LABORATORY ELEVEN

Stream Processes, Landscapes, Mass Wastage, and Flood Hazards

OBJECTIVES

A. Be able to use topographic maps and stereograms to describe and interpret streams: their valley shapes, channel configurations, drainage patterns, and the erosional landscapes and depositional features they create.
B. Understand erosional and mass wastage processes that occur at Niagara Falls, and be able to evaluate rates at which the falls is retreating upstream.
C. Be able to map and assess the extent of flood hazards along the Flint River, Georgia.
D. Explore meander evolution on the Rio Grande River.
E. Search Internet sites for information about the NFIP, how to prepare for floods, and what to do if you are caught in a flood.

STUDENT MATERIALS **(Remind students to bring items you check below.)**

_____ laboratory manual
_____ laboratory notebook
_____ pencil with eraser
_____ calculator
_____ piece of string about 30 cm or 12 inches long (or provided by instructor)
_____ metric ruler (cut from GeoTools sheet 1)
_____ pocket stereoscope (or provided by instructor)

_____:

INSTRUCTOR MATERIALS **(Check off items you will need or provide.)**

_____ pieces of string about 30 cm or 12 inches long for students (or obtained by students)
_____ pocket stereoscopes (or obtained by students)

_____:

_____:

INSTRUCTOR NOTES AND REFERENCES

1. General information. Refer to Laboratory 11 on the Internet site at http://www.prenhall.com/agi for additional information and links related to all parts of this laboratory.

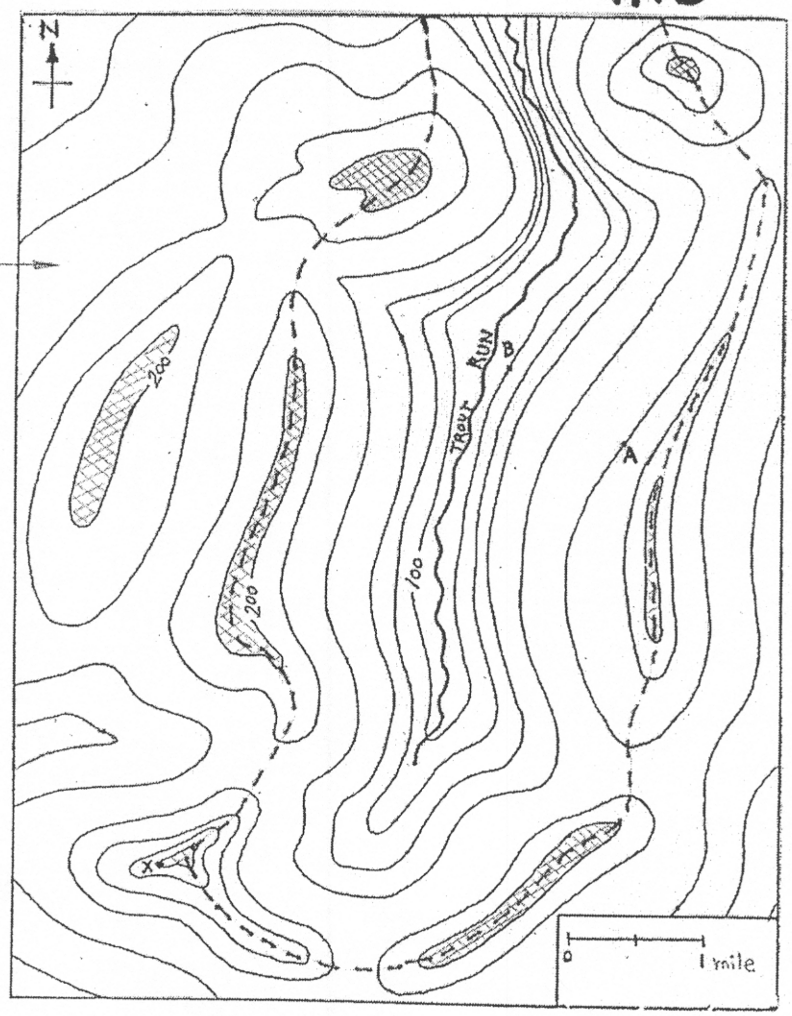
2. Reading Fine Print. Some printed words and numerals on topographic maps are very small and difficult for some students to read. Plastic sheet magnifiers aid in map reading. They can be purchased in most bookstores for a few dollars (or less) each. They also come in large sheet or credit card sizes.

ANSWERS TO QUESTIONS IN LABORATORY 11

Part 11A: Stream Processes and Landscapes

1a. 20 feet
1b. 240 feet
1c. 100 feet
1d. 180 feet
1e. 1 mile
1f. 80 feet/mile
1g. See shaded hill tops (crosshached) and dashed drainage divide shown here.
1h. north

11.5



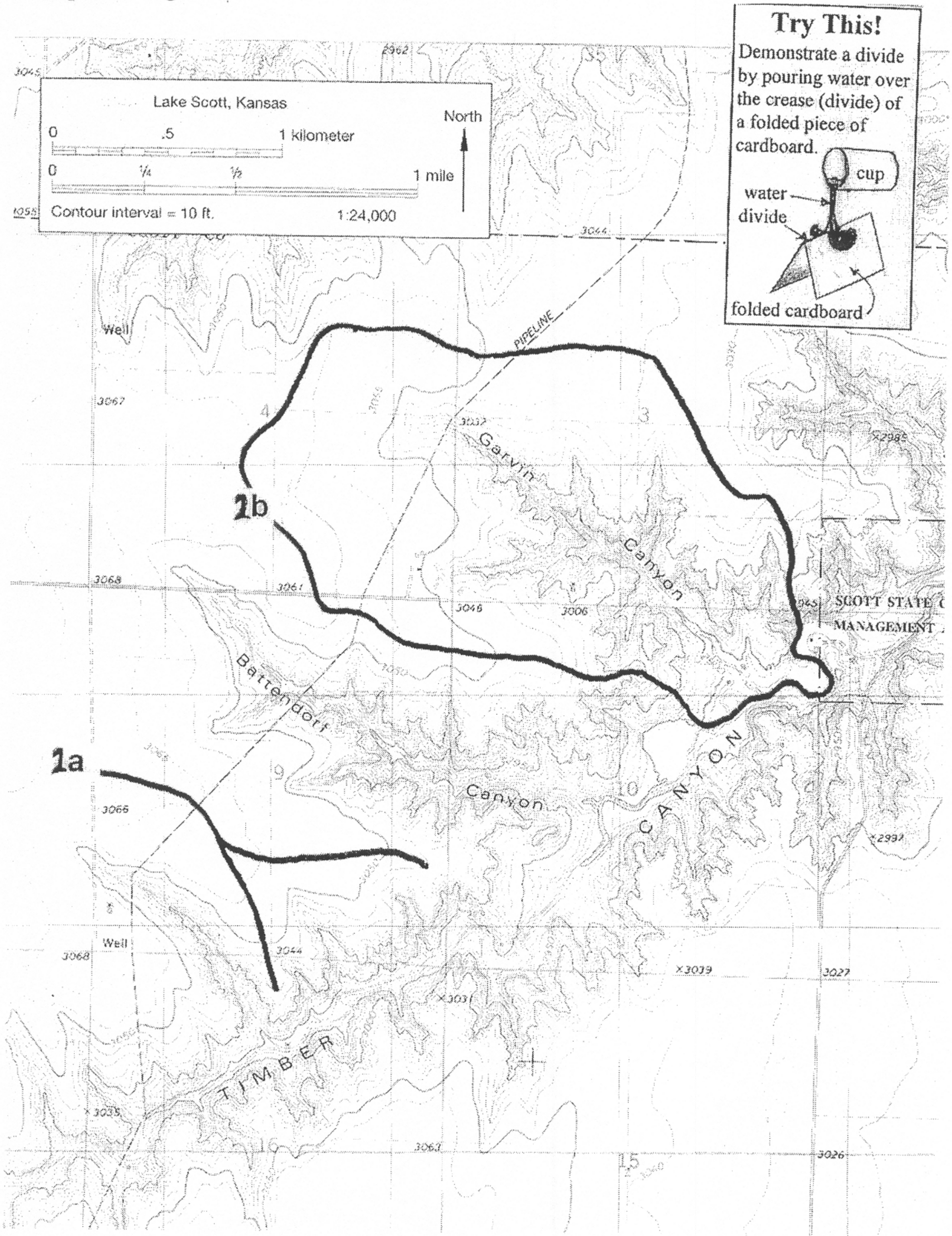
2. No. It is unlikely that oil spilled at location **x** would wash downhill into Trout Run because **x** is outside the Trout Run drainage basin.

