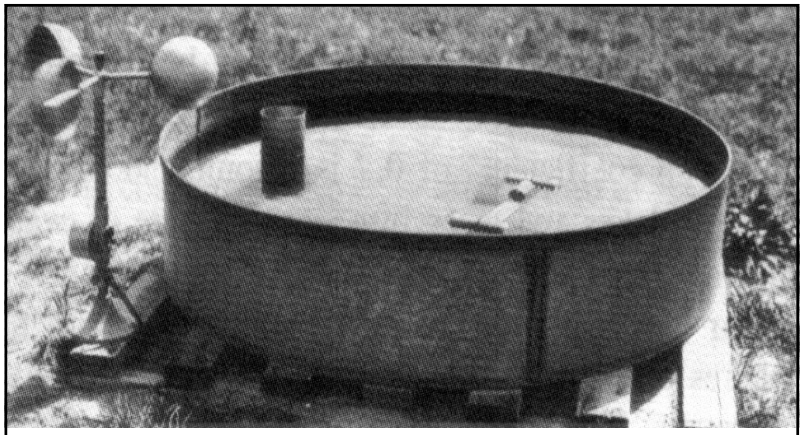
- Runoff = Rainfall – Initial abstractions – Infiltration
- Initial abstractions are mostly detention storage (“puddles”), interception by vegetation, flash evaporation, etc. Runoff cannot occur until these initial losses are satisified.
- Infiltration mostly occurs on pervious surfaces and is represented by one of several historical equaitons (Horton’s equation, or the Green Ampt equation are the most common).



http://www.naturegrid.org.uk/rivers/graphics/pudd-soil.gif

Initial Abstractions

Micro-scale detention storage “puddles” on rough pavement



Standard Class A Evaporation Pan with cup anemometer

U.S. Weather Bureau

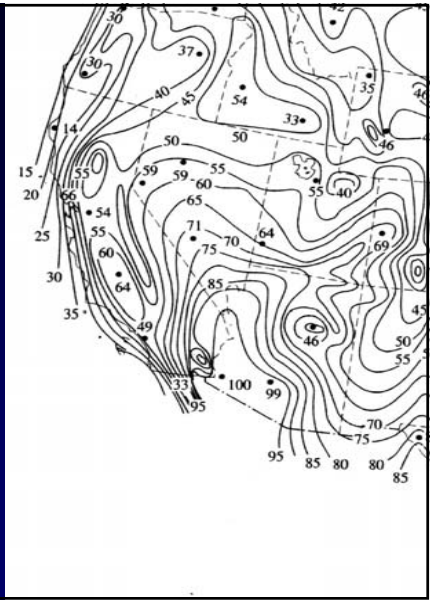
Monthly Pan Evaporation at Boulder City, NV
110 inches (9.2 ft) annual total

Oct	7.6	April	9.8
Nov	4.2	May	13.6
Dec	3.2	June	15.7
Jan	3.4	July	16.2
Feb	4.1	Aug	14.2
Mar	7.0	Sept	10.9
Total period:	29.5	Total period:	80.4

NOAA Climatological Data

Mean Annual Evaporation from Shallow Lakes (inches)

U.S. Dept. of Agriculture, Soil Conservation Service



Soil modifications can result in greatly enhanced infiltration in marginal soils.

SOIL STRUCTURE

O-horizon: leaf litter, organic material

A-horizon: plough zone, rich in organic matter

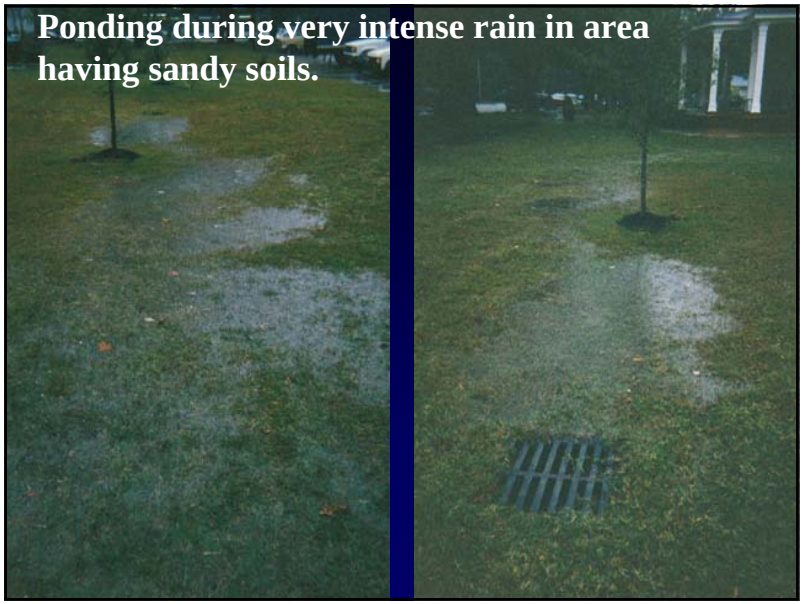
B-horizon: zone of accumulation

C-horizon: weathering soil; little organic material or life

R-horizon: unweathered parent material

www.seafriends.org.nz/enviro/ soil/geosoil.htm

Ponding during very intense rain in area having sandy soils.



Watershed Soil Characteristics

- County Soil Surveys contain much information concerning local soils
- Generally prepared with 2 samples per acre, therefore only general
- They do not consider the disruption to the soils that occurs with land development (compaction, cut and fill, etc.)
- Basic information is very important, but information must be modified based on these modifications

Soil Surveys

Soil surveys have been generated by the U.S. Department of Agriculture (National Resource Conservation Service – formerly the Soil Conservation Service) and are typically available through the county extension office.

Information typically available in a soil survey:

- Soil type by general area
- Descriptions of the various soil types
- Tables of information regarding the various soil types
- Soil classification (Hydrologic Soil Group A, B, C, and D)

Alabama Online Soil Survey Manuscripts

http://soils.usda.gov/survey/online_surveys/alabama/

Baldwin County (1964)
- **Manuscript (13.0 MB)**
- **Index to Detailed Soil Map Sheets (630 KB)**
- **General Soil Map (927 KB)**

Barbour County (2004)
- **Text, tables, and maps (2.2 MB)**

Butler County (1997)
- **Text and Tables (4.0 MB)**
- **General Soil Map (453 KB)**

Index to Detailed Soil Map Sheets.

Choctaw County (2003)
- **Manuscript (2.64 MB)**
- **Index to Detailed Soil Map Sheets (1.26 MB)**
- **General Soil Map (493 KB)**

General Soil Map for Alabama

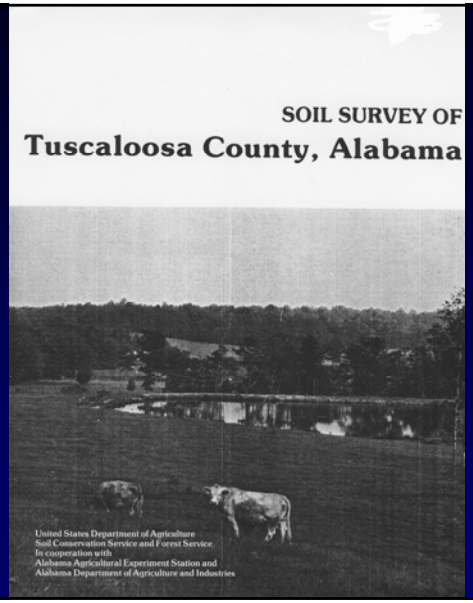
Soil Survey Background Information:

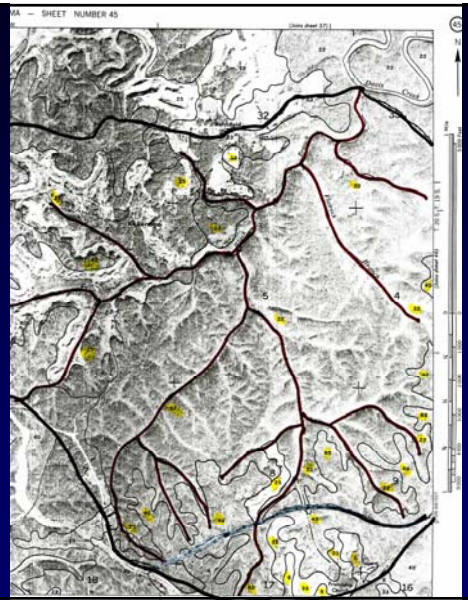
- Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They dug many holes to study the soil profile, which is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the material in which the soil formed. The material is devoid of roots and other living organisms and has not been changed by other biological activity.

