FLOODPLAIN MANAGEMENT STUDY
BRADLEY RUN WATERSHED

Prepared By

STATE OF MARYLAND

DEPARTMENT OF NATURAL RESOURCES

WATER RESOURCES ADMINISTRATION

FLOOD MANAGEMENT DIVISION

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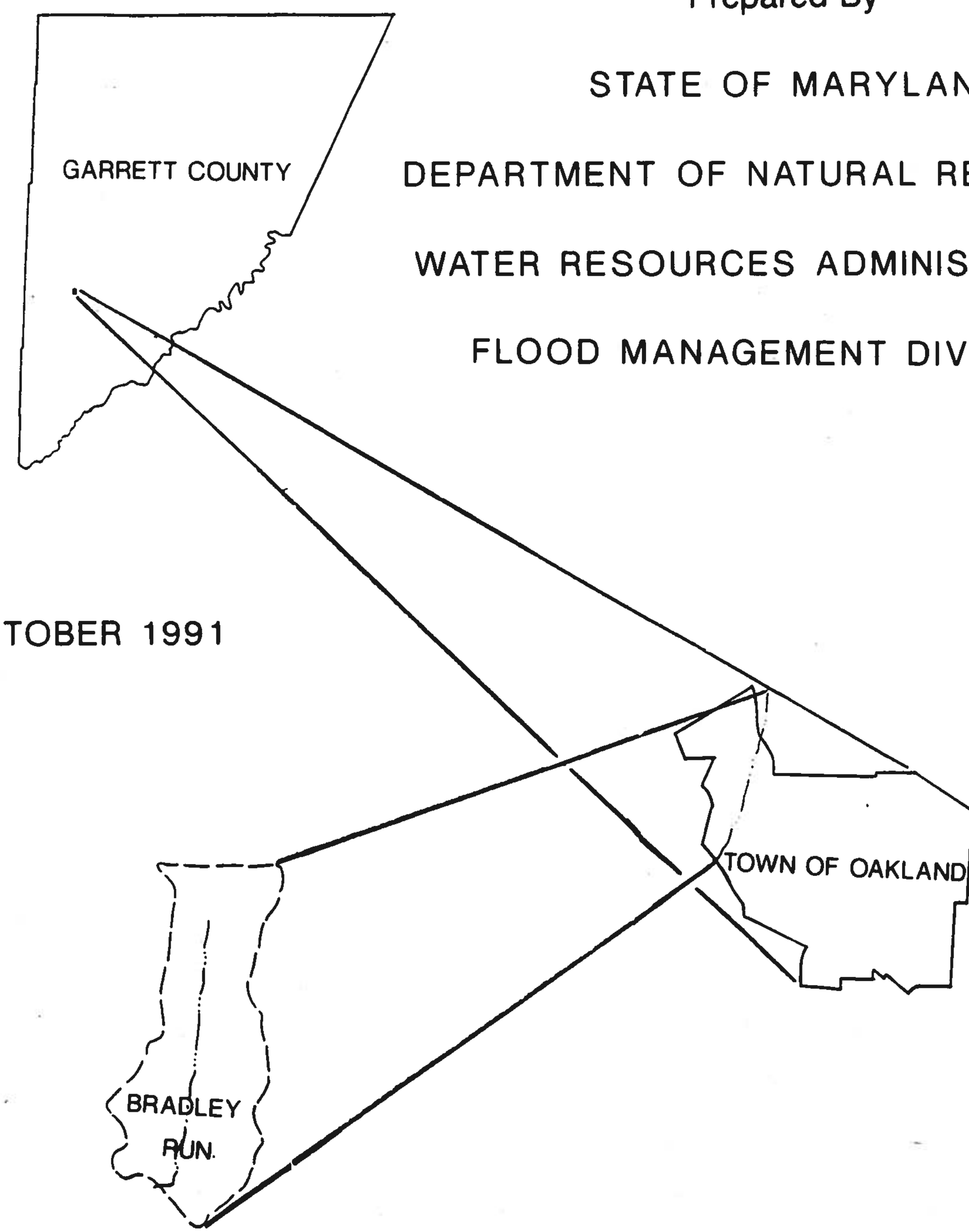

BRADLEY RUN FLOOD MANAGEMENT STUDY

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CHAPTER I

INTRODUCTION/GENERAL INFORMATION

The Flood Hazard Management Act of 1976 gave the Water Resources Administration authority to establish a statewide flood management program. This authority allows the Administration to designate priority watersheds, perform watershed studies, approve flood management plans and administer a flood management grant program. The objective of the program is to lessen the impacts caused by flooding by implementing flood management plans and projects. Projects may consist of acquisition of flood-prone buildings, construction of structural measures, or administrative controls. Partial funding may be provided through the State's Flood Management Grant Program. Non-structural projects such as acquisition are preferred although structural measures are eligible for funding.

This report contains the results of the Flood Management Study for the Bradley Run Watershed. The study was performed by the Department of Natural Resources, Water Resources Administration as a result of requests by both the Town of Oakland and Garrett County.

A. OBJECTIVES OF THE STUDY

The objectives of the study are to delineate the floodplain, to identify problem areas, to aid local management, and to evaluate a range of alternatives for reducing flood hazards and damage. The results will produce data to form the basis for a flood management plan. The plan is to be developed and implemented by the Town of Oakland and Garrett County. It will serve to correct existing flood problems and to avoid the increase of flood damage in the future. The information from the study may be used to analyze the effects of proposed roads, bridges, stormwater management structures, land use changes, etc. on existing flood-prone areas.

B. LOCATION/DESCRIPTION OF THE WATERSHED

Bradley Run, a tributary of the Little Youghiogheny River, is located in southwestern Garrett County. Most of the watershed is within the Town of Oakland. The drainage area of the Bradley Run Watershed is 1.014 square miles. It consists of 310 acres of forest, 277 acres of open space, and 62 acres of development. The lower watershed is comprised of wetlands, residential, open space, and forested areas. The upper watershed is comprised of open space and forested areas.

C. FLOOD HISTORY

The main area of historic flooding is located in the lower watershed from the CSX Railroad upstream to Fairway Drive (Figure 8). At West Liberty Street, one structure and the road have experienced flooding from Bradley Run and/or the Little Youghiogheny. At Fairway Drive, the road and some residential basements have experienced flooding. Basement flooding is caused by floodwater entering through poorly designed and located drains. The flooding of the roads eliminates emergency access for those persons living on the west side of the stream. The location and design of both roads allow frequent inundation.

The flooding caused by backwater from the Little Youghiogheny River was not separately addressed by this study. The reasons include: no realistic alternative exists for relief of backwater flooding on Bradley Run caused by the Little Youghiogheny; and the Bradley Run floodplain encompasses an area greater than that flooded by the Little Youghiogheny. Any selected alternative implemented for Bradley Run will suffer no adverse impacts as a result of backwater from the Little Youghiogheny.

D. DEVELOPMENT PRESENT/FUTURE

Presently developed areas are located within the lower watershed. Existing development is mostly residential, varying in density from townhouses to single family dwellings, although some commercial properties exist. Future development may be limited due to the steep topographical features of the watershed. A large portion of the undeveloped area is occupied by the Oakland Country Club's golf course, which will likely remain in an open space environment. If the watershed is developed to maximum allowable density, the impacts caused by flood waters are likely to be greatly increased.

E. PREVIOUS STUDIES

Prior to this study, the watershed was partially analyzed by both the Federal Insurance Administration (reference 1) and the Water Resources Administration (WRA)(reference 2). Both studies analyzed the flooding problem on a limited basis. It was subsequently determined that an indepth study was necessary to fully address the flooding problems.

CHAPTER II
TECHNICAL RESULTS

A. HYDROLOGY

The storm runoff for the watershed was calculated using the SCS TR-20 computer program (reference 3). The procedures used are explained in NEH-4 (reference 4). Variables considered in this methodology are drainage areas, runoff curve numbers, times of concentration, reach routing tables, structure properties, and rainfall. Explanations of these variables follow, with numerical data tabulated by subwatershed in Figures 5 and 6.

Drainage Areas (DA)

Drainage area is the measurement of the size of a subwatershed in acres or square miles. The Bradley Run watershed was delineated on the U.S.G.S. quadrangle map (reference 5). Area was calculated by use of a grid dot system. The Bradley Run watershed was divided into two subwatersheds which are shown in Figure 1.