3a. Refer to divide (bold black line) labeled "1a" on the next page (completed Figure 11.3).

3b. Refer to divide (bold black line) labeled "1b" on the next page (completed Figure 11.3).

See completed Figure 11.3 on the next page.

Completed Figure 11.3



Try This!

Demonstrate a divide by pouring water over the crease (divide) of a folded piece of cardboard.

4a. Elevations along the western margin of the map are 3067 to 3080 feet and elevations along the east margin of the map are just under 3000 feet. So, water flows from west to east over the upland surface (until it flows into a canyon or seeps into the ground).

4b. Using the elevation information from 2a, the upland surface slopes 67 to 80 feet (20.4 to 24.3 m) over about 3 miles (4.8 km). So the gradient is:

67 to 80 ft/3 miles = **22 to 27 feet/mile**

20.4 to 24.3 m/4.8 km = **4.25 to 5.1 meters/km**

4c. Kansas is located east of the Great Divide, and the Great Divide is an imaginary line along the crest of the Rocky Mountains. So, the Rocky Mountains were the likely source of water and sediments that formed the alluvial gravel deposit (that is now Kansas upland).

5a. The present-day drainage pattern in the Lake Scott quadrangle is dendritic.

5b. Dendritic drainage patterns commonly develop in regions having relatively flat-lying (horizontal) layers of rock or homogeneous sediment layers (see Figure 11.2). Folded strata and faulted strata would cause the water to flow in annular, radial, trellis, or rectangular patterns. Therefore, the bedrock of this region must be comprised of relatively horizontal layers.

6. This question is best answered by using a blue marking pen to trace over all of the streams in an overhead transparency of this map. This process shows most clearly that the general drainage pattern of the Waldron map (Figure 11.6) is an annular drainage pattern (Figure 11.2).

Once students recognize the annular drainage pattern, most of them will reason that the Waldron region must be a structural dome or basin. Most conclude that it is a basin because Ross Mountain, Piney Mountain, and Square Rock Ridge give the impression that the rocks are dipping toward Waldron. Notice how the south sides of Ross and Piney Mountains are steep escarpments, while their north sides resemble gentle dip slopes dipping toward Waldron. Also note that the north side of Square Rock Ridge is a steep escarpment, while its southern side is a more gentle dip slope.

More persistent students with an eye for detail will notice that Waldron also appears to be located on a fold within the "basin." Have these students use a broad felt-tip marking pen (yellow highlighter works best) to trace the path of each of the ridges in the map. The true structure of the region then becomes obvious. **The region is actually a series of plunging folds that trend east-west and northeast-southwest.**

Part 11B: Stream Processes and Landscapes near Voltaire, North Dakota

7. Steams that drained the Lake Scott region as the glaciers melted deposited a wedge of gravel on an inclined surface (they were probably sediment-choked braided streams). However, this region was a more level plain as the glaciers melted, so meandering streams developed and carried the sediment downstream.

8. The oxbow just east of Westgaard Cemetery indicates that the Souris River used to flow through this meander, but the river has now cut through the narrow northern end (neck) of the meander. Thus, the meander changed from a river meander to an oxbow lake.

9. Yes, they are particularly obvious in Figure 11.7 in locations like:
center of the SE ¼ of sec. 35, center of the southern edge of sec. 34,
NE ¼ of sec. 4, and SE ¼ of sec. 5.

10. There are many examples where the meander necks are very narrow and neck-cutoff is imminent. Note examples in the SE ¼ of sec. 35, SE ¼ of sec 34, and NE ¼ of sec. 4.

11a. stream terraces

11b. The terraces are remnants of floodplains developed along the river at past times when the river flowed at different levels. The older, higher terraces are cut by small, modern streams.

11c. The modern floodplain can generally be mapped as forested areas, which are colored green on the topographic map, but appear very dark blue (almost black) in the stereogram. These green and dark blue regions are apparently low-lying flood prone areas upon which crops cannot be profitably planted (because they are too wet or the frequency of flood hazards is too great).

12. This is a yazoo tributary, as illustrated in Figure 11.1C in the lab manual. It probably formed because a small stream could not cross the river terrace between it and the Souris River. Thus, it had to flow northeast along the floodplain (more or less parallel to the river) to a point where it was able to flow across a low portion of the modern Souris River floodplain and enter the river.

13. The marsh seems to be an abandoned yazoo tributary.

14. It was noted at the start of this exercise that glaciers were melting in this region about 11,000–12,000 years ago. Therefore, the discharge of the Souris River was probably greater at that time (and less at this modern time).

Part 11C: Stream Processes and Landscapes near Ennis, Montana

15. Mountains east of the Cedar Creek Alluvial Fan are the source of sediments being transported to the fan.

16a. The stream flows from the NW ¼ of section 26 (on Figure 11.8) to the edge of the mountains in the NW ¼ of section 22 (just one kilometer northeast of Lawton Ranch). This is a distance of about 1.8 miles or 2.9 kilometers. Over this distance, the stream decreases in elevation from 6560 to 6080 feet. This is a difference of 480 feet or 146 meters. Therefore, the stream's gradient is:

480 ft/1.8 miles = **267 feet/mile** or 146 m/2.9 km = **50.3 meters/kilometer**

16b. 600 feet/2.9 miles = **207 feet/mile (about 200 feet per mile)**
183 meters/4.64 km = **39.4 meters/kilometer (about 40 meters/kilometer)**

16c. The river is 4920 feet west of Jeffers in the SW ¼ of section 34 and it is 4840 feet at the lowest labeled contour line it crosses (about 3 miles downstream). So the gradient of Madison River in this map is 80 ft/3 miles, or **26.6 feet/mile (about 5.08 meters/kilometer)**

17a. straight channels
17b. straight channels
17c. braided and meandering channels

18. The mountain stream (Questions 16a, 17a) and streams on the alluvial fan (Questions 16b, 17b) both have a high gradient, so their channels are straight and they erode and transport sediment downhill. The Madison River floodplain is a homogeneous deposit of gravel and sand located at base level of this region, so its channels are sediment-choked (braided streams) and meandering.