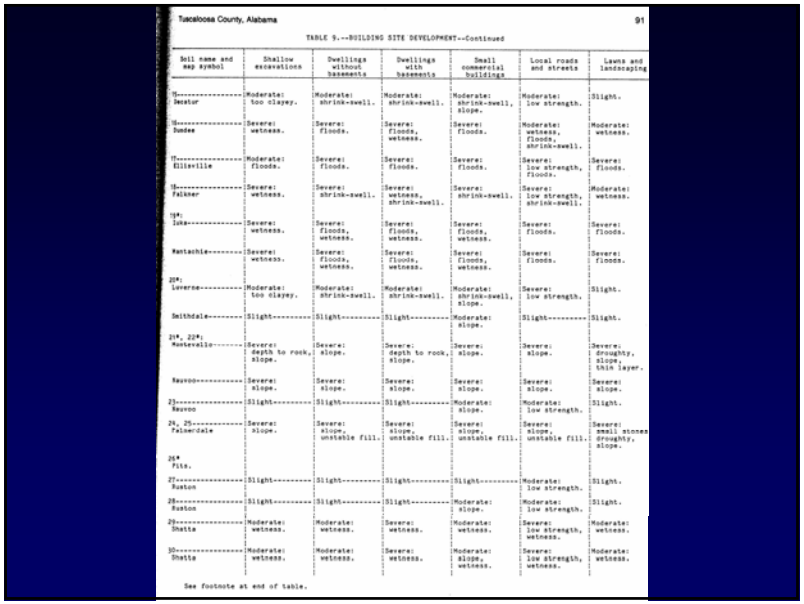
Arendtsville Soil Profile

Soil Survey Information on Building Site Development

- Shows the degree and kind of soil limitations that affect shallow excavations, dwellings with and without basements, small commercial buildings, local roads and streets, and lawns and landscaping.
- The limitations are considered *slight* if soil properties and site features are generally favorable for the indicated use and limitations are minor and easily overcome; *moderate* if soil properties or site features are not favorable for the indicated use and special planning, design, or maintenance is needed to overcome or minimize the limitations; and *severe* if soil properties or site features are so unfavorable or so difficult to overcome that special design, significant increases in construction costs, and possibly increased maintenance are required. Special feasibility studies may be required where the soil limitations are severe.





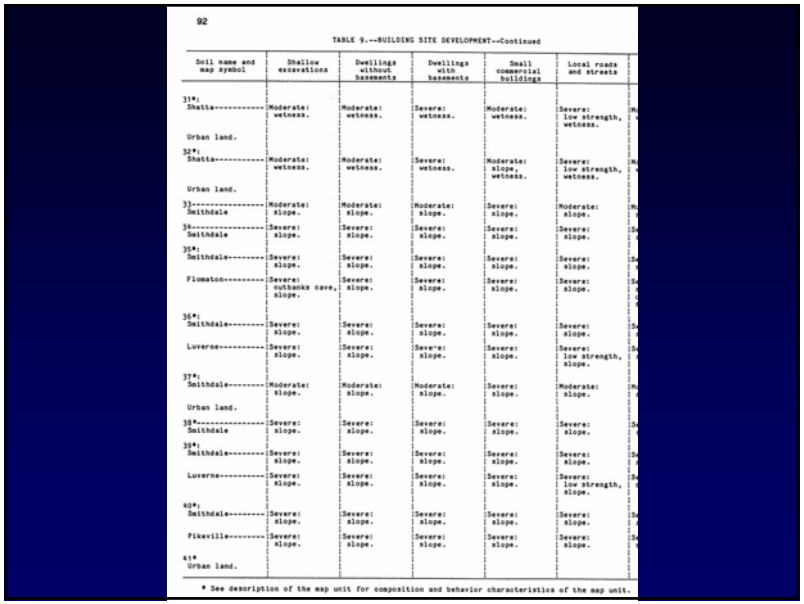


Tuscaloosa County, Alabama 91

TABLE 9.--BUILDING SITE DEVELOPMENT--Continued

Soil name and map symbol	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets	Lawns and landscaping
15---------- Decatur	Moderate: too clayey.	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell, slope.	Moderate: low strength.	Slight.
16---------- Dundee	Severe: wetness.	Severe: floods.	Severe: floods, wetness.	Severe: floods.	Moderate: wetness, floods, shrink-swell.	Moderate: wetness.
17---------- Ellisville	Moderate: floods.	Severe: floods.	Severe: floods.	Severe: floods.	Severe: low strength, floods.	Severe: floods.
18---------- Falkner	Severe: wetness.	Severe: shrink-swell.	Severe: wetness, shrink-swell.	Severe: shrink-swell.	Severe: low strength, shrink-swell.	Moderate: wetness.
19*: Luka----------	Severe: wetness.	Severe: floods, wetness.	Severe: floods, wetness.	Severe: floods, wetness.	Severe: floods.	Severe: floods.
Mantachie----------	Severe: wetness.	Severe: floods, wetness.	Severe: floods, wetness.	Severe: floods, wetness.	Severe: floods.	Severe: floods.
20*: Luverne----------	Moderate: too clayey.	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell, slope.	Severe: low strength.	Slight.
Smithdale----------	Slight----------	Slight----------	Slight----------	Moderate: slope.	Slight----------	Slight.
21*, 22*: Montevallo----------	Severe: depth to rock, slope.	Severe: slope.	Severe: depth to rock, slope.	Severe: slope.	Severe: slope.	Severe: droughty, slope, thin layer.
Sauvoo----------	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.
23---------- Sauvoo	Slight----------	Slight----------	Slight----------	Moderate: slope.	Moderate: low strength.	Slight.
24, 25---------- Palmerdale	Severe: slope.	Severe: slope, unstable fill.	Severe: slope, unstable fill.	Severe: slope, unstable fill.	Severe: slope, unstable fill.	Severe: small stones droughty, slope.
26* Pits.						
27---------- Ruston	Slight----------	Slight----------	Slight----------	Slight----------	Moderate: low strength.	Slight.
28---------- Ruston	Slight----------	Slight----------	Slight----------	Moderate: slope.	Moderate: low strength.	Slight.
29---------- Shatta	Moderate: wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Severe: low strength, wetness.	Moderate: wetness.
30---------- Shatta	Moderate: wetness.	Moderate: wetness.	Severe: wetness.	Moderate: slope, wetness.	Severe: low strength, wetness.	Moderate: wetness.

See footnote at end of table.

