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FINAL REPORT
HYDRAULIC AND SEDIMENTATION STUDY
TOWN OF ONALASKA, WI

Vierbicher Associates, Inc.
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Final Report
Hydraulic & Sedimentation Study

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ABSTRACT

This report summarizes a hydraulic and sedimentation study of Halfway Creek and Sand Lake Coulee Creek watersheds for the purpose of identifying recommended actions to protect homes, businesses, public infrastructure, hazardous materials, the State Bike Trail, and Upper Mississippi River National Wildlife and Fish Refuge lands from future flooding and water quality degradation.

Issues of concern to the Town of Onalaska, addressed by this study report include:

- Analysis of stormwater runoff flow rates (hydrology) in Halfway and Sand Lake Coulee Creek watersheds.
- Analysis of approximate rates of sedimentation in both watersheds.
- Identification of sediment sources.
- Recommendations for location and size of sediment control and removal structures.
- Development of conceptual solutions to address maintaining the viability of Upper Mississippi River National Wildlife and Fish Refuge Lands and Lake Onalaska.
- Analysis and recommendations of future land use density thresholds.
- Analyze by hydraulic modeling, flood profile levels downstream of STH 35 for the 2, 5, 10, 25, 50, and 100 year storm events for both watersheds.
- Recommendations to implement structural and non-structural best management practices to mitigate flooding, sedimentation, and water quality degradation for both watersheds.
- Recommendations for location and size of flood control structures.
- Probable opinions of costs to implement the study recommendations including the quantification of costs of doing nothing.
- Overview of funding sources to implement study recommendations.

Introduction

I. INTRODUCTION

As is easily imagined, the presence of water is a strong influence in man's activities, and this influence extends far beyond a basic need for survival. Water has been an intricate part of man's creations and progress, from his ability to produce food to uses in transportation, invention, and industry. Therefore, since before white colonization, man has been drawn to the waters of the Mississippi River to fulfill his needs and further his progress. The western boundaries of Wisconsin are no exception, with the most significant colonization occurring in the late 18th and early 19th centuries. This influx was comprised mostly of farmers of European descent, who brought with them the tools and experiences for successful agricultural enterprise. Watersheds draining to the Mississippi provided good soil parameters and abundant water supplies. What the early settlers could not foresee is the profound effect their land use practices could have on future residents of the watershed. The removal of native vegetation from the forests to the prairies, and the cultivation of the soil drastically changed the hydrology of the area.

The ultimate result of these and other watershed changes are emerging as catastrophic events for today's residents, as is the case in the community of Midway. In June and July of 1993, Midway and the surrounding area experienced severe flooding. Runoff waters from the Sand Lake Coulee and Halfway Creek watersheds were the major contributors. Midway is located at the outlet end of both watersheds. Residents experienced high water problems and have witnessed increasing sedimentation in the lowlands separating them from the Mississippi River. The cause and effect of high water and increased sedimentation is the central subject of this study.

The study basically addresses three questions: 1) What is the cause of flooding in the lower reaches of these two watersheds?, 2) What is the source of sedimentation evident in the marshy confluence of the two watersheds?, 3) Are the flooding and sedimentation issues entirely separate, or interdependent? The process of answering these questions allows us to define management practices aimed at watershed improvement and mitigate catastrophic events. It is necessary to review the history of the watersheds, define existing hydrology, and predict impacts of future watershed changes. This study focused on accumulating data necessary to make judgements with regard to these definitions and predictions, and recommend practices to manage watershed change.

Project Overview

II. PROJECT OVERVIEW

The Town of Onalaska's boundaries encompass the majority of the Halfway Creek and Sand Lake Coulee watersheds. In order to minimize future flooding and sedimentation impacts, the Town applied for and received funding from the U.S. Department of Commerce's Economic Development Administration for a Hydraulic Study of the two watersheds.

The purpose of the study is to define possible solutions to flooding and sediment build up in and around Midway. Specific problems to be addressed include:

- Flooding of Agricultural Land
- Flooding of Businesses and Residences
- Impacts on CTH 'ZN'
- Deterioration of the Upper Mississippi River National Wildlife and Fish Refuge
- Stream Bank Erosion
- Future Impacts on Lake Onalaska

In the fall of 1994, the Town of Onalaska selected a consulting firm to perform the necessary investigation to complete the study, including:

- Determine Flow Rates and Flood Profiles for Sand Lake Coulee and Halfway Creek Watersheds
- Identify Sources of Sediment and Determine Sedimentation Rates
- Recommend Appropriate Drainage and Erosion Control Measures
- Recommend Urban and Rural Management Practice for Both Watersheds
- Provide Information on Probable Implementation Costs

Due to a limited availability of funds to perform the watershed analysis, the primary focus of this study was to define existing conditions and sediment sources, and conceptualize feasible management practices for the two watersheds. The expected outcome is to minimize future flood occurrences.

As the consultant chosen to perform the investigation, Vierbicher Associates, Inc., believes that building a strong project team is important to the success of the study. The project team listed below represents a variety of interests, to ensure a broad range of input and guidance.

- Town of Onalaska
- Mississippi River Regional Planning Commission
- U.W. Extension - LaCrosse County
- U.S. Fish & Wildlife Service
- Natural Resources Conservation Service (f/k/a SCS)
- Wisconsin DNR
- Wisconsin DOT
- LaCrosse County Land Conservation Department
- LaCrosse County Zoning and Land Information Department
- LaCrosse County Highway Department
- Ducks Unlimited
- U.S. Department of Commerce - Economic Development Administration

Study Area

III. STUDY AREA

Halfway Creek and Sand Lake Coulee Creek watersheds are located in LaCrosse County, north of the City of Onalaska. These watersheds encompass lands in the City of Onalaska, Towns of Onalaska, Holland, and Hamilton, with the majority of land in the Town of Onalaska. Within the watershed boundaries lie the communities of Midway, Holmen, and Onalaska.

Halfway Creek is comprised of two primary sub-watersheds, Long Coulee and Halfway Creek. For purposes of this study, these two sub-watersheds were combined and are referred to, in total, as the Halfway Creek Watershed. The total Halfway Creek watershed encompasses approximately 22,944 acres (36 $mi.^2$), of which 10,558 acres are in agricultural use, 10,336 acres are wooded, 1,130 acres are developed, and the remaining 520 acres are miscellaneous open spaces.

Sand Lake Coulee watershed encompasses approximately 5,120 acres (8 $mi.^2$), of which 1,356 acres are in agricultural use, 2,403 acres are wooded, 1,142 acres are developed, and the remaining 219 acres are miscellaneous open spaces. Watershed boundaries and subwatershed areas are depicted on the map provided in the Appendix pocket folder.

Developed areas, primarily residential and commercial, are located in or around Midway and Holmen. Additional developments exist or are proposed throughout the Sand Lake Coulee watershed, as well as along or near State Highways 35 and 53. Upland areas of both watersheds remain relatively free of any residential or commercial development.

The following pages provide Tables 1 through 6 which depict existing land use, probable future land use, and recommended future urban density thresholds within Sand Lake Coulee and Halfway Creek watersheds used for this study report. Future land use and future urban density thresholds include an assumed **20-year build out period to year 2015.** Existing land uses were determined based on review of recent 1994 and 1995 aerial photographs of the watersheds. The methodology used to obtain probable future land uses and future urban density thresholds were determined based on American Planning Association document "The Small Town Planning Handbook". The assumed future land uses and future urban density thresholds are very approximate and will need to be refined at the time when comprehensive data is obtained, land use plan and zoning documents are prepared for this study area. The following tasks were completed to obtain probable future land uses provided in Tables 2, 3, 5, and 6.

- Reviewed comprehensive soils maps and aerial photographs to determine what undeveloped land will best support the different land uses.

- Projected approximate future demand for land in acres based on population growth, land needed for roads, land needed for housing replacement, and land needed for community facilities and institutional needs based on the general character of the watersheds.

- Predicted goals within watershed areas as they pertain to the future development or undeveloped lands with regard to the pattern of desired type and density of development.

- Preliminary review and examination of the future demand for commercial and industrial uses, and watershed goals for the expansion and placement of these uses.

Both creeks drain to a marsh area southwest of Midway, which outlets into Lake Onalaska. Sand Lake Coulee Creek outlets to the marsh on the southeast side of Midway. Halfway Creek enters the marsh west of Midway, following along CTH 'ZN' before dispersing. At one time, this creek followed a more defined channel to Lake Onalaska. Deposition of sediments into the marsh have virtually eliminated the old channel south of CTH 'ZN'.

TABLE 1

Halfway Creek Watershed
Existing Land Use

Subarea No. (Reach)	Land Use-Acres				Total (AC)
	Agricultural	Wooded	Urban	Open Space	
1A	661		158	366	1185
1B	517	348	525	154	1544
2	550	739	---	---	1297
2A	325	114	---	---	439
3	1096	1304	30	---	2430
3A	453	263	20	---	736
4	784	1104	---	---	1888
5	596	1388	---	---	1984
6	396	495	---	---	891
6A	275	224	---	---	499
7	862	1305	---	---	2167
7A	586	194	---	---	780
8	545	968	---	---	1513
8A	935	560	---	---	1495
9	753	984	7	---	1744
9A	737	333	---	---	1070
9B	479	413	390	---	1282
Total Area(AC)	10,558	10,736	1130	520	22,944
Percent of Total	46%	46.8%	4.9%	2.3%	100%

TABLE 2

Halfway Creek Watershed
Probable Future Land Use
20-Year Projection

Subarea No. (Reach)	Land Use-Acres				Total (AC)
	Agricultural	Wooded	Urban*	Open Space	
1A	---	---	699	486	1185
1B	160	348	700	336	1544
2	80	739	342	136	1297
2A	80	114	169	76	439
3	690	1304	250	186	2430
3A	160	263	207	106	736
4	448	1104	200	136	1888
5	260	1388	200	136	1984
6	210	495	100	86	891
6A	80	224	119	76	499
7	526	1305	200	136	2167
7A	160	194	310	116	780
8	259	968	150	136	1513
8A	320	560	479	136	1495
9	280	984	294	186	1744
9A	160	333	441	136	1070
9B	160	413	524	185	1282
Total Area(AC)	4033	10,736	*5384	2791	22,944
Percent of Total	17.6%	46.8%	23.4%	12.2%	100%

*See Table 3 for recommended future urban land use density thresholds.

1. Urban land use density thresholds are based on a total acreage of 5384 acres.
2. Assumed that wooded acreage remains undeveloped and percentage of agricultural land is developed.

TABLE 3

Halfway Creek Watershed
Recommended Future Urban Density Thresholds
20-Year Projection

Subarea No. (Reach)	Residential						Commercial		Industrial		Total		
	Single Family		Two Family		Multi Family								
	Acres	Units	Acres	Units	Acres	Units	Acres	Units	Acres	Units	Acres	Units	Units /Ac
1A	150	150	99	99	50	100	200	40	200	40	699	429	.61
1B	250	250	100	100	50	12	200	40	100	20	700	422	.60
2	300	200	42	42	---	---	---	---	---	---	342	242	.71
2A	169	113	---	---	---	---	---	---	---	---	169	113	.67
3	250	167	---	---	---	---	---	---	---	---	250	167	.67
3A	207	138	---	---	---	---	---	---	---	---	207	138	.67
4	200	133	---	---	---	---	---	---	---	---	200	133	.66
5	200	133	---	---	---	---	---	---	---	---	200	133	.66
6	100	67	---	---	---	---	---	---	---	---	100	67	.67
6A	119	79	---	---	---	---	---	---	---	---	119	79	.66
7	200	133	---	---	---	---	---	---	---	---	200	133	.66
7A	150	100	60	60	---	---	100	20	---	---	310	180	.58
8	150	100	---	---	---	---	---	---	---	---	150	100	.67
8A	250	167	100	100	29	7	100	20	---	---	479	294	.61
9	294	196	---	---	---	---	---	---	---	---	294	196	.67
9A	200	200	111	111	30	8	100	20	---	---	441	339	.77
9B	224	224	50	50	50	13	100	20	100	20	524	327	.62
Total	3413	2550	562	562	209	140	800	160	400	80	*5384	3492	.65
Percent of Total	63.4%	73.0%	10.4%	16.1%	3.9%	4.0%	14.9%	4.6%	7.4%	2.3%	100%	100%	

*Total urban land use acreage from Table 2.

TABLE 4

Sand Lake Coulee Creek Watershed
Existing Land Use

Subarea No. (Reach)	Land Use-Acres				Total (AC)
	Agricultural	Wooded	Urban	Open Space	
3	112	337	---	---	449
4	121	373	---	---	494
5	106	306	---	---	412
6	42	78	---	---	120
6A	62	26	22	---	110
7	85	236	---	---	321
8	158	241	110	---	509
8A	---	75	30	119	224
9	186	271	222	---	679
10	144	260	150	---	554
10A, 11 & 12	340	200	608	100	1248
Total Area(AC)	1356	2403	1142	219	5120
Percent of Total	26.5%	46.9%	22.3%	4.3%	100%

TABLE 5

Sand Lake Coulee Creek Watershed
Probable Future Land Use
20-Year Projection

Subarea No. (Reach)	Land Use-Acres				Total (AC)
	Agricultural	Wooded	Urban*	Open Space	
3	---	337	97	15	449
4	---	373	106	15	494
5	---	306	91	15	412
6	---	78	37	5	120
6A	---	26	79	5	110
7	---	236	75	10	321
8	---	241	248	20	509
8A	---	75	30	119	224
9	---	271	358	50	679
10	---	260	264	30	554
10A, 11 & 12	100	200	798	150	1248
Total Area(AC)	100	2403	*2183	434	5120
Percent of Total	1.9%	46.9%	42.6%	8.6%	100%

*See Table 6 for recommended future urban land use density thresholds.

1. Urban land use density thresholds are based on a total acreage of 2,183 acres.
2. Assume that wooded acreage remains undeveloped and all of agricultural land is developed except for 100 acres within subarea 12 adjacent to Sand Lake Creek and Wildlife and Fish Refuge.

TABLE 6

Sand Lake Coulee Creek Watershed
Recommended Future Urban Density Thresholds
20-Year Projection

Subarea No. (Reach)	Residential						Commercial		Industrial		Total		
	Single Family		Two Family		Multi Family								
	Acres	Units	Acres	Units	Acres	Units	Acres	Units	Acres	Units	Acres	Units	Units/Ac
3	97	65	---	---	---	---	---	---	---	---	97	65	.67
4	106	70	---	---	---	---	---	---	---	---	106	70	.66
5	91	60	---	---	---	---	---	---	---	---	91	60	.66
6	37	25	---	---	---	---	---	---	---	---	37	25	.67
6A	79	52	---	---	---	---	---	---	---	---	79	52	.66
7	75	50	---	---	---	---	---	---	---	---	75	50	.67
8	188	125	30	30	10	20	20	4	---	---	248	179	.72
8A	30	20	---	---	---	---	---	---	---	---	30	20	.67
9	218	145	50	50	20	40	50	10	20	4	358	249	.69
10	214	143	30	30	10	20	10	2	---	---	264	195	.74
10A, 11 & 12	368	368	100	100	80	160	150	30	100	20	798	678	.85
Total	1503	1123	210	210	120	240	230	46	120	24	*2183	1643	.75

*Total urban land use acreage from Table 4

Historical Background

IV. HISTORICAL BACKGROUND

Although the scope of this study did not provide for a detailed historical review, some general events are likely to have occurred within the watersheds, as is evidenced in other watershed studies along the Mississippi River. Also, several significant events in the recent past have bearing on this analysis. This section includes a brief overview of changes in the area and some specific information applicable to the Halfway Creek and Sand Lake Coulee Creek watersheds.

As stated in the Introduction Section of this report, the one most significant change to these watersheds was the shift from natural wilderness area to agricultural use in the early 19th century. Geologic and vegetative features, which had taken centuries to evolve and equilibrate, were drastically impacted when trees and prairies were cleared to make way for plows and tilled fields. These early farmers and their descendants were concerned with making their way in what this country considered a noble venture, providing food and nourishment for a burgeoning population. The secondary impacts of their labors were not evident until recent times, as problems began to occur in numerous other watersheds around Wisconsin.

Agricultural practices are not the only source of unforeseen secondary impacts. As farmers responded to the demands of increasing populations, there was a need for additional residential housing. What began as small, support communities expanded to become regional centers of activity that demanded more and more space as populations increased. The Halfway Creek and Sand Lake Coulee Creek watersheds continue to see increased pressures for urbanization and residential growth. These land use changes provide their own set of secondary impacts on watershed functions.

As stated earlier, the Mississippi has also seen accelerated use as a transportation corridor. Man's use of this waterway to transport himself and his products has resulted in several man-made revisions. One structure in particular, Lock-and-Dam number 7 located south of Lake Onalaska, have had secondary impacts on the two study watersheds. The closing of this dam in the 1930's has impeded Lake Onalaska's ability to "flush" itself out, allowing sediment to build and depths to decrease. In 1989, an Environmental Management Plan Habitat project was undertaken in Lake Onalaska to remove sediment and create channels around Rosebud Island. The cost of the project was $2.8 million. It is also probable that Halfway Creek and Sand Lake Coulee Creek have lost some of their ability to "flush" out, as their outlets became impeded by built up sediments. Also, sediments currently moving through these two creeks could seriously effect the life of the recent habitat project in Lake Onalaska.

The flooding that occurred in 1993 in the community of Midway was associated with heavy rains and runoff experienced in numerous locations around the region. However, increasing sediment loads may have seriously hindered the ability of Halfway Creek and Sand Lake Coulee Creek to carry additional waters, and overbank flows are likely to have occurred more rapidly than in the past. CTH 'ZN' is an excellent example of the amounts of sediment that exist in the system. The large drainage ditch south of CTH 'ZN' was constructed in January 1994 to act as a sediment trap and requires cleaning out approximately every three months. As sediments fill the marsh areas north and south of 'ZN', a loss of depth is experienced and water flows over the roadway. This has caused numerous problems with icing as well as deterioration of the road bed. In an attempt to raise the road, LaCrosse County repaired CTH 'ZN' and added additional pavement depth. This adjustment is likely to have a minimal effect on preventing future water on the roadway, unless sediment reduction methods are instituted in the watershed. It is important to note that CTH 'ZN' is a vital link to the community of Brice Prairie, which is west of Midway.

As part of the study, a Public Information Meeting was held on May 30, 1995, and July 19, 1995, to solicit local input on historical problems and identify possible solutions. Concerned citizens and agency representatives attended this meeting. Area residents and local officials indicated that sedimentation problems have existed in the area for many years. Reports of past efforts to open up and clean channels are numerous. Additional reports of channel changes, deposition of sediments in new and expanding areas, and water back ups and saturated soils in the lower reaches indicate that problems may be accelerating.

Hydrology / Hydraulics

V. HYDROLOGY / HYDRAULICS

A. Hydrologic Cycle

Water moves around the earth. It goes from the ocean to the atmosphere, to the earth and back to the oceans. Where water starts and how it moves over the earth's surface is described by the *hydrologic cycle*. The process is simple; solar energy (sun) evaporates water from oceans, carries the water in the atmosphere until conditions are right, and then deposits the water over land in the form of rain or snow. An illustration of the Hydrologic Cycle is included as Figure 1 in the Appendix of this report.

Not all rain water reaches a stream. Some of the water is caught by vegetation and either absorbed by plants or evaporated back into the atmosphere. Some of the water is absorbed by the soil and percolates into the ground water. Other water evaporates directly from streams, lakes, and wetlands.

The water that is not evaporated or transpired transports as *stormwater runoff* in one of two ways. If soils are saturated, which is common in the spring with melting snows, water may move near the soil's surface as *subsurface runoff* and eventually deposit into streams or lakes. Rain that is not absorbed runs over the surface of the ground and eventually reaches streams and lakes as *overland flow*.

B. Flooding

If overland flow reaches a stream channel during or within a day or so of a rainfall event, it is usually classified as *direct runoff*. This type of runoff can cause high rates of discharge in streams.

Flooding is a natural event that occurs when the rate of runoff exceeds the capacity of a stream to transport the water. Under natural conditions, a stream channel is large enough to hold approximately a two-year peak flow, the highest flow likely to occur on the average of every two years. When the rate of runoff is larger than the channel can handle, the water moves out of the channel and flooding occurs.

The frequency and severity of flooding is directly related to the capacity of the stream to transport water and the amount of stormwater runoff.

The capacity of a stream is a function of:

- Slope: steepness of the channel
- Flow Area: depth and width of a channel
- Channel Roughness: vegetation types and the shape of the waterway.

The rate of stormwater runoff is a function of three things:

- Rainfall Event: amount, intensity, and duration of the storm
- Flow Area: depth and width of the channel valley
- Soil conditions: types of soils, moisture, and frost

The rate of stormwater runoff is a complex inter-relationship between the storm event and the watershed. Generally, large intense rainfalls create more runoff than small less-intense rainfalls. Similarly, watersheds that are steep with silt/clay soils and little vegetation create more runoff than watersheds that are flat, sandy, and have a lot of vegetation.

Modifications to a stream and watershed can significantly increase flooding. If part of a stream is filled in, the flow area is reduced. This results in a reduction in the stream's capacity to transport water. Excessive sedimentation can also reduce the flow area of a stream, and its ability to transport water.

Changes to a watershed, such as a change in land use, can significantly increase the amount of stormwater runoff. For example, when prairies become residential subdivisions, the amount of vegetation is reduced and impervious surfaces increased. As a result, more of the rainfall will runoff. This increase in runoff can be significant and flooding may become more frequent or more severe.

C. Hydrology

The simplest method of predicting the volume of storm runoff is by direct correlation with anticipated volumes of rainfall. Reviewing historical data and performing statistical analysis on rainfall events, allows us to determine what maximum rainfall is likely to occur over a period of time. Then we can estimate the probable maximum 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year storms. For instance, the 10-year storm is the largest rainfall event that is likely to occur once every ten years.

The processes that deliver storm flow and the volumes and timing of their contributions, vary with climate, vegetation type, land use, soil type, topography and area rainfall amounts. For this study, a data collection process was undertaken to define the parameters specific to the Halfway Creek and Sand Lake Coulee Creek watersheds. This process consisted of field reviews and surveys, inspection of aerial photography and soils maps, review of USGS contour mapping, and research of available published data. Field cross sections of each of the streams, from the marsh upstream to STH 53, were obtained from the Natural Resource Conservation Service (f/k/a SCS).

Utilizing this data, rainfall amounts were adjusted and converted into probable runoff volumes by mathematical means, or *models*. For this study, two primary methods were used - the "TR-20" method and the "U.S.G.S. Flood Frequency Equations for Wisconsin - Conger" method. The results of the two methods were then compared and final judgements were made based on available historic information from the watershed and/or from similar watersheds. This analysis produced the following results:

Halfway Creek Watershed - Existing Land Use

Occurrence	Probable Maximum Flow (Q)
2-year	540 cfs
5-year	940 cfs
10-year	1200 cfs
25-year	1700 cfs
50-year	2000 cfs
100-year	2300 cfs

Sand Lake Coulee Watershed - Existing Land Use

Occurrence	Probable Maximum Flow (Q)
2-year	280 cfs
5-year	470 cfs
10-year	630 cfs
25-year	840 cfs
50-year	1000 cfs
100-year	1200 cfs

cfs = Cubic Feet per Second

Halfway Creek Watershed - Future Land Use

Occurrence	Probable Maximum Flow (Q)
2-year	2700 cfs
5-year	3500 cfs
10-year	3750 cfs
25-year	4200 cfs
50-year	4550 cfs
100-year	4850 cfs

Sand Lake Coulee Watershed - Future Land Use

Occurrence	Probable Maximum Flow (Q)
2-year	1050 cfs
5-year	1220 cfs
10-year	1380 cfs
25-year	1590 cfs
50-year	1750 cfs
100-year	1950 cfs

cfs = Cubic Feet per Second

D. Flood Profiles

When the rate of runoff waters accommodated in the stream channel is larger than the channel can handle, the water moves out of the channel and flooding occurs. In predicting the impacts or extent of probable floods, we utilize storm runoff volumes and peak discharges/flows to determine how deep water will be and where it will go when it leaves the channel. We use mathematical models to route the peak flood discharges though the stream system. The cross sections of the stream, obtained in the data collection process, are input into the model and flood heights determined at each location. Flood heights are plotted and result in a *flood profile* along the length of the stream. Comparison of flood height to individual cross sections will also indicate what areas will be inundated with water. The model used for this study is the U.S. Geological Survey 1988 Water-Surface Profile Model (WSPRO).

Flood profiles and cross section information were calculated for each stream, from the marsh outlet upstream to STH 53. We have included results for the 2, 5, 10, 25, 50, and 100-year storms in the Appendix of this report in Figures 2 through 13.

E. Analysis Methodology

Hydrologic and hydraulic analysis was performed for existing land use and assumed probable future land use conditions to determine runoff amounts from respective storm events. Assumed probable future land uses include **20-year period to year 2015.**

An analysis of assumed probable future land use conditions with the recommended wet detention basin structural controls mentioned in Section VII © was performed to reduce post-development runoff amounts (future land use) below pre-development runoff amounts (existing land use). Analysis was performed using the TR-20 computer program model with the interconnected detention pond storage subroutine.

Summary results of TR-20 hydrologic/hydraulic analysis are provided in the Appendix. Approximate location of recommended flood storage/wet detention/sedimentation basins are illustrated on the maps in the Appendix pocket folder. The existing and probable future land uses used in the TR-20 model are provided in Section III "Study Area" portion of the report.

Sedimentation

VI. SEDIMENTATION

A. General

The natural processes of erosion, transport, and deposition of sediments have occurred throughout geologic times and they have shaped the landscape of the Sand Lake Coulee and Halfway Creek Watersheds. Eroded soil is the largest pollutant of surface waters in the United States. Sediment transport affects water quality and its suitability for consumption, industrial use, recreation, and wildlife sustainability. The source of most sediments transported by rivers, channels, drainageways, and storm sewers to receiving water bodies is soil eroded from upland areas. Erosion often causes serious damage to agricultural land by reducing the fertility and productivity of soils.

Problems associated with deposition of sediments vary. Sediment deposition in stream channels reduces the flood carrying capacity, which results in greater flood damage to adjacent properties. Receiving water bodies trap the incoming sediment load and flood risks increase due to aggradation upstream. Upstream aggradation depends on the stream slope, the sediment size distribution, and the water-level fluctuations in the receiving water body. Streams, drainageways, and channels with low slope carrying large quantities of sediment result in aggradation many miles upstream of the receiving water body. Receiving water body sedimentation results in loss of storage capacity for flood control.

Human activities increased the rate of erosion over the normal erosion rate, also known as the geologic erosion rate. The erodibility of natural soils may be altered when the soil's natural condition is disturbed by plowing, tillage, and construction type activities. Erosion rates accelerated due to human activities can be more than 100 times greater than geologic erosion rates of 0.10 ton/acre-year. Erosion rates of grazed areas can exceed 5-tons/acre-year, and we can expect average values of 40 to 50 tons/acre-year during urban development when the soil is not vegetated and it is constantly reworked. Human activities also influence the natural characteristics of channel flows through channel stabilization and hydraulic structures.

The extent of erosion and sediment loading from the Sand Lake Coulee and Halfway Creek Watersheds relates to a complex interaction between topography, geology, climate, soil, vegetation, land use, and man-made developments. Erosion and sediment loading includes the detachment and transport of solid particles from the land surface or from the bed and banks of streams, channels, and drainageways. Erosion occurs in various forms by water, gravity, wind, and ice. A complete cycle of erosion and transport creates sedimentation.

Water is the most common agent of erosion. Water erosion includes sheet erosion and channel erosion. Sheet erosion is the removal of land surface material due to rainfall and thawing ground and its subsequent removal by overland flow. The impact of rainfall causes the removal of soil material. Sheet erosion can include rill erosion, which is the removal of soil by concentrated sheet flow. Rills are usually small enough to be removed by normal tillage. Channel erosion is discussed in Section VI B.4.

Wind erosion can be important in arid and semiarid areas. The rate of wind erosion primarily depends on the soil particle size, wind velocity, soil moisture, surface roughness, and vegetation cover.

When large amounts of rainfall and snowmelt runoff occurs during spring months and there is minimal soil cover and freeze-thaw cycles that cause weathering, extremely high erosion rates and sedimentation loads are recorded. In cold areas, the major portion of the annual sediment load from the watershed can be observed during snowmelt runoff.

The water that runs off streets, parking lots, driveways, and lawns carries pollutants to nearby lakes and streams. Both urban and rural runoff carry "conventional" pollutants such as sediments, nutrients, oxygen-demanding materials, bacteria, and trace metals. The Town of Onalaska Hydraulic Study includes identifying sources of sediments, determining approximate sediment rates, and recommending appropriate best management practices to reduce sediment impacts.

B. Sources of Sediment

1. Urban and Rural Areas

Both rural and urban areas contribute to sediment loads. Soil erosion is the primary source of sediment. Older parts of a municipality may have less soil erosion than rural areas since the land consists of buildings and pavement. The concentration of sediment is generally lower in urban runoff than in rural runoff. However, the total amount of sediment from urban areas is comparable to rural areas since more water runs off man-made surfaces in developed areas.

2. Construction Sites

Although existing urban areas such as parking lots and street surfaces are important sources of sediment, by far the highest amounts of sediment come from areas under construction. Studies estimate that an average unprotected acre under construction delivers 60,000 pounds (30 tons) of sediment per year to downstream waterways. This is about 60 times more than any other land use.

Two factors account for the importance of construction sites as sediment sources:

- High Erosion Rates
- High Delivery Rates

Typical erosion rates for construction sites are 35 to 45 tons per acre per year as compared to one to ten tons per acre per year for cropland.

Construction sites have high erosion rates because they are typically stripped of vegetation and topsoil for long periods of time. More importantly, construction sites have very high delivery rates compared to cropland. During the first phase of construction, the land is graded and ditches or storm sewers are installed to provide good drainageways. This efficient drainage system does not allow sediment to settle out. While much of the sediment from croplands is filtered out by ground cover, or deposited in a low spot or on the next field downhill, most soil erosion from a construction site gets delivered directly to a lake or stream.

Section VII Best Management Practices, Part B.1., provides reference to LaCrosse County's adopted "Construction Site Erosion Control Ordinance" for protection of LaCrosse County's unique natural resources by minimizing the amount of sediment carried by runoff or discharged from construction sites to perennial waters, wetlands, and public rights-of-way within the watersheds.

3. Gully Erosion

Gully erosion and sedimentation is very apparent in the Sand Lake Coulee and Halfway Creek Watershed due to the steep bluffs in the area. Gully erosion is the removal of soil in larger upland channels and drainageways that cannot be destroyed by farming tillage operations. Gully erosion can include waterfall type of erosion at the gully head, channel erosion within the gully, and large amounts of soil bank material moving into the gully as it widens and as the gully head progresses upslope. The channel or drainageway then reaches a stable slope and vegetation begins to grow to stabilize the gully. The non-vegetated portion of the gully transports sediments downland to channels, drainageways, and eventually to the wetlands and Lake Onalaska.

4. Channel Erosion

Channel erosion, which includes bed and bank erosion, can be very significant in channels with changes in flow volume. The sediment transport capacity of a channel is proportional to the amount of discharge and channel slope. This capacity varies inversely with bed sediment size. Channel bed erosion rates can be determined by comparing the actual cross-sectional geometry with earlier profiles. Channel bank erosion rates can be measured by comparing channel positions from a pair of recent aerial photographs to an old set of aerial photographs. Field observations and review of aerial photographs have confirmed that a considerable amount of channel erosion is present in Sand Lake Coulee and Halfway Creek Watersheds.

5. Changes in Flow

From the beginning of construction, urbanization dramatically changes the cycle of water movement. Clearing land removes much of the vegetated cover that intercepts rainfall before it reaches the ground. Once the trees and grasses are gone, less water is returned to the air through evaporation or transpiration (loss of water vapor from plants). Instead, rain falls directly on the exposed soil.