19. The mountain stream (Cedar Creek) has a high gradient and high discharge, so it erodes and carries sediment through the mountains. When the stream enters the broad valley, its gradient and discharge decrease rapidly, the stream spreads out into a distributary pattern, and the stream drops its load of sediment to form the alluvial fan. With each successive storm/flood more sediment accumulates on the top and front of the fan.

Part 11D: Rio Grande River Meander Evolution

20. The cutbanks moved downstream and toward the outside of the meanders.

21a. Mexico
21b. USA
21c. These meanders (H and I) got longer and narrower until the river cut across them at their narrowest point (neck cutoff), thus leaving an oxbow lake behind.

22. Meanders here will experience meander cutoff, so an oxbow lake will result.

23. L, M, and N are oxbow lakes that indicate the former locations of meanders. This indicates that meandering and neck cutoff have occurred here for a long time.

24. The meanders have migrated 300–800 meters over the 55 years from 1936–1992, so they migrate at a rate between 5 and 15 meters/year. The data from meanders A–G reveal an average rate of about 500 meters/55 years, or **about 9 meters/year**.

25. A straight channel develops sinuosity that leads to well-developed meanders that migrate downstream and outward (toward the edges of the floodplain). During floods, the river cuts through the neck of some meanders (neck cutoff). This leaves an oxbow lake behind and re-establishes a straight channel.

26. For example: increased discharge, more frequent floods

27. For example: decreased discharge, less frequent floods

Part 11E: Stream Erosion and Mass Wastage at Niagara Falls

28. The falls has retreated about 12 kilometers (1,200,000 cm) in 11,000 years.
So, 1,200,000 cm ÷ 11,000 yr = **109 cm/yr**.

29. Some factors that could speed up the retreat of the falls are:
-increase in river discharge caused by a change to a wetter climate.
-increase in river discharge caused by more frequent episodic discharges of water from dams or factories on the Niagara River or its tributaries.
-slight differences in the composition or fracturing (more fractures) of the bedrock being eroded may make it easier to erode.

30. Some factors that could slow down the retreat of the falls are:
-decrease in river discharge caused by a change to a drier climate.
-decrease in river discharge caused by fewer episodic discharges of water from dams or factories on the Niagara River or its tributaries.
-slight differences in the composition or fracturing (fewer fractures) of the bedrock being eroded may make it more difficult to erode.

31. Based on Question 28, the falls has been retreating at a rate of about 109 cm/year. Also, there are 100,000 cm/km, so 35 km = 3,500,000 cm.

3,500,000 cm ÷ 109 cm/yr = **32,110 yr (or about 32,000 years)**

Part 11F: Flood Hazard Mapping, Assessment, and Risks

32. Refer to completed Figure 11.14 on the next page of this book.

33a. about 0.12 kilometers or 1200 meters
33b. about 1.77 kilometers

34a. Some structures that were underwater during the 1994 flood of Montezuma:

-over 130 homes
-over 25 larger buildings (warehouses, businesses)
-2 churches
-1 water tower (the base of the tower)
-1 radio tower (the base of the tower)
-Felton Cemetery
-Beaver Creek
-the dam and pond at Spring Creek Road
-highway 26/49/90 to Oglethorpe
-highway 224 in Montezuma
-highway 26/90 through Montezuma

34b. All travel to Oglethorpe was ended because both railroads and highway 26/49/90 were flooded.

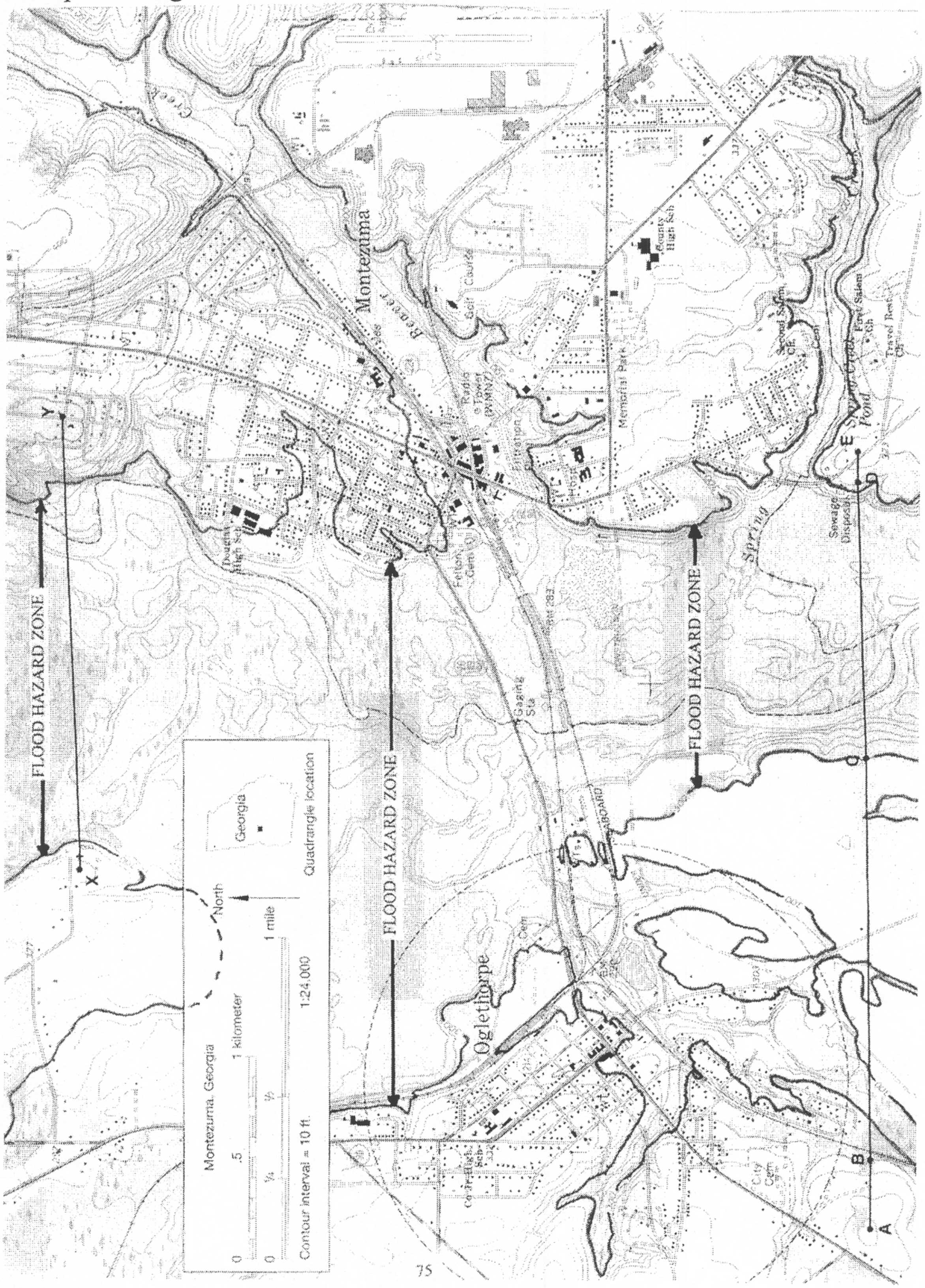
34c. One of the school's buildings was flooded.