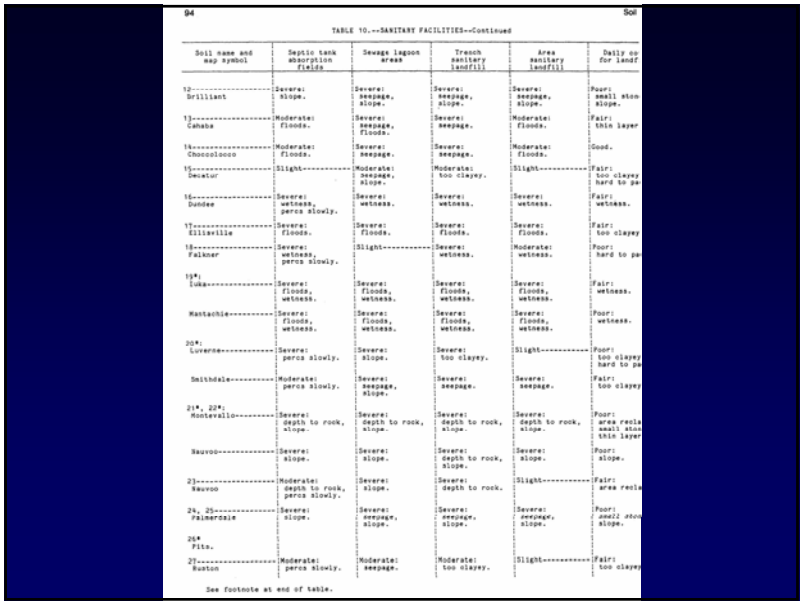


92

TABLE 9.--BUILDING SITE DEVELOPMENT--Continued

Soil name and map symbol	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets	
31*: Shatta---------- Urban land.	Moderate: wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Severe: low strength, wetness.	M a
32*: Shatta---------- Urban land.	Moderate: wetness.	Moderate: wetness.	Severe: wetness.	Moderate: slope, wetness.	Severe: low strength, wetness.	M a
33---------- Smithdale	Moderate: slope.	Moderate: slope.	Moderate: slope.	Severe: slope.	Moderate: slope.	M a
34---------- Smithdale	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Sa a
35*: Smithdale----------	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Sa a
Flomaton----------	Severe: outbanks cave, slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Sa a s
36*: Smithdale----------	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Sa a
Luverne----------	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: low strength, slope.	Sa a
37*: Smithdale---------- Urban land.	Moderate: slope.	Moderate: slope.	Moderate: slope.	Severe: slope.	Moderate: slope.	M a
38*---------- Smithdale	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Sa a
39*: Smithdale----------	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Sa a
Luverne----------	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: low strength, slope.	Sa a
40*: Smithdale----------	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Sa a
Pikeville----------	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Sa a
41* Urban land.						

* See description of the map unit for composition and behavior characteristics of the map unit.

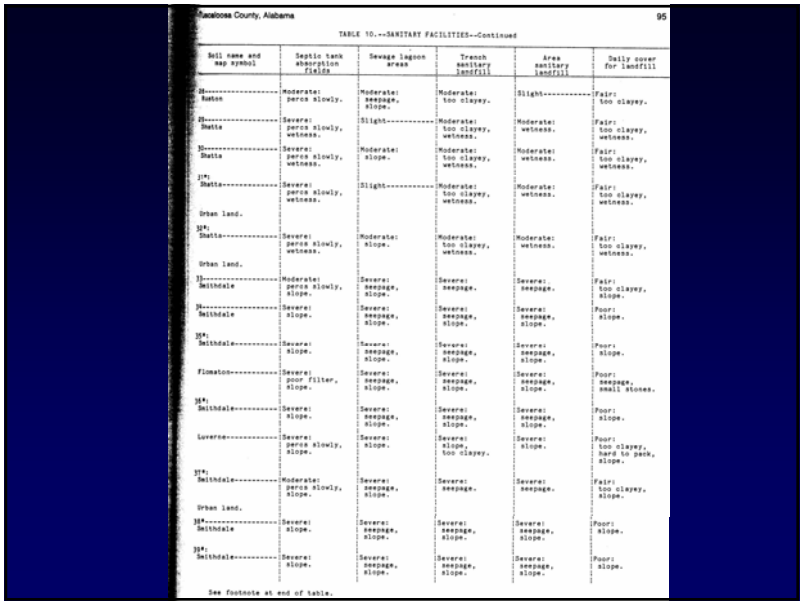


94 Soi

TABLE 10.--SANITARY FACILITIES--Continued

Soil name and map symbol	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Area sanitary landfill	Daily co for landf
12---------- Brilliant	Severe: slope.	Severe: seepage, slope.	Severe: seepage, slope.	Severe: seepage, slope.	Poor: small ston slope.
13---------- Canaba	Moderate: floods.	Severe: seepage, floods.	Severe: seepage.	Moderate: floods.	Fair: thin layer
14---------- Chocolocco	Moderate: floods.	Severe: seepage.	Severe: seepage.	Moderate: floods.	Good.
15---------- Decatur	Slight----------	Moderate: seepage, slope.	Moderate: too clayey.	Slight----------	Fair: too clayey hard to pa
16---------- Dundee	Severe: wetness, perco slowly.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Fair: wetness.
17---------- Ellisville	Severe: floods.	Severe: floods.	Severe: floods.	Severe: floods.	Fair: too clayey
18---------- Falkner	Severe: wetness, perco slowly.	Slight----------	Severe: wetness.	Moderate: wetness.	Poor: hard to pa
19*: Luka----------	Severe: floods, wetness.	Severe: floods, wetness.	Severe: floods, wetness.	Severe: floods, wetness.	Fair: wetness.
Mantachie----------	Severe: floods, wetness.	Severe: floods, wetness.	Severe: floods, wetness.	Severe: floods, wetness.	Poor: wetness.
20*: Luverne----------	Severe: perco slowly.	Severe: slope.	Severe: too clayey.	Slight----------	Poor: too clayey hard to pa
Smithdale----------	Moderate: perco slowly.	Severe: seepage, slope.	Severe: seepage.	Severe: seepage.	Fair: too clayey
21*, 22*: Montevallo----------	Severe: depth to rock, slope.	Severe: depth to rock, slope.	Severe: depth to rock, slope.	Severe: depth to rock, slope.	Poor: area reela small ston thin layer
Sauvoo----------	Severe: slope.	Severe: slope.	Severe: depth to rock, slope.	Severe: slope.	Poor: slope.
23---------- Sauvoo	Moderate: depth to rock, perco slowly.	Severe: slope.	Severe: depth to rock.	Slight----------	Fair: area reela
24, 25---------- Palmerdale	Severe: slope.	Severe: seepage, slope.	Severe: seepage, slope.	Severe: seepage, slope.	Poor: small ston slope.
26* Pits.					
27---------- Ruston	Moderate: perco slowly.	Moderate: seepage.	Moderate: too clayey.	Slight----------	Fair: too clayey

See footnote at end of table.

