City of Scottsdale
Desert Greenbelt Project

VOLUME I:

REATA PASS/BEARDSLEY WASH CHANNEL RESPONSE ANALYSIS WITH ULTIMATE LEVEE ENCROACHMENT

The Desert Greenbelt
SCOTTSDALE, ARIZONA

February 1997
Prepared by:
Simons, Li & Associates, Inc.
Costa Mesa, California and Tempe, Arizona

sla

CITY OF SCOTTSDALE DESERT GREENBELT PROJECT
MARICOPA COUNTY, ARIZONA

VOLUME I

REATA PASS WASH/BEARDSLEY WASH CHANNEL RESPONSE ANALYSIS WITH ULTIMATE LEVEE ENCROACHMENT

Prepared for:

City of Scottsdale
7447 East Indian School Road, Suite 250
Scottsdale, Arizona 85252

Prepared by

Simons, Li & Associates, Inc.

3150 Bristol Street, Suite 500
Costa Mesa, California 92626

4600 South Mill Avenue, Suite 200
Tempe, Arizona 85282-6759

February 14, 1997

TABLE OF CONTENTS

I. INTRODUCTION 1
- 1.1 GENERAL 1
- 1.2 WATERSHED AND CHANNEL CHARACTERISTICS 5
- 1.3 EXISTING FLOODPLAIN CONDITIONS 12
- 1.4 LAND USE 12
- 1.5 APPLICATION FOR A CONDITIONAL LETTER OF MAP REVISION 12

II. HYDROLOGIC ANALYSIS 16

III. HYDRAULIC ANALYSIS 25
- 3.1 METHODOLOGY 25
- 3.2 REVISIONS TO PREVIOUS HYDRAULIC MODEL 26
- 3.3 SUMMARY OF THE HYDRAULIC CHARACTERISTICS OF THE MAIN CHANNEL 27
- 3.4 SUMMARY OF THE HYDRAULIC CHARACTERISTICS OF THE TRIBUTARY CHANNELS 41

IV. SOILS CHARACTERISTICS 48
- 4.1 GENERAL 48
- 4.2 SOILS ANALYSIS 58

V. EROSION AND SEDIMENTATION 60
- 5.1 EROSION/SEDIMENTATION ANALYSIS - GENERAL 60
- 5.2 QUALITATIVE (LEVEL I) ANALYSIS 60
  - 5.2.1 Plan Form Characteristics 60
  - 5.2.2 Erosion/Sedimentation Characteristics 61
- 5.3 METHODOLOGY FOR SEDIMENT TRANSPORT COMPUTATIONS 63

TABLE OF CONTENTS (Continued)

5.4 STEADY STATE (LEVEL II) ANALYSIS 64
5.4.1 Sediment Inflows - Tributaries 64
5.4.2 Main Channel 64
5.4.3 Hydrologic Scenarios 74
5.5 QUASI-DYNAMIC STATE (LEVEL III) ANALYSIS HEC2-SR 78

VI. MAXIMUM SCOUR DEPTH ESTIMATES 92
6.1 ARMORING POTENTIAL 92
6.2 GENERAL SCOUR 93
6.3 LOW-FLOW INCISEMENT 93
6.4 ANTI-DUNE SCOUR 94
6.5 CONTRACTION SCOUR 94
6.6 BEND SCOUR 95
6.7 LONG-TERM SCOUR ANALYSIS 95
6.8 TOTAL SCOUR DEPTH 100

VII. MINIMUM LEVEE/WALL ELEVATION ESTIMATES 105
7.1 TOP OF LEVEE (LEVEE HEIGHT) 105

VIII. CHANNEL MAINTENANCE 113

IX. REFERENCES 115

LIST OF FIGURES

Figure 1.1	Location Map	2
Figure 1.2	Vicinity Map	3
Figure 1.3	Study Area and Project Phases	4
Figure 1.4	Aerial Photograph of Project Site Showing Proposed Levee Alignment	6
Figure 1.5	Hydrologic Map Showing Watershed Boundary, Subwatershed Boundaries and Location of Concentration Points	10
Figure 1.6	Existing Floodplain Map	13
Figure 2.1	Flood Frequency Curves at Concentration Points Along Main Channel	18
Figure 2.2	100-Year Hydrographs Along the Main Channel	19
Figure 2.3	100-Year Hydrographs - Tributaries at Confluence with Main Channel	22
Figure 2.4	100-Year Hydrographs - Comparison of Main Channel to Tributary Hydrographs	23
Figure 2.5	Discharge for Various Hydrologic Scenarios	24
Figure 3.1	Reach Definitions (Reaches 1 - 27)	34
Figure 3.2	Channel Profile - Thalweg, 100-Year, and 10-Year Water Surface Profiles	35
Figure 3.3	Velocity and Top-Width Profiles	39
Figure 3.4	Average Velocities for Subreaches	43
Figure 4.1	Representative Soils Groups	50
Figure 4.2	Representative Gradation Curves - Main Channel	52
Figure 4.3	Representative Gradation Curves - Tributaries	53
Figure 4.4	Average D_{16}, D_{50}, and D_{84} for Main Channel	54
Figure 4.5	Average D_{16}, D_{50}, and D_{84} for Tributaries	55
Figure 4.6	Silt and Clay Contents for Main Channel	56
Figure 4.7	Silt and Clay in Original Samples for Tributaries	57
Figure 5.1	Q_s vs Q Relationships for Tributaries	65
Figure 5.2	Sediment Inflow Hydrograph	67
Figure 5.3	Reata Pass/Beardsley Wash 100-Year Sediment Transport Rate	69
Figure 5.4	Reata Pass/Beardsley Wash 100-Year Aggradation/Degradation Rate	70

LIST OF FIGURES (Continued)

Figure 5.5 Reata Pass/Beardsley Wash 100-Year Sediment Transport Rate Compared with Smaller Floods 71
Figure 5.6 Reata Pass/Beardsley 100-Year Aggradation/Degradation Rate Compared with Smaller Floods 72
Figure 5.7 Comparison of Scenarios 1, 2 and 3 Sediment Transport Rates 75
Figure 5.8 Comparison of Scenarios 1, 2 and 3 Potential Aggradation/Degradation Depths 76
Figure 5.9 Typical Discretized Hydrograph 80
Figure 5.10 Average Degradation/Aggradation Depths for 100-Year and 10-Year Floods 82
Figure 5.11 Comparison of Existing Thalweg Before and After 100-Year Flood (Level III) 85
Figure 5.12 Typical Sections Illustrating Channel Geometry Before and After 100-Year Flood Event 89
Figure 5.13 Maximum Aggradation/Degradation Depths from Thalweg for 100-Year Storm 90
Figure 5.14 Maximum Aggradation/Degradation Depths from Thalweg for 10-Year Storm 91
Figure 6.1 Potential Aggradation/Degradation Depths Due to Long-Term Conditions 97
Figure 7.1 Profile Showing Top of Levee, Water Surface, and Thalweg before and after Scour 109

LIST OF TABLES

Table 2.1 Summary of Peak Discharges for Reata Pass/Beardsley Wash Main Channel 17
Table 2.2 Summary of Peak Discharges for Tributaries 21
Table 3.1 100-Year Flood Hydraulics Summary 28
Table 3.2 100-year Hydraulic Summary (Per Reach) for Sediment Transport Computations 44
Table 3.3 10-year Hydraulic Summary (Per Reach) for Sediment Transport 45
Table 3.4 Hydraulic Summary - Tributaries 46
Table 4.1 Sources for Sediment Data 49
Table 4.2 Representative Soils Groups 50
Table 5.1 Summary of Regression Analysis for Tributary Sediment Inflow Relationships ... 66
Table 5.2 Potential Short-Term Aggradation/Degradation Trends 73
Table 5.3 Sediment Routing Results - Volume Change and Potential Average Aggradation/Degradation Along Each Reach Short-Term Response for 100-Year Flood Event 83
Table 5.4 Sediment Routing Results - Volume Change and Potential Average Aggradation/Degradation along each Reach Short-Term Response for 10-Year Flood Event 84
Table 6.1 Summary of Potential Long-Term Aggradation (+)/Degradation (-) For Each Reach 98
Table 6.2 Maximum Scour Depth Estimates 101
Table 7.1 Mimimum Levee/Wall Elevation Estimates 106
Table 8.1 Sediment Scour(-)/Deposition(+) for Channel Maintenance based on Short-Term Channel Response 114

EXECUTIVE SUMMARY

The Reata Pass/Beardsley Wash originates from the McDowell Mountains located in northeast Scottsdale. The sediment-laden flow within these washes is transported downstream through steep washes to the desert plain. Sediments are primarily supplied from the following sources: Reata Pass Wash east branch, North Reata Pass Wash, a tributary south of Foothills Drive Bridge (referred to as Foothills Tributary), North Beardsley Wash, South Beardsley Wash, and Thompson Peak Channel.

The Reata/Beardsley alluvial fans were formed along the desert plains, creating a wide floodplain within the study area. The floodplain is currently designated by FEMA as Zone "AO", an area of 100-year, shallow flooding where the average depths are from 1 to 3 feet. In addition to flood hazards, the alluvial fan channels are subject to dynamic changes causing erosion and sedimentation problems. The objective of the Desert Greenbelt Project proposed by the City of Scottsdale is to confine the alluvial fan flows for protection of the existing developments within the floodplain and to provide land use opportunities for housing, transportation, and recreational facilities as well environmental preservation. Under the ultimate condition, the Desert Greenbelt Project will include levee encroachment on both banks and necessary channel improvements and erosion/sedimentation control along a 5.3 mile reach from Pinnacle Peak Road Bridge to the WestWorld detention basin. However, a portion of east levee from downstream of the North Beardsley Wash confluence to upstream of the Bell Road Bridge will not be constructed during the first phase of the project.

The City intends to construct the Phase I project and remove a large portion of the AO zone shown on the existing flood insurance rate map. The remaining AO zone will be removed after implementation of the ultimate flood control system. To ensure its compatibility with the future ultimate condition, the Phase I facilities, which may include levees, flood walls, channelization, and other erosion/sedimentation control facilities, will be designed to accommodate the design requirements for the future ultimate system.

This report documents a comprehensive analysis of potential channel responses with ultimate levee encroachment along the proposed Reata Pass/Beardsley Wash channel prepared by Simons, Li & Associates, Inc. (SLA). The information will be referenced during development of design alternatives under both ultimate and Phase I project conditions.

To assess the overall channel stability, SLA performed a detailed hydraulic, hydrologic, and erosion/sedimentation analysis of the proposed channel. To determine the sediment inflow contributions to the main channel, the channels upstream of Pinnacle Peak Road Bridge (North Reata Pass and main channel east branch) and all lateral tributaries (Foothills Tributary, North Beardsley Wash, and South Beardsley Wash and Thompson Peak Channel) were included in the study. Analyses were performed for various flood frequencies considering short- and long-term sediment supply conditions.

The hydraulic analysis was performed for both subcritical and supercritical flow regimes. Comparison of the results of hydraulic models indicates that mixed-flow conditions will be encountered throughout the entire study area. In general, supercritical flow is the dominant hydraulic feature except for a few localized areas where the flows change to subcritical. The mixed flow condition predicted using the HEC-2 Model compares consistently with the HEC-RAS Model. The mixed-flow conditions were assumed in the sediment transport analysis to ensure that high flow velocities in the supercritical flow areas are considered for scour and sedimentation depth determination. However, the subcritical HEC-2 Model was used for determination of water surface elevations.

In order to allow conservative estimates of the sediment transport and aggradation/degradation analyses and resistance reduction under high-flow conditions, the hydraulic parameters were computed considering a low Manning's *n* value of 0.030 for the main channel. The results of this low Manning's *n* hydraulic analysis were used in the sediment transport analysis. On the other hand, a relatively high Manning's *n* value of 0.050 was used for conservative estimation of the flow depths to account for high flow resistance due to vegetation growth. This value was determined by investigation of the vegetation distribution within the proposed channel or levee encroachment area using the existing aerial photograph. The results of the high Manning's *n* hydraulic analysis were only used in the computation of the water surface elevations. A

Manning's *n* value of 0.04-0.05 was used for the overbank areas within incised channel sections for both cases as estimated from the aerial photographs.

Conclusions from the hydraulic analysis are summarized as follows:

Main Channel East Branch (Station 316+00 to 292+50) - Within this reach, the 100-year flow depths and velocities range from 2.4 to 5.6 feet and 7.7 to 15.6 fps, respectively. The floodplain width ranges from approximately 210 feet to 430 feet.

North Reata Pass Wash Confluence to Pinnacle Peak Road Bridge (Station 292+50 to 272+25)- Within this reach, the 100-year flow depths and velocities for most sections range from 3.3 to 5.8 feet and 11.8 to 15.6 fps, respectively. However, high velocities (up to 24.8 fps) exist at the existing drop structure (Station 277+25) and reinforced concrete box culvert at the Pinnacle Peak Road Bridge. The floodplain width varies from 110 feet to 530 feet.

Pinnacle Peak Road Bridge to Deer Valley Road Alignment (Station 272+25 to 215+00)- Within this reach, the 100-year flow depths and velocities for most sections range from 3.3 to 7.1 feet and 17 to 26 fps, respectively. The high velocities result from a relatively steep channel slope and confined floodplain width. The floodplain width ranges from 100 ft to 150 ft for most of the reach. A small portion of the reach downstream of Pinnacle Peak Road Bridge, however, shows subcritical flow characteristics with higher depths (up to 10.8 ft) , lower velocities (as low as 10.0 fps), and wider floodplain widths (up to 390 ft.)

Deer Valley Road Alignment to North Beardsley Wash Confluence (Station 215+00 to 172+50)- Velocities in this reach are generally slower than those in the above reach. The 100-year flow depths and velocities for most sections range from 3.3 to 7.1 feet and 13 to 17 fps, respectively. The floodplain width is approximately 116 feet to 380 feet. A portion of the reach near Station 200+00 has higher velocities (up to 27.2 fps) due to flow confinement in the divided flow area.

North Beardsley Wash Confluence to Bell Road (Station 172+00 to 46+50) - Within this reach, the 100-year flow depths and velocities for most sections range from 2.3 to 7.9 feet and

5.9 to 15 fps, respectively. However, higher depths and velocities (up to 9.7 ft and 20 fps, respectively) exist at localized areas near the North Beardsley Wash confluence and immediately upstream of the future Union Hills Bridge. The floodplain width ranges from 260 feet to 510 feet, except for Stations 151+50 to 150+00, where the flow width expands to 760 ft in the divided flow area.

Bell Road to the Outlet (downstream of Station 46+50) - Within this reach, the 100-year flow depths and velocities range from 4.7 to 9.1 feet and 6.4 to 16 fps, respectively. High velocities (approximately 20 fps) exist from stations 19+50 to 10+50 where the flow is confined in a channelized portion of the reach. The floodplain width varies from 170 to 550 feet.

The erosion and sedimentation characteristics of the Reata Pass Wash along the proposed channel were evaluated using a three-level approach. Level I is a qualitative analysis based on field observation, soils data, channel geomorphology, and hydraulic features of the main channel and tributaries. Level II is a quantitative analysis to determine the sediment inflow and outflow rates through each channel reach using sediment transport equations assuming a steady-state (fixed-bed) condition. This analysis provides an estimate on sediment transport capacity for each channel reach, aggradational and degradational trend and magnitude along the main channel for flood magnitudes ranging from the 2-year to the 100-year floods. A Level III analysis further evaluates the channel responses during the 100-year and the 10-year flood event utilizing a sophisticated mathematical model. Other factors which may increase the scour/sedimentation depth (e.g. local scour) or limit the scour depth (e.g. armoring) were considered in addition to the results of Level II and III sediment transport analysis.

Long-term degradation was estimated considering changes in sediment supply. The short-term sediment transport analysis was performed assuming that the sediment supply to a given channel reach is from the reach immediately upstream. After long term adjustment, the upstream reaches may achieve equilibrium relative to the upstream supply through continuous erosion and sedimentation and channel adjustment. Under this condition each channel reach will receive the sediment inflow from the ultimate sediment sources mentioned previously.

The long-term sediment sources from the upper reach and tributaries are subject to changes. Most likely the sediment supply may be reduced due to urbanization or natural river armoring. A sediment supply reduction will potentially increase degradation of the channel. Urbanization of the watershed Future developments typically affect efficient conveyance of sediment flow due to constriction by culverts, junction structures, recreational accesses, landscaping, etc. Natural armoring will partially or entirely cover up the underlying sand and gravel and significantly reduce the sediment supply from North Beardsley Wash, South Beardsley Wash, and Thompson Peak Channel.

In general, reducing the sediment inflow will result in long-term degradation or reduction in aggradation. Conversely, increasing the sediment inflow will result in aggradation. In the analysis, various sediment supply assumptions were considered in the long-term sediment transport analysis. The long-term scour deposition depths were obtained by conservative estimate assuming a 50% reduction in the sediment inflow contributing from each source area (North Reata Pass, main channel east branch, Foothills Tributary, North Beardsley Wash, South Beardsley Wash, and Thompson Peak Channel). In addition to short-term and long-term general erosion, bend scour, contraction scour, and low flow degradation were added to obtain total scour depths.

The following reaches were considered critical scour reaches in addition to local areas such as Union Hills Drive Bridge.

1. Station 262+00 to 232+50: total scour depth range from 10 to 21 ft.

2. Station 205+00 to 201+00: total scour depth ranges from 10 to 17 ft.

3. Station 22+50 to 16+50: total scour depth ranges from 12 to 15 ft.

These critical scour areas will be stabilized by using grade control, grading modification, lining, and low-flow channelization within the levee/wall structures to reduce the total scour depths, which will be presented in the future reports.

It was identified that the downstream reaches have general long-term aggradation potential. Upstream of Bell Road Bridge where Thompson Peak Channel and South Beardsley Wash confluence with the proposed channel has the most severe aggradation potential. The lower reach in WestWorld also has high potential of aggradation. For mitigation, sediment basins may be considered in addition to increasing the bank/levee height and channelization.

I. INTRODUCTION

1.1 GENERAL

Simons, Li & Associates, Inc. (SLA), was requested by the City of Scottsdale (City), and the Flood Control District of Maricopa County (County), Arizona, to provide a design and analysis of a flood control system for the City of Scottsdale Desert Greenbelt Project in Maricopa County, Arizona. Figures 1.1 and 1.2 show general and specific locations of the project site. Under the ultimate condition, the Desert Greenbelt Project will include levee encroachment on both banks and necessary channel improvements and erosion and sedimentation control structures along a 5.3 mile reach from Pinnacle Peak Road Bridge to the WestWorld detention basin (see Figure 1.3). However, a portion of the east levee from downstream of the North Beardsley Wash confluence to upstream of the Bell Road Bridge will not be constructed during the first phase of the project.

The objective of the subject flood control system is to control the alluvial fan from the McDowell Mountains (Reata Pass Wash and its tributaries), and to provide protection to existing development as well as future land developments from erosion, sedimentation, and flooding by the Reata Pass/Beardsley Wash flood flows.

Typical of alluvial fan channels, the Reata Pass/Beardsley Wash fluvial system is dynamic in nature, and the erosion/sedimentation feature is complicated. In addition, the proposed channel will confine flows and significantly change the existing flow pattern and its hydraulic and geomorphologic characteristics. To assess the overall channel stability, SLA performed a detailed hydraulic, hydrologic, and erosion/sedimentation analysis of the proposed channel. To determine the sediment inflow contributions to the main channel, the channel upstream of Pinnacle Peak Road Bridge (North Reata Pass Wash and main channel east branch) and all lateral tributaries (Foothills Tributary, North Beardsley Wash, South Beardsley Wash, and Thompson Peak Channel) were included in the study. Analysis was performed for various flood frequencies considering short and long-term sediment supply conditions. A three- level approach involving qualitative, quantitative, and model analysis was applied to assess the erosion/sedimentation potentials along the reach.

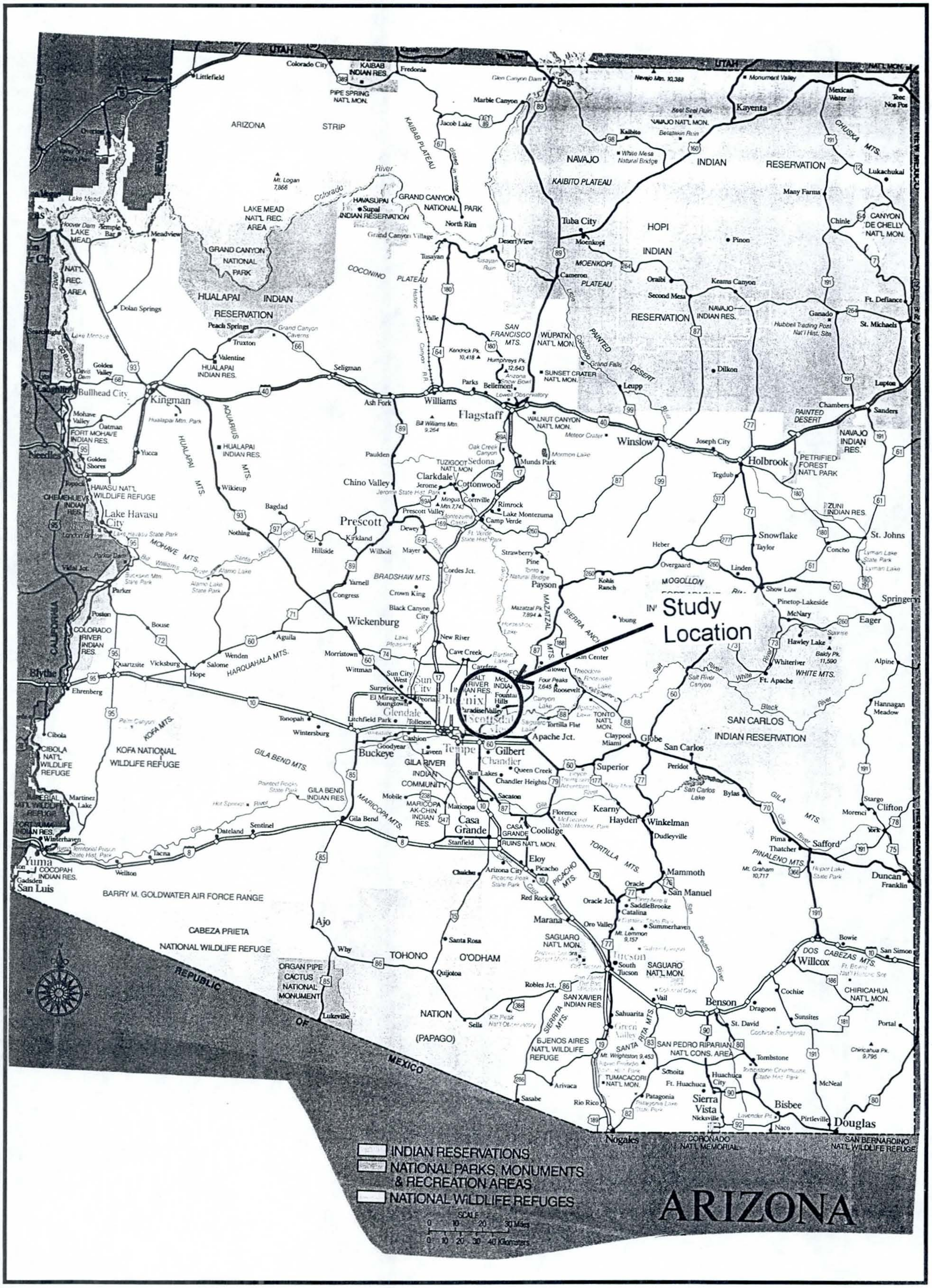


Figure 1.1 Location Map

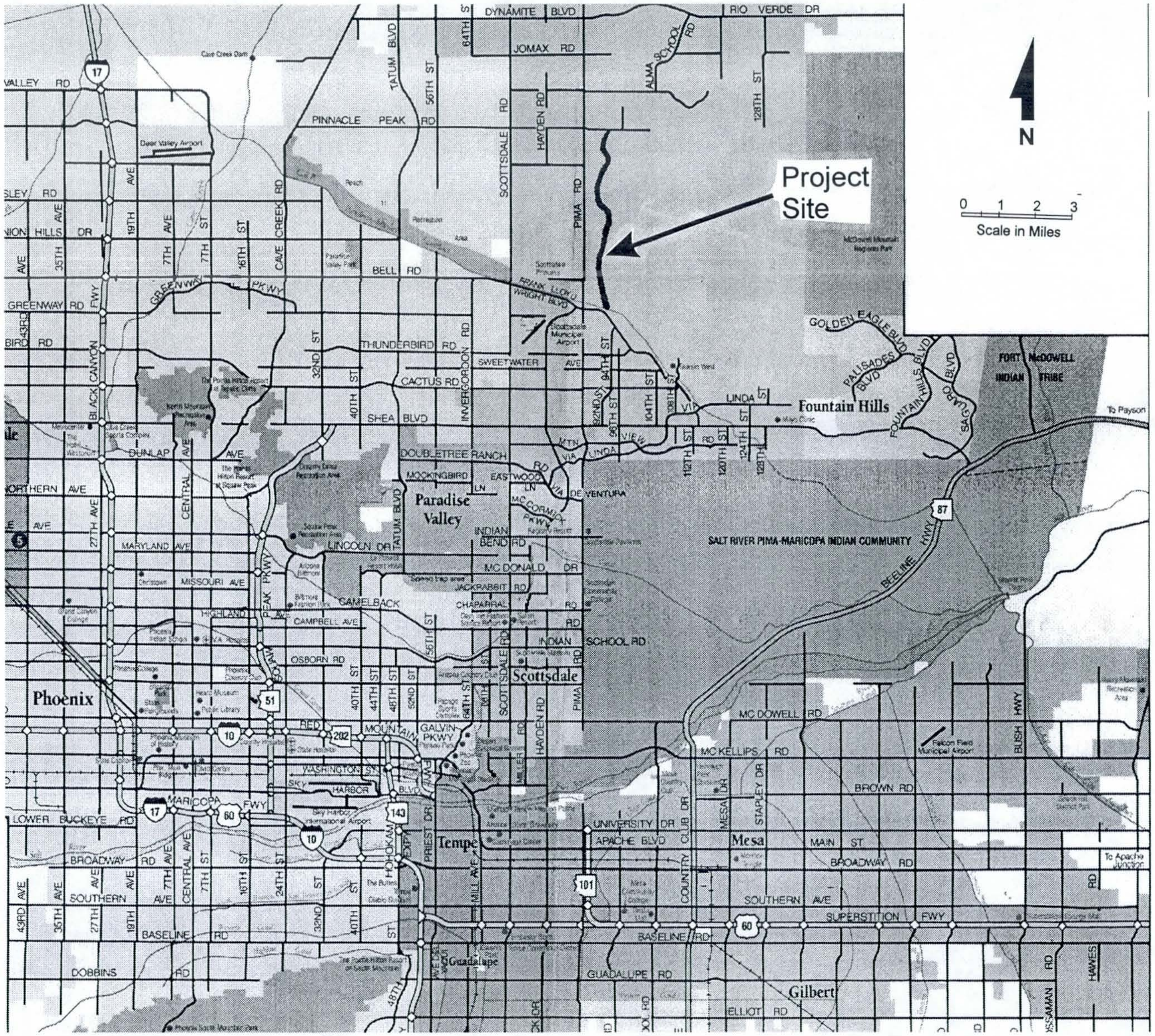


Figure 1.2 Vicinity Map

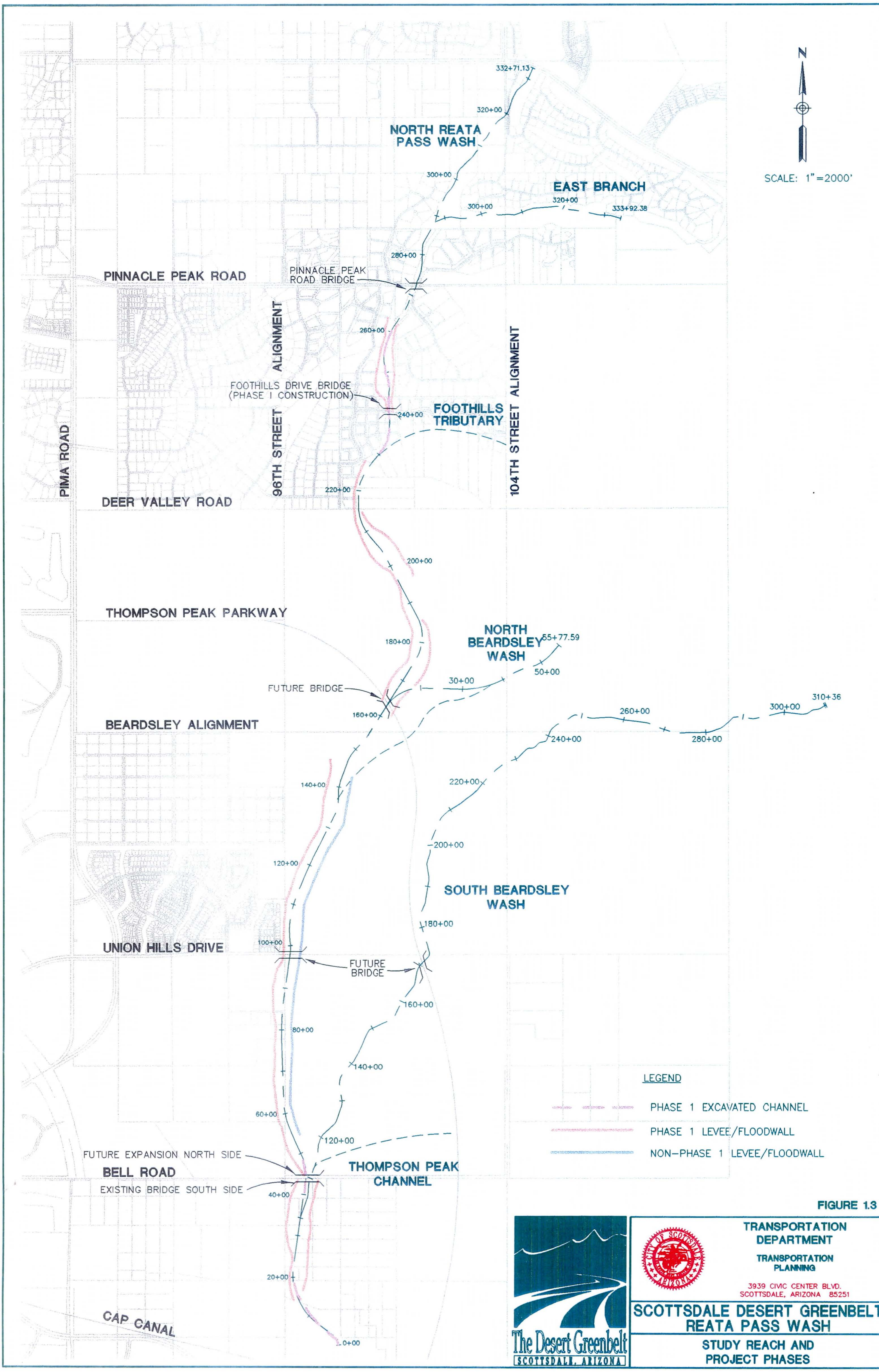


FIGURE 1.3

SCOTTSDALE DESERT GREENBELT
REATA PASS WASH
STUDY REACH AND PROJECT PHASES

1.2 WATERSHED AND CHANNEL CHARACTERISTICS

The Reata Pass Wash originates from the McDowell Mountains located in northeast Scottsdale. The mountains are composed of Tertiary Cretaceous volcanic andesite, rhyolite, and granite rock formations. The headwaters from the mountains are conveyed through washes that are characterized by steep slopes resulting in high-flow velocities. The steep washes and slopes consist of alluvial sand and gravel materials. The sediment-laden flow within these washes was transported downstream through steep washes to the desert plain. Alluvial fans were formed along the desert plains. The sediment-laden flow formed the extensive fan terraces and alluvial-braided washes, creating a wide floodplain within the study area. Vegetation within the study area consists of cactus, trees, desert shrubs, and grasses.

Figure 1.4 shows a series of aerial photographs of the project reach. This figure shows the ultimate condition levee encroachment and drainage easement. The existing channel is characterized as a steep, braided alluvial fan channel. Note that the existing channel contains major breakouts at the fan apex downstream of Pinnacle Peak Road Bridge and at the North Beardsley Wash confluence. Between Union Hills Drive and Bell Road there is no existing natural channel. Downstream of Bell Road, most flows have been contributed from South Beardsley Wash and Thompson Peak with very little contribution from upstream channels.

As mentioned above, the alluvial fan drainage system is complicated in nature. This alluvial fan system is also uniquely characterized by a steep slope among the fan apexes of North Reata Pass Wash, Foothills, North Beardsley Wash, and South Beardsley Wash. This feature complicates the flow patterns and will result in high flow velocities once the alluvial fan is confined to the base of the McDowell Mountains. Under the proposed condition, flows will be confined by levees downstream of the Pinnacle Peak Road Bridge. This new channel essentially acts as the "collector" for alluvial fans emerging from the drainage basins at the McDowell Mountains as shown in Figure 1.5. Channel slopes range from approximately .035 to .040 ft/ft from upstream of the Pinnacle Peak Road Bridge to upstream of the Bell Road Bridge. Slopes reduce dramatically to 0.015 to 0.020 ft/ft from Bell Road to the USBR dike, and further to .005 ft/ft in the downstream near the outlet at the detention basin in WestWorld.

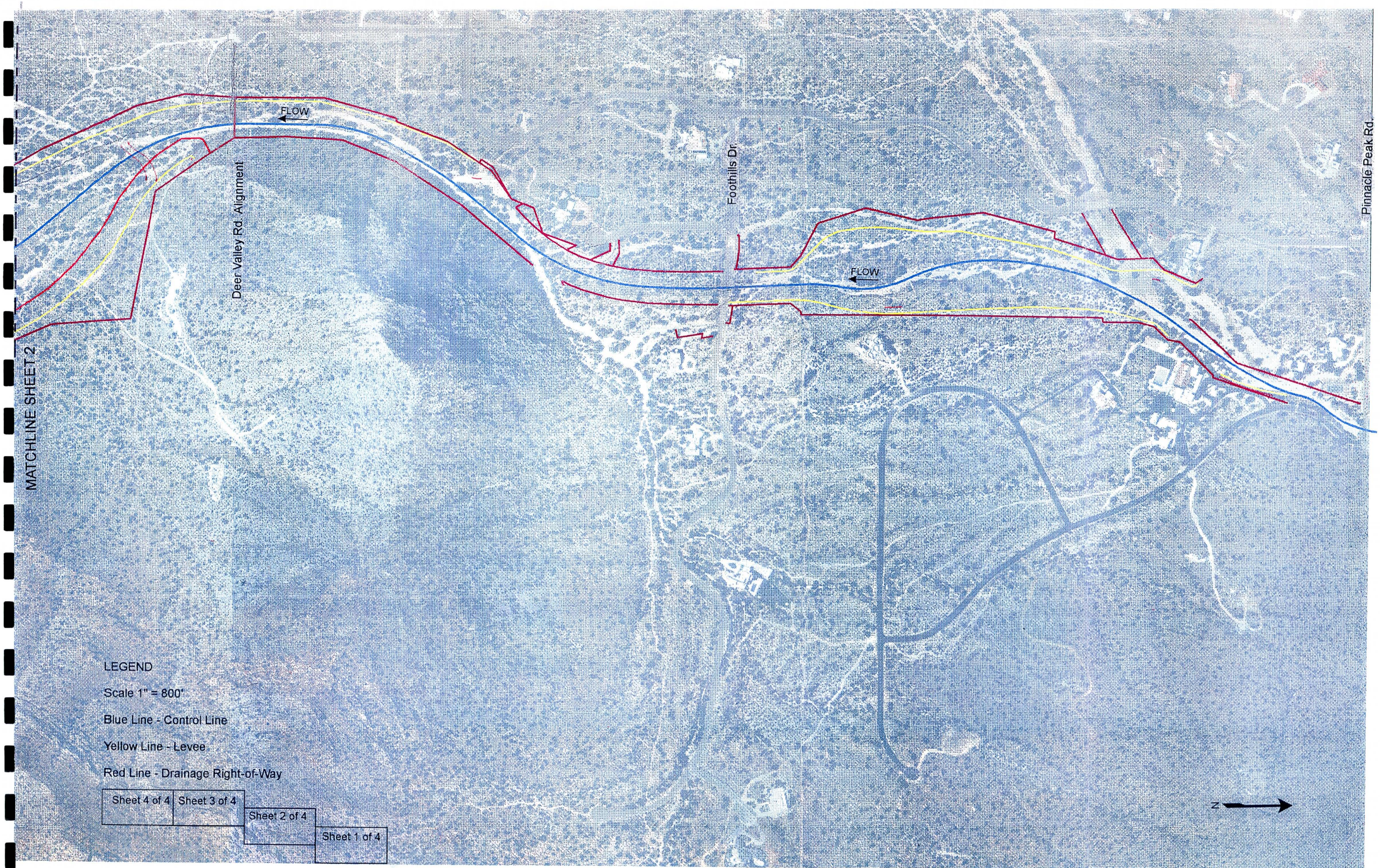


Figure 1.4 - Aerial Photograph of Project Site Showing Proposed Levee Alignment: SHEET 1 OF 4

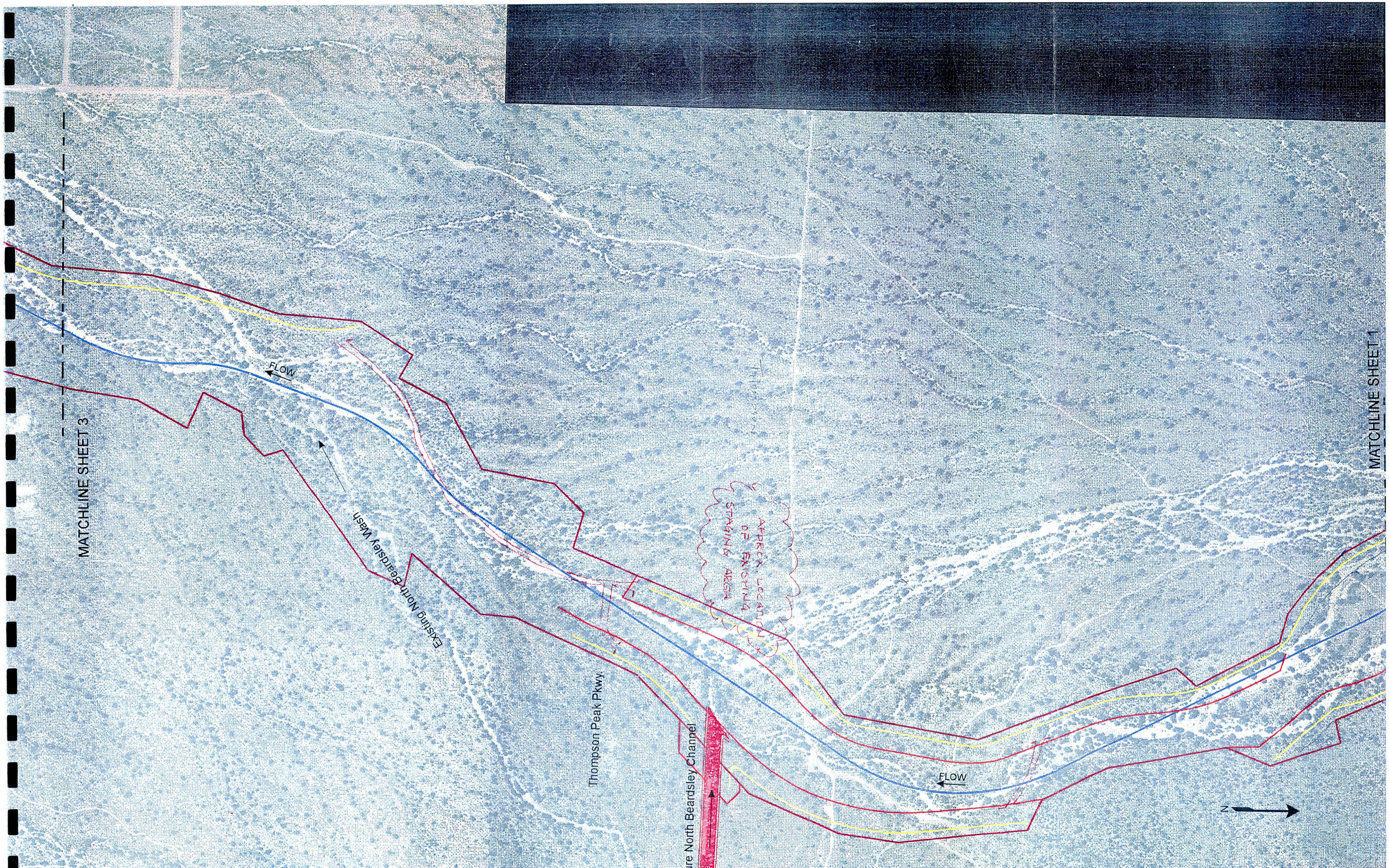


Figure 1.4 - Aerial Photograph of Project Site Showing Proposed Levee Alignment: SHEET 2 OF 4