34d. Both the filtration plant and the sewage plant were flooded. Sewers backed up. People could not flush their toilets. There were health risks from raw sewage entering the Flint River. People could not drink water from their home faucets (they had to drink bottled water). People could not use their washing machines.

35a. about 278 to 280 feet
35b. about 260 feet
35c. The 1994 flood flooded all parts of this modern floodplain and surely contributed sediment/debris to the floodplain.

35d. Based on answers 35a and 35b, 280 feet is the highest level of the floodplain. Therefore, FEMA's assessment of the flood hazard zone was reasonable until 1994. Since the 1994 flood (and others since 1994), it is clear that floods can occur up to about 300 feet of elevation. Therefore, FEMA should reassess its estimation of the flood hazard zone and revise it to include areas below 300 feet of elevation.

Completed Figure 11.14



35e. The higher floodplain occurs at a level of about 300 feet, which is just a few feet above the level of the 1994 flood (that crested at 297 feet). Therefore, the higher floodplain represents past times when the Flint River has flooded to levels at or above 300 feet. Apparently, all of the floods recorded in historic times for this region were below 300 feet and they only affected continued development of the lower floodplain. Although the 1994 flood did not reach the higher floodplain, it is reasonable to suspect that the higher floodplain is not just a relict from the past. It may be an active floodplain for very rare, major floods that only occur in this region every few hundred years or so.

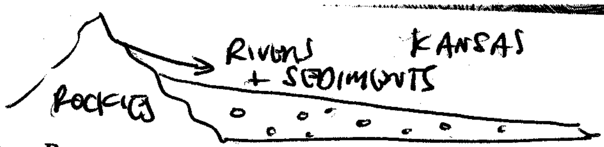
36. The NFIP is the National Flood Insurance Program. It was established by the federal government of the U.S. to provide flood insurance for people who live in flood-prone areas, but cannot buy flood insurance from private companies.

37. Supplies include:

-emergency building materials like plywood, plastic sheets, nails, hammer, saw, pry bar, shovels, sandbags
-corks or stoppers to plug showers, tubs, and basins that may back up as sewers back up
-information about safe routes (above flood level) to disaster relief centers
-flashlights with extra batteries
-portable, battery-operated radio with extra batteries
-first aid kit and manual
-emergency food and water
-nonelectric can opener
-essential medicines
-cash and credit cards
-sturdy shoes and boots
-an emergency communication plan (in case family members get separated)
-flood insurance policy and other important papers stored in a waterproof container or location

38a. -Climb to higher ground and stay there.
-Avoid walking through any flood waters (because swift-moving water only 6 inches, or 15 cm, deep can sweep a person off his/her feet).

38b. -Do not drive through flood waters. If you come to a flooded area, then retreat and go another way. Cars are easily swept away by moving flood waters only 2 feet, or 0.6 meters, deep.
-If your car stalls, then abandon it immediately and climb to higher ground. Do not attempt to move the vehicle.



Still farther downstream, the gradient decreases even more as discharge and load increase. The stream valleys develop very wide, flat floodplains with sinuous channels. These channels may become highly sinuous, or **meandering** (Figures 10.1B, C). Erosion occurs on the outer edge of meanders, which are called **cutbanks.** At the same time, **point bar** deposits accumulate along the inner edge of meanders. Progressive erosion of cutbanks and deposition of point bars makes meanders "migrate" over time.

Channels may cut new paths during floods. This can cut off the outer edge of a meander, abandoning it to become a crescent-shaped **oxbow lake** (Figure 10.1C). When low-gradient/high-discharge streams become overloaded with sediment, they may form **braided stream** patterns. These consist of braided channels with linear, underwater sandbars **(channel bars)** and islands (Figures 10.1B, D).

Some stream valleys have level surfaces that are higher than the present floodplain. These are remnants of older floodplains that have been dissected (cut by younger streams) and are called **stream terraces.** Sometimes several levels of stream terraces may be developed along a stream, resembling steps.

Where a stream enters a lake, ocean, or dry basin, its velocity decreases dramatically. The stream drops its sediment load, which accumulates as a triangular or fan-shaped deposit. In a lake or ocean, such a deposit is called a **delta.** A similar fan-shaped deposit of stream sediment also occurs where a steep-gradient stream abruptly enters a wide level plain, creating an **alluvial fan.**

Questions

1. Refer to the topographic map of the Lake Scott quadrangle, Kansas (Figure 10.3).

   a. Draw and label a dashed line on this map that is the divide between Battendorf Canyon (NE¼ sec. 9) and the smaller canyon that runs from the SW¼ sect. 9 to the "B" in the word "TIMBER" (half mile north of the center of sec. 16).

   SEE MAP

   b. Draw and label a dashed line at the boundary of the Garvin Canyon drainage basin.

   SEE MAP

2. Notice that the upland surface of the Lake Scott, Kansas quadrangle is not horizontal.

   a. In what general direction does water flow over the upland surface?

   b. What is the gradient of this upland surface? (Show your mathematical calculation.)

   $GRAD = \frac{ACL}{H} = \frac{40ft}{1.2mi} = 33.33\frac{ft}{mi}$

   c. The mudstone bedrock of these uplands is overlain by alluvium (sand and gravel) that was deposited about 10,000–12,000 years ago by streams draining from melting glaciers (prior to dissection of the surface as it appears today). It is the upper surface of this alluvium that has the attitude described in **a** and **b** above. What is the probable source area for the water and sediments that formed this alluvial deposit? Explain your reasoning. (*Hint:* Kansas is just east of the Great Divide.)

   THE ROCKIES TO THE WEST

3. Reconsider the uplands and upland alluvium discussed in Question 2. The extensive sheet of upland alluvium was probably deposited by braided streams (Figures 10.1B, D).

   a. What drainage pattern shown in Figure 10.2 is currently developed in this area? DENDRITIC

   b. What does this modern drainage pattern suggest about the attitude of bedrock layers (the mudstone beneath the upland alluvium) in this area? Explain your reasoning.