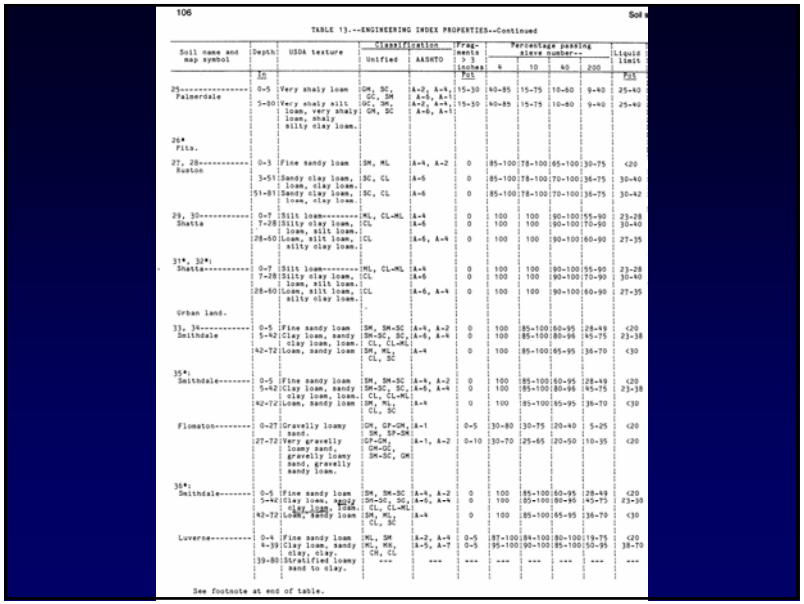


Tuscaloosa County, Alabama 95

TABLE 10.--SANITARY FACILITIES--Continued

Soil name and map symbol	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Area sanitary landfill	Daily cover for landfill
28---------- Ruston	Moderate: perco slowly.	Moderate: seepage, slope.	Moderate: too clayey.	Slight----------	Fair: too clayey.
29---------- Shatta	Severe: perco slowly, wetness.	Slight----------	Moderate: too clayey, wetness.	Moderate: wetness.	Fair: too clayey, wetness.
30---------- Shatta	Severe: perco slowly, wetness.	Moderate: slope.	Moderate: too clayey, wetness.	Moderate: wetness.	Fair: too clayey, wetness.
31*: Shatta---------- Urban land.	Severe: perco slowly, wetness.	Slight----------	Moderate: too clayey, wetness.	Moderate: wetness.	Fair: too clayey, wetness.
32*: Shatta---------- Urban land.	Severe: perco slowly, wetness.	Moderate: slope.	Moderate: too clayey, wetness.	Moderate: wetness.	Fair: too clayey, wetness.
33---------- Smithdale	Moderate: perco slowly, slope.	Severe: seepage, slope.	Severe: seepage.	Severe: seepage.	Fair: too clayey, slope.
34---------- Smithdale	Severe: slope.	Severe: seepage, slope.	Severe: seepage, slope.	Severe: seepage, slope.	Poor: slope.
35*: Smithdale----------	Severe: slope.	Severe: seepage, slope.	Severe: seepage, slope.	Severe: seepage, slope.	Poor: slope.
Flomaton----------	Severe: poor filter, slope.	Severe: seepage, slope.	Severe: seepage, slope.	Severe: seepage, slope.	Poor: seepage, small stones.
36*: Smithdale----------	Severe: slope.	Severe: seepage, slope.	Severe: seepage, slope.	Severe: seepage, slope.	Poor: slope.
Luverne----------	Severe: perco slowly, slope.	Severe: slope.	Severe: slope, too clayey.	Severe: slope.	Poor: too clayey, hard to pack, slope.
37*: Smithdale---------- Urban land.	Moderate: perco slowly, slope.	Severe: seepage, slope.	Severe: seepage.	Severe: seepage.	Fair: too clayey, slope.
38*---------- Smithdale	Severe: slope.	Severe: seepage, slope.	Severe: seepage, slope.	Severe: seepage, slope.	Poor: slope.
39*: Smithdale----------	Severe: slope.	Severe: seepage, slope.	Severe: seepage, slope.	Severe: seepage, slope.	Poor: slope.

See footnote at end of table.

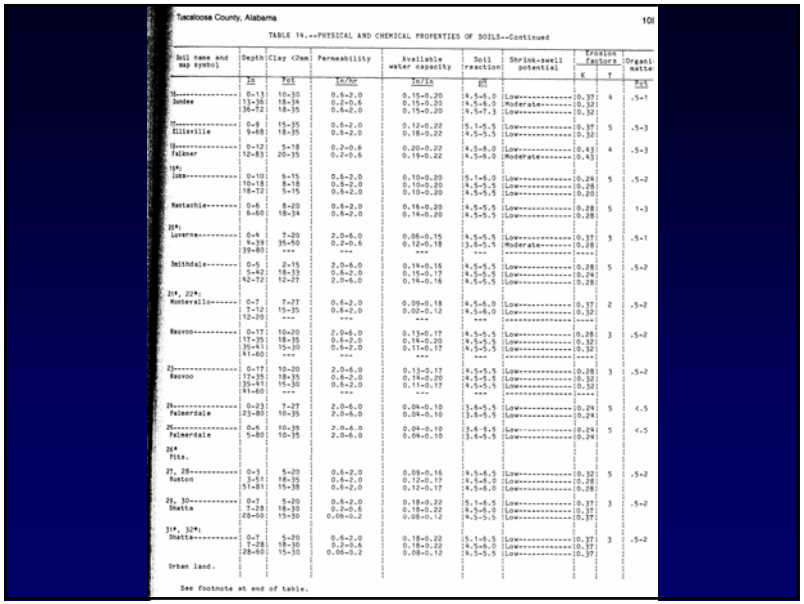


106 Soil

TABLE 13.--ENGINEERING INDEX PROPERTIES--Continued

Soil name and map symbol	Depth	USDA texture	Classification: Unified	Classification: AASHTO	Fragments > 3 inches	Percentage passing sieve number--: 4	10	40	200	Liquid limit
	In				Pct					Pct
25---- Palmerdale	0-5	Very shaly loam	GM, SC, GC, SM	A-2, A-4, A-6, A-1	15-30	40-85	15-75	10-60	5-40	25-40
	5-80	Very shaly silt loam, very shaly loam, shaly silty clay loam.	GC, SM, GM, SC	A-2, A-4, A-6, A-1	15-30	40-85	15-75	10-60	5-40	25-40
26* Pits.										
27, 28---- Ruston	0-3	Fine sandy loam	SM, ML	A-4, A-2	0	85-100	78-100	65-100	30-75	<20
	3-51	Sandy clay loam, clay loam.	SC, CL	A-6	0	85-100	78-100	70-100	36-75	30-40
	51-81	Sandy clay loam, clay loam.	SC, CL	A-6	0	85-100	78-100	70-100	36-75	30-42
29, 30---- Shatta	0-7	Silt loam	ML, CL-ML	A-4	0	100	100	90-100	55-90	23-28
	7-28	Silty clay loam, silt loam.	CL	A-6	0	100	100	90-100	70-90	30-40
	28-60	Loam, silt loam, silty clay loam.	CL	A-6, A-4	0	100	100	90-100	60-90	27-35
31*, 32*: Shatta----	0-7	Silt loam	ML, CL-ML	A-4	0	100	100	90-100	55-90	23-28
	7-28	Silty clay loam, silt loam.	CL	A-6	0	100	100	90-100	70-90	30-40
	28-60	Loam, silt loam, silty clay loam.	CL	A-6, A-4	0	100	100	90-100	60-90	27-35
Urban land.										
33, 34---- Smithdale	0-5	Fine sandy loam	SM, SM-SC	A-4, A-2	0	100	85-100	60-95	28-49	<20
	5-42	Clay loam, sandy clay loam, loam.	SM-SC, SC, CL, CL-ML	A-6, A-4	0	100	85-100	80-96	45-75	23-38
	42-72	Loam, sandy loam	SM, ML, CL, SC	A-4	0	100	85-100	65-95	36-70	<30
35*: Smithdale----	0-5	Fine sandy loam	SM, SM-SC	A-4, A-2	0	100	85-100	60-95	28-49	<20
	5-42	Clay loam, sandy clay loam, loam.	SM-SC, SC, CL, CL-ML	A-6, A-4	0	100	85-100	80-96	45-75	23-38
	42-72	Loam, sandy loam	SM, ML, CL, SC	A-4	0	100	85-100	65-95	36-70	<30
Flomaton----	0-27	Gravelly loamy sand.	GM, GP-GM, SM, SP-SM	A-1	0-5	30-80	30-75	20-40	5-25	<20
	27-72	Very gravelly loamy sand, gravelly clay loam, loam.	GP-GM, GM-GC, SM-SC, GM	A-1, A-2	0-10	30-70	25-65	20-50	10-35	<20
36*: Smithdale----	0-5	Fine sandy loam	SM, SM-SC	A-4, A-2	0	100	85-100	60-95	28-49	<20
	5-42	Clay loam, sandy clay loam, loam.	SM-SC, SC, CL, CL-ML	A-6, A-4	0	100	85-100	80-96	45-75	23-38
	42-72	Loam, sandy loam	SM, ML, CL, SC	A-4	0	100	85-100	65-95	36-70	<30
Luverne----	0-4	Fine sandy loam	ML, SM	A-2, A-4	0-5	87-100	84-100	80-100	19-75	<20
	4-39	Clay loam, sandy clay, clay.	ML, MH, CH, CL	A-5, A-7	0-5	95-100	90-100	85-100	50-95	38-70
	39-80	Stratified loamy sand to clay.	---	---	---	---	---	---	---	---

See footnote at end of table.