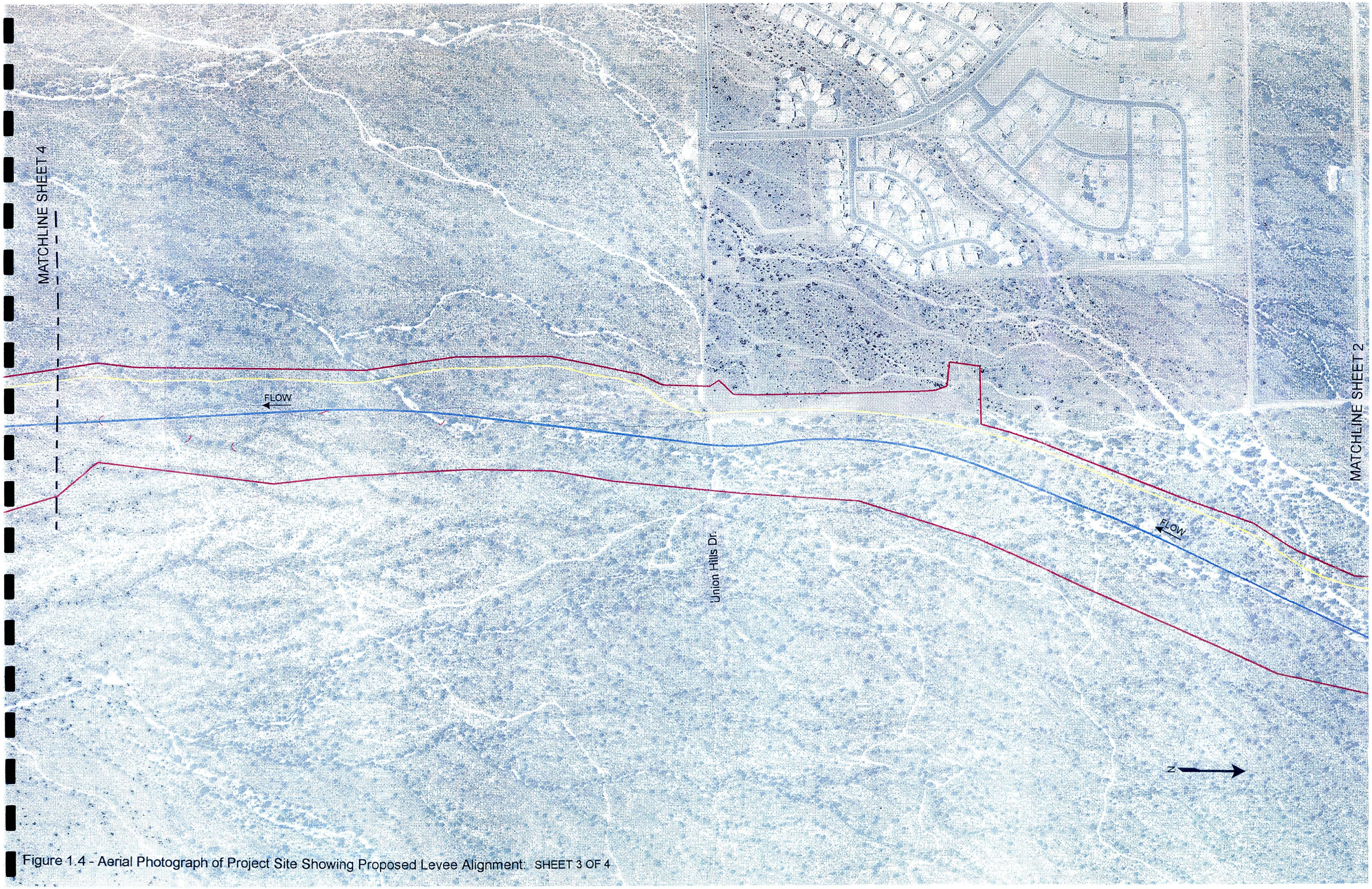


Figure 1.4 - Aerial Photograph of Project Site Showing Proposed Levee Alignment: SHEET 3 OF 4

Figure 1.4 - Aerial Photograph of Project Site Showing Proposed Levee Alignment: SHEET 4 OF 4

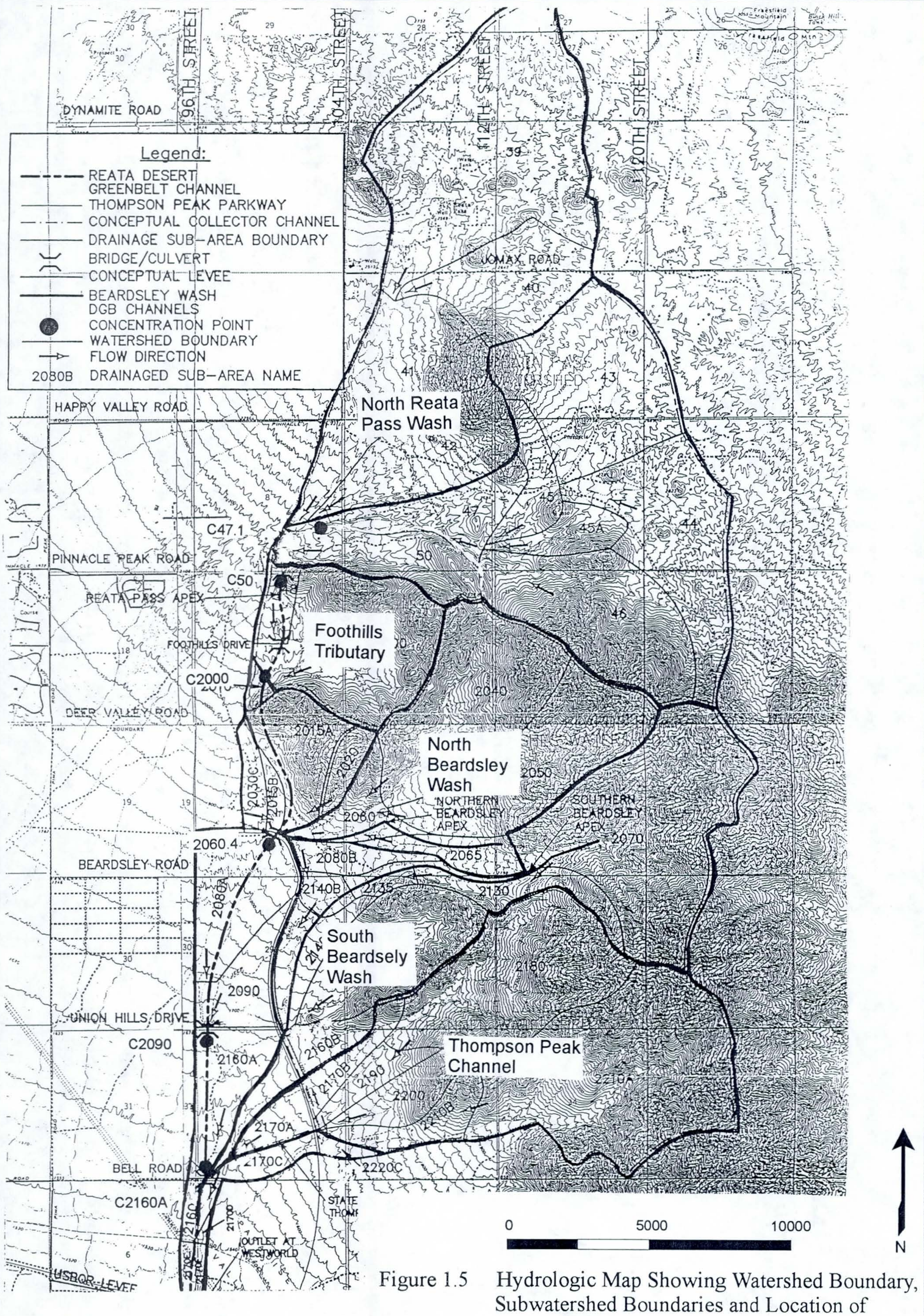


Figure 1.5 Hydrologic Map Showing Watershed Boundary, Subwatershed Boundaries and Location of Concentration Points

Source: Greiner

The Reata Pass Wash watershed is approximately 7.9 square miles in size at Pinnacle Peak Road Bridge and increases to approximately 19.5 square miles near the terminus of the channel (downstream of USBR Dike No. 4). Figure 1.5 shows the Reata Pass Wash watershed boundary.

In this report, the Reata Pass east branch (Station 316+50 to 292+50) was considered as the headwater reach of the main channel. In addition to this headwater reach, there are five major tributaries (see Figure 1.3 and Figure 1.5). Each tributary is briefly described as follows.

North Reata Pass Wash Tributary - The North Reata Pass Wash tributary flows in a southwesterly direction and confluences with the main channel upstream of Pinnacle Peak Road Bridge. The North Reata Pass Wash is one of the major sediment sources to the Reata Pass Wash. This tributary channel bed consists of 60% sand and 40% fine gravel, which is similar to the Reata Pass main channel. The total drainage area is approximately 3.9 square miles.

Foothills Tributary - The Foothills Tributary, which drains an area of approximately 0.9 square miles joins the main channel approximately 0.7 miles downstream of Pinnacle Peak Road Bridge. The Foothills Tributary is the smallest of the five major tributaries of Reata Pass Wash/Beardsley Wash channel in watershed size and has the least influence on the overall alluvial fan formation. The channel bed generally consists of 50% sands and 50% gravel.

North Beardsley Wash - North Beardsley Wash drains an area of approximately 2.2 square miles. The tributary flows in a southwesterly direction and confluences with the main channel approximately one mile south of Deer Valley Road. North Beardsley Wash contains mostly gravel with zones of cobble and boulders.

South Beardsley Wash - South Beardsley Wash has a drainage area of approximately 3.1 square miles. The tributary channel confluences with the Reata Pass Wash channel immediately upstream of Bell Road. This wash contains coarse sand and gravel with zones of cobble and boulders.

Thompson Peak Channel - Thompson Peak Channel drains an area of approximately 3.4 square miles and confluences with South Beardsley Wash and proposed the Reata Pass Channel immediately upstream of Bell Road. Thompson Peak flows are contained by a levee and an improved channel near the confluence. Thompson Peak Channel contains materials similar to the South Beardsley Wash bed near the confluence except that armor layers of boulders and large cobbles have not formed in the newly excavated channel. However, cobble and boulders were observed upstream of the improved Thompson Peak channel.

1.3 EXISTING FLOODPLAIN CONDITIONS

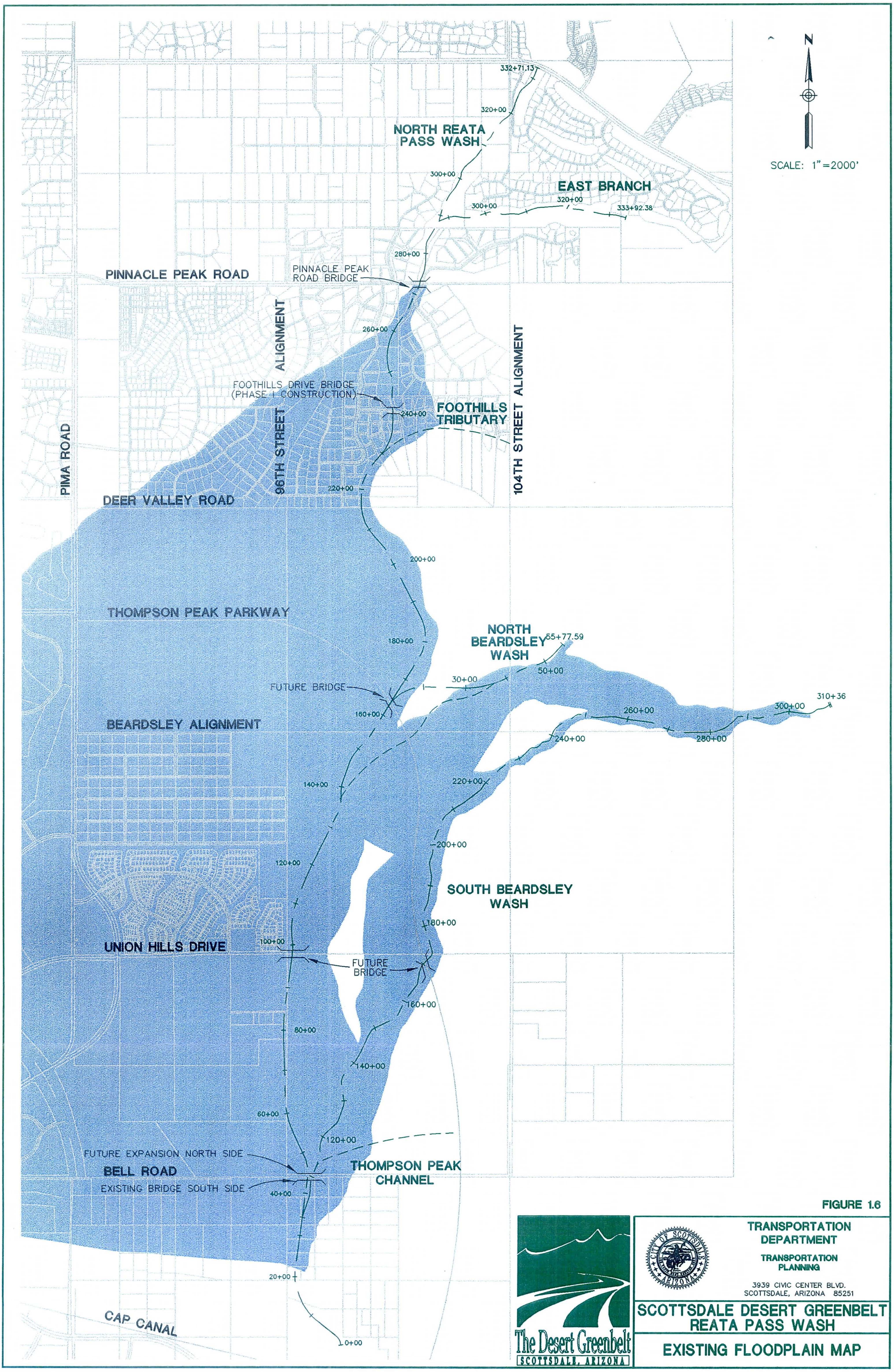
Figure 1.6 illustrates the existing floodplain. The floodplain is currently designated by Federal Emergency Management (FEMA) as Zone "AO". Zone AO is defined as an area of 100-year, shallow flooding where the average depths are from 1 to 3 feet. Alluvial fan flood hazard areas are typically designated as Zone AO on Flood Insurance Rate Maps (FIRM). As shown in Figure 1.6, the floodplain begins at the apexes of Reata Pass Wash and the tributaries and expands downstream in a southwesterly direction. The area west of the Reata Pass/Beardsley Wash main channel is inundated by the floodplain.

1.4 LAND USE

A large portion of the land within the "AO" floodplain is primarily owned by DC Ranch, Grayhawk, and the Arizona State Land Department. Existing land use within the study area, which consists primarily of residential and open space areas, is shown in the aerial photographs (Figure 1.4). As mentioned previously, the project objective is to confine flows so the floodplain can be removed and the open space can ultimately be safely developed.

1.5 APPLICATION FOR A CONDITIONAL LETTER OF MAP REVISIONS

The City intends to construct the Phase I project and remove a large portion of the AO zone shown on the existing flood insurance rate map (Figure 1.6). The remaining AO zone will be removed after implementation of the ultimate flood control system. To ensure its compatibility with future ultimate condition, the Phase I facilities, including


SCALE: 1"=2000'
N
NORTH REATA PASS WASH
EAST BRANCH
332+71.13
320+00
300+00
300+00
320+00
333+92.38
280+00
PINNACLE PEAK ROAD
PINNACLE PEAK ROAD BRIDGE
260+00
96TH STREET ALIGNMENT
104TH STREET ALIGNMENT
FOOTHILLS DRIVE BRIDGE (PHASE I CONSTRUCTION)
240+00
FOOTHILLS TRIBUTARY
PIMA ROAD
220+00
DEER VALLEY ROAD
200+00
THOMPSON PEAK PARKWAY
180+00
NORTH BEARDSLEY WASH
55+77.59
50+00
30+00
FUTURE BRIDGE
160+00
310+36
300+00
260+00
280+00
240+00
BEARDSLEY ALIGNMENT
220+00
140+00
200+00
120+00
SOUTH BEARDSLEY WASH
180+00
UNION HILLS DRIVE
100+00
FUTURE BRIDGE
160+00
80+00
140+00
60+00
120+00
FUTURE EXPANSION NORTH SIDE
BELL ROAD
EXISTING BRIDGE SOUTH SIDE
THOMPSON PEAK CHANNEL
40+00
20+00
CAP CANAL
0+00
FIGURE 1.6
TRANSPORTATION DEPARTMENT
TRANSPORTATION PLANNING
3939 CIVIC CENTER BLVD.
SCOTTSDALE, ARIZONA 85251
CITY OF SCOTTSDALE ARIZONA
The Desert Greenbelt
SCOTTSDALE, ARIZONA
SCOTTSDALE DESERT GREENBELT
REATA PASS WASH
EXISTING FLOODPLAIN MAP

levees, flood walls, channelization, and other erosion/sedimentation control facilities, will be designed to accommodate the design requirements for the future ultimate system.

Where applicable, the ultimate design will be modified to facilitate the Phase I implementation. The worst-case levee height and scour toe-down estimates will be applied to the Phase I project design.

This report documents results of SLA's analysis of potential river responses to the confinement of Reata Pass/Beardsley Wash alluvial fans by the proposed levees under the ultimate project conditions. Detailed data and calculations are included in the technical addendum under separate cover. Based on this analysis, SLA and the Desert Greenbelt Project Team will provide a design to reduce potential erosion and sedimentation along the proposed channel. SLA will evaluate the possibility of reducing levee height and toe-down depths through the use of grade control/drop structure, channel improvements and sediment basins. SLA will redetermine the necessary heights and toe-down depths for levees and flood walls as well as design parameters for other channel improvements and erosion/ sedimentation control facilities for final revised ultimate channel design. SLA will also analyze the Phase I project conditions to ensure that the levee/wall design based on the ultimate channel conditions will meet the scour protection and flood protection requirements.

The City of Scottsdale is interested in obtaining a Conditional Letter of Map Revision (CLOMR) for the Phase I project condition and a Letter of Map Revision (LOMR) after construction of the Phase I project. In support of the CLOMR application, the following documents will be forwarded to FEMA for review.

Volume I: The Reata Pass/Beardsley Wash Channel Response Analysis with Ultimate Levee Encroachment

Volume II:. Technical Addendum to Volume I

Volume III: Erosion/Sedimentation Control and Channel Improvement Design for Ultimate Project Condition

Volume IV: Technical Addendum to Volume III

Volume V: Reata Pass/Beardsley Wash Channel Response Analysis and Design Modification for the Phase I Project Condition

Volume VI: Technical Addendum to Volume V

Volume VII: Final Design Plans, Specifications, and Miscellaneous Calculations for the Phase I Project

Volume VIII: Technical Addendum to Volume VII

Volume IX: Modification of Flood Zones Rate Map (FIRM) for Phase I conditions.

II. HYDROLOGIC ANALYSIS

The hydrologic analysis for the Desert Greenbelt project was performed previously by Water Resource Associates, Inc.; Robert L. Ward Consulting Engineer, Greiner, Inc.; and the City of Scottsdale using the U.S. Army Corps of Engineers HEC-1 Model. Hydrographs and peak discharges for various return periods at certain concentration points along the study reach were used to evaluate the sedimentation characteristics of the system, as well as to compute the necessary depths and elevations for proposed hydraulic structures such as levees, drop structures, and bridge pier footings. The hydrologic analysis is summarized in the report *"Scottsdale Desert Greenbelt Reata Pass/Beardsley Wash Hydrology Report"* prepared in February 1995 for the 100-year flood and other additional HEC-1 Models for floods less than the 100-year flood by Greiner, Inc., and the City of Scottsdale.

Figure 1.5 illustrates the delineated watershed and sub-watersheds used in the model. Concentration points at primary locations are identified in Figure 1.5. The 100-year peak discharge along the main channel ranges from 5,766 cubic feet per second (cfs) at the main channel east branch to 15,265 cfs downstream of Bell Road. The computed peak discharges for the 2-year through the 100-year flood events at various concentration points are summarized in Table 2.1. Figure 2.1 presents the flood frequency curves at concentration points located along the main channel. The 100-year hydrographs at each of the concentration points along the main channel are presented in Figure 2.2. As shown in this figure, both the peak discharge time and flood duration vary significantly between upstream and downstream reaches; the estimated lag time from the apex to downstream of Bell Road is approximately 20 minutes. Attenuation and lag in flood peak hours occur at each major tributary confluence (e.g. from downstream of North Reata Pass Wash confluence to upstream of Foothills tributary and from downstream of North Beardsley Wash to Union Hills Drive, which is upstream of South Beardsley Wash). Detailed hydrologic information is provided in the technical addendum.

These peak discharges and hydrographs were used in the hydraulic analysis as well as sediment transport analysis to assess the erosion and sedimentation characteristics of the channel for various return periods and for short- and long-term conditions.

Table 2.1 Summary of Peak Discharges for Reata Pass/Beardsley Wash Main Channel (Discharge in Cubic Feet per Second, cfs)

Location Main Channel at:	Concentration Point	2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr
East Branch[1]	C47.1	1,022	1,896	2,684	3,803	4,823	5,766
Pinnacle Peak Road Bridge[2]	C50	2,027	3,689	5,069	7,438	9,324	11,236
Foothills Tributary Confluence[3]	C2000	2,162	3,827	5,227	7,644	9,538	11,742
Upstream of N. Beardsley Wash[4]	R2015A1	2,044	3,537	4,745	6,838	8,751	10,579
N. Beardsley Wash Confluence[5]	2060.4	2,456	4,222	5,666	8,208	10,496	12,814
Union Hills Road[6]	C2090	2,338	3,976	5,319	7,721	9,821	12,185
Bell Road Bridge[7, 8]	C2160A	3,065	5,031	6,613	9,546	12,231	15,265
Source: Hydrologic Analysis HEC-1 Model							

[1] Flows used in hydraulic model for entire east branch (Station 316+50 to 292+50, inclusive).
[2] Flows used in hydraulic model for the main channel from North Reata Pass Wash confluence (Station 289+50) to Foothills Tributary confluence (Station 235+50), inclusive.
[3] Flows used in hydraulic model for the main channel between Foothills Tributary and immediately upstream of North Beardsley Wash (Station 234+00 to 174+00, inclusive).
[4] Flows used in hydraulic model for one station (Station 172+50) to account for attenuation before the North Beardsley Wash confluence.
[5] Flows used in hydraulic model for the main channel between North Beardsley Wash confluence and Union Hills Road (Station 171+00 to 98+00, inclusive).
[6] Flows used in hydraulic model for the main channel between Union Hills Road and immediately upstream of South Beardsley Wash confluence (Station 97+50 to 48+00, inclusive).
[7] Flows used in hydraulic model for the main channel from upstream of Bell Road Bridge to the outlet at WestWorld detention basin (Station 45+00 to 0+00, inclusive).
[8] Peak flows for Bell Road Bridge were deducted by the Thompson Peak Channel discharges (which are concurrent with the flood peaks at Bell Road Bridge) for Station 46+50 (100-year resulting discharge is 13,633 cfs).

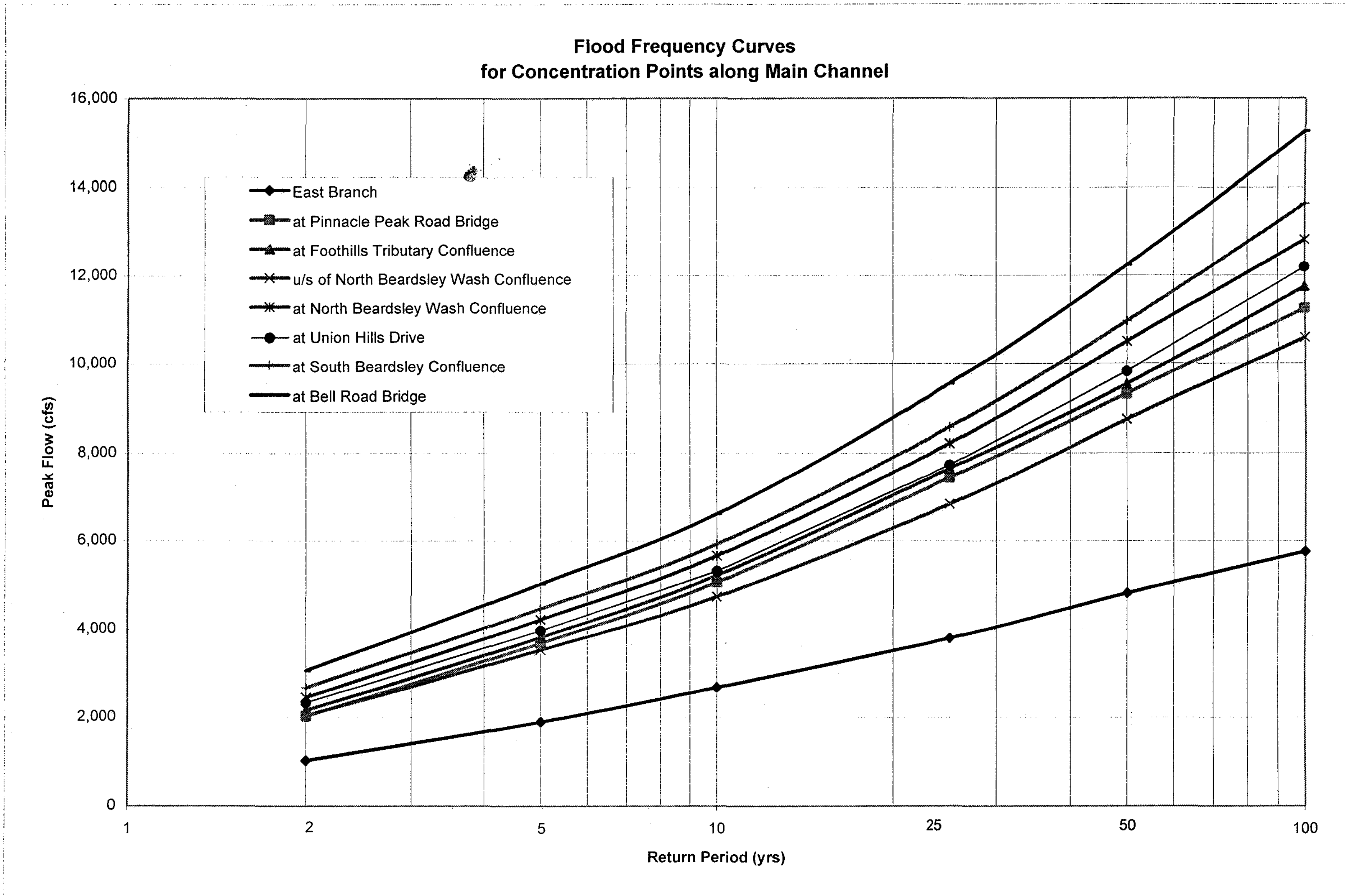


Figure 2.1: Flood Frequency Curves at Concentration Points along Study Reach

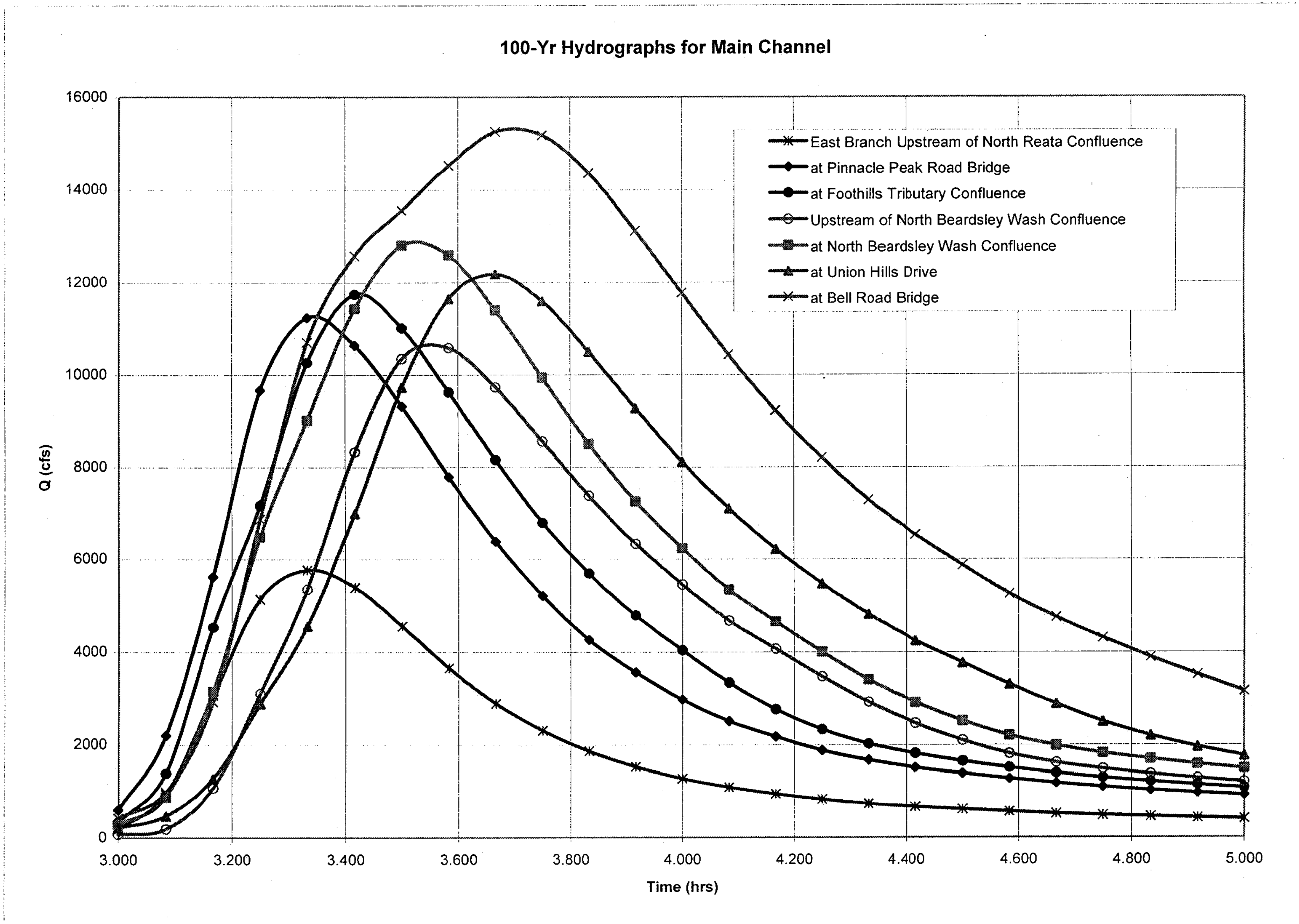


Figure 2.2: 100-Yr Hydrographs along the Main Channel

Peak discharges for each tributary at the main channel confluence are presented in Table 2.2. The 100-year hydrographs for each tributary are shown in Figure 2.3. Comparison of Figure 2.3 with 2.2 shows that peak flows for the main tributaries occur concurrently with each other. These tributary peak discharges are similar to the upper reach of the Reata Pass Wash, but lead the downstream channel discharge by approximately 20 minutes as shown in Figure 2.4.

As a result of the major differences in the time of peak discharge along the main channel and tributaries, several scenarios were assumed for sediment transport analysis. The three scenarios assume discharges for the following conditions:

1. Peak discharges along the main channel;

2. Concurrent discharges at the peak discharge time of the upper main channel and the major tributaries (3.33 hour); and

3. Concurrent discharges at the peak discharge time of the downstream main channel (3.67 hours).

Figure 2.5 illustrates discharges at various concentration points under the three scenarios. It is important to identify the scour and sedimentation patterns under various scenarios. Reaches wich exhibit a degradation pattern under one scenario may not remain the same under other scenarios. These scenarios are discussed further in Section 5.3.4.

Table 2.2 Summary of Peak Discharges for Tributaries
(Discharges in Cubic Feet per Second, cfs)

Tributary	Concentration Point	2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr
North Reata Pass Wash	C42	1,053	1,870	2,574	3,621	4,622	5,480
Foothills Tributary	2000	336	659	949	1,399	1,682	2,058
North Beardsley Wash	C2060.1	631	1,164	1,582	2,271	2,906	3,477
South Beardsley Wash	C2160B	881	1,644	2,262	3,257	4,041	4,914
Thompson Peak Channel	C2170A	880	1,827	2,548	3,672	4,531	5,499
Source: Hydrologic Analysis HEC-1 Model							

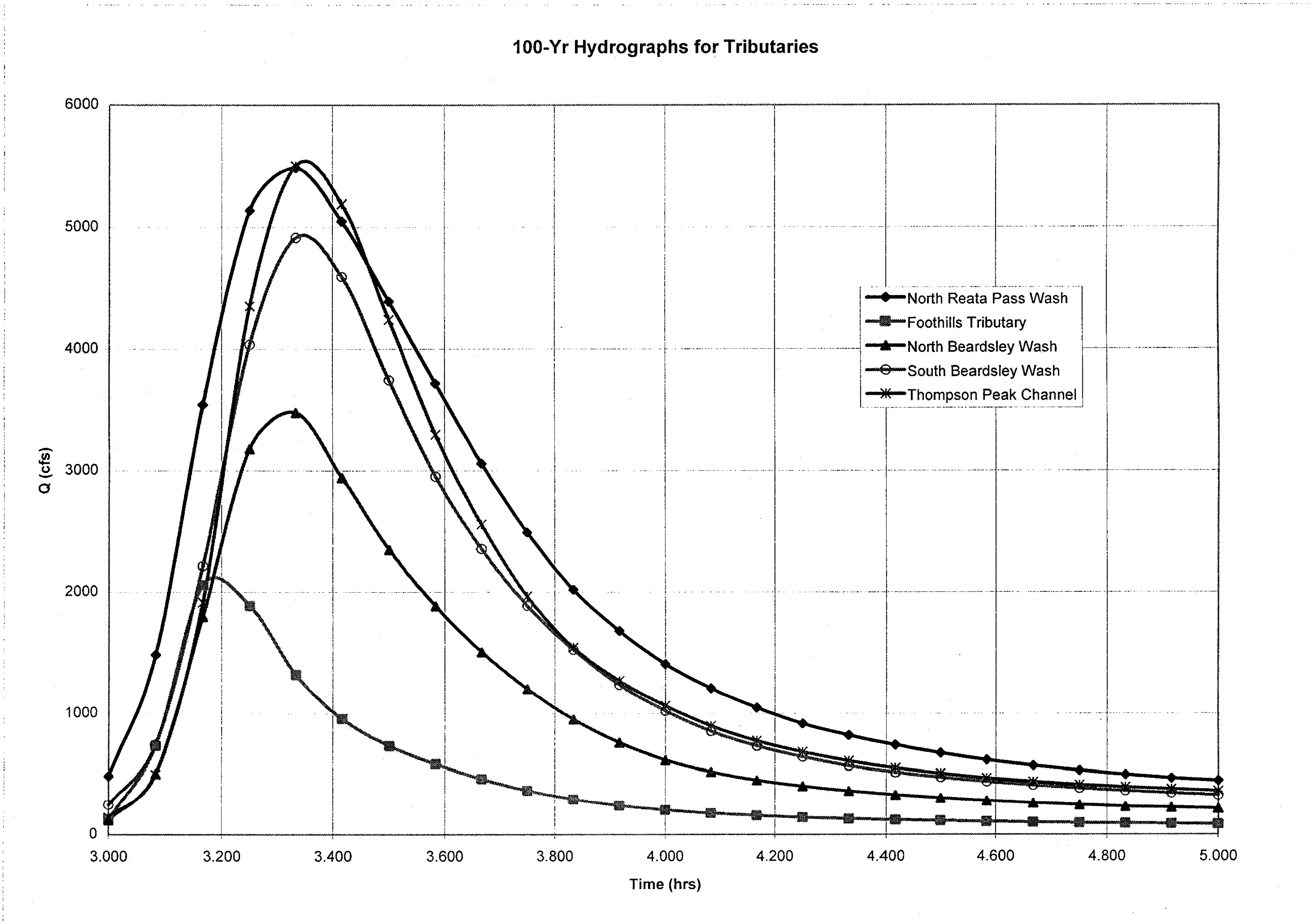


Figure 2.3: 100-Yr Hydrographs - Tributaries at Confluence with Main Channel

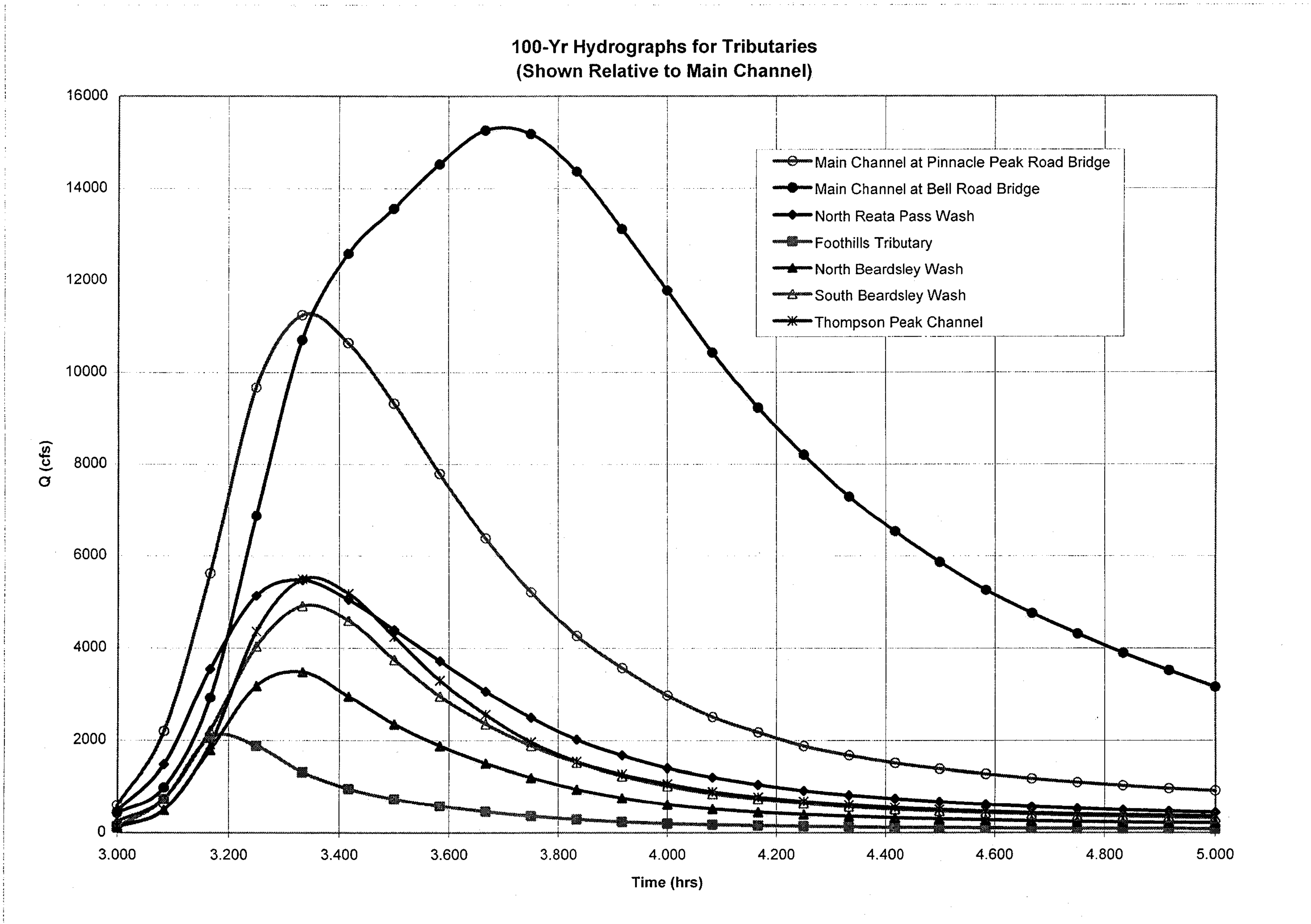


Figure 2.4: 100-Yr Hydrographs - Comparison of Main Channel to Tributary Hydrographs

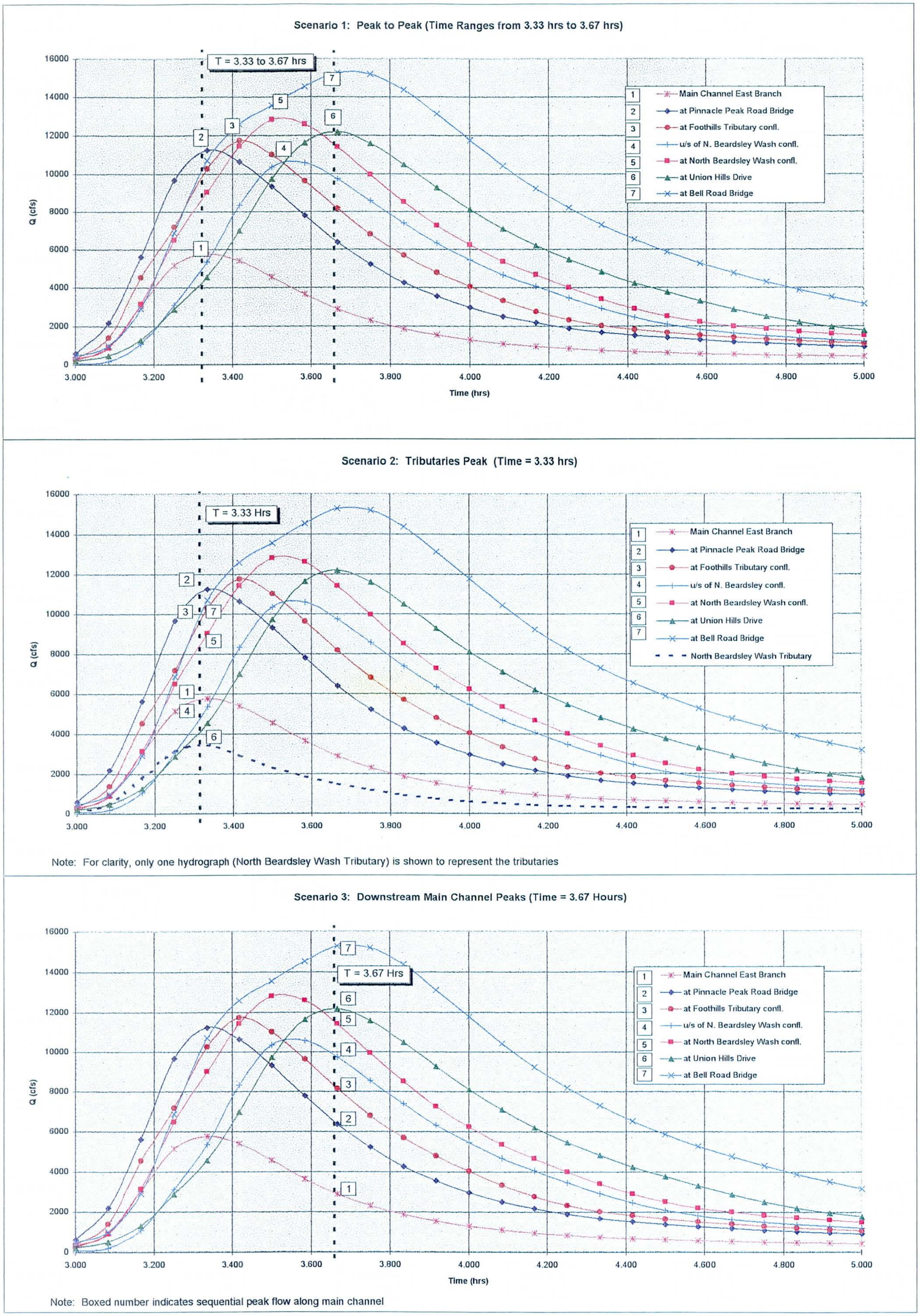


Figure 2.5 Discharge for Hydrologic Scenarios

III. HYDRAULIC ANALYSIS

3.1 METHODOLOGY

This chapter presents the results of the hydraulic analysis of the Reata Pass Wash and tributaries along the proposed study reach under the ultimate levee encroachment conditions. A multiple-profile HEC-2 model consisting of the 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year floods was prepared for the main channel and major tributaries, (North Reata Pass Wash, North Beardsley Wash, and South Beardsley Wash). Normal depth computations were performed for Thompson Peak Channel and the Foothills Tributary.