As construction and land disturbing activity proceeds, soil conditions also change. Topsoil is usually stripped away and heavy construction equipment compacts the remaining subsoil which affects what happens to rain water that falls on the site. Less water soaks into the ground after the "spongy" layer of topsoil is removed. More water runs off the compacted subsoil rather than percolating down to recharge groundwater supplies. Water that once seeped through the upper layers of soil as interflow now runs off the surface. The loss of the shallow groundwater is significant because it supplies much of the baseflow in steams between storms.

In many development projects, major grading changes the shape of the land surface to provide better drainage. Construction and land development design fills low spots and wetlands to provide more "buildable" land. These natural depressions or detention areas no longer collect and store stormwater for gradual release after a storm. Instead, storm sewers or ditches are built to improve drainage by carrying runoff and sediments directly to Sand Lake Coulee Creek, Halfway Creek, the Wildlife and Fish Refuge, and Lake Onalaska.

Stormwater runoff problems continue even after developers and builders complete construction. Water runs off hard (impervious) surfaces covered by parking lots, buildings, and streets picking up speed and carrying sediments and pollutants along the way. However, in some places spreading salvaged topsoil and planting vegetation allows the soil to regain much of its ability to soak up stormwater runoff.

The amount and timing of Sand Lake Coulee Creek and Halfway Creek flow changes have increased sediment loading in the following ways:

- Peak Discharge: After development peak stream flows are two to five times higher than they were before development. Consequently, the frequency and severity of flooding and sedimentation increases. A stream that once overflowed its banks once every two years may now flood three or four times per year. When the banks overflow, sediments are deposited within the flood plain and transported downstream.

- Volume: The volume of runoff increases about 50 percent in a moderately developed or altered watershed.

- Timing: Urban drainage systems are so efficient that the time required for runoff to reach the stream can decrease as much as 50 percent. This results in high flows compressed into a shorter period of time. The Sand Lake Coulee and Halfway Creek are "flashy" because water levels rise and fall very quickly in response to storms.

- Velocity: Flow velocity increases in Sand Lake Coulee and Halfway Creek during storms because peak discharges are higher and new drainage systems are smooth.

- Baseflow: Stream flow is reduced by development activities. Portions of Halfway Creek that were once wet and flowed year-round become seasonally dry.

Described above are the dramatic flow changes in Sand Lake Coulee Creek and Halfway Creek that have extensive consequences in terms of flooding patterns, channel erosion, and wildlife habitat destruction.

C. Consequences of Increased Sediment Loading

1. Channel and Floodplain Impacts

Under natural conditions, the Sand Lake Coulee and Halfway Creek develop a channel large enough to hold approximately a two-year peak flow, the highest flow likely to occur on an average of every two years. Therefore, the creek is somewhat larger than the average annual flood.

Urbanization will significantly increase the typical two-year peak flows. In response, the creek erodes to form a larger channel. The creek will become two to four times wider after urbanizing within the watershed.

Channel erosion is often quick and severe because most floodplain soils are loose and wash away easily. However, downstream transport of eroded sediment is slow and moves gradually as "bed load".

Bed load is the total rate of sediment transport for sediment particle sizes readily apparent on the surface of the creek bed in the processes of rolling, sliding, and/or hopping. Movement of these particles is related to the flow and sediment characteristics of the bed. These constantly shifting deposits form dikes, sand bars, and smother bottom life for many years.

The floodplain and the channel of the creek become wider as development occurs in the watershed. Just as the two-year peak flow increases, so do peak flows for larger storms. Land, buildings, and homes that were once safe from the 100-year storm may now be at risk.

2. Lost Value of Water Resources

Increased sediment loadings directly influence the value of Sand Lake Coulee Creek, Halfway Creek, The Wildlife and Fish Refuge, and Lake Onalaska. Sedimentation and a variety of toxic pollutants conveyed by stormwater runoff make waterways and wetlands unsafe for people, fish, and wildlife.

For example, water turbid with sediment or inundated with algae makes feeding difficult for sight feeders like northern pike and waterfowl. Smallmouth bass are especially sensitive to sediment deposits that smother the gravel creek and lake bottoms where they spawn. Low oxygen content and warm temperatures from sediments are intolerable for trout. Toxic chemicals that attach to sediments may affect fish and waterfowl in a variety of ways varying from disorientation, impaired reproduction, lowered disease resistance, or even death. Over time these individual impacts add up to three major changes in fish and waterfowl populations:

- Diversity Decreases
- Abundance Decreases
- Pollution-Tolerant Species Replace Pollution-Sensitive Species

The high flows and pollutants typical of urban runoff create serious problems for aquatic insects that fish and waterfowl feed upon. High flows may scour these organisms from some parts of the ecosystem while sediment deposits may smother them in other areas. Toxic chemicals attached to sediments may kill aquatic insects or affect their ability to feed and reproduce.

As waterfowl and fish populations change, urban water resources become less valuable for recreation and tourism. Lake Onalaska, Sand Lake Coulee Creek, Halfway Creek, and other inland ponds will be populated by carp, catfish, Buffalo, and suckers which are less popular for recreational fishing than pan fish, Northern Pike, and Smallmouth Bass that are typically found in unpolluted waterways. There is also concern about some fish being unsafe to eat due to contamination with toxic chemicals that attach to sediments. Chemicals like mercury and PCB's deposit in muscle or fatty tissue and become more concentrated as they move up the food chain. These chemicals are especially dangerous to human health.

In addition to losing fishing and hunting value, Sand Lake Coulee Creek, Halfway Creek, Wildlife and Fish Refuge, and Lake Onalaska will also lose value for other types of recreation. If they are turbid with sediment or algae they are less attractive for boating, swimming, sightseeing, and picnicking. If bacteria and toxic chemical concentrations become too high the water may become unsafe for swimming and other body contact recreation. When Sand Lake Coulee Creek, Halfway Creek, Lake Onalaska, and the Wildlife and Fish Refuge lose their recreational and aesthetic values, they will be regarded as sewers and they will be subject to more dumping and spills.

D. Determination of Approximate Sediment Loads

1. General

In addition to flood control, hydrology, and hydraulic concerns an important aspect of this study is determining approximate sedimentation loads. Deterioration of the Upper Mississippi National Wildlife and Fish Refuge and Lake Onalaska is evident. Prior to determining solutions to the sedimentation problems, we must first determine their source and develop conclusive evidence of the approximate amount of sediments being transported and deposited in Sand Lake Coulee Creek, Halfway Creek, the Wildlife and Fish Refuge, and Lake Onalaska. It is our goal to present the sedimentation loading estimates in a manner that is easily understood so the public, municipalities, governing agencies, developers, engineers, and builders, can see why changes are now necessary to prevent further degradation and loss of the water resources in the watersheds.

2. Methodology

Since it was not economically feasible to sample and monitor the suspended solids (sediment) mean concentrations of all water bodies in the watersheds, mathematical methods and computer models were used to estimate sediment pollutant loads of ponds, creeks, drainageways, Wildlife and Fish Refuge, and Lake Onalaska under existing land uses and developed conditions.

We selected the following methods and models to determine approximate mean seasonal sediment loads:

- Universal Soil Loss Equation - USLE
- U.S.G.S. Survey Report 88-191 Method
- Source Loading and Management Model - SLAMM
- Agricultural Non-Point Source Pollution Model - AGNPS

A majority of the sediment loading calculations used the USLE equation and U.S.G.S. survey report 88-191 linear regression method based on their objectives and limitations. The SLAMM model and AGNPS model were used to verify the general results of the USLE and U.S.G.S. methods. Each of the methods and models have limitations, advantages, and disadvantages, based on the characteristics of the watershed and subwatersheds. We anticipate that future field monitoring and sample testing will be performed within the watersheds during the implementation of recommended best management practices.

The Universal Soil Loss Equation (USLE) is a computerized tool used for estimating sediment, sheet, and rill erosion. USLE provides estimates of soil erosion, taking into account modern cropping and management systems. The USLE was developed by the United States Department of Agriculture (USDA).

The U.S.G.S. Survey Report 88-191 is a linear regression methodology for estimating storm runoff pollutant loads and volumes, storm runoff pollutant mean concentrations, and mean seasonal or annual pollutant loads. Two explanatory variables are used in the U.S.G.S. Regression Models, (1) the physical and land use characteristics for the individual outfall catchment areas, and (2) the climatic characteristics for the watershed area. Thirty-four regression models of storm-runoff constituent loads and storm-runoff volumes were developed and 31 models of storm-runoff mean concentrations were developed. Ten models of mean seasonal or mean annual constituent loads were developed by analyzing long-term storm-rainfall records using at-site linear regression models. Three statistically different regions of the United States were delineated on the basis of mean annual rainfall to improve linear regression models where adequate data was available. Multiple regression analysis, including ordinary least squares and generalized least squares, were used to determine the optimal linear regression models. These developed models can be used to estimate storm-runoff constituent loads, storm-runoff volumes, storm-runoff mean concentrations of constituents, and mean seasonal or mean annual constituent loads at gaged and ungaged urban watersheds. The most significant explanatory variables in all linear regression models were storm rainfall and total contributing drainage area. Impervious area, land use, and mean climatic characteristics were also significant explanatory variables in some linear regression models.

The Source Loading And Management Model (SLAMM) is an Urban Non-point Source Water Quality Model that was originally developed to better understand the relationships between sources of urban runoff pollutants and runoff quality. SLAMM is strongly based on actual field observations, with minimal reliance on theoretical processes that have not been adequately documented or confirmed in the field. SLAMM provides a better understanding of sources of urban runoff pollutants and their control. Special emphasis has been placed on small storm hydrology and particulate wash off. SLAMM incorporates unique process descriptions to more accurately predict the sources of runoff pollutants and flows for the storms of most interest in stormwater quality analysis. SLAMM has evolved to include a variety of source area and end of pipe controls and the ability to predict the concentrations and loadings of many different pollutants from a large number of potential source areas.

SLAMM calculates mass balances for both particulate and dissolved pollutants and runoff flow volumes for different development characteristics and rainfalls, and the use of many combinations of common urban runoff control practices.

The Agricultural Non-Point Source Pollution Model (AGNPS) is a single-event computer model developed by U.S. Department of Agriculture, Agriculture Research Center. An SCS-Version 4.0 was developed to simulate sediment and nutrient transport from agricultural watersheds. AGNPS can be used to evaluate non-point source pollution from agricultural watersheds. It can compare the effects of implementing various conservation alternatives within the watershed. The basic components of the model are hydrology, erosion, sediment transport, nutrient, and chemical oxygen demand. The model is based on a square grid (cell) geometric representation of the watershed. Each cell homogeneously represents the landscape within the respective grid cell boundary (e.g., only a single runoff curve number and set of Universal Soil Loss Equation (USLE) parameters are permitted for any individual cell). The respective physical or chemical constituents are routed from its point of origin within a cell using logical hydrologic processes to its storm event destination. This destination may be either deposition within the stream channel system or to the outlet of the watershed.

3. Approximate Mean Seasonal Sediment Loads

SAND LAKE COULEE WATERSHED

Subarea Reach No.	Area (AC)	Area (Mi^2)	*Load (Tons/ Year)	*Load Tons/ AC/Yr	*Load CY/ Year	*No. of Truck Loads
4	495	0.77	490	0.99	368	25
6	122	0.19	40	0.33	30	2
5	410	0.64	230	0.56	173	12
3	450	0.70	280	0.62	210	14
7	720	0.50	150	0.21	113	8
6A	110	0.17	40	0.36	30	2
8	512	0.80	380	0.74	286	19
10	557	0.87	530	0.95	398	26
10A	813	1.27	1300	1.60	1000	67
8A	224	0.35	80	0.36	60	4
9	678	1.06	800	1.18	601	40
11	269	0.42	100	0.37	75	5
12	160	0.25	50	0.31	37	3
TOTAL	5120 ±	8±	*4470±	*0.87±	*3381 ±	*227±

*These estimates do not include sediment loads from areas under construction.

Note: 1 truck load equals approximately 20± tons or 15± cubic yards (CY). 1 CY equals approximately 1.33 tons.

<u>HALFWAY CREEK WATERSHED</u>

Subarea Reach No.	Area (AC)	Area (Mi^2)	Load (Tons/ Year)	*Load Tons/ AC/Yr	*Load CY/ Year	*No. of Truck Loads
8A	1495	2.28	3200	2.14	2406	160
8	1513	2.31	7500	4.96	5639	376
9	1744	2.67	3400	1.95	2556	170
9A	1070	1.61	2800	2.62	2105	140
1A	1185	1.80	4100	3.46	3083	205
1B	1544	2.36	5300	3.43	3985	266
2	1297	1.97	2200	1.70	1654	110
2A	439	0.63	220	0.50	165	11
3	2430	3.70	4800	1.97	3609	241
3A	736	1.09	800	1.09	602	40
4	1888	2.89	3500	1.85	2632	175
5	1984	3.04	3200	1.61	2406	160
6	891	1.34	1600	1.80	1203	80
6A	499	0.73	500	1.00	376	25
7	2167	3.30	3700	1.71	2782	185
7A	780	1.16	950	1.22	714	48
9B	1282	1.94	4200	3.28	3158	210
TOTAL	22,944±	36±	50,170±	*2.19±	*39,075±	*2602±

*These estimates do not include sediment loads from areas under construction.

Note: 1 truck load equals approximately 20± tons or 15± cubic yards (CY). 1 CY equals approximately 1.33 tons.

E. Benefits of Sedimentation Control

When fish, wildlife, and waterfowl populations change Lake Onalaska, Wildlife and Fish Refuge, Sand Lake Coulee Creek, and Halfway Creek become less valuable as a water resource for recreation, tourism, and property value appreciation. As previously mentioned, sedimentation and the toxic chemicals that attach to sediments that are conveyed by stormwater runoff make the water resources of this area unsafe for people, fish, wildlife, and waterfowl. Cleaning up urban runoff may be expensive, but the potential payoff from this investment is high. The rewards include sustaining fish, waterfowl and wildlife, providing recreation close to home, providing hunting and fishing resources, making urban neighborhoods healthier places to live, and fostering tourism, economic, and waterfront development within the community.

Controlling sediments also provides the following benefits:

- Mitigate flooding and loss of agricultural lands.
- Mitigate flooding of businesses and residences within the community
- Mitigate structural deterioration and flooding of CTH 'ZN' which is vital to Brice Prairie
- Mitigate stream bank erosion and associated flooding which threatens agricultural fields, residences, businesses, railroad tracks, and State bike trail
- Mitigate environmental and community damage from flooding of hazardous areas such as bulk fuel storage tanks, bulk fertilizer storage areas, sewage septic systems, and private sump pump systems.

Best Management Practices

VII. BEST MANAGEMENT PRACTICES

A. General

Best management practices (BMPs) recommended in this study and report are measures intended to reduce or mitigate flood control and sedimentation to the maximum extent practicable. Certain measures can help reduce impacts, but no BMP will totally mitigate past problems and development. Although real flows may be controlled to reduce sedimentation, volumes from urbanization will continue to increase, and the volume of water and sedimentation will increase potential damage to Sand Lake Coulee Creek, Halfway Creek, the Wildlife and Fish Refuge, and Lake Onalaska. There are many ways to approach BMP site design but it is most easily done within developing areas.

Developing areas allow for unique opportunities to incorporate BMPs into site design. The BMPs can be incorporated into natural areas serving as open spaces for community enjoyment. This idea can be expanded into a fingerprinting concept that requires developments to duplicate BMPs to some extent at each site. The fingerprinting requirements ensure a minimum set of controls at each site.

Another technique is for a community to purchase land next to a water resource and create a buffer strip around the area and construct BMPs. In certain cases, this may be the only way to protect a sensitive water body from further degradation, even with several BMPs in place.

Sedimentation and Flood Control Best Management Practices can be categorized as either structural or non-structural controls. Structural best management controls include wet detention-sedimentation basins, constructed wetlands, infiltration basins, infiltration trenches, dry detention basins, sump storm sewer inlets, riprap, gabions, construction of grassed channels and drainageways, silt fence, and straw bales. Non-structural controls include street sweeping, catch basin cleaning, public education and information program, salt/sand/deicer use on winter streets, leaf and lawn waste control, construction site erosion control regulations and enforcement, stormwater management planning education and ordinances, and land use planning. A large percentage of sedimentation control can be obtained by using non-structural best management practices rather than using expensive structural best management practices. However, some structural controls must be provided in order to obtain the greatest amount of sedimentation reduction and flood control within the Sand Lake Coulee and Halfway Creek watersheds.

We recommend the following non-structural and structural best management practices be implemented to address sedimentation loading and flood control within the study area.

B. Recommended Non-structural Best Management Controls

1. Public Education and Information Program

Changing urban stormwater management will require investments in information and education as well as in engineering and construction. A carefully conceived and administered information and education program is essential for several reasons.

First, few people are aware of the problems caused by sedimentation and pollutants in stormwater runoff or the common sources of sedimentation and pollutants. Before the public will support changes in sedimentation and stormwater management controls, they must understand the need for these changes.

Several stormwater structural treatment methods such as detention, infiltration, and biofiltration are unfamiliar.. Therefore, they are not widely accepted by many urban residents, local governmental officials, and developers.

New technology and engineering design, construction, and maintenance techniques for stormwater treatment devices are evolving as these devices gain wider use. Therefore, local governmental agencies and construction industry staff need to regularly share experiences and learn about the latest developments in the field.

Urban developments originally desired stormwater systems for drainage and water quality, not for sedimentation and pollution control. Public expectation and engineering practices must change to expand stormwater management and include wet detention, infiltration, sedimentation, and pollution prevention. Since sedimentation and pollutant sources are so wide-spread, the public needs to cooperate in carrying out pollution prevention, which is the most effective control.

The public education program should include individual and societal changes. Changes in human behavior seldom occur overnight. From an individual perspective, there are three basic steps to change: awareness, acceptance, and implementation. A person must first recognize a problem exists and understand what causes that problem, then the person must overcome any resistance and accept the solutions. The person is ready to learn how to carry out the solution only after completing these steps.

Societal change is more than an individual process, it is also a group process. People adopt new practices at different rates. Some people are more willing to take the lead and experiment. Others will wait until the "bugs are worked out" and adopt the practice only after they have proof that it works. Some will resist until they are forced to change. Thus societal change also has three basic steps: innovation by a few, voluntary adoption by the leaders, and mandatory compliance by the rest.

We recommend that an information and education program be implemented to adapt to these different stages of individual and societal change. First you must build public awareness of the impacts of urban stormwater runoff with an understanding of the sources of sediment and pollutants. Then you need to overcome the public's resistance to sedimentation and pollution prevention and control practices by encouraging those who are willing to try them. Information from the experience of these innovators must be used to improve the practices. The successes of these innovators must be shared with others to encourage the leaders to adopt the new stormwater management techniques. Support required for widespread implementation of stormwater controls is built once a solid foundation of awareness, acceptance, voluntary adoption, and feedback is accomplished.

Public education and information programs can use newsletters, news releases, public information meetings, and field trips. The overwhelming temptation in developing an information and education program is to use a "shotgun" approach and plan to do a little bit of everything with the hope that something will work. The reality is that when faced with the day-to-day demands to provide good service and hold down the tax levy, most communities invest very little time and effort in information and education. We recommend the best approach is to lie somewhere between these two extremes. The program strategies should achieve specific objectives by educating key audiences whose actions or support is needed to carry out change.

We recommend the first step in developing an information and education strategy is to determine what needs to be done and why. Communities should determine which audiences need to receive what information to achieve a certain change. These decisions can be summarized in a list of long-term goals supplemented by a list of objectives for each year. After completing this, select appropriate activities to accomplish each objective.

2. Construction Site Erosion Control

Even small areas under construction can have profound effects on Sand Lake Coulee Creek, Halfway Creek, Wildlife and Fish Refuge, and Lake Onalaska since construction site erosion produces such a heavy concentration of sediment load.

LaCrosse County finds that runoff from land disturbance activities on environmentally sensitive areas and construction sites may carry a significant amount of sediment and pollutants to the waters and rights-of-way of the County and State.

Under authority granted by 5.59.974 Wisconsin Statutes, LaCrosse County adopted a "Construction Site Erosion Control Ordinance". The purpose of this ordinance is to protect LaCrosse County's unique natural resources by minimizing the amount of sediment carried by runoff or discharged from construction sites to perennial waters, wetlands, and public rights-of-way. This ordinance applies to land disturbance activities on lands within the boundaries and jurisdiction of LaCrosse County in the unincorporated areas.

To control erosion and sedimentation from construction sites, we recommend that all governing agencies within the Sand Lake Coulee and Halfway Creek watersheds follow the provisions, requirements, inspection, and enforcement of this ordinance to the maximum extent practicable.

A copy of LaCrosse County "Construction Site Erosion Control Ordinance" is provided in the Appendix.

3. Stormwater Management Plan and Ordinance

To provide a guideline for structural and non-structural best management practices as they relate to development and urbanization within the Sand Lake Coulee and Halfway Creek

Watersheds, we recommend implementing a stormwater management plan and ordinance. A portion of the stormwater management plan has been completed by this hydraulic and sedimentation study report.

Stormwater planning should be implemented on a watershed basis. Therefore, the four components required in a stormwater plan are as follows:

- Land Use Planning
- Performance or Design Criteria for BMPs
- Financing Mechanisms
- Stormwater Ordinance

Before completing any component, all municipalities within the watershed must develop an outline for the stormwater plan. This outline must guide both water quality and water quantity aspects of stormwater planning. To protect human and environmental concerns there are four fundamental elements considered as part of the stormwater planning and ordinance document:

- Flood Control
- Urban Water Resource Protection
- Generic Nonpoint Sources Pollution Control
- Specific Nonpoint Source Pollutant Control

A strong comprehensive stormwater management plan results in developer constructed and financed BMPs rather than municipality funded BMPs.

A stormwater ordinance provides the legal framework to require suitable management practices to reduce flooding and damage to water resources. An ordinance gives performance or construction guidelines and promotes consistency with a best management practice.

We recommend the following stormwater ordinance elements be considered:

- Findings of Fact/Purpose and Objection
- Authority/Jurisdiction
- Definitions
- Applicability
- Plan Review
- Enforcement
- Performance Standards
- Off-site Management Facilities
- Maintenance
- Performance Bond
- Appeals Process
- Variance Procedure

We recommend you review several approaches to a stormwater ordinance. The ordinance may specify performance standards, runoff detention, specific BMPs, or limit peak flow. We recommend that a companion document be provided with the ordinance to contain standards or specifications for BMP installation.

Ultimately, a stormwater management ordinance concludes the stormwater planning effort for a municipality. The ordinance will be the first step toward implementing the plan.

4. Land Use Planning and Zoning

To protect the water resources within the Sand Lake Coulee Creek and Halfway Creek watersheds from unfavorable land uses we recommend developing a comprehensive land use planning and zoning plan or updating any existing plans. Integrating economic and environmental needs can spare the Sand Lake Coulee Creek, Halfway Creek, the Wildlife and Fish Refuge, and Lake Onalaska from permanent damage.

Proper land use planning is one of three points the U.S. Environmental Protection Agency believes will solve sedimentation and nonpoint source pollution. In Wisconsin, both federal and state agencies support land use planning, but it is the responsibility of the local unit of government.

The Wisconsin statutes describe land use control powers for water quality protection. State statute 61.345 gives authority to municipalities to enact construction site erosion control and stormwater management zoning ordinances. Similarly, state statute 92.11 gives authority to a County, Town, City, or Village to develop land use regulations to control nonpoint source pollution such as sediments and other constituents.

The scope of authority to control land use decisions depends on the number of participants, each of which has certain powers to control land use and improve water quality.

Planning for an industrial, commercial, highway, and high density residential property away from sensitive water resources can provide positive benefits. Protecting Sand Lake Coulee Creek and Halfway Creek with wide expansive conservancy areas will provide maximum water quality benefits. These are examples of some of the items a good land use plan should address.

5. Catch Basin Sumps and Cleaning

Recent studies and research by U.S. EPA have concluded that catch basins designed and constructed with 1.5 foot to 2 foot sumps (holding areas below storm sewer pipe flow lines) provide a tremendous benefit of capturing sediments. The amount of catch basin sediment is very large in comparison with stormwater runoff yields. Sediments in catch basins are not very mobile. Therefore, cleaning the sediment from catch basins reduces the potential for very large discharges of sediment during large scouring rains. The sediments found in catch basins are typically the largest particles washed from streets, steep hillsides, and construction sites. The sumps in catch basins can also provide water quality benefits for other pollutants. If catch basin sumps are full of sediment they cannot remove additional sediments and pollutants from the runoff.

Catch basin sediments and particulates can be conveniently removed from sumps to eliminate this potential source of sediments and pollution from being discharged to Sand Lake Coulee Creek, Halfway Creek, the Wildlife and Fish Refuge, and Lake Onalaska. We recommend that all storm sewer catch basins be designed and constructed with sumps. They should be cleaned two times per year, which will allow the catch basins to capture sediments and particulates for most rains. This cleaning schedule can be expected to reduce the total sediment and pollutant lead loads in stormwater runoff by 10 and 25 percent. It can also reduce loads of other common pollutants such as COD (chemical oxygen demand), total Kjeldahl nitrogen, total phosphorus, and zinc by between 5 and 10 percent.

We recommend that storm sewer catch basins and structures be cleaned at a minimum of twice a year. These structures should be cleaned in late spring or early summer and in the fall of the year. Storm sewer catch basins will need to be monitored on a regular basis to adjust the frequency needed for cleaning. Some areas may require more frequent cleaning and other areas may require less frequent cleaning. We recommend that a schedule and agreement between the Villages, Town, State, City, and County be devised to determine which governing agency has jurisdiction in particular areas. Typically all County Trunk Highway drainage structures should be addressed by the County, Town roads by the Township, Village streets by the Village, City streets by the City, and State Highway 35 and U.S. Highway 53 by the Wisconsin DOT.

6. Street Sweeping

Past research and studies show that street sweeping has limited success as a BMP on existing urban land uses. However, street sweeping can be used in conjunction with other BMPs to control sediments and pollutants in stormwater runoff.

We recommend that street sweeping or increased street sweeping be implemented to provide some benefits beyond cleaning sediments and pollutants from streets. Street sweeping is very visible and can be used as an information and educational tool to promote public awareness of sediment transport and stormwater pollution.

Street dirt size and loadings, street texture, moisture, parked car conditions, and equipment operating conditions significantly affect street cleaning performance. Street cleaning can be more effective in industrial and commercial areas, especially if paved parking and storage areas are effectively cleaned. Street sweeping with the proper equipment in these areas can reduce sediments and pollutants by approximately 70 percent. However, more common industrial and commercial street sweeping and cleaning programs would be 10 percent effective because of limited parking and street sweeping.

Street sweeping and cleaning within industrial and commercial areas should be done on a bi-weekly basis by the respective property owners beginning in the early spring into the late fall of the year.

Street sweeping and cleaning within City and Village streets, and heavily traveled Town roads, County Trunk Highways, and STH 35, and U.S. Highway 53 should be addressed at a minimum on a monthly basis in early spring and late fall to the maximum extent practicable. Town roads should be cleaned by the Township, County Trunk Highways by the County, Village streets by the Village, City streets by the City, and STH 33 and U.S. Highway 53 by the WI DOT. Cooperative agreements may be worked out between these governing agencies to delegate areas of responsibility with reimbursement from each agency to the other. The following are recommended high priority areas:

- U.S. Highway '53' - CTH 'MH' to Briggs Road
- STH '35' - CTH 'OT' to STH '53'
- Local Streets - Midway & Holmen
- City Streets - City of Onalaska
- CTH 'SN' - U.S. Hwy '53' to CTH 'D' (Holmen)
- CTH 'OT' - CTH 'SN' to CTH 'ZN' and CTH 'XX'
- CTH 'V' - CTH 'D' to Holmen north Village Limits
- CTH 'XX' - CTH 'ZN' to Briggs Road
- CTH 'ZN' - CTH 'OT' to CTH 'Z'
- CTH 'DN' - Village Limits of Holmen
- CTH 'D' - Village Limits of Holmen

If local municipalities determine that it is not feasible to street sweep the above high priority areas, we recommend that street sweeping be concentrated in areas of curb and gutter sections only. The benefits as related to costs need to be thoroughly evaluated prior to implementing this BMP.

7. Contour Strip Farming

Our visual observations made throughout the Sand Lake Coulee and Halfway Creek Watersheds confirm that local governing agencies and farmers are implementing strip farming practices to control soil erosion and sedimentation from agricultural lands. Alternative row crops with hay, oats, and alfalfa reduce the amount of soil erosion and runoff. Strip farming practices will preserve the fertility and productivity of soils and improve the water quality of Sand Lake Coulee Creek, Halfway Creek, the Wildlife and Fish Refuge, and Lake Onalaska.

We recommend that strip farming practices continue and be expanded to the maximum extent practical. Farming hay, oats, and alfalfa near sensitive water resources where soil can easily erode and run off into adjacent water bodies is recommended rather than row crops. A grassed buffer strip adjacent and along sensitive areas will help filter out pollutants and capture sediments prior to discharge to Sand Lake Coulee Creek, Halfway Creek, the Wildlife and Fish Refuge, and Lake Onalaska.

C. Recommended Structural Best Management Controls

1. Creek/Channel Improvements

Field observations, cross-sections, hydrologic and hydraulic analysis indicate that only a portion of Halfway Creek and Sand Lake Coulee Creek require channel improvement work. It is our opinion that by constructing the detention basins and sedimentation basins as discussed in the following sections the 100-year flood amounts can be reduced by approximately 75% and sedimentation amounts reduced by 50-90%. The watersheds will receive greater benefits by using available funds to construct wet detention/sedimentation basins to reduce increased runoff in lieu of increasing channel and creek capacity to convey increased runoff downstream.

At Sand Lake Coulee Creek we recommend that areas approximately 100 linear feet upstream and downstream of culverts and bridge structures be excavated to remove sediments, reshape channel section, and restore with riprap and erosive tolerant vegetation. These areas include the bridges at CTH 'OT', STH '35', and U.S. Hwy. '53'. Excavating built-up sediments and debris within these locations will increase the intended hydraulics of the bridge sections.

Placement of riprap and vegetative plantings will help mitigate the stream bank erosion typically observed upstream and downstream of the bridges. The Sand Lake Coulee Creek profile analyzed from U.S. Hwy. '53' downstream to its outlet at CTH 'OT' has sufficient slope and cross-sectional area to convey the 100-year storm event runoff. There are some isolated areas that could use some reshaping and regrading work but it would be very expensive and difficult to get into the creek area because of the steep topographic relief adjacent to the creek. Also we feel that disturbing Sand Lake Coulee Creek wooded areas and natural vegetation would be more detrimental than beneficial.

At Halfway Creek we recommend that channel improvements be constructed from CTH 'ZN' approximately 4,300 linear feet north to the bridge at the bike trail crossing. This channel section does not have an adequate slope to convey runoff to the culvert and wetland area at the south side of CTH 'ZN'. A wet detention sedimentation basin is proposed at the bike trail bridge structure to store excess stormwater runoff and sediments, control the release of pristine water to the wildlife refuge area, control the release of excess water to this improved channel, and convey downstream. This channel improvement is intended to adequately convey excess runoff from the proposed wet detention/sedimentation basin and the wildlife/fish refuge through the culvert at CTH 'ZN' so that traffic at CTH 'ZN' will not be impeded during a 100-year storm event. The channel in this area currently does not have a well defined cross-section and slope to convey excess runoff. By reshaping and regrading this channel, additional storage and hydraulic capacity can be obtained and runoff directed to the south side of CTH 'ZN'. This channel improvement will increase the hydraulic efficiency of the culvert at CTH 'ZN' and reduce the amount of water that ponds along the north side of CTH 'ZN'. We also recommend that areas approximately 100 linear feet upstream and downstream of culverts and bridge structures at Halfway Creek be excavated of sediments, reshaped, and restored with riprap and erosive tolerant vegetation. These areas include structures at STH '35', U.S. Hwy '53', and CTH 'XX'. This work will increase the hydraulic efficiency of the structures and mitigate erosive forces typically observed within these areas.