   SEE p. 176 — RELATIVELY FLAT-LYING

4. Examine the landscape of the Waldron, Arkansas quadrangle (Figure 10.4). What drainage pattern is developed in this area, and what does it suggest about the attitude of bedrock layers in this area? Explain. (*Hint:* Refer to Figure 9.9 and 9.11.)

   ANNULAR – FOLDED DOME ROCKS

PART 2: STREAM PROCESSES AND LANDSCAPES NEAR VOLTAIRE, NORTH DAKOTA

Refer to the Voltaire, North Dakota quadrangle (Figure 10.5) and stereogram (Figure 10.6).

Questions

5. Glaciers (composed of a mixture of ice, gravel, sand, and mud) were present in this region at the end of the Pleistocene Ice Age. When the glaciers melted about 11,000–12,000 years ago, a thick layer of sand and gravel was deposited on top of the bedrock and streams began forming from the glacial meltwater. Therefore, streams have been eroding and shaping this landscape for about 11,000–12,000 years. Notice how well developed the meanders and floodplains of the Souris River are.

   The landscape around Lake Scott, Kansas (Figure 10.3) is about the same age (i.e., 10,000–12,000 years old). What factors might explain the differences in form of the stream valleys of this region and the Lake Scott region?

   SKIP

Questions are continued on page 186.

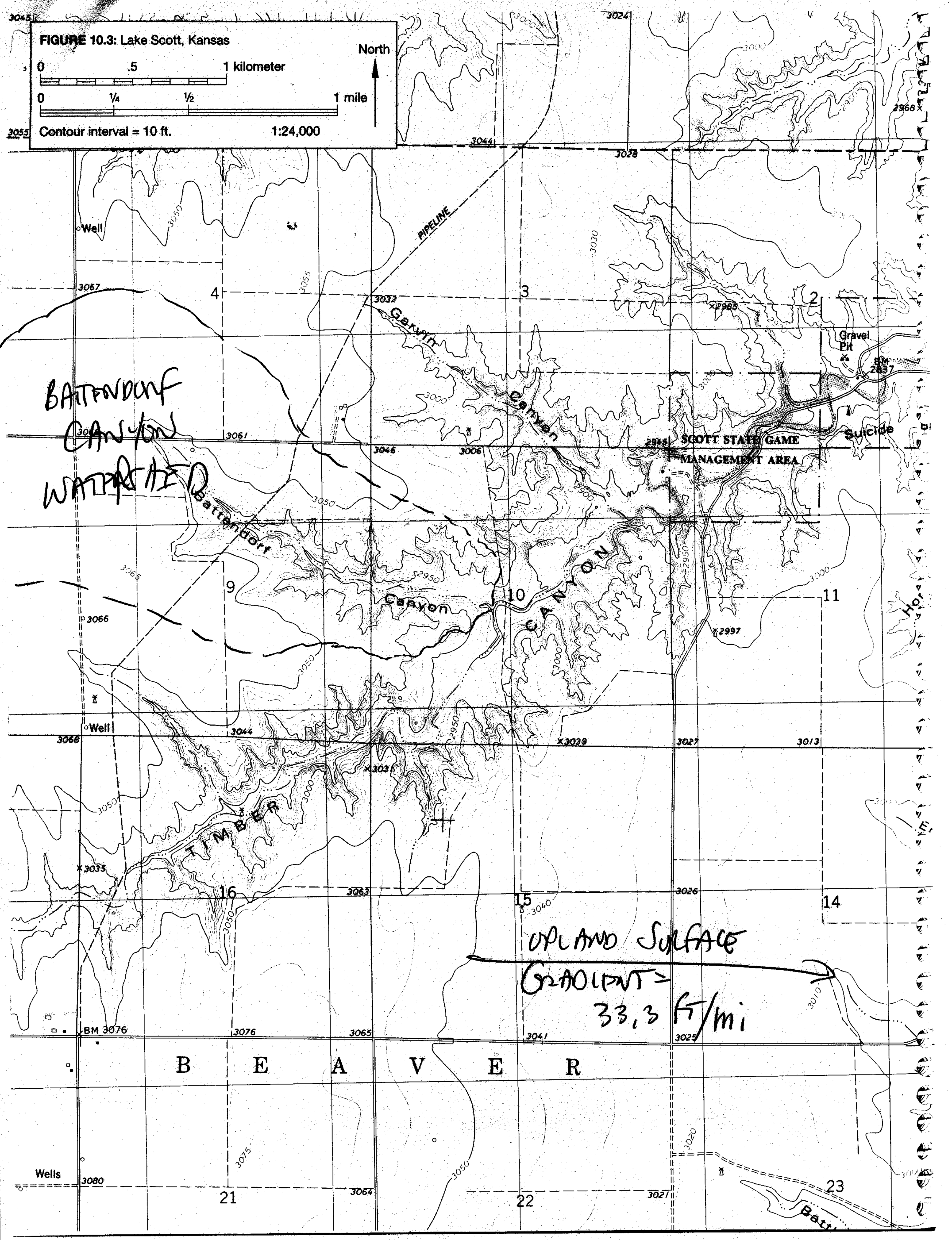
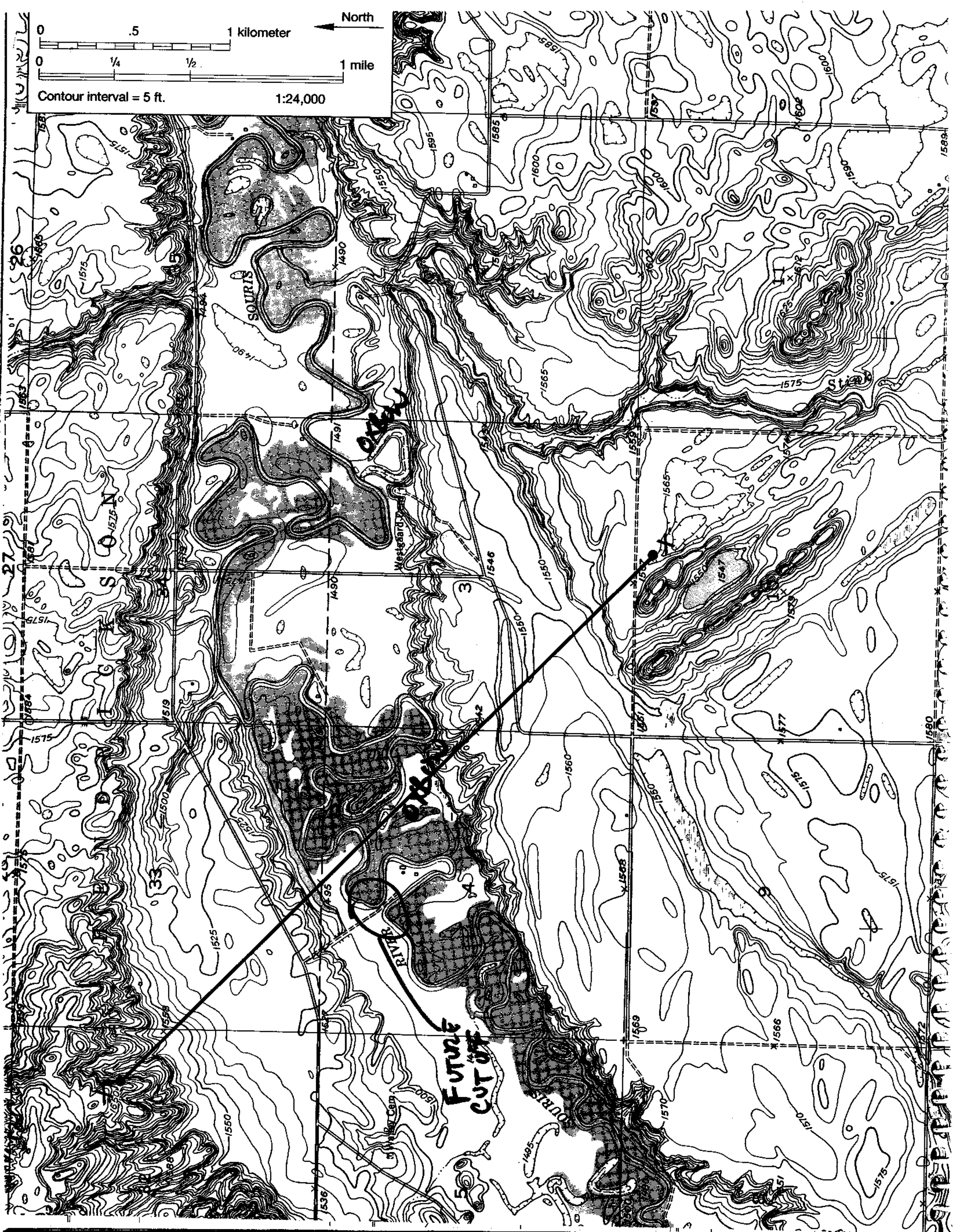
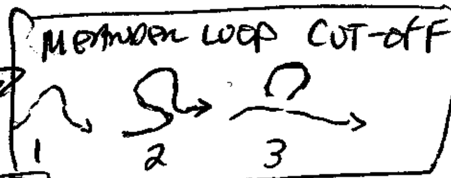