Cross-sectional data for the HEC-2 model were prepared previously by Greiner, Inc., and modified by SLA. The hydraulic model has a total of 206 cross-sections generally spaced 150 feet apart (300 feet along east branch). Near the bridges, the distance between cross-sections is less than 20 feet. As-built improvement plans including future expansion plans at Bell Road were used to model the five bridges crossed by the Reata Pass Wash proposed channel. The channel crosses (from upstream to downstream) the Pinnacle Peak Road Bridge (existing new bridge), Foothills Drive Bridge (Phase I construction), Thompson Peak Parkway Bridge (future bridge), Union Hills Bridge (future bridge), and Bell Road Bridge (existing south half, to be expanded in width in the future). The locations of these bridges are shown in Figure 1.3. These bridges were modeled in HEC-2 by the Special Bridge Method.

Manning's n values, representing the roughness of the channel and the overbanks were first determined based upon field evaluation of current vegetation conditions revealed in the aerial photographs (Figure 1.4). In order to allow conservative estimates of the sediment transport and aggradation/degradation analyses and resistance reduction under high-flow conditions, the hydraulic parameters were computed considering a low Manning's n value of 0.030 for the main channel. The results of this low Manning's n hydraulic analysis were used in the sediment transport analysis (Level II and Level III, Chapter V). On the other hand, a relatively high Manning's n value of 0.050 was used for conservative estimation of the flow depths to account for high resistance due to in the computation of the levee height requirement (see Chapter VII). Manning's *n* values of 0.040-0.050 were used for the overbank areas for both cases as estimated by the aerial photographs.

The hydraulic analysis was performed for both subcritical and supercritical flow regimes. Comparison of the results of hydraulic models indicates that mixed flow conditions will be encountered throughout the entire reach. In general, supercritical flow is the dominant hydraulic feature. There are a few localized areas where the flows change to subcritical. The mixed flow condition predicted using the HEC-2 Model compares consistently with the HEC-RAS Model. The hydraulic characteristics described in the following sections are based upon mixed-flow conditions. Hydraulic information used in the sediment routing model is also based upon mixed-flow conditions to ensure that high flow velocities in the supercritical flow reach are considered for scour and sedimentation depth determination. However, the subcritical HEC-2 Model was used for the levee height determination.

3.2 REVISIONS TO PREVIOUS HYDRAULIC MODEL

Several revisions were made to the previous hydraulic model provided by Greiner. The revisions are listed below.

1. The channel bed was modified at several locations to remove the existing low-flow channels directly impinging on the proposed levees. To eliminate the threat of low-flow impingement, these low-flow channels will have to be filled with suitable materials. The cross sectional data were modified to reflect these necessary changes to the low-flow channels.

2. Revision was also made to the channel data to reflect the grading modification at the South Beardsley Wash/Thompson Peak confluence just upstream of the Bell Road bridge in order to redirect the flow away from the levees (refer to the design plans previously submitted by Greiner, Inc.). The revised hydraulic model includes the channel bed changes.

3. Cross-sections near the channel outlet were revised to reduce constriction losses and bank erosion potential immediately above the USBR Detention Basin (refer to Greiner's Design Plans, C2.1 and C2.2).

4. Defined bank stations at appropriate locations such as at the levee location where an incised channel does not exist.

5. The bridge invert and low chord elevations were modified for bridges if necessary to match the as-built conditions.

6. Pinnacle Peak Road Bridge was remodeled as a special bridge rather than a normal flow culvert. The drop structure and channel improvements to this bridge were modeled in the new HEC-2 Model.

7. Discharge cards were added to reflect proper hydrograph changes throughout the study reach (refer to Chapter II).

8. Contraction, expansion, and ineffective flow areas were modeled at bridge locations and at other natural features where a constriction occurs.

3.3 SUMMARY OF THE HYDRAULIC CHARACTERISTICS OF THE MAIN CHANNEL

Table 3.1 summarizes the results of the hydraulic analysis under the ultimate levee encroachment conditions for the 100-year flood event. Based on hydrologic variation and soils characteristics (described in Chapter IV), SLA divided the entire study area into 27 reaches as shown in Figure 3.1. Figure 3.2 shows the thalweg, 100-year, and 10-year water surface profiles, as well as locations of bridges and tributaries. The profiles show that the depth of flow ranges from 3 to 7 feet for the majority of the study reach except for local areas where there is a major gradient change or where a hydraulic structure such as a drop structure or a bridge exists. It is also evident that the flow depths change in areas where there is contraction and expansion in width such as the Pinnacle Peak Road and Bell Road Bridges.

Table 3.1 100-Year Flood Hydraulics Summary

Cross-Section	Distance to u/s (ft)	Q total (cfs)	Thalweg Elevation (ft)	Water Surface El. (ft)	Maximum Depth (ft)	Channel Velocity (fps)	Top Width (ft)	Energy Slope (ft/ft)	Froude No.
316.50	0	5,766	2309.6	2313.2	3.6	7.7	426.0	0.0113	1.0
313.50	300	5,766	2300.1	2302.5	2.4	15.6	370.5	0.0991	2.7
310.50	600	5,766	2291.9	2295.6	3.7	8.5	385.9	0.0138	1.1
307.50	900	5,766	2282.5	2286.0	3.5	13.5	373.3	0.0631	2.2
304.50	1,200	5,766	2273.5	2276.1	2.6	10.1	373.2	0.0234	1.4
301.50	1,500	5,766	2262.9	2267.8	4.9	12.8	212.7	0.0248	1.5
298.50	1,800	5,766	2256.2	2259.9	3.7	12.9	228.5	0.0278	1.6
295.50	2,100	5,766	2247.4	2251.2	3.8	12.1	291.4	0.0315	1.7
292.50	2,400	5,766	2237.9	2243.5	5.6	11.7	247.1	0.0222	1.5
289.50	2,700	11,236	2228.6	2234.4	5.8	13.0	491.1	0.0324	1.7
288.00	2,850	11,236	2224.2	2227.5	3.3	15.6	392.6	0.0441	2.0
286.50	3,000	11,236	2217.7	2222.6	4.9	12.9	504.6	0.0332	1.7
284.15	3,235	11,236	2210.8	2216.1	5.3	11.8	529.7	0.0260	1.5
280.60	3,590	11,236	2200.8	2205.5	4.7	14.1	369.4	0.0280	1.7
277.45	3,905	11,236	2194.6	2199.4	4.8	14.8	182.4	0.0127	1.3
277.25	3,925	11,236	2188.6	2192.2	3.6	24.8	134.9	0.0504	2.4
275.70	4,080	11,236	2183.9	2188.8	4.9	20.4	130.0	0.0270	1.8
272.65	4,385	11,236	2174.2	2178.7	4.5	22.1	114.0	0.0300	1.8
272.25	4,425	11,236	2173.3	2179.0	5.7	17.2	114.0	0.0134	1.3
271.50	4,500	11,236	2171.5	2181.4	9.9	10.0	170.0	0.0029	0.6
270.00	4,650	11,236	2167.9	2178.7	10.8	15.3	138.0	0.0059	0.9
267.00	4,950	11,236	2162.0	2166.0	5.7	26.0	308.3	0.1723	3.8
265.50	5,100	11,236	2158.0	2162.6	4.6	13.6	391.8	0.0281	1.7
264.00	5,250	11,236	2153.8	2158.1	4.3	14.6	313.9	0.0262	1.6
262.50	5,400	11,236	2150.5	2154.6	4.1	14.7	252.5	0.0204	1.5
261.00	5,550	11,236	2144.9	2149.6	4.7	17.3	243.1	0.0291	1.8
259.50	5,700	11,236	2139.4	2145.4	6.0	19.6	216.0	0.0172	1.5
258.00	5,850	11,236	2133.9	2139.7	5.8	22.4	98.2	0.0243	1.8
256.50	6,000	11,236	2128.3	2133.6	5.3	24.7	96.2	0.0325	2.0
255.00	6,150	11,236	2122.8	2128.0	5.2	25.4	95.8	0.0354	2.1
253.50	6,300	11,236	2117.2	2122.4	5.2	25.7	95.5	0.0364	2.1
252.00	6,450	11,236	2111.7	2116.8	5.1	25.7	95.5	0.0368	2.1
250.50	6,600	11,236	2106.1	2111.2	5.1	25.8	95.4	0.0369	2.1
249.00	6,750	11,236	2100.5	2105.7	5.2	25.8	95.4	0.0370	2.1
247.50	6,900	11,236	2095.0	2100.1	5.1	25.8	95.5	0.0370	2.1
246.00	7,050	11,236	2089.5	2094.6	5.1	25.8	95.4	0.0368	2.1
244.50	7,200	11,236	2083.9	2089.0	5.1	25.8	95.4	0.0370	2.1
243.00	7,350	11,236	2078.4	2082.5	4.1	26.2	108.2	0.0464	2.3
240.80	7,570	11,236	2070.8	2075.5	4.7	23.0	109.3	0.0307	1.9
240.30	7,615	11,236	2069.2	2075.7	6.5	16.3	112.9	0.0103	1.2

Table 3.1 100-Year Flood Hydraulics Summary (Continued)

Cross-Section	Distance to u/s (ft)	Q total (cfs)	Thalweg Elevation (ft)	Water Surface El. (ft)	Maximum Depth (ft)	Channel Velocity (fps)	Top Width (ft)	Energy Slope (ft/ft)	Froude No.
240.00	7,650	11,236	2067.5	2072.9	5.4	20.0	110.6	0.0197	1.6
238.50	7,800	11,236	2062.5	2067.2	4.7	22.9	109.4	0.0301	1.9
237.00	7,950	11,236	2057.4	2062.0	4.6	23.5	109.2	0.0329	2.0
235.50	8,100	11,236	2052.3	2056.8	4.5	23.7	109.1	0.0336	2.0
234.00	8,250	11,742	2047.2	2052.0	4.8	23.6	109.5	0.0317	2.0
232.50	8,400	11,742	2040.5	2044.9	4.4	23.9	197.3	0.0704	2.7
231.00	8,550	11,742	2036.9	2043.0	6.1	18.2	132.7	0.0167	1.5
229.50	8,700	11,742	2032.5	2038.5	6.0	20.2	149.0	0.0277	1.8
228.00	8,850	11,742	2029.8	2034.9	5.1	19.0	175.5	0.0277	1.8
226.50	9,000	11,742	2025.8	2031.3	5.5	18.7	151.0	0.0215	1.6
225.00	9,150	11,742	2022.3	2028.9	6.6	17.4	155.8	0.0179	1.5
223.50	9,300	11,742	2018.2	2025.3	7.1	18.8	134.7	0.0189	1.5
222.00	9,450	11,742	2014.6	2021.6	7.0	20.0	124.7	0.0200	1.6
220.50	9,600	11,742	2011.2	2017.5	6.3	20.8	136.7	0.0272	1.8
219.00	9,750	11,743	2007.8	2013.7	5.9	20.6	152.0	0.0249	1.7
217.50	9,900	11,742	2004.4	2011.3	6.9	19.0	149.5	0.0188	1.5
216.00	10,050	11,742	2001.2	2007.3	6.1	20.1	146.1	0.0232	1.7
214.50	10,200	11,742	1997.0	2004.1	7.1	19.5	173.4	0.0247	1.7
213.00	10,350	11,742	1994.0	2000.0	6.0	18.6	225.9	0.0351	1.9
211.50	10,500	11,742	1990.0	1996.2	6.2	16.0	275.7	0.0288	1.7
210.00	10,650	11,742	1985.2	1990.4	5.2	17.0	330.8	0.0430	2.0
208.50	10,800	11,742	1980.2	1984.8	4.6	17.1	256.4	0.0319	1.9
207.00	10,950	11,742	1974.9	1978.6	3.7	17.7	323.8	0.0480	2.2
205.50	11,100	11,742	1967.8	1973.4	5.6	15.1	382.6	0.0360	1.9
204.00	11,250	11,742	1960.1	1965.6	5.5	19.2	210.3	0.0359	2.0
202.50	11,400	11,742	1950.1	1957.3	7.2	23.4	116.3	0.0326	2.0
201.00	11,550	11,742	1941.3	1946.7	5.4	27.2	163.0	0.0823	3.0
199.50	11,700	11,742	1937.4	1941.8	4.4	20.6	188.3	0.0397	2.1
198.00	11,850	11,742	1930.9	1941.5	10.6	12.6	288.9	0.0136	1.3
196.50	12,000	11,742	1925.5	1930.3	4.8	23.9	210.9	0.0759	2.8
195.00	12,150	11,742	1921.3	1926.0	4.7	18.1	219.2	0.0317	1.9
193.50	12,300	11,742	1916.6	1921.3	4.7	17.7	241.5	0.0334	1.9
192.00	12,450	11,742	1911.0	1915.8	4.8	17.7	272.0	0.0390	2.0
190.50	12,600	11,742	1905.0	1909.8	4.8	18.0	263.1	0.0397	2.0
189.00	12,750	11,742	1901.9	1905.2	3.3	16.5	268.1	0.0299	1.8
187.50	12,900	11,742	1897.5	1901.1	3.6	16.3	256.8	0.0262	1.7
186.00	13,050	11,742	1892.3	1895.6	3.3	17.7	269.3	0.0372	2.0
184.50	13,200	11,742	1887.8	1892.0	4.2	15.4	269.8	0.0240	1.6
183.00	13,350	11,742	1882.8	1889.0	6.2	15.9	195.8	0.0146	1.4

Table 3.1 100-Year Flood Hydraulics Summary (Continued)

Cross-Section	Distance to u/s (ft)	Q total (cfs)	Thalweg Elevation (ft)	Water Surface El. (ft)	Maximum Depth (ft)	Channel Velocity (fps)	Top Width (ft)	Energy Slope (ft/ft)	Froude No.
181.50	13,500	11,742	1879.1	1883.0	3.9	18.9	347.1	0.0678	2.5
180.00	13,650	11,742	1875.4	1880.4	5.0	12.9	357.3	0.0181	1.4
178.50	13,800	11,742	1872.2	1877.6	5.4	12.9	355.3	0.0188	1.4
177.00	13,950	11,742	1869.6	1874.7	5.1	12.8	380.2	0.0210	1.5
175.50	14,100	11,742	1866.1	1871.5	5.4	13.1	356.7	0.0205	1.5
174.00	14,250	11,742	1862.7	1868.7	6.0	13.5	279.3	0.0146	1.3
172.50	14,400	10,579	1857.5	1863.9	6.4	17.3	204.0	0.0267	1.8
171.00	14,550	12,814	1853.5	1863.0	9.5	12.5	354.5	0.0116	1.3
169.50	14,700	12,814	1850.5	1858.4	7.9	16.1	442.0	0.0339	1.8
168.00	14,850	12,814	1846.7	1853.1	6.4	17.1	264.3	0.0256	1.8
166.50	15,000	12,814	1844.8	1852.7	7.9	5.9	494.1	0.0020	0.5
166.00	15,050	12,814	1843.3	1849.0	5.7	14.4	282.1	0.0183	1.4
165.50	15,100	12,814	1841.7	1849.7	8.0	8.4	309.1	0.0036	0.7
165.00	15,150	12,814	1840.2	1845.7	5.5	16.8	280.5	0.0299	1.8
163.50	15,300	12,814	1836.0	1842.5	6.5	14.4	338.2	0.0236	1.6
162.00	15,450	12,814	1832.4	1838.0	5.6	16.1	269.1	0.0251	1.7
160.50	15,600	12,814	1827.7	1834.8	7.1	14.9	302.6	0.0225	1.6
159.00	15,750	12,814	1825.4	1830.6	5.2	15.8	314.6	0.0281	1.7
157.50	15,900	12,814	1821.9	1828.0	6.1	13.6	324.7	0.0179	1.4
156.00	16,050	12,814	1818.8	1823.6	4.8	14.9	431.3	0.0362	1.9
154.50	16,200	12,814	1815.5	1820.1	4.6	13.7	332.8	0.0196	1.4
153.00	16,350	12,814	1811.7	1815.9	4.2	14.6	420.4	0.0328	1.8
151.50	16,500	12,814	1804.6	1810.2	5.6	14.3	567.0	0.0460	2.0
150.00	16,650	12,814	1801.0	1807.2	6.2	10.1	760.2	0.0189	1.4
148.50	16,800	12,814	1797.8	1803.3	5.5	11.9	555.6	0.0237	1.5
147.00	16,950	12,814	1793.1	1798.9	5.8	13.0	507.2	0.0288	1.6
145.50	17,100	12,814	1790.9	1794.8	3.9	12.7	518.4	0.0275	1.6
144.00	17,250	12,814	1786.6	1790.7	4.1	13.0	450.1	0.0247	1.6
142.50	17,400	12,814	1782.2	1786.6	4.4	14.1	356.0	0.0235	1.6
141.00	17,550	12,814	1777.7	1782.3	4.6	15.1	348.6	0.0286	1.7
139.50	17,700	12,814	1774.0	1779.0	5.0	13.4	396.0	0.0225	1.5
138.00	17,850	12,814	1770.5	1774.5	4.0	14.5	416.1	0.0315	1.8
136.50	18,000	12,814	1767.6	1771.8	4.2	12.3	385.6	0.0162	1.3
135.00	18,150	12,814	1765.1	1769.4	4.3	12.4	356.2	0.0150	1.3
133.50	18,300	12,814	1762.6	1767.0	4.4	12.7	353.8	0.0161	1.3
132.00	18,450	12,814	1759.8	1763.7	3.9	13.7	379.1	0.0228	1.5
130.50	18,600	12,814	1755.9	1760.8	4.9	12.7	417.8	0.0201	1.4
129.00	18,750	12,814	1751.5	1757.4	5.9	12.9	455.5	0.0239	1.5
127.50	18,900	12,814	1746.8	1753.0	6.2	13.9	443.0	0.0295	1.7

Table 3.1 100-Year Flood Hydraulics Summary (Continued)

Cross-Section	Distance to u/s (ft)	Q total (cfs)	Thalweg Elevation (ft)	Water Surface El. (ft)	Maximum Depth (ft)	Channel Velocity (fps)	Top Width (ft)	Energy Slope (ft/ft)	Froude No.
126.00	19,050	12,814	1743.6	1749.4	5.8	12.6	479.0	0.0240	1.5
124.50	19,200	12,814	1740.5	1745.1	4.6	13.2	505.3	0.0297	1.7
123.00	19,350	12,814	1736.2	1741.4	5.2	12.4	499.4	0.0237	1.5
121.50	19,500	12,814	1732.2	1737.1	4.9	13.2	493.6	0.0290	1.7
120.00	19,650	12,814	1727.7	1732.7	5.0	13.4	483.2	0.0291	1.7
118.50	19,800	12,814	1724.3	1728.3	4.0	13.4	477.8	0.0291	1.7
117.00	19,950	12,814	1720.3	1724.4	4.1	12.9	475.2	0.0254	1.6
115.50	20,100	12,814	1715.6	1720.6	5.0	13.2	423.9	0.0233	1.5
114.00	20,250	12,814	1712.4	1718.2	5.8	11.4	460.6	0.0160	1.3
112.50	20,400	12,814	1709.8	1714.7	4.9	12.9	447.0	0.0237	1.5
111.00	20,550	12,814	1706.6	1711.0	4.4	13.2	411.0	0.0229	1.5
109.50	20,700	12,814	1702.7	1707.3	4.6	13.6	402.3	0.0244	1.6
108.00	20,850	12,814	1698.7	1704.7	6.0	12.1	407.5	0.0170	1.3
106.50	21,000	12,814	1696.5	1701.9	5.4	12.6	386.5	0.0179	1.4
105.00	21,150	12,814	1693.9	1698.5	4.6	13.7	352.8	0.0210	1.5
103.50	21,300	12,814	1689.1	1695.3	6.2	13.8	349.8	0.0212	1.5
102.00	21,450	12,814	1686.7	1692.0	5.3	13.8	364.0	0.0225	1.5
100.50	21,600	12,814	1684.0	1687.5	3.5	15.3	332.8	0.0280	1.7
99.00	21,750	12,814	1675.8	1678.1	2.3	20.3	278.7	0.0569	2.4
98.50	21,800	12,814	1674.2	1677.0	2.8	17.1	275.9	0.0315	1.8
98.00	21,850	12,814	1672.6	1677.2	4.6	10.2	276.2	0.0058	0.8
97.50	21,900	12,185	1671.0	1673.8	2.8	16.6	268.8	0.0295	1.8
96.00	22,050	12,185	1669.5	1673.4	3.9	10.9	290.5	0.0082	1.0
94.50	22,200	12,185	1668.0	1672.3	4.4	10.3	366.3	0.0090	1.0
93.00	22,350	12,185	1666.0	1670.5	4.5	10.7	425.5	0.0124	1.1
91.50	22,500	12,185	1662.6	1666.2	3.6	14.3	421.1	0.0323	1.8
90.00	22,650	12,185	1658.5	1662.8	4.3	12.3	445.5	0.0215	1.5
88.50	22,800	12,185	1655.3	1660.6	5.3	11.0	438.7	0.0142	1.2
87.00	22,950	12,185	1652.1	1656.6	4.5	13.6	426.3	0.0275	1.6
85.50	23,100	12,185	1647.9	1652.9	5.0	13.0	423.0	0.0239	1.5
84.00	23,250	12,185	1645.0	1650.3	5.3	11.8	415.9	0.0169	1.3
82.50	23,400	12,185	1643.0	1648.9	5.9	10.1	400.0	0.0096	1.0
81.00	23,550	12,185	1641.0	1644.9	3.9	14.2	378.9	0.0276	1.7
79.50	23,700	12,185	1637.3	1641.5	4.2	13.1	400.2	0.0226	1.5
78.00	23,850	12,185	1633.9	1638.3	4.4	12.6	422.8	0.0218	1.5
76.50	24,000	12,185	1630.3	1634.9	4.6	12.6	441.4	0.0230	1.5
75.00	24,150	12,185	1627.5	1633.0	5.5	10.5	431.1	0.0120	1.1
73.50	24,300	12,185	1623.9	1628.9	5.0	14.4	351.2	0.0256	1.6
72.00	24,450	12,185	1620.4	1628.3	7.9	7.3	393.4	0.0032	0.6

Table 3.1 100-Year Flood Hydraulics Summary (Continued)

Cross-Section	Distance to u/s (ft)	Q total (cfs)	Thalweg Elevation (ft)	Water Surface El. (ft)	Maximum Depth (ft)	Channel Velocity (fps)	Top Width (ft)	Energy Slope (ft/ft)	Froude No.
70.50	24,600	12,185	1620.0	1626.7	6.7	10.4	378.6	0.0095	1.0
69.00	24,750	12,185	1618.2	1623.4	5.2	13.4	359.3	0.0210	1.5
67.50	24,900	12,185	1615.4	1619.8	4.4	14.0	362.0	0.0091	1.6
66.00	25,050	12,185	1611.8	1616.2	4.4	13.1	463.3	0.0273	1.6
64.50	25,200	12,185	1608.2	1613.0	4.8	11.6	510.0	0.0210	1.4
63.00	25,350	12,185	1604.2	1609.9	5.7	11.5	511.7	0.0100	1.4
61.50	25,500	12,185	1600.3	1605.7	5.4	13.0	475.6	0.0277	1.6
60.00	25,650	12,185	1597.0	1602.0	5.0	12.6	465.6	0.0240	1.5
58.50	25,800	12,185	1593.3	1599.8	6.5	10.8	451.9	0.0105	1.2
57.00	25,950	12,185	1589.3	1596.3	7.0	13.5	303.7	0.0174	1.4
55.50	26,100	12,185	1585.9	1593.7	7.8	13.6	286.4	0.0163	1.4
54.00	26,250	12,185	1583.7	1590.0	6.3	14.4	422.7	0.0335	1.8
52.50	26,400	12,185	1580.7	1588.3	7.6	10.8	371.4	0.0107	1.1
51.00	26,550	12,185	1577.5	1583.8	6.3	15.7	259.2	0.0234	1.6
49.50	26,700	12,185	1574.5	1579.5	5.0	16.3	290.1	0.0305	1.8
48.00	26,850	12,185	1571.2	1578.9	7.7	10.1	407.1	0.0096	1.0
46.50	27,000	13,633	1568.0	1571.6	3.6	19.2	271.8	0.0422	2.1
45.00	27,150	15,265	1566.1	1575.2	9.1	6.4	299.1	0.0010	0.4
44.50	27,184	15,265	1566.2	1575.0	8.8	7.2	253.3	0.0013	0.4
43.60	27,294	15,265	1565.8	1574.8	9.0	7.0	254.1	0.0012	0.4
42.00	27,450	15,265	1567.4	1572.6	5.2	11.9	293.9	0.0083	1.0
40.50	27,600	15,265	1563.2	1567.9	4.7	17.1	306.8	0.0286	1.8
39.00	27,750	15,265	1559.2	1566.1	6.9	13.6	326.4	0.0149	1.3
37.50	27,900	15,265	1558.0	1563.3	5.3	14.4	317.6	0.0172	1.4
36.00	28,050	15,265	1554.7	1561.7	7.0	12.9	296.2	0.0111	1.1
34.50	28,200	15,265	1552.7	1558.0	5.3	15.5	355.3	0.0252	1.6
33.00	28,350	15,266	1549.6	1554.7	5.1	13.7	502.1	0.0263	1.6
31.50	28,500	15,265	1547.3	1552.6	5.3	10.9	553.8	0.0141	1.2
30.00	28,650	15,265	1544.6	1550.5	5.9	11.0	520.7	0.0134	1.2
28.50	28,800	15,265	1542.6	1548.2	5.6	11.7	473.2	0.0146	1.2
27.00	28,950	15,265	1539.0	1546.8	7.8	10.7	432.5	0.0094	1.0
25.50	29,100	15,265	1536.2	1544.8	8.6	11.9	360.5	0.0105	1.1
24.00	29,250	15,265	1534.7	1543.7	9.0	11.8	329.7	0.0089	1.0
22.50	29,400	15,265	1533.0	1541.2	8.2	13.5	354.9	0.0157	1.3
21.00	29,550	15,265	1531.4	1538.0	6.6	16.6	380.1	0.0108	1.2
19.50	29,700	15,264	1528.6	1534.3	5.7	18.9	218.2	0.0167	1.5
18.00	29,850	15,265	1525.8	1530.7	4.9	19.9	166.4	0.0216	1.6
16.50	30,000	15,265	1523.0	1527.7	4.7	19.4	179.4	0.0218	1.6
15.00	30,150	15,265	1520.2	1525.1	4.9	18.4	182.0	0.0186	1.5

Table 3.1 100-Year Flood Hydraulics Summary (Continued)

Cross-Section	Distance to u/s (ft)	Q total (cfs)	Thalweg Elevation (ft)	Water Surface El. (ft)	Maximum Depth (ft)	Channel Velocity (fps)	Top Width (ft)	Energy Slope (ft/ft)	Froude No.
13.50	30,300	15,265	1517.4	1523.3	5.9	17.1	168.2	0.0130	1.3
12.00	30,450	15,265	1514.6	1519.5	4.9	19.3	170.6	0.0204	1.6
10.50	30,600	15,265	1511.8	1516.5	4.7	19.0	187.4	0.0213	1.6
9.00	30,750	15,265	1510.9	1519.2	8.3	10.4	204.2	0.0033	0.7
7.50	30,900	15,265	1510.1	1518.6	8.5	10.7	197.2	0.0034	0.7
6.00	31,050	15,265	1509.5	1518.1	8.6	10.7	204.2	0.0035	0.7
4.50	31,200	15,265	1509.1	1516.0	6.9	14.0	184.3	0.0073	1.0
3.00	31,350	15,265	1508.0	1515.3	7.3	13.0	178.7	0.0057	0.9
1.50	31,500	15,265	1507.0	1514.5	7.5	12.8	176.9	0.0054	0.9
0.00	31,650	15,265	1506.0	1512.9	6.9	14.3	170.5	0.0074	1.0