Tuscaloosa County, Alabama 101

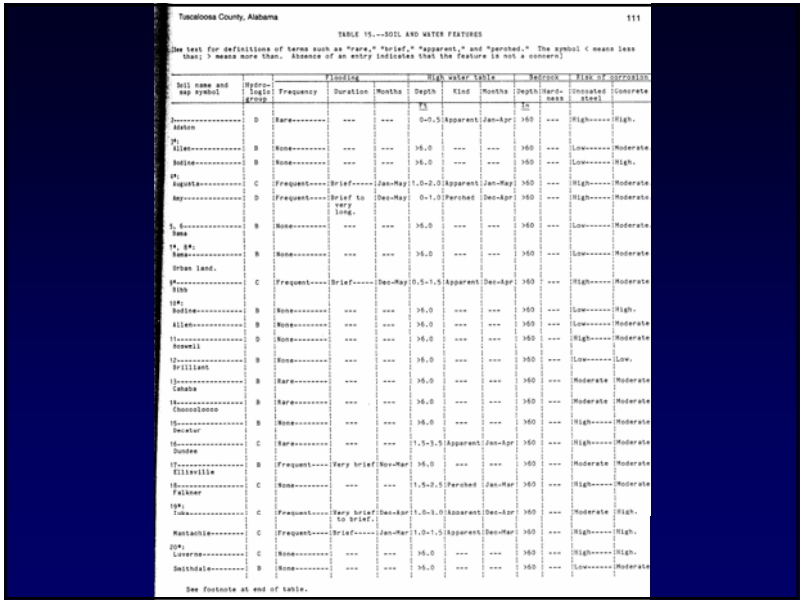
TABLE 14.--PHYSICAL AND CHEMICAL PROPERTIES OF SOILS--Continued

Soil name and map symbol	Depth	Clay <2mm	Permeability	Available water capacity	Soil reaction	Shrink-swell potential	Erosion factors: K	Erosion factors: T	Organic matter
	In	Pct	In/hr	In/in	pH				Pct
14---- Dundee	0-13	10-30	0.6-2.0	0.15-0.20	4.5-6.0	Low	0.37	4	.5-1
	13-36	18-34	0.2-0.6	0.15-0.20	4.5-5.5	Moderate	0.32		
	36-72	18-35	0.6-2.0	0.15-0.20	4.5-7.3	Low	0.32		
17---- Ellisville	0-9	15-35	0.6-2.0	0.12-0.22	5.1-5.5	Low	0.37	5	.5-3
	9-48	18-35	0.6-2.0	0.18-0.22	4.5-5.5	Low	0.32		
18---- Falkner	0-12	5-18	0.2-0.6	0.20-0.22	4.5-6.0	Low	0.43	4	.5-3
	12-83	20-35	0.2-0.6	0.19-0.22	4.5-5.0	Moderate	0.43		
19*: Ios----	0-10	5-15	0.6-2.0	0.10-0.20	5.1-6.0	Low	0.24	5	.5-2
	10-18	8-18	0.6-2.0	0.10-0.20	4.5-5.5	Low	0.28		
	18-72	5-15	0.6-2.0	0.10-0.20	4.5-5.5	Low	0.20		
Kantachie----	0-6	8-20	0.6-2.0	0.15-0.20	4.5-5.5	Low	0.28	5	1-3
	6-60	18-34	0.6-2.0	0.14-0.20	4.5-5.5	Low	0.28		
20*: Luverne----	0-4	7-20	2.0-6.0	0.06-0.15	4.5-5.5	Low	0.37	3	.5-1
	4-39	35-50	0.2-0.6	0.12-0.18	3.6-5.5	Moderate	0.28		
	39-80	---	---	---	---	---	---		
Smithdale----	0-5	2-15	2.0-6.0	0.14-0.16	4.5-5.5	Low	0.28	5	.5-2
	5-42	18-33	0.6-2.0	0.15-0.17	4.5-5.5	Low	0.24		
	42-72	12-27	2.0-6.0	0.14-0.16	4.5-5.5	Low	0.28		
21*, 22*: Montevallo----	0-7	7-27	0.6-2.0	0.09-0.18	4.5-6.0	Low	0.37	2	.5-2
	7-12	15-35	0.6-2.0	0.00-0.12	4.5-6.0	Low	0.32		
	12-20	---	---	---	---	Low	---		
Ruston----	0-17	10-20	2.0-6.0	0.13-0.17	4.5-5.5	Low	0.28	3	.5-2
	17-35	18-35	0.6-2.0	0.14-0.20	4.5-5.5	Low	0.32		
	35-41	15-30	0.6-2.0	0.11-0.17	4.5-5.5	Low	0.32		
	41-60	---	---	---	---	Low	---		
23---- Ruston	0-17	10-20	2.0-6.0	0.13-0.17	4.5-5.5	Low	0.28	3	.5-2
	17-35	18-35	0.6-2.0	0.14-0.20	4.5-5.5	Low	0.32		
	35-41	15-30	0.6-2.0	0.11-0.17	4.5-5.5	Low	0.32		
	41-60	---	---	---	---	Low	---		
24---- Palmerdale	0-23	7-27	2.0-6.0	0.04-0.10	3.6-5.5	Low	0.24	5	<.5
	23-80	10-35	2.0-6.0	0.04-0.10	3.6-5.5	Low	0.24		
26---- Palmerdale	0-6	10-35	2.0-6.0	0.04-0.10	3.6-4.5	Low	0.24	5	<.5
	6-80	10-35	2.0-6.0	0.04-0.10	3.6-5.5	Low	0.24		
26* Pits.									
27, 28---- Ruston	0-3	5-20	0.6-2.0	0.09-0.16	4.5-6.5	Low	0.32	5	.5-2
	3-51	18-35	0.6-2.0	0.12-0.17	4.5-6.0	Low	0.28		
	51-81	15-38	0.6-2.0	0.12-0.17	4.5-6.0	Low	0.28		
29, 30---- Shatta	0-7	5-20	0.6-2.0	0.18-0.22	5.1-6.5	Low	0.37	3	.5-2
	7-28	18-30	0.2-0.6	0.18-0.22	4.5-6.0	Low	0.37		
	28-60	15-30	0.06-0.2	0.08-0.12	4.5-5.5	Low	0.37		
31*, 32*: Shatta----	0-7	5-20	0.6-2.0	0.18-0.22	5.1-6.5	Low	0.37	3	.5-2
	7-28	18-30	0.2-0.6	0.18-0.22	4.5-6.0	Low	0.37		
	28-60	15-30	0.06-0.2	0.08-0.12	4.5-5.5	Low	0.37		
Urban land.									

See footnote at end of table.

Water Features of the Soil: Hydrologic Soil Group

- ***Hydrologic soil groups*** are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.
- The four hydrologic soil groups are:
  - ***Group A***. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.
  - ***Group B***. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.
  - ***Group C***. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.
  - ***Group D***. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.