FIGURE 10.3: Lake Scott, Kansas



North
0 .5 1 kilometer
0 1/4 1/2 1 mile
Contour interval = 5 ft.
1:24,000
SOURIS
RIVER
OXBOW
FUTURE CUT OFF
Stink



6. On Figures 10.5 and 10.6, note the swampy oxbow lakes and depressions (hachured contours on Figure 10.5) in the Souris River floodplain. These show that the river channel has changed course repeatedly. Explain how its course has changed at the oxbow just east of Westgaard Cemetery (northeast of map center, NE¼ sect. 3, Figure 10.5).

7. Do the hachured contours and other oxbows of the Souris River Valley show that this same process has occurred elsewhere along the valley? If so, then suggest one location.

YES – MANY OXBOWS SHOWN

8. What is one location along the course of the Souris River where the same thing may happen in the future if the course of the channel is not controlled by engineers?

NORTHWEST CORNER OF SECTION 4

9. Imagine what the topographic profile looks like along X–X′. (Refer to the stereogram in Figure 10.6 to help you with this.) Notice the relatively flat areas of the profile such as those in SW¼ sec. 33 and SE¼ sec. 4 (Figure 10.5).

   a. What are these features called? TERRACES

   b. How did they form? RIVER INCISION/FLOODPLAIN ABANDONMENT

   c. How could vegetation be used to map the location of the modern floodplain?

TREES IN VALLEY BOTTOM – NO FARMING/CROPLAND

10. In SE¼ sec. 3 (Figure 10.5), a stream trends northeast–southeast. What is the name of this type of stream and how did it probably form?

YAZOO TRIBUTARY

11. Notice the marsh in sec. 9 and the depression on which it is located. What was this depression before it became a marsh? YAZOO

12. How might the discharge of the Souris River have changed over the past 12,000 years? Why?

~12,000 YRS = GLACIAL MELTWATER
DISCHARGE HAS DECREASED

PART 3: STREAM PROCESSES AND LANDSCAPES NEAR ENNIS, MONTANA

Some rivers are subject to large floods, either seasonal or periodic. In mountains, this flooding is due to snow melt; in deserts it is caused by thunderstorms. During such times, rivers transport exceptionally large volumes of sediment. This causes characteristic features, two of which are braided (anastomosing) channels and alluvial fans. Both features are relatively common in arid mountainous regions such as the Ennis, Montana area in Figures 10.7 and 10.8. (Both features also can occur wherever conditions are right, even at construction sites!)

Questions

13. What was the source of the sediments that have accumulated on the Cedar Creek Alluvial Fan?

CREEK IN MOUNTAINS EAST OF LAWTON RANCH

14. What is the approximate stream gradient of:

   a. The main stream in the forested southeastern corner of the map (Figure 10.7) and stereogram (Figure 10.8)? GRAD = 200 ft/0.8 mi = 250 ft/mi

   b. Most streams on the Cedar Creek Alluvial Fan? GRAD. = 400 ft/1.9 mi = 210 ft/mi

   c. The Madison River? GRAD = 40 ft/1 mi = 40 ft/mi

15. What drainage patterns (shown in Figure 10.2) are present on:

   a. The forested southeastern corner of the stereogram (Figure 10.8)? DENDRITIC/STRAIGHT

   b. The Cedar Creek Alluvial Fan? DISTRIBUTARY

   c. The valley of the Madison River (northwestern portion of Figure 10.7)? BRAIDED

16. How are the stream gradients and drainage patterns described above (Questions 14 and 15) related? WITH ∠ GRADIENT, TRANSITION FROM STRAIGHT TO BRAIDED

17. How did the Cedar Creek Alluvial Fan form?

SEDIMENTS DEPOSITED AT MOUTH OF RIVER CANYON

PART 4: STREAM EROSION AND MASS WASTAGE AT NIAGARA FALLS

Mass wastage is the downslope movement of Earth materials such as soil, rock, and other debris. It is common along steep slopes such as those created where rivers cut into the land. Some mass wastage occurs along the steep slopes of the river valleys. However, mass wastage can also occur in the bed of the river itself, as it does at Niagara Falls.

The Niagara River flows from Lake Erie to Lake Ontario (Figure 10.9). The gorge of the Niagara presents good evidence of the erosion of a caprock falls, Niagara Falls (Figure 10.10). The edge of the falls is composed of the resistant Lockport Dolostone. The retreat of the falls is due to undercutting of mudstones that support the Lockport Dolostone. Water cascading from the lip of the falls enters the plunge pool with tremendous force, and the turbulent water easily erodes the soft mudstones. With the erosion of the mudstones, the Lockport Dolostone collapses.