Time of Concentration (Tc)

Time of Concentration (Tc) is described as the longest time of flow from a watershed boundary to the lower end of the watershed. The flow path naturally consists of a combination of overland (sheet), swale (shallow concentrated), and channel flows. In developed areas, closed systems such as storm drains and culverts may replace the entire natural system. Existing and ultimate condition Tc were calculated for the watershed.

Tc flow paths were delineated and measured on the quadrangle map for all types of flow. Actual limitations of the flow paths were determined by a combination of field inspection, slopes, vegetative cover type, and experience.

Overland or sheet flow is described as flow over plane surfaces. A mean flow depth of .002' for paved areas to .02' for vegetated areas is applicable. Times were calculated using the Manning-Kinematic formula as described in SCS Technical Note, Hydrology N4 (reference 6). This methodology uses a combination of surface roughness, slope, rainfall, and flow length to determine Tc for the overland segment. Surface roughness was determined through field investigations for existing conditions. Slope was calculated from quadrangle maps. Rainfall was obtained from TP-40 (reference 7) for all storm events. Flow length was determined from field inspection, steepness of slopes, and experience. For ultimate development, surface roughness was adjusted for zoning (i.e., commercial = paved) with the other values unchanged.

Swale or shallow concentrated flow occurs in depressions or low areas during storms, but is otherwise absent. If a defined channel exists, the reach should not be considered a swale flow area. Velocity for swale areas was calculated using figure 1 in reference 6.

Channel flows occur where a defined channel is evident, such as ditches, streams, or structural drainageways. Channels may be defined in specific terms of top width, depth, cross sectional area, perimeter, slope, and surface roughness. Flow velocities are then calculated by use of Mannings Equation, HEC-2, or other acceptable methods. Velocities were calculated by applying Manning's equation to field measured channel sections. Tc is calculated by dividing the flow length by the computed velocity.

Total Tc for each subwatershed is calculated by adding the times for all of the flow paths. Results are listed in Figures 5 and 6.

Runoff Curve Numbers (RCN)

Runoff Curve Number is described as the runoff potential of a combination of soil and cover (land use) when the soil is not frozen. The higher the RCN, the higher the runoff from a given amount of rainfall. RCN's were calculated by using a combination of data from the SCS Soil Survey for Garrett County (reference 8), quadrangle maps, field observations, and local zoning maps (reference 9).

Soil types can be used as an indicator of the permeability of the ground surface and the water infiltration rates of the subsoils. The SCS has grouped all soil types into four hydrologic groups based on their permeability and infiltration as follow:

Group A - (low runoff potential) Soils having high infiltration rates when thoroughly wetted and consisting of deep, well to excessively drained sand or gravels. These soils have a high rate of water transmission.

Group B - Soils having moderate infiltration rate when thoroughly wetted and consisting chiefly of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission.

Group C - Soils having slow infiltration rates when thoroughly wetted and consisting chiefly of soils having a layer that impedes downward movement of water, or soils with moderately fine to fine texture. These soils have a slow rate of water transmission.

Group D - (high runoff potential) Soils having very slow infiltration when thoroughly wetted and consisting chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a clay pan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very slow rate of water transmission.

Land use is an indicator of the cover condition of the ground surface throughout the watershed. Industrial land use implies a large amount of impervious area, therefore, high runoff. "Open" land use (woods, parks, meadow, etc.) implies an absence of impervious areas, therefore, lower runoff. The general land use categories used in the Bradley Run model were: forest, open, half-acre lots, townhouses, and industrial/business.

Both present and ultimate land use were analyzed for the purpose of this study. Present land use (Figure 3) was determined from a combination of quad maps and field observations. Ultimate land use was considered to be development to maximum density in accordance with existing zoning (Figure 4).

Soil groups C and D were delineated on soil maps from the SCS Soil Survey of Garrett County. Soils in groups A and B are not present within the watershed.

Land use and soil groups were combined to calculate a weighted percentage for each subwatershed. Using these calculated values and the appropriate general RCN, weighted RCNs were calculated. Results are listed in Figures 5 and 6.

GENERAL RUNOFF CURVE NUMBERS
existing conditions

Land Use	Hydrologic Soil Group C	D
Forest	70	77
Open Space	74	80
Half-Acre Lots	80	85
Townhouses	90	92
Industrial/Business	93	94

GENERAL RUNOFF CURVE NUMBERS
ultimate conditions

Land Use/Symbol	Hydrologic Soil Group C	D
Open Space/OS Environmental Protection/EP	74	80
Suburban Residential/SR Town Residential/TR	90	92
Commercial/C Employment Center/EC	90	92

Rainfall

Rainfall data were obtained from TP-40 for the 2, 10, and 100-year events. This information is based upon analysis of rainfall gages within a region. Rainfall amounts were not reduced by an areal distribution factor. Rainfall amounts used for the analysis are 2.8" (2-year), 4.3" (10-year), and 5.9" (100-year).

There are no recording rainfall gages in the Bradley Run watershed. A non-recording gage is located in the Oakland area. Therefore, actual storm data are suspect with reference to distribution and amounts.

Antecedent Moisture Condition (AMC)

Antecedent moisture condition is the representation of the amount of moisture in the soil at the beginning of the rainfall event. AMC II is applied to all design storms. Modeling of actual events should reflect the AMC for that specific storm, a critical step when attempting to calibrate hydrologic models.

Rating Table

A rating table relates water surface elevation to discharge (cfs), and cross-sectional area (sq.ft.) for a range of discharges. These tables are used in the TR-20 model for routing a calculated runoff through a reach. This accounts for travel time and reduction of peak discharge due to available flood storage within the reach.

Rating tables for this study were developed by inputting various discharges into the HEC-2 computer model (see Hydraulics). The output was reviewed and values for discharge, elevation, and cross-sectional area were selected for use.

Structures

The TR-20 model can route a hydrograph through any structure which stores water, such as a dam or roadway embankment, given a storage versus discharge relationship (structure table). Only one structure within the Bradley Run watershed has sufficient storage capacity to reduce peak flows. The structure consists of the CSX Railroad embankment with an undersized culvert. The structure table was developed using field surveyed topography to determine storage. Procedures in HDS-5 (reference 10) were used to determine the elevation/discharge curve for the culvert.

Special Investigations

The WRA performed a topographic survey of the Bradley Run stream valley from the CSX Railroad to 1,320 feet upstream of Fairway Drive. The survey data were used to produce a topographic map at a scale of 1" = 100' with contour intervals of one foot. The map was used to measure available flood storage for use in the hydrologic analysis. The final floodplain boundaries for existing development conditions were delineated on the map (Figure 8).

Calibration

Ideally, the results of hydrologic models should be compared with data gathered from actual flood events. This is usually accomplished using data recorded by stream and rainfall gages located within the study watershed. Bradley Run has neither recording stream nor rainfall gages within the watershed. Although a non-recording rain gage is located in the Oakland area, the absence of actual flood information makes calibration by this method impossible.

An alternative method for calibration is to compare the watershed in question with known events in similar watersheds. Comparison watersheds must be similar in all aspects, including size, shape, land use, geography, etc.

The only gaged watershed that is sufficiently similar to Bradley Run is Sand Run, located in southern Garrett County. It has two tributaries which are gaged, the North Fork with a drainage area of 1.9 square miles, and the South Fork with a drainage area of 1.5 square miles. These areas are mostly forested with some open space and strip mines. Due to the presence of the mining operations, the gage records are suspect, and this method of calibration was not attempted.

B. HYDRAULICS

Water surface profiles were computed using the HEC-2 computer program (reference 11). The program uses a procedure referred to as the Standard Step Method which balances energy between cross sections, accounting for energy losses in the process. The losses considered are friction losses, transition losses, and losses at structures. The procedures are explained in Volume 6 of Hydrologic Engineering Methods for Water Resources Development (reference 12).

The HEC-2 program requires input of certain basic data: stream cross sections; bridge/culvert geometry; roughness coefficients; and discharges. Explanations of the variables follow and the results are tabulated in Tables 1 and 2.

Cross Section Data

Cross sections are located where changes in hydraulic properties occur, such as slope, structures, roughness, and constrictions or expansions. The distance between sections is normally less than 1000'. Greater distances are used in rural areas where accuracy is less important. Closer spacing is necessary in developed or developing areas. Section locations along Bradley Run are shown on the maps in Figure 8. Cross sections were field surveyed by the Water Resources Administration or measured from topographic maps. All elevations are based on the National Geodetic Vertical Datum of 1929 (NGVD).

Culvert Data

All stream crossings in the watershed are either box or circular culverts. Data for the crossings were gathered through field surveys and observation.