2. Wet Detention Basins

Wet detention basins are the most effective and most commonly used best management practices for flood control, sedimentation control, and control of numerous pollutants found in stormwater runoff. They are reliable and attractive systems that help control stormwater quality and quantity. These systems consist of a single permanent pool of water or a combination of a single permanent pool of water with a pretreatment sedimentation area that treats incoming stormwater and discharges pristine stormwater to sensitive receiving water bodies. Wet detention basins are typically engineered with three to seven feet of standing water, allowing sediments and pollutants to settle out, with a defined sedimentation basin, forebay, and outlet control structure.

Many studies have shown that wet detention basins consistently remove sediments and pollutants that attach to sediments. Removal rates can vary from 50 to 90 percent, depending on the design size and shape of the system. Wet detention basins can also control pollutants such as heavy metals, phosphorus, and bacteria, but at lower removal rates than sediments. Pollution control rates can also vary depending on the construction of the system, but in general the following approximate rates apply:

Pollutant	Percent Reduction
Suspended Solids (sediment)	50-90%
Phosphorus	12-79%
Nitrogen	6-62%
Chemical Oxygen Demand (COD)	7-76%
Lead	8-84%
Copper	7-65%
Zinc	13-87%

If wet detention basins are properly designed, engineered, and constructed they can also be an attractive environmental asset for wildlife, humans, and property value appreciation. The systems can be integrated with green space areas to provide park-like settings, while also controlling sediments and stormwater pollutants from being discharged to Sand Lake Coulee Creek, Halfway Creek, the Wildlife and Fish Refuge, and Lake Onalaska.

Negative impacts of wet detention basins are very limited concerning water resources and include downstream warming from thermal discharges. A typical public concern is child safety near the standing pools of water. Another common concern is the long-term maintenance requirement associated with these systems. These negative impacts and concerns can be mitigated with proper system design and construction.

Sediment settling is the most important function of the BMP which makes it the highest priority recommendation as concluded by the study review. Wet detention basin design considerations should include the following:

- Soil Type
- Slope of the System Banks
- Depth to Groundwater
- Depth to Bedrock
- Pretreatment and Control of Sediment Input
- Size and Depth of the System
- Flood Control Design
- Hydrological and Hydraulic Impacts Downstream and Upstream of the System
- Maintenance

Due to the size of the Sand Lake Coulee and Halfway Creek Watersheds more than one wet detention basin will be necessary to obtain maximum sediment and pollutant removal goals and also control flooding. We recommend that several wet detention basins be designed and constructed over time as financial resources and private developments permit. The approximate location of the recommended wet detention basin/sedimentation basins are illustrated on the maps in the Appendix pocket folder. The highest priority wet detention/sedimentation basin locations are those immediately upstream of the Wildlife and Fish Refuge on Sand Lake Creek and Halfway Creek. Designing and constructing several interconnected wet detention basins will provide a multi-stage stormwater treatment train system to mitigate further flooding, sediment, and pollutant discharges to the wetlands, Wildlife and Fish Refuge, and eventually Lake Onalaska. The siting location of these wet detention basins is very critical for construction, operation and maintenance, public enjoyment and recreation, park land use, and flood control. The wet detention/sedimentation basins shown on the maps within the upland areas are intended to be implemented by private developers as part of their urbanization and development plans in these areas. As discussed in the Non-Structural BMP Control Section of this report we recommend a stormwater management plan and ordinance be implemented to force developers to contribute their fair share to improve the sedimentation and water quality degradation within the Sand Lake Coulee and Halfway Creek Watersheds. The financial burden on the municipalities within these watersheds can be greatly reduced and the benefits greatly increased by partnering with private and public entities.

Extended wet detention basins are effective in controlling post-development peak discharge rates to the designed pre-development levels for the design storms specified. The optimum level of flood control is achieved when multiple storms are controlled. The recommended wet detention basins are intended to manage both smaller and larger floods that contribute to channel erosion and sedimentation loading problems. Peak-shaving design with the wet-detention basins should reduce the extent of downstream channel flooding and erosion when geared to control the two-year storm. Early research demonstrated that bank full discharges occurring on average every 1.5 to 2 years, control the shape and form of natural channels. We recommend that all municipalities within Sand Lake Coulee and Halfway Creek Watershed adopt stormwater detention basin policies that require the post-development peak discharges for all storms, including the 2-year storm, be controlled at or less than pre-development levels for flood and sediment control.

Stormwater erosion can only be controlled when both the magnitude and frequency of the post-development floods are adequately managed by detention basin storage. After a watershed is developed, small intense storms can dramatically increase the frequency in which two-year bank full discharges occur. The increased number of bank full floods, in turn, increases the probability of downstream bank and channel erosion and subsequent sediment loading.

We recommend a five to ten year sediment clean-out cycle for wet detention basins. This schedule may need revisions based on design and observations. Extra storage in the lower stage can be provided to accommodate additional sediment deposition. To reduce removal costs, we recommend on-site disposal or the local municipality should plan for use of the sediment.

3. Constructed Wetlands

We recommend that constructed wetlands be considered as a BMP to control stormwater runoff. The concept of constructed wetlands is not new. Point source dischargers have used these treatment structures for years. Constructed stormwater wetlands are shallow pools that enhance growing conditions for marsh plants to maximize sediment and pollutant removal. These wetlands differ from created wetlands since they do not reproduce the ecological diversity found in natural wetlands.

Constructed wetlands can effectively remove sediments and most pollutants from stormwater runoff. This takes place by the diverse treatment mechanisms of sedimentation, infiltration, chemical precipitation, absorption, microbial interactions, and uptake by vegetation.

Pollution control rates will vary depending on design, construction methods, and the vegetation associated with the wetland. In general, constructed wetlands can be expected to provide the following approximate removal efficiencies:

Pollutant	Percent Reduction
Suspended Solids (sediments)	14-98%
Phosphorus	0-97%
Nitrogen	25-30%
COD	22-27%
Iron	43-92%
Lead	68-82%
Zinc	34-50%

Please keep in mind that constructed wetlands are designed for pollutant removal and they differ from natural wetlands in many ways. The most obvious difference is that constructed wetlands may not fulfill the requirements associated with wetland mitigation action since they are not designed to replace existing wetlands.

We recommend the design and construction of wetland marshes be considered to create the bottom stage of proposed wet-detention basins to help remove soluble pollutants that cannot be removed by conventional settling.

Constructed wetlands can provide wildlife habitat and hide unsightly debris and sediment deposits that frequently accumulate at detention basin inlets and outlets.

Design considerations for constructed wetlands can be numerous. Site selection, wet surface area, water depth, wetland plantings, and maintenance all play important roles. We do not recommend that constructed wetlands be located within natural wetland areas. The wetland area should be adjusted so the average annual watershed loading does not exceed 45 pounds of phosphorus or 225 pounds of nitrogen for surface area of wetland. Water depths of 6-12 inches are recommended for optimal wetland growth. The wetland should be planted with native species suited to that environment. By effectively controlling soluble nutrients such as nitrogen and ortho-phosphorus, eutrophication of the water resources can be mitigated.

Constructed wetlands do have some negative impacts on land and water resource such as the following:

- Possible impact on the wetland biota from trace metal uptake
- Discharges are warmer than inflows
- Possible takeover by invasive aquatic nuisance plants such as loosestrife, and cattails
- Construction may adversely impact existing wetlands or forest areas
- Potential safety hazards
- Occasional nuisance problems (odor, algae, debris)
- Eventual need for costly sediment removal and wetland restoration

We recommend objectives for wet detention basins and wetlands be considered at every potential site and everyone should be aware that final design may never achieve all objectives. However, wet-detention basins and constructed wetlands are unique since they can truly be a multi-purpose BMP, by providing stormwater management, pollutant removal, and landscaping/habitat improvement.

4. Infiltration Basins / Dry Detention Basins

Infiltration basins / dry detention basins are large open depressions that store incoming stormwater runoff while percolation occurs through the bottom and sides. Soils, slopes, geology, hydrogeology, and drainage area restrict the use of the basins. Infiltrating stormwater allows groundwater recharge to maintain creek baseflow and colder creek temperatures. Infiltrating and dry retention basins also control flooding and stream bank erosion by reducing runoff.

Infiltration / dry detention basins are effective by removing both soluble and fine particulate pollutants borne in stormwater runoff if site conditions are right. Coarse-grained pollutants should generally be removed before they enter a basin. Unfortunately, limited performance data exists on infiltration basins.

We recommend that infiltration / dry retention basins be considered as a secondary BMP with wet detention basins and constructed wetlands. There may be isolated areas within the watershed where it may be feasible to use infiltration / dry detention basins as the primary BMP. Individual site specific conditions should be thoroughly investigated prior to design and construction of the BMP.

The following are some of the negative impacts that can be associated with infiltration / dry detention basins:

- Limited life span
- Maintenance to prevent clogging or sealing of the structure
- Regular mowing
- Raise groundwater table and cause flooding
- Contaminants in stormwater could negatively affect groundwater quality
- Retreat runoff with sediment removal
- Limited performance data

We recommend the following minimum design criteria for infiltration / dry detention basins:

- Area served <50 acres
- Areas <50% impervious
- High seasonal water table > 3 feet below basin
- Percolation rate > 12 hours, < 24 hours
- Depth to bedrock > 5 feet below basin
- Do not locate in groundwater discharge zones or high traffic areas
- Sideslopes <3.5:1 for safety and mowing
- Smoothly distribute inflow
- Densely grass basin area
- Provide overflow spillway emergency outlet
- Prevent compaction of soils in basin during construction
- Large enough to store snowmelt until spring thaw
- French drain infiltration back-up system
- Provide minimum sedimentation distances to wells, foundations, and septic drain fields

5. Riprap / Gabions / Geotextiles

During our field reconnaissance of Sand Lake Coulee Creek and Halfway Creek we observed a large amount of stream bank erosion throughout the watersheds. We observed that a majority of the stream buffer zones have been cleared so trees and vegetation do not provide natural stream bank stabilization.

We recommend implementation of a creek restoration program to stabilize the severely eroded sections of Sand Lake Coulee Creek and Halfway creek. This restoration can include a reforestation and vegetative planting program, installation of riprap, gabions, and geotextile erosion control measures. Riprap and gabions should only be installed at the hard corners of the creek. Riprap and gabions can be buried in the stream bank and covered with vegetative type plantings so that they aesthetically fit into the natural features of the environment. A properly designed stream bank system can provide both bank stabilization and aquatic habitat benefits. Riprap and gabions need to be properly sized and designed for the stream flow and velocity conditions so they are not transported and displaced downstream during large rainfall events.

6. Grassed Channels and Drainageways

Grassed channels and drainageways are unconnected storm drainage systems. Storm sewer pipes, curbs and gutters, streets, and parking lots are connected storm drainage systems. Wherever feasible and practicable, we recommend stormwater runoff be routed to water resource areas by unconnected systems rather than connected systems. Unconnected systems such as grassed swales, drainageways, and channels can remove substantial amounts of particulates, sediments, and pollutants prior to discharge to Sand Lake Coulee Creek, Halfway Creek, the Wildlife and Fish Refuge, and Lake Onalaska. Directly connected systems directly discharge sediments to those receiving water bodies without any filtration or pretreatment mechanisms. Grassed channels, swales, and drainageways should be implemented as a secondary BMP to primary BMPs such as wet-detention and constructed wetland systems. These systems can serve as pretreatment of stormwater runoff prior to final treatment by the primary system before it is discharged to Sand Lake Coulee Creek, Halfway Creek, the Wildlife and Fish Refuge, and Lake Onalaska. Should connected stormwater systems be necessary we recommend they discharge to a disconnected system.

The disadvantages of a disconnected grassed swale, channel, and drainageway as compared to a connected system are increased costs due to long term operation and maintenance. Sediments need to be removed and disposed of on a periodic basis. Mowing and brush work maintenance can be a problem with limited staff and financial resources. However, the advantages of these systems outweighs the disadvantages with respect to increased water quality benefits.

7. Sand Lake Coulee Creek - Community of Midway

At the Public Information Meetings several residents stated their concerns with flooding due to high ground water from CTH 'OT' north to the gravel pit. Property owners have suggested that the Sand Lake Coulee Creek be lowered and cross-sectional area increased to reduce ground water levels and control flooding.

We recommend that a resident survey be conducted in this area to better understand residents desire to modify the creek in their backyards which would affect natural vegetation and woodlands.

We also recommend that a hydrogeological subsurface investigation and report be performed to determine if lowering of the creek would alleviate high ground water concerns and reduce sump pump operations by residents. We recommend that this report provide suggested alternatives and opinions of probable costs if high ground water concerns cannot be addressed by lowering the creek based on subsurface conditions.

Cost of Implementation

VIII. COST OF IMPLEMENTATION

A. Estimate of Probable Costs - 1995 Dollars

The following are Preliminary Opinions of Probable Present Worth Construction Costs for Recommended Flood Control and Sedimentation Control Best Management Practices. These cost estimates are based on field observations, investigations, preliminary analyses, and existing topographic maps. Probable costs will need to be refined following field surveys, soil borings, geotechnical investigations, and detailed engineering and design.

The following are our recommended priority of construction improvements and summary of costs over a **20 year period** to address the problems and concerns based on probable severity as analyzed within the Sand Lake Coulee Creek and Halfway Creek watersheds.

1. Halfway Creek - Immediate Improvements

Channel Improvement CTH 'ZN' to Bike Trail	$ 55,000
Clean Out and Expand Existing Sedimentation Basin #1	50,000
Construct Wet Detention/Sedimentation Basin #2 ..... (includes land costs 10± acres)	275,000
Construct Wet Detention/Sedimentation Basin #3 ..... (includes land costs 10± acres)	275,000
Channel Improvements at CTH 'XX' Structure	35,000
Miscellaneous Channel Erosion Control Measures	20,000
Subtotal	$ 710,000

2. Sand Lake Coulee Creek - Immediate Improvements

Clean-Out and Expand Existing Sedimentation Basin #1	$ 50,000
Channel Improvements at STH '35', U.S. Hwy '53' & CTH 'OT'	105,000
Construct Wet Detention/Sedimentation Basin #2 ..... (includes land costs 10± acres)	275,000
Construct Wet Detention/Sedimentation Basin #3 ..... (includes land costs 10± acres)	275,000
Miscellaneous Channel Erosion Control Measures	20,000
Subtotal	$ 725,000

3. Halfway Creek - Intermediate Improvements

Construct Wet Detention/Sedimentation Basin #6 ..... (includes land costs 15± acres)	$ 325,000
Construct Wet Detention/Sedimentation Basin #7 ..... (includes land costs 15± acres)	325,000
Stormwater Master Plan/Ordinances	20,000
Land Use Plan	20,000
Miscellaneous Channel Improvements at Bridges and Culverts	70,000
Miscellaneous Channel Erosion Control Measures	30,000
Subtotal	$ 790,000

4. Sand Lake Coulee Creek - Intermediate Improvements

Retrofit Existing Wet Detention Basin #4	$ 75,000
Construct Wet Detention Basin/Sedimentation Basin #5 (includes land costs 10± acres)	275,000
Stormwater Master Plan/Ordinances	20,000
Land Use Plan	20,000
Miscellaneous Channel Improvements at Bridges and Culverts	35,000
Miscellaneous Channel Erosion Control	30,000
Subtotal	$ 455,000

5. Halfway Creek - Ultimate Future Improvements

Construct Wet Detention/Sedimentation Basin #8 ..... (includes land costs 20± acres)	$ 375,000
Construct Wet Detention/Sedimentation Basin #9 ..... (includes land costs 20± acres)	375,000
Miscellaneous Channel Improvements at Bridges and Culverts	70,000
Miscellaneous Channel Erosion Control	30,000
Subtotal	$ 850,000

6. Sand Lake Coulee Creek - Ultimate Future Improvements

Construct Wet Detention/Sedimentation Basin #6 ..... (includes land costs 10± acres)	$ 275,000
Construct Wet Detention/Sedimentation Basin #7 ..... (includes land costs 10± acres)	275,000
Miscellaneous Channel Improvements at Bridges and Culverts	35,000
Miscellaneous Channel Erosion Control	20,000
Subtotal	$ 605,000
TOTAL - 1995 Dollars	**$4,135,000**

These priority based stormwater management water quantity and quality improvements are intended to be planned and phased over a number of years to coincide with funding availability and development of undeveloped land.

B. Quantification of Costs of Doing Nothing - 1995 Dollars

As presented in the previous sections, controlling stormwater runoff quantity and quality (sedimentation) will be expensive. Everyone has to accept the fact that funding to construct the recommended improvements may not be available. An important aspect of this study is to quantify the approximate costs of doing nothing within the Halfway Creek and Sand Lake Coulee Creek Watersheds and compare the do nothing consequences with the benefits of implementing the recommended improvements.

If nothing is done within the Halfway Creek and Sand Lake Coulee Creek Watersheds the following can be expected to occur:

- Flooding will be more frequent as urbanization expands.
- Sedimentation loads will increase over time.
- Flooding and loss of agricultural land will expand.
- Flooding of CTH "ZN" will be more frequent. A major transportation link to Brice Prairie, 18 businesses, and several farms will be impacted.
- Upper Mississippi River National Wildlife and Fish Refuge land will continue to deteriorate due to sedimentation, flooding, and siltation.
- Increased flooding at State Bike Trail and Burlington Northern Railroad will affect local and regional economy.
- Increased flooding and sedimentation will directly or indirectly impact approximately 1,520 people, 220 residences, 26 businesses, and several farms.
- Private sewage systems may collapse and cause environmental damage.
- Hazardous materials within the watersheds such as bulk fuel storage tanks and bulk fertilizer storage areas may be subject to flooding and cause environmental and community damage.
- Deterioration of Lake Onalaska and its recreation economy.
- Emergency services to Brice Prairie will be interrupted.
- School busing and services to Brice Prairie will be interrupted.

The following are our approximate determination of probable present worth of costs to do nothing within the Sand Lake Coulee and Halfway Creek Watersheds over a **20-year period**:

1. Loss of Agricultural Land .... $ 750,000
(Assume 5 acres/year @ $7,500/acre)

2. Economic Impact to Local Business Economy
(Assume two major floods affect businesses for total of 30 days)

   a. 26 Businesses @ $3,500/day average $2,730,000
   b. 35 Jobs @ $80/day .... $ 84,000

3. Flood Damage Costs - Property/Personal/Inventory
(Assume two major floods)

   a. 20 Residences @ $5,000/flood .... $ 200,000
   b. 10 Businesses @ $15,000/flood .... $ 300,000

4. State Bike Trail Local Economic Impact
(Assume two major floods close bike path for total of 30 days and trail used by 50,000 people/year)

   a. 100 Persons @ $15/day (average) .... $ 45,000

5. Burlington Northern Railroad Local and Regional Impact
(Assume two major floods close railroad for total of 15 days at 24 train cars/day)

   a. 24 Train Cars @ $2,500/car (average) .... $ 900,000

6. Deterioration of Upper Mississippi River Wildlife and Fish Refuge Land
(450± acres total)

   a. Lost Land, Tourism, and Recreational Value 300 acres @ $5,000/acre $1,500,000

7. Deterioration of Lake Onalaska Recreational Value

   a. 1989 Environmental Management Plan Habitat Project to Remove Sediment and Restore Channels $2,800,000

8. Private Sewage System Repair Costs

   a. 20 Residences @ $5,000/residence .... $ 100,000

ESTIMATED TOTAL - 1995 Dollars ... $9,409,000

Unit costs are factually based in historical data gathered from other comparable regions. These costs are approximate and will vary by a wide margin in some cases. These costs are included only to illustrate that the costs of "doing nothing" are greater than other alternatives and should not be taken literally.

C. Funding Overview

In order to implement the recommended Best Management Practices a source of funding must be obtained. The following are funding alternatives available for stormwater controls:

- Taxation
- Bonding
- Stormwater Utilities
- Grants
- Loans
- Assessments

1. Taxation

Local governments historically funded stormwater management services with Ad Valorem Property Tax Revenue.

The rationale for local government involvement (taxation) is the public benefits in managing runoff. The rationale for the financing mechanism (taxes) is either (1) higher-valued properties benefit more, or (2) owners of higher-valued properties can pay more for a public good (the benefits available to everyone that cannot be quantified). Unfortunately, this means stormwater expenditures must compete with other local government services and consequently funding is highly variable. With this disparity, local governing officials often give low priority to maintenance of drainage infrastructure.

With property tax as a financing mechanism, equity of funding is a concern. Residential and commercial property owners are better served under a charge or utility system (see Utility Structure Overview) and industrial property owners, in general, are better served under a property tax system. Commercial property owners are better off with the user charge system. Owners of agricultural land and exempt parcels are better off under the tax system.

If property values reflected benefits of stormwater management, the property tax system could be more equitable.

2. Bonding

Long term borrowing can effectively finance stormwater projects within a municipality. A municipality can use bonding authority to issue long-term bonds for water systems. Issuing bonds is less expensive than financing a project with a bank loan because it eliminates the "middle person" when borrowing money.

A long-term municipal bond is characteristically exempt from federal taxation. The federal government does not tax the interest on local securities through income taxation. State and Federal Governments may tax their own securities, although most do not exercise this right.

When a municipality wants to issue a bond, it must go through a rating process to learn how secure the municipality is from defaulting on this security. Receiving the highest rating makes it easier for a municipality to sell bonds. If a lower rating is received, in some cases the municipality must find an underwriter to help secure financing.

There are limits on the amount a municipality can borrow in Wisconsin. The indebtedness of a municipality cannot exceed five percent of the taxable property value within its boundaries. This limit ensures some proper fiscal management when borrowing. Certain types of bonding must also go through a referendum, which gives the public a chance to vote on issuing bonds.

A Wisconsin municipal bond can be issued for 20 to 50 years. For additional information on long-term bonding and legal requirements refer to Wisconsin State Statutes Chapter 66: Municipal Law, and Chapter 67: Municipal Borrowing.

3. Stormwater Utility

Over the past few years the concept of creating a stormwater utility has become popular. The utility approach redefines how people think about runoff and stormwater management. A basic premise in the utility approach is that runoff is a man-made problem and property owners are responsible. This approach designates property owners as stormwater generators with a government authority controlling these discharges. To finance government activities property owners pay user charges or fees proportional to their discharges. This utility approach uses the "polluter pays" principle. The American Public Works Association (APWA) concludes:

> "The user charge and utility concept are the most dependable and equitable approaches available to local governments for financing stormwater management."

Care must be taken when forming utilities. Listed below are steps to consider:

- Document the need for Stormwater Utility Program
- Educate Administrative Staff
- Establish a Steering Committee
- Develop a Public Participation Program
- Develop a Comprehensive Implementation Plan
- Calculate Current Stormwater Program Costs
- Estimate the Stormwater Revenue Needs
- Prioritize Needs and Projects
- Establish a Preliminary Budget
- Create a Rate Structure
- Refine Budget and User Charges
- Prepare a Stormwater Utility and User Charge Ordinance
- Develop a Billing System

4. Grants

The Town of Onalaska Hydraulic Study has been funded by a U.S. Department of Commerce Economic Development Administration Grant. The watershed's stormwater runoff discharges to a wildlife refuge that is overseen by the U.S. Fish & Wildlife Service and Lake Onalaska, which is a state water body. The watersheds are unique because this area qualifies for both federal and state funding assistance. All potential state and federal grant programs will need to be investigated for funding the recommended stormwater management improvements. Grants from FEMA, State Department of Development Community Development Block Grant Program, State Priority Watershed Program, and U.S. Department of Commerce's Economic Development Administration Program are some of the available grant funding sources.

5. Loans

The State of Wisconsin has been reviewing the need to include stormwater management and water quality based projects under the Clean Water Fund low interest loan program. This program has been used to finance projects such as wastewater treatment plant projects for years. Direct loans through local financial institutions are another loan funding alternative.

6. Assessments

For over a century, Wisconsin municipalities have used special assessments as a method to finance local improvement projects. Special assessments are flexible and they can be used to pay for public improvements such as stormwater management facilities. In addition, because only those properties which specially benefit from the improvement bear the improvement cost, the general property tax is not further burdened. Therefore, special assessments are useful financial tools for municipalities. Their usefulness has increased as demand continues to grow for each municipal tax dollar.

The procedures for levying special assessments is prescribed by Wisconsin law. Special assessments can be levied against property specially benefitted by a public improvement or work. Municipalities specially assess under either of two optional powers granted to them by the Special Assessment Statute, Sec. 66.60 statute. The police power allows the local legislative body to enact ordinances and take action ". . . for the health, safety, and welfare of the public." The taxing authority is the general power of any government to levy taxes on its citizens to pay for improvements and services provided. The difference between specially assessing under either power lies in the criteria necessary to establish the amount to be assessed and the procedures to be followed in the special assessment process. Accordingly, under the police power, the governing body must determine the actual existence of benefits while under the taxing power it must calculate the actual value of the benefits conferred.

Permit Requirements / State and Federal Laws

IX. PERMIT REQUIREMENTS / STATE AND FEDERAL LAW

The following are some of the typical State and Federal laws enacted to mitigate stormwater runoff problems. These laws and permit requirements were designed to protect humans and improve water quality.

Wis. State Statute Section 30.19 - Enlargement and Protection of Waterways
While this section does not directly relate to stormwater, it will affect BMP construction near water bodies. If a BMP is built within 500 feet of a navigable water body, a permit may need to be obtained before construction begins. The DNR Bureau of Water Regulation and Zoning issues the permit. There are exceptions to this rule, the most notable are water bodies that affect agricultural land and Milwaukee County.

Wis. State Statute Section 30.195 - Changing of Stream Courses
This section directly impacts stormwater discharges if a stream channel needs alterations because of increased flows or possibly if stream repair work, such as rip rap, gabions, etc., are needed to stabilize the streambanks. The DNR Bureau of Water Regulation and Zoning issues the permit.

Wis. State Statute Section 59.974 p Construction Site Erosion Control and Stormwater Management Zoning - County
Under this section, a county may enact a construction site erosion control and stormwater management zoning ordinance to all of its unincorporated areas. The county has the authority to set stormwater and construction site standards for local developers. The county has the power to enforce these standards. If a city or village annexes part of the county land, the county ordinance supersedes the city or village until they adopt an ordinance at least as restrictive as the county's. In addition, the county may also delegate this enforcement authority to a Regional Planning Commission.

Wis. State Statute Section 81.345 - Construction Site Erosion Control and Stormwater Management Zoning - Village
Under this section, a village may enact a construction site erosion control and stormwater management zoning ordinance applicable to all of its incorporated area. The village has the authority to set stormwater and construction site standards that local developers must meet. The village has the power to enforce these standards. The village may also delegate this enforcement authority to the Regional Planning Commission, and in Dane County, to the Lakes and Watershed Commission.

Wis. State Statute Sections 87.30-87.31 - Floodplain Zoning
The DNR Bureau of Water Regulation and Zoning administers the floodplain zoning section. This section delineates floodplain zones to protect people in these areas. The DNR and the municipality go through a hydrologic modeling and mapping process to delineate these areas. After delineation, it is possible no further development may be allowed within this floodplain zone. In addition, all structures in the floodplain may be removed.

Wis. State Statute Chapter 88 - Drainage of Lands
This chapter refers to creating drainage districts and maintaining drainageways adjacent to these districts. This chapter affects stormwater only on very small developments not under the jurisdiction of a town, village, or municipality. The district has the power to levy fees for the maintenance and improvement of drainageways. In essence a drainage district is the agricultural equivalent to municipal stormwater utility district.

Wis. State Statute Section 92.11 - Regulation of Local Soil and Water Resource Management Practices
This section promotes soil and water conservation and nonpoint source water pollution abatement. A county, city or village may develop ordinances to regulate land use, land management and pollution management practices. This section gives power to local governments to adopt and enforce stormwater and construction site ordinances.. This section does not set performance or design standards. This section also encourages county wide adoption of these ordinances.

Wis. State Statute Section 62.234 - Construction Site Erosion Control and Stormwater Management Zoning - City
Under this section, a city may enact a construction site erosion control and stormwater management zoning ordinance for all of its incorporated areas. The city has the authority to set stormwater and construction site standards for local developers. The city also has the power to enforce these standards. In addition, the city can delegate this enforcement authority to a Regional Planning Commission, and in Dane County, to the Lakes and Watershed Commission.

Wis. State Statute Section 92.17 - Shoreland Management
Created in 1992, this section establishes standards for activities related to maintaining and improving surface water quality. A county, city or village may enact a shoreland management ordinance.

Wis. State Statute Section 144.235 - Financial Assistance Program; Local Water Quality Planning
This section allows for funding of water quality and stormwater planning under the supervision of the DNR Bureau of Water Resources Management. Cost-share dollars are available to designated planning agencies to develop stormwater and construction site erosion control plans.

Wis. State Statute Section 144.25 - Financial Assistance; Nonpoint Source Water Pollution Abatement
This statute authorizes cost-share dollars for planning and implementation of nonpoint source Priority Watershed Projects. The DNR and the Wisconsin Department of Agriculture, Trade and Consumer Protection jointly administer this program. Cost-share dollars are available to develop and implement construction site erosion control and stormwater plans. Cost-share dollars are also available for BMP installation.

Wis. State Statute Section Chapter 147 - Pollution Discharge Elimination
This chapter give authority to the DNR to issue Wisconsin Pollutant Discharge Elimination System (WPDES) permits for point source discharges of stormwater. The DNR used this authority in the past to bring selected stormwater discharges under permit, primarily at industrial sites. Authority comes, in part, from the federal stormwater permit program (40 CFR parts 122-124) enacted under the 1987 Clean Water Act Amendments. The DNR will issue two general permits for stormwater associated with industrial activity. One permit covers discharges from construction sites that disturb more than five acres. Administration of the permit complements existing construction site erosion control regulation administered by the Wisconsin Department of Industry, labor, and Human Relations. The other DNR general permit covers all other stormwater discharges associates with industrial activity. In addition, the DNR is developing WPDES permits that cover the stormwater discharges from municipal storm sewers in Madison and Milwaukee.

Wis. State Statute Chapter 160 - Groundwater Protection Standards
This chapter sets standards for groundwater quality. It applies to all facilities, practices and activities that may affect groundwater quality and are regulated by state agencies. It establishes groundwater quality standards for substances that may be present in groundwater. It specifies procedures to determine if a numerical standard was exceeded. The chapter also provides standards for evaluating monitoring data, responding to exceedances and providing exemptions.

Wis. State Statute Section 66.072 - Utility Districts
A town, village and city can form a stormwater utility district along with other service districts. The local government must hold public hearings before it votes on the utility district. In towns, a majority of the governing body must support the utility district. In villages and cities, a three-fourths vote of all members of the governing body is required to establish a utility district.

Wis. State Statute Section 66.076 - Sewerage System, Service Charge
This section allows rate setting for sewerage collection, both for sanitary and stormwater systems.

Wis. State Statute Section 85.19 and 101.653 - Construction Site Erosion Control - Statewide
Created in 1992, these sections enact a statewide construction site erosion control ordinance administrated by the Wisconsin Department of Industry, Labor and Human Relations. It targets two areas for control. The first is highway and bridge construction funded in part or whole by state or federal funds, and the second controls one and two family dwellings. There is also a provision for training and certification in the preparation and review of erosion control plans and inspection of construction sites.

Local Agency Contacts

X. LOCAL AGENCY CONTACTS

The following is a list of local governing agencies contacted by telephone and/or newsletter as part of this Study Report.