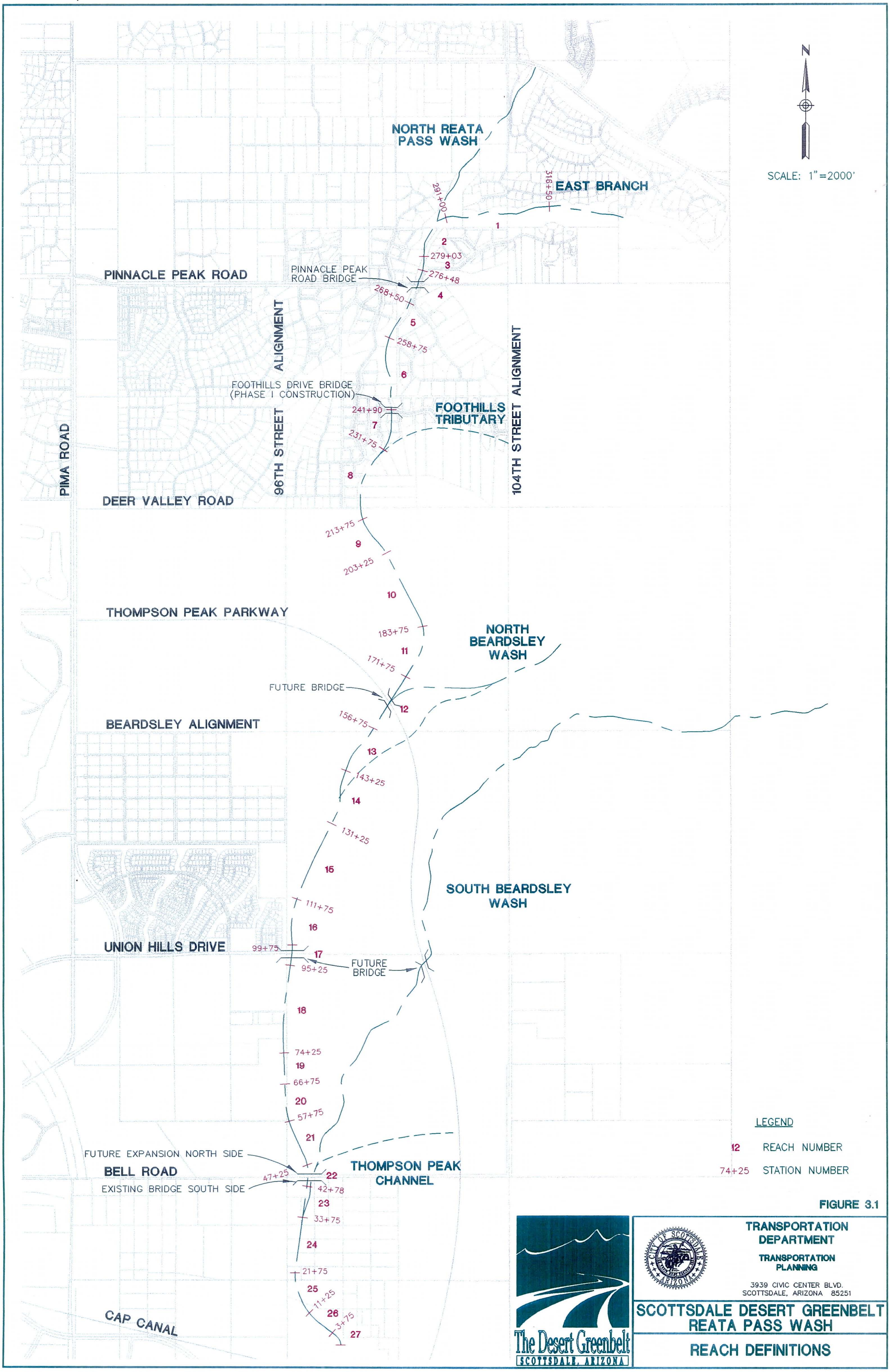


FIGURE 3.1

TRANSPORTATION DEPARTMENT

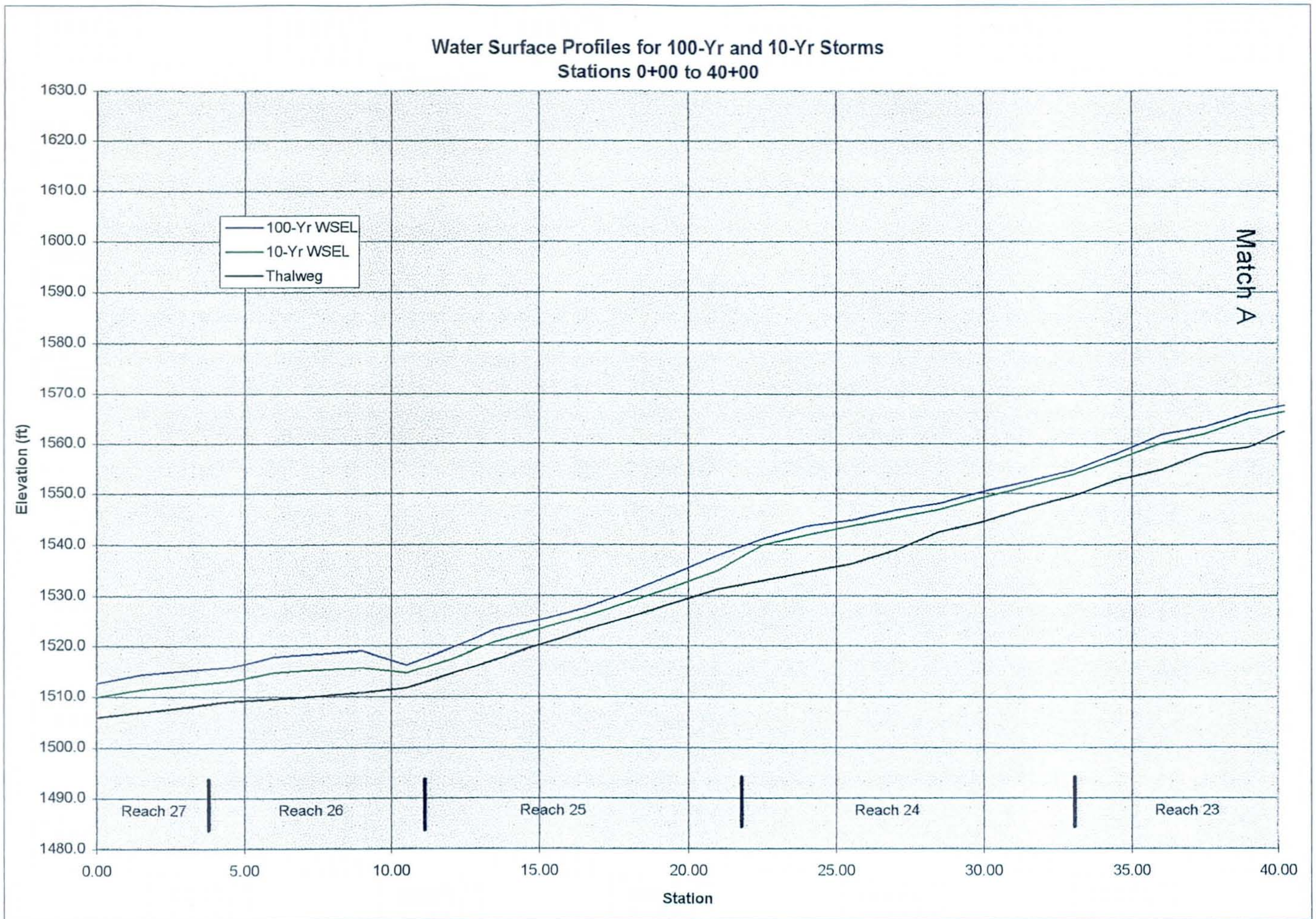
TRANSPORTATION PLANNING

3939 CIVIC CENTER BLVD.
SCOTTSDALE, ARIZONA 85251

The Desert Greenbelt
SCOTTSDALE, ARIZONA

SCOTTSDALE DESERT GREENBELT REATA PASS WASH

REACH DEFINITIONS



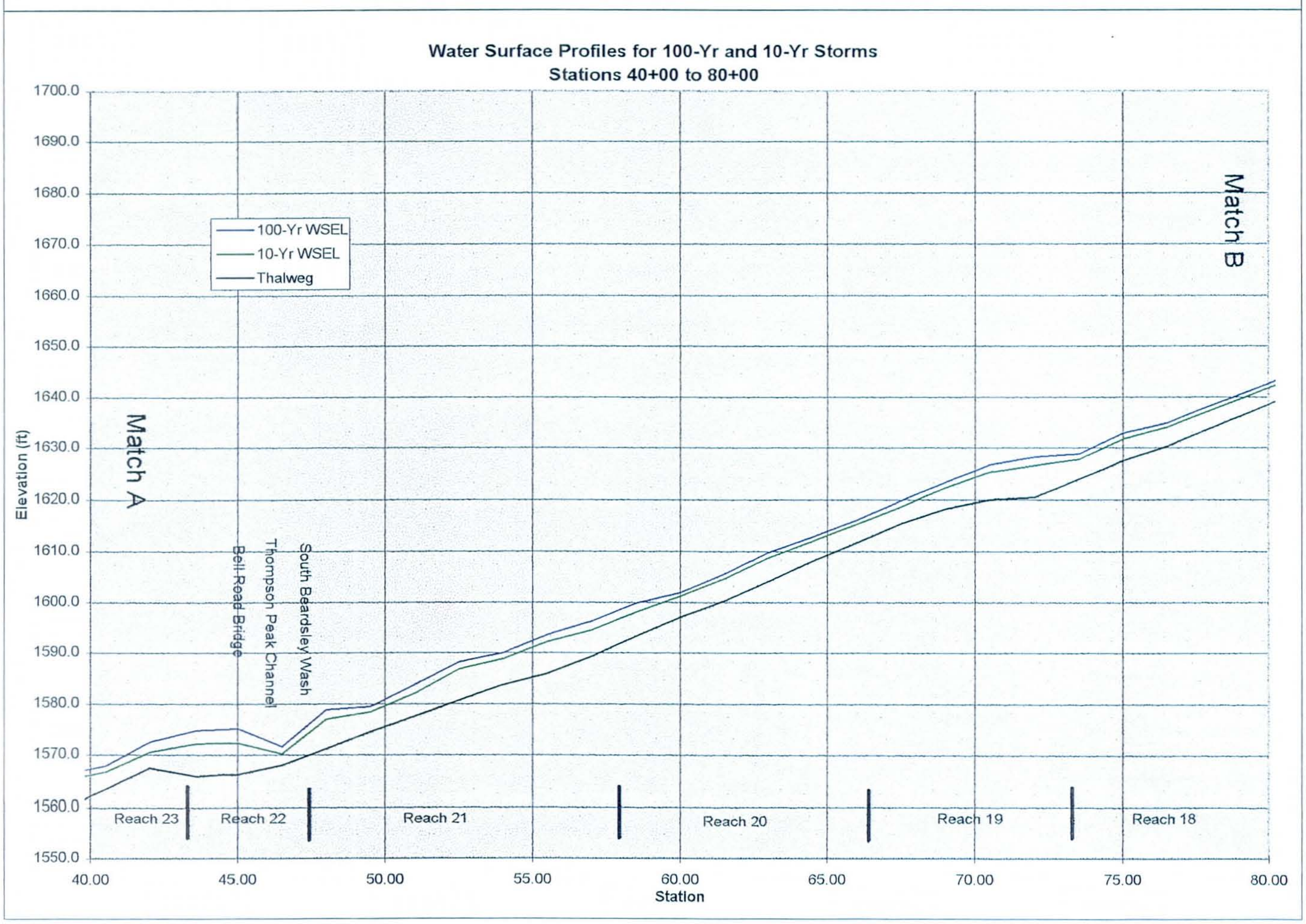
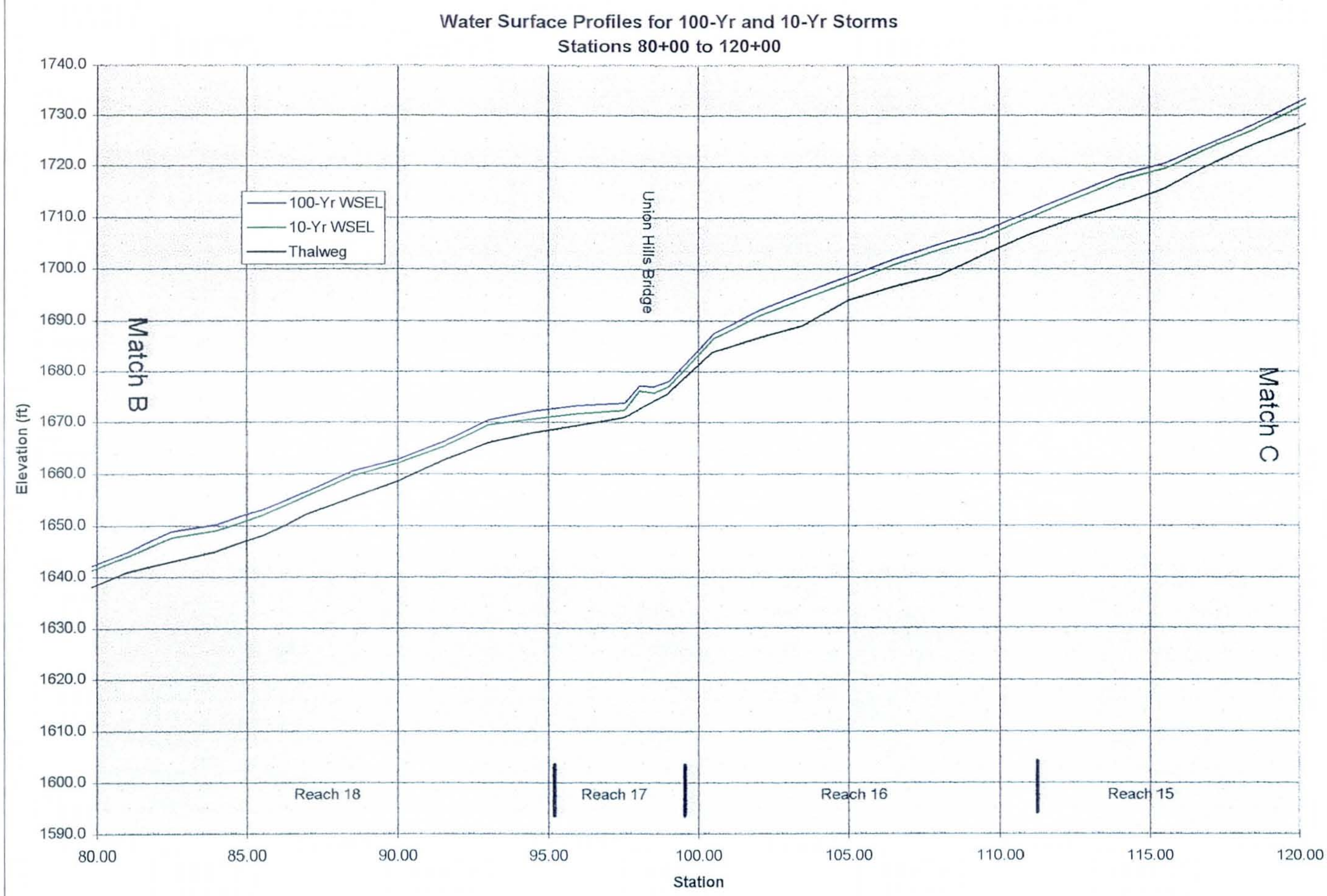


Figure 3.2: Thalweg, 100-Year, and 10-Year Water Surface Profiles



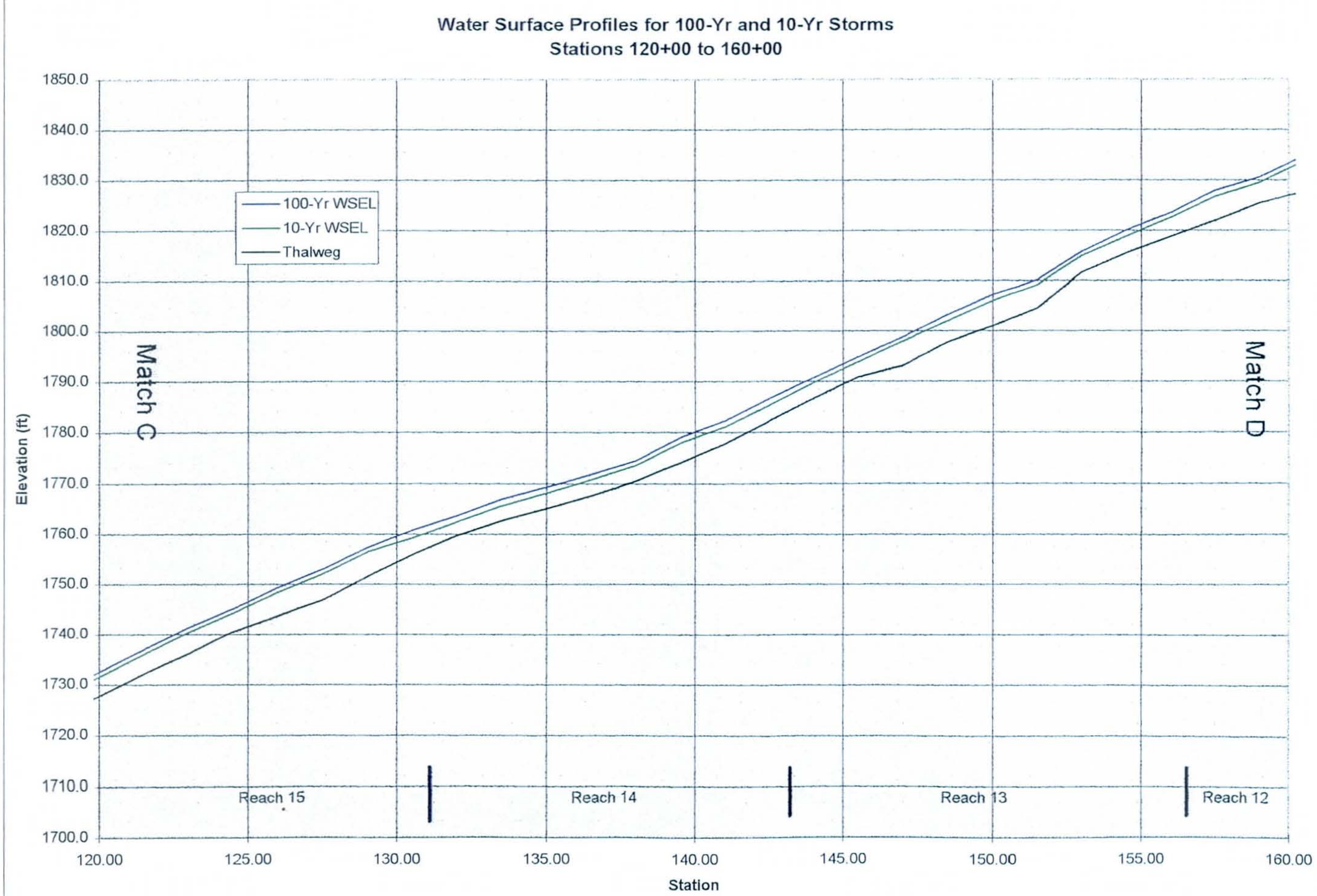
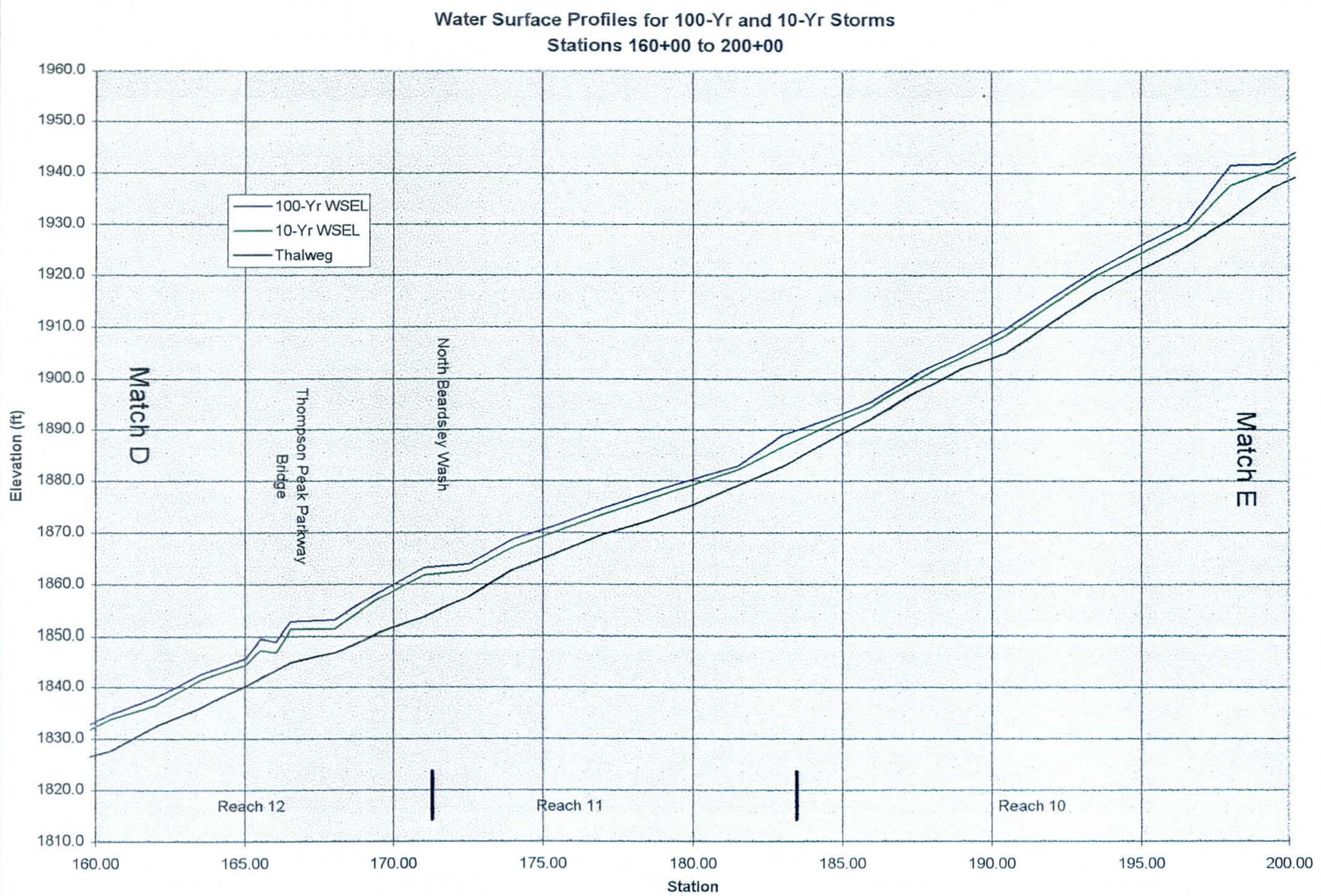


Figure 3.2: Thalweg, 100-Year, and 10-Year Water Surface Profiles (continued)



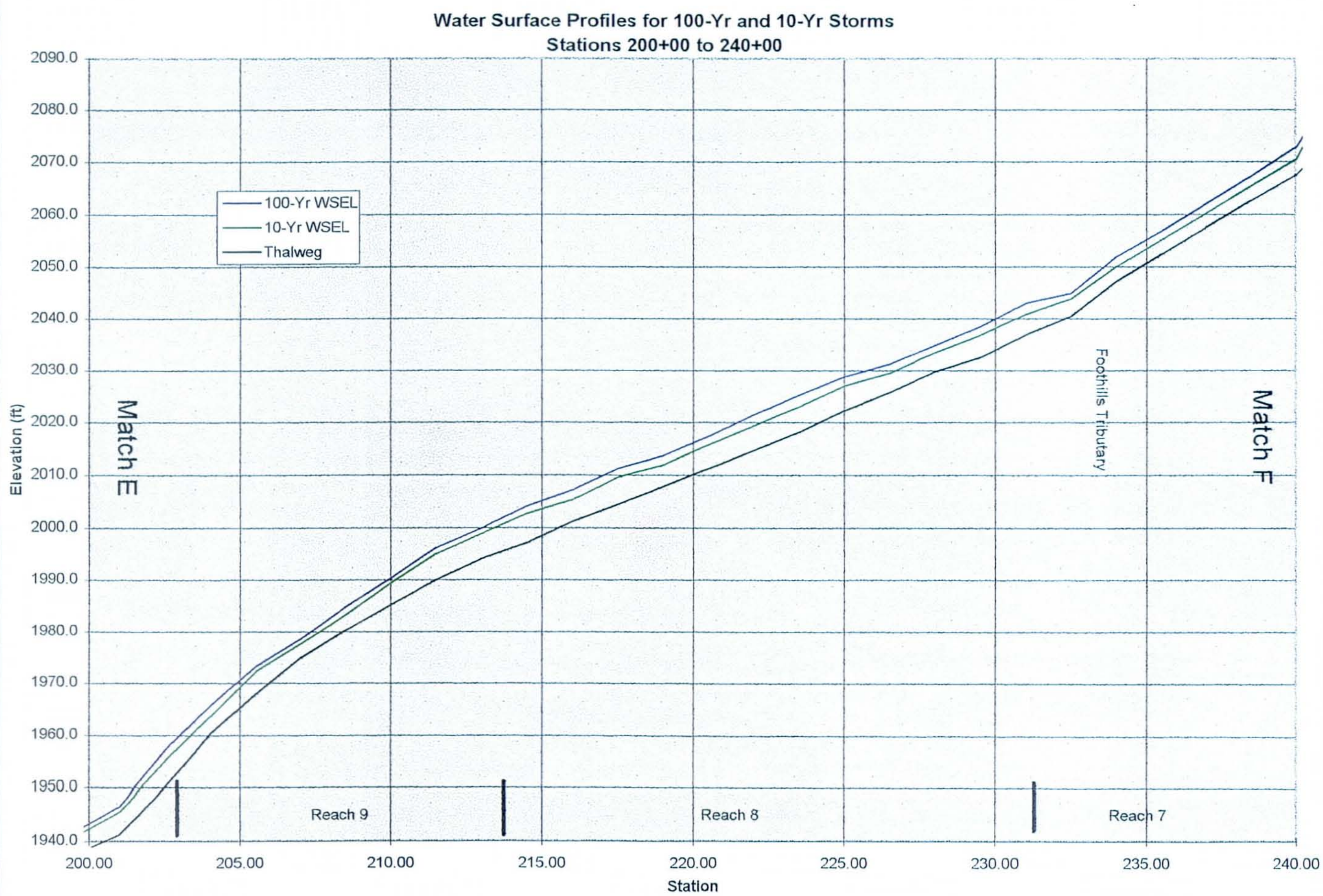
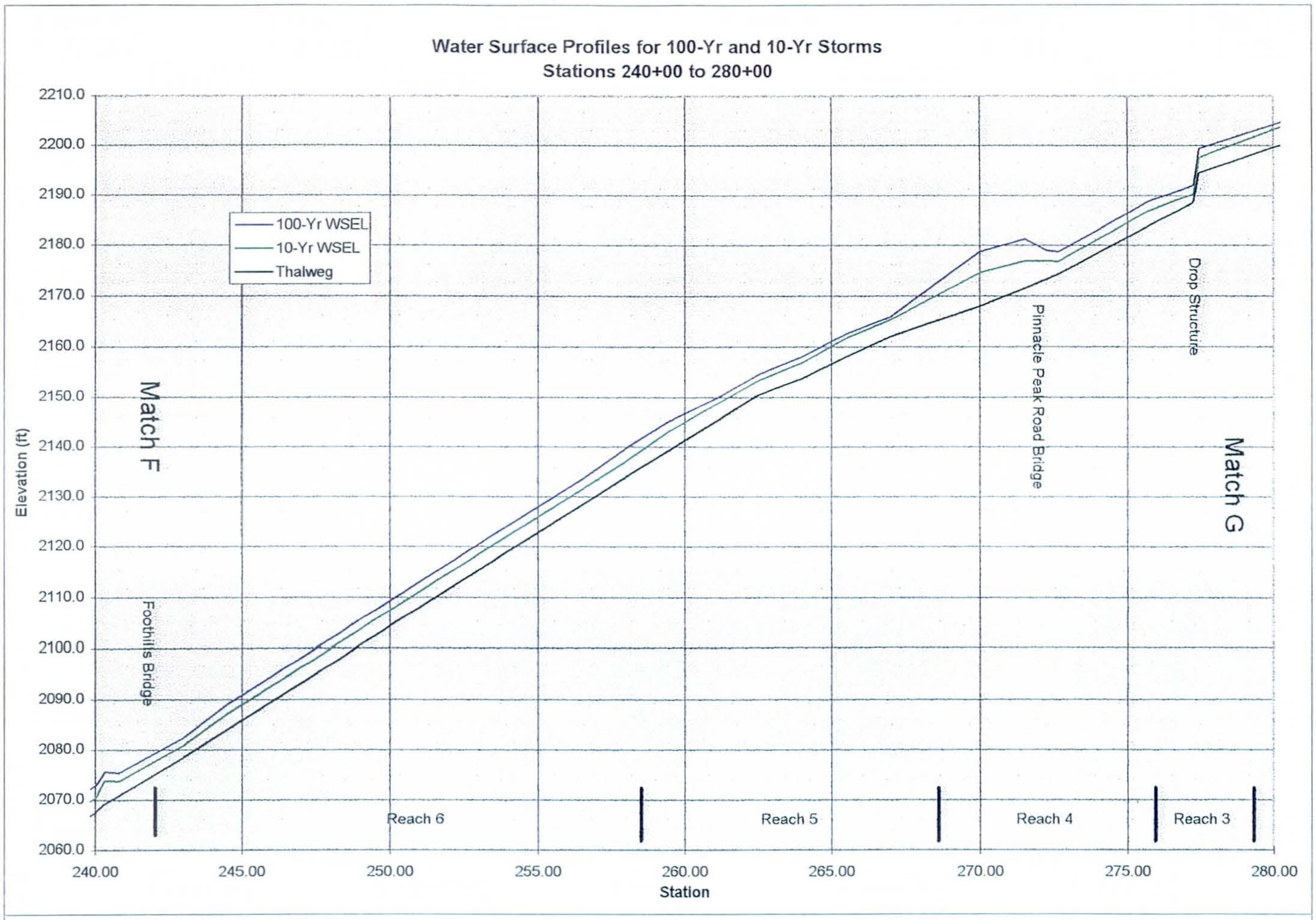


Figure 3.2: Thalweg, 100-Year, and 10-Year Water Surface Profiles (continued)



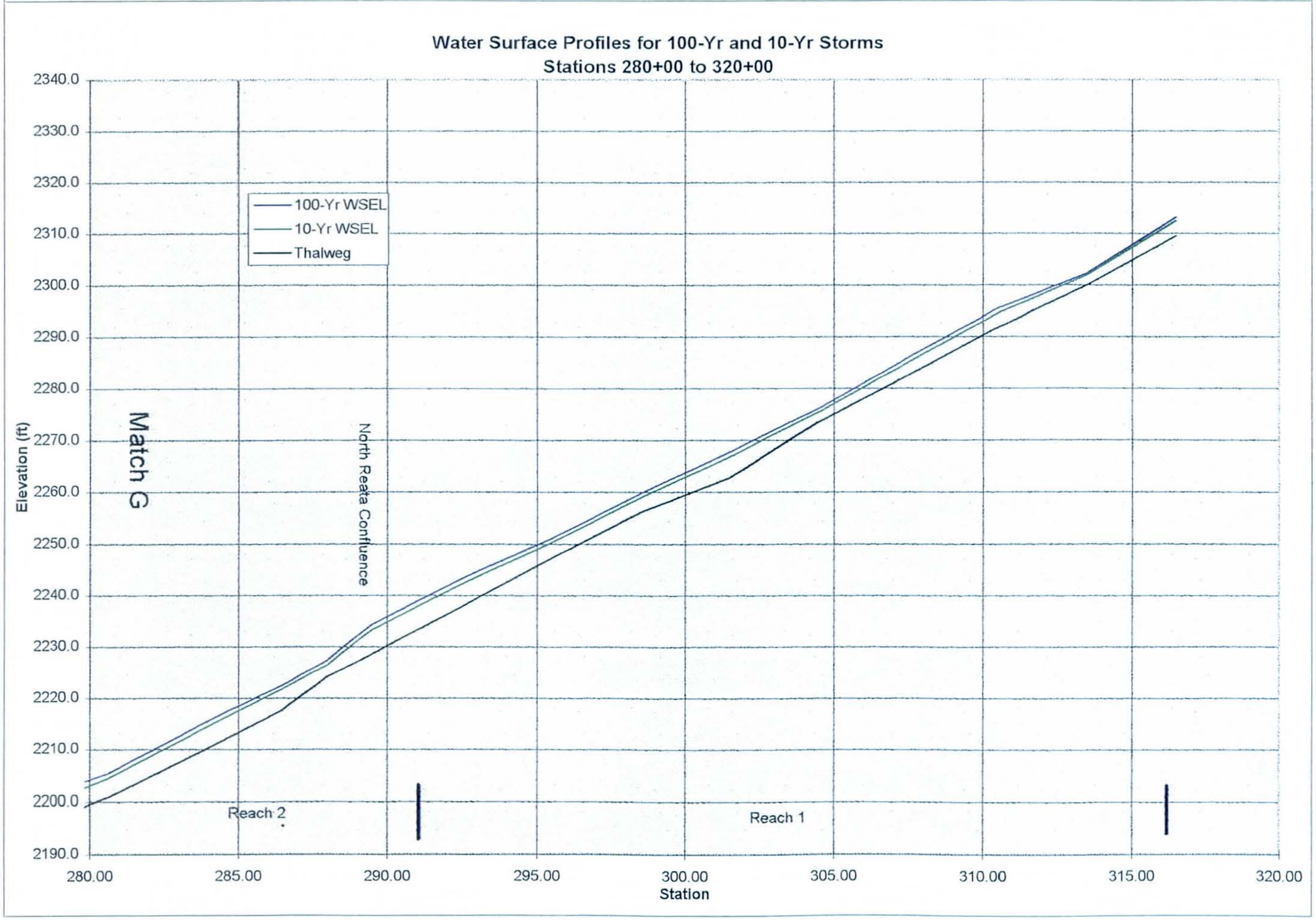


Figure 3.2: Thalweg, 100-Year, and 10-Year Water Surface Profiles (continued)

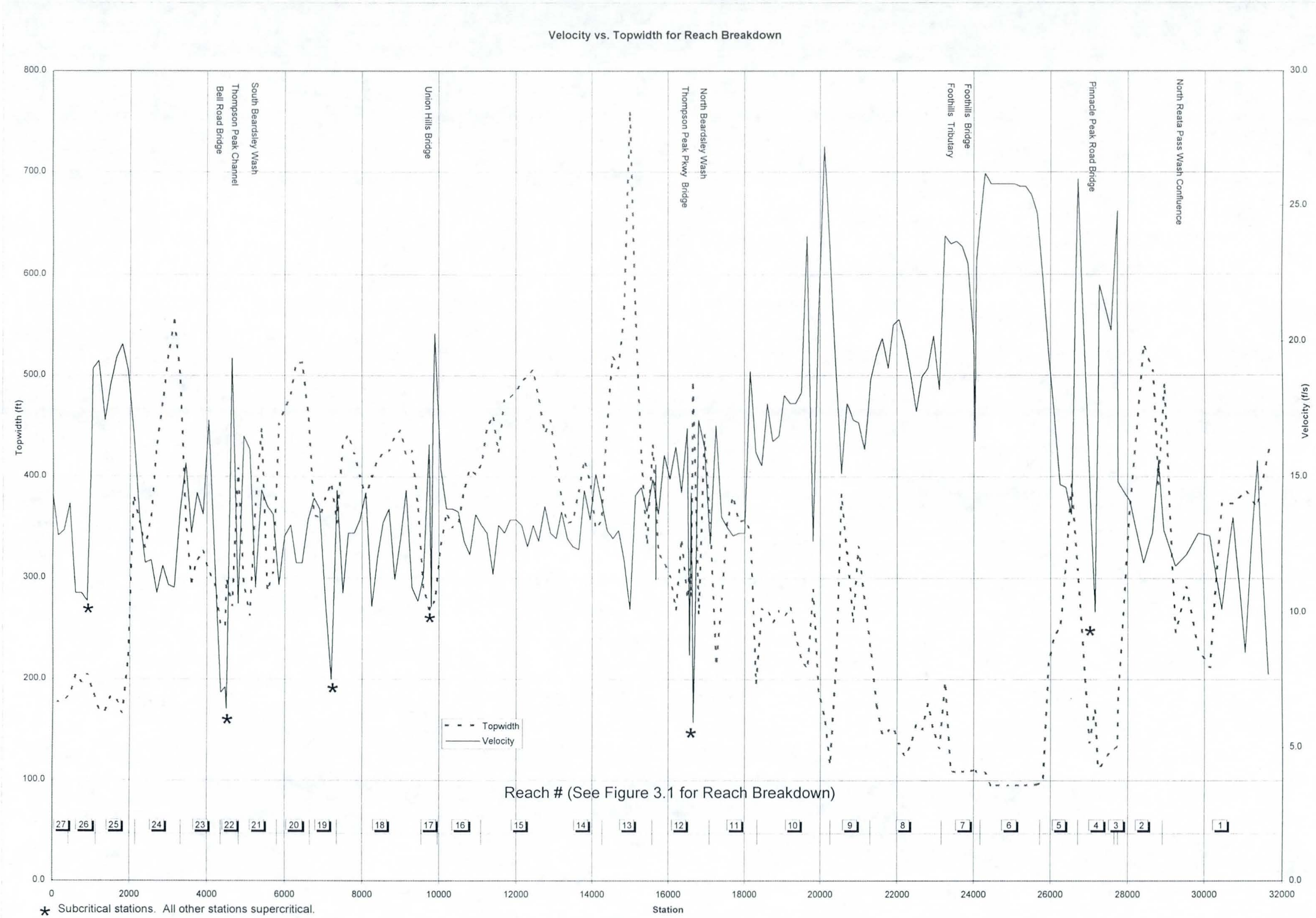


Figure 3.3: Velocity and Top-Width Profiles

Figure 3.3 illustrates the flow velocity and flow top width variation along the study reach. Detailed hydraulic information for the ultimate levee conditions is provided in the technical addendum. A technical addendum is included under separate cover. General hydraulic characteristics are discussed below.

Main Channel East Branch (Station 316+00 to 292+50) - Within this reach, the 100-year flow depths and velocities range from 2.4 to 5.6 feet and 7.7 to 15.6 fps, respectively. The floodplain width ranges from approximately 210 feet to 430 feet.

North Reata Pass Wash Confluence to Pinnacle Peak Road Bridge (Station 292+50 to 272+25)- Within this reach, the 100-year flow depths and velocities for most sections range from 3.3 to 5.8 feet and 11.8 to 15.6 fps, respectively. However, high velocities (up to 24.8 fps) exist at the existing drop structure (Station 277+25) and reinforced concrete box culvert at the Pinnacle Peak Road Bridge. The floodplain width varies from 110 feet to 530 feet.

Pinnacle Peak Road Bridge to Deer Valley Road Alignment (Station 272+25 to 215+00)- Within this reach, the 100-year flow depths and velocities for most sections range from 3.3 to 7.1 feet and 17 to 26 fps, respectively. The high velocities result from a relatively steep channel slope and confined floodplain width. The floodplain width ranges from 100 ft to 150 ft for most of the reach. A small portion of the reach downstream of Pinnacle Peak Road Bridge, however, shows subcritical flow characteristics with higher depths (up to 10.8 ft) , lower velocities (as low as 10.0 fps), and wider floodplain widths (up to 390 ft.)

Deer Valley Road Alignment to North Beardsley Wash Confluence (Station 215+00 to 172+50)- Velocities in this reach are generally slower than those in the above reach. The 100-year flow depths and velocities for most sections range from 3.3 to 7.1 feet and 13 to 17 fps, respectively. The floodplain width is approximately 116 feet to 380 feet. A portion of the reach near Station 200+00 has higher velocities (up to 27.2 fps) due to flow confinement in the divided flow area.

North Beardsley Wash Confluence to Bell Road (Station 172+00 to 46+50) - Within this reach, the 100-year flow depths and velocities for most sections range from 2.3 to 7.9

feet and 5.9 to 15 fps, respectively. However, higher depths and velocities (up to 9.7 ft and 20 fps, respectively) exist at localized areas near the North Beardsley Wash confluence and immediately upstream of the future Union Hills Bridge. The floodplain width ranges from 260 feet to 510 feet, except for Stations 151+50 to 150+00, where the flow width expands to 760 ft in the divided flow area.

Bell Road to the Outlet (downstream of Station 46+50) - Within this reach, the 100-year flow depths and velocities range from 4.7 to 9.1 feet and 6.4 to 16 fps, respectively. High velocities (approximately 20 fps) exist from stations 19+50 to 10+50 where the flow is confined in a channelized portion of the reach. The floodplain width varies from 170 to 550 feet.

Average hydraulic parameters for the 100-year and the 10-year floods were obtained for the 27 subreaches. The detailed velocity variations along the channel were compared to the average velocity for each subreach as shown in Figure 3.4. Tables 3.2 and 3.3 show the average velocities as well as other hydraulic parameters for the 27 subreaches. These data were used for the sediment transport analysis. The effective width was used for computing the sediment transport capacity instead of the flow top width, since there is significant irregularity in the channel geometry (see cross-section plots in the technical addendum). The effective width is defined as the flow area divided by the thalweg depth.

3.4 SUMMARY OF THE HYDRAULIC CHARACTERISTICS OF THE TRIBUTARY CHANNELS

Detailed topographic information was available for the North Reata Pass Wash and the North Beardsley Wash and South Beardsley Wash channels. A detailed HEC-2 model was prepared for these three tributaries to determine the hydraulic characteristics of the channels. No detailed topographic information was available for Foothills Tributary, and the Thompson Peak Channel is a man-made channel; therefore, hydraulic information for these channels was obtained by normal depth computations. Table 3.4 summarizes the average hydraulic characteristics of the tributaries for six return periods. Detailed hydraulic data for the tributaries are included in the technical addendum.

As shown in Table 3.4, North Beardsley Wash, South Beardsley Wash, and Thompson Peak Channel have similar magnitudes of peak discharges. These tributaries also have similar channel slopes of approximately three percent, which results in similar hydraulic characteristics. The flow velocities for North Beardsley Wash, South Beardsley Wash, and Thompson Peak under the 100-year flow range from 16 to 18 feet per second. The effective flow widths and flow depths for the same flood are similar for the three tributaries (flow width ranges from 70 to 80 feet and flow depth ranges from 4 to 5 feet). The Foothills Tributary has a relatively flatter channel slope and small peak discharge; therefore, its velocities are relatively small compared to the other tributaries. The North Reata Pass Wash is similar to the main channel east branch in channel slope, width, and discharge; therefore, this tributary has similar hydraulic parameters similar to the main channel east branch. Both North Reata Pass Wash and the main channel east branch are major flow and sediment sources to the main study reach upstream of the North Beardsley Wash confluence.