Mannings "n" Values

Mannings "n" Values are used to determine friction losses through the stream reaches. The values were determined by field observation throughout the Bradley Run watershed. The basis for the selection is explained in NEH-5 (reference 13), Water Supply Paper 1849 (reference 14), and FHWA-TS-84-204 (reference 15).

Discharges

Discharges were obtained from the TR-20 results for the 2, 10, and 100-year events. These values were input in the HEC-2 model to develop final water surface profiles shown in Figure 9.

Calibration

Calibration of the HEC-2 model normally involves matching observed versus computed water surface elevations for known discharges. Obtaining discharges for actual events for Bradley Run is unlikely due to the absence of a stream gage. One procedure for ungaged areas is to use a structure which controls the flow, in this case the CSX Railroad embankment. The purpose is to estimate a discharge by computing a stage-storage-discharge curve. An observed flood elevation is used to select an associated discharge from the curve. This discharge is input in the hydraulic model to determine the accuracy of the model. However, due to the absence of actual flood data, calibration was not attempted.

Chapter III
FLOOD MANAGEMENT ALTERNATIVES

A. PRELIMINARY INVESTIGATIONS

The initial step in evaluating flood management alternatives is to determine the extent of potential flooding. The next step is to select alternatives that may correct or lessen the flood problems. This forms a list from which alternatives are selected for detailed analysis.

Extent of Flooding

The flood-prone area as determined by this study is extensive with respect to total watershed size. The main flood-prone area is located from the CSX Railroad embankment upstream to Fairway Drive. The primary cause of the flooding is the undersized culvert under the Railroad. This results in the backup of floodwaters even during frequent events. Seven buildings are predicted to be flooded during the 100-year event. The flooded structures consist of three houses, two mobile homes, a garage, and a commercial property. Two roads are flooded by all events greater than the 2-year flood, due to undersized culverts. One residence is surrounded by flood water, but appears unlikely to experience structural flooding. Other areas impacted by floodwaters are the Oakland Country Club's golf course and Bradley Lane.

Considered Alternatives

The alternatives considered but not chosen for detailed analysis were: floodproofing; retention structures; detention structures; channelization; flood warning; flood insurance; and levee/dikes. The chosen alternatives are covered in detail in the next section of the report.

The structural alternatives mentioned above were considered inappropriate because of the causes and location of flooding with respect to the stream. Specifically these alternatives were not chosen for the following reasons:

- floodproofing - must be physically installed before the flood occurs; insufficient warning time for installati on; may consider the use of backflow valves to prevent basement flooding

- retention and detention structures - lack of appropriate site locations; does not relieve backwater flooding caused by the Little Youghiogheny or the CSX Railroad embankment constriction

- channelization - negative impacts on existing stream habitat; lack of construction area due to structure locations; does not relieve backwater flooding caused by the Little Youghiogheny or the CSX Railroad embankment constriction

- levees/dikes - lack of sufficient area for construction.

The non-structural alternatives mentioned were inappropriate because of the following reasons:

- flood warning - the watershed is too small for acceptable warning times

- flood insurance - although it will relieve some financial burden caused by flood-related damages, it does nothing to correct the problems.

B. ANALYSIS OF SELECTED ALTERNATIVES

The alternatives selected for detailed analyses were reviewed for costs, benefits, flood and environmental impacts, and any other applicable items. Certain cost figures were based on Means' cost data (reference 16). The Little Youghiogheny backwater (elevation 2370 NGVD) as per the Flood Insurance Rate Map floodplain delineation (reference 1) was considered the limiting factor with respect to the floodplain reduction of Bradley Run. All areas removed from the Bradley Run floodplain by an alternative will also be out of the Little Youghiogheny floodplain. Any area below elevation 2370 would remain within the 100-year floodplain of both streams. The alternatives and data are as follow.

Enlarge CSX Railroad Culvert

The existing culvert is only 3' x 6', which causes upstream ponding even during the 2-year event. Replacement of this culvert appears to be necessary if any alternative is to succeed. If replacement is undertaken, the design should allow passage of the 100-year event at a maximum headwater elevation equal to that of the 100-year flood elevation of the Little Youghiogheny River.

The approximate size of a replacement structure should be equivalent to twin 12' x 6' box culverts. This would decrease the 100-year water surface approximately 4.6' below the existing flood level and would remove five structures from the Bradley Run floodplain. West Liberty Street and Fairway Drive would remain impassable during the 2-year flood and greater.

ESTIMATED COST:

Box Culverts (4-6' x 6' boxes, 52' long)	$46,000
Riprap (390 cu. yds.)	8,400
Tunneling/Jacking ($1500/L.F.)	78,000
subtotal	$132,400
Contingencies, Engineering, & Design 21%	27,800
total	$160,204

Elevate West Liberty Street

Elevating the existing roadway would provide flood-free access for emergency vehicles and residents. The additional right of way for the road improvement would require purchasing existing structures and property. The fill required to elevate the roadway 10 feet would increase flooding due to lost flood storage which would have to be mitigated by excavating an equivalent volume from the floodplain. This alternative would only provide improved access, with other flood problems remaining uncorrected.

ESTIMATED COST:

Box Culvert (6' x 6' box, 87' long)	$ 19,140
Embankment Fill (13,392 cu. yds.)	174,100
Paving (3903 sq. yds.)	55,300
Seeding (41,170 sq. ft.)	10,500
Guard Rail (2342 L.F.)	13,500
Sediment Control (silt fence)	7,000
subtotal	$279,540
Contingencies, Engineering,	

& Design 21%	59,753
total	$339,293

Cost for mitigating impacts of floodplain fill:

Excavation (13,392 cu. yds.)	$135,125
Seeding (90,395 sq. ft.)	23,020
subtotal	$158,145
Contingencies, Engineering,& Design 21%	33,210
total	$191,355
total project cost	$530,648*

* Does not include costs of acquisition of four structures and removal of two mobile homes.

Elevate Fairway Drive

Elevating and relocating the existing roadway would provide access for emergency vehicles and residents. Two alternatives were considered: (1) extending the east roadway straight across the stream to West Liberty Street; and (2) extending the west roadway across the stream joining the east roadway outside the floodplain. Either alternative could be constructed without impacting existing flood elevations. The extensive fill required by alternative 1 would be less desirable, therefore, the following cost estimate is for alternative 2. Both alternatives would only provide access, with other flood problems remaining uncorrected.

ESTIMATED COST:

Box Culverts (4-12' x 8', 60' long)	$111,600
Riprap (390 cu. yds.)	8,400
Embankment Fill (2581 cu. yds.)	33,600
Paving (2743 sq. yds.)	38,800
Seeding (13,700 sq. ft.)	3,500
Guard Rail (600 ft.)	3,500
Sediment Control (1526 ft.)	4,600
	$204,000

Contingencies, Engineering,

& Design 21%	42,840
	$246,840

Acquire Flood-Prone Properties

Acquisition is generally considered the most desirable form of flood management when applicable. The benefits are permanent elimination of flood damage, elimination of most risks to safety, increase in open space, minimal maintenance, increased flood storage, and absence of negative environmental impacts. In order to eliminate the most significant problem, six structures would need to be removed from the Bradley Run floodplain. Four buildings should be acquired and moved or demolished, and two mobile homes should be moved. The total acquisition costs would be the appraisal value plus demolition and stabilization for four structures, and the property costs plus removal of the two mobile homes. This alternative would not alleviate access problems during floods.

The locations of the impacted structures and the mobile homes are shown on Figure 8 by letter (A through F). The cumulative 1989 assessed value of these structures, as supplied by Garrett County Planning and Zoning is $132,500. Although actual costs would be based on appraisals, this figure provides some measure of the expected cost of this alternative.

Administrative Controls

Preventing increases in flooding and related damage through zoning is vital to any alternative. Less dense zoning may prevent increases in flooding associated with future development. Restriction of floodplain uses to those not susceptible to significant damage is critical to good flood management. Acceptable floodplain uses are open space, recreation areas, parks, tree farms, agriculture, etc.

C. COMBINATIONS OF ALTERNATIVES

Enlarge Railroad Culvert/Elevate West Liberty Street

ESTIMATED COST:

Box Culverts (4-6' x 6' boxes, 152'long*)		$133,800
Embankment Fill (4830 cu. yds.)		62,800
Tunneling/Jacking ($1500/L.F.)		78,000
Paving (2700 sq. yds.)		37,800
Guard Rail (1340 L.F.)		7,700
Riprap (390 cu. yds.)		8,400
Seeding (18,100 sq. ft.)		4,600
Sediment Control (silt fence)		4,800
	subtotal	$337,900
Contingencies, Engineering, & Design 21%		70,959
	total	$408,859**

* If the elevated road is relocated to abut the railroad fill, only 82' of culvert is required. Cost reduction would total $74,559, lowering the total project cost to $334,300.