Questions

18. Geologic evidence indicates that the Niagara River began to cut its gorge about 11,000 years ago as the Laurentide Ice Sheet retreated from the

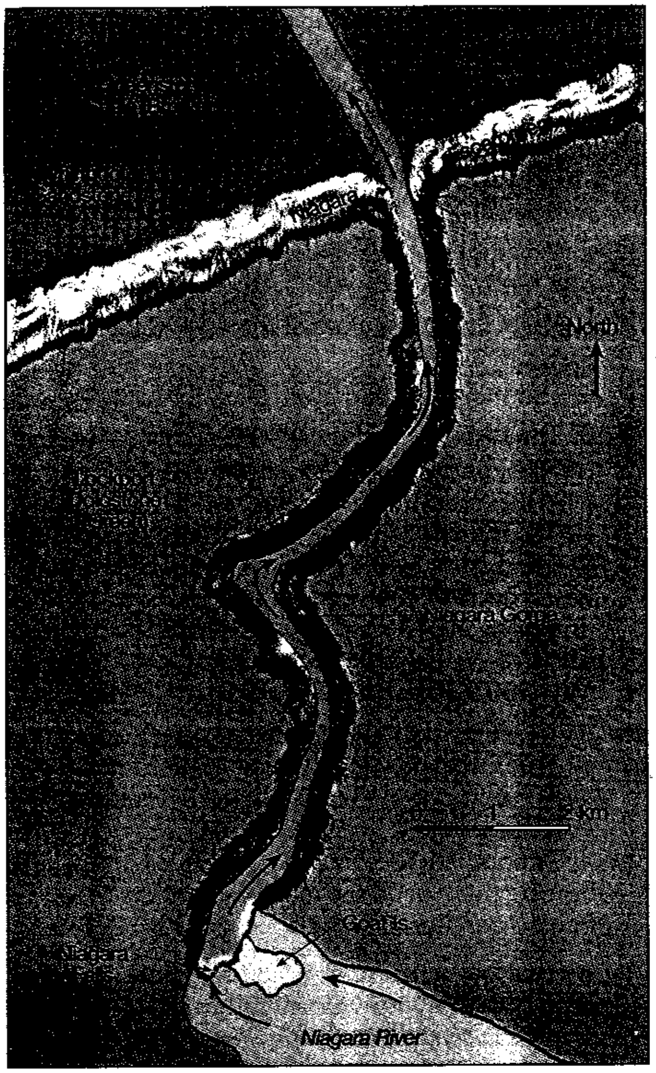


FIGURE 10.9 Map of the Niagara Gorge region of Canada and the United States.

(hint use dist. from escarpment to present falls)

area. It started at the Niagara Escarpment (Figure 10.9). Based on this geochronology and the length of the gorge, calculate the average rate of falls retreat in cm/year. $\frac{(12\,km)(1000\,m/km)(100\,cm/m)}{11{,}000\,YR} = 109\,cm/YR$

(19.) Name some factors that could cause the falls to retreat at a faster rate. CHANGE IN DISCHARGE, CHANGE IN ROCK RESISTANCE

(20.) Name some factors that could cause the falls to retreat more slowly. DECREASE DISCHARGE, INCREASE ROCK RESISTANCE

(21.) Niagara Falls is about 35 km north of Lake Erie, and it is retreating southward. If the falls were to continue its retreat at the average rate calculated in Question 18, how many years from now would the falls reach Lake Erie?

RETREAT RATE = 12km/11,000yrs

$35\,km\left(\frac{11{,}000\,yr}{12\,km}\right) = 32{,}083$ YEARS

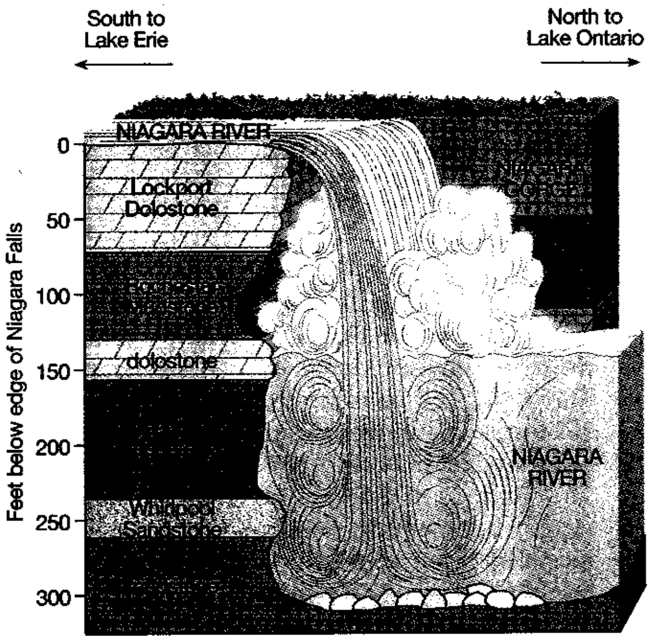


FIGURE 10.10 Schematic of Niagara Falls and geologic units of the Niagara escarpment.

PART 5: FLOOD HAZARD MAPPING, ASSESSMENT, AND RISKS

The water level and discharge of a river fluctuates from day to day, week to week, and month to month. These changes are measured at *gaging stations*, with a permanent water-level indicator and recorder. On a typical August day in downtown St. Louis, Missouri, the Mississippi River normally has a discharge of about 130,000 cubic feet of water per second and water levels well below the boat docks and concrete *levees* (retaining walls). However, at the peak of an historic 1993 flood, the river discharged more than 1 million cubic feet of water per second (eight times the normal amount), swept away docks, and reached water levels at the very edge of the highest levees.

When the water level of a river is below the river's banks, the river is at a **normal stage.** When the water level is even with the banks, the river is at **bankfull stage.** And when the water level exceeds (overflows) the banks, the river is at a **flood stage.**

Early in July 1994, Tropical Storm Alberto entered Georgia and remained in a fixed position for several days. More than 20 inches of rain fell in southeastern Georgia over those three days and caused severe flooding along the Flint and Ocmulgee Rivers. Montezuma was one of the towns along the Flint River that was flooded.

This question is designed for you to map and assess the extent of flooding that occurred at Montezuma based on river gauge records and a 7½-minute quadrangle map (Figure 10.11). You will then use your map to discuss flood damage, hazards, and risks in Montezuma.

Questions

22. On Figure 10.11, locate the gaging station along the east side of the Flint River near the center of the map, between Montezuma and Oglethorpe. The gaging station is located at an elevation of 262 feet, and the river is considered to be at flood stage when it is 20 feet above this level (282 ft). The old flood record was 27 feet above the gaging station, but the July 1994 flood established a new record of 35 feet above the gaging station, or 297 feet above sea level. Trace the imaginary contour line for this elevation on both sides of the Flint River on Figure 10.11. The line will be just below the 300-foot contour line that is already drawn on the map. Label the area within these contours (land areas lower than 297 ft) as the Flood Hazard Zone for the 1994 event.