City of Onalaska
Mr. Ronald V. Lund, City Engineer

Village of Holmen
Mrs. Sylvia Finch, Village President

Village of Holmen
Mr. Eugene Alberts, Administrator/Clerk

Village of Holmen
Mr. Philip Scholze, Director of Public Works

Town of Holland
Ms. Lorraine Halverson, Clerk

Town of Hamilton
Ms. Janette Hoyer, Clerk

Appendix

Figures

Hydrologic Cycle

HYDROLOGIC CYCLE

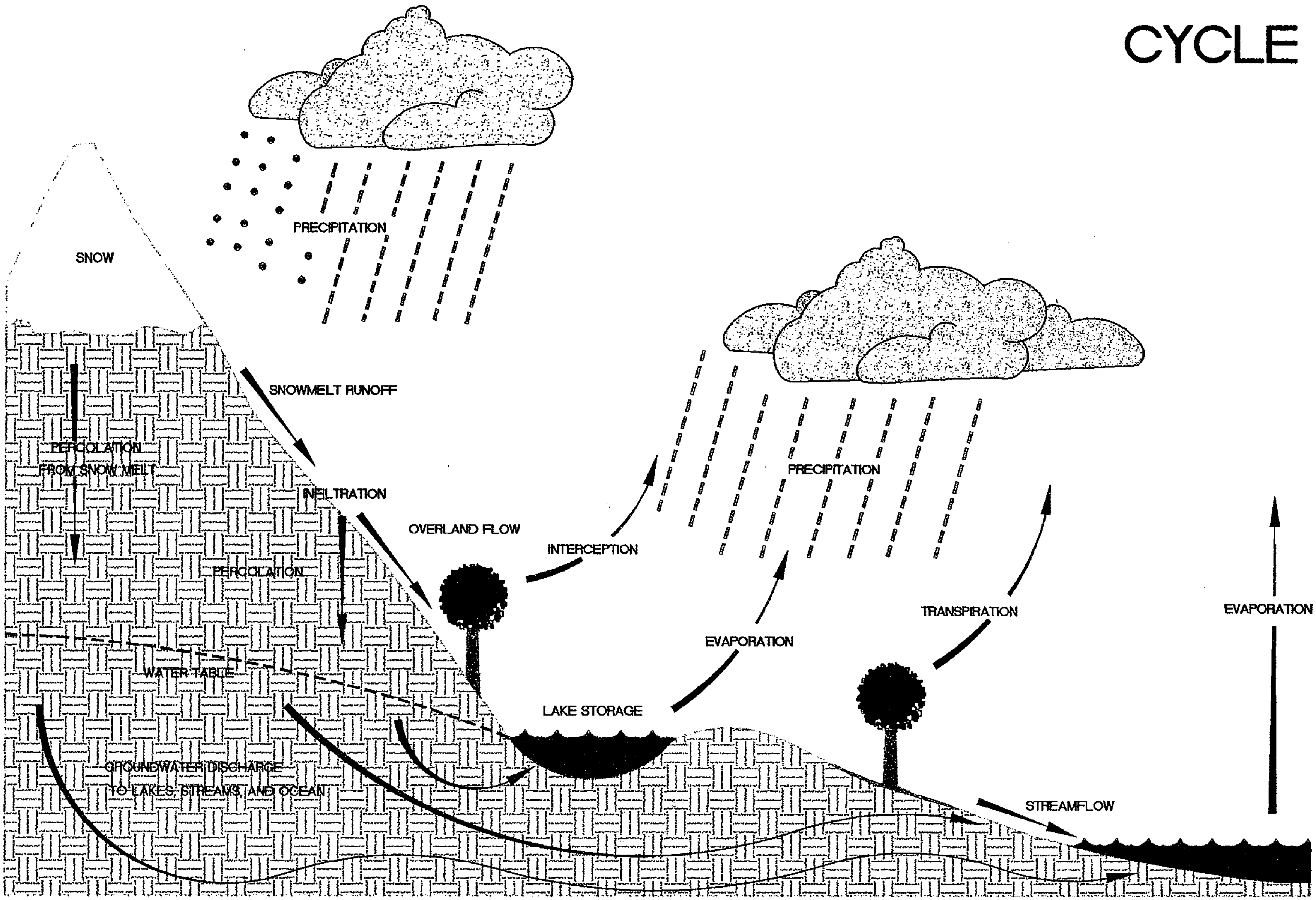


FIGURE 1

VIERBICHER ASSOCIATES

Water Surface Profile Plots

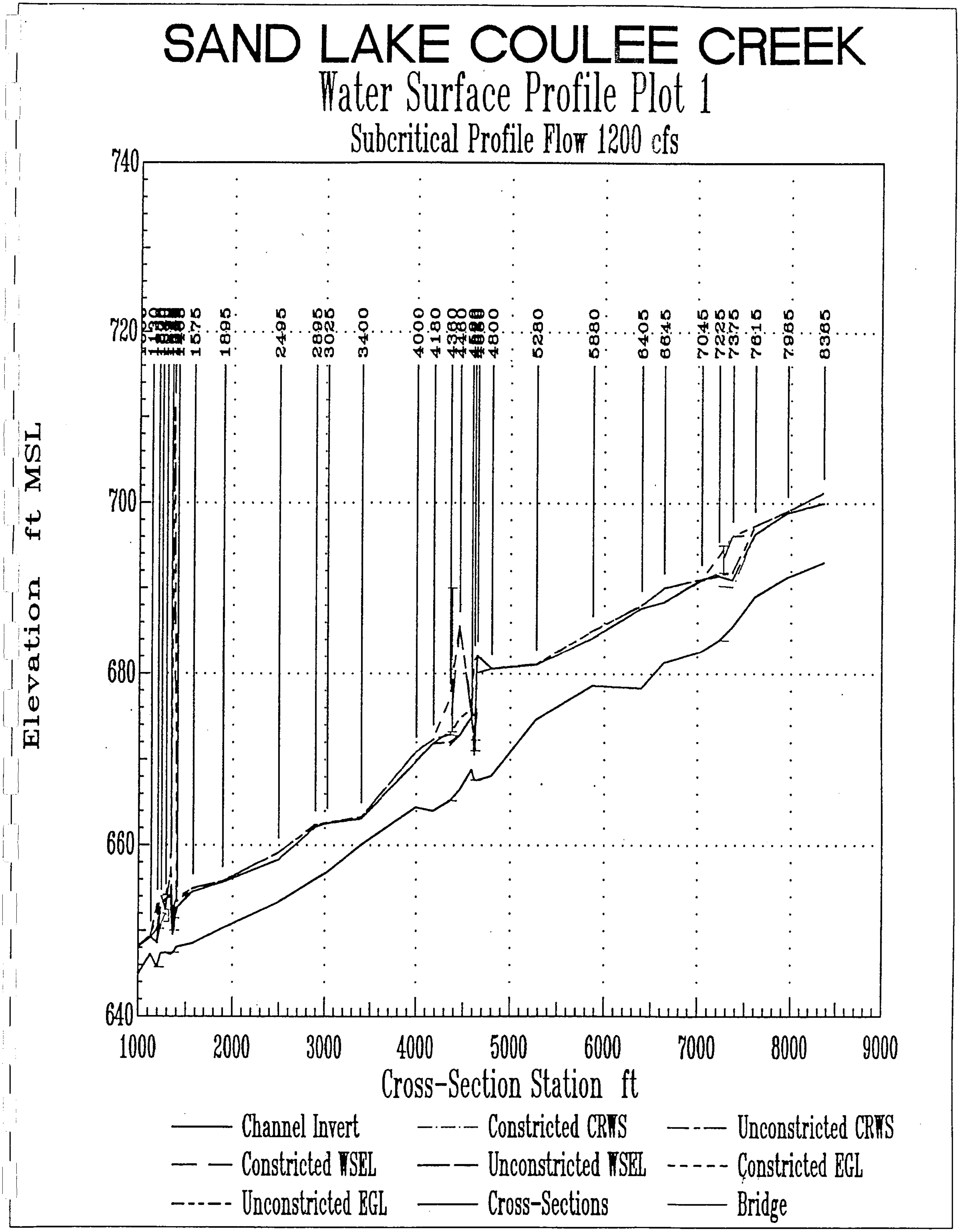

SAND LAKE COULEE CREEK
Water Surface Profile Plot 1
Subcritical Profile Flow 1200 cfs
Elevation ft MSL
Cross-Section Station ft
740
720
700
680
660
640
1000
2000
3000
4000
5000
6000
7000
8000
9000
1575
1895
2495
2895
3025
3400
4000
4180
4380
4480
4800
5280
5880
6405
6645
7045
7225
7375
7615
7985
8385
Channel Invert
Constricted CRWS
Unconstricted CRWS
Constricted WSEL
Unconstricted WSEL
Constricted EGL
Unconstricted EGL
Cross-Sections
Bridge

FIGURE 2

SAND LAKE COULEE CREEK

Water Surface Profile Plot 2

Subcritical Profile Flow 1000 cfs

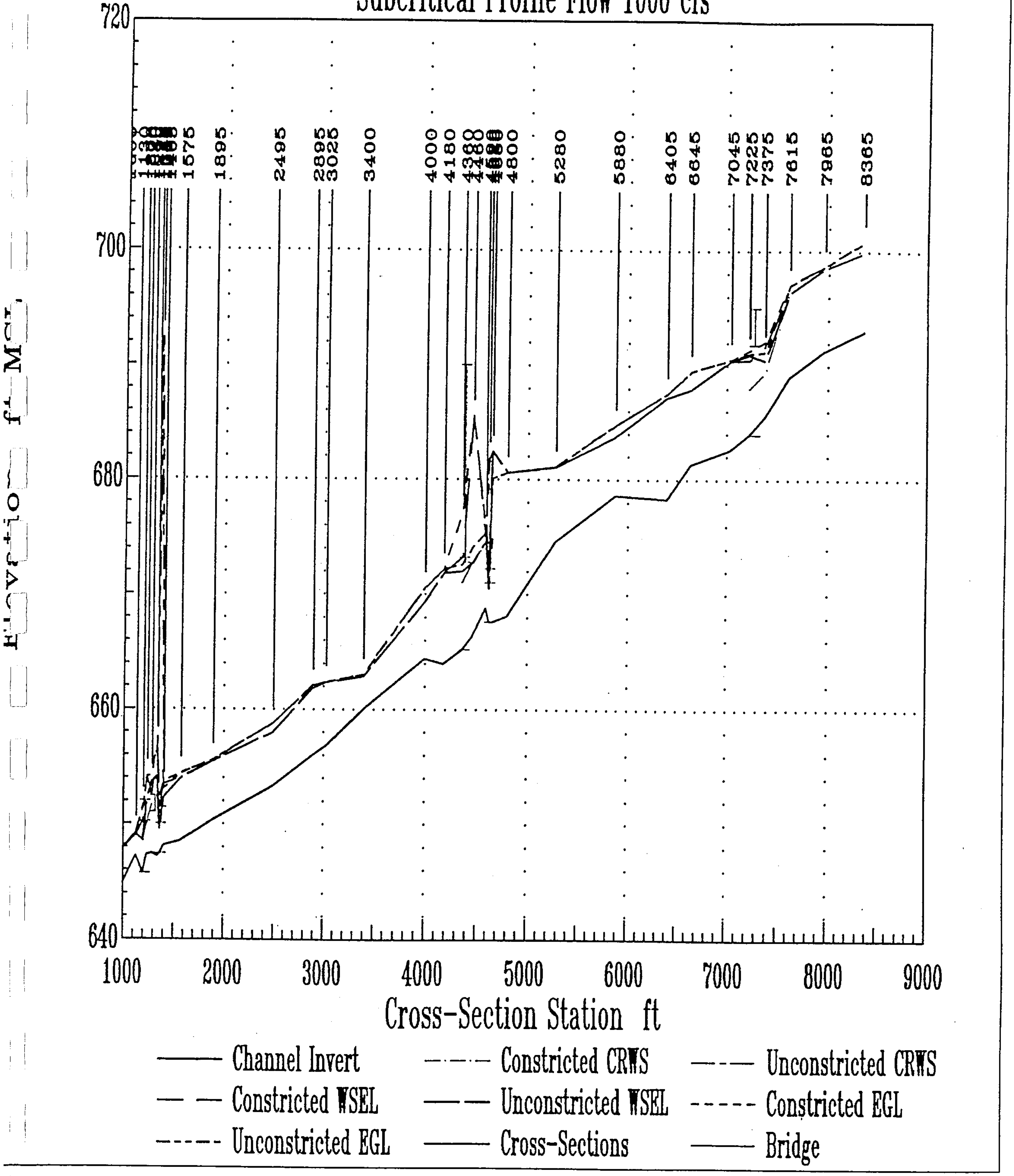


FIGURE 3

SAND LAKE COULEE CREEK

Water Surface Profile Plot 3

Subcritical Profile Flow 840 cfs

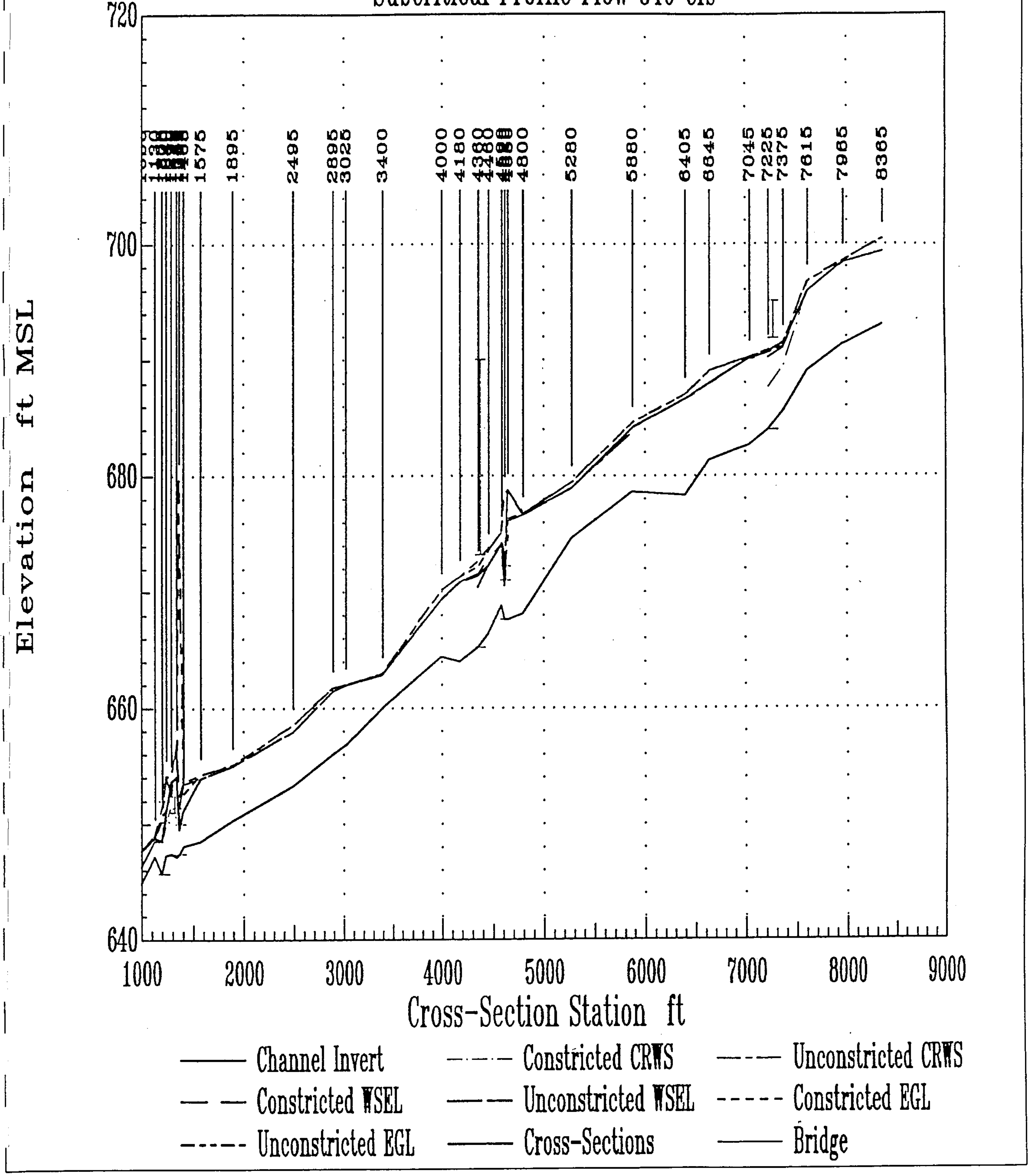


FIGURE 4

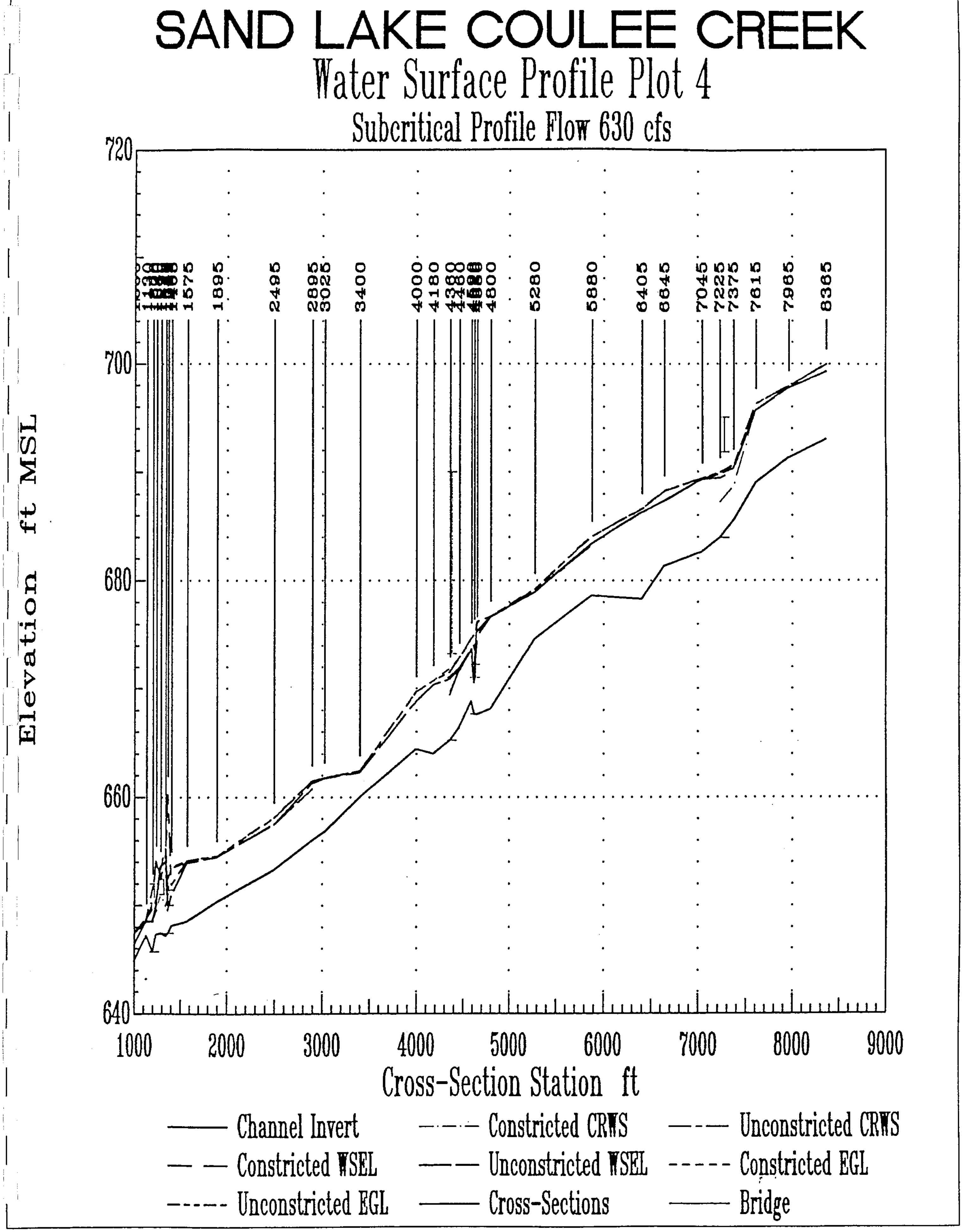

SAND LAKE COULEE CREEK
Water Surface Profile Plot 4
Subcritical Profile Flow 630 cfs
Elevation ft MSL
720
700
680
660
640
1000
2000
3000
4000
5000
6000
7000
8000
9000
Cross-Section Station ft
1575
1895
2495
2895
3025
3400
4000
4180
4800
5280
5880
6405
6645
7045
7225
7375
7615
7985
8365
Channel Invert
Constricted CRWS
Unconstricted CRWS
Constricted WSEL
Unconstricted WSEL
Constricted EGL
Unconstricted EGL
Cross-Sections
Bridge

FIGURE 5

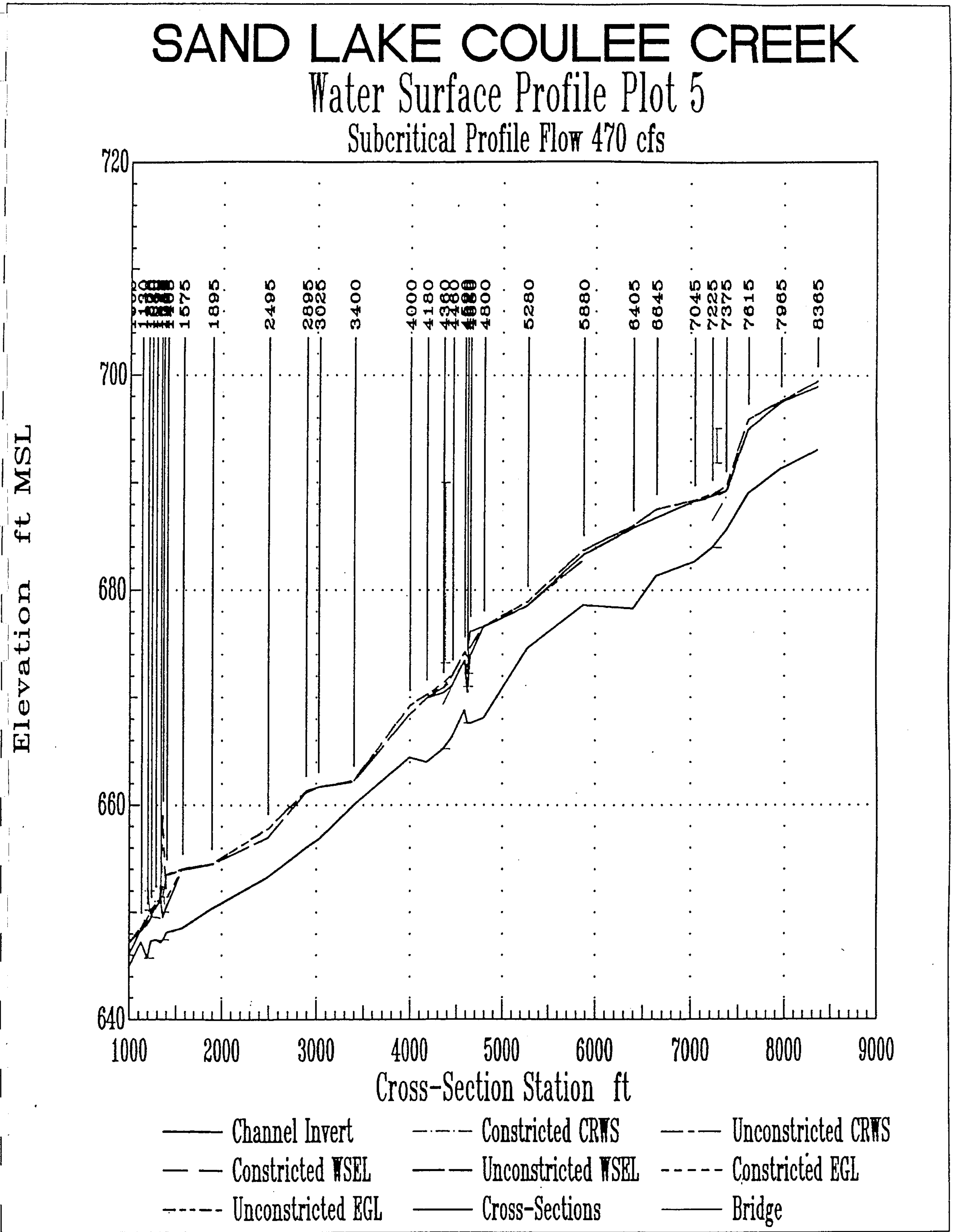

SAND LAKE COULEE CREEK
Water Surface Profile Plot 5
Subcritical Profile Flow 470 cfs
Elevation ft MSL
720
700
680
660
640
1575
1895
2495
2895
3025
3400
4000
4180
4800
5280
5880
6405
6645
7045
7225
7375
7615
7985
8365
1000
2000
3000
4000
5000
6000
7000
8000
9000
Cross-Section Station ft
Channel Invert
Constricted CRWS
Unconstricted CRWS
Constricted WSEL
Unconstricted WSEL
Constricted EGL
Unconstricted EGL
Cross-Sections
Bridge

FIGURE 6

SAND LAKE COULEE CREEK

Water Surface Profile Plot 6

Subcritical Profile Flow 280 cfs

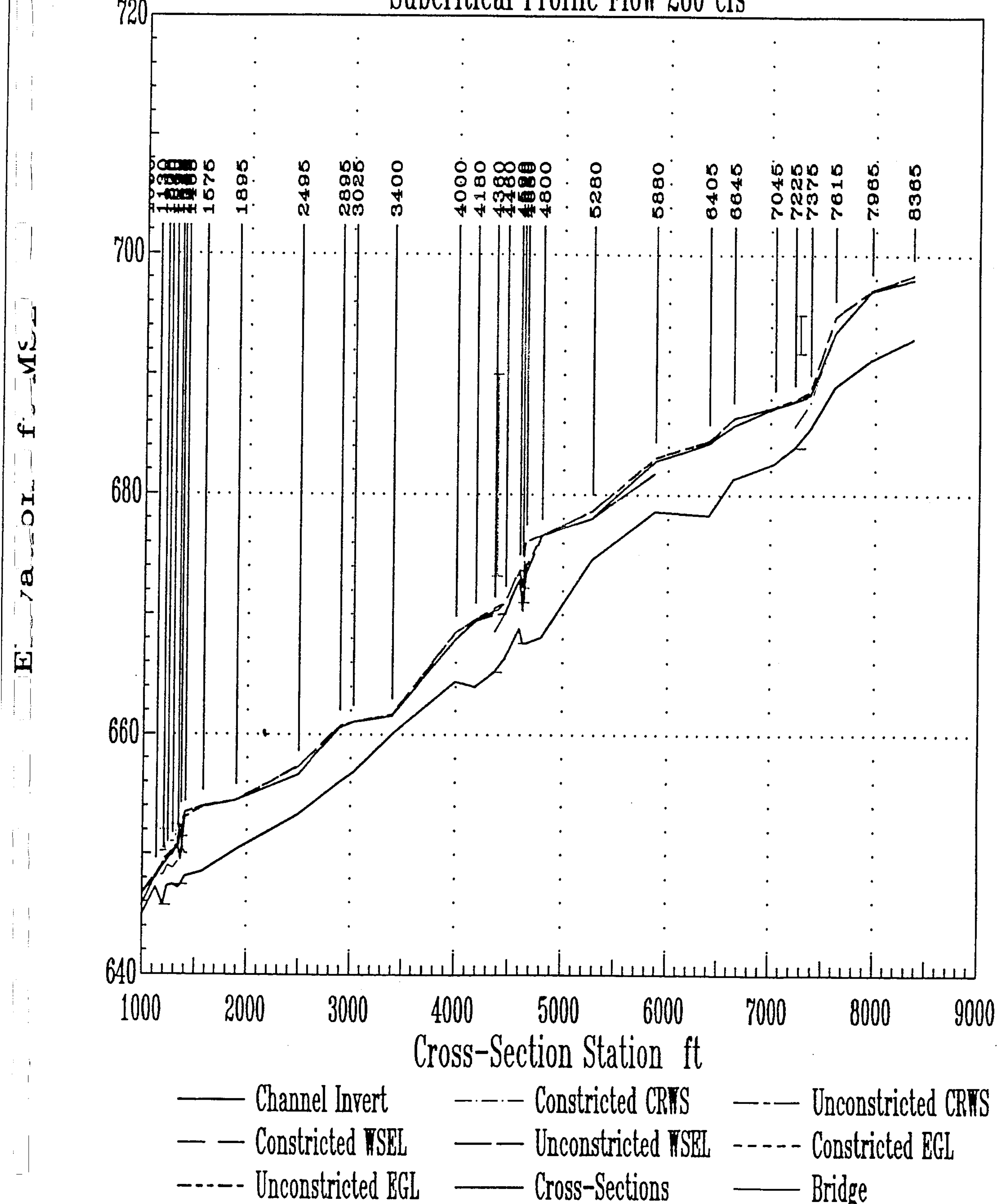


FIGURE 7

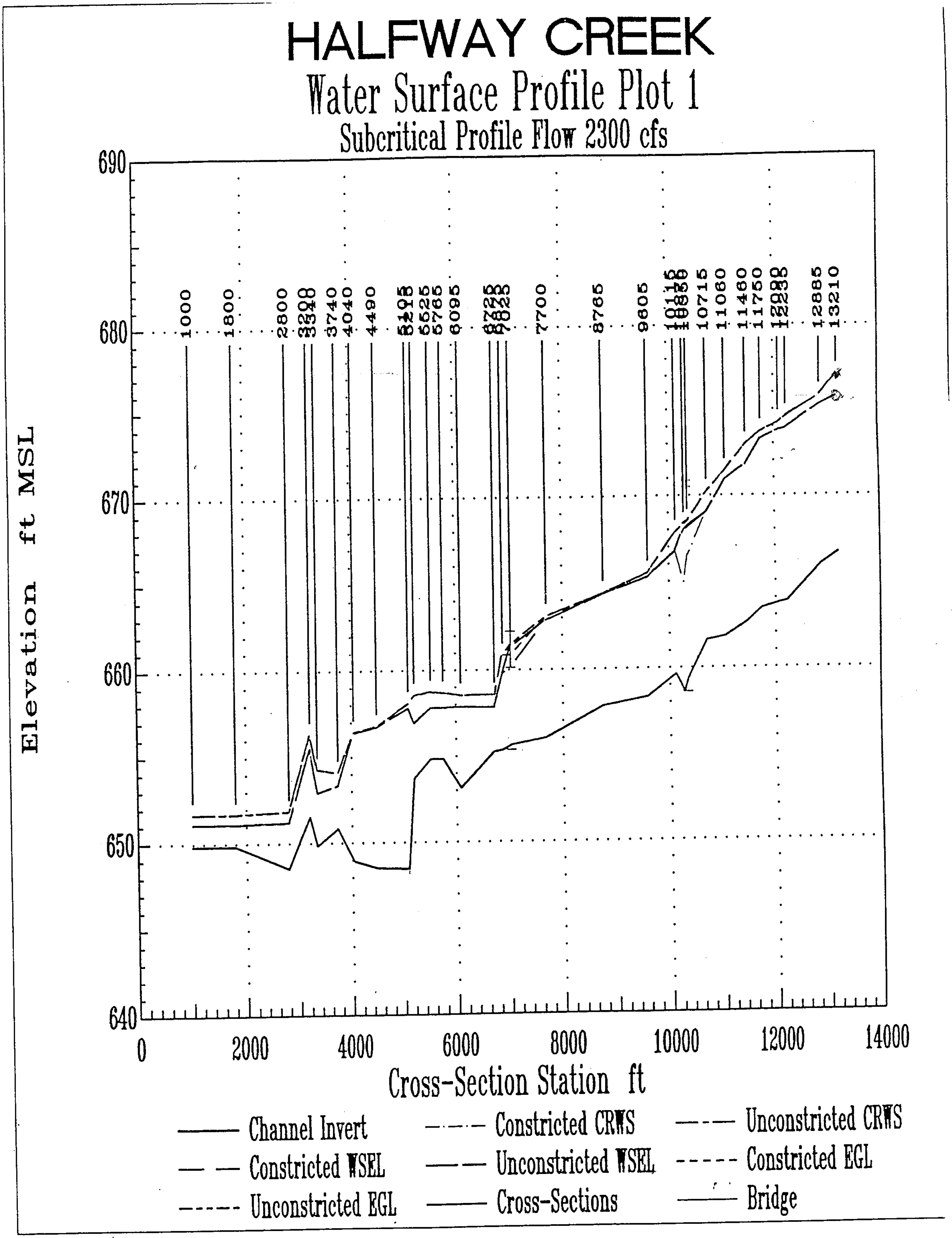

HALFWAY CREEK
Water Surface Profile Plot 1
Subcritical Profile Flow 2300 cfs
Elevation ft MSL
Cross-Section Station ft
690
680
670
660
650
640
0
2000
4000
6000
8000
10000
12000
14000
1000
1800
2800
3740
4040
4490
5765
6095
7700
8765
9805
10715
11060
11460
11750
12885
13210
Channel Invert
Constricted CRWS
Unconstricted CRWS
Constricted WSEL
Unconstricted WSEL
Constricted EGL
Unconstricted EGL
Cross-Sections
Bridge