** Does not include costs of acquisition of one structure and removal of one mobile home necessary for construction area.

Enlarge Railroad Culvert/Elevate Fairway Drive

ESTIMATED COST:

Total cost of this alternative is simply a total of the two separate alternatives, which is $407,044. This estimate does not include costs associated with acquisition of one structure.

Questions regarding this study, the technical models, and alternatives considered should be directed to:

Water Resources Administration
Watershed Management Division
Tawes State Office Building, D-3
580 Taylor Avenue
Annapolis, Maryland 21401
(301) 974-3825

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V. TABLES AND FIGURES

TABLE 1
BRADLEY RUN WATERSHED
EXISTING CONDITIONS

	100 - YEAR		10 - YEAR		2 - YEAR	
SECTION	DISCHARGE	ELEVATION	DISCHARGE	ELEVATION	DISCHARGE	ELEVATION
.5	1615	2374.78	928	2372.38	366	2369.25
1	1615	2374.82	928	2372.48	366	2369.61
2	1349	2374.92	770	2372.72	298	2370.13
3	1349	2375.23	770	2373.42	298	2371.76
4	1349	2375.31	770	2373.59	298	2372.10
5	1349	2375.38	770	2373.78	298	2372.34
6	1349	2375.62	770	2374.44	298	2373.48
6.5	1349	2376.02	770	2375.19	298	2374.29
7	1102	2376.72	625	2375.92	237	2375.05
8	1102	2377.65	625	2377.12	237	2376.44
9	1102	2381.29	625	2380.75	237	2380.14
10	1102	2388.74	625	2388.41	237	2387.99
11	855	2389.80	480	2389.37	177	2388.87
11.3	855	2394.60	480	2394.17	177	2393.52
12	855	2394.61	480	2394.18	177	2393.52
12.1	855	2394.58	480	2394.16	177	2393.51
12.2	855	2394.63	480	2394.19	177	2393.52
13	855	2394.71	480	2394.24	177	2393.54
13.5	855	2395.19	480	2394.67	177	2393.56
14	855	2398.44	480	2397.81	177	2397.29

TABLE 2
BRADLEY RUN WATERSHED
ULTIMATE CONDITIONS

	100 - YEAR		10 - YEAR		2 - YEAR	
SECTION	DISCHARGE	ELEVATION	DISCHARGE	ELEVATION	DISCHARGE	ELEVATION
.5	2245	2376.29	1468	2374.20	776	2371.53
1	2245	2376.32	1468	2374.25	776	2371.68
2	1856	2376.37	1201	2374.36	618	2371.99
3	1856	2376.55	1201	2374.75	618	2372.91
4	1856	2376.60	1201	2374.85	618	2373.12
5	1856	2376.64	1201	2374.94	618	2373.28
6	1856	2376.76	1201	2375.27	618	2374.15
6.5	1856	2376.92	1201	2375.78	618	2374.97
7	1500	2377.37	959	2376.54	479	2375.68
8	1500	2378.05	959	2377.50	479	2376.89
9	1500	2381.62	959	2381.16	479	2380.54
10	1500	2388.96	959	2388.58	479	2388.28
11	1147	2390.09	721	2389.69	347	2389.18
11.3	1147	2394.86	721	2394.46	347	2393.95
12	1147	2394.87	721	2394.47	347	2393.95
12.1	1147	2394.82	721	2394.44	347	2393.94
12.2	1147	2394.89	721	2394.49	347	2393.96
13	1147	2395.00	721	2394.56	347	2394.00
13.5	1147	2395.50	721	2395.02	347	2394.41
14	1147	2398.75	721	2398.18	347	2397.45

Figure 1

BRADLEY RUN WATERSHED

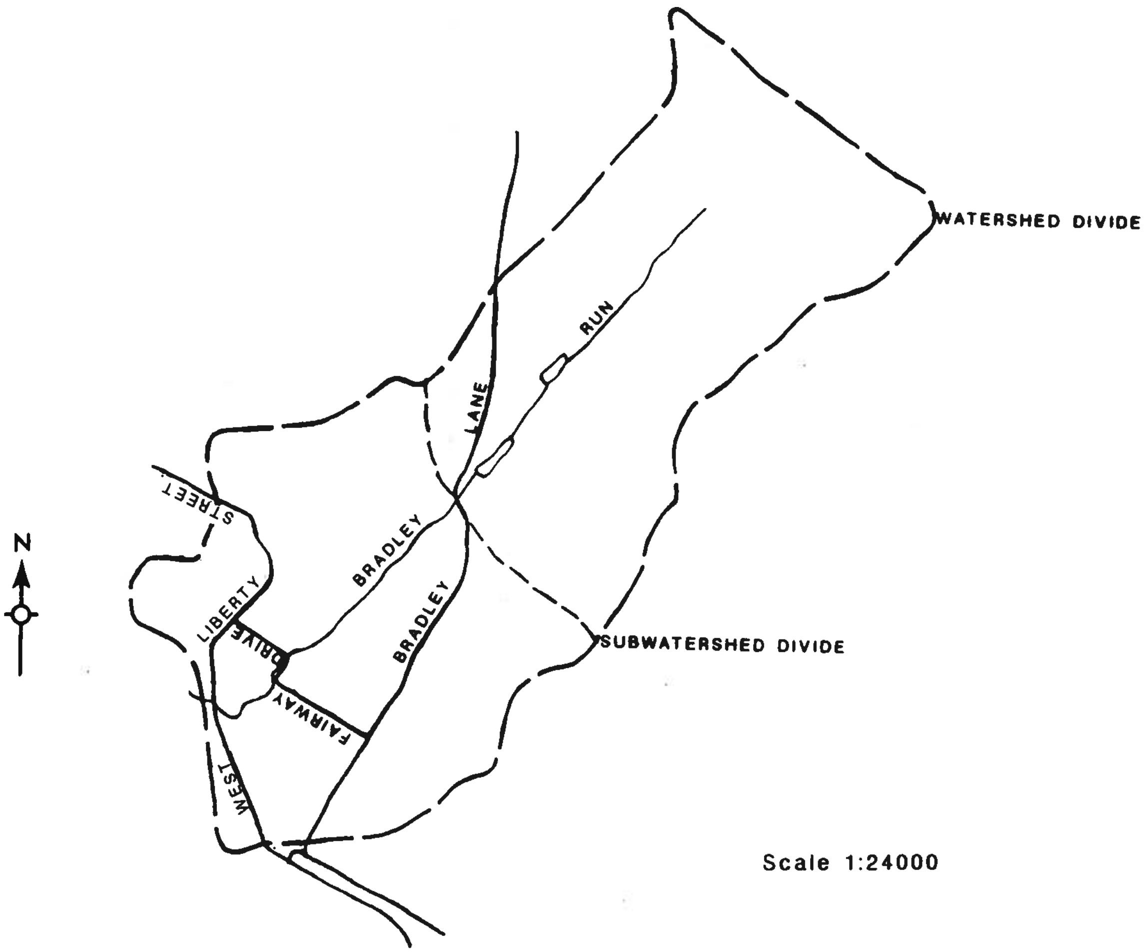
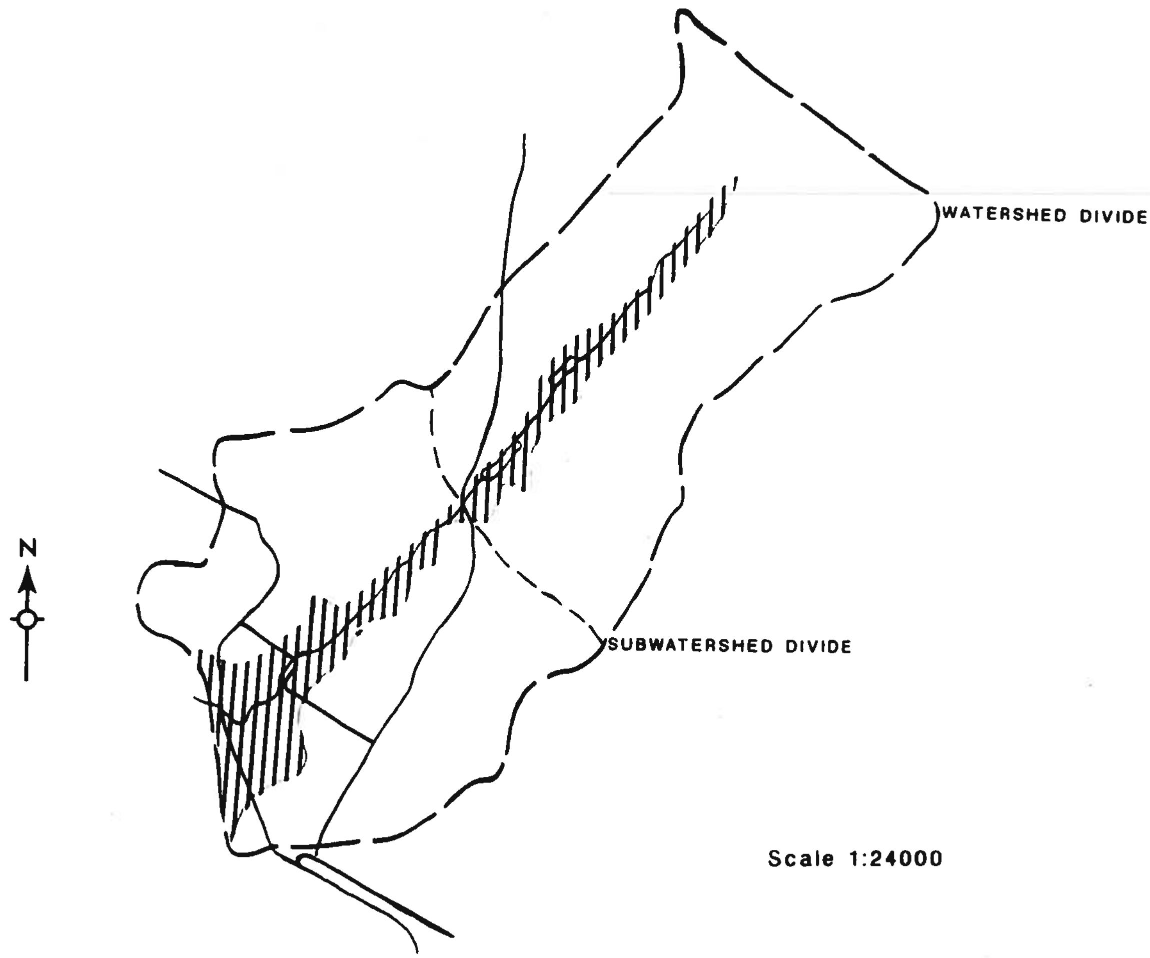