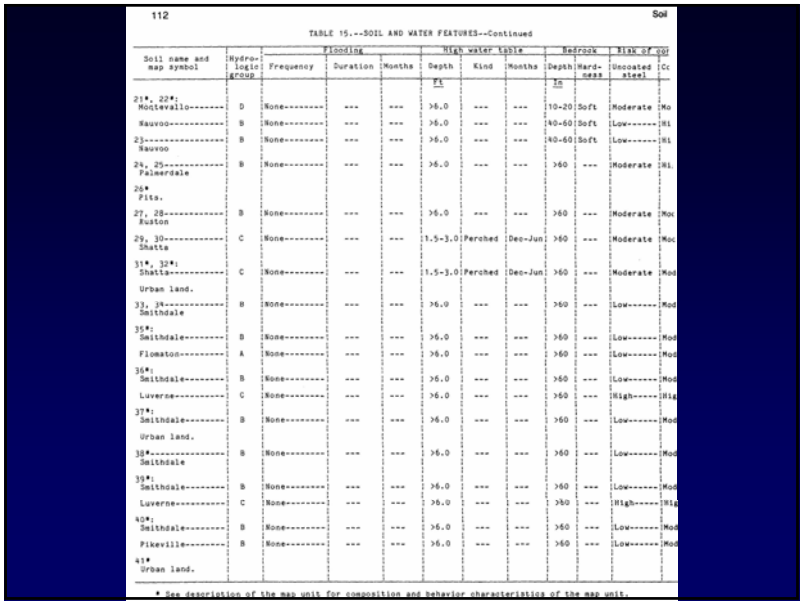
Tuscaloosa County, Alabama 111

TABLE 15.--SOIL AND WATER FEATURES

[See text for definitions of terms such as "rare," "brief," "apparent," and "perched." The symbol < means less than; > means more than. Absence of an entry indicates that the feature is not a concern]

Soil name and map symbol	Hydrologic group	Flooding: Frequency	Flooding: Duration	Flooding: Months	High water table: Depth	High water table: Kind	High water table: Months	Bedrock: Depth	Bedrock: Hardness	Risk of corrosion: Uncoated steel	Risk of corrosion: Concrete
					Ft			In			
2---- Adelon	D	Rare	---	---	0-0.5	Apparent	Jan-Apr	>60	---	High	High.
3*: Allen	B	None	---	---	>6.0	---	---	>60	---	Low	Moderate
Bodine	B	None	---	---	>6.0	---	---	>60	---	Low	High.
4*: Augusta	C	Frequent	Brief	Jan-May	1.0-2.0	Apparent	Jan-May	>60	---	High	Moderate
Bay	D	Frequent	Brief to very long.	Dec-May	0-1.0	Perched	Dec-Apr	>60	---	High	Moderate
5, 6---- Bama	B	None	---	---	>6.0	---	---	>60	---	Low	Moderate
7*, 8*: Bama	B	None	---	---	>6.0	---	---	>60	---	Low	Moderate
Urban land.											
9---- Bibb	C	Frequent	Brief	Dec-May	0.5-1.5	Apparent	Dec-Apr	>60	---	High	Moderate
10*: Bodine	B	None	---	---	>6.0	---	---	>60	---	Low	High.
Allen	B	None	---	---	>6.0	---	---	>60	---	Low	Moderate
11---- Boswell	D	None	---	---	>6.0	---	---	>60	---	High	Moderate
12---- Brilliant	B	None	---	---	>6.0	---	---	>60	---	Low	Low.
13---- Cahaba	B	Rare	---	---	>6.0	---	---	>60	---	Moderate	Moderate
14---- Choccolocco	B	Rare	---	---	>6.0	---	---	>60	---	Moderate	Moderate
15---- Decatur	B	None	---	---	>6.0	---	---	>60	---	High	Moderate
16---- Dundee	C	Rare	---	---	1.5-3.5	Apparent	Jan-Apr	>60	---	High	Moderate
17---- Ellisville	B	Frequent	Very brief	Nov-Mar	>6.0	---	---	>60	---	Moderate	Moderate
18---- Falkner	C	None	---	---	1.5-2.5	Perched	Jan-Mar	>60	---	High	Moderate
19*: Ios	C	Frequent	Very brief to brief.	Dec-Apr	1.0-3.0	Apparent	Dec-Apr	>60	---	Moderate	High.
Kantachie	C	Frequent	Brief	Jan-Mar	1.0-1.5	Apparent	Dec-Mar	>60	---	High	High.
20*: Luverne	C	None	---	---	>6.0	---	---	>60	---	High	High.
Smithdale	B	None	---	---	>6.0	---	---	>60	---	Low	Moderate

See footnote at end of table.



112 Soil

TABLE 15.--SOIL AND WATER FEATURES--Continued

Soil name and map symbol	Hydrologic group	Flooding			High water table			Bedrock		Risk of corrosion	
		Frequency	Duration	Months	Depth	Kind	Months	Depth	Hardness	Uncoated steel	Co
					Ft			In			
21*, 22*: Montevallo	D	None	---	---	>6.0	---	---	10-20	Soft	Moderate	Mo
Nauvoo	B	None	---	---	>6.0	---	---	40-60	Soft	Low	Hi
23 Nauvoo	B	None	---	---	>6.0	---	---	40-60	Soft	Low	Hi
24, 25 Palmerdale	B	None	---	---	>6.0	---	---	>60	---	Moderate	Hi
26* Pits.											
27, 28 Ruston	B	None	---	---	>6.0	---	---	>60	---	Moderate	Mo
29, 30 Shatta	C	None	---	---	1.5-3.0	Perched	Dec-Jun	>60	---	Moderate	Mo
31*, 32*: Shatta	C	None	---	---	1.5-3.0	Perched	Dec-Jun	>60	---	Moderate	Mo
Urban land.											
33, 34 Smithdale	B	None	---	---	>6.0	---	---	>60	---	Low	Mo
35*: Smithdale	B	None	---	---	>6.0	---	---	>60	---	Low	Mo
Flomaton	A	None	---	---	>6.0	---	---	>60	---	Low	Mo
36*: Smithdale	B	None	---	---	>6.0	---	---	>60	---	Low	Mo
Luverne	C	None	---	---	>6.0	---	---	>60	---	High	Hi
37*: Smithdale	B	None	---	---	>6.0	---	---	>60	---	Low	Mo
Urban land.											
38* Smithdale	B	None	---	---	>6.0	---	---	>60	---	Low	Mo
39*: Smithdale	B	None	---	---	>6.0	---	---	>60	---	Low	Mo
Luverne	C	None	---	---	>6.0	---	---	>60	---	High	Hi
40*: Smithdale	B	None	---	---	>6.0	---	---	>60	---	Low	Mo
Pikeville	B	None	---	---	>6.0	---	---	>60	---	Low	Mo
41* Urban land.											

* See description of the map unit for composition and behavior characteristics of the map unit.

Precipitation

Precipitation includes

- Rain
- Snow
- Hail
- Sleet

Precipitation is the primary source of water in streams, lakes, springs and wells.

Precipitation is expressed as an average intensity over a specified time period (usually as rain depth/unit time)

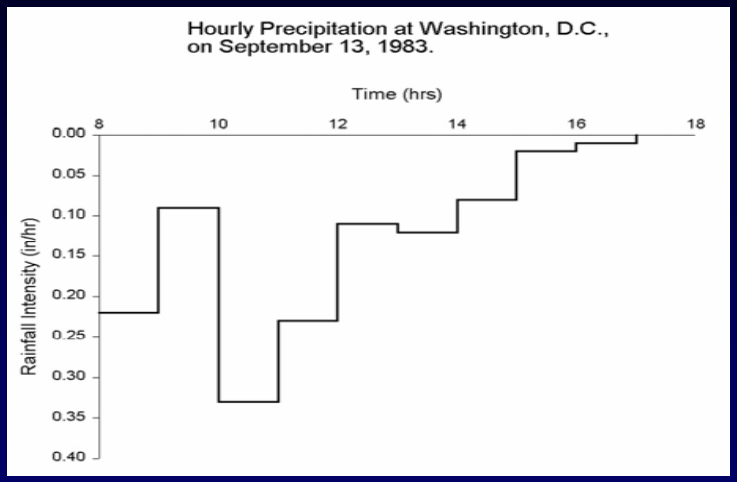
Precipitation patterns for a region determined by:

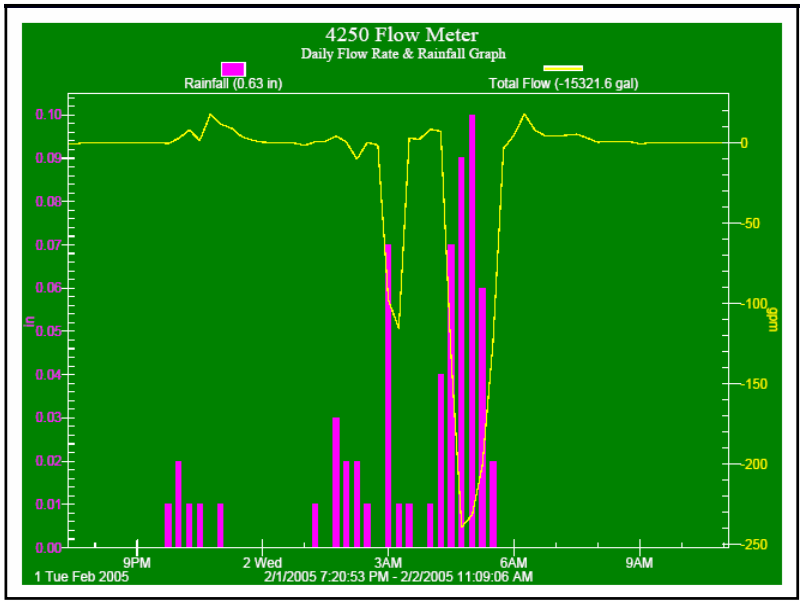
- Meteorological conditions
- Geographic conditions
- Topographic conditions
- Geologic conditions

Rainfall characteristics

- **Duration:** length of time over which a precipitation event occurs
- **Volume:** amount of precipitation occurring over the storm duration (usually reported as a depth that is assumed to have occurred evenly across watershed)
- **Frequency:** the “regularity/oftenness” of events with the same duration and volume

Intensity: volume/duration (units of depth/time)





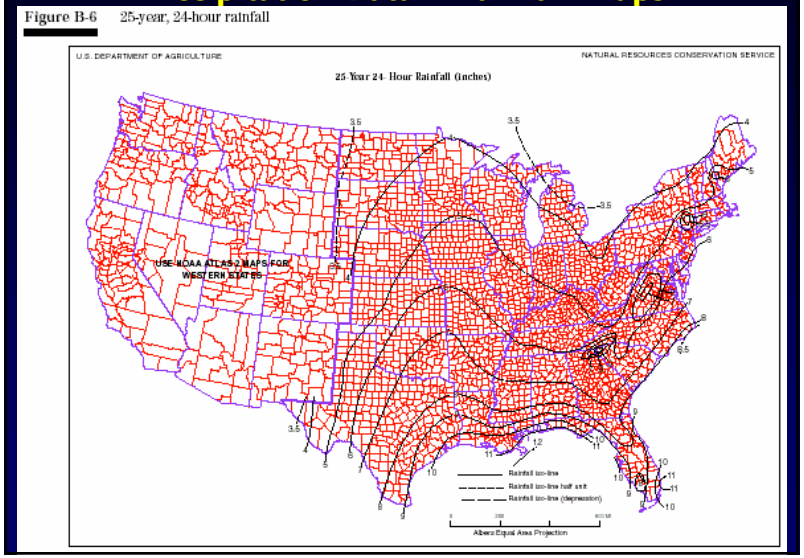
Frequency can be reported in two ways:

- **Exceedence probability**: the probability that an event having a specified depth and duration will be exceeded in one time period (usually 1 year)
- **Return period**: average length of time between events having the same depth and duration

Relationship between exceedence period (p) and return period (T):

$$p = 1/T$$

Precipitation Data – Rainfall Maps



Rainfall Patterns and IDF Curves

Rainfall Frequency

- Rainfall frequency is commonly expressed as the average return period of the event.
- The value should be expressed as the probability of that event occurring in any one year.
- As an example, a 100-yr storm, has a 1% chance of occurring in any one year, while a 5-yr storm has a 20% chance of occurring in any one year.
- Multiple rare events may occur in any one year, but that is not very likely.

Developing Design Storms for Drainage Design

- Constant Intensity Design Storms
- Unit Hyetograph Storms (such as the 24-hour SCS Storm Design Distribution)

Design Storm Selection Guidelines

(Source: *Model Drainage Manual*, American Association of State Highway and Transportation Officials, Washington, D.C. 1991 as given in Garber and Hoel. *Traffic and Highway Engineering, Second Edition*. PWS Publishing Company, 1997).

Roadway Classification	Exceedence Probability	Return Period
Rural principal arterial system	2%	50 year
Rural minor arterial system	2 – 4%	25 – 50 year
Rural collector system, major	4%	25 year
Rural collector system, minor	10%	10 year
Rural local road system	10 – 20%	5 – 10 year
Urban principal arterial system	2 – 4%	25 – 50 year
Urban minor arterial street system	4%	25 year
Urban collector street system	10%	10 year
Urban local street system	10 – 20%	5 – 10 year

NOTE: Federal law requires interstate highways to be provided with protection from the 2% flood event, and facilities such as underpasses, depressed roadways, etc. where no overflow relief is available should be designed for the 2% event.

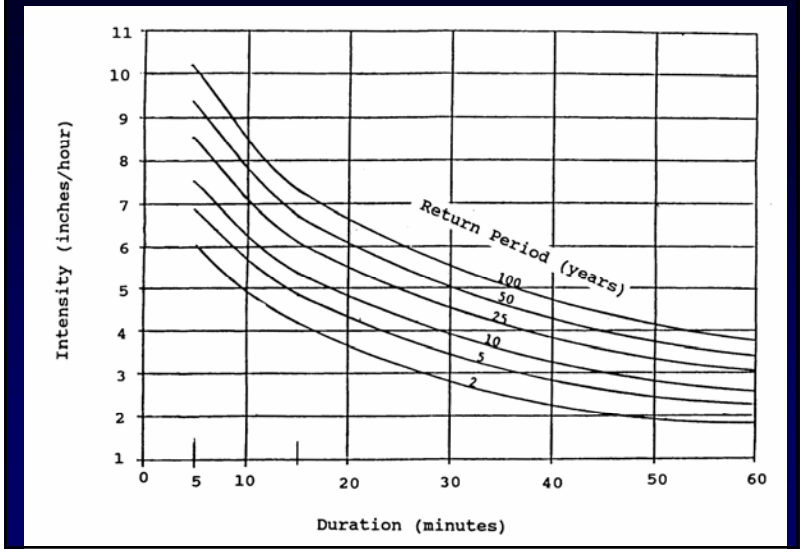
Time of Concentration (t_c)

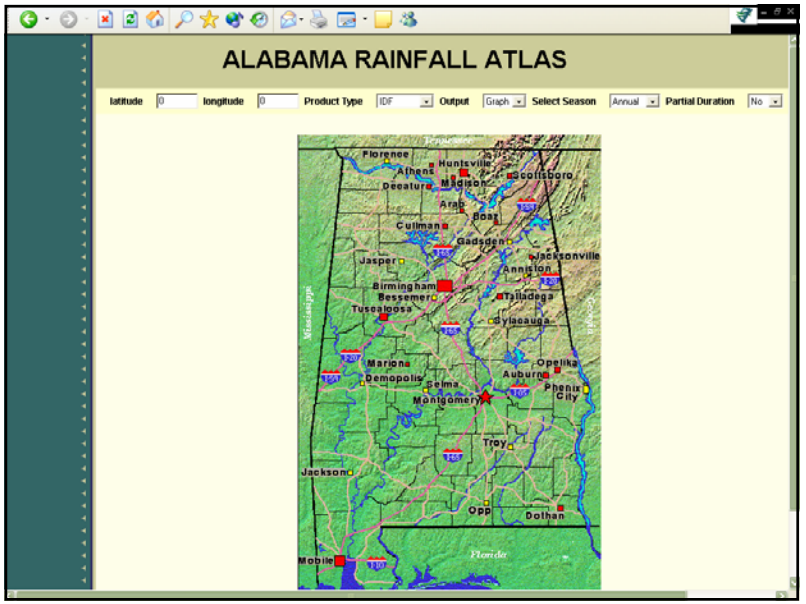
- The duration must be equal to the time of concentration for the drainage area.
- The time of concentration (t_c) is equal to the longest flow path (by time).
- If the t_c is 5 min for a storm having a return period of 25 years, the associated peak intensity (which has a duration of 5 min) would be about 8.6 in/hr.
- If the t_c for this same return period was 40 min, the peak rain intensity would be "only" 3.8 in/hr.