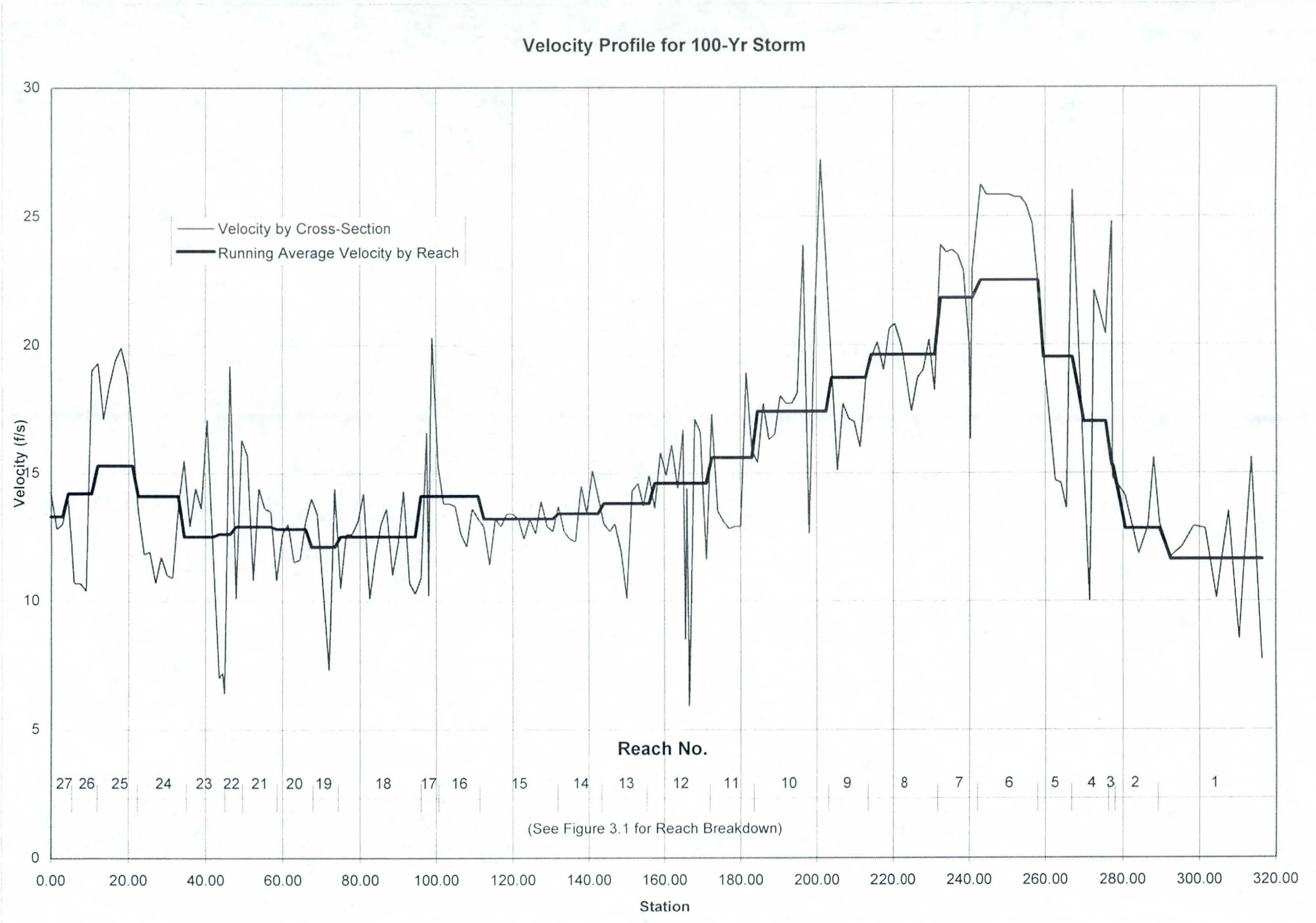


Figure 3.4: Average Velocities for Subreaches

Table 3.2 100-year Hydraulic Summary (Per Reach) for Sediment Transport Computations

Reach No.	Discharge (cfs)	Energy Slope (ft/ft)	Main Channel		
			Velocity (fps)	Depth (ft)	Effective Width (ft)
1	5,766	0.0286	11.6	3.5	154
2	11,236	0.0267	12.8	4.4	159
3	11,236	0.0247	15.3	4.9	147
4	11,236	0.0272	17.0	5.7	130
5	11,236	0.0307	19.5	5.8	114
6	11,236	0.0344	22.5	5.3	101
7	11,236-11,742	0.0321	21.8	5.3	102
8	11,742	0.0311	19.6	5.6	110
9	11,742	0.0355	18.7	5.4	124
10	11,742	0.0323	17.4	5.2	140
11	10,579-11,742	0.0267	15.6	5.7	144
12	12,814	0.0265	14.6	5.9	155
13	12,814	0.0255	13.8	5.2	189
14	12,814	0.0244	13.4	4.9	203
15	12,814	0.0238	13.2	5.0	198
16	12,814	0.0270	14.1	4.4	216
17	12,185	0.0272	14.1	4.1	233
18	12,185	0.0208	12.5	4.9	215
19	12,185	0.0201	12.1	5.3	200
20	12,185	0.0213	12.8	5.6	179
21	12,185	0.0174	12.9	6.3	172
22	13,633-15,265	0.0146	12.6	6.5	191
23	15,265	0.0149	12.5	6.5	198
24	15,265	0.0158	14.1	6.3	183
25	15,265	0.0140	15.3	6.4	167
26	15,265	0.0096	14.2	6.9	165
27	15,265	0.0065	13.3	7.2	160

Table 3.3 10-year Hydraulic Summary (Per Reach) for Sediment Transport Computations

Reach No.	Discharge (cfs)	Energy Slope (ft/ft)	Main Channel		
			Velocity (fps)	Depth (ft)	Effective Width(ft)
1	2,684	0.0288	9.7	2.7	114
2	5,069	0.0280	10.2	3.6	116
3	5,069	0.0269	12.1	3.5	117
4	5,069	0.0283	13.5	3.7	111
5	5,069	0.0312	15.2	3.8	99
6	5,069	0.0348	17.3	3.3	94
7	5,069-5,227	0.0317	16.5	3.5	93
8	5,227	0.0302	14.8	4.1	91
9	5,227	0.0347	14.5	4.0	99
10	5,227	0.0320	13.7	3.8	110
11	4,745-5,227	0.0265	12.2	4.4	110
12	5,666	0.0263	11.5	4.7	114
13	5,666	0.0254	10.8	4.0	140
14	5,666	0.0244	10.4	3.8	153
15	5,666	0.0239	10.1	4.0	147
16	5,666	0.0270	10.9	3.4	178
17	5,319	0.0270	11.0	2.9	200
18	5,319	0.0209	9.6	3.7	172
19	5,319	0.0201	9.3	4.1	151
20	5,319	0.0212	10.2	4.4	129
21	5,319	0.0182	10.7	4.7	129
22	5,927-6,613	0.0154	10.2	4.7	155
23	6,613	0.0150	9.4	4.9	158
24	6,613	0.0164	10.6	4.7	149
25	6,613	0.0145	11.5	4.3	149
26	6,613	0.0097	10.6	4.3	153
27	6,613	0.0070	10.1	4.4	151

Table 3.4 Hydraulic Summary - Tributaries

North Reata Pass Wash							
Return Period (yrs)	Discharge (cfs)	Slope (ft/ft)	Max. Depth (ft)	Average Depth (ft)	Velocity (fps)	Top Width (ft)	Effective Width (ft)
100	5,479	0.0337	3.7	1.4	11.0	391	134
50	4,621	0.0328	3.6	1.3	10.6	365	121
25	3,620	0.0337	3.3	1.2	10.0	335	109
10	2,573	0.0350	3.0	1.1	9.3	296	92
5	1,869	0.0382	2.6	1.1	9.2	259	78
2	1,052	0.0342	2.2	1.0	8.1	209	59
Foothills Tributary							
Return Period (yrs)	Discharge (cfs)	Slope (ft/ft)	Max. Depth (ft)	Average Depth (ft)	Velocity (fps)	Top Width (ft)	Effective Width (ft)
100	2,058	0.0150	3.0	2.0	9.7	104	71
50	1,682	0.0150	2.7	1.9	9.1	100	68
25	1,399	0.0150	2.5	1.7	8.6	96	65
10	949	0.0150	2.1	1.4	7.6	90	59
5	659	0.0150	1.8	1.2	6.7	85	55
2	336	0.0150	1.4	0.8	5.3	78	46
North Beardsley Wash							
Return Period (yrs)	Discharge (cfs)	Slope (ft/ft)	Max. Depth (ft)	Average Depth (ft)	Velocity (fps)	Top Width (ft)	Effective Width (ft)
100	3,476	0.0310	3.6	2.5	15.1	112	64
50	2,905	0.0314	3.3	2.2	14.3	108	62
25	2,270	0.0319	2.9	2.0	13.3	100	59
10	1,581	0.0326	2.5	1.6	11.9	89	53
5	1,163	0.0332	2.2	1.4	10.8	84	49
2	630	0.0357	1.6	1.1	9.2	69	40

Table 3.4 Hydraulic Summary - Tributaries (Continued)

South Beardsley Wash							
Return Period (yrs)	Discharge (cfs)	Slope (ft/ft)	Max. Depth (ft)	Average Depth (ft)	Velocity (fps)	Top Width (ft)	Effective Width (ft)
100	4,373	0.0389	4.1	2.1	15.2	206	70
50	3,589	0.0394	3.9	2.0	14.4	194	64
25	2,876	0.0401	3.6	1.8	13.5	181	59
10	1,990	0.0412	3.1	1.5	12.3	158	52
5	1,453	0.0428	2.8	1.3	11.4	135	46
2	781	0.0431	2.2	1.1	10.0	98	35
Thompson Peak Channel							
Return Period (yrs)	Discharge (cfs)	Slope (ft/ft)	Max. Depth (ft)	Average Depth (ft)	Velocity (fps)	Top Width (ft)	Effective Width (ft)
100	5,475	0.0315	4.0	3.0	17.6	105	78
50	4,551	0.0315	3.7	2.7	16.5	103	75
25	3,623	0.0315	3.3	2.4	15.2	101	72
10	2,534	0.0315	2.8	2.0	13.3	98	68
5	1,829	0.0315	2.4	1.6	11.8	96	65
2	883	0.0315	1.8	1.1	9.2	88	53

Note: Slope listed is energy slope, with the exception of Foothills Tributary and Thompson Peak Channel, where channel bed slope is listed.

IV. SOILS CHARACTERISTICS

4.1 GENERAL

Knowledge of the soils characteristics within the system is critical to the study since soils are a key factor in determining the erosion and sedimentation characteristics of the channel. This is particularly important in the Reata Pass/Beardsley Wash alluvial fan system where complicated soils features are present. A comprehensive analysis of the soils characteristics was performed by analyzing more than 90 sediment samples collected along the main channel and tributaries. These samples were taken at the low-flow channels as well as the floodplains. From these samples, a sieve analysis was performed to produce sediment gradation curves. Pebble counts were applied to armored surfaces typically found in the low-flow channel where gravels are significant (North Beardsley Wash, South Beardsley Wash, and main channel downstream of these tributaries). Detailed samples, locations, and results of soils tests are included in the technical addendum.

Various soils gradation curves were examined and compared to each other in order to determine representative soils data for sediment transport analysis along the study reach. Silt and clay (the portion of each curve finer than .0625 mm) were separated from each of the samples to make the comparisons consistent. Low-flow channel samples were found to be much coarser than samples taken outside of the low-flow channel. Since the low-flow channel is a small portion of the proposed channel width, these samples were excluded for representative soils analysis. Most samples were taken from within 1 to 5 feet of the surface. Some soil borings showed variation within the upper 10 feet. Where samples from multiple depths were available for one location, the shallowest sample was used, except for locations where the channel will be excavated. Samples taken at depths greater than the maximum expected scour were ignored.

Table 4.1 shows sources of sediment data. Figures 4.1 and Table 4.2 describe the source and area coverage of representative samples resulting from investigation of samples collected for the study.

Table 4.1 Sources for Sediment Data

Source (Testing Lab)	# of Samples	Location	Date
Greiner, Inc. (ATL)	5	Main Channel and South Beardsley	October, 1995
AGRA Earth & Environmental	18	Pinnacle Peak Road to Bell Road	August 25, 1995
SLA (Atkinson-McBee & Assoc.)	2	Upper Reata Pass	November 11, 1996
SLA (Atkinson-McBee & Assoc.)	3	Basin, Foothills, Union Hills	October 22, 1996
R. Ward (Western Technologies)	4	Thompson Peak and lower main	July 12, 1993

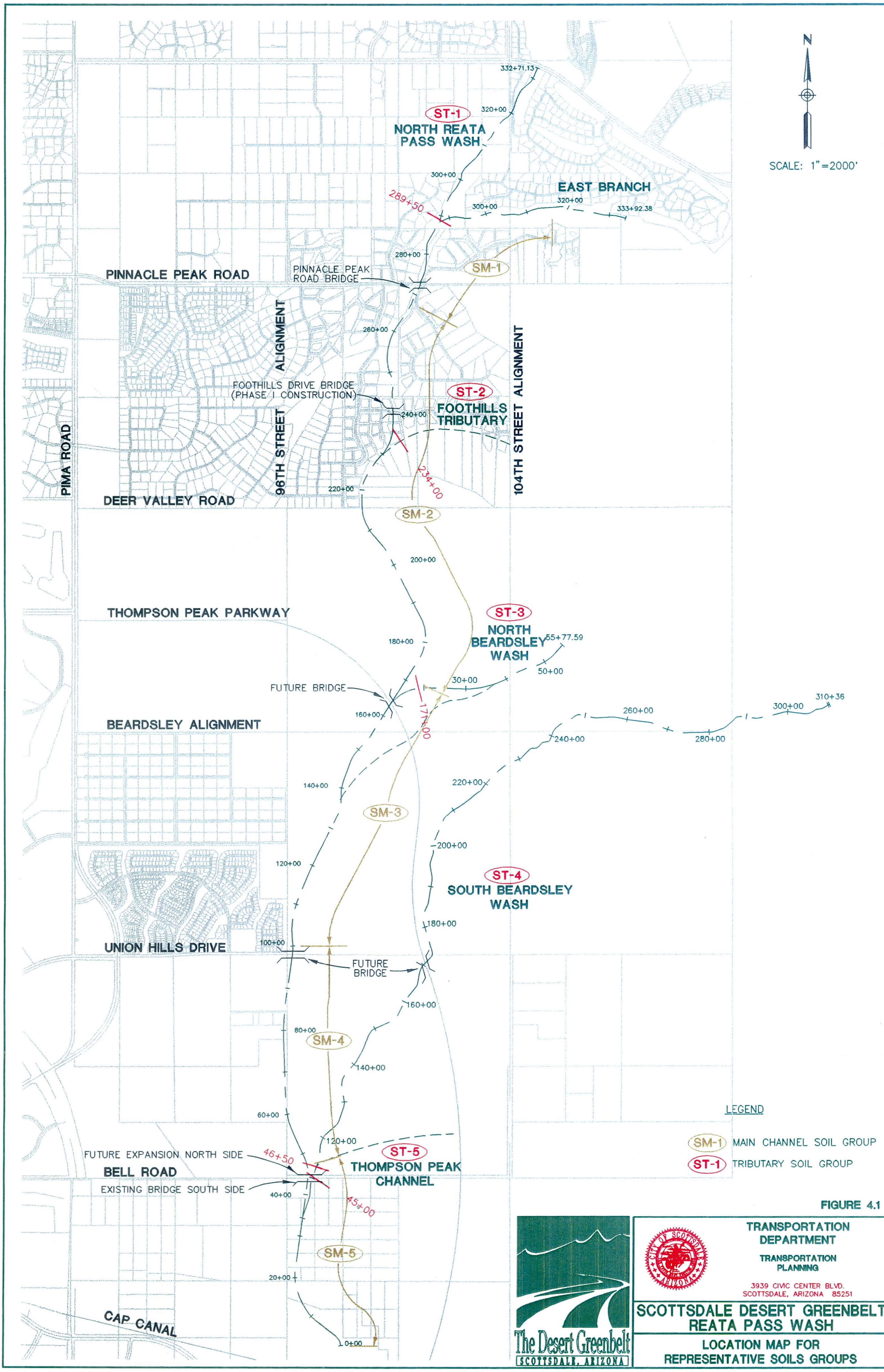


FIGURE 4.1

TRANSPORTATION DEPARTMENT
TRANSPORTATION PLANNING
3939 CIVIC CENTER BLVD.
SCOTTSDALE, ARIZONA 85251

SCOTTSDALE DESERT GREENBELT
REATA PASS WASH

LOCATION MAP FOR REPRESENTATIVE SOILS GROUPS

Table 4.2 Representative Soils Groups

Main Channel Soils Groups			
Group	**Location**	**Stations**	**Source Sample**
SM-1	Upstream to Pinnacle	316.50 to 268.50	Greiner and AGRA (GR S3-6, 7, & 10; AGRA BK)
SM-2	Pinnacle to North Beardsley Wash	268.50 to 171.75	AGRA (RP-1,3,4,5,6; RTP-1,3)
SM-3	North Beardsley Wash to Union Hills	171.75 to 99.75	AGRA (RTP-5, 6, 9, 12)
SM-4	Union Hills to Bell	99.75 to 47.25	SLA and AGRA (RTP-14, 16, 19; SLA UH)
SM-5	Downstream of Bell	47.25 to 0.00	SLA and AGRA (RTP-22, RW-3,5)
Tributary Soils Groups			
Group	**Tributary**	**Confluence Station**	**Source Sample**
ST-1	Upper Tributary	289.50	SLA (SLA 1,2)
ST-2	Foothills	234.00	SLA (SLA FH)
ST-3	North BeardsleyWash	171.00	Greiner (GR S6-1)
ST-4	South Beardsley Wash	46.50	Greiner (GR S6-2)
ST-5	Thompson Peak	45.00	R. Ward (RW-1,2)

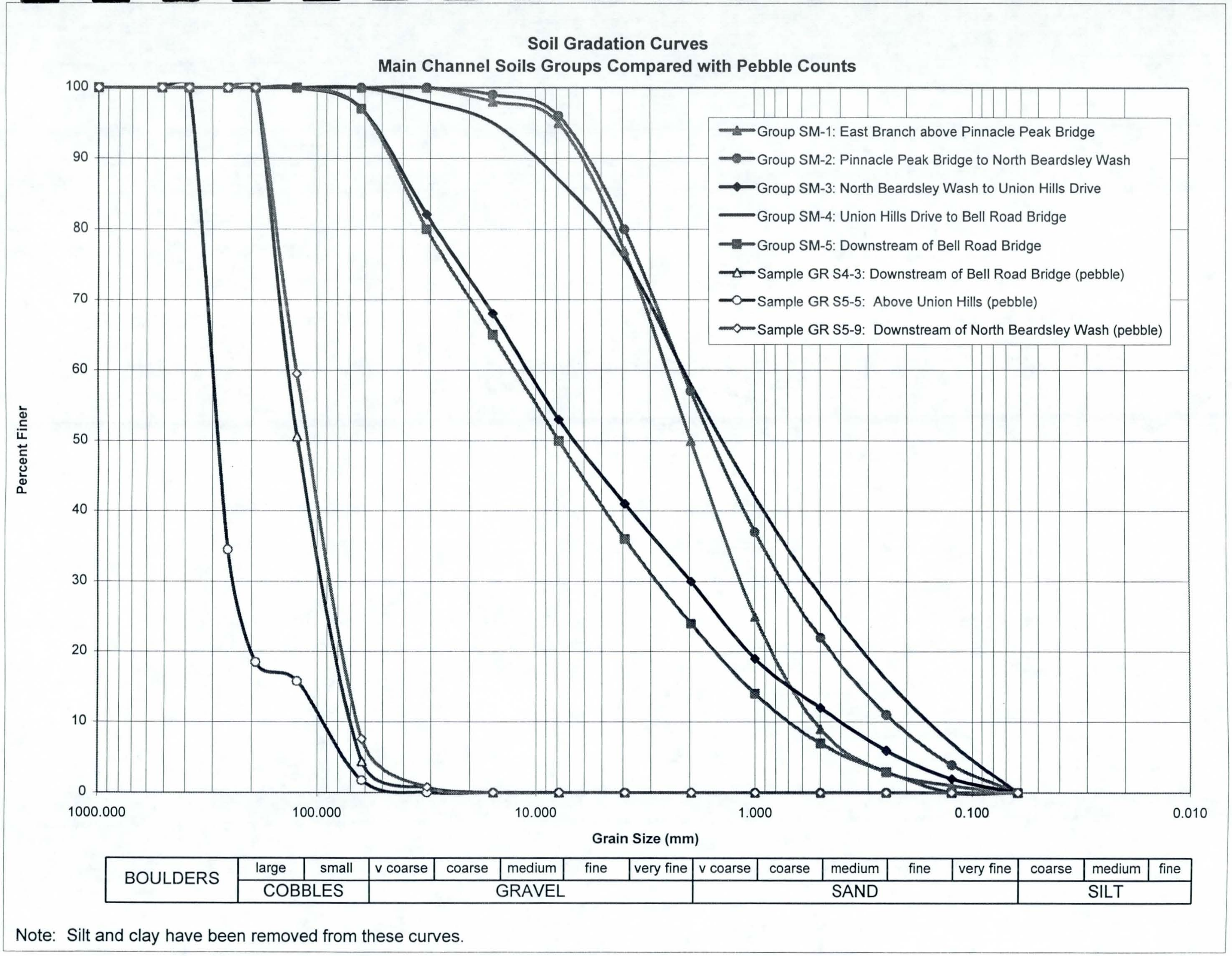
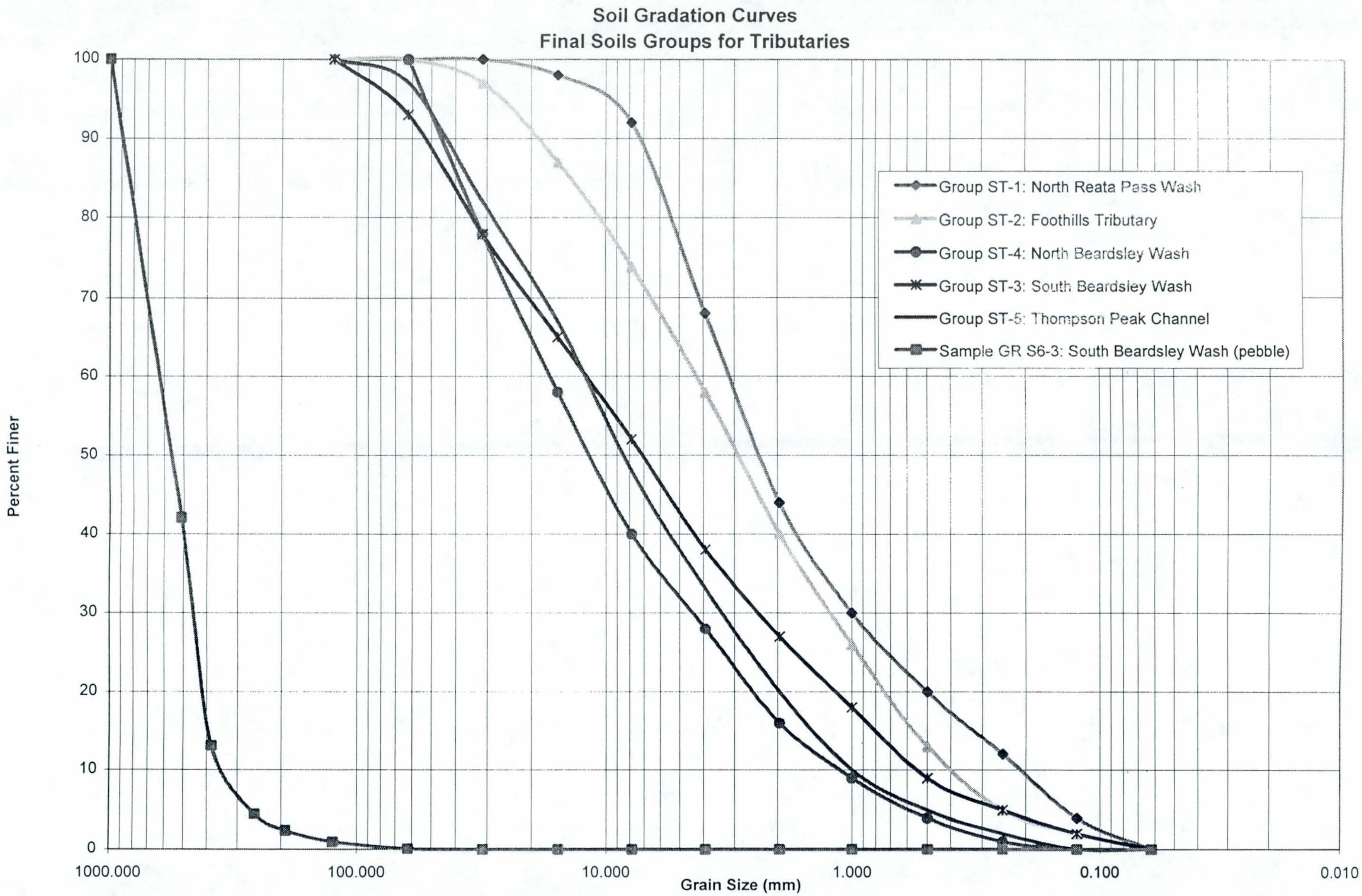


Figure 4.2: Representative Gradation Curves - Main Channel



BOULDERS	large	small	v coarse	coarse	medium	fine	very fine	v coarse	coarse	medium	fine	very fine	coarse	medium	fine
	COBBLES		GRAVEL					SAND					SILT		

Note: Silt and clay have been removed from these curves.

Figure 4.3: Representative Gradation Curves - Tributaries

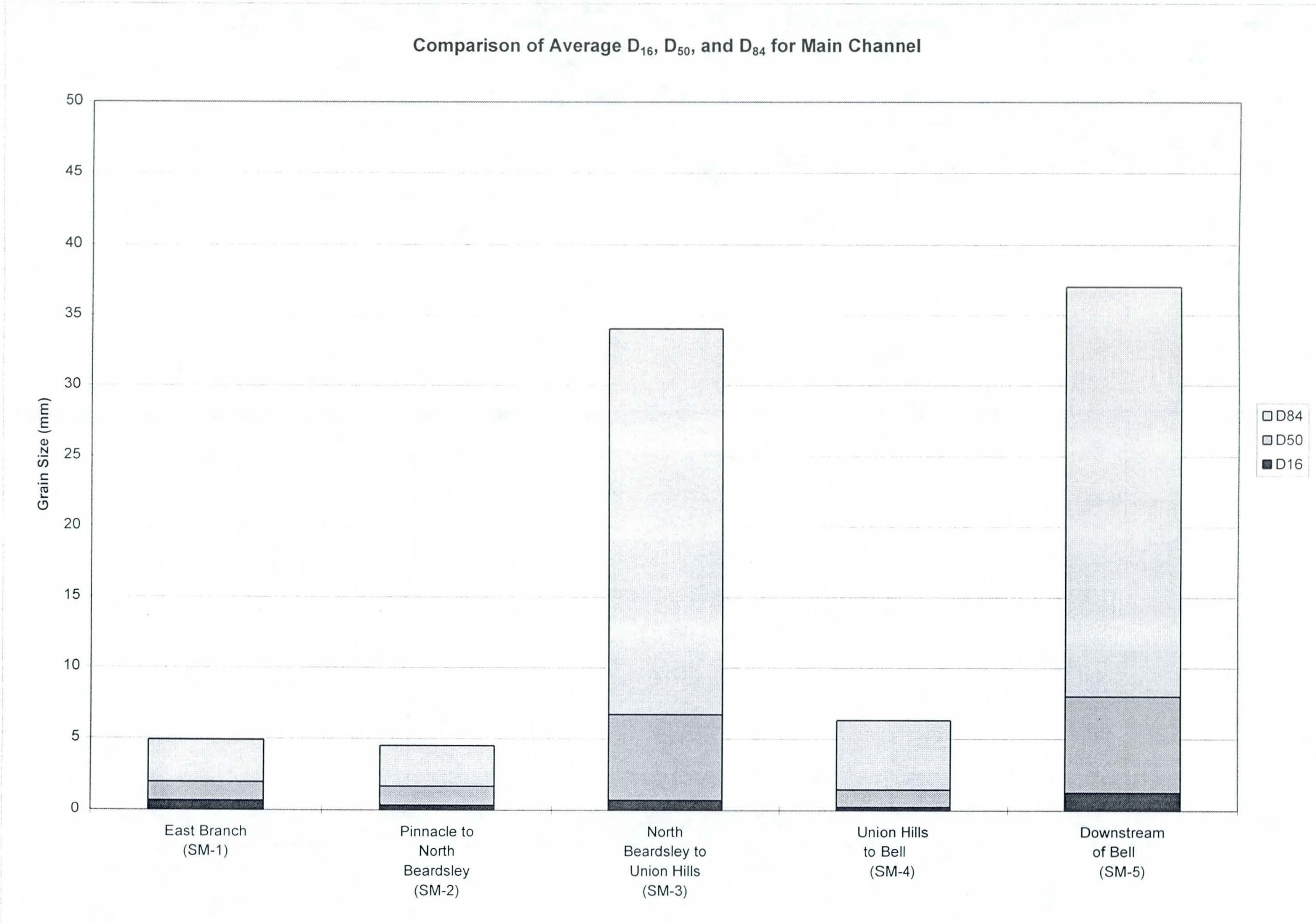


Figure 4.4: Average D_{16}, D_{50}, and D_{84} for Main Channel

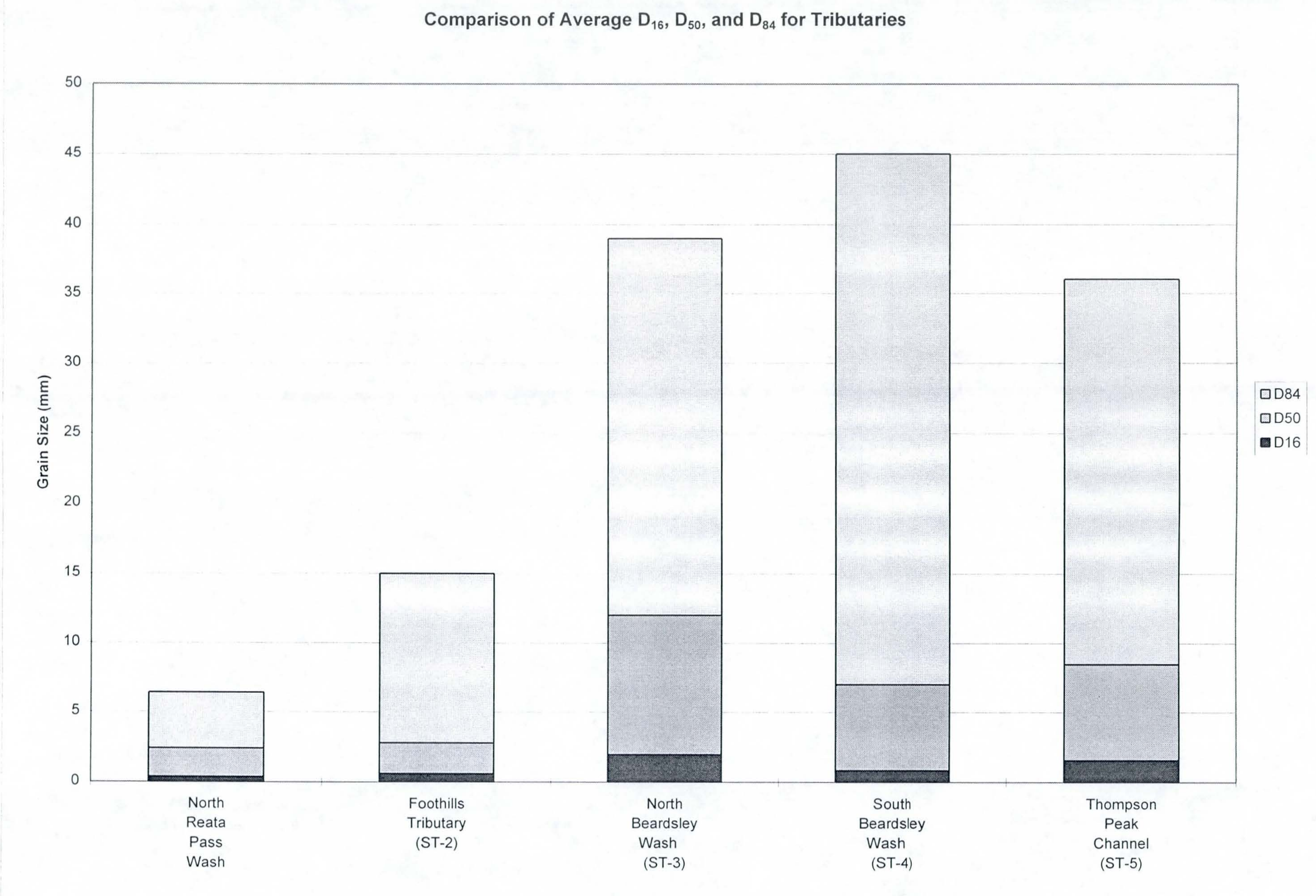


Figure 4.5: Average D_{16}, D_{50}, and D_{84} for Tributaries

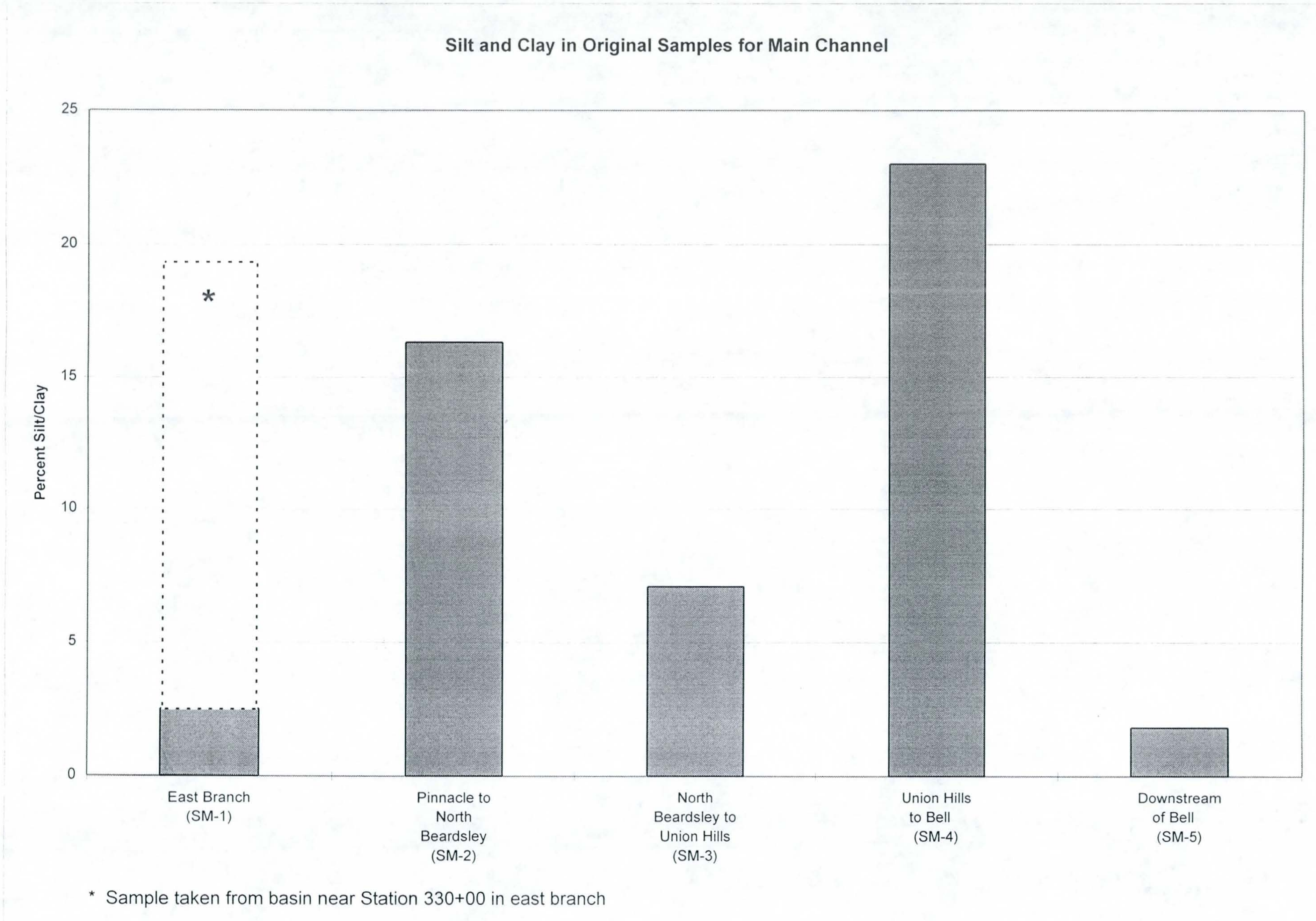


Figure 4.6: Silt and Clay Content for Main Channel

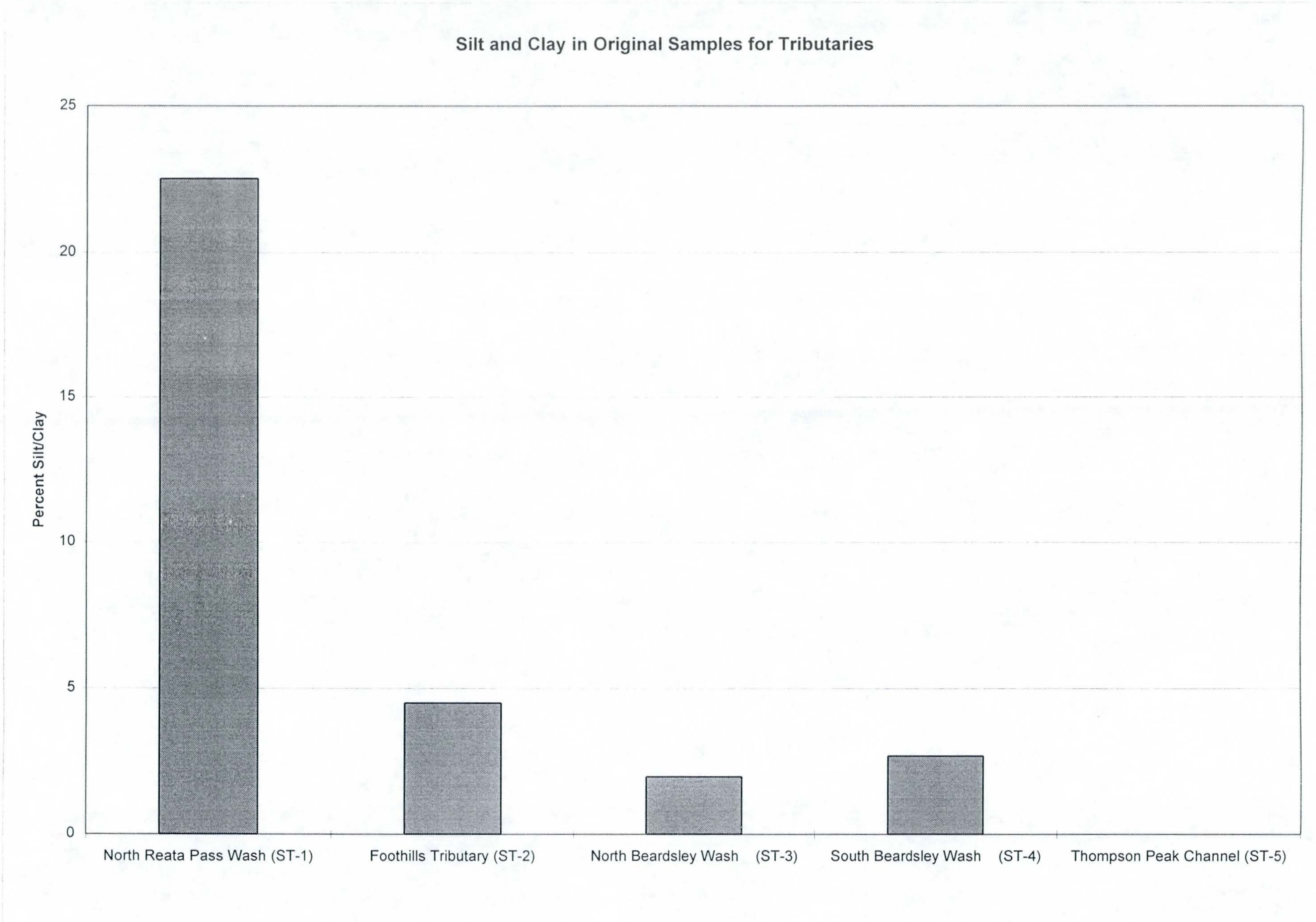


Figure 4.7: Silt and Clay in Original Samples for Tributaries

The pebble counts generally are not representative of the average soils characteristics; therefore, these are not included in the representative samples. However, these samples were taken in the historical incised channel, and are representative of potential armor conditions due to erosion.

4.2 SOILS ANALYSIS

A composite curve was obtained for each soils group shown in Table 4.2. Figures 4.2 and 4.3 show the representative curves for each soils group for the main channel and the tributaries, respectively. Pebble counts are included in Figure 4.2 and Figure 4.3 for reference. The D_{16}, D_{50}, and D_{84} (16%, 50% and 84% finer in sieve analysis) sizes are shown in Figures 4.4 and 4.5. The silt and clay contents which were not included in Figures 4.2 through 4.5 are shown in Figures 4.6 and 4.7, respectively, for the main channel and tributaries.

Soils variations were identified through examination of the geology, topography, historical flood path, and existing main channel relative to the proposed channel alignment. As confirmed by field observation, the soils analysis shows finer sediment along the channel upstream of North Beardsley Wash confluence and coarser sediment downstream. Upstream of North Beardsley Wash, the sediment contains 20% silt and clay (see Figure 4.6 for Pinnacle Peak Road Bridge to North Beardsley Wash and Figure 4.7 for North Reata Pass Wash). The portion of the channel immediately below North Beardsley Wash is fairly coarse and contains little silt and clay. Examination of the aerial photograph of the area shows that the proposed channel is generally aligned with the existing North Beardsley Wash. Fine sediments have thus been transported through this portion of the channel, leaving coarser sediments and an armored bed.

From upstream of the future Union Hills Bridge to upstream of the South Beardsley Wash confluence, the proposed channel is located on an alluvial fan but does not contain historical low-flow channels. Significant silt and clay are present in this portion of the channel (approximately 20%), and the sediment is relatively fine compared to most of the area downstream of North Beardsley Wash. The proposed channel below Bell Road Bridge is aligned with the South Beardsley Wash channel; the sediment again is coarser and armored, with little or no silt and clay.

Most of the tributaries are fairly steep (on the order of 3-4%) and the sediment is slightly coarser than the main channel. Soils in the North Reata Pass Wash, however, are relatively fine, and are very similar to the main channel east branch. Both are major contributors to the sand alluvium in the Reata Pass Wash upstream of the North Beardsley Wash. The silt and clay content in the North Reata Pass Wash is also similar to the main channel near Pinnacle Peak Road Bridge.

The Foothills Tributary is slightly coarser than the North Reata Pass Wash and the main channel near the confluence. Coarse gravels and small boulders were found in the tributary and downstream channel; however, its contribution to the Reata Pass Wash alluvial deposits is minimal compared to other major tributaries.

The remaining tributaries consist of very coarse material. As part of McDowell Mountain, which contains significant bed rock formation (see Department of Geology, Arizona State University data), the North Beardsley Wash, South Beardsley Wash and Thompson Peak Channel drainage basins are the sources of gravels, cobbles, and boulders found in the existing low-flow channels. Although, there are still abundant coarse sands and gravels for sediment supply to the main channel from the tributaries, armoring will continue to occur over time, which will further reduce sand and gravel supply to the downstream channel.

V. EROSION AND SEDIMENTATION

5.1 EROSION/SEDIMENTATION ANALYSIS - GENERAL

The erosion and sedimentation characteristics of the Reata Pass Wash along the proposed channel were evaluated using a three-level approach. Level I is a qualitative analysis based on field observation, soils data, channel geomorphology, and hydraulic features of the main channel and tributaries. Level II is a quantitative analysis to determine the sediment inflow and outflow rates through each channel reach using sediment transport equations assuming a steady-state (fixed-bed) condition. This analysis provides an estimate of sediment transport capacity for each channel reach, aggradational and degradational trend, and magnitude along the study reach for flood magnitudes ranging from the 2-year to the 100-year floods. A Level III analysis further evaluates the channel responses during the 100-year and the 10-year flood event utilizing a sophisticated mathematical model. Other factors which may increase the scour/sedimentation depth (e.g. local scour) or limit the scour depth (e.g. armoring) were considered in addition to the results of Level II and III sediment transport analysis. A detailed description of each level of analysis, the methodology used, and the results are provided in the following sections and Chapter VI.