FIGURE 8

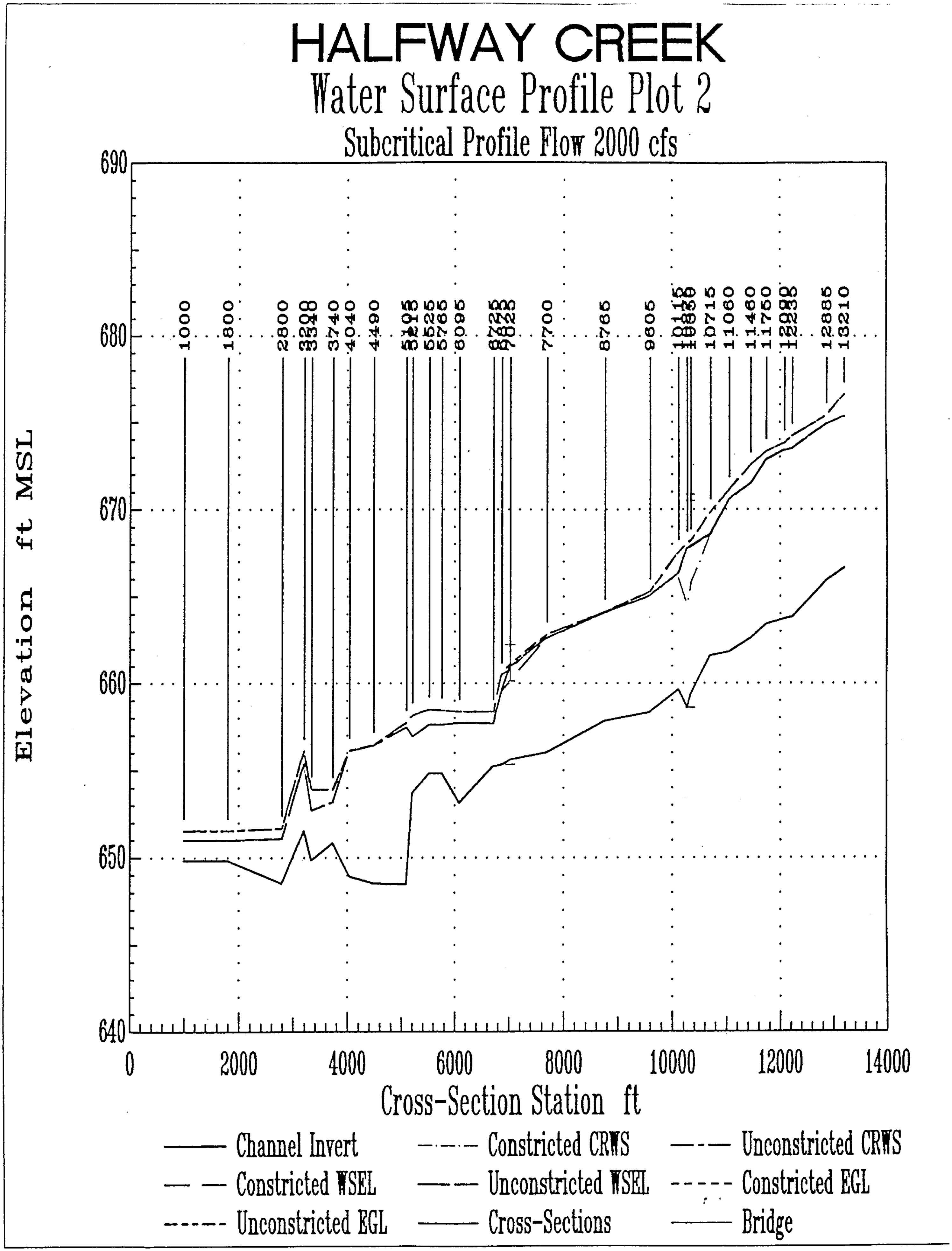

HALFWAY CREEK
Water Surface Profile Plot 2
Subcritical Profile Flow 2000 cfs
Elevation ft MSL
Cross-Section Station ft
690
680
670
660
650
640
0
2000
4000
6000
8000
10000
12000
14000
1000
1800
2800
3740
4040
4490
5525
5765
6095
7700
8765
9605
10715
11060
11460
11750
12885
13210
Channel Invert
Constricted CRWS
Unconstricted CRWS
Constricted WSEL
Unconstricted WSEL
Constricted EGL
Unconstricted EGL
Cross-Sections
Bridge

FIGURE 9

HALFWAY CREEK

Water Surface Profile Plot 3

Subcritical Profile Flow 1700 cfs

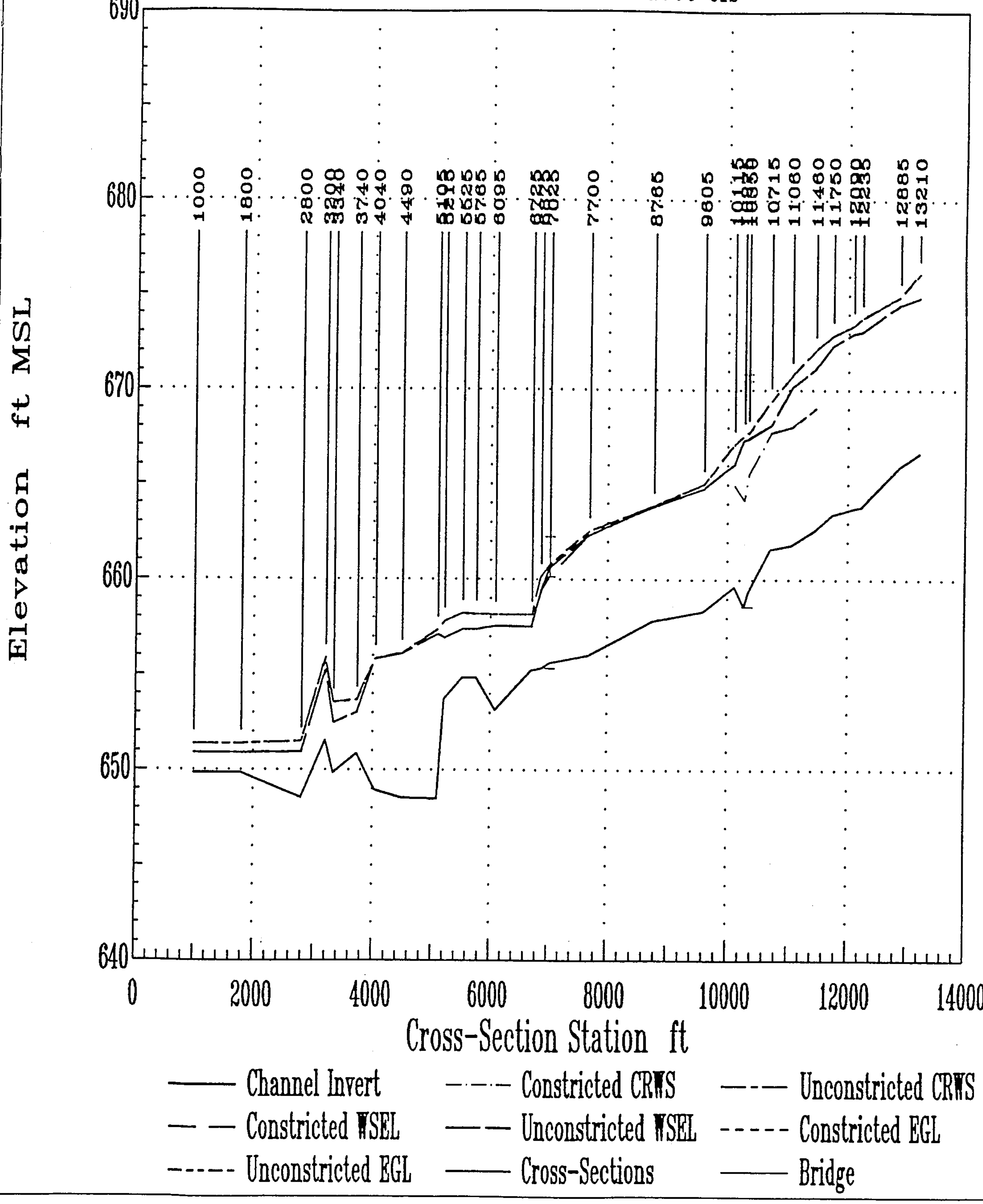


FIGURE 10

HALFWAY CREEK

Water Surface Profile Plot 4

Subcritical Profile Flow 1200 cfs

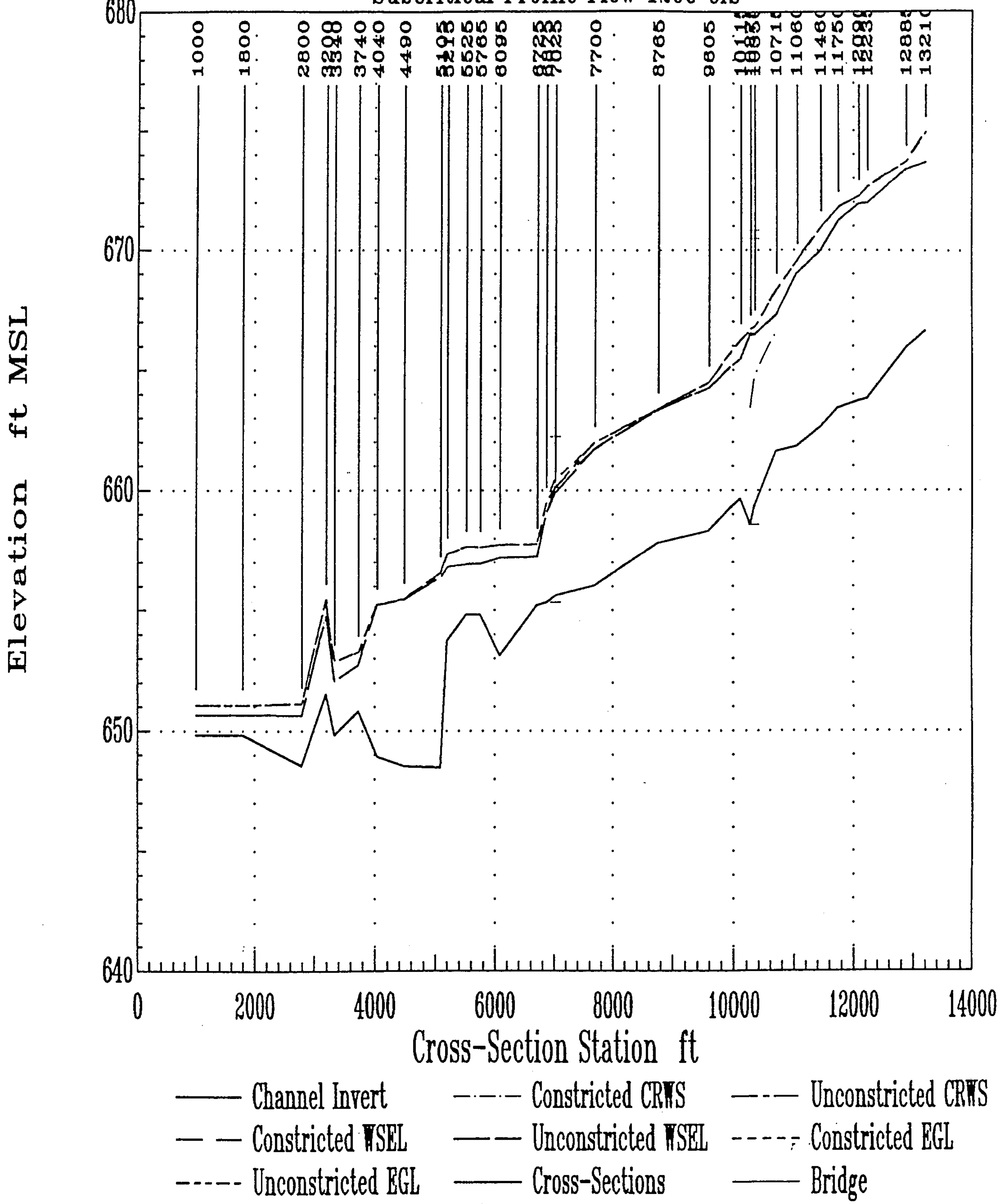


FIGURE 11

HALFWAY CREEK

Water Surface Profile Plot 5

Subcritical Profile Flow 940 cfs

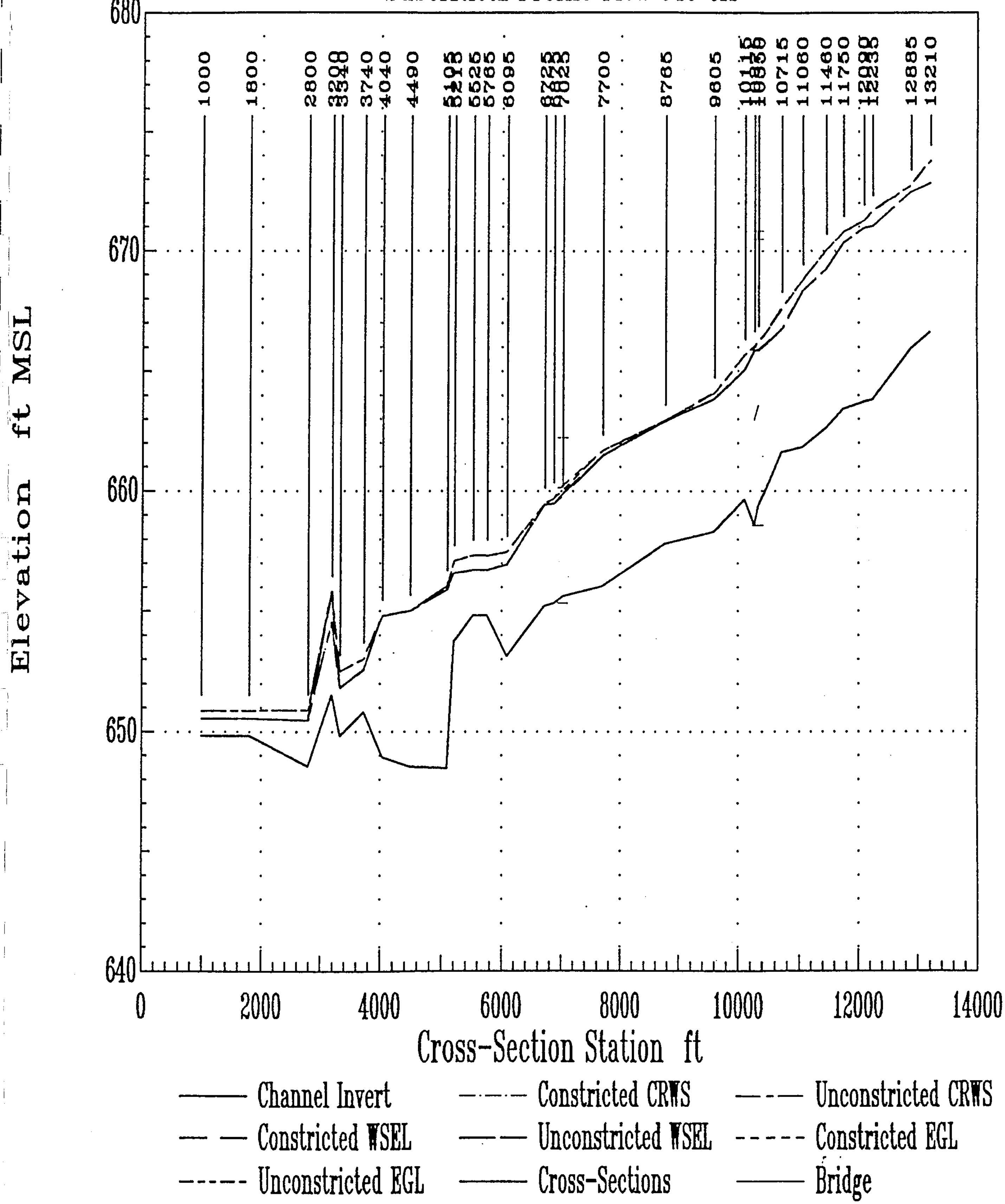


FIGURE 12

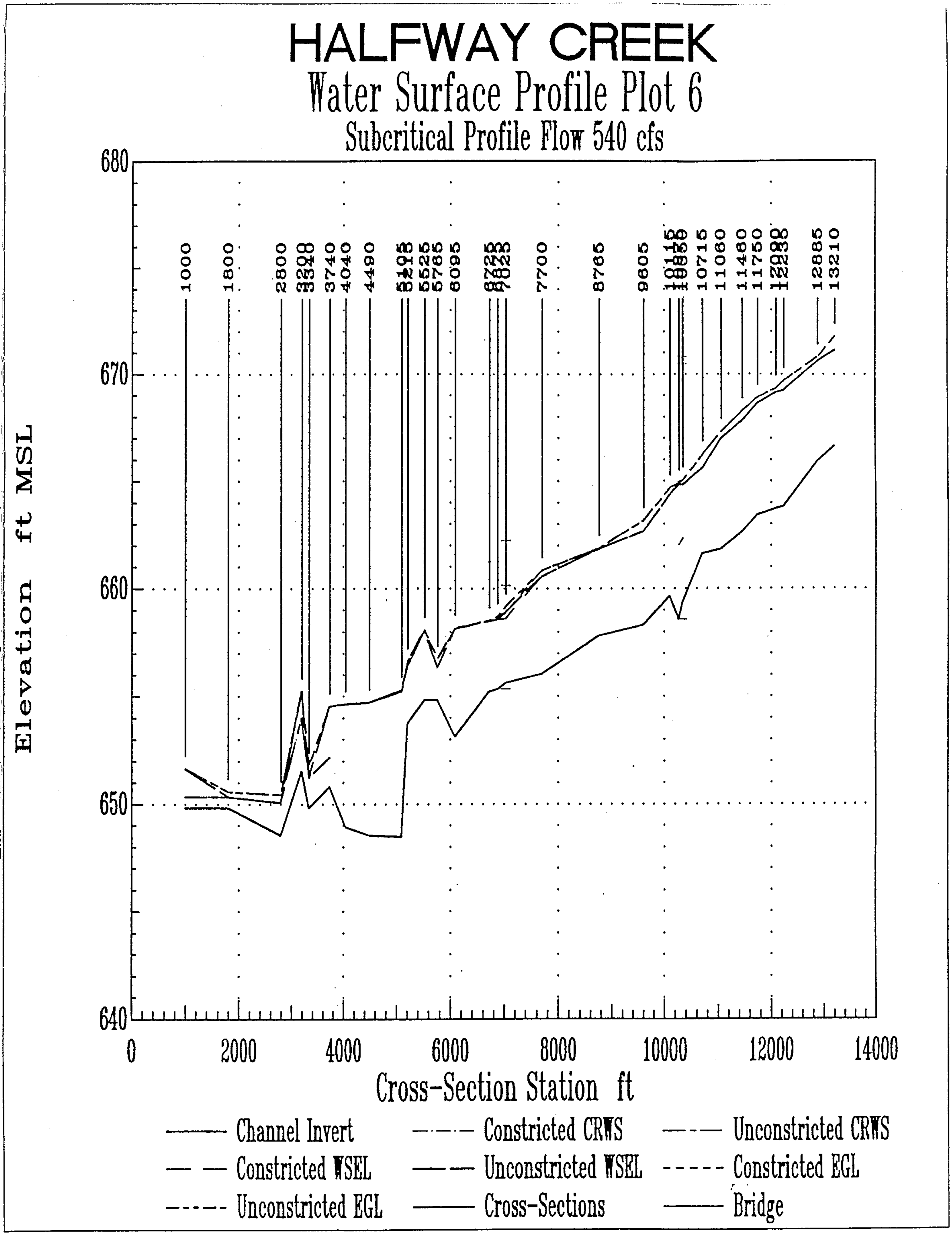

HALFWAY CREEK
Water Surface Profile Plot 6
Subcritical Profile Flow 540 cfs
Elevation ft MSL
Cross-Section Station ft
680
670
660
650
640
0
2000
4000
6000
8000
10000
12000
14000
1000
1800
2800
3740
4040
4490
5525
5765
8095
7700
8765
9805
10715
11060
11460
11750
12885
13210
Channel Invert
Constricted CRWS
Unconstricted CRWS
Constricted WSEL
Unconstricted WSEL
Constricted EGL
Unconstricted EGL
Cross-Sections
Bridge

FIGURE 13

Design Schematic of a Wet Pond

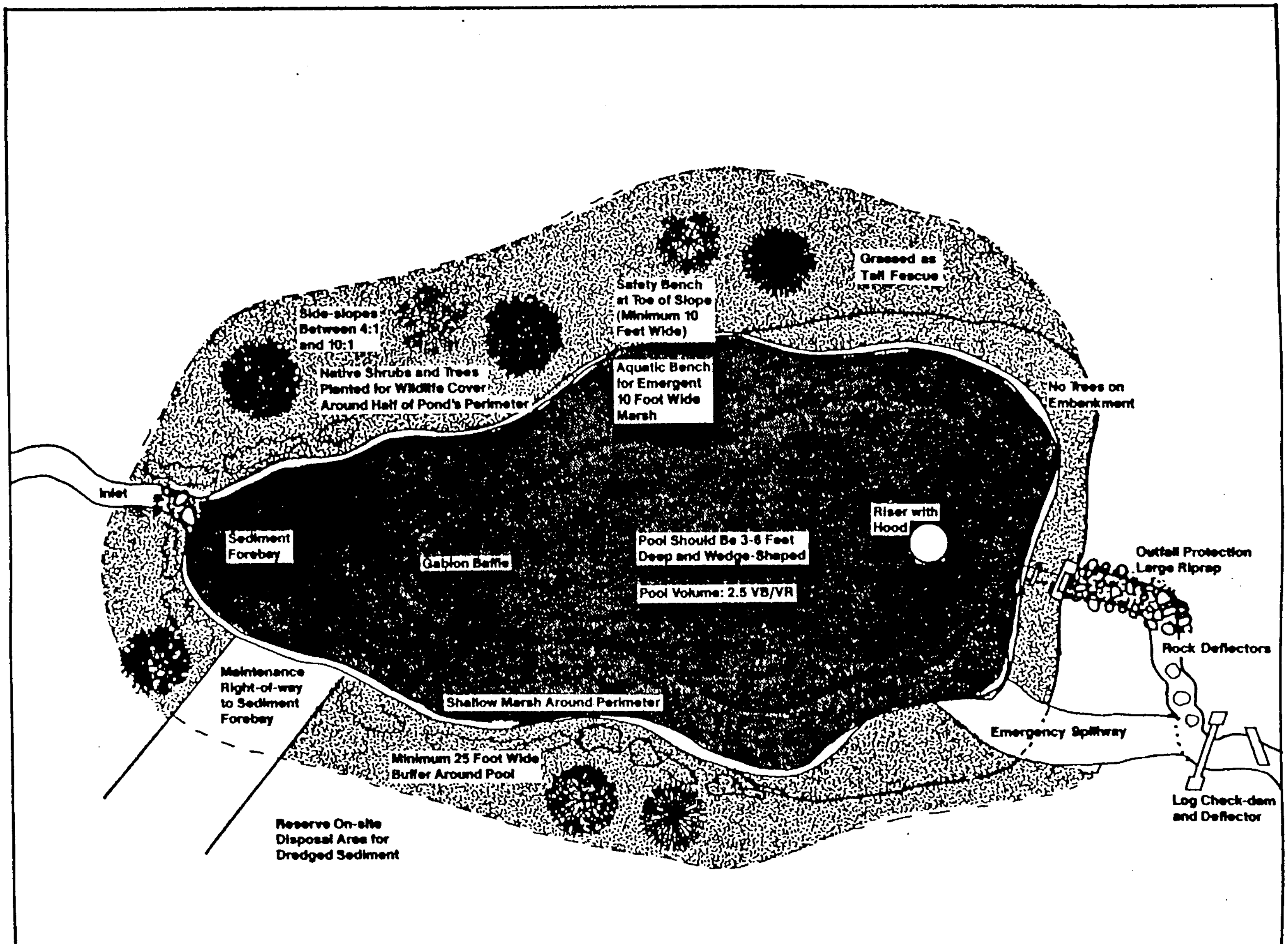


FIGURE 14

Schematic of a Wet Pond

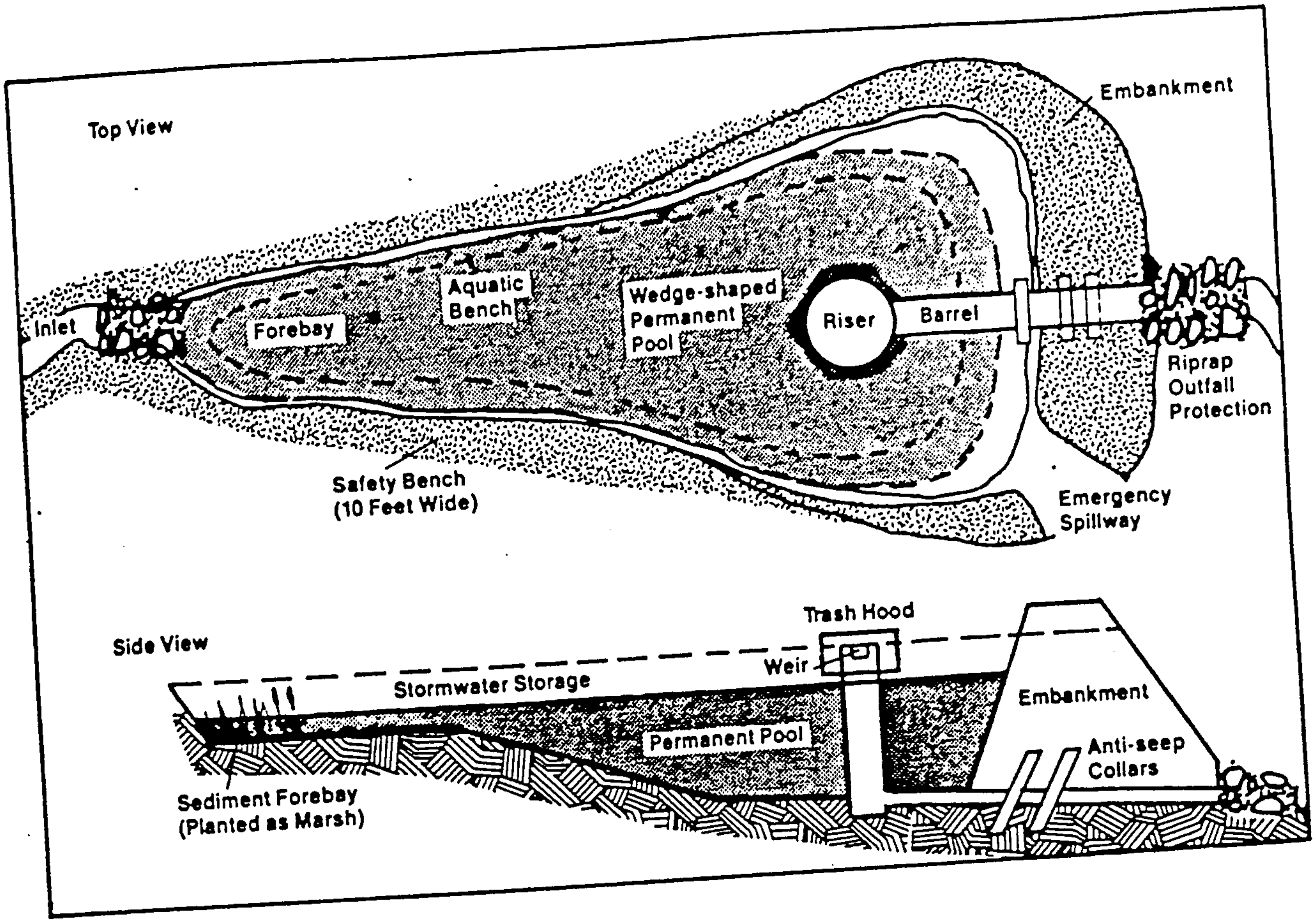


FIGURE 15

Schematic of Extended Detention Pond Design Features

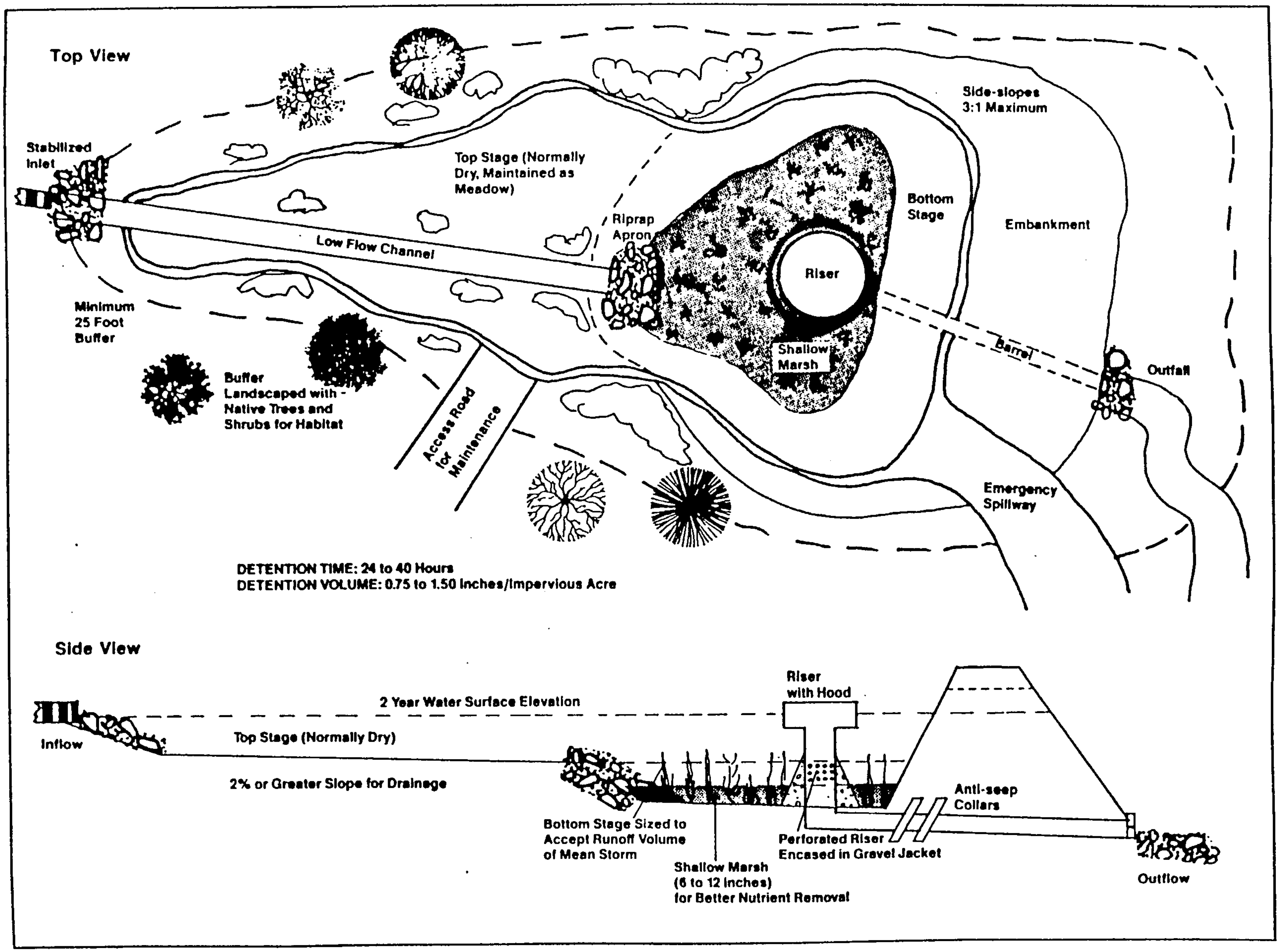
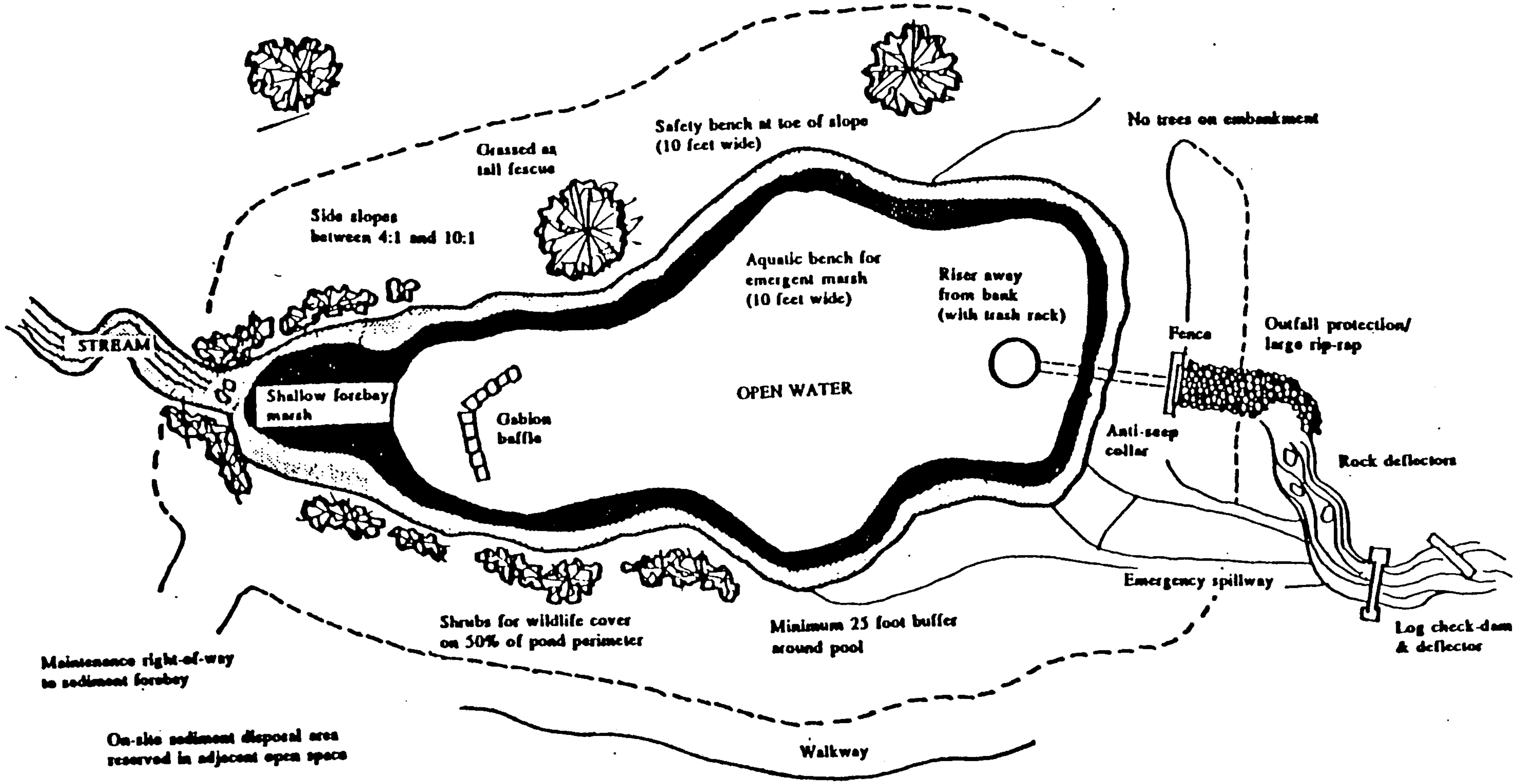