Figure 2

BRADLEY RUN WATERSHED

HYDROLOGIC SOIL GROUPS



MAP KEY

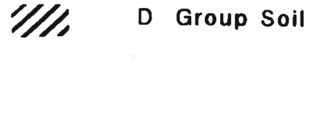
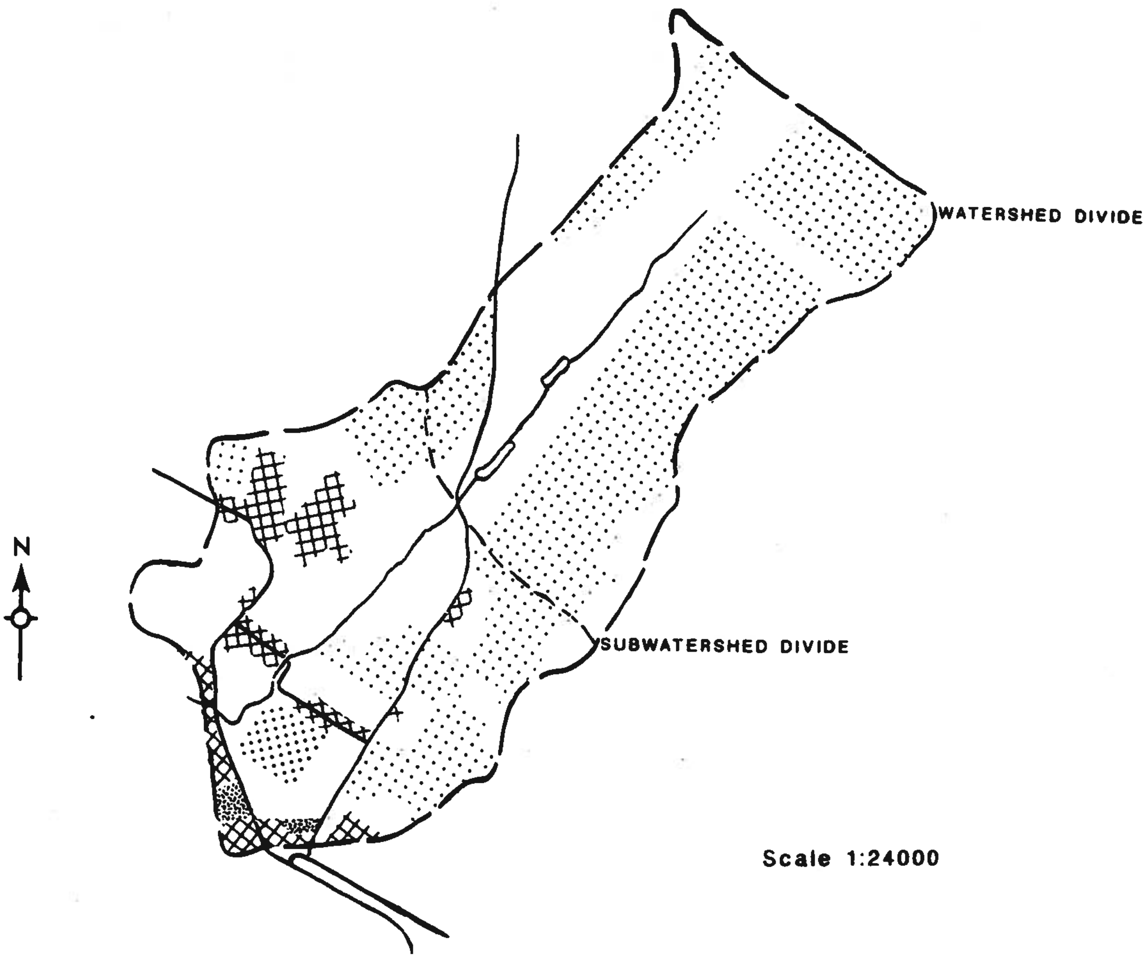