5.2 QUALITATIVE (LEVEL I) ANALYSIS

A qualitative analysis was performed based upon observation of the system using available historical information including flood history, an interpretation from aerial photographs, land use alterations from past to future, and an evaluation of physical geomorphic constraints.

5.2.1 Plan Form Characteristics

The alluvial fan geomorphologic features of the study area were analyzed based on aerial photographs and field observations. The Reata Pass/Beardsley Wash is described as a steep, braided, alluvial fan channel originating from the McDowell Mountains. The wash is generally wide, containing braided channels with poorly defined and unstable banks. Figure 1.4 illustrates the existing conditions of the channel. As shown in the aerial photographs, these braided channels are generally aligned with the direction of flows from each alluvial fan apex. It is apparent that the flows from the fan apex are supplied with more sediments than the channel can carry, resulting in partial deposition of sediment loads on steep slopes. Within the alluvial deposits, low-flow channels which carry more unit width discharge are subject to erosion and dynamic changes. Further downstream of the fan apex, the braided channels become smaller and more numerous and the fan becomes a shallow, wide sheet flow area.

The dynamic feature of the alluvial fan channel is also reflected in the topographic data. The cross-sections along the proposed channel alignment (detailed in the technical addendum) illustrate the irregularity of the channel geometry due to the alluvial fan characteristic of the Reata Pass/Beardsley Wash channel. The irregularity of the channel is also explained by the presence of a proposed series of overlapping fans along the channel. Historical channels are observed crossing and leaving the main channel. Note that the existing and historical low-flow channels are aligned generally in a south/southwesterly direction. The existing low flow channel depth is generally less than 3 feet, including the apex channel downstream of Pinnacle Peak Road Bridge The proposed levee will intersect the southwesterly low-flow channels. A major focus of the channel design will be redirecting the flow toward the proposed channel alignment shown on Figure 1.4. Thus, low flow incisement scour will be a major component of the total toe-down depth.

5.2.2 Erosion/Sedimentation Characteristics

It is important to note that the existing Reata Pass Wash flows in a southwesterly direction from the fan apex downstream of the Pinnacle Peak Road Bridge. Historically, only minor flows remain in the channel flowing to the south (see Figures 1.4 and 1.5). The channel reach from the apex to downstream of the Foothills Tributary has not experienced major floods or erosion/sedimentation. The proposed channel alignment will confine all flows to the south (11,000 cfs), which is a practical solution to relieve flood hazards in the extensive floodplains shown in Figure 1.6. However, the proposed levee will restrict the flow area and severely limit lateral migration and potential self-adjustment of the channel. The hydraulic analysis shows that this reach is subject to an average flow velocity of 22 fps for a 100-year flood and the average width is 100 feet (see Figures 3.3 and 3.4). This reach also contains erodible soils sands and fine gravels. The significant concentration of flow, high flow velocity, erodible materials, and restriction in lateral migration all indicate that this reach will be subject to severe downcutting.

Existing desert vegetation is found throughout the study area; however, it may be unstable under the new channel, because under the existing condition the vegetation is not experiencing much of the flow from the North Reata Pass Wash. After the project improvements, all of the flows will be diverted into this channel causing higher velocity even for smaller events. Thus, vegetation may wash out during the flood events. It is expected that a large range of flow resistance (Manning's *n* from 0.030 to 0.050) could occur in the proposed channel, depending on the plant survival.

The existing soils conditions show a distinct boundary in the study area: sands and very fine gravels are dominant in the reach upstream of North Beardsley (see Figures 4.2 and 4.3) and gravels with armor layers composed of boulders exist downstream of South Beardsley Wash. These representative soils are consistent with the sediment source areas; for example, the North Beardsley and South Beardsley Washes, are those composed of gravels and cobble with boulders forming armor layers.

The reach from Union Hills Drive to upstream of Bell Road is an exception to the lower reach which contains alluvial deposits similar to the upper reach. Although significant confinement will dramatically increase the flow velocities and erosion potential, sediment transport rates are expected to be relatively small in the coarse material reach downstream of the North Beardsley Wash as compared to the upper sand/gravel reach. Since the flow velocity and width are relatively uniform (see Figures 3.3 and 3.4), it is expected that this reach will be relatively stable except for local area deposition and scour described in the following paragraphs.

The confluence area upstream of Bell Road, which has a very low velocity and significant sediment loading, may be subject to sedimentation. Conversely, the reach near Union Hills Road Bridge, which has finer materials and higher velocities, may be subject to erosion. Erosion may occur at the downstream end (Station 13+00 to 22+00) where channel width is reduced and flows are suddenly confined to a narrow channel. The lower reach in the WestWorld retention basin, which has very mild channel gradients and velocities, will be subject to sedimentation. It is expected there would be new sand and gravel deposition due to sand and gravel supply from the upstream reaches. However, low-flow erosion and migration and the formation of braided channels within the levee/wall containment area will be inevitable.

5.3 Methodology for Sediment Transport Computations

The sediment transport analysis utilized the Meyer-Peter, Muller's (MPM) bed load function combined with the modified suspended load Einstein procedure to determine the total sediment load. The analysis was conducted to evaluate the relative sediment transport rates and volumes for each reach. A detailed description of sediment transport equations and validation using the USGS measurements is included in the technical addendum. The following USGS data were used to verify the SLA sediment transport equations.

1. Salt River at 24th Street, Arizona (Gaging Station 095121900), January 9 to March 26, 1992

2. Colorado River above Little Colorado River, Arizona (09383100), July 12 to December 13, 1983

3. Rillito Creek Basin, Alamo Wash at Glenn Street, Arizona (09485570), February 25, 1987 to January 6, 1992

4. Calleguas Creek at Camarillo State Hospital Access Road, California (11106550) 1969 to 1978

5. Santa Clara River at Montalvo, California (11114000), 1969 to 1978

5.4 STEADY STATE (LEVEL II) ANALYSIS

5.4.1 Sediment Inflows - Tributaries

Sediment inflows from the tributaries have a significant effect on the sedimentation characteristics of the main channel. A detailed sediment inflow analysis was performed for each of the five tributaries using the hydraulic data and soils information obtained in Chapters III and IV (see Table 3.4 and Figure 4.3). A Level II analysis was performed to determine the sediment transport characteristics of the tributaries. The Meyer-Peter, Muller's bed load function combined with the modified Einstein suspended load procedure was used for both main channel and tributaries to determine the total bed material loads. Sediment transport capacities were computed for various flood events and a sediment discharge versus water discharge (Q_s vs. Q) relationship was derived for each tributary as shown in Figure 5.1. From the tributary sediment inflow relationships, a regression analysis was performed. Table 5.1 lists the "a" and "b" coefficients for each tributary developed from the regression equation, $Q_s=a*Q_w{}^b$. The results of the regression analysis for tributaries are used as the input data to the Level II analysis for the main channel. Level II analysis for the main channel is discussed in Section 5.4.2.

Sediment inflow hydrographs from each tributary were computed using the 100-year flow hydrograph and the sediment discharge versus water discharge relationship for each tributary. These sediment inflow hydrographs are shown in Figure 5.2. These sediment inflow hydrographs were used for sediment continuity analyses presented in Section 5.4.2 and sediment routing through the proposed channel in Section 5.5.

5.4.2 Main Channel

The sediment transport characteristics of the Reata Pass/Beardsley Wash channel were evaluated for the ultimate levee encroachment conditions. The erosion and sedimentation trends along the study reach were predicted by performing a steady state (or fixed bed) sediment continuity analysis for various flood peak discharges. The analysis computes the sediment inflow and outflow rates at the peak discharges

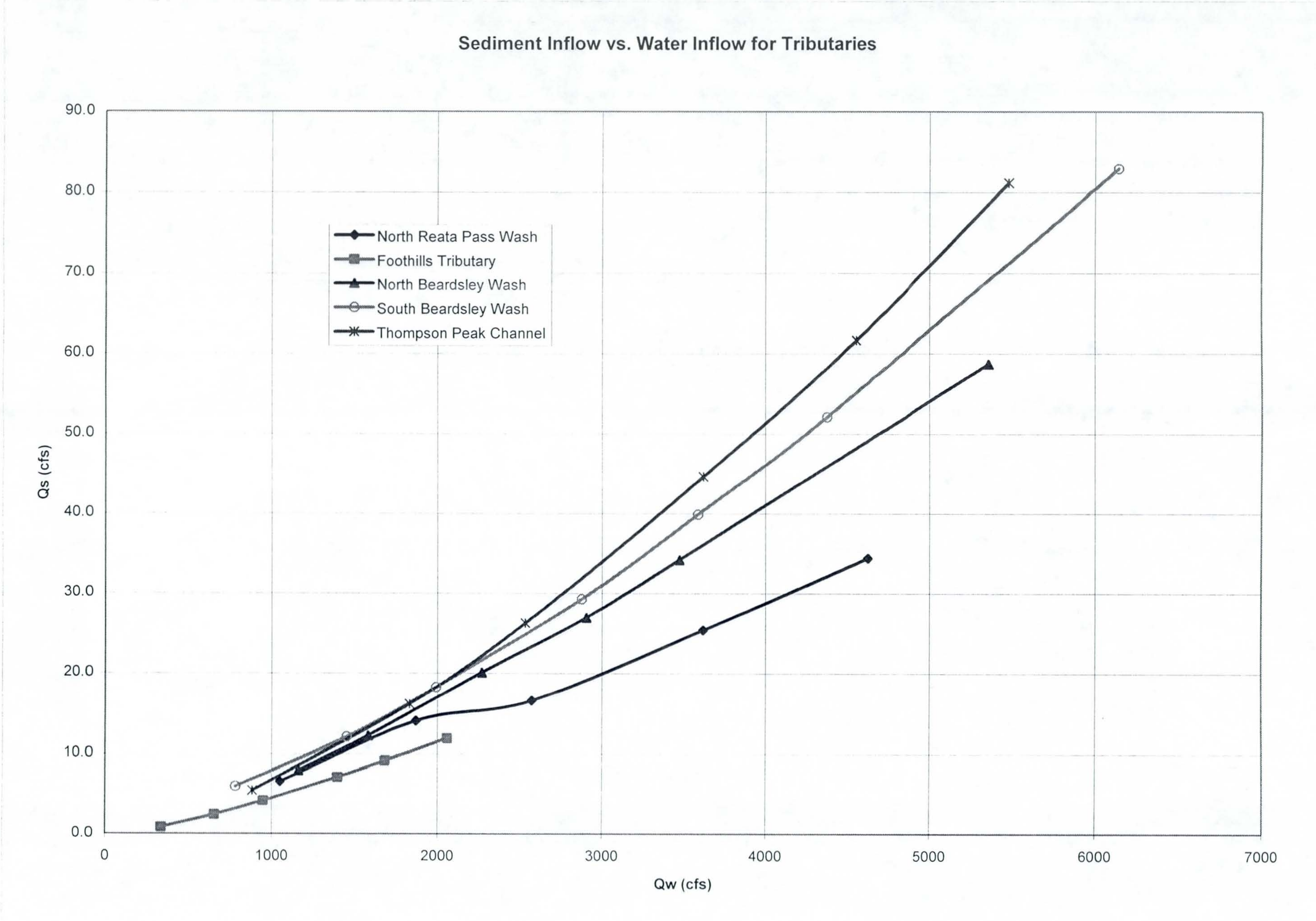


Figure 5.1: Q_s vs. Q Relationship for Tributaries

Table 5.1 Summary of Regression Analysis for Tributary Sediment Inflow Relationships

$$Q_s = a * Q_w^{\ b}$$

Tributary	a	b
North Reata Pass Wash	0.0029	1.11
Foothills Tributary	0.0002	1.44
North Beardsley Wash	0.0008	1.30
South Beardsley Wash	0.0011	1.28
Thompson Peak Channel	0.0002	1.48

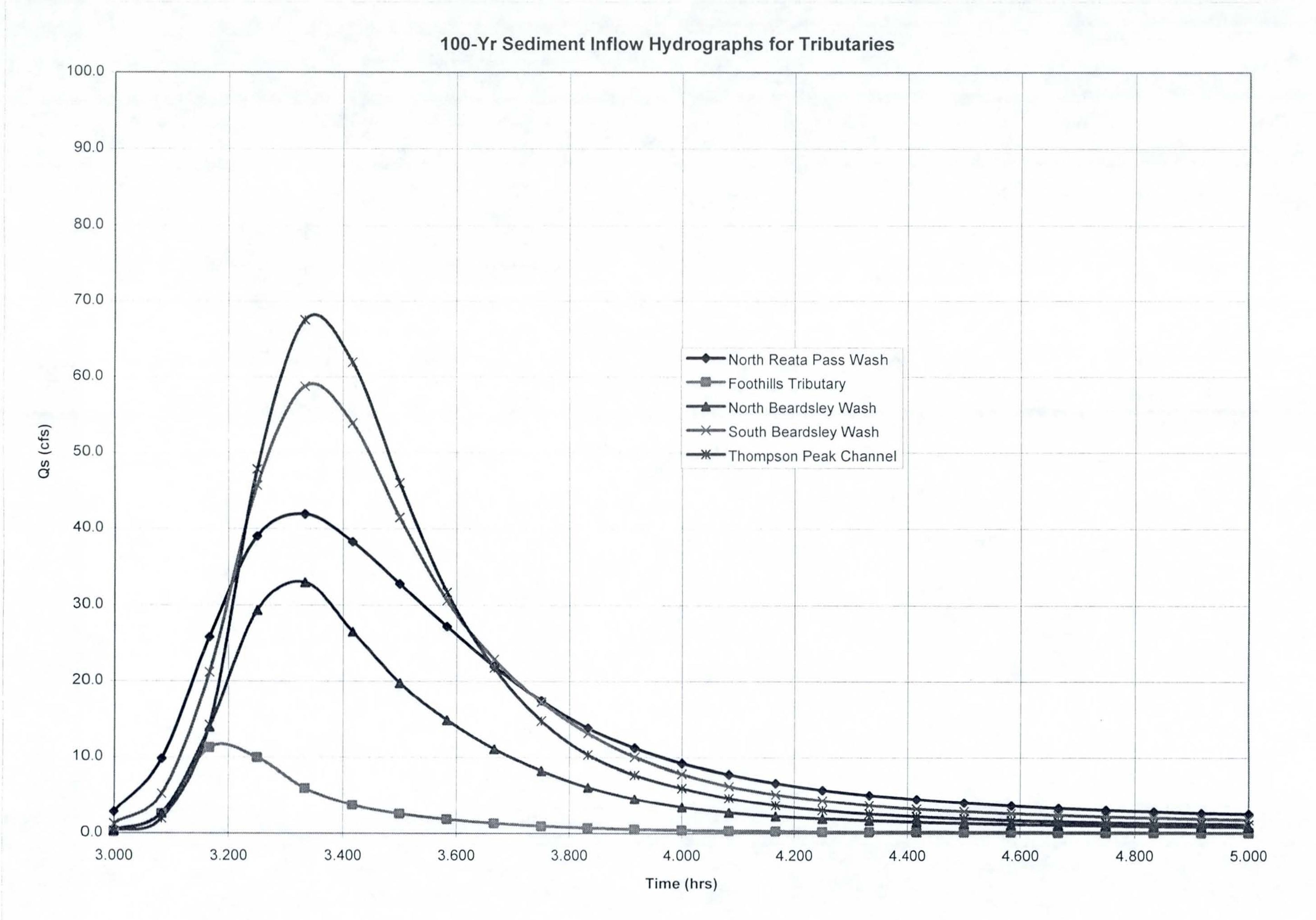


Figure 5.2: Sediment Inflow Hydrograph

of the various floods for the 27 reaches as defined in Figure 3.1. The results of the analysis were used to evaluate the aggradation/degradation potentials within each reach based on the sediment continuity principle.

The sediment flow transported out of one reach acts as the inflow to the next reach downstream. Channel degradation is expected in the reaches where the transport capacity exceeds the upstream supply. Conversely, channel aggradation is expected at reaches where the transport capacity is less than the sediment inflow.

The MPM-Einstein sediment transport equation introduced in Section 5.3 was used to compute sediment transport capacities. The hydraulic parameters and soils data for each subreach were obtained using the information shown in Tables 3.3 and 3.4 and Figures 4.1 and 4.2. Note that the effective width and thalweg depth were used for sediment transport rate computation, but the movable bed extends across the entire flow width with the exception of the grade control areas. Figure 5.3 shows the sediment transport capacities for a 100-year flood along the study reach. Figure 5.4 shows the results of sediment continuity analysis based on Figure 5.3 and sediment inflow from all tributaries. This was to illustrate the relative magnitudes and trends of aggradation/degradation for each subreach. The same procedures were performed for the 2-, 5-, 10-, 25-, and 50- year floods to observe the channel response to various flood levels. Figures 5.5 and 5.6 compares the sediment transport characteristics of the proposed channel for a 100-year flood to floods with return periods smaller than 100-year. It is concluded from the analysis that the degradation/aggradation characteristics throughout the study area remain the same for low, medium, and high floods.

Based on Figures 5.4 and 5.6, a summary table of aggradation/degradation trends was prepared as shown in Table 5.2 for reference. Significant degradation potential is expected for the following reaches

- Reaches 5 and 6 (uppermost confined reach from downstream of Pinnacle Peak Road Bridge to Foothills Tributary)

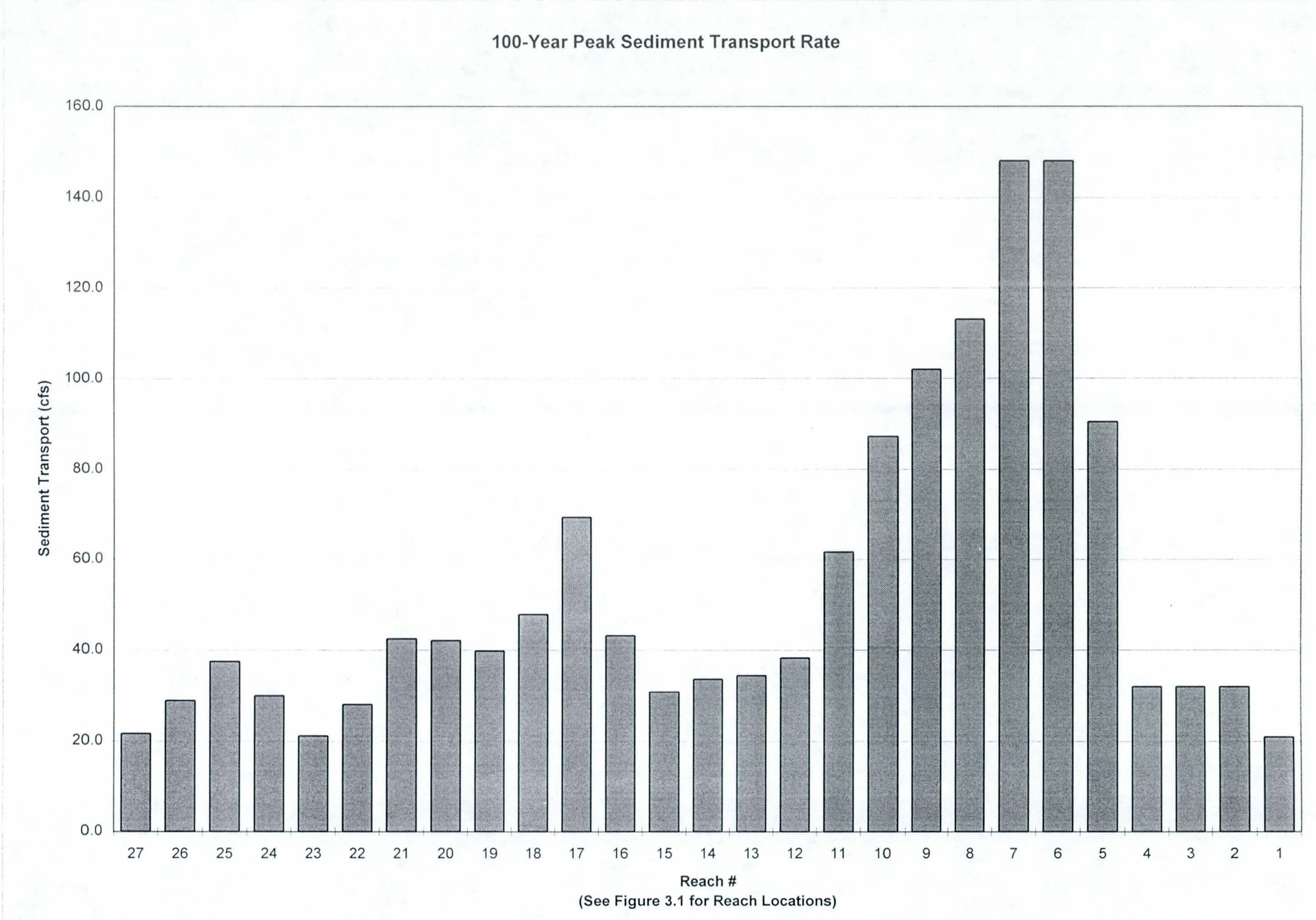


Figure 5.3: Reata Pass/Beardsley Wash 100-Year Sediment Transport Rates

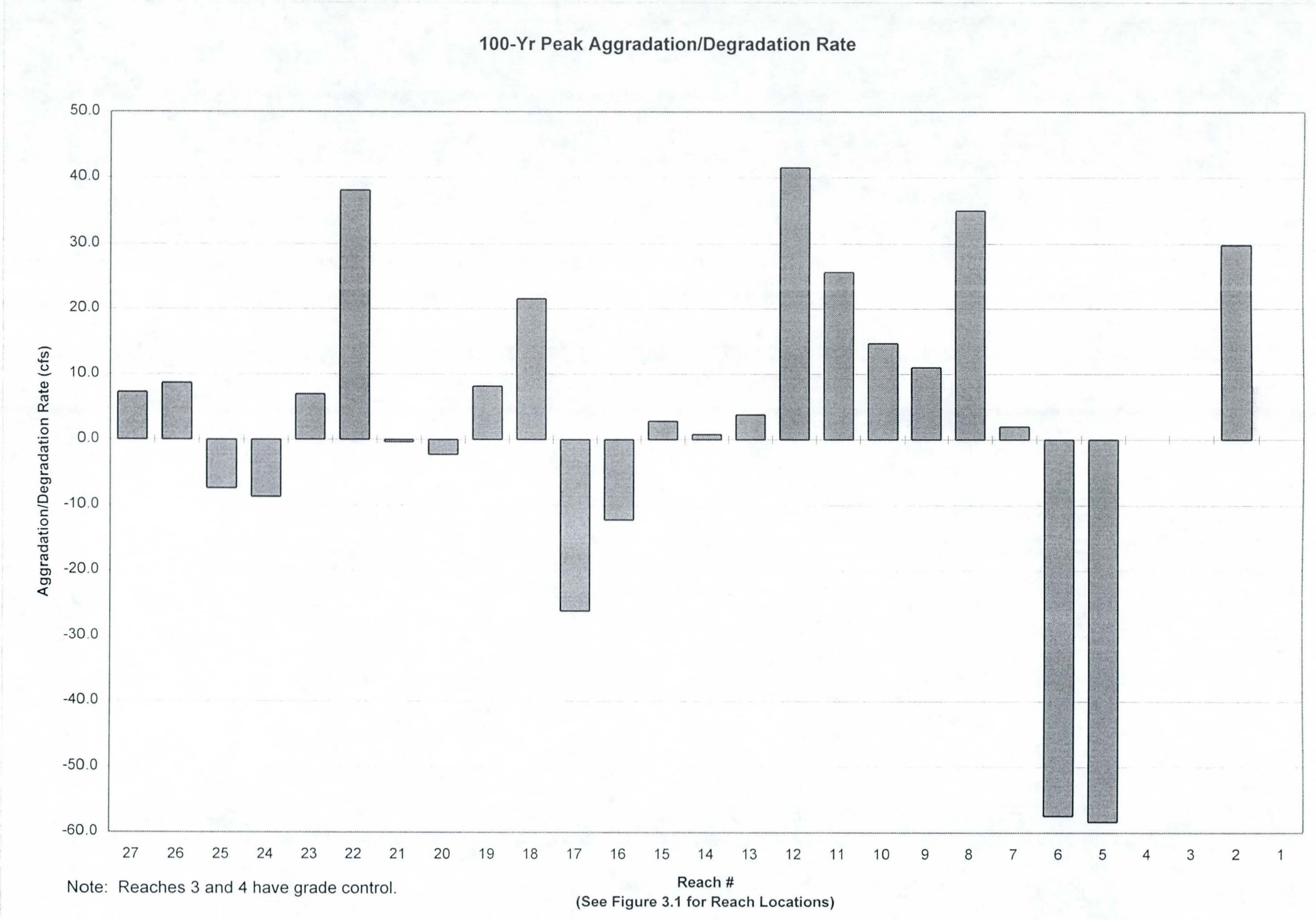


Figure 5.4 Reata Pass/Beardsley Wash 100-Year Aggradation/Degradation Rate

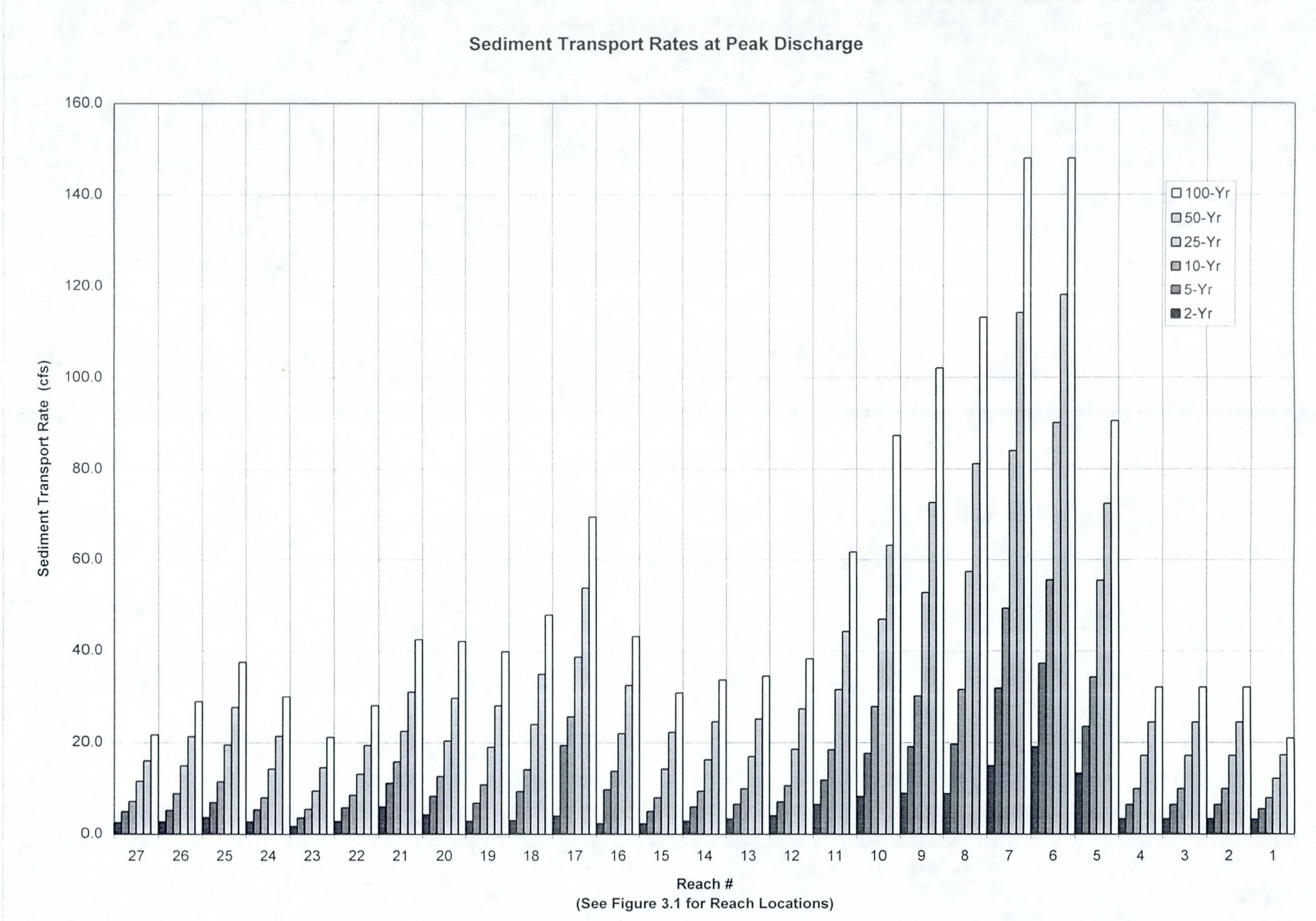


Figure 5.5 Reata Pass/Beardsley Wash 100-Year Sediment Transport Rate Compared with Smaller Floods

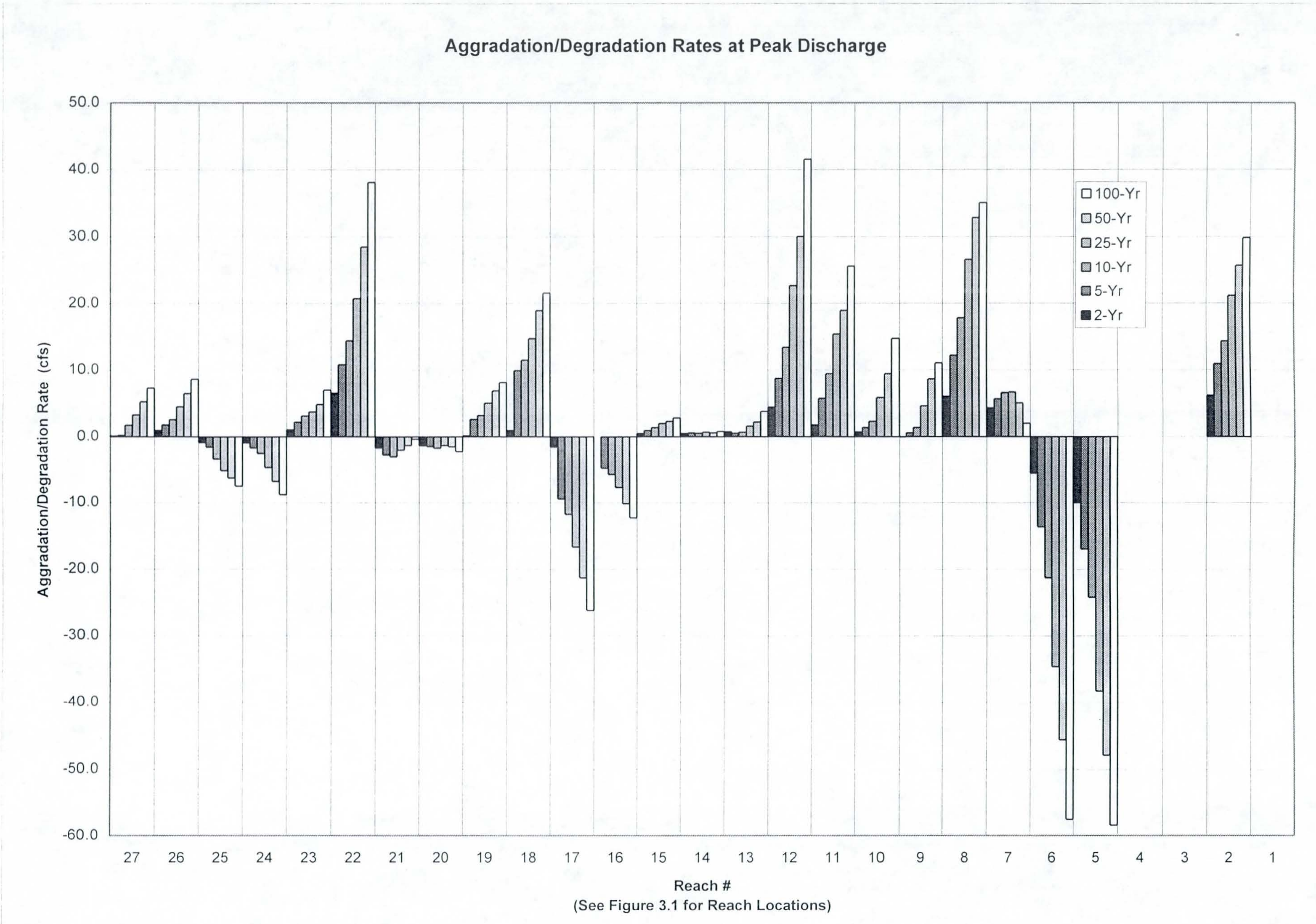


Figure 5.6 Reata Pass/Beardsley Wash 100-Year Aggradation/Degradation Rate Compared with Smaller Floods

Table 5.2. Potential Short-Term Aggradation/Degradation Trends

Reach Number*	Station		Aggradation/Degradation Trend
	From	To	
1	316.50	291.00	Supply Reach
2	291.00	279.03	Significant Aggradation
3	279.03	276.48	Minimal Change - Grade-Control
4	276.48	268.50	Minimal Change -Concrete Invert/Caliche Layer/Grade Control
5	268.50	258.75	Significant Degradation
6	258.75	241.90	Significant Degradation
7	241.90	231.75	Slight Aggradation
8	231.75	213.75	Significant Aggradation
9	213.75	203.25	Aggradation
10	203.25	183.75	Aggradation
11	183.75	171.75	Aggradation
12	171.75	156.75	Significant Aggradation
13	156.75	143.25	Slight Aggradation
14	143.25	131.25	Slight Aggradation
15	131.25	111.75	Slight Aggradation
16	111.75	99.75	Degradation
17	99.75	95.25	Significant Degradation
18	95.25	74.25	Aggradation
19	74.25	66.75	Aggradation
20	66.75	57.75	Slight Degradation
21	57.75	47.25	Slight Degradation
22	47.25	42.78	Significant Aggradation
23	42.78	33.75	Aggradation
24	33.75	21.75	Degradation
25	21.75	11.25	Degradation
26	11.25	3.75	Aggradation
27	3.75	0	Aggradation

* See Figure 3.1 for Reach Locations.

- Reach 17 near the Union Hills Bridge (confined flow and steep slope)

Significant aggradation is expected for the following reaches:

- Reach 22 near Bell Road, where South Beardsley Wash and Thompson Peak Channel confluence with the proposed Reata Pass Wash (channel gradient is relatively flat).

- Reaches 26 and 27, where the channel enters the WestWorld detention basin (these reaches have a limited channel conveyance and significantly reduced channel gradient).

5.4.3 Hydrologic Scenarios

As mentioned previously, the hydrologic analysis shows that peak discharges along the study reach occur over a 20-minute time period. The sediment transport analysis shown in the previous sections assumes peak discharges occur along the study reach at the same time. Sediment transport characteristics of the channel were further evaluated by comparing the following three scenarios:

1) Peak discharges occur at all concentration points along the channel.

2) Concurrent discharges when the upper reach and most tributary flows are at peaks (time 3.33 hours).

3) Concurrent discharges when the downstream channel flow is a peak (time 3.67 hours).