FIGURE 16

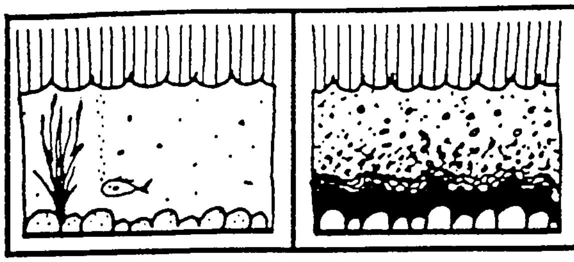
Detention Pond Design Features - Aerial View



Source: Metropolitan Washington Council of Governments

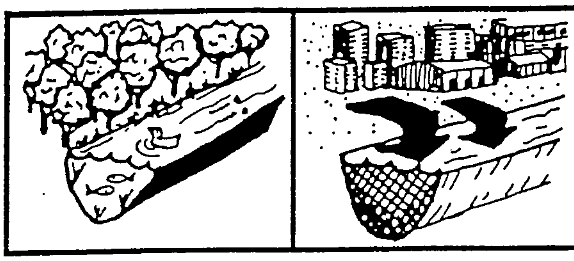
FIGURE 17

Before After



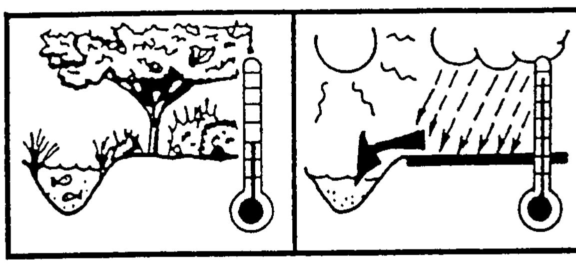
CONSTRUCTION SEDIMENT PULSE

During the initial phase of development, an urban stream receives a massive pulse of sediment that has eroded from upland construction sites. In the Anacostia, sediment levels often decline once upland development is stabilized, yet never return to pre-development levels, because of increased streambank erosion.



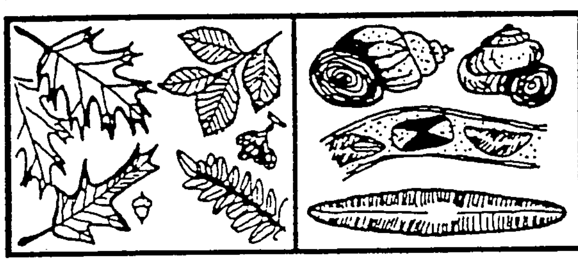
INCREASED POLLUTANT LEVELS

Pollutant levels in urban streams can often be one to two orders of magnitude greater than a forested watershed. In the Anacostia, pollutant wash-off from impervious areas include: nitrogen, phosphorus, carbon, solids, fecal material, herbicides, pesticides, and trace metals, and oil and grease.



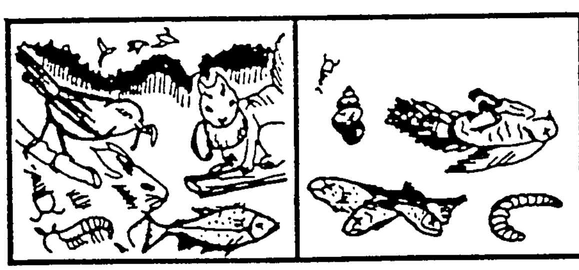
INCREASED WATER TEMPERATURE

Impervious areas function as heat sinks. This heat is transferred to stormwater runoff. Intensive urbanization can raise stream water temperatures by 5 to 10 degrees celsius. In the Anacostia, this thermal loading severely interferes with the physiological requirements of coldwater aquatic organisms such as trout and stoneflies creating stress and environmentally uninhabitable conditions.



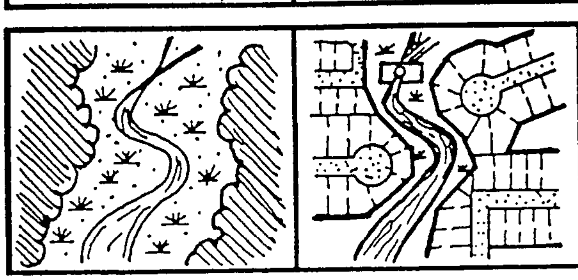
SHIFT IN ENERGY SOURCE

In a natural stream, the aquatic community is driven by an energy source made up of decomposing leaves and woody debris. In urban streams, reduced tree canopy in combination with nutrient accumulation results in increased benthic algal production. This change manifests itself in a dramatic shift of species in the stream.



REDUCTION OF COMMUNITY DIVERSITY

In intensively developed areas, urban streams support only a fraction of the fish and aquatic insects that exist in undeveloped watersheds. This loss of biological diversity leaves the natural community vulnerable to changes in climate and habitat.



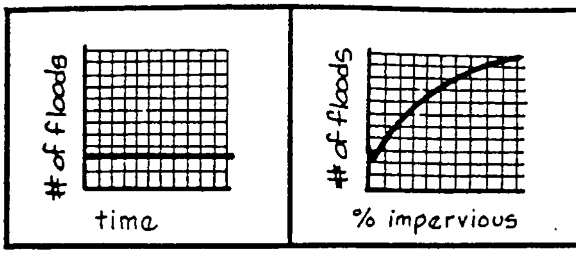
LOSS OF FRESHWATER WETLAND BUFFERS

A stream ecosystem is dependant upon its extensive freshwater wetlands, floodplains, riparian buffers, seeps, springs, and ephermal channels. Historically in the Anacostia, these associated areas were frequently destroyed or altered by agriculture and urban development.

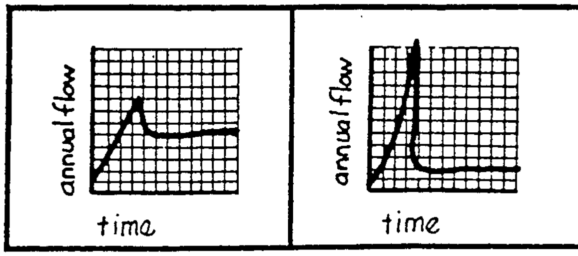
FIGURE 18

IMPACTS OF URBANIZATION

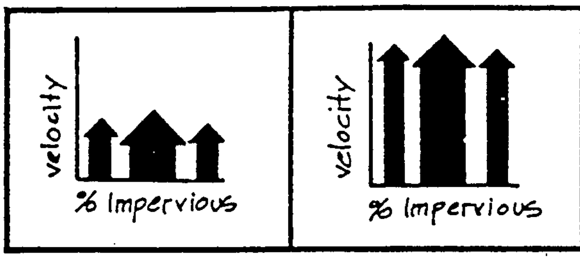
Before | After



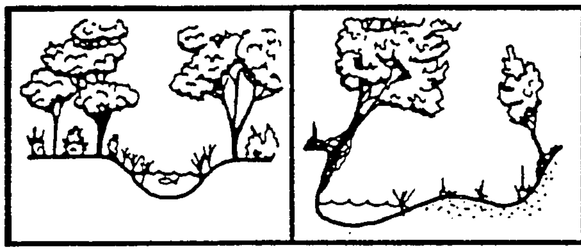
INCREASED BANKFULL FLOODING
The frequency of bankfull floods increases from once every other year prior to development, to over 5 each year for a 50% impervious watershed. In the Anacostia, short but intense summer storms turn stream channels into raging torrents, causing severe channel scour and erosion.



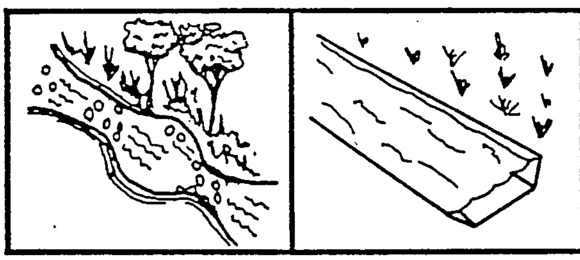
LOWER DRY WEATHER FLOW
Reduced dry weather flows may cause small perennial urban streams to become seasonally dry, while significantly reducing the wetted perimeter of larger urban streams, thus reducing aquatic habitat area. In much of the Anacostia, seasonally reduced discharges significantly restrict the availability of fish and aquatic habitat.



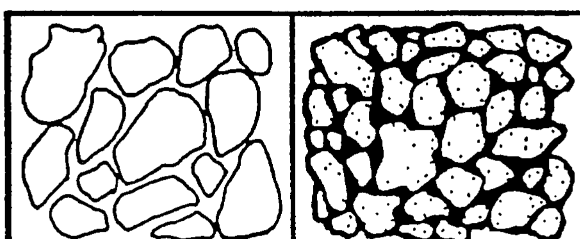
INCREASED STREAM VELOCITY
Greater amounts of stormwater discharge in concert with rapid concentration times over smooth, paved surfaces produce increases in stream velocity. In portions of the Anacostia, this increased channel velocity has caused severe erosion and destruction of both aquatic and riparian habitat.



CHANNEL WIDENING
Increased stormflow velocity in urban streams severely erodes the adjacent stream banks, resulting in a loss of riparian habitat and forest cover. In portions of the developed Anacostia, channels have become two to eoght times wider than in undeveloped zones.



LOSS OF POOLS & RIFFLES
Pools and riffles provide habitat diversity for the aquatic community. Stream channel erosion and construction site runoff create significant changes in stream morphology. In portions of the Anacostia, this change has eliminated many pools and riffles that support fish habitat.



CHANGE IN SUBSTRATE QUALITY
With urbanization comes a shift in the grain size of channel sediments, from coarser grained particles, to a mixture of fine and coarse particles. This results in a phenomena known as embedding: sand, silt, and clay fill voids in the channel bottom, reducing water circulation, oxygen, and organic matter needed by aquatic insects.

FIGURE 19

Schematic of an Infiltration Basin

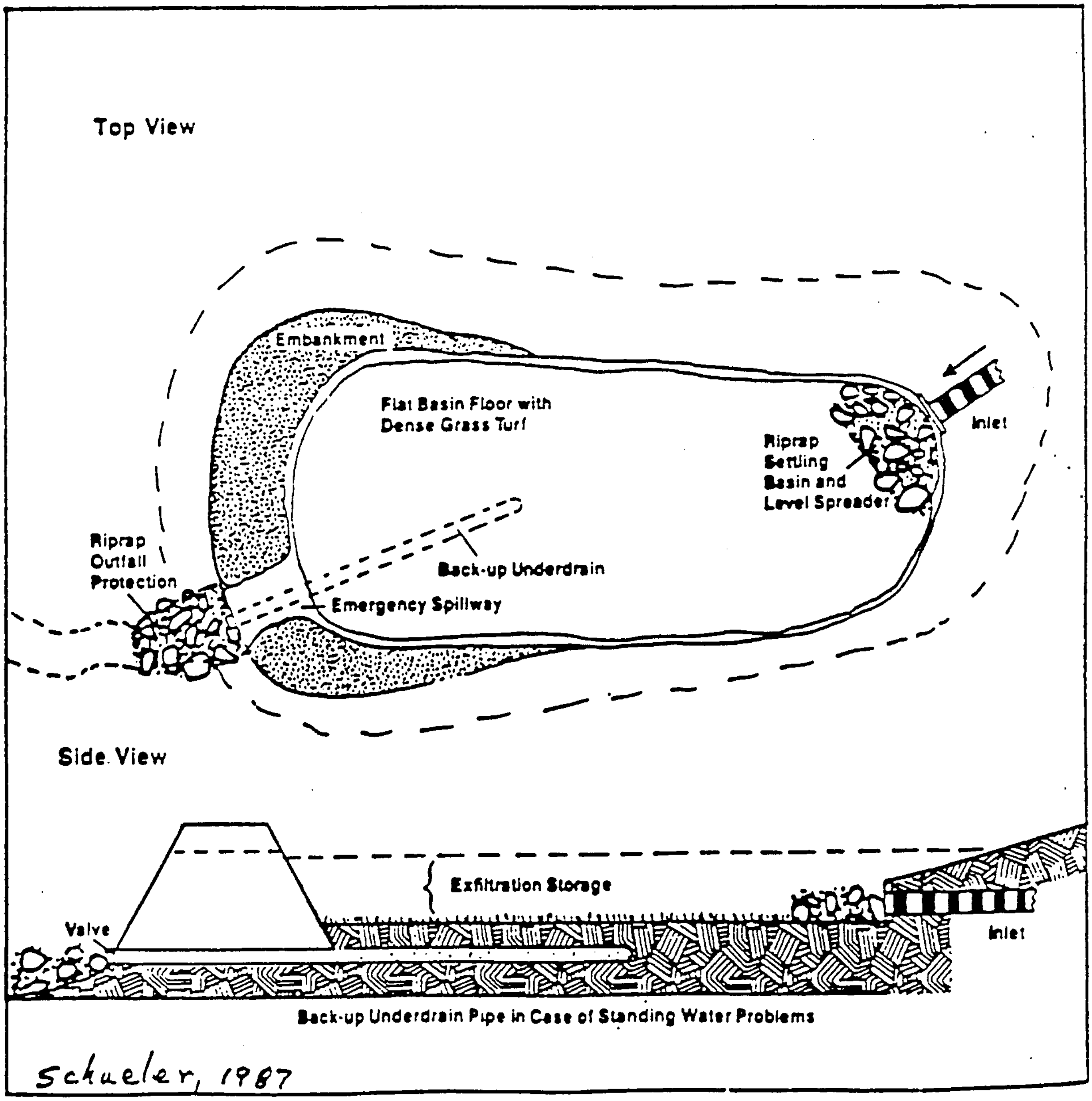
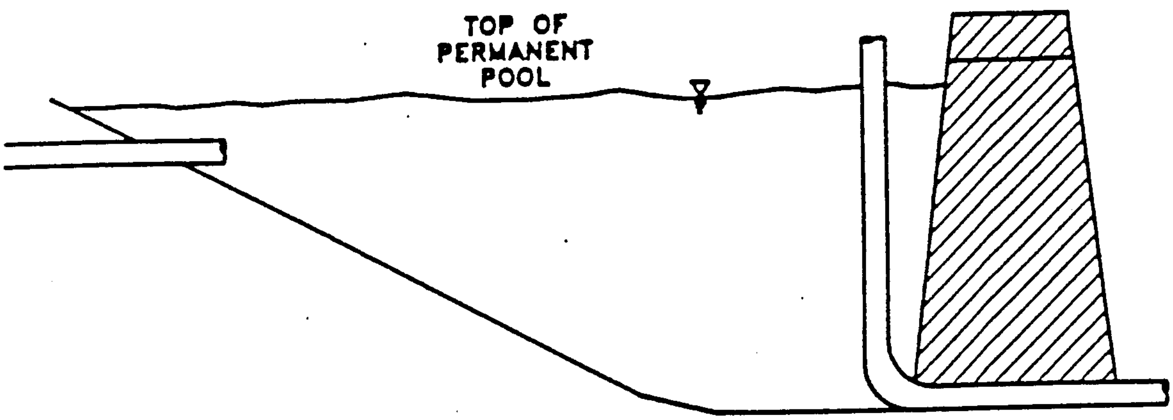
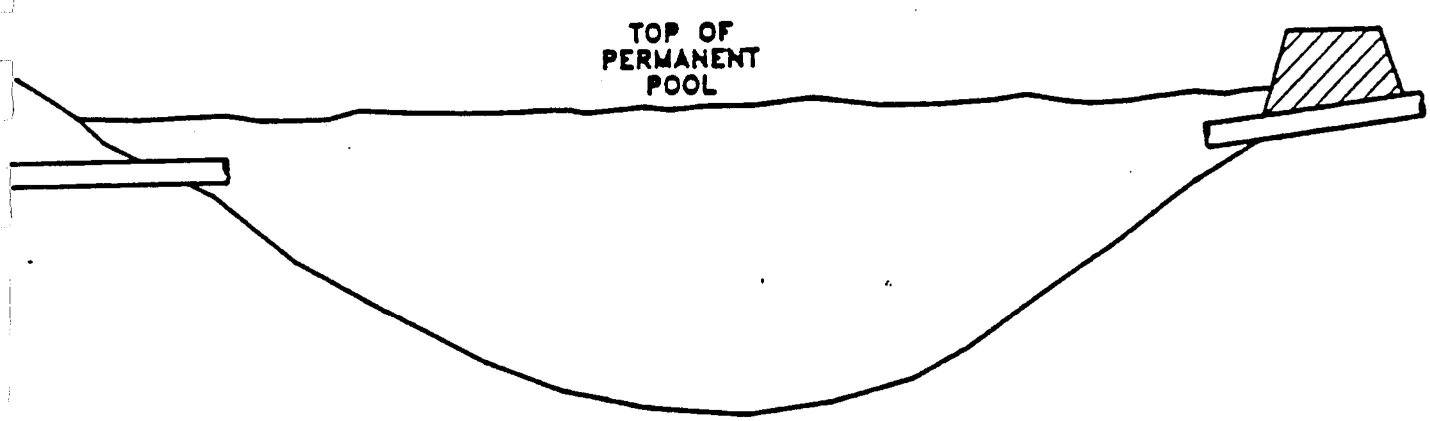


FIGURE 20

ALTERNATIVE PROFILES FOR WET DETENTION PONDS



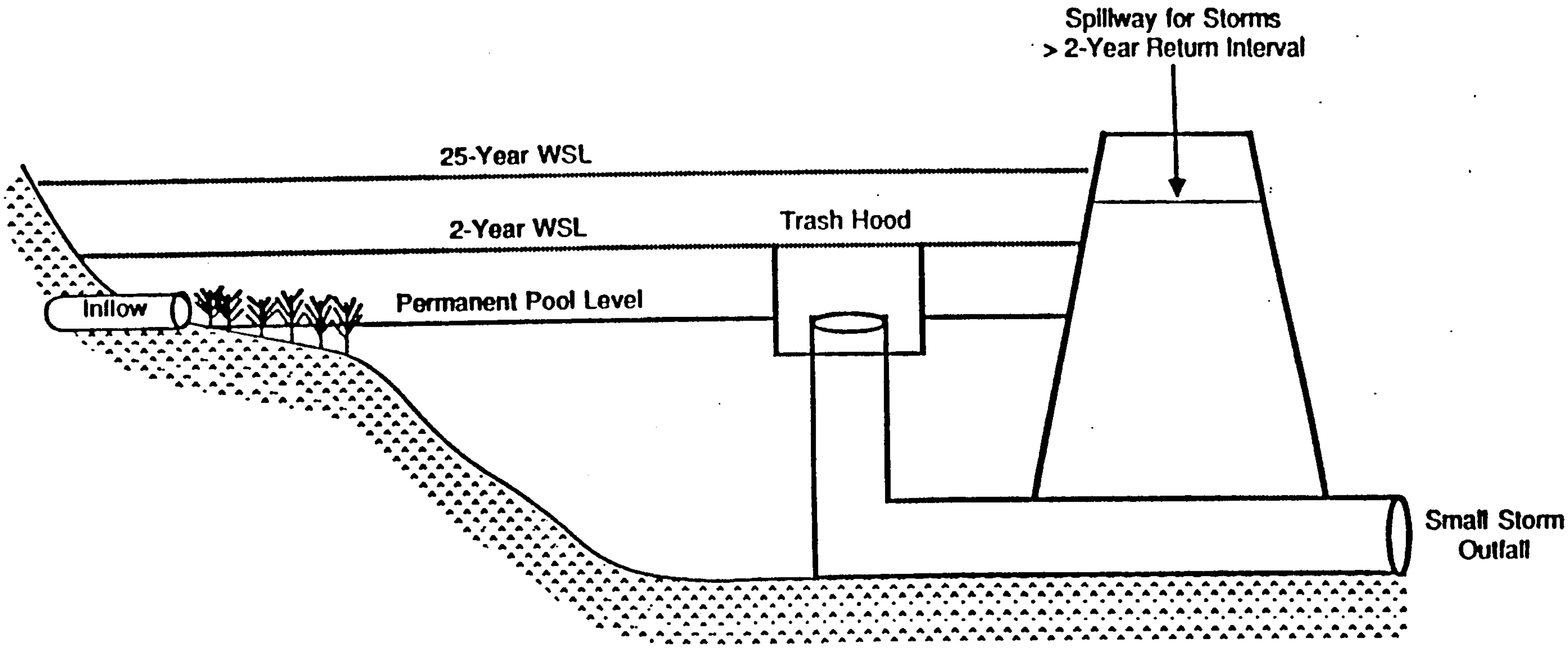
AREAS WITH HIGH RELIEF



AREAS WITH LOW RELIEF

FIGURE 21

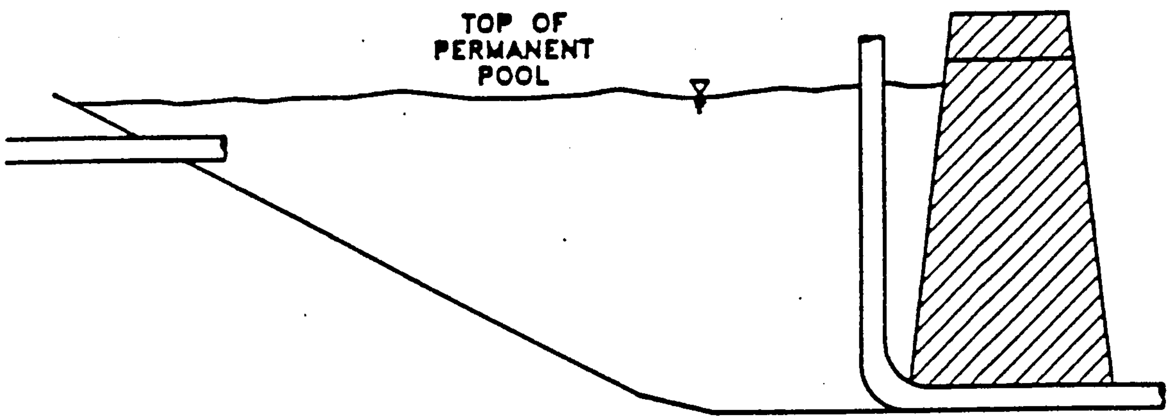
CONCEPTUAL DESIGN OF THE "PERFECT" WET POND



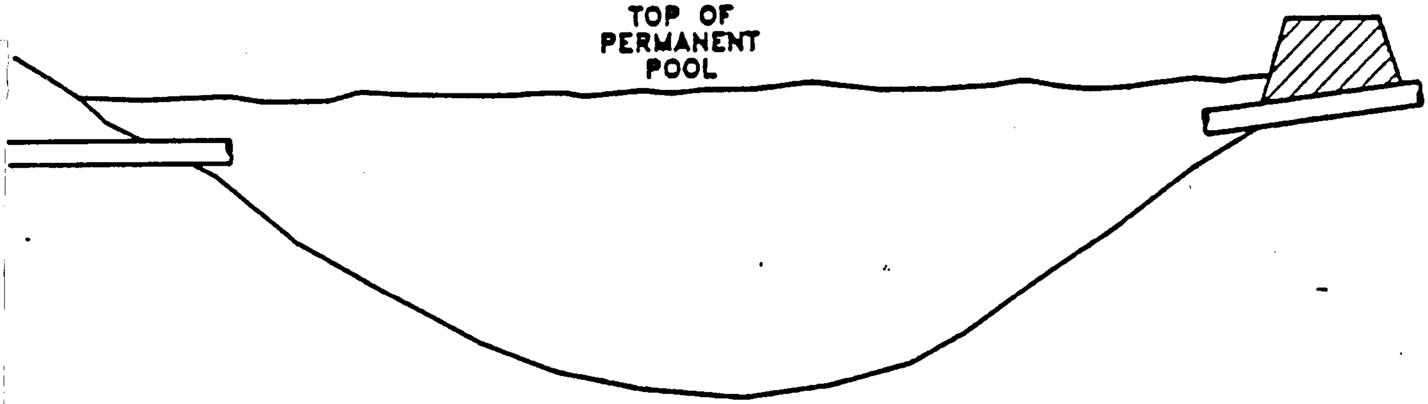
(ASCE 1990/91)

FIGURE 22

ALTERNATIVE PROFILES FOR WET DETENTION PONDS



AREAS WITH HIGH RELIEF

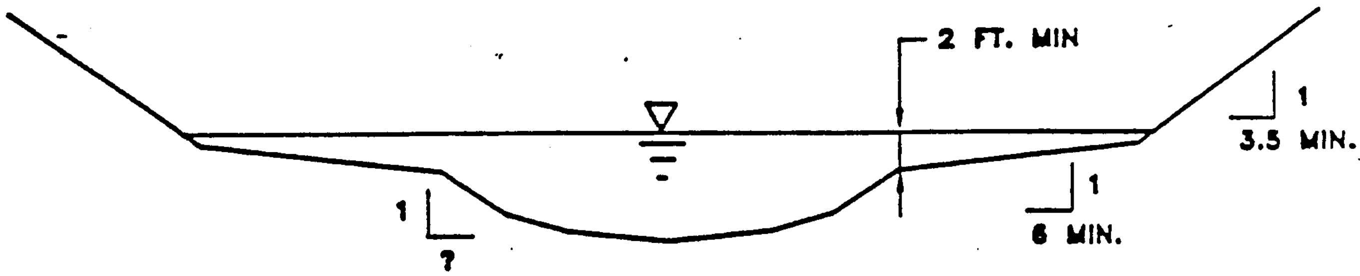


AREAS WITH LOW RELIEF

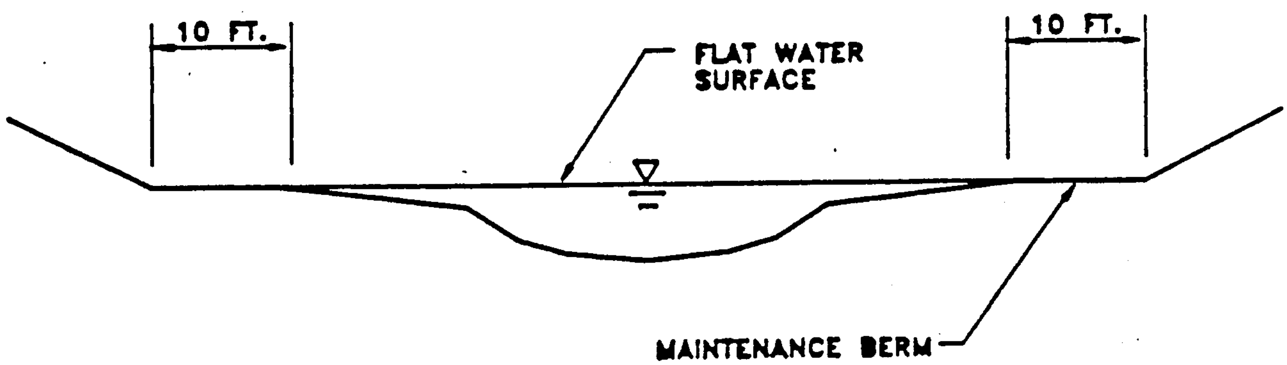
(ASCE 90/91)

FIGURE 23

ALTERNATIVE CROSS SECTIONS



MINIMUM REQUIREMENTS



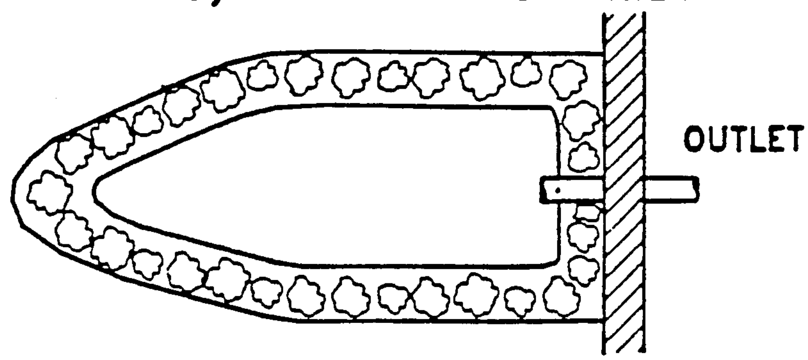
ALTERNATIVE CROSS SECTION WITH MAINTENANCE BERM

(ASCE 90/91)