23. Notice line X–Y near the top center part of the map (Figure 10.11).

a. What is the width of the Flint River along this line when the river is at a normal stage? 0.1 Km

b. What was the width of the river along this line when it was at maximum flood stage (297 ft) during the July 1994 flood? 1.7 Km

24. Assess the damage caused by the July 1994 flood.

a. Describe the features/structures that were under water in Montezuma during the flood. These are things like roads, homes, schools, cemeteries, and railroads. SIGNIFICANT ROADS, HOMES

b. How was travel between Oglethorpe and Montezuma affected during the 1994 flood? FLOODED HWY RT 29

c. How was Douglas High School affected by the flood? JUST ABOVE FLOOD LEVEL

d. Locate the Filtration Plant (for drinking water) and the Sewage Disposal plant for Montezuma. How did the 1994 flood affect these plants, and what effect do you think this had on the citizens of Montezuma?

BOTH WERE FLOODED = DRINKING WATER + SANITATION PROBLEMS

25. The floodplain of the Flint River is bounded by steep slopes that are eroded during severe floods. You can determine the edge of the floodplain as the point where the relatively flat floodplain (with more widely spaced contour lines) meets the steep walls of the valley (with closely spaced contour lines).

a. What is the elevation of the floodplain along line X-Y? ~280–290 ft

b. What is the elevation of the floodplain along line A–E? ~240–230

c. Did the 1994 flood leave the floodplain? YES

d. The Federal Emergency Management Agency (FEMA) published a map of Montezuma in April 1996 that showed areas where a flood hazard exists. The FEMA flood hazard zone is essentially the land areas below about 280 feet of elevation. Based on your answers in **a** and **b** above, do you think that FEMA's assessment of the flood hazard zone is reasonable, should include areas of higher elevation, or should include areas of lower elevation? Explain your reasoning. UNDERESTIMATED

e. The floodplain along line A–E seems to have two levels: a high level along line B–C and a lower level along line C–D. Explain how these two floodplain levels probably formed and what bearing this has on the magnitude of the 1994 flood (*Hint:* Recall Part 2, Questions 5–12). TERRACE = HIGH LEVEL FLOODPLAIN = LOW

Use Internet resources to help you complete the items below and reduce your vulnerability to flood hazards. Refer to the *Laboratory Manual in Physical Geology* home page as needed, **www.prenhall.com/agi**

26. What is the NFIP, and why was it established by the U.S. Congress? **(http://www.fema.gov/nfip/)**

27. If you live in an area that is prone to flooding, then what disaster supplies should you keep on hand? **(http://www.fema.gov)**

28. What should you do if severe flooding occurs in your area while you are

a. Outdoors?

b. Driving in your car?

SEE ATTACHED WEB LINKS FOR INTERNET EXERCISE

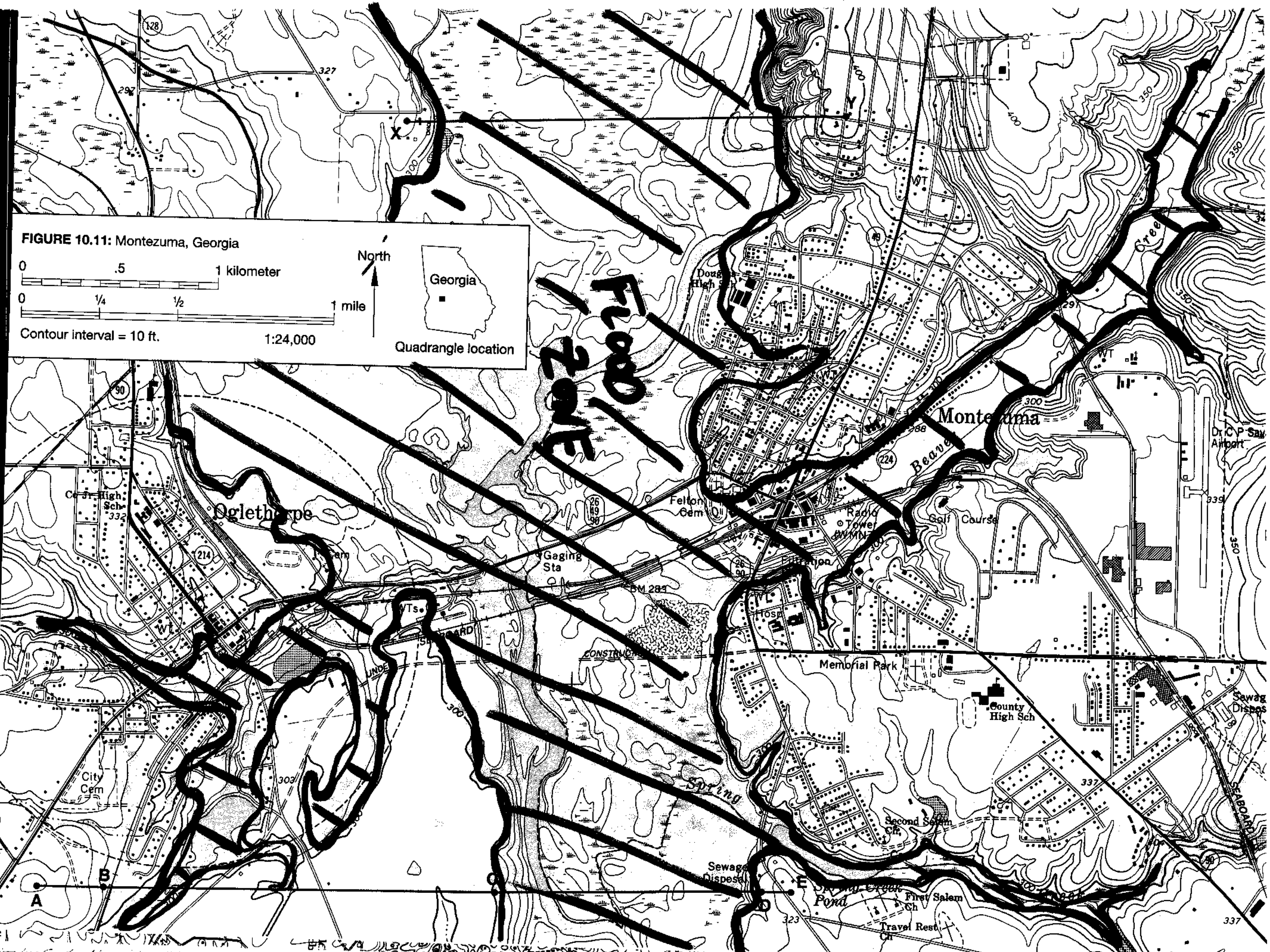


FIGURE 10.11: Montezuma, Georgia
0
.5
1 kilometer
0
1/4
1/2
1 mile
Contour interval = 10 ft.
1:24,000
North
Georgia
Quadrangle location
FLOOD ZONE
Montezuma
Oglethorpe
Memorial Park
County High Sch
Golf Course
Radio Tower
Felton Cem
Gaging Sta
Spring
Beaver
Creek
Second Salem Ch
First Salem Ch
Travel Rest Ch
Sewage Disposal
City Cem
Airport
SEABOARD
A
B
C
D
E
X
Y