Figure 3

BRADLEY RUN WATERSHED

EXISTING LAND USE



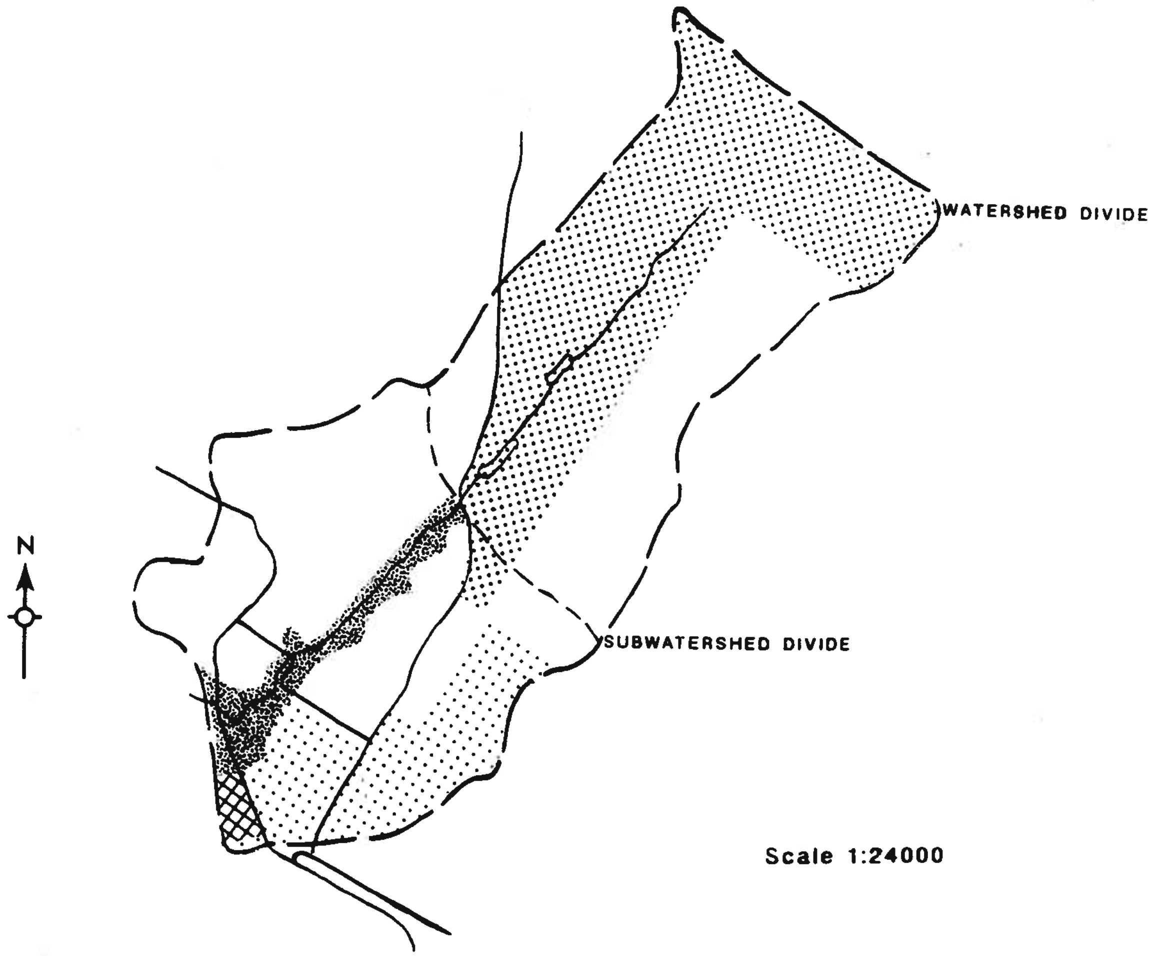
MAP KEY

- Forested Areas - woodland
- Open Areas - golf course,meadow,lawn
- Single Family - .5 acre lot
- Townhouses
- Commercial

Figure 4

BRADLEY RUN WATERSHED

EXISTING ZONING (Ultimate Land Use)



MAP KEY

SR -Surburban Residential

TR - Town Residential

C - Commercial

EC - Employment Center

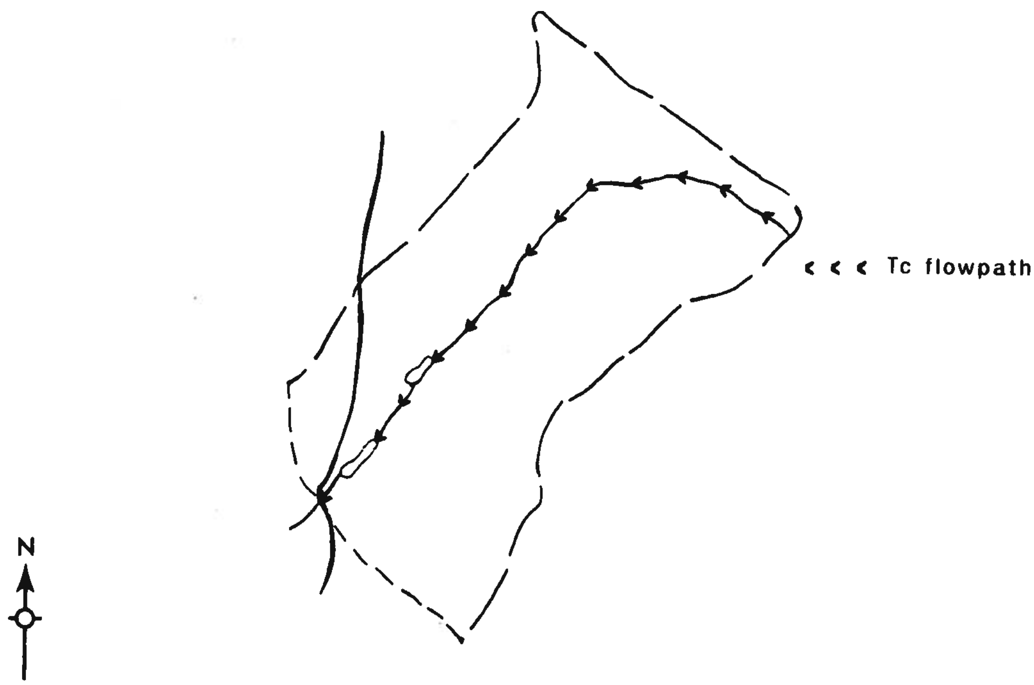
EP - Environmental Protection

OS - Open Space or Recreation (Public)

Figure 5

BRADLEY RUN WATERSHED

Subwatershed 1



DRAINAGE AREA - .539 square miles

SOIL GROUPS - C - 309 acres D - 36 acres*

LAND USE (existing) Forest - 210 acres Open Space - 135 acres

LAND USE (ultimate) SR - 128 acres OS,EP - 217 acres

RUNOFF CURVE NUMBER - Existing - 72 Utimate - 81

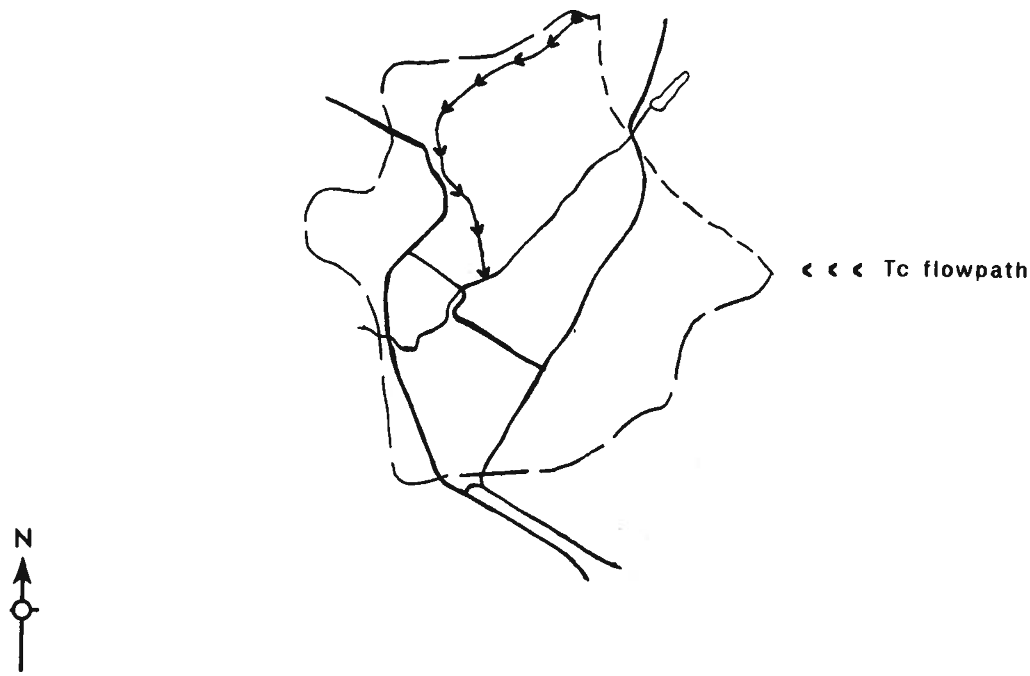
TIME OF CONCENTRATION - Existing - .475 hours Ultimate - .448 hours

* all open space -

Figure 6

BRADLEY RUN WATERSHED

Subwatershed 2



DRAINAGE AREA - .475 square miles

SOIL GROUPS - C - 246 acres D - 58 acres

LAND USE (existing) Forest - 100 acres Open Space - 142 acres .5 Acre Lots - 42 acres