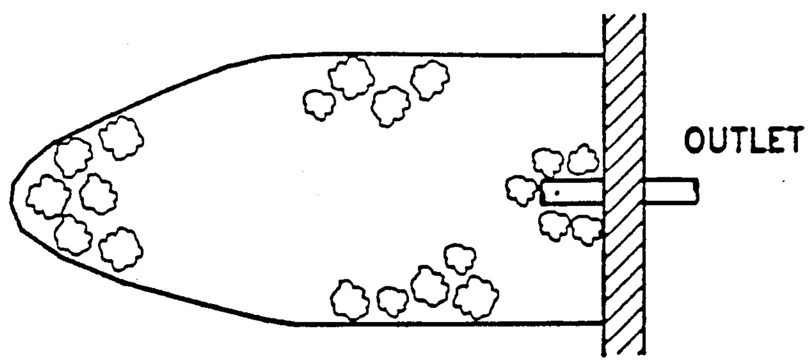
FIGURE 24

ALTERNATIVE PLANTING SCENARIOS

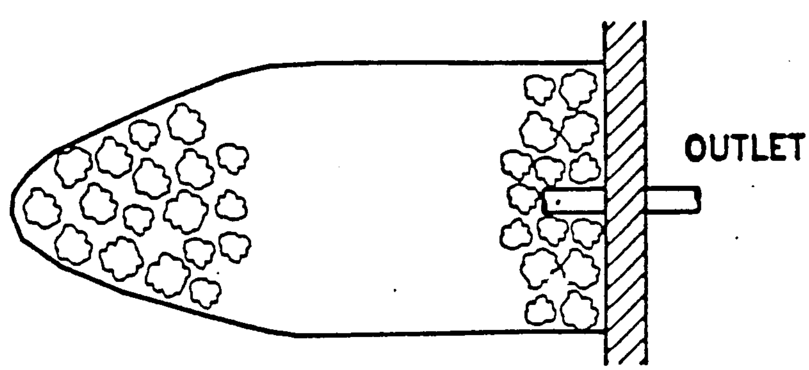
CRITERIA: 1) MINIMUM 30% PLANTS
2) 50 TO 70% OPEN WATER



AQUATIC BENCH



CLUSTER PLANTING

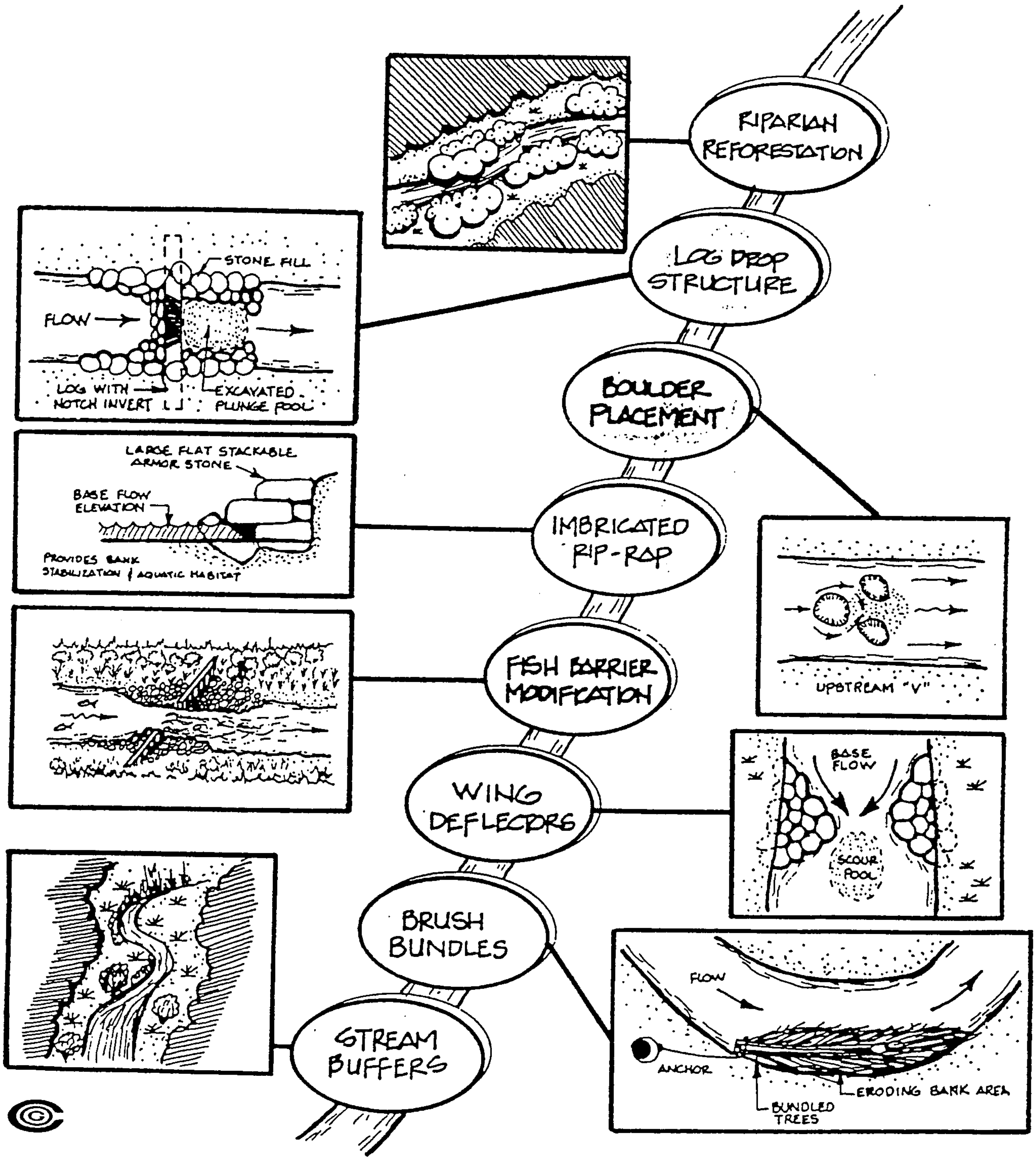


INLET AND OUTLET MARSHLANDS
(ASCE 1990/91)

FIGURE 25

Restoration Accomplishments

Urban Stream Restoration Techniques - Part of the process of restoring an urban watershed such as the Anacostia involves rebuilding or the re-creation of its streams that have become damaged or severely altered by years of urbanization and agriculture. The following eight stream restoration techniques are being used in the Anacostia.



(Washington, D.C. COG 1990)

FIGURE 26

Construction Site Erosion Control

La Crosse County, Wisconsin

CONSTRUCTION SITE EROSION CONTROL ORDINANCE

Developed Pursuant to S. 144.266 Wis. Stats.

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APPENDIX

"Type of Erosion Control Plan Required" - Quick reference guide to determine plan category required, A,B,C, or D.

"Standard Erosion Control Plan for Minor Disturbances" Minimum plan to be submitted for Category A sites.

"Standard Erosion Control Plan for Nonresidential Access Roads and Timber Cutting Notice", Minimum plan to be submitted for Category D.

La Crosse County Erosion Control Ordinance Plan Approval Fee Schedules.

LA CROSSE COUNTY
EROSION CONTROL ORDINANCE

S.21.01 AUTHORITY

This ordinance is adopted under the authority granted by S.59.974 Wis Stats.

S.21.02 FINDINGS AND PURPOSE.

(1) FINDINGS. La Crosse County finds that runoff from land disturbance activities on environmentally sensitive areas and construction sites may carry a significant amount of sediment and other pollutants to the waters and rights-of-way of the county and state.

(2) PURPOSE. It is the purpose of this ordinance to protect La Crosse County's unique natural resources by minimizing the amount of sediment carried by runoff, or discharged from construction sites to perennial waters, wetlands and public rights-of-way.

S.21.03 APPLICABILITY OF ORDINANCE.

This ordinance applies to land disturbance activities on lands within the boundaries and jurisdiction of La Crosse County in the unincorporated areas. Permits granted under this ordinance do not release the permittee or landowner from other applicable federal, state or local regulations. The recipient of a permit agrees to indemnify and hold harmless the County of La Crosse, it's employees or designated agents from any cost, suit, liability or award which might be assessed due to the acceptance of a control plan or issuance of permits, or because of any adverse effect upon any person or property attributed to a project of the permittee.

The provisions of this ordinance relating to the requirement of submission of an erosion control plan for land disturbance activities and the requirements of fees for review of said plan may be waived by La Crosse County for towns, cities or villages or other governmental units if the governmental unit enters into a cooperative agreement pursuant to S.66.30, Stats., with La Crosse County concerning compliance with this ordinance.

S. 21.04 DEFINITIONS.

(1) "Access Road Development" means any excavation or filling for the construction of roads and trails where access is needed for public or private use.

(2) "Agricultural land use" means use of land for planting, growing, cultivating and harvesting of crops for human or livestock consumption and pasturing or yarding of livestock.

(3) "Control measure" means a practice or combination of practices to control erosion and attendant pollution

S.21.03 amended May 21, 1992.

(4) "Control plan" means a written description and/or plan map of the number, locations, sizes, and other pertinent information of soil and water erosion control measures designed to meet the requirements of this ordinance submitted by the applicant for review and acceptance by the Land Conservation Committee or Land Conservation Department Staff.

(5) "Department" means the La Crosse County Department of Land Conservation.

(6) "Department of Land Conservation" means the designated staff of the department, as authorized under S 92.09 Wis. Stats.

(7) "Erosion" means the detachment and movement of soil, sediment or rock fragments by water, wind, ice or gravity.

(8) "Inactive" means no land disturbance or construction related activity is occuring.

(9) "Land Conservation Committee" means the committee created under S 92.06 Wis Stats.

(10) "Land disturbance activity" means any man-made change of the land surface including removing protective cover to expose the soil, excavating, filling, grading, construction of buildings, roads, parking lots and similar facilities, but not including agricultural land uses.

(11) "Landowner" means any person having fee title ownership of the land.

(12) "Land user" means any person operating, leasing, renting, or having made other arrangements by which the land owner authorizes the use of their land.

(13) "Perennial waters" means the springs, rivers, lakes, ponds and wetlands of the county lasting or continuing throughout the year and includes the navigable waters as defined in the La Crosse County Shoreland Zoning Ordinance.

(14) "Permit" means the authority granted by the Zoning and Planning Department to conduct activities regulated by this ordinance.

(15) "Percent slope" means the grade of the land determined by the vertical rise or fall in feet per horizontal length in feet measured perpendicular to the existing land contour and expressed as a percentage.

(16) "Planning Administrator" means the county Land Use Coordinator.

(17) "Pollutant control requirements" means control measures used to meet the requirements of S.21.07(2).

(18) "Runoff" means the rainfall, snowmelt, or irrigation water flowing over the ground surface.

(19) "Site" means the entire area on which the land disturbance activity is proposed in the permit application.

(20) "Stabilize" means to make the site steadfast or firm, minimizing soil movement.

(21) "Wetland" means those areas where water is at, near or above the land surface long enough to be capable of supporting aquatic or hydrophytic vegetation and which have soils indicative of wet conditions and indicated on county wetland inventory maps.

(22) "Zoning and Delinquent Tax Committee" means the committee appointed by the county board under S 59.97 Wis. Stats.

S. 21.05 DESIGN CRITERIA, STANDARDS & SPECIFICATIONS FOR CONTROL MEASURES.

All control measures required to comply with this ordinance shall meet the design criteria, standards and specifications contained within the "Wisconsin Construction Site Best Management Practice Handbook" and Soil Conservation Service standards and specifications. Other control measures are allowed if they will accomplish the objectives of the ordinance and are approved by the Land Conservation Committee or Department

S. 21.06 MAINTENANCE OF CONTROL MEASURES.

All control measures, permanent or otherwise, necessary to meet the requirements of this ordinance shall be maintained by the land user or landowner to ensure adequate performance and to prevent nuisance conditions.

S. 21.07 CONTROL OF EROSION AND POLLUTANTS DURING LAND DISTURBANCE ACTIVITIES

(1) APPLICABILITY. This section applies to any of the following sites:

(a) Those requiring subdivision plat approval, or the construction of houses or commercial, industrial or institutional buildings on lots of approved subdivision plats;

(b) Those involving the construction of houses or commercial, industrial or institutional buildings on lots of approved certified surveys or on all parcels in excess of five acres in area;

(c) Those involving land disturbance activities affecting a surface area of 4000 square feet or more on slopes less than 20 percent;

(d) Those involving land disturbance activities affecting a surface area of 2000 square feet or more on slopes 20 percent and greater;

(e) Those involving excavation or filling or a combination of both affecting 400 cubic yards or more of soil;

(f) Those involving road or bridge construction, enlargement, relocation, road ditch maintenance, or reconstruction which meet the criteria in (c) or (d) or (e); or

(g) Other sites as determined by the Department where severe actual or potential erosion problems warrant corrective action.

(2) EROSION AND OTHER POLLUTANT CONTROL REQUIREMENTS. The following requirements shall be met on all sites described in sub. (1).

(a) Site dewatering. Water pumped from a site shall be treated by control measures in S.21.05. Water may not be discharged in a manner that causes erosion or sedimentation of the site or receiving channels.

(b) Tracking. Each site shall have roads, access drives and parking areas of sufficient width and length to minimize sediment tracking onto public or private roadways. Any sediment reaching a public or private road shall be removed by street cleaning, not flushing, before the end of each workday.

(c) Drain inlet protection. All storm drain inlets shall be protected with straw bales, filter fabric, or equivalent barriers upon completion of the inlet and until the site has been stabilized.

(d) Site erosion control. Site erosion control shall be attained by the following:

1. All site developments and land disturbance activities shall be planned and implemented to best fit the terrain, minimize exposed area, and retain as much existing vegetation as possible.

2. With the exception of those areas identified in the control plan, all disturbed ground not established to final grade within 14 days of the initial land disturbance, or left inactive for 14 days shall be stabilized by temporary or permanent seeding, sodding or equivalent control measures. Seeding should be completed within 24 hours of final grading. In areas determined to be environmentally sensitive by either the planning administrator or the department, authority is granted to require immediate revegetation and erosion control measures. If temporary seeding is used a permanent cover shall also be used as part of final site stabilization. Variances may be granted by the planning administrator due to any delay beyond the control of the landowner or land user.

3. Runoff from areas adjacent to the site shall be diverted around disturbed areas where possible.

4. All land disturbance activities on the site shall be conducted in a logical sequence in accordance with the control plan to minimize the area of bare soil exposed at one time.

5. Cuts and fills shall be planned and constructed to minimize the length and steepness of slopes.

6. Channels and other concentrated flow areas shall be properly designed and constructed to control runoff within and from the site in a manner that wil not erode the conveyance and receiving channels.

7. Sediment shall be contained on site through the use of filter fabric fences, straw bale fences, sediment basins or other methods approved by acceptance of the erosion control plan by the Land Conservation Committee or Department.

8. Earth storage piles should be located no closer than 25 feet from drainage channels or roadways and no closer than 100 feet from perennial waters or wetlands.

9. Earth storage piles located closer than 25 feet to a roadway or drainage channel or located closer than 100 feet to perennial waters and wetlands shall require silt fences or other suitable means if left more than 5 days. Earth storage piles located on slopes of 12 percent or greater shall meet the requirements of 2 above or runoff shall be contained within a silt fence or other approved measure.

S. 21.08 PERMITS AND CONTROL PLANS.

No landowner or land user may commence a land disturbance activity subject to this ordinance without receiving prior acceptance of a control plan from the Department of Land Conservation, and a permit from the County Planning Administrator. The landowner or land user undertaking a land disturbance activity subject to this ordinance shall submit a control plan, and apply for a permit. An application for a permit, or submission of a control plan authorizes representatives of the Zoning & Planning Department and the Department of Land Conservation to enter the site to obtain information required for the review of the control plan.

(1) CONTROL PLAN CONTENTS. Required contents of control plans will depend on the slope of the land proposed for the land disturbance, amount of land to be disturbed, and proximity of the proposed land disturbance activity to streams, rivers, lakes and wetlands. See appendix for "Type of Erosion Control Plan Required".

a. Category A. A "Standard Erosion Control Plan for Minor Land Disturbances" may be submitted in lieu of a more detailed plan for land disturbance activities on land slopes less than 12 percent if all of the following conditions are met:

1. 20,000 sq. ft. of land or less will be disturbed;
2. 1,000 cu yds. or less of excavation and/or filling will occur;
3. Land disturbances will not occur within 100 feet of perennial waters and wetlands; and
4. Final grades will be no steeper than 3 horizontal to 1 vertical unit of measure.

b. Category B. Category B control plans will be required for land disturbance activities on slopes less than 12 percent where any of the above conditions of S.21.08 (1)a.1., 2., 3., 4. cannot be met. Category B plans will also be required for land disturbance activities on slopes of 12 percent or greater but less than 20 percent where the above conditions S.21.08 (1)a. 1., 2., 3., 4. can be met. These control plans shall contain the following.

1. Existing site sketch. A sketch of the existing site conditions indicating the following:
    a. Approximate property boundaries and adjacent lands which accurately identify property location;
    b. Perennial waters, wetlands, channels, ditches and other water courses on, and immediately adjacent to the site;
    c. Existing ground cover;
    d. Approximate locations of, and distances to stormwater drainage systems and natural drainager patterns on and immediately adjacent to the site; and
    e. Approximate locations and dimentions of utilities, structures, roads, highways and paving.

2. Site development plan. A sketch of the site and a short narrative indicating the following:
    a. Location and dimensions of all proposed land disturbances, including driveways, buildings, waste disposal systems and utility construction;
    b. Locations and dimensions of all temporary earth stockpiles.
    c. Locations and dimensions of all construction site erosion control measures necessary to meet the requirements of this ordinance;
    d. Proposed development schedule indicating the sequence of development and installation of control measures and anticipated starting date; and
    e. Provisions for maintenance of erosion control measures.

c. Category C. Category C control plans will be required for land disturbance activities on slopes of 12 percent or greater but less than 20 percent where the conditions of S.21.08 (1)a. 1., 2., 3., 4. cannot be met. Category C control plans will also be required for all land disturbance activities except nonresidential access roads where slopes are 20 percent or greater. These control plans shall contain the following.

1. Property map showing boundaries of the entire parcel and the approximate location within that parcel of the proposed land disturbance activity.

2. Existing site map. A map of existing site conditions at a scale of at least 1"-50' unless smaller scales are determined to be adequate by the department indicating the following:

a. Site boundaries and adjacent lands which accurately identify the site on a scale of at least 1 inch equals 50 feet;
b. Perennial waters, wetlands, channels, ditches and other water courses on and immediately adjacent to the site;
c. Location of predominant soil types;
d. Existing ground cover;
e. Location and dimensions of stormwater drainage systems and natural drainage patterns on and immediately adjacent to the site;
f. Location and dimensions of utilities, structures, roads, highways and paving; and
g. Site topography at a contour interval not to exceed two feet unless other intervals are determined adequate by the department. Sufficient survey points to determine significant changes in slope should be provided.

3. Site development and erosion control plan indicating the following:

a. Locations and dimensions of all proposed land disturbances;
b. Locations and dimensions of all temporary earth stockpiles;
c. Locations and dimensions of all control measures necessary to meet the requirements of this ordinance;
d. Proposed development schedule indicating the sequence of development and installation of control measures and anticipated starting date;
e. Provisions of maintenance of the control measures;
f. Provisions for maintenance of permanent control measures and water managment practices; and
g. Drawings, including cross sections and profiles, necessary to determine extent of cuts and fills and finished grades.

d. Category D. For all nonresidential access road developments meeting the applicability requirements of S. 21.07(1) a "Standard Erosion and Sediment Control Plan for Nonresidential Access Roads and Timber Cutting Notice" may be submitted in place of category A, B, or C plans.

(2) <u>SLOPE RESTRICTIONS</u>. The county has determined that land disturbance activities on slopes in excess of 30 percent create an erosion hazard and that the potential for offsite damage to public and private property warrants protection of these environmentally sensitive areas. Land disturbance activities regulated by this ordinance on slopes greater than 30 percent are limited to the following:

a. Access road developments for nonresidential purposes where a Category D control plan has been submitted and a permit has been granted;
b. Access road developments for residential purposes where a Category C control plan has been submitted and a permit has been granted.

c. Quarry operations where a Category C control plan has been submitted and a permit has been granted.

(3) SOIL CONSERVATION PRACTICES. Soil conservation practices installed for the purpose of controlling erosion and reducing nonpoint source pollution shall not require a permit when such practices are designed by Department of Land Conservation or Soil Conservation staff and installed according to S.21.05.

(4) REVIEW OF CONTROL PLAN. Control plans are to be submitted to the Department of Land Conservation. The department shall determine if the requirements of the ordinance have been met. Accepted control plans will be submitted to the Planning Administrator according to the following schedule. Time frames will begin upon receipt of the control plan by the department. Special conditions may warrant extended review periods.

a. 7 working days for category A and D sites.
b. 10 working days for category B sites.
c. 20 working days for category C sites.
d. Control plans requiring Land Conservation Committee approval must be received by the department by the 15th of each month preceeding the regularly scheduled meeting.

If the conditions are not met, the department shall inform the applicant and Planning Administrator, and may either require additional information or disapprove the plan. Within 5 working days of receipt of the additional information by the department the Planning Administrator shall issue or deny the permit. If the plan is disapproved, the Planning Administrator shall inform the applicant in writing of the reasons for the disapproval, and will specify those modifications needed for approval.

(5) PERMITS. Permits shall be applied for at the Zoning and Planning Office. Permits shall be issued by the Planning Administrator upon acceptance of the control plan by the department and payment of any applicable fees.

(a) DURATION. Category A, B, and C permits shall be valid for one year. Category D permits shall be valid for two years. The Planning Administrator may extend any permit one or more times for up to an additional 180 days. The Planning Administrator may require additional control measures as a condition of the extension if they are necessary to meet the requirements of this ordinance.

(b) SURETY BOND. As a condition of approval and issuance of the permit, the Planning Administrator may require the applicant to deposit a surety bond or irrevocable letter of credit to guarantee a good faith execution of the approved control plan and any permit conditions.

(c) PERMIT CONDITIONS. All permits shall require the landowner or land user to:

1. Notify the department at least 24 hours prior to commencing any land disturbance activity;.
2. Obtain permission from the department prior to modifying the control plan;
3. Install and maintain all control measures as identified in the control plan;
4. Repair any siltation or erosion damage to adjoining areas, such as perennial waters, wetlands, and drainageways resulting from land disturbance activities;
5. Keep a copy of the control plan on the site;
6. Notify the department within 48 hours of completion of the land disturbance activity; and
7. Keep permit plaque posted so as to be visible from a public roadway at entrance to the site.

S. 21.09 INSPECTION.

The department, Planning Administrator, or designee of either are authorized to inspect the site at any time prior to, or after the issue of the permit.

If the land disturbance is being carried out without a permit and control plan, the Planning Administrator shall enter the land to implement enforcement provisions (s. 66.122 and 66.123, Wis. Stats.).

S. 21.10 ENFORCEMENT AND PENALTIES.

(1) The Planning Administrator, department or designee of either may post a stop-work order if;

(a) Any land disturbance regulated under this ordinance is being undertaken without a permit and approved control plan;
(b) The control plan is not being implemented as approved; or
(c) The conditions of the permit are not being met.

(2) If the applicant does not cease the land disturbance activity and comply with the control plan or permit conditions within 48 hours after posting the stop work order, the Planning Administrator may revoke the permit.

(3) Where no permit has been issued and a stop work order has been posted, the Planning Administrator may request the district attorney to obtain a cease and desist order, or any other form of injunction relief as needed.

(4) After consulting the department, the Planning Administrator may retract the stop-work order or the revocation.

(5) After posting a stop-work order, the Planning Administrator may issue a notice of intent to the landowner and land user, if applicable, of the County's intent to perform work necessary to comply with this ordinance.
The County may go on the site and commence the work no sooner than 5 days after issuing the notice of intent. Exceptions may be granted in emergency situations where the potential for severe offsite damage warrants immediate attention. The cost of the work performed by the County, plus interest, at the rate authorized by the County Board shall be billed to the landowner. In the event a landowner fails to pay the amount due, the clerk shall enter the amount due on the tax rolls and collect as a special assessment against the property pursuant to section 66.60(16). Wis Stats.

(6) Any person violating any of the provisions of this ordinance shall be subject to a forfeiture of not less than $50.00 nor more than $500.00 and the costs of prosecution for each violation.. Each day a violation exists shall constitute a separate offense.

(7) Compliance with the provisions of this ordinance may also be enforced by injunction.

<u>S. 21.11 APPEALS.</u>

(1) BOARD OF ADJUSTMENT. The board of adjustment created pursuant to section 17.80 of the La Crosse County zoning ordinance pursuant to section 59.99 and 68.11, Wis. Stats:

(a) Shall hear and decide appeals where it is alleged that there is error in any order, decision or determination made by the department or Planning Administrator in administering this ordinance;

(b) Upon appeal, may authorize variances from the provisions of this ordinance, which are not contrary to the public interest, and where, due to special conditions, a literal enforcement of the provisions of the ordinance will result in unnecessary hardship; and

(c) Shall use the rules, procedures, duties and powers authorized by statute in hearing and deciding appeals and authorizing variances.

(2) WHO MAY APPEAL. Any applicant, landowner, land user or aggrieved party may appeal any order, decision or determination made by the department or Planning Administrator relative to sites in which such person has interest.

S.21.12 CONFLICTING ORDINACES.

The provision of this ordinance shall prevail over any previous ordinances of La Crosse County that are or may be in conflict therewith.

S.21.13 AMENDMENTS.

Amendments to this ordinance may be made upon petition of any interested party by using the same procedure as is provided for in section 59.97 Wis. Stats. except that any amendment does not require approval and is not subject to disapproval by any town board.

S. 21.14 FEES.

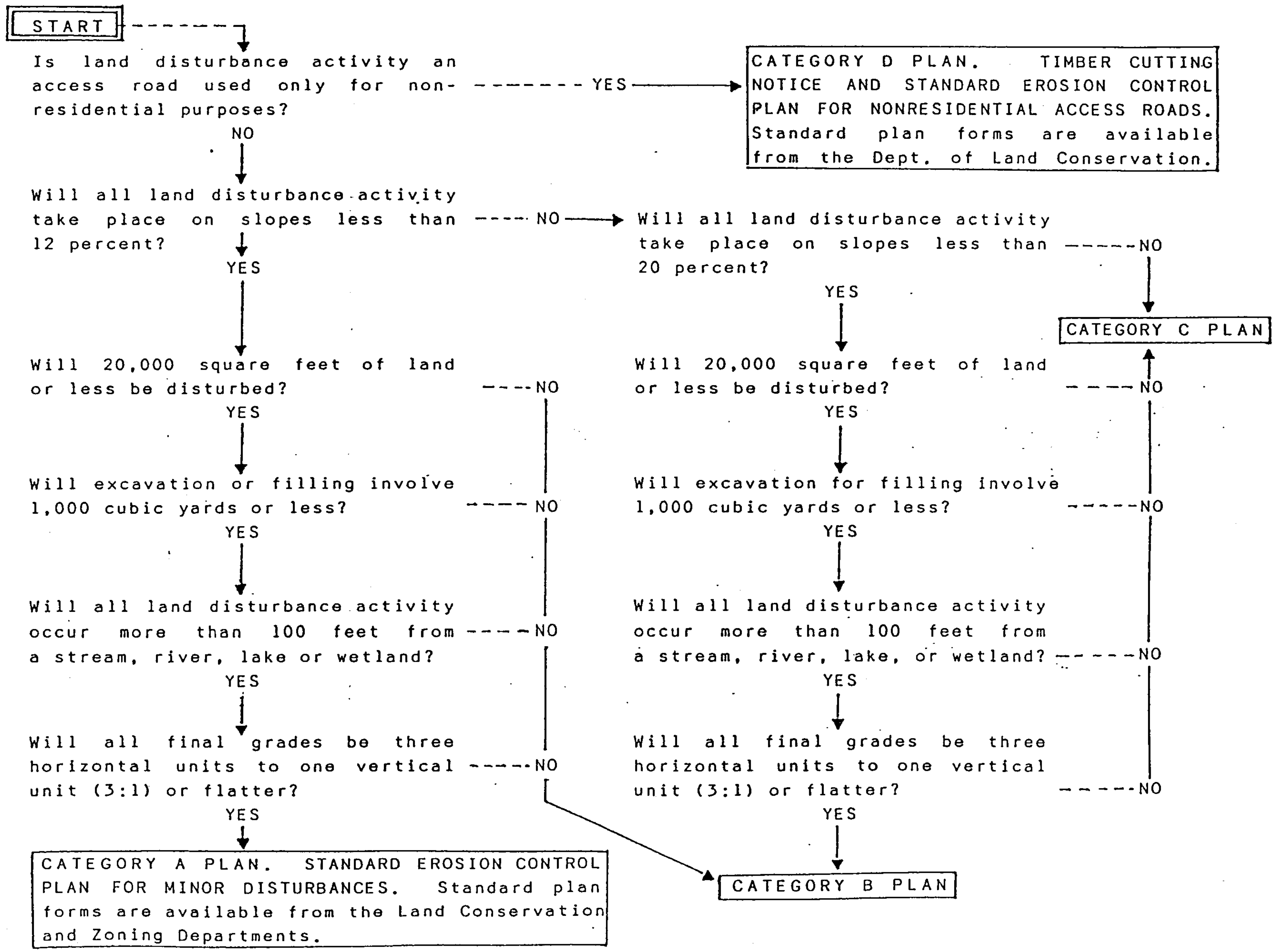
(1) CONTROL PLAN REVIEW FEES. Control plan review fees will be established by the Land Conservation Committee and may be modified by motion of that committee. Only one fee per each control plan submitted may be charged.

S. 20.15 EFFECTIVE DATE

This ordinance shall take effect on January 1, 1992. All lots in subdivision plats and certified surveys that have been duly recorded in the office of register of deeds prior to the effective date of this ordinance are exempt from the maximum slope requirements contained herein. No land disturbance is permitted on these lots unless a permit is issued in accordance with s. 21..08.

APPENDIX

TYPE OF EROSION PLAN REQUIRED



EROSION CONTROL PERMIT APPLICATION
La Crosse County, Wisconsin

Permit No. ____/____

The undersigned is applying for an EROSION CONTROL PERMIT. The applicant agrees that all erosion control practices and procedures shall be in accordance with the requirements of La Crosse County's Construction Site Erosion Control Ordinance and with all other applicable County and State regulations. Submit this application and EROSION CONTROL PLAN to the Department of Land Conservation for review and acceptance. Fees are to be paid prior to issuance of permits. NOTE: Contact your township before proceeding. Township permits may be required.

Landowner ______________________________ ____________
Print Name Phone

______________________________ ____________
Address Zip Code

Landowner's Signature ______________________ Date ____/____/____

Site Location:
Subdivision Name ______________________Lot ___ Block ___

Town of ______________ Town _____N Range _____W Section ____

Address/Street ______________________ Parcel No. __________

Person responsible for erosion control if other than owner:

Signature ______________Phone __________ Date ____/____/____

Address ______________________________ Zip Code __________

Description of activity: ______________________________

____

Anticipated starting date: ______________

Amount of area to be disturbed: Square Feet ________ (or) Acres ________

Distance between disturbed area and perennial waters, streams, lakes, etc.
(Check One) 0-100'___, 101'-300'___, Within 1/4 mi.___, Over 1/4 mi.___

Slope of the site where land disturbance will occur: _____ %

****

FOR OFFICE USE ONLY

Erosion control plan received, ____/____/____.

Category ____ erosion control plan required. Fee required $__________

Plan accepted by: ______________________ Fee received ____/____/____

Erosion control plan submitted to Zoning and Planning Dept. ____/____/____

Revised 5/18/93

#010

STANDARD EROSION CONTROL PLAN FOR MINOR LAND DISTURBANCES
CATEGORY A SITES ONLY

I. <u>APPLICABILITY</u>

Submit this STANDARD PLAN if all conditions in I. A. thru E. apply.