The discharges at various concentration points for the three scenarios as shown in Figure 2.5 were used to compute hydraulic and sediment transport capacities for each subreach. Figure 5.7 shows the comparison of the 100-year sediment transport capacities for each scenario. Figure 5.8 shows a comparison of the computed

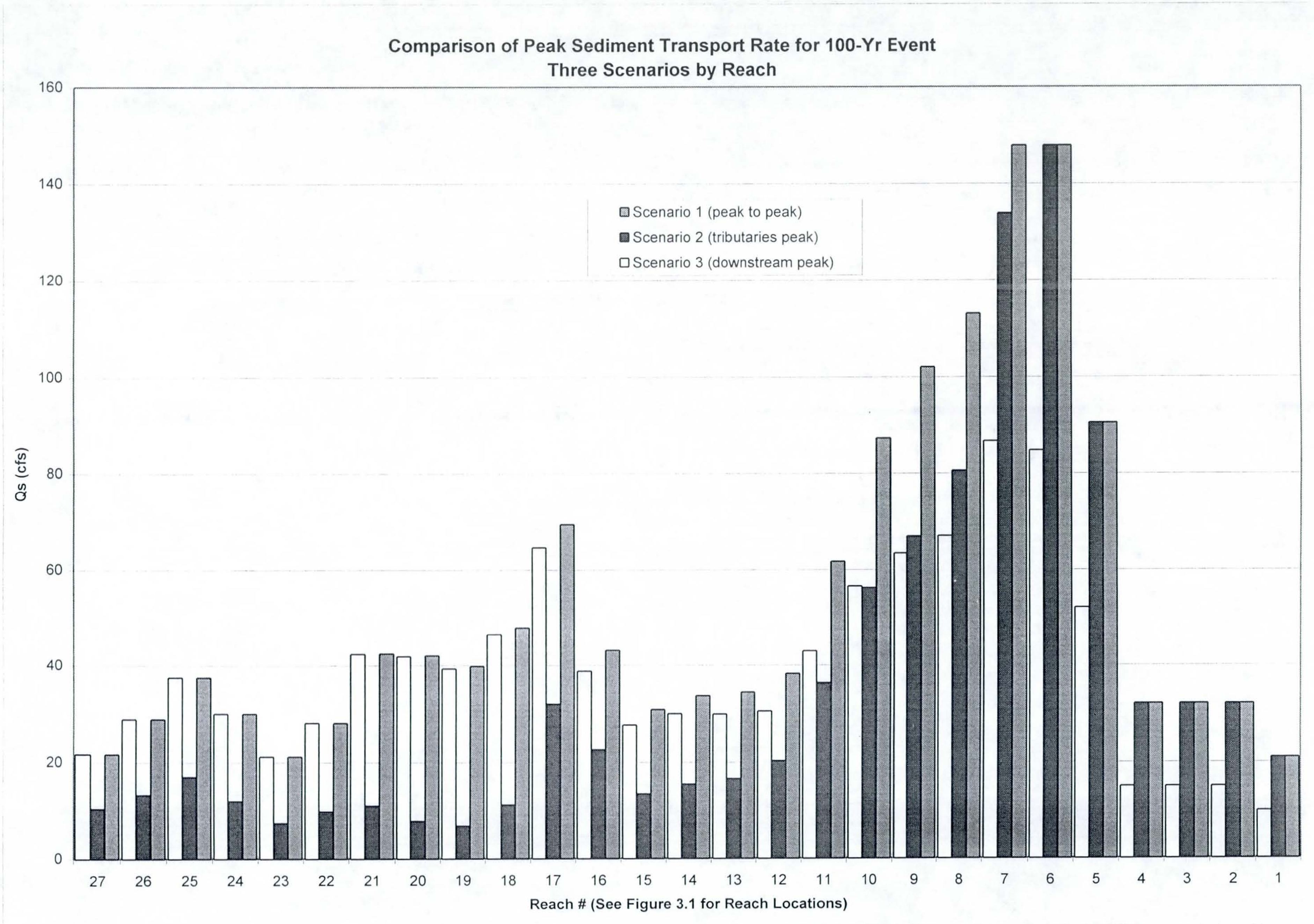


Figure 5.7: Comparison of Scenarios 1, 2, and 3 Sediment Transport Rates

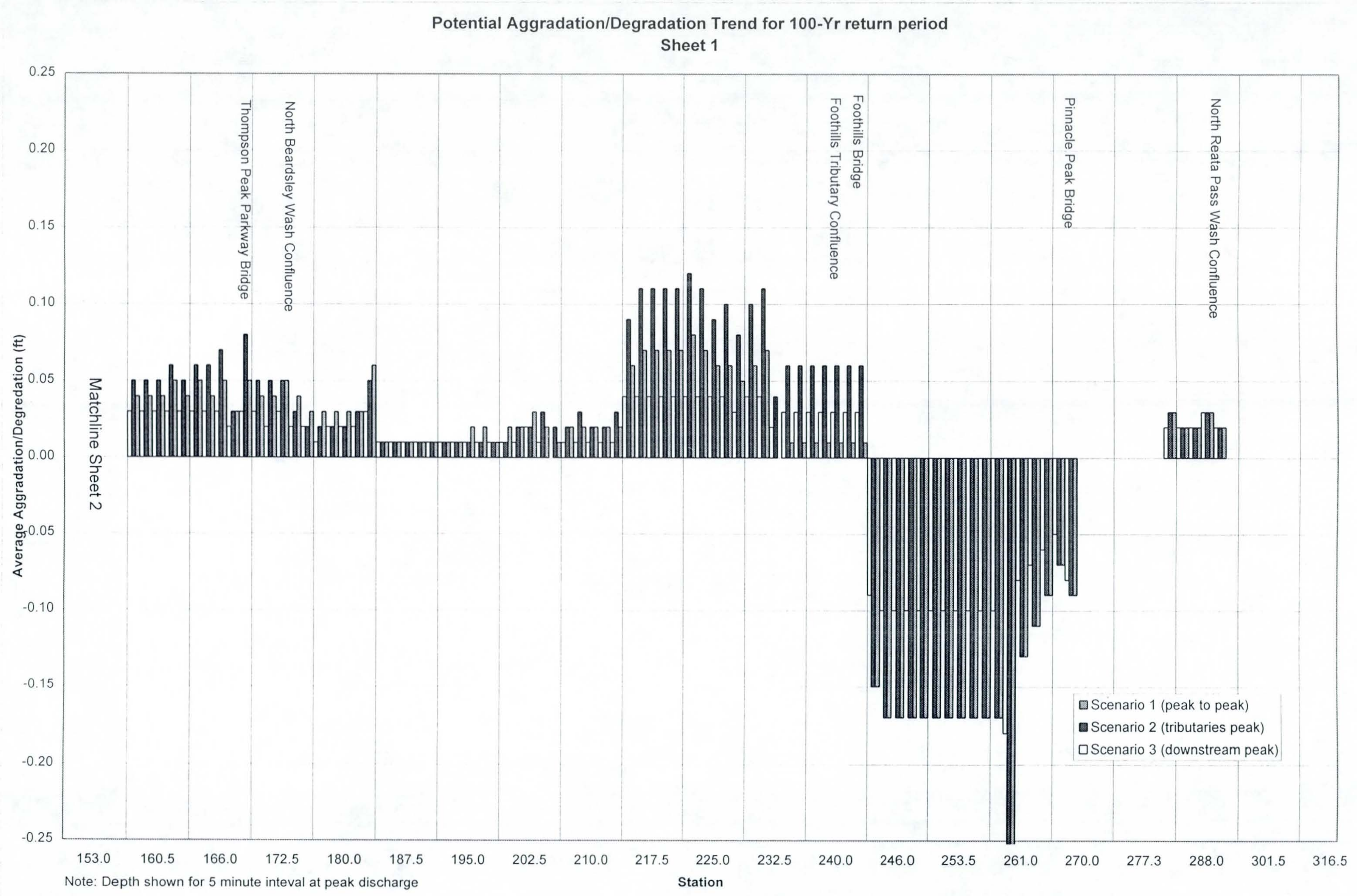


Figure 5.8: Comparison of Scenarios 1, 2, and 3 Potential Aggradation/Degradation Depths

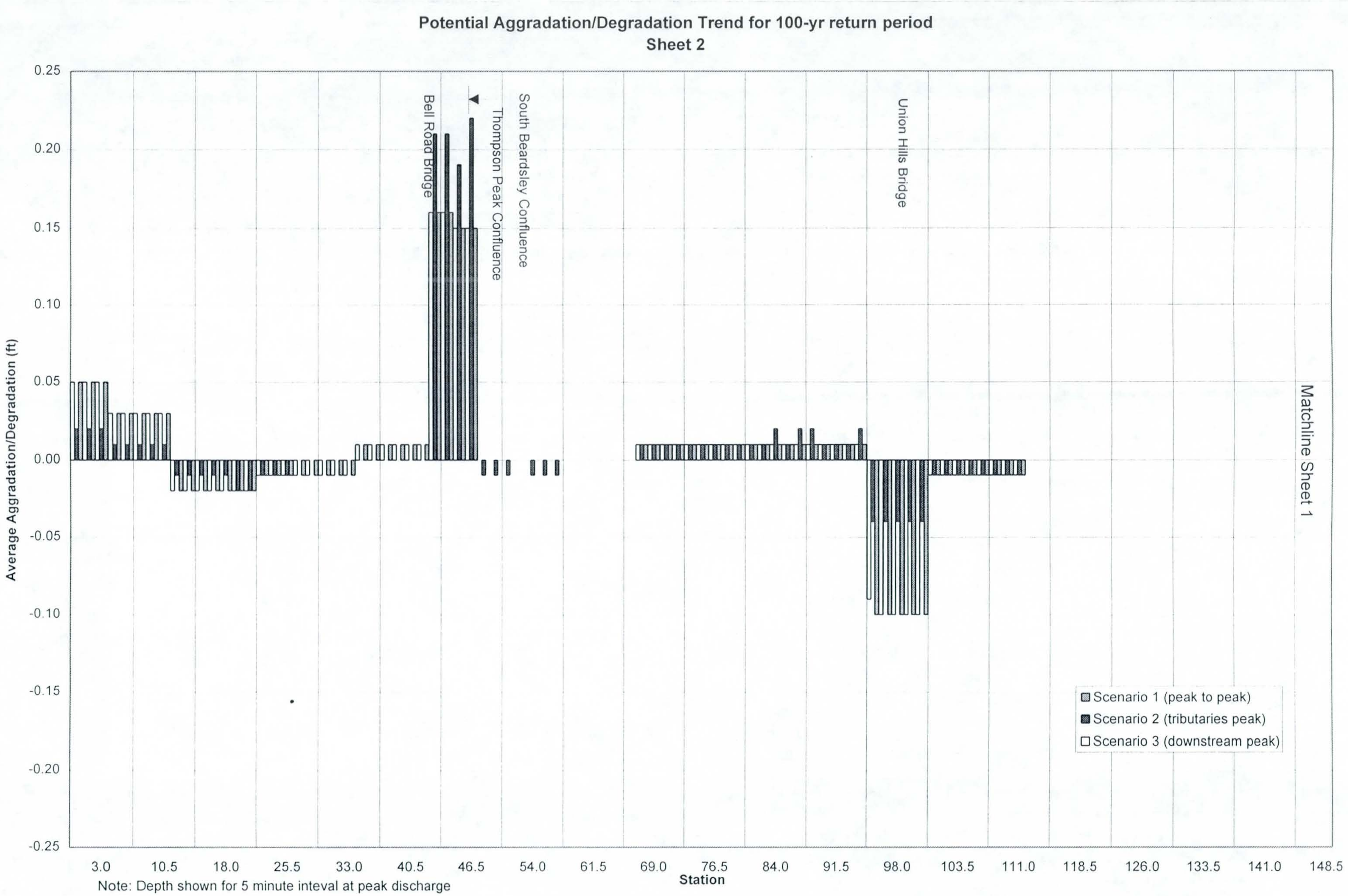


Figure 5.8: Comparison of Scenarios 1, 2, and 3 Potential Aggradation/Degradation Depths (continued)

average aggradation/ degradation depths (for five-minute intervals) for each scenario. The difference in erosion/sedimentation trend is minor for the three scenarios, but the magnitudes vary between scenarios, depending on the reach locations. Scenario 2, considering flood peaks to occur in the upper reach and major tributaries, shows slightly greater magnitude in aggradation compared to the other scenarios. In general, Scenario 2 results in higher sediment transport rates, while Scenario 3, where the downstream reach is at peak discharge, would result in the lowest magnitude in aggradation/degradation depths. In the areas with aggradation concern, such as near the Bell Road Bridge, determination of the levee height and maintenance requirement must take into account the higher aggradation magnitude at the flood peaks of South Beardsley Wash and the Thompson Peak Channel. This is further discussed in Chapter VII.

5.5 QUASI-DYNAMIC STATE (LEVEL III) ANALYSIS HEC-2SR

A quasi-dynamic sediment routing model, HEC-2SR, was developed by SLA to determine potential erosion and sedimentation occurring in the study area (Level II to detailed simulation of analysis). A quasi-dynamic sediment routing model was prepared for the 100-year and the 10-year flood events. The model utilizes the same sediment transport equations described in the Level II analysis. The Level III analysis differs from the Level II analysis primarily because the HEC-2SR model computes the erosion and sedimentation depths over the entire hydrograph with the channel geometry, hydraulics, and bed material data updated at the end of each discretized time step.

The HEC-2SR model requires the following input data:

1. Computation Reach Definitions

   There are 27 reaches defined over the distance of six miles; each reach has similar hydrologic, hydraulic, and soils features. The reaches were defined previously in Figure 3.1. For detailed analysis of channel response at each cross-section, a separate model was prepared using each cross-section as a reach except for bridge and grade control areas. The cross-sections near the bridges were considered as one reach.

2. Bed Material Size Distributions

There are five separate bed material size distributions defined over the entire study reach as shown in Figures 4.1 and 4.2. This information was used as the soils data for each computation reach according to its location relative to the representative soils. Chapter IV describes in detail the soils characteristics, sample locations, and gradation analysis.

3. Flow Hydrograph

Discretized hydrographs were prepared for each concentration point in the study area described in Chapter II for the 100-year and the 10-year flood analysis. A typical 100-year unified, discretized hydrograph for downstream reaches is shown in Figure 5.9. An approximate 20-minute lag time of flow from upstream to downstream was observed from the results of the hydrologic analysis as shown in Figure 2.2. Attenuation of flood peaks and approximately five-minute lag in flood peak time occur from Foothills to immediately upstream of the North Beardsley Wash confluence and from the North Beardsley Wash confluence to Union Hills Road. These features were modeled in sediment routing by using representative hydrographs for each reach (see Table 2.1 and Figure 2.2).

4. Sediment Inflow Relationships

The sediment discharge versus flow discharge (Q_s vs Q) relationships were provided as input data to obtain the sediment inflow hydrographs from each tributary. This information was described in Table 5.1 and Figure 5.2.

5. Hydraulic Data

The hydraulic data were provided through backwater computations using the HEC-2 model. The supercritical/subcritical, mixed-flow hydraulic characteristics of the main channel were simulated in the model and the results were used for sediment transport computations. The channel bed elevations for each cross-section (GR card) were updated in the model at the end of each time step defined in the

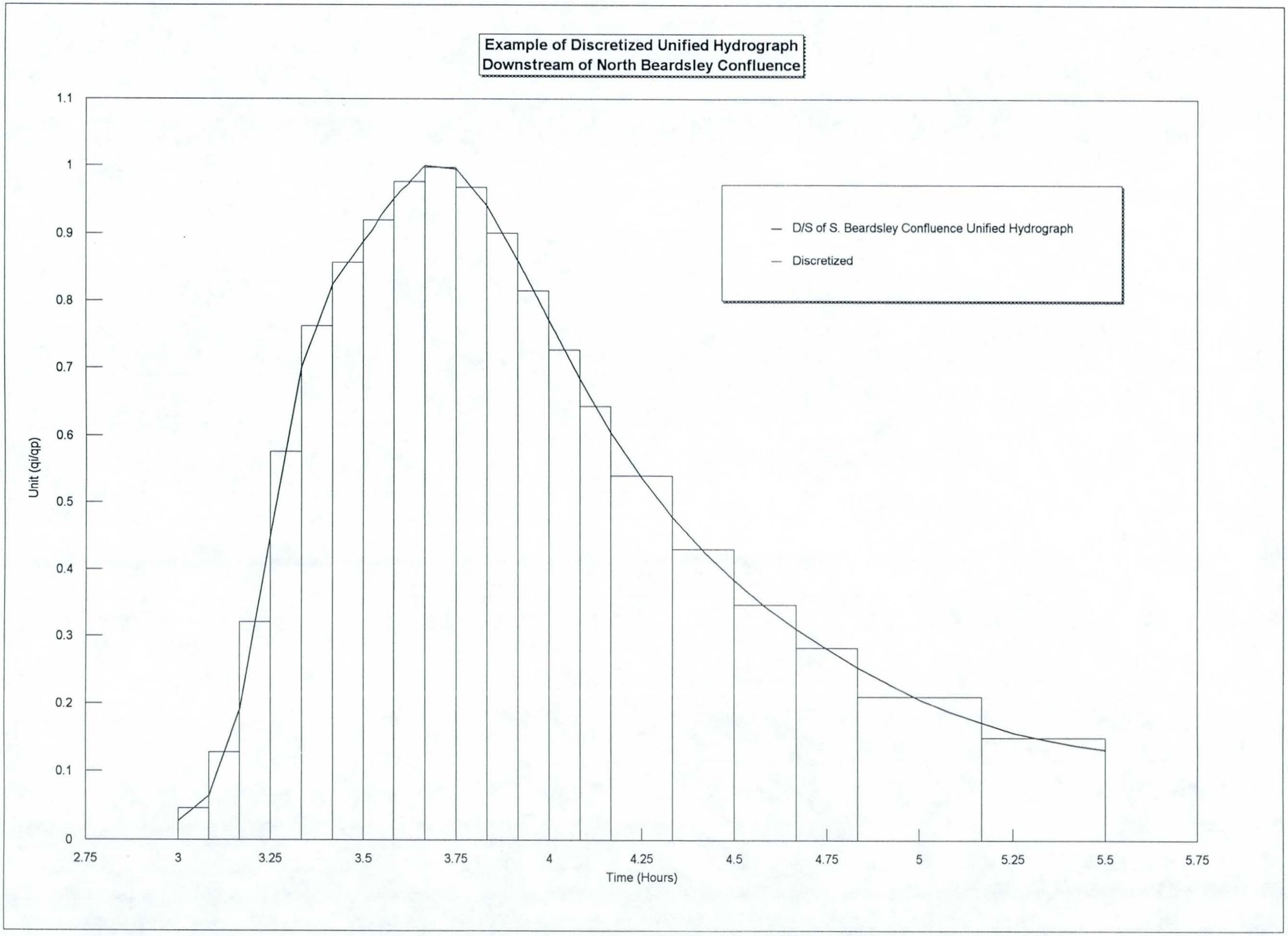


Figure 5.9 Typical Discretized Hydrograph

discretized hydrograph. The new HEC-2 data were used for routing in the subsequent time step.

Sediment routing models were prepared for 100-year flood and 10-year flood events. The average degradation and aggradation depths for the 27 reaches throughout the 100-year and 10-year storm are shown in Figure 5.10. Tables 5.3 and 5.4 show more detailed information on sediment inflow, outflow, volume change, and average depth change in each of the 27 reaches. This inormation was used to understand the depth and volume magnitude of channel changes within each subreach. Bbased on Figure 5.10, the aggradation/degradation trend for a 100-year flood is similar to a 10-year flood. The aggradation/degradation trend is also consistent with the qualitative and Level II analysis. A before and after 100-year flood thalweg profile is shown in Figure 5.11, resulting from detailed routing by section. Typical channel cross-sections illustrating before and after a 100-year flood are shown in Figure 5.12. The scour or deposition volume was distributed over each routing reach between each consecutive cross section, and the average scour or deposition area was then distributed over each cross-section based on flow area weighting. The maximum aggradation/degradation depths relative to thalweg for the 100-year and the 10-year flood events are presented in Figures 5.13 and 5.14, respectively. The maximum degradation depths are 5 to 7 feet near Station 280+00 (grade control), Station 260+00 (downstream of existing fan apex), Station 206+00 (divided island), and Station 22+00 (confined low-flow). Aggradation depths exceed three feet near Bell Road and downstream of the North Beardsley Wash confluence.

It should be noted that the average aggradation/degradation depths shown in Table 5.3 and Figure 5.10 better represent the magnitude of the overall channel response within a subreach, since the channel geometry is very irregular (Figure 5.12), and the section-by-section routing results shown in Figure 5.13 may overstate the average response of the subject reach. However, the section-by-section model results will be used for toe-down evaluation along the proposed levee alignment to address local protection requirements. Detailed results of the Level III analysis are included in the technical addendum.

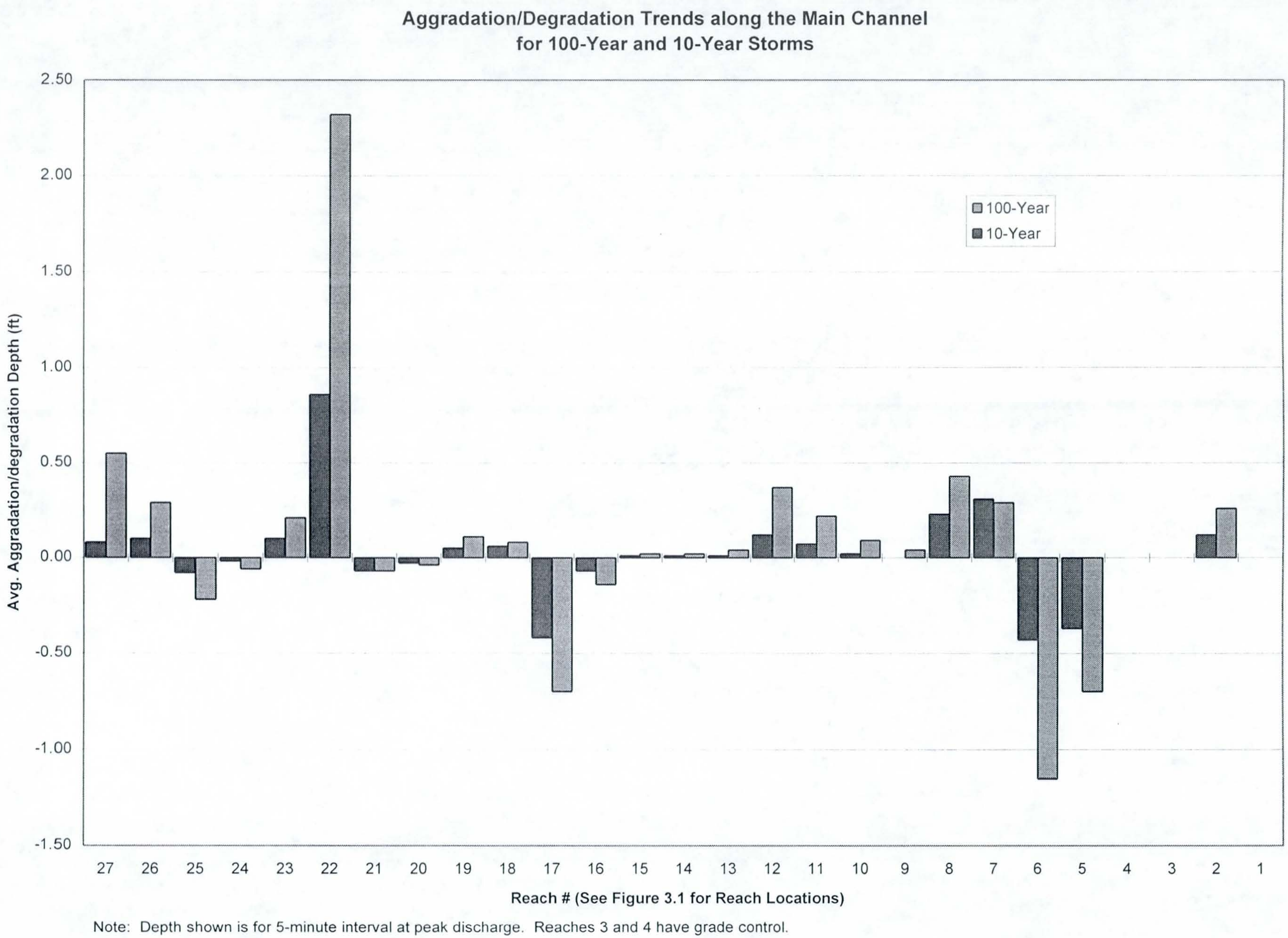


Figure 5.10: Average Aggradation/Degradation Depths for 100-Yr and 10-Yr Floods

Table 5.3. Sediment Routing Results - Volume Change and Potential Average Aggradation/Degradation Along Each Reach Short-Term Response for 100-Year Flood Event

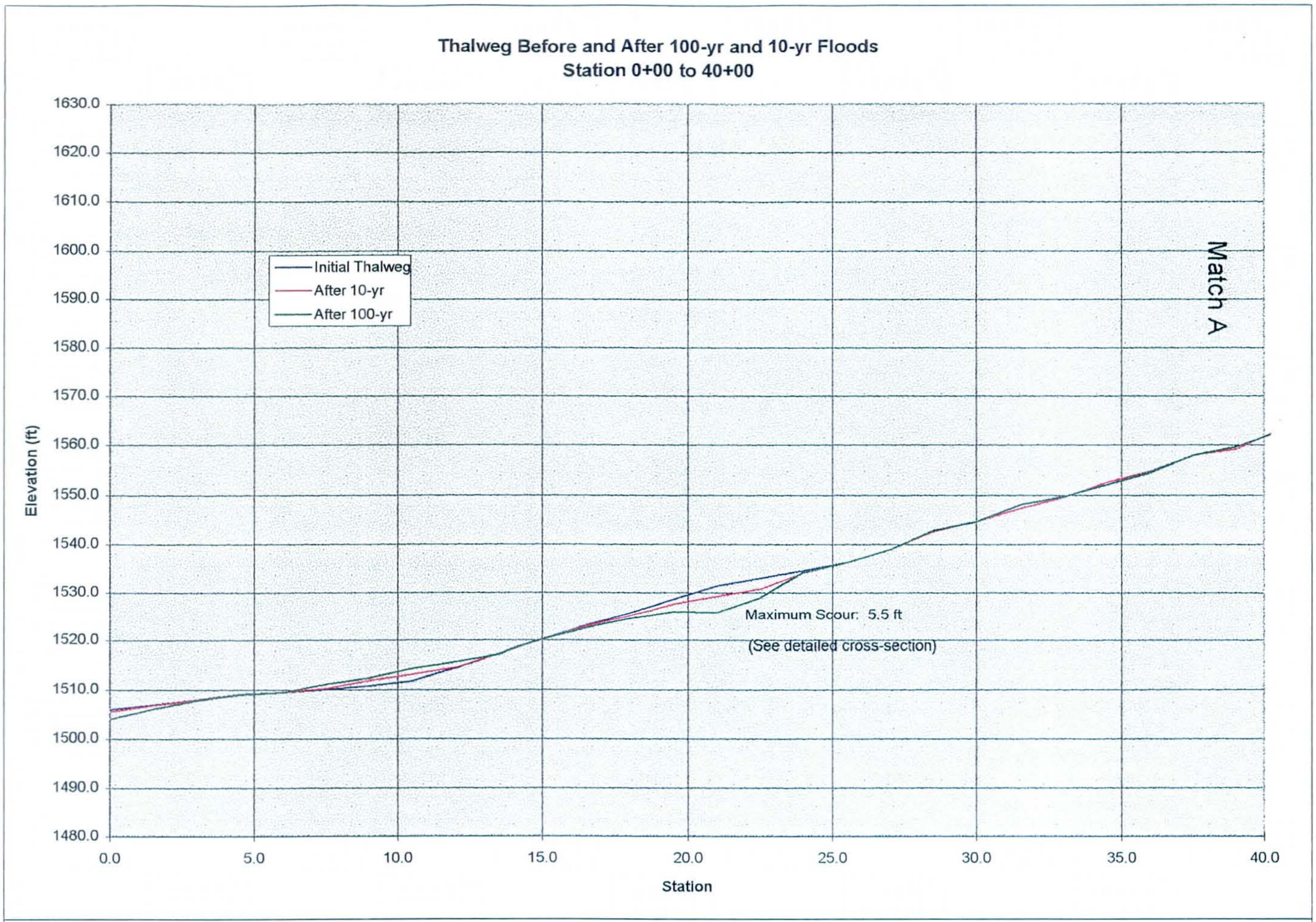
Reach Number*	Volume in (CY)	Volume out (CY)	Volume Change (CY)	Reach Length (ft)	Average Width (ft)	Avg Agg/Deg Depth (ft)
1	2,922	2,922	0	2,550	323	0.00
2	9,578	4,315	5,263	1,197	454	0.26
3	4,315	4,315	0	255	155	0.00
4	4,315	4,315	0	798	116	0.00
5	4,315	10,890	-6,575	975	261	-0.70
6	10,890	17,840	-6,950	1,685	97	-1.15
7	19,110	17,770	1,340	1,015	121	0.29
8	17,770	13,716	4,054	1,800	141	0.43
9	13,716	13,282	434	1,050	284	0.04
10	13,282	11,830	1,452	1,950	232	0.09
11	11,830	8,790	3,040	1,200	306	0.22
12	12,874	6,344	6,530	1,500	316	0.37
13	6,344	5,441	903	1,350	503	0.04
14	5,441	5,042	399	1,200	374	0.02
15	5,042	4,473	569	1,950	465	0.02
16	4,473	6,731	-2,258	1,200	376	-0.14
17	6,731	9,953	-3,222	450	278	-0.70
18	9,953	7,362	2,591	2,100	415	0.08
19	7,362	6,236	1,126	750	363	0.11
20	6,236	6,921	-685	900	478	-0.04
21	6,921	7,845	-924	1,050	334	-0.07
22	17,351	7,305	10,046	447	262	2.32
23	7,305	5,099	2,206	903	316	0.21
24	5,099	6,177	-1,078	1,200	436	-0.06
25	6,177	7,588	-1,411	1,050	166	-0.22
26	7,588	6,012	1,576	750	195	0.29
27	6,012	4,678	1,334	375	175	0.55

* See Figure 3.1 for reach locations.

Table 5.4. Sediment Routing Results - Volume Change and Potential Average Aggradation/Degradation along each Reach Short-Term Response for 10-Year Flood Event

Reach Number*	Volume in (CY)	Volume out (CY)	Volume Change (CY)	Reach Length (ft)	Average Width (ft)	Avg Agg/Deg Depth (ft)
1	1,263	1,263	0	2,550	323	0.00
2	3,925	1,474	2,451	1,197	454	0.12
3	1,474	1,474	0	255	155	0.00
4	1,474	1,474	0	798	116	0.00
5	1,474	4,921	-3,447	975	261	-0.37
6	4,921	7,526	-2,605	1,685	97	-0.43
7	7,890	6,473	1,417	1,015	121	0.31
8	6,473	4,272	2,201	1,800	141	0.23
9	4,272	4,281	-9	1,050	284	0.00
10	4,281	3,870	411	1,950	232	0.02
11	3,870	2,853	1,017	1,200	306	0.07
12	4,180	1,987	2,193	1,500	316	0.12
13	1,987	1,683	304	1,350	503	0.01
14	1,683	1,496	187	1,200	374	0.01
15	1,496	1,276	220	1,950	465	0.01
16	1,276	2,418	-1,142	1,200	376	-0.07
17	2,418	4,382	-1,964	450	278	-0.42
18	4,382	2,430	1,952	2,100	415	0.06
19	2,430	1,893	537	750	363	0.05
20	1,893	2,333	-440	900	478	-0.03
21	2,333	3,178	-845	1,050	334	-0.07
22	6,130	2,378	3,752	447	262	0.87
23	2,378	1,340	1,038	903	316	0.10
24	1,340	1,767	-427	1,200	436	-0.02
25	1,767	2,315	-548	1,050	166	-0.08
26	2,315	1,788	527	750	195	0.10
27	1,788	1,604	184	375	175	0.08

* See Figure 1.3 for reach locations.



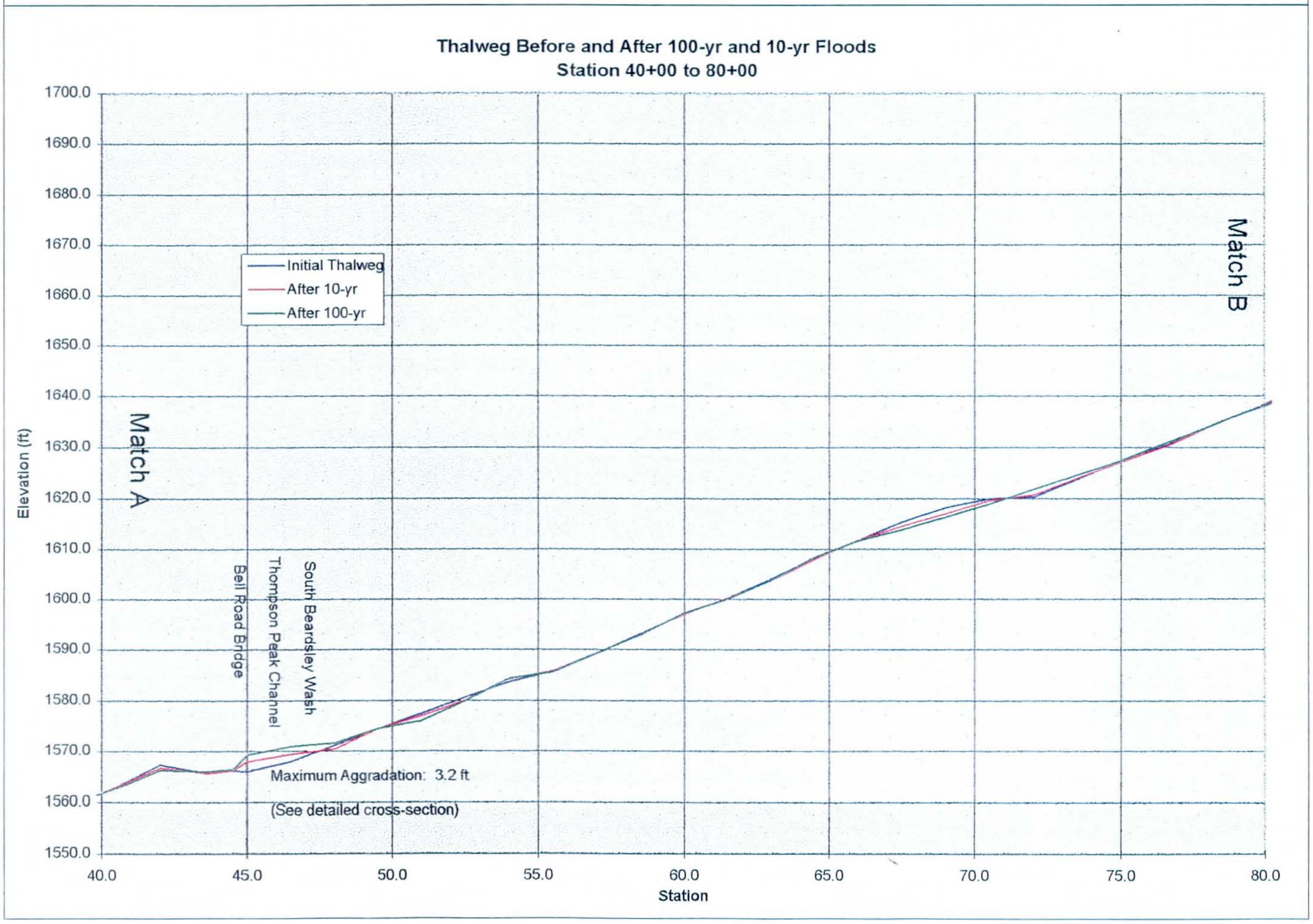
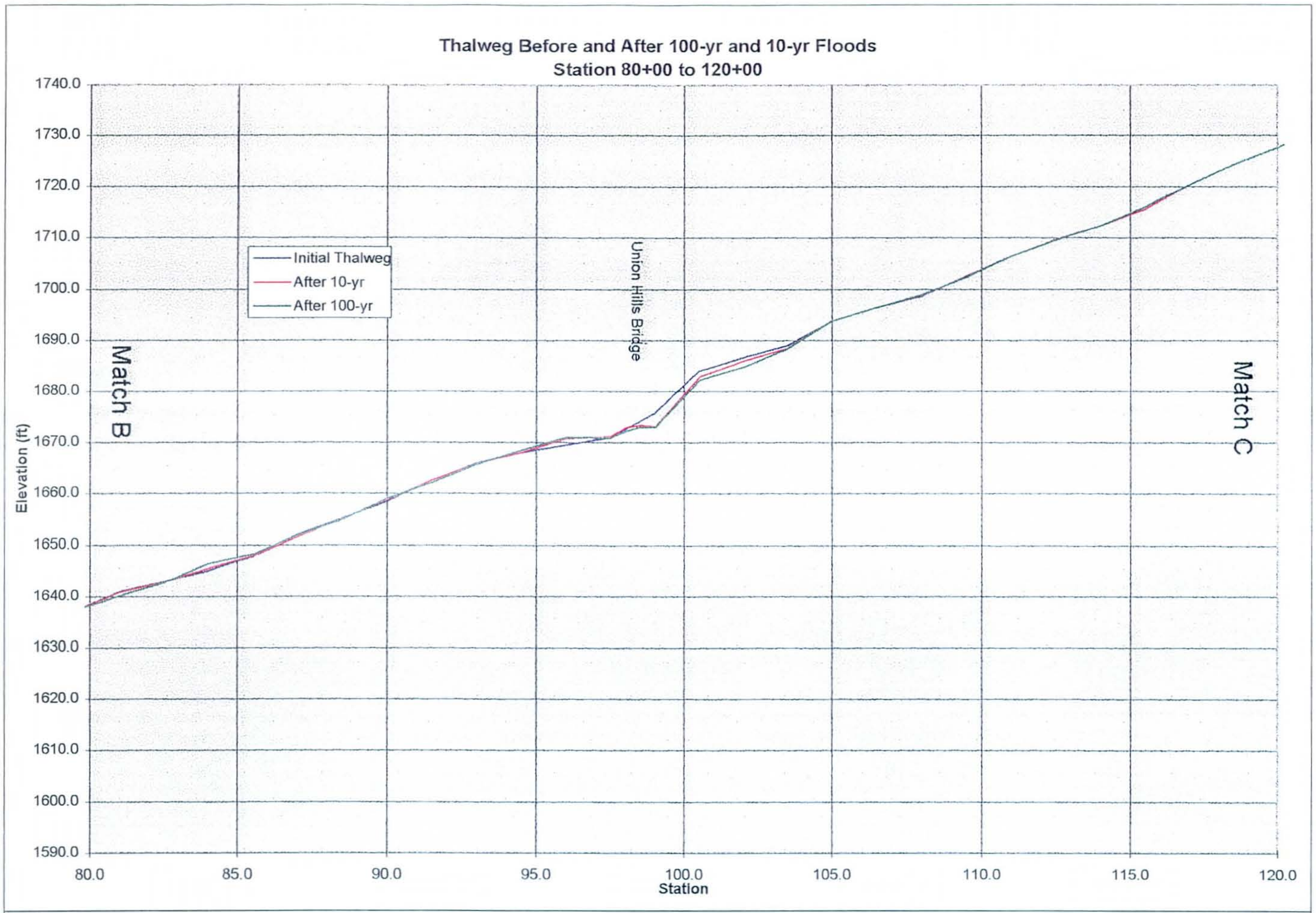


Figure 5.11: Comparison of Existing Thalweg before and after 100-Year Flood



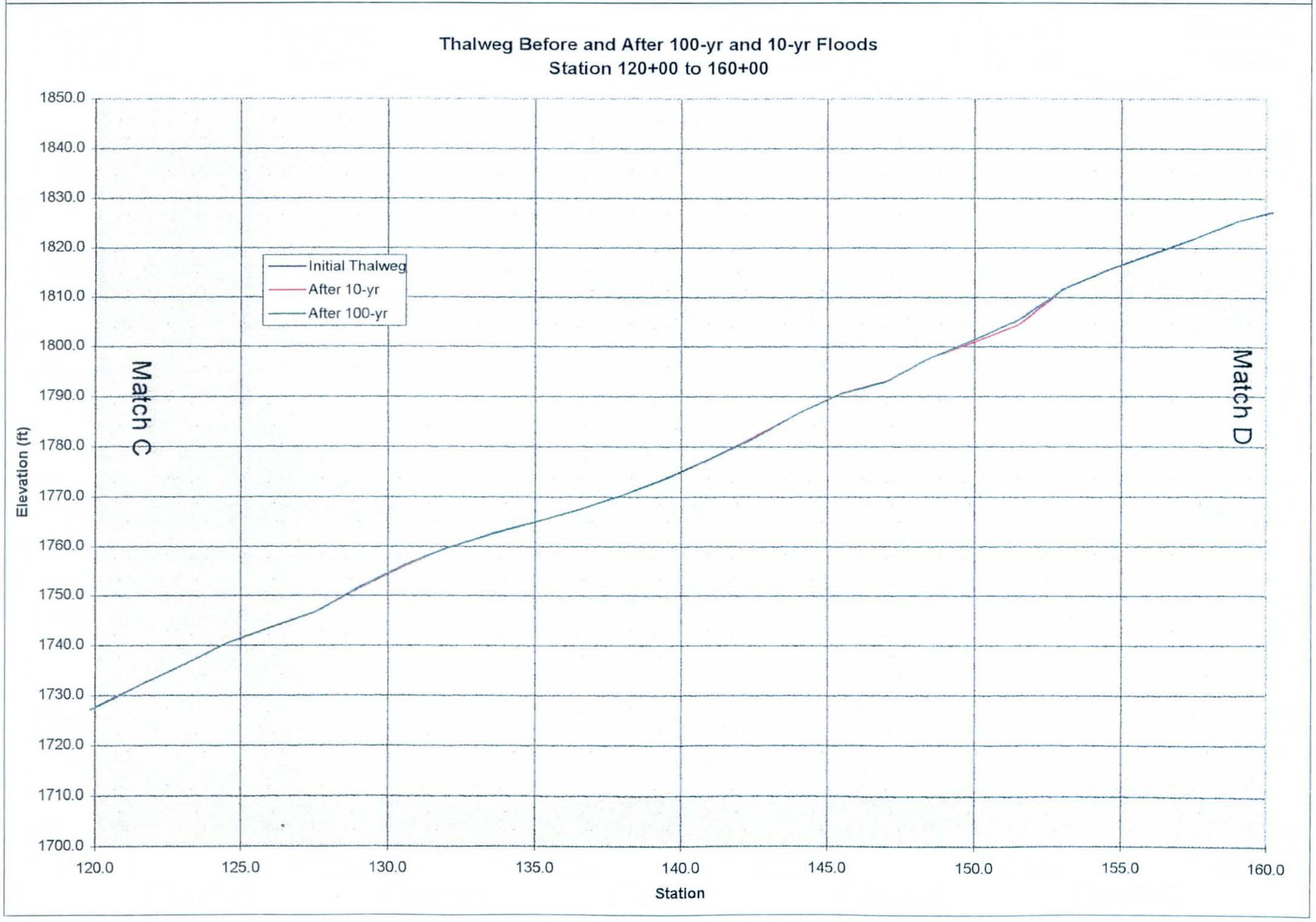
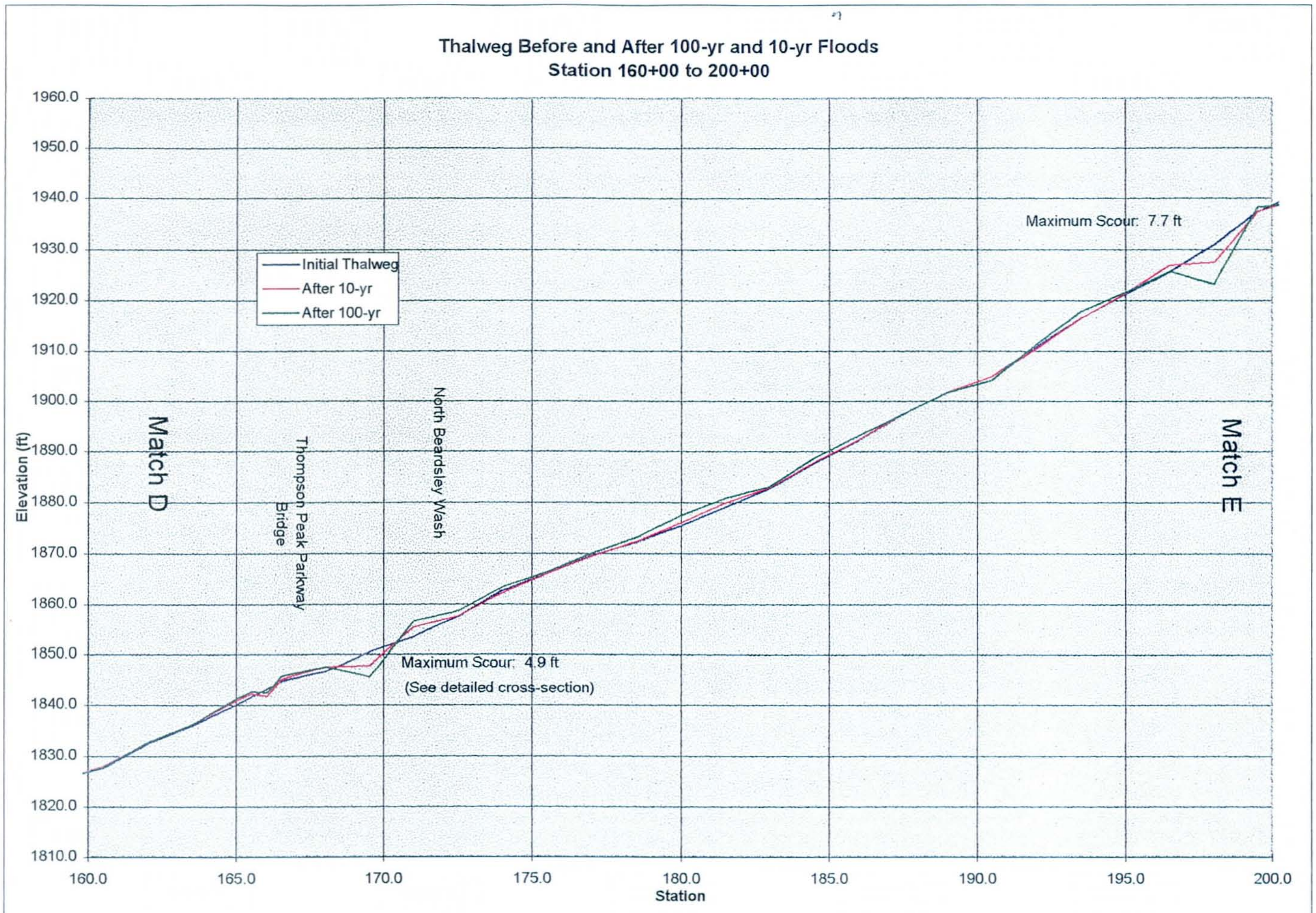