Townhouses - 13 acres Commercial - 7 acres

LAND USE (ultimate) OS,EP - 36 acres* SR,TR,C,EC - 268 acres

RUNOFF CURVE NUMBER Existing - 76 Ultimate - 89

TIME OF CONCENTRATION Existing - .277 hours Ultimate - .25 hours

* all D soil

Figure 7

BRADLEY RUN WATERSHED

TR-20 SCHEMATIC

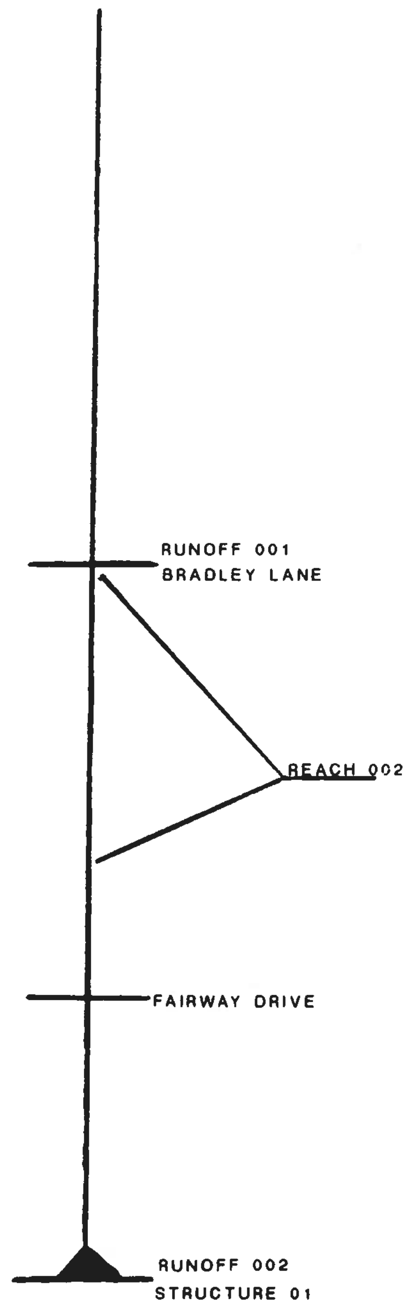
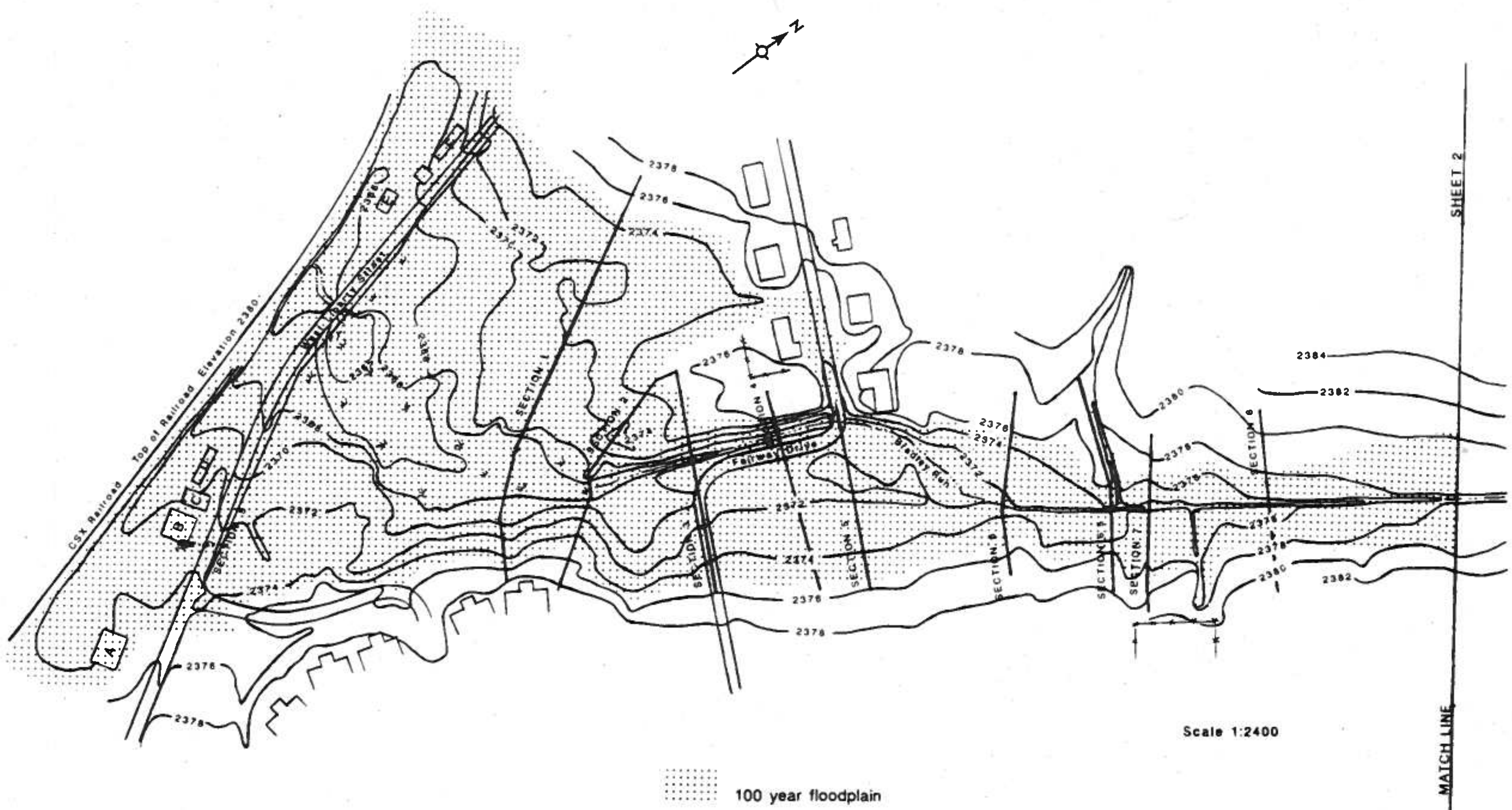