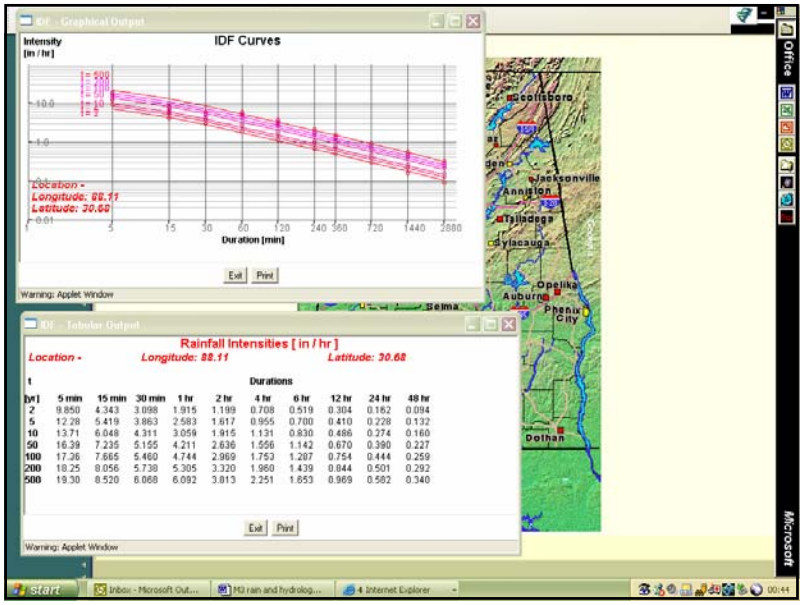
Rainfall Frequency

- Rainfall frequency is commonly expressed as the average return period of the event.
- The value should be expressed as the probability of that event occurring in any one year.
- As an example, a 100-yr storm, has a 1% chance of occurring in any one year, while a 5-yr storm has a 20% chance of occurring in any one year.
- Multiple rare events may occur in any one year, but that is not very likely.

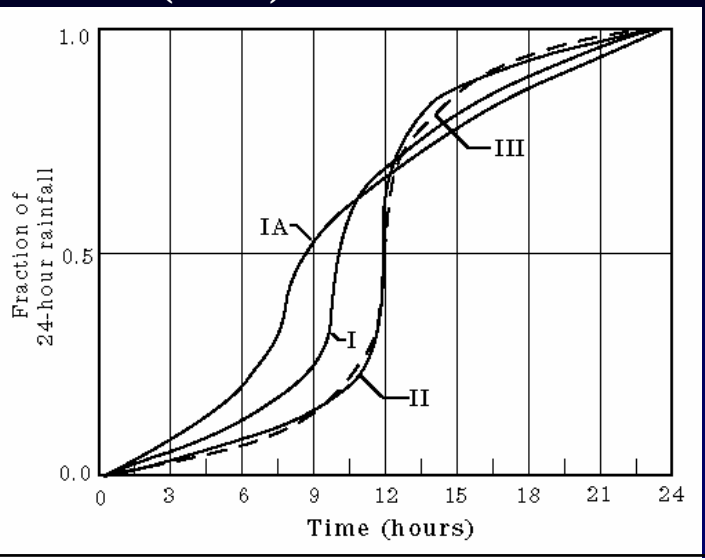
Birmingham Intensity - Duration - Frequency (IDF) Curve



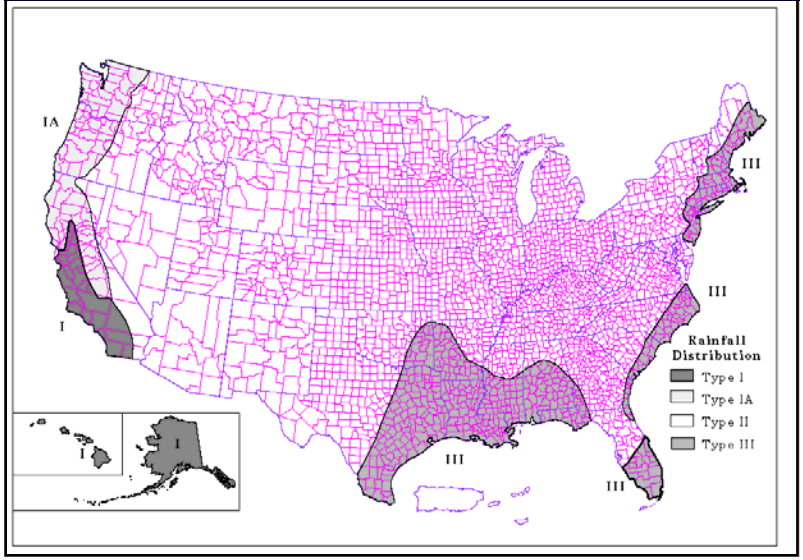




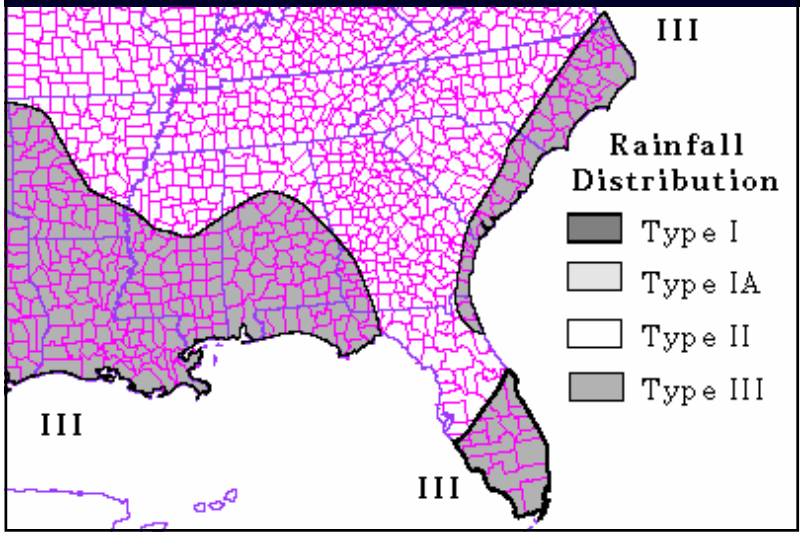
SCS (NRCS) Rainfall Distributions

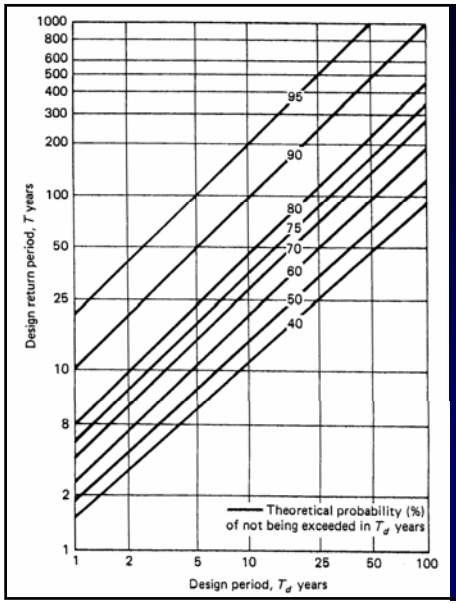


Zones of Different Rainfall Distributions



Rainfall Distributions in the Southeastern U.S.





Probability of design storm (design return period) not being exceeded during the project life (design period).

As an example, if a project life was 5 years, and a storm was not to be exceeded with a 90% probability, a 50 year design return period storm must be used.