A. The site where the land disturbance occurs is less than 12% slope.
B. No more than 20,000 square feet of area will be disturbed.
C. No more than 1,000 cubic yards of excavation and/or filling occur.
D. No land disturbing activity occurs within 100 feet of perennial waters or wetlands.
E. No final grades will be steeper than 3 horizontal units to one vertical unit.
F. Upon plan submission, and a site investigation, the Department of Land Conservation may determine a site as having minimal impact.

II. <u>CONDITIONS</u>

A. The county shall have access to the site for inspection.
B. The Land Conservation Department shall be notified at least 24 hrs. prior to the start of a land disturbance activity.
C. All control measures shall be maintained by the landowner or user. Inspection will follow S.21.09 of the county ordinance.
D. The applicant shall repair any siltation or erosion damage to adjoining areas and be subject to S.21.10 of the county ordinance.
E. All other Federal, State, County or Town regulations still apply.
F. The permit plaque must be kept posted so as to be visible from a public roadway at the entrance to the site.

III. <u>REQUIREMENTS</u>

A. Where surface runoff from any disturbed or graded areas flows off the site, silt fences, straw bales or equivalent measures shall be installed to specifications prior to the land disturbance.
B. The access road shall be of sufficient size to minimize sediment being tracked onto public roadways. Any sediment reaching public roads shall be removed, not flushed, at the end of each workday.
C. Swales and channels that transport concentrated runoff shall be stabilized by sodding, erosion control mats or fabrics, diverting flow until vegetation is established or other approved measures.
D. Grading shall not impair existing surface drainage, create erosion hazards or a source of sediment to adjacent waters or property.
E. Final grades shall be completed as soon as practical.
F. A site sketch shall be submitted. Directional arrows must show the drainage patterns of the site before and after development.

IV. <u>STABILIZATION</u>

All disturbed ground not established to final grade within 14 days of initial land disturbance shall be temporarily stabilized by seeding or other approved measures. Permanent seeding, sodding or other measures shall be used as part of final site stabilization and shall be completed within 24 hrs. of final grading unless a variance is granted.

V. <u>SPECIFICATIONS</u>

Erosion control measures shall be in accordance with LCC approved standards and specifications, including the Wisconsin Construction Site Best Management Practice Handbook, or SCS specifications.

****

Complete this form, and return with the EROSION CONTROL PERMIT APPLICATION to: LaCrosse County DLC, 400 No. 4th. St., Courthouse, LaCrosse, WI 54601.

____ ____/____/____

Signature of person responsible for erosion control. Date

SITE SKETCH <u>MUST</u> INCLUDE:

1. Locations and dimensions of the areas to be disturbed.
2. Existing and proposed drainage patterns.
3. Locations and dimensions of all erosion control practices. (SEE SECTION III. A. THRU F.)
4. Locations of soil stacking areas. See attached example site sketch.

LOCATION MAP, DIRECTIONS TO SITE

N

EROSION CONTROL PLAN SITE SKETCH FOR CATEGORY A SITES ONLY

Use grid to indicate length and width in feet

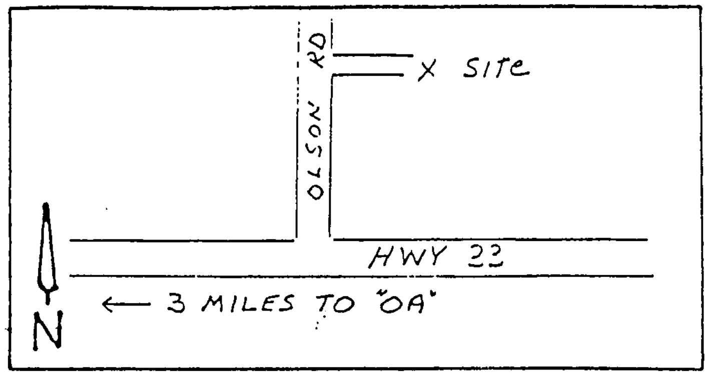
****************************** OFFICE USE ONLY ******************************

SEE ATTACHED ADDITIONAL CONSTRUCTION SITE INVESTIGATION REPORT YES NO

SITE SKETCH <u>MUST</u> INCLUDE:

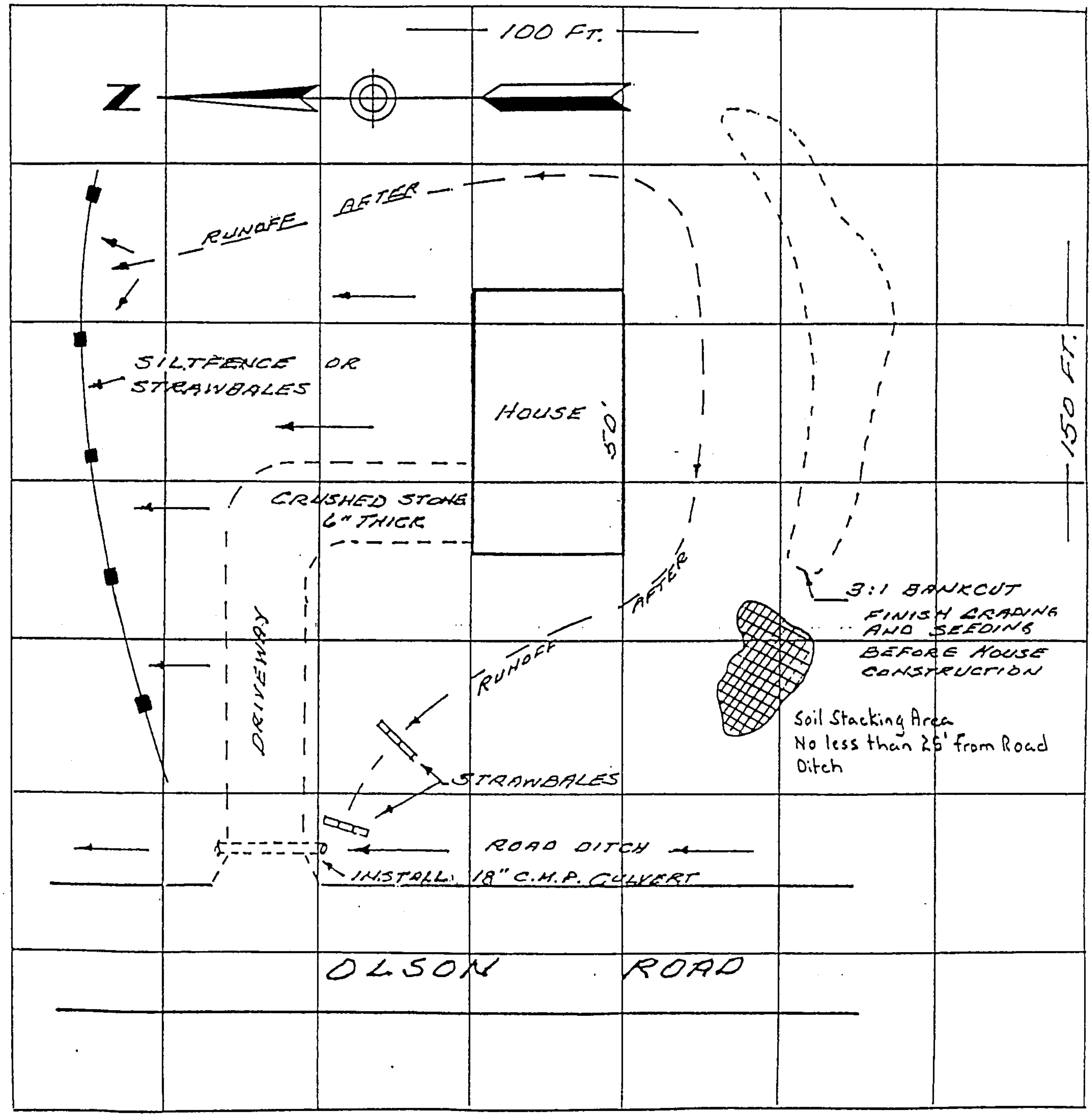
1. Locations and dimensions of the areas to be disturbed.
2. Existing and proposed drainage patterns.
3. Locations and dimensions of all erosion control practices. (SEE SECTION III. A. THRU F.)
4. Locations of soil stacking areas. See attached example site sketch.

LOCATION MAP, DIRECTIONS TO SITE



EXAMPLE

TYPICAL EROSION CONTROL PLAN FOR CATEGORY A



USE GRID TO INDICATE LENGTH AND WIDTH IN FEET

TIMBER CUTTING NOTICE & STANDARD EROSION CONTROL PLAN FOR NONRESIDENTIAL ACCESS ROADS

Plan Received ___/___/___ Permit # ____/____

****

PART A COMPLETE THIS PART TO FILE AS TIMBER CUTTING NOTICE.

Per S.26.03 WI. Stats. I notify that (print cutters name, address & phone)

_____________ _____________ _______ _______

will cut logs, poles, pulpwood, or other forest products on lands owned by:

Print Landowner Name	Address	Zip	Phone

Description of lands on which cutting will occur (one plan per landowner):

Activity	Mo.	Yr.	Township	Sec.	1/4 of 1/4		Town	Range
							____N	____W
							____N	____W
							____N	____W

Check here if no land disturbance will occur.____No permit or fee Required.

****

PART B COMPLETE THIS PART TO FILE FOR OTHER NONRESIDENTIAL ACCESS ROADS.

Print Landowner Name	Address	Zip	Phone

Project Location: Township_____1/4_____1/4_Section____Town____N Range____W

Description of Activity:____
____Start Date,___/___/___

****

I <u>APPLICABILITY (CATEGORY D PLAN)</u>

A. Sections I, II, III & IV apply to all applications submitted under PART B, and to PART A only if land disturbance activities occur. See S.21.04(10) & S.21.07 of La Crosse County's Erosion Control Ordinance for definitions of land disturbance activities.

B. Additional permits may be required if access roads are constructed through areas regulated by shoreland, wetland or floodplain zoning.

II <u>CONDITIONS</u>

A. The Land Conservation Department shall be notified at least 24 hrs. prior to the start of a land disturbance activity.

B. Install and maintain all control measures as identified in this plan.

C. Repair any siltation or erosion damage to adjoining areas caused by lack of plan implementation, and subject to S.21.10.

D. No modifications to the control plan without prior DLC approval.

E. The county shall have access to the site for inspection.

F. Post permit plaque to be visible from point of access to a public roadway at entrance to the site.

G. All other Federal, State, County or Town regulations still apply.

III <u>REQUIREMENTS</u>

A. It is recommended that a site plan be submitted to the department showing the general location of the planned access roads or other planned land disturbance activities.

B. Road grades should be as close to the contour as possible and not steeper than 10 percent, except for short distances.

C. (Logging roads only). When skidding is completed between May 11th and November 1st, the final grading and seeding of logging roads shall be completed within 5 working days. Skidding operations completed between Nov. 2nd and May 10th shall be graded and seeded by May 15th.

D. Water breaks will be installed on all access roads as follows:

1. A water break shall be placed at the head of the slope. Maximum spacing is listed below according to the grade of the road.

ROAD GRADE (PERCENT)	DISTANCE BETWEEN BREAKS (FEET)
1	400
2	245
5	125
10	80
15	60
20	50
25	40
30	35
40	30

2. Water breaks will be constructed at a 30 degree angle pointing downslope, and with a minimum of 3 percent outslope.
3. Water break outlets will be stabilized and left open to drain.
4. Earth water breaks will be at least one foot high. Wood water breaks must be at least 6 inches deep and 4 inches wide.
5. It is recommended roads be outsloped a minimum of 3 percent.

E. All seeding shall be completed within 24 hours of final grading, see III (c) for exceptions. Seed mix #1 or #2 shall be used. Alternative mixes must be pre-approved, and are to be submitted with this form.

Seed Type	Pounds Per Acre of Pure Live Seed
Mix #1	
White Dutch Clover	4 lbs.
Perennial Ryegrass	5 lbs.
Annual Ryegrass	10 lbs.
Creeping Red Fescue	15 lbs.
Mix #2	
Annual Ryegrass	45 lbs.

Dormant seeding rates, September 15 to April 1, must be doubled.

F. Disturbed areas, other than logging roads, left inactive 14 days or longer shall be stabilized by mulching or seeding, unless other control measures are pre-approved by the department.

G. Access roads shall be located at least 50 feet from streams and springs, except at designated crossings. Cross drainage ways at approximate right angles. Do not construct roads in drainage ways.

H. Access to public roads shall be constructed and maintained in a manner which will prevent tracking of sediment on to public roads.

IV. SPECIFICATIONS

Erosion control measures shall be in accordance with LCC approved standards and specifications, including the Wisconsin Construction Site Best Management Practice Handbook, and SCS specifications.

****

I agree to meet applicable conditions of this standard plan.

Landowners Signature____Date ___/___/___

Person(s) responsible for erosion control if other than owner:
Signature______________________Address_____________________Phone___________

Attach $25.00 permit fee to this form, unless no land disturbance occurs.
Permits for Part A & B applications will be mailed to landowner in 7 days.

Mail this form filed for PART A to: Sharon Lemke, County Clerk, Courthouse, Room 102, 400 No. 4th St., La Crosse, WI. 54601

Mail this form filed for PART B to: La Crosse County DLC, 400 No. 4th St., Courthouse, La Crosse, WI. 54601

****

Fee Received, ___/___/___ Plan Approved By:_______ Returned __/__/__

EROSION CONTROL PLAN CHECKLIST

CATEGORY B and C PLANS

		YES	NO
1.	Is the application form complete, including all information and all signatures?	___	___
2.	Existing site sketch.		
	a. Are property and adjacent land boundaries shown?	___	___
	b. Channels, ditches, watercourses, wetlands identified?	___	___
	c. Existing ground cover identified?	___	___
	d. Drainage patterns on and adjacent to site identified?	___	___
	e. Locations and dimensions of utilities, roads, highways, and paving identified?	___	___
3.	Site development plan.		
	a. Does your sketch of the site show:		
	Locations and dimensions of land disturbances including driveways, buildings, utilities, etc?	___	___
	Locations and dimensions of earth stockpiles?	___	___
	Locations and dimensions of erosion control measures?	___	___
	b. Does your proposed development schedule indicate:		
	Sequence of development including length of time involved through each phase of site development?	___	___
	Timing for installation of erosion control measures?	___	___
	Anticipated starting date?	___	___
	Provisions for maintenance of control measures?	___	___
	Seed mixtures and seeding and mulching requirements?	___	___
	c. All documentation for design of engineered practices such as sediment traps and basins, channels and waterways, diversions etc., including hydrology and hydraulic analysis for stability?	___	___

Note: The above items are required for all Category C sites except that the site sketch shall be a topographic map generated by recent survey information and drawn to scale. In addition, the following information shall be provided for Category C sites.

	YES	NO
Soil type information? (see LaCrosse Co. Soil Survey)	___	___
Additional drawings including cross sections and profiles that will clarify extents of cuts and fills and final grades?	___	___

NOTE: This list may not be all-inclusive for every site, additional information may be required. Please refer to the La Crosse County Erosion Control Ordinance for more information.

Revised 2/14/92

APPENDIX

LA CROSSE COUNTY
EROSION CONTROL ORDINANCE
PLAN APPROVAL FEE SCHEDULE

Control plan review fees are established by the Land Conservation Committee. There will be only one fee per each control plan. Control plans are to be submitted to and reviewed by the Land Conservation Department. The control plan fee may be submitted to either the Land Conservation or Zoning Departments. It is recommended that the control plan fee be submitted with the control plan to the Land Conservation Department. Accepted plans are transferred to the Zoning Department for issue of permits. Control plan fees are separate from other applicable Zoning and Planning Department fees.

Zoning Occupancy, Conditional Use, or Special Exception permits are still applied for at the Zoning Department. All permits (see exception below) are issued by the Planning Administrator upon acceptance of the control plan by the department and payment of all applicable fees.

Category D plans, are to be submitted to the Land Conservation Department. Permits for these plans will be issued by the Land Conservation Department. Exceptions for category D plans are for access roads being constructed through an area defined under shoreland, wetland, or floodplain zoning. In these cases zoning permits are also required.

CATEGORY A PLANS		
"Standard Erosion Control Plan for Minor Land Disturbance"	Fee	= $ 25.00
CATEGORY B PLANS		
Less than one acre of land disturbed.	Fee	= $ 75.00
One or more acre(s) of land disturbed.	Fee	= $150.00
CATEGORY C PLANS		
Less than one acre of land disturbed	Fee	= $150.00
One or more acre(s) of land disturbed.	Fee	= $400.00
CATEGORY D PLANS		
"Standard Erosion Control Plan for Nonresidential Access Roads and Timber Cutting Notice."	Fee	= $ 25.00

Updated 01/01/92

Glossary

GLOSSARY

Best Management Practice (BMP): A practice or combination of practices that are determined to be most effective and practical (including technological, economic, and institutional considerations) means of controlling point and nonpoint pollutant levels compatible with environmental quality goals.

Drainage Basin: A geographic and hydrologic subunit of a watershed.

Dry Detention Ponds: A structural BMP or retrofit that consists of a large open depression that stores incoming stormwater runoff while percolation occurs through the bottom and sides.

EPA: United State Environmental Protection Agency

Groundwater: Subsurface water occupying the zone of saturation. In a strict sense, the term is applied only to water below the water table.

Heavy Metals: Metallic elements with high atomic weights, (e.g. mercury, cadmium and lead). They can damage living organisms at low concentrations and tend to accumulate in the food chain.

Impervious Surface: Hard surface that prevents and retards the entry of water into the soil mantle as natural conditions prior to development and/or a hard surface area that causes water to runoff the surface in greater quantities or at increased flow rates from the flow present under conditions prior to development. Common impervious surfaces include, but are not limited to rooftops, walkways, patios, driveways, parking lots, storage areas, concrete or asphalt paving, gravel roads, packed earthen materials, and oiled, macadam, or other surfaces that similarly impede the natural infiltration of urban runoff.

Infiltration: The penetration of water through the ground surface into subsurface soil or the penetration of water from the soil into sewer or other pipes through defective joints, connections, or manhole walls.

Land Conversion: A change in land use, function, or purpose.

Local Government: Any County, City, or Town having its own incorporated government for local affairs.

Nonpoint Source Pollution: Pollution whose sources cannot be traced to a single point such as a municipal or industrial wastewater treatment plant discharge pipe.

Pollution Prevention: A management measure to prevent and reduce nonpoint source loadings generated from a variety or everyday activities within urban areas. These can include turf management, public education, ordinances, planning and zoning, pet waste control, and proper disposal of oil.

Post-Development Peak Runoff: Maximum instantaneous rate of flow during a storm, after development is complete.

Pre-Development Peak Runoff: Maximum instantaneous rate of flow during a storm prior to development activities.

Removal Efficiency: The capacity of a pollutant (sediment) control device to remove pollutants from wastewater or runoff.

Retrofit: The modification of a urban runoff management system in a previously developed area. This may include wet ponds, infiltration systems, wetland plantings, streambank stabilization, and other BMP techniques for improving water quality and creating aquatic habitat. A retrofit can consist of new BMP construction in a developing area, enhancing and older runoff management structure, or combining improvements and new construction.

Runoff: That part of precipitation, snow melt, or irrigation water that runs off the land into streams or other surface water. Runoff can carry pollutants from the air and land into receiving waters.

Sedimentation Basins: Sediment storage areas that may consist of wet detention basins or dry detention basins. Excavated areas with storage depression below the natural ground surface; creek, stream, channel or drainageway bottoms properly engineered and designed to trap and store sediment for future removal.

Watershed: A drainage area or basin where all land and water areas drain or flow toward a central collector such as a creek, stream, river or lake at a lower elevation.

Wet Detention Ponds: A structural BMP or retrofit that consists of a single permanent pool of water that stores and treats incoming stormwater. Wet detention ponds usually have three to seven feet of standing water, allowing pollutants to settle, with a defined siltation/sedimentation pond and outlet structure.

References

REFERENCES

Adams, L.W., Dove, L.E., Leedy, E.L., and Franklin, T., Urban Methods for Stormwater Control and Wildlife Enhancement: Analysis and Evaluation (Urban Wildlife Research Center, Columbia, MD, 1983), 200 pp.

AGNPS, Agricultural Non-point Source Pollution Model, SCS - Version 4.0, Water quality Model, USDA, Agricultural Research Services, North Central Soil Research Laboratory, Morris, Minnesota, May 1003.

American Public Works Association, "Urban Stormwater Management," Special Report No. 49 (Chicago, IL, 1981).

Bannerman, Roger, J.G. Konrad, D. Becker, G.V. Simsiman, G. Chesters, J. Goodrich-Mahoneyu, B. Abrams 1979. "The International Joint Commission Menomonee River watershed study. Volume III" Surface water monitoring data." Wisconsin Department of Natural Resources and Wisconsin Water Resources Center. Madison, Wisconsin.

Bannerman, Roger, Ken Baun, Mike Bohn, Peter E., Hughes, David A. Grasczyk 1983. "Evaluation of urban nonpoint source pollution management in Milwaukee County, Wisconsin. Volume I: Urban stormwater characteristics, pollutant sources and management by street sweeping." Wisconsin Department of Natural Resources and United States Geological Survey, Madison, Wisconsin.

Bannerman, Roger 1991. "Pollutants in Wisconsin Stormwater." Unpublished document. Wisconsin Department of Natural Resources. Madison, Wisconsin.

Bannerman, Roger T., Richard Dodds, David Owens, Peter Hughes 1992. "Sources of pollutants in Wisconsin stormwater." Wisconsin Department of Natural Resources and United States Geological Survey. Madison, Wisconsin.

Bannerman, R., K. Baun, M. Bohn, P.E. Hughes and D.A. Graczyk 1983. "Evaluation of Urban Non-point Source Pollution Management in Milwaukee County, Wisconsin," U.S. Environmental Protection Agency. PB 84-114164. Chicago, IL.

Blake, Tom 1991. Notes from 1991 Minocqua stormwater sampling. Unpublished document. Wisconsin Department of Natural Resources. Rhinelander, Wisconsin.

Brach, John 1989. "Protecting water quality in urban areas: Best management practices for Minnesota." Prepared by the Minnesota Pollution Control Agency. St. Paul, Minnesota.

Dindorf, Carolyn J. 1991. "Toxic and hazardous substances in urban runoff. Interim report prepared by Hennepin Conservation District." Minnetonka, Minnesota.

Duda, A.M., D. Lenat, and D. Penrose, 1982. "Water quality in urban streams - what we can expect:, I. Water Pollut. Contr. Fed. 54(7): 1139-1147.

EPA 1985, Characterizing and Controlling Urban Runoff through Street and Sewage Cleaning, Pitt, R.E., Consulting Engineer, Blue Mounds, WI, EPA 600/2-85/038, (NTIS PB 85-186500/Reb.) 1985.

EPA 1988(a), Nonpoint Source Monitoring and Evaluation Guide, U.S. Environmental Protection Agency, Nonpoint Source Branch, February 26, 1988.

EPA 1988(b), Design manual, Constructed wetlands and Aquatic Plant Systems for municipal Water Treatment, EPA 625/1-88/022, September 1988.

EPA 1989, Retrofitting Stormwater Management Basins for Phosphorus Control, EPA Office of Water, Nonpoint Source Branch, Publication U-1, August 1989.

Fitzpatrick, M., M. Koplan, E. Selig, R. Howe, N. White, and A. Waldo 1977. "Preventive approaches to stormwater management." U.S. Environmental Protection Agency Publication 440/9-77/001. Washington, D.C.

Hammer. D. 1989. "Constructed Wetlands for Wastewater Treatment." Lewis Publishers.

Horner, R. 1988, Biofiltration Systems for Storm Runoff Water Quality Control, Report to Washington State Department of Ecology, Municipality of Metropolitan Seattle, King County and the Cities of Bellevue, Mountlake Terrace, and Redmond, 1988.

Klein, R. 1979, Urbanization and Stream Quality Impairment, Water Resources Bulletin, American Water Resources Association, August 1979.

Kuo, C.Y. and others 1989, A Study of Infiltration Trenches, Virginal Water Resources Control Board, Bulletin 163, April 1989.

Leopold, Luna B. 1968. "Hydrology for urban land planning: a guidebook on the hydrologic effects of urban land use." U.S. Geological Survey Circular 554. U.S. Government Printing Office, Washington, D.C.

Lindsay, Greg 1988. "Financing Stormwater Management: The Utility Approach." Sediment and Stormwater Administration, Maryland Department of the Environment.

Lindsay, Greg 1990. "Charges For Urban Turnoff" Issues In Implementation. Water Resources Bulletin. American Water Resources Association. Vol. 26, No. 1.

Lindsay, Greg 1990. "Update To A Survey of Stormwater Utilities." Sediment and Stormwater Administration, Maryland Dept. of the Environment.

Mancini, J.L., "Development of Methods to Define Water Quality Effects of Urban Runoff," Report Nol EPA 600/2-83-125 (Municipal Environmental Research Laboratory, U.S. EPA Office of Research and Development, 1983).

Marsh, William M., "Environmental Analysis: For Land Use and Site Planning" (McGraw-Hill, Inc., 1978).

McCuen, R. 1987, Policy Guidelines for Controlling Stream channel Erosion with Detention Basins, Richard McCuen, Department of Civil Engineering, University of Maryland, December 1987.

Minnesota Pollution Control Agency 1978. "Highway De-Icing Chemicals." Division of Water Quality, Planning Section. June.

MWCOG 1991, Developing Effective BMP systems for Urban Watersheds, Metropolitan Washington Council of Governments, 1991, from EPA 1991, Nonpoint Source Watershed Workshop: Nonpoint Source Solutions, EPA Office of Research and Development, Office of Water, EPA 625/4-91/027, September 1991.

Novotny, V. and Chesters, G., "Handbook of Nonpoint Source Pollution: Sources and Management" (Van Nost and Reinhold Company, New York, NY, 1981), 545 pp.

Nowak, Peter J. 1990. "Water quality in the Milwaukee metropolitan area: The citizens' perspective." University of Wisconsin Environmental Resources Center. Madison, Wisconsin.

Omernik, James, "Nonpoint Source -- Stream Nutrient Level Relationships" A Nationwide Study." Report No. EPA-600/3-77-105 (Special Studies Branch, Corvallis Environmental Research Laboratory, U.S. EPA).

Pfender, Jon, Carolyn Johnson, Gary Korb, Keigh Foye 1991. "A nonpoint source control plan for the Milwaukee River South Priority Watershed Project." Wisconsin Department of Natural Resources PUBL-WR-245-91. Madison, Wisconsin.

Pitt, R. 1979. "Demonstration of Nonpoint Pollution Abatement Through Improved Street Cleaning Practices," EPA-600-2-79-161. U.S. Environmental Protection Agency, Cincinnati, Ohio.

Pitt, R. 1979. "Characterization, Sources, and Control of Urban Runoff by Street and Sewerage Cleaning." Contract No. R-80597012. U.S> Environmental Protection Agency and the City of Bellevue (WA). Cincinnati, Ohio.

Pitt, R. and J. McLean 1985. "Toronto Area Watershed Management Strategy Study: Humber River Pilot Watershed Project." Ontario Ministry of the Environment. Toronto, Ontario. (Draft).

Pitt, R. and G. Shawley 1981. "A Demonstration of Nonpoint Pollution Management on Castro Valley Creek." Alameda County Flood Control District (Hayward, California) and the U.S. Environmental Protection Agency. Washington, D.C. June.

Pitt, R., J. Ugelow and J.D. Sartor 1976. "Systems Analysis of Street Cleaning Techniques." American Public Works Association and the National Science Foundation, RANN Program. Washington, D.C. March.

Pitt, R., PE, PhD, Birmingham Alabama, John Voorhees, Madison, Wisconsin. "Source Loading and Management Model: AN Urban Nonpoint Source Water Quality Model." 1993 & 1994.

Pitt, PE, PhD, Birmingham, Alabama, John Voorhees, Madison, Wisconsin. DetPond, A Model for Evaluation, Wet Detention Ponds for Water Quality Benefits." 1993 & 1994.

Roseboom, Don, Thomas Hill, Joh Rodsater, Allan Felsot 1990. "Stream yields from agricultural chemicals and feedlot runoff from an Illinois watershed." Prepared by the Illinois State Water Survey, Peoria, Illinois, and the Illinois State Natural History Survey, Champaign, IL.

RUSLE, Revised Universal Soil Loss Equation, Model for Predicting Erosion and Soil Loss, U.S. Department of Agriculture.

Sartor, J.D. and G.B. Boyd 1072. "Water Pollution Aspects of Street Surface Contaminants." EPA-R2-72-081. U.S> Environmental Protection Agency. Washington, D.C.

Scholl, James, F., 1991. "Stormwater Management Utility Billing Rate Structure." Water Resources and Environmental & Technology. January 1991.

Schueler, T. 1991, Mitigating the Adverse Impacts of Urbanization on Streams: A Comprehensive Strategy for Local Governments, Metropolitan Washington Council of Governments, 1991.

Schueller, Michelle 1992. "Bulk Storage Pile Contamination of Stormwater: Concerns and Recommendations for Wisconsin." WDNR, Bureau of Wastewater Management - Storm Water Program. April.

Schueler, Thomas R. 1987. "Controlling urban runoff: A practical manual for planning an designing urban BMPs." Prepared for the Washington Metropolitan Water Resources Planning Board. Washington, D.C.

Thronson, Robert, "Nonpoint Source Pollution Control Guidance Construction Activities," (U.S. EPA, Washington, D.C., 1976).

Thurow, Charles, Toner, W., and Erley, D., "Performance Controls for Sensitive Lands: A Practical Guide for Local Administrators, Parts 1 and 2 (American Society of Planning Officials, 1975) (Author affiliation - Office of Research and Development, U.S. EPA).

Tourbier, Joachim and Westmacott, R., "Water Resources Protection Measures in Land Development: A Handbook" (Water Resources Center, University of Delaware, Newark, DE, 1974).

Tourbier, J. Toby and Westmacott, Richard, "Water Resources Protection Technology" (Urban Land Institute, Washington, DC, 1981) pp. 178.

The Urban Institute, American Society of Civil Engineers, and the National Association of Home Builders, "Residential Storm Water Management" Objectives, Principles and Design Consideration" (Washington, DC, March 1979), pp. 64

TR-20, Technical Release 20, Project Formulation Hydrology, USDA, Soil Conservation Service, Revised by Northeast NTC and Hydrology Unit SCS, May 1983.

TR-55, Technical Release 55, Urban Hydrology for Small Watersheds, U.S. Department of Agriculture, Soil Conservation Service, Engineering Division, June 1986.

U.S. Environmental Protection Agency, "Methodology for Analysis of Detention Basins for Control of Urban Runoff Quality" (Nonpoint Source Division, Office of Water, U.S. EPA, 1986).

U.S. Environmental Protection Agency, "Best Management Practices Guidance Document, "Report No. EPA-600/9-79-045 (Hydroscience, Inc., Washington, DC. 1979).

U.S.G.S. Report 88-191, Techniques for Estimation of Storm-runoff loads, Volumes, and Selected Constituent Concentrations in Urban Watersheds in the United States", Department of the Interior, U.S. Geological Survey, Denver, Colorado, 1988.

USLE, Universal Soil Loss Equation, Model for Predicting Erosion and Soil Lost, U.S. Department of Agriculture

Watshke, Thomas L. and Ralph O. Mumma 1989. "The effect of nutrients and pesticides applied to turf on the quality of runoff and percolating water." Final report for the U.S. Department of the Interior, Geological Survey. Penn State Environmental resources Research Institute, University Park, Pennsylvania.

Wilson, Homer 1990. "Utility Approach to Stormwater Management." Public Works. June 1990

Wisconsin Department of Agriculture, Trade and Consumer Protection. 1992. Pesticide licensing regulations.

Wisconsin Stormwater Manual, Part I: Overview Wisconsin Department of Natural Resources Bureau of Water Resources Management Nonpoint Source and Land Management Section, Madison, Wisconsin. PN WR-349-94

WSPRO - Water Surface Profile Program, Boss WSPRO Version 2.00, Enhanced Version of James O. Sherman's June 1988 Federal Highway Administration - U.S. Geological Surety.

Young, Mary 1990. Toxic chemical fact sheet series. Wisconsin Department of Health and Social Services. Madison, Wisconsin.