Figure 8

BRADLEY RUN WATERSHED

Floodplain Map

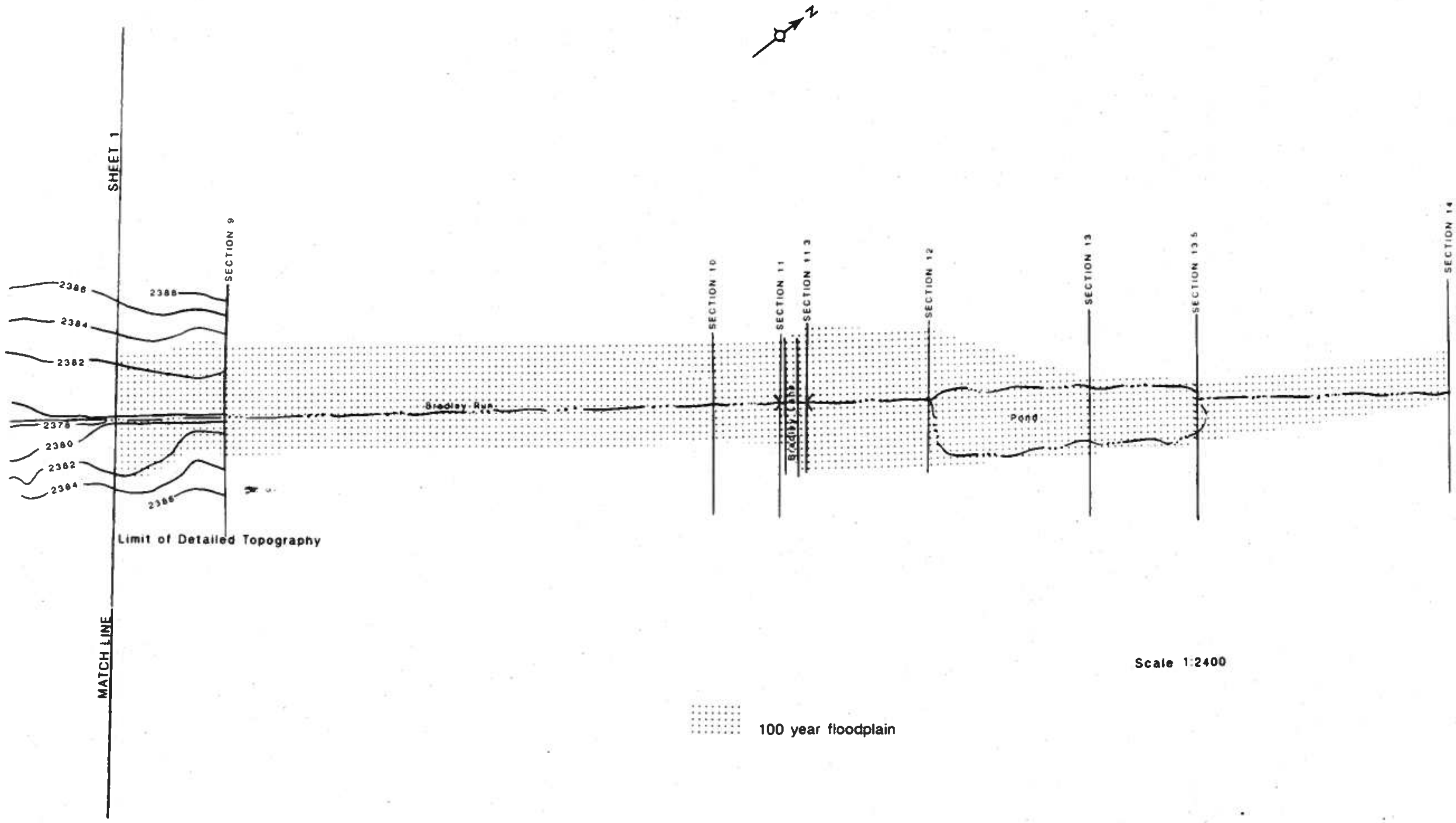


SHEET 1

Figure 8

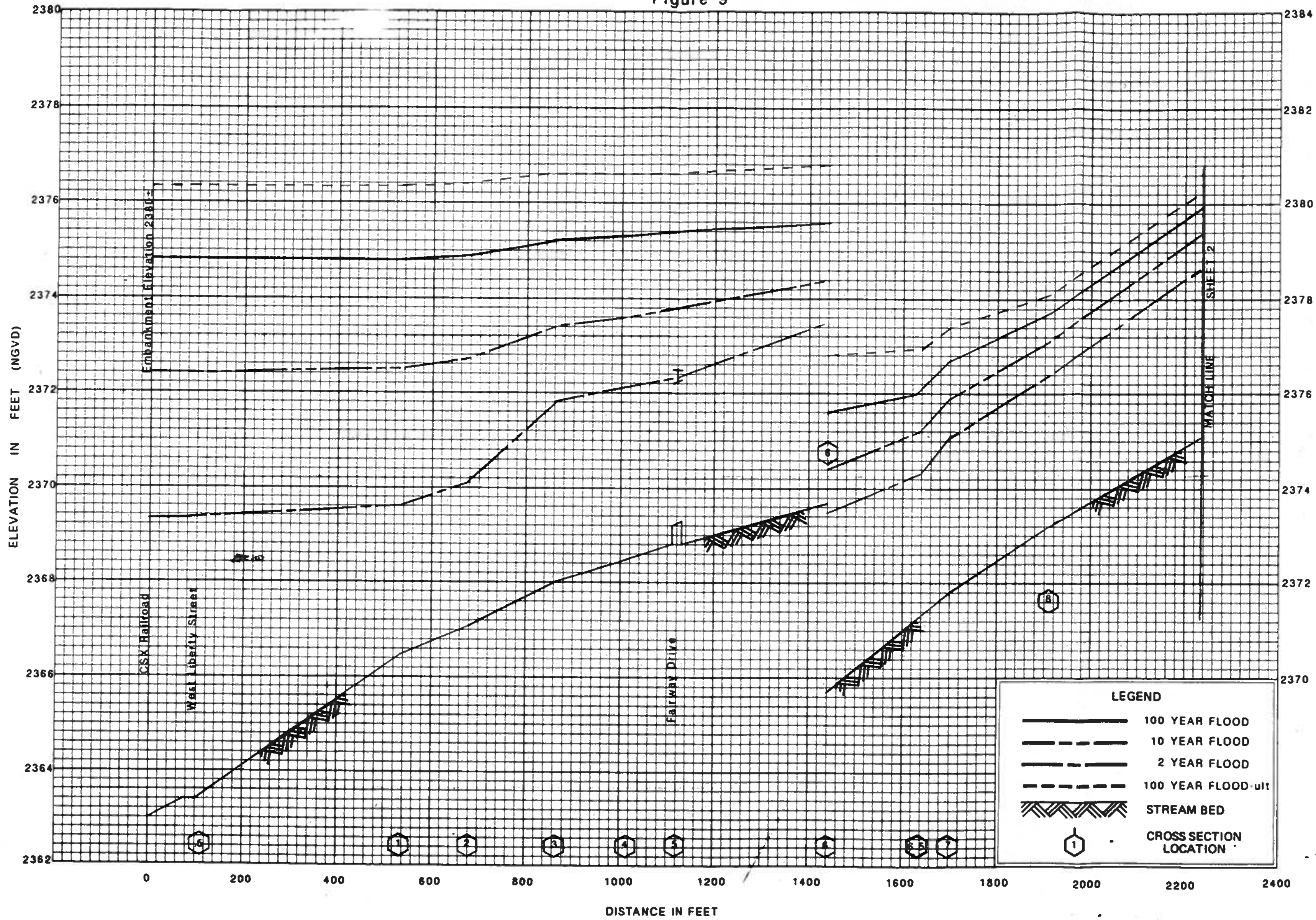
BRADLEY RUN WATERSHED

Floodplain Map



SHEET 2

Figure 9



FLOOD PROFILES

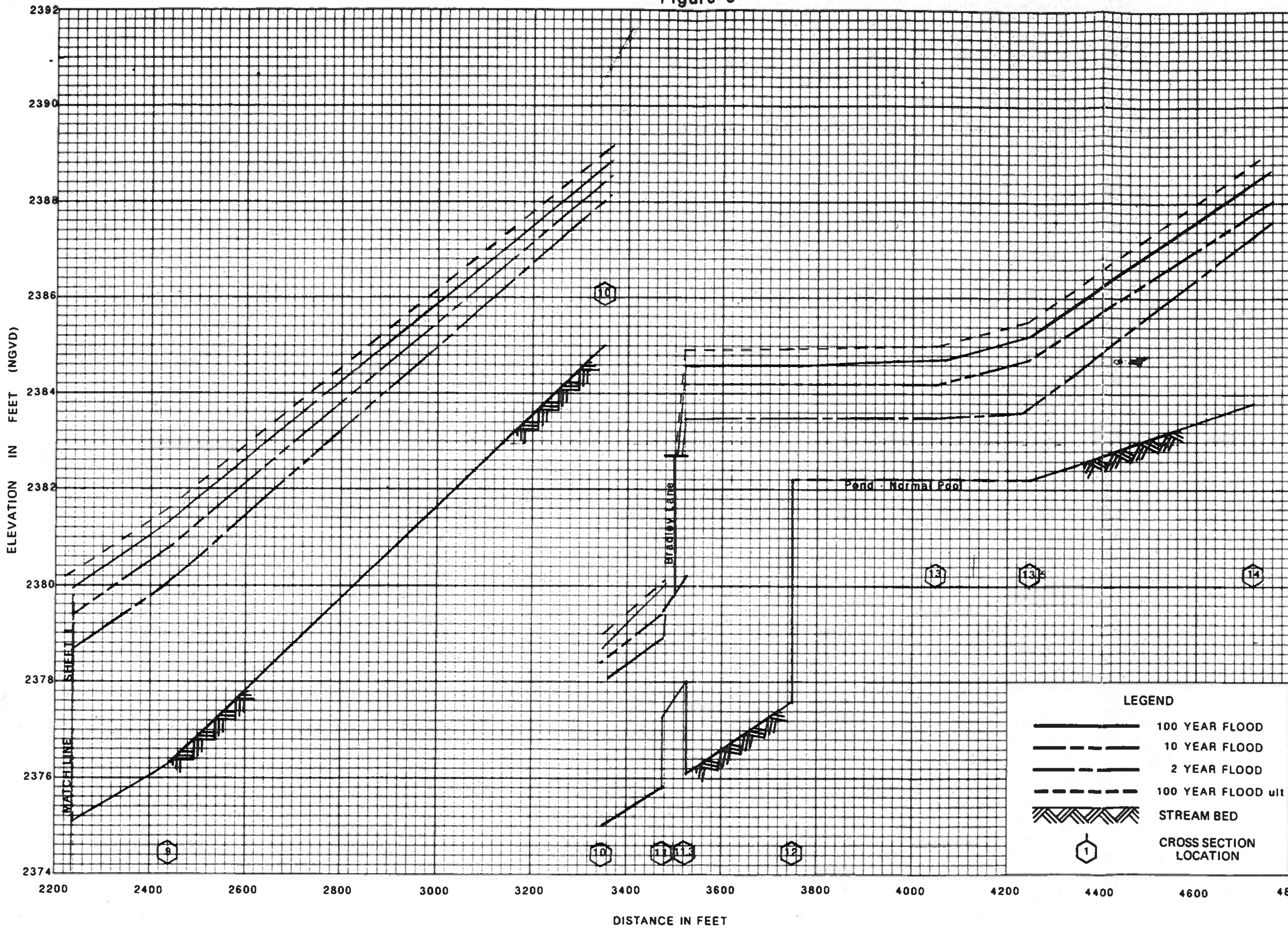
BRADLEY RUN

TOWN of OAKLAND

GARRETT COUNTY

SHEET 1

Figure 9



FLOOD PROFILES

BRADLEY RUN

TOWN of OAKLAND

GARRETT COUNTY

SHEET 2