Figure 5.11: Comparison of Existing Thalweg before and after 100-Year Flood (continued)



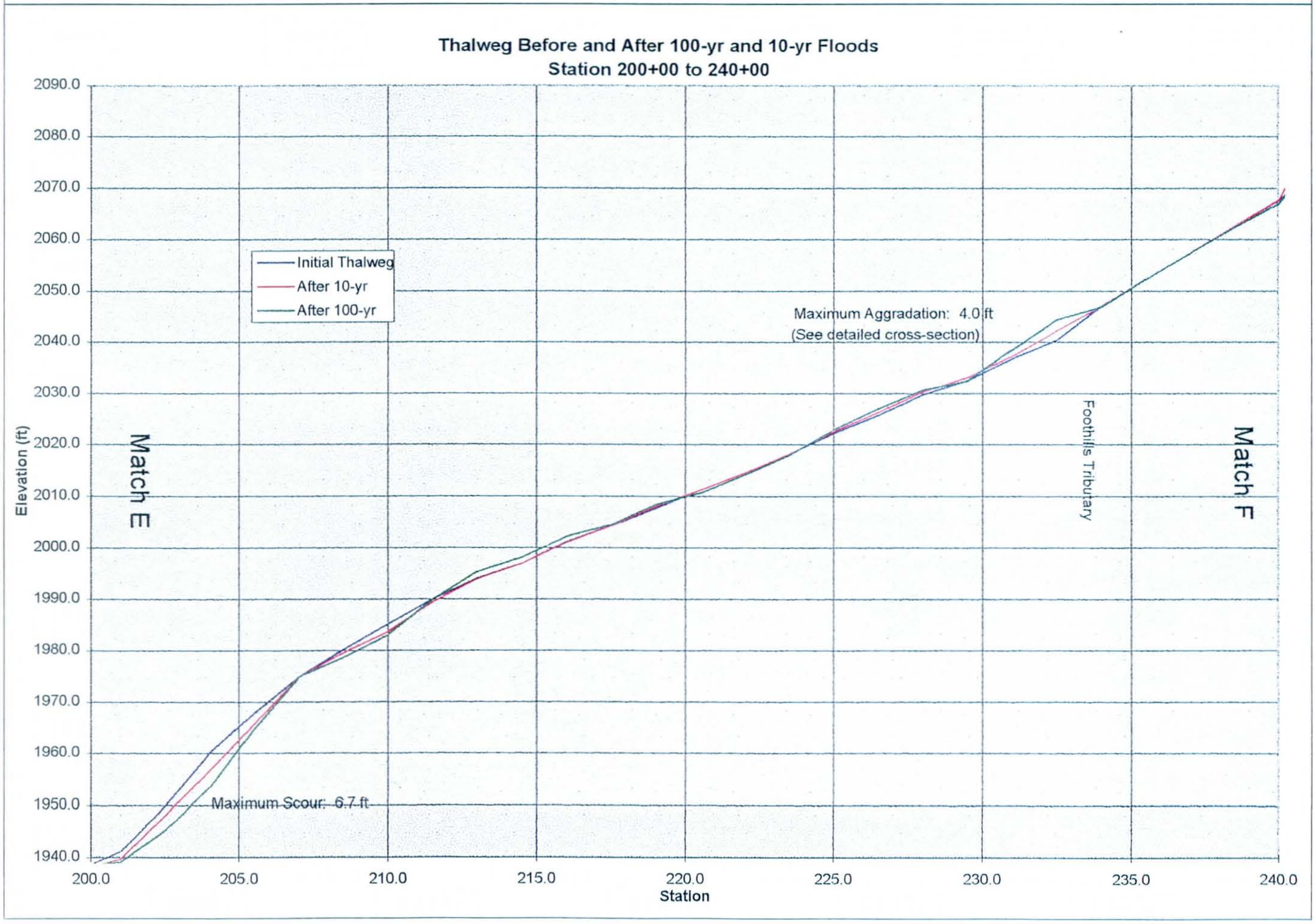
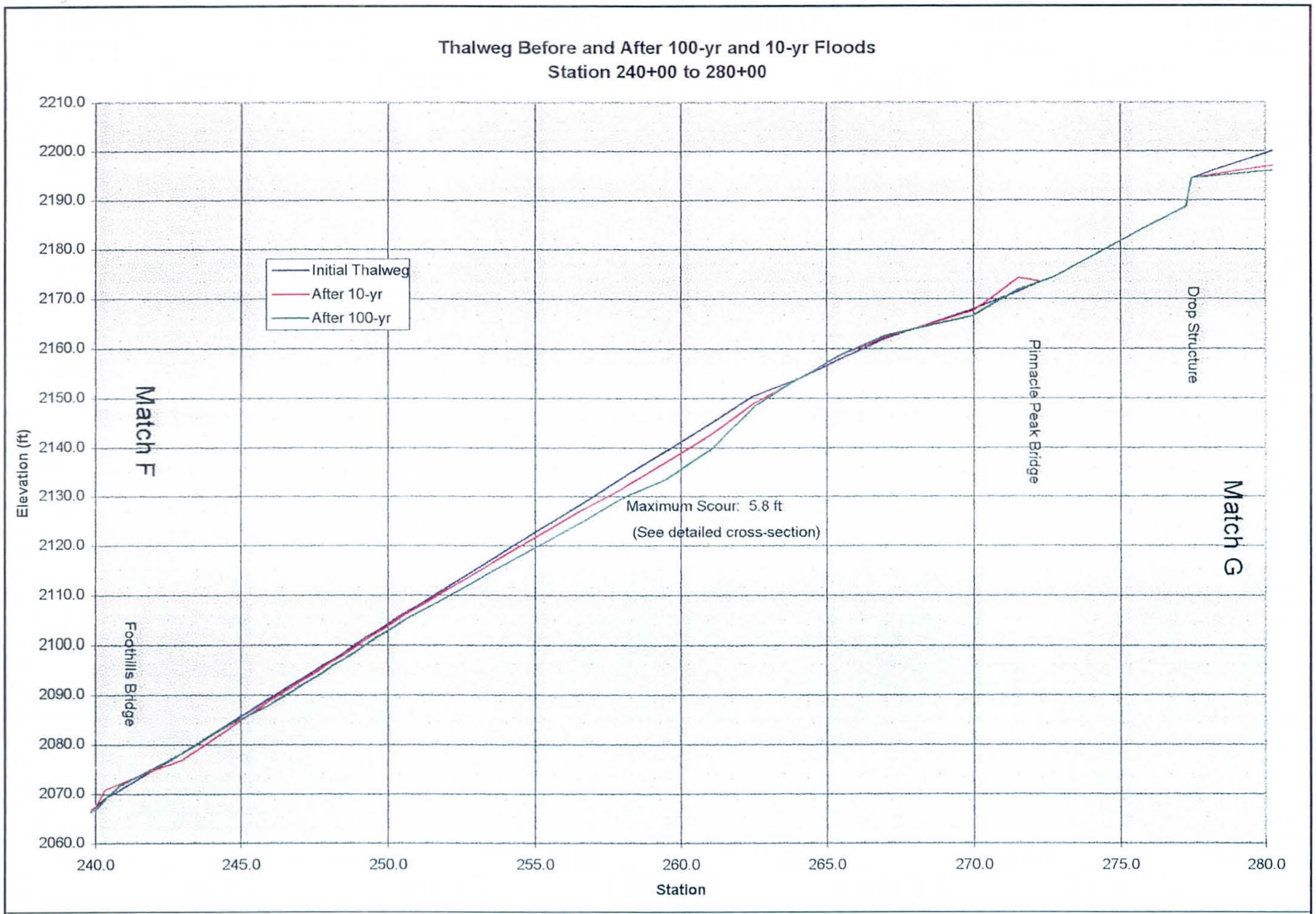


Figure 5.11: Comparison of Existing Thalweg before and after 100-Year Flood (continued)



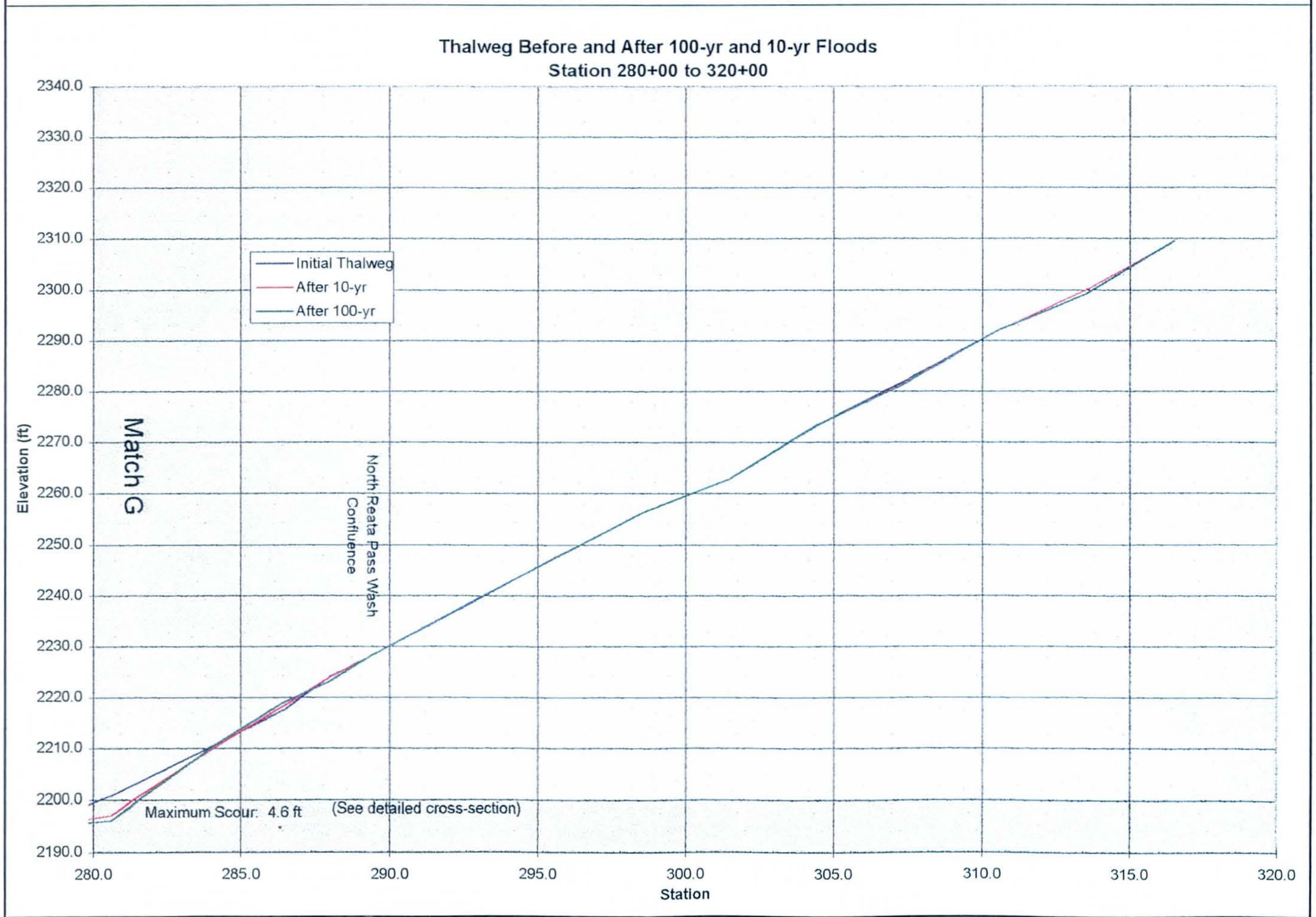


Figure 5.11: Comparison of Existing Thalweg before and after 100-Year Flood

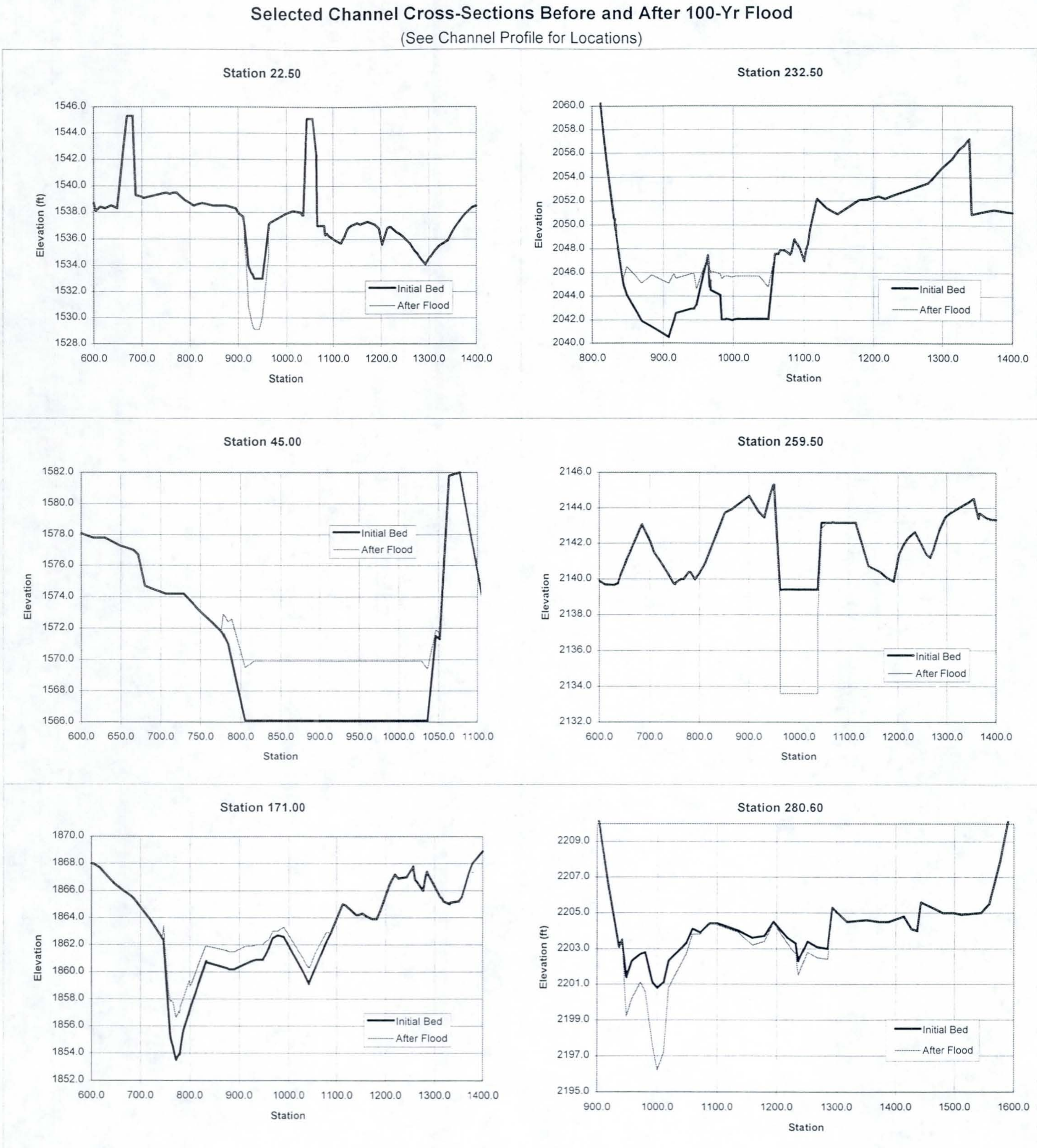


Figure 5.12 Typical Sections Illustrating Channel Geometry Before and After 100-Yr Flood Event

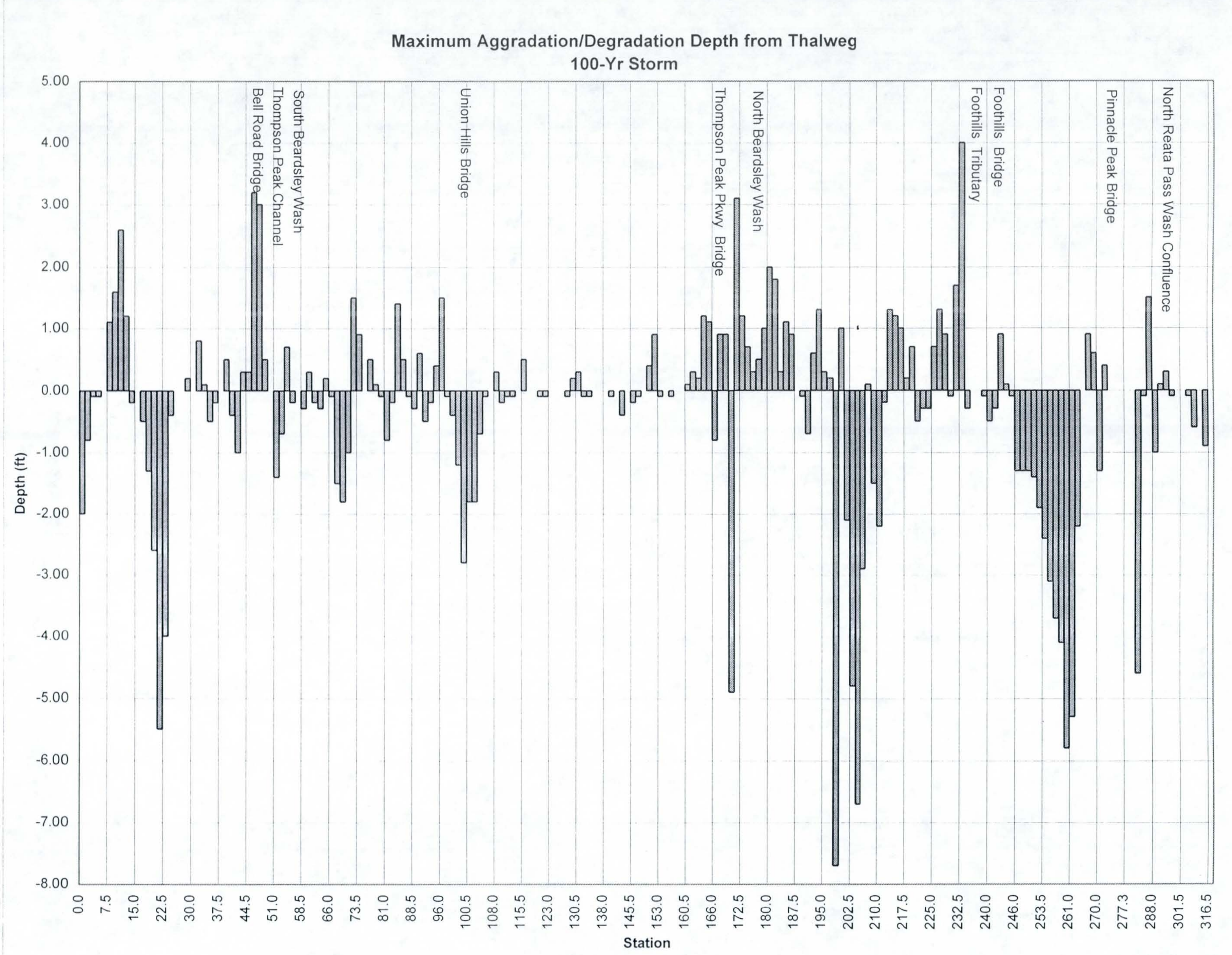


Figure 5.13: Maximum Aggradation/Degradation Depths from Thalweg for 100-Year Storm

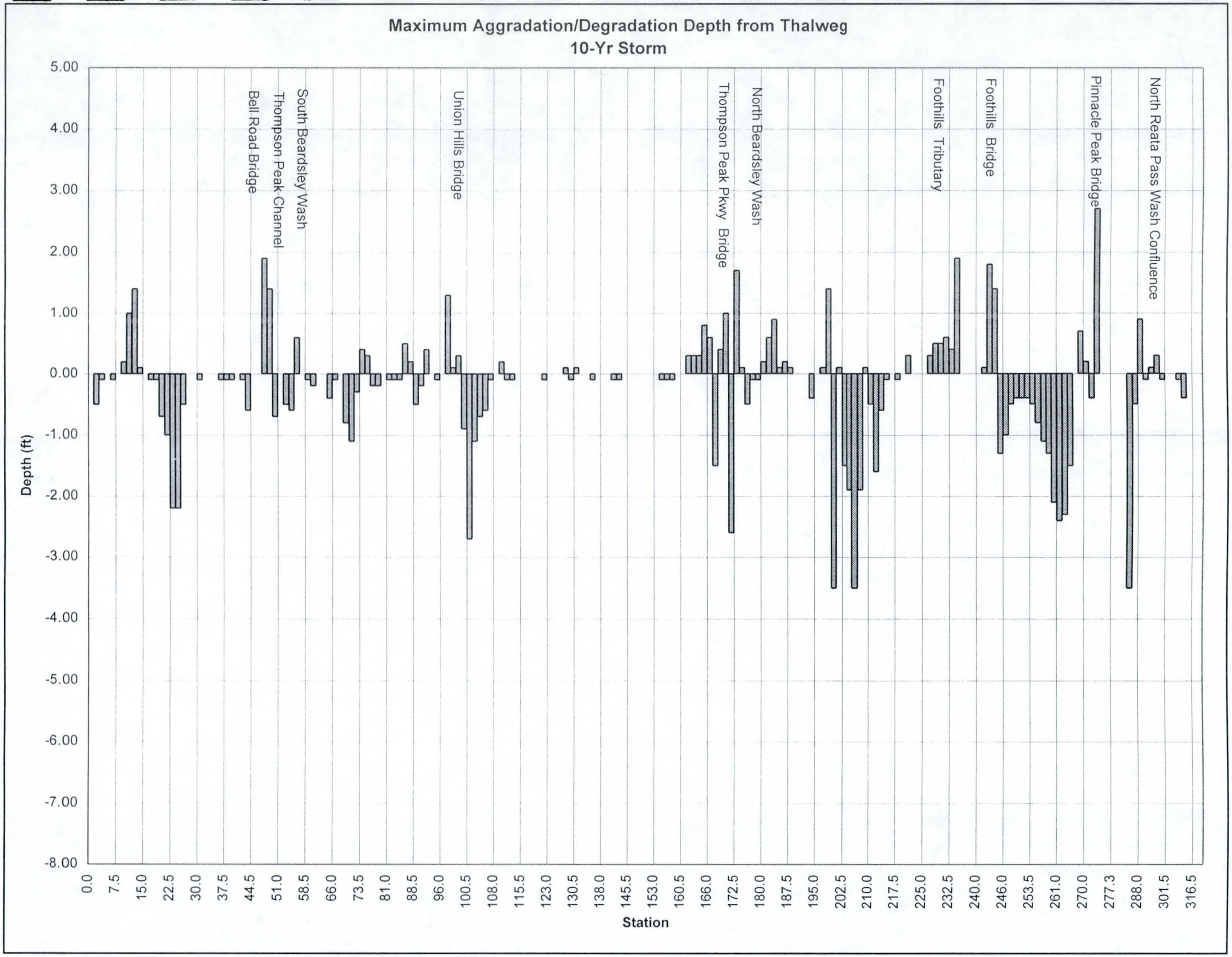


Figure 5.14: Maximum Aggradation/Degradation Depths from Thalweg for 10-Yr Storm

VI. MAXIMUM SCOUR DEPTH ESTIMATES

Estimation of total scour depth for levee/wall toe-down requirements must consider short-term general scour, long-term scour (future channel and sediment supply), low-flow incisement, sand dune movement, contraction scour, and other local scour. However, the total scour will be limited to the channel depths where armor layer will be formed to reduce and eliminate channel scour. The following sections describe each scour component. Detailed calculations for each scour component are included in the technical addendum.

6.1 ARMORING POTENTIAL

Armoring of alluvial channel beds occurs when the channel bed contains materials too large to be transported significantly by water. The slow moving coarse particles will "shield" the underlying finer, erodible materials from efficient transport by the flow. This results in the formulation of an "armor layer". The coarser particles gradually accumulate on the surface after finer particles are removed by the flow. As sediment transport continues and degradation progresses, degradation will be arrested when a significant depth of the slow moving particles accumulate and the armor layer forms over a large portion of the channel bed. When this occurs, the scour process will be limited to the scour depth prior to formation of the armor layer.

The armoring depth is one indicator of the maximum depth to which a stream may be expected to degrade. The armoring depth is based on the particle sizes, size distribution, and critical shear stress. The critical shear stress is the minimum shear stress which will initiate motion of a particle. If the actual shear stress is less than the critical shear stress of a sufficient amount of the bed material, armoring may occur.

An armoring analysis was conducted for Reata Pass Wash Channel using the 100-year and 10-year hydraulic conditions described in Chapter II, and the results show that most reaches upstream of North Beardsley Wash have minimal armoring potential. These reaches will be subject to scour (see Figures 5.10, 5.11, 5.13, and 5.14) and require protection based on the scour computations presented in the following sections. Boulders (greater than 200 mm) are available in some areas from North Beardsley Wash to Union

Hills Drive and from the South Beardsley Wash and Thompson Peak confluence to WestWorld. These areas have a general aggradational trend but scour may develop along the low-flow channel and local scour areas. It is expected that armor sizes similar to those found in the existing channel will appear in the low flow and severe scour areas (see pebble distributions on Figures 4.2 and 4.3). Note that soil gradation curves taken from outside of low flow channels and armor areas have been used in the sediment transport analysis for conservative erosion analysis.

6.2 GENERAL SCOUR

General scour is a more localized and temporary form of channel bed degradation that occurs during a series of small flood events or at a single large flood event. It is mostly governed by sediment continuity: degradation occurs when sediment supply is deficient and aggradation occurs when sediment transport has a surplus compared to sediment transport in a given reach. A 100-year flood single event sediment transport analysis was performed as discussed in the Level III analysis. The results of the analysis indicate that a single-event 100-year flood would result in scour depths as high as 7.7 feet.

6.3 LOW-FLOW INCISEMENT

Low-flow channel incisement is a natural process of low-flow channel formation and erosion within an earthen channel. Based upon field observation, a low-flow channel of three feet was estimated for the current study. In the upstream reach (from Pinnacle Peak Road Bridge to Deer Valley Road Alignment), flow velocities are extremely high and certain forms of stabilization such as grade control and/or channel bed lining must be applied in addition to bank protection. In this case, control of the low flow channel will be part of the design effort. For the remaining downstream reaches, the existing low flow channels impinging on proposed levees will be filled and the low flow channel will be redirected away from the levee to avoid flow concentration and development of a local scour hole at the structure base. Downstream of the existing North Beardsley Wash confluence, there is a potential for armor layer formation as the new low flow channel develops and experiences continuous erosion. The 3 ft low flow incision was added to the existing low flow channel for conservative scour estimates.

6.4 ANTI-DUNE SCOUR

Bed form scour can occur primarily in sand bed channels during a flood event. The bed forms are called anti-dunes and it is customary to consider one half of the anti-dune height, from crest to trough, as the bed form scour component. Based upon a range of channel velocity of 5.9 to 27.2 fps, the maximum one-half anti-dune height for the channel is estimated to range from 0.5 to 3.8 feet. This scour depth may be ignored if the channel bed materials coarsen and sand and gravels are depleted. However, this was included for conservative scour depth estimates.

6.5 CONTRACTION SCOUR

Scour at contractions occurs when the normal channel flow area suddenly reduces, resulting in higher flow velocity. The increase in velocity through the contraction results in more bed material transported through the contracted section than is transported into the section. Contraction scour was estimated for five locations along the study reach:

1. Above Pinnacle Peak Road Bridge, where the flow width is reduced to pass beneath the bridge

2. Below Pinnacle Peak Road Bridge (Stations 261+00 to 258+00) where the flow is confined to a narrow channel

3. Above Bell Road Bridge crossing (Stations 48+00 to 45+00) where the confluence area reduces to accommodate the bridge opening

4. Stations 31+50 to 21+00, where the channel width between the east and west levees reduces

5. Station 21+00 to 16+50, where the flow confines to a narrow channel

The scour depth resulting from contraction scour was evaluated by using the modified Laursen Equation (1960) documented in HEC-18 by the Federal Highway Administration.

6.6 BEND SCOUR

"Secondary" currents are observed at a channel bend, which results in scouring of sediments from the outer bend. The study area has a total of four major channel bends from the apex to the outlet. The bend scour depth was computed for these locations and will only be applied to the levees located on the outer bend. The maximum bend scour depth computed for the proposed channel is 1.1 feet.

6.7 LONG-TERM SCOUR ANALYSIS

Long-term degradation was estimated considering changes in sediment supply. It should be noted that both the Level II and Level III sediment transport analysis presented in Chapter V were performed assuming that the sediment supply to a given channel reach is from the reach immediately upstream. After long-term adjustment, the upstream reaches may reach equilibrium relative to the upstream supply through continuous erosion and sedimentation and channel adjustment. Under this condition each channel reach will receive the sediment inflow from the ultimate sediment sources from upper reaches and tributaries in the headwater area. The ultimate supply reaches in the Reata Pass channel system include:

1. Main Channel East Branch
2. North Reata Pass Channel
3. Foothills Tributary
4. North Beardsley Wash
5. South Beardsley Wash
6. Thompson Peak Channel

The long-term sediment sources from the upper reach and tributaries are subject to change. Most likely, the sediment supply may be reduced some due to urbanization or natural river armoring. Future developments typically affect efficient conveyance of sediment flow due to constriction by culverts, junction structures, recreational accesses, landscaping, etc. Natural armoring will partially or entirely cover up the underlying sand and gravel and significantly reduce the sediment supply.

In general, reducing the sediment inflow will result in long-term degradation or reduction in aggradation. Conversely, increasing the sediment inflow will result in aggradation. Figure 6.1 illustrates the long term average potential aggradation/degradation depths for a 100-year flood under the following sediment supply conditions:

1. Short-term conditions; assuming channels have not attained equilibrium and the sediment supply from each source area remains stable.

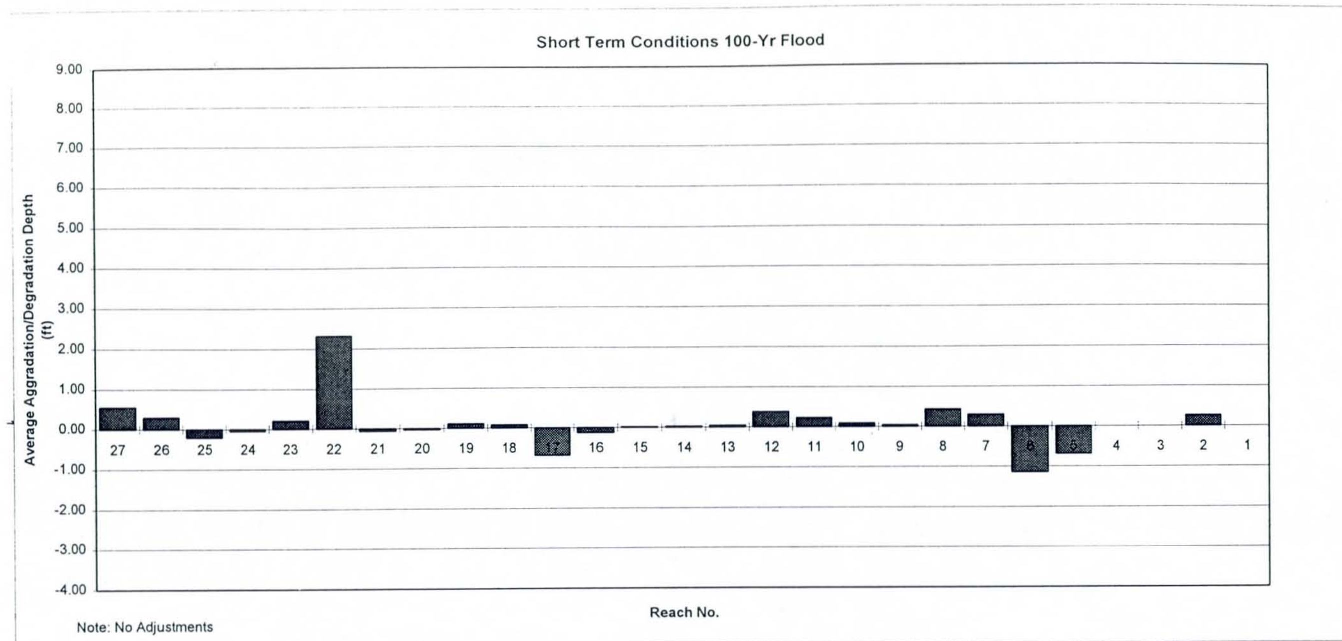
2. Short-term conditions with a reduction in sediment supply from tributaries which have armoring potential, i.e. North Beardsley Wash, South Beardsley Wash, and Thompson Peak Channel.

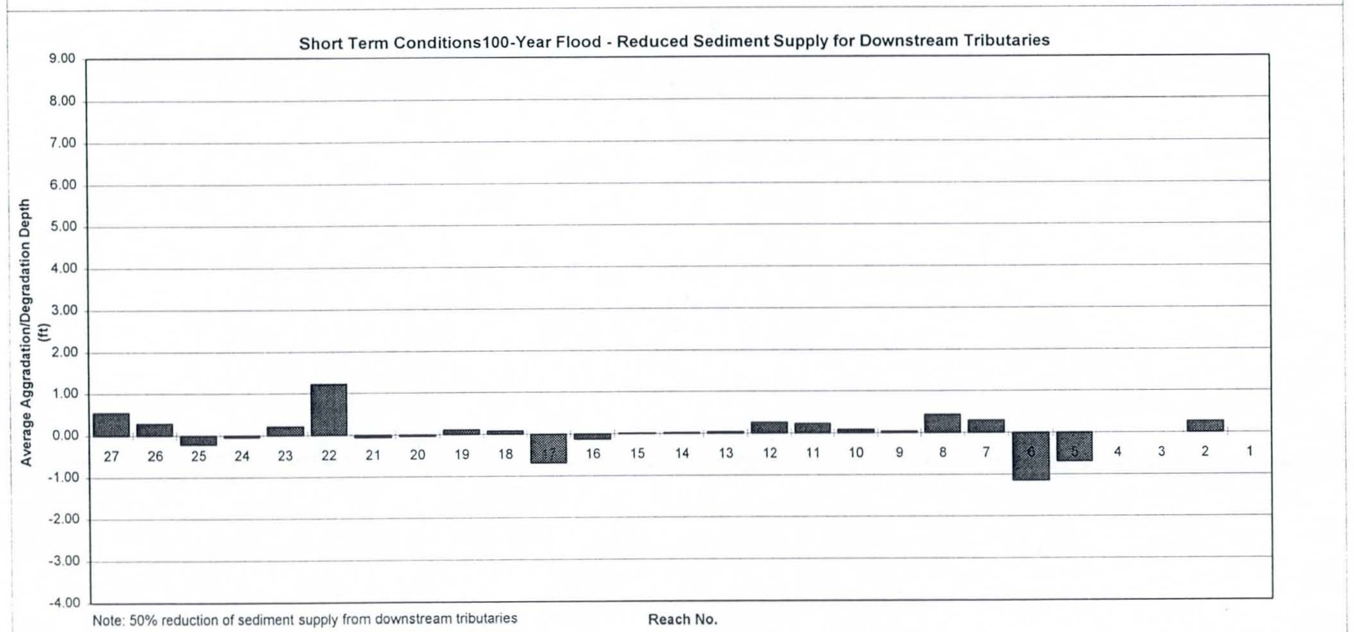
3. Long-term conditions assuming cumulative tributary inflows as incoming sediment inflow. This assumes that the upstream channel reach has been adjusted to a equilibrium condition which passes the supply from the sediment sources.

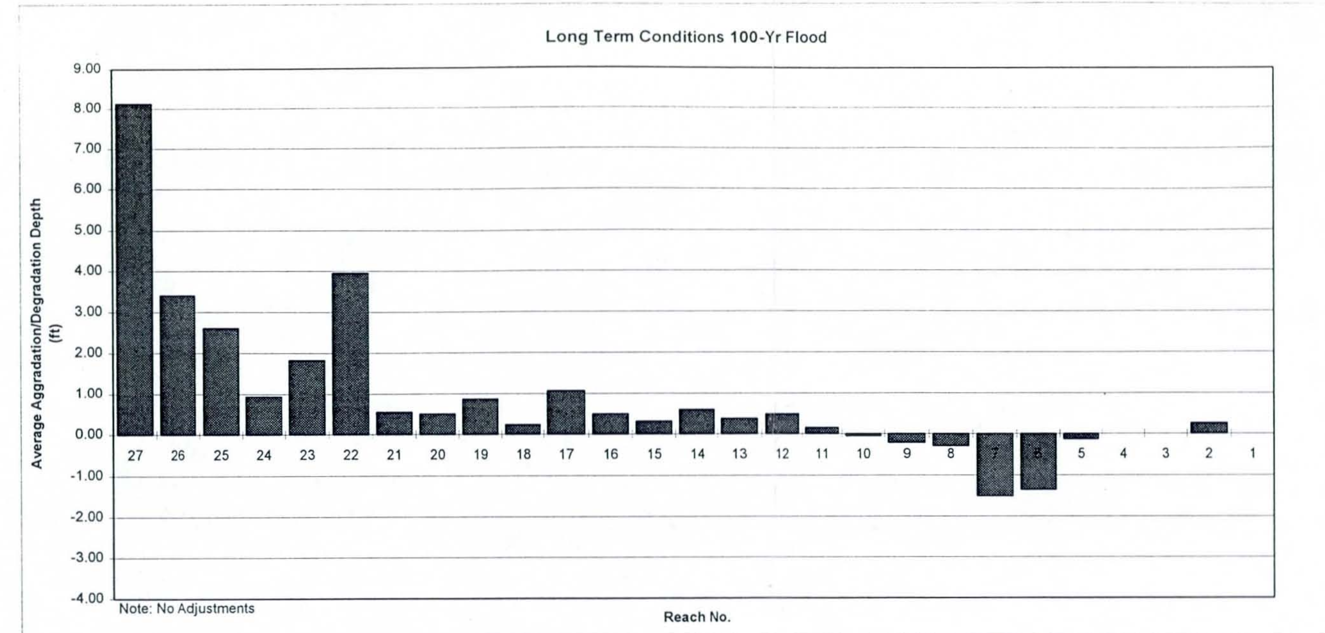
4. Long-term conditions as in Scenario 3 and with a 50% reduction in sediment supply from North Beardsley Wash, South Beardsley Wash, and Thompson Peak tributaries due to continual armoring of the channel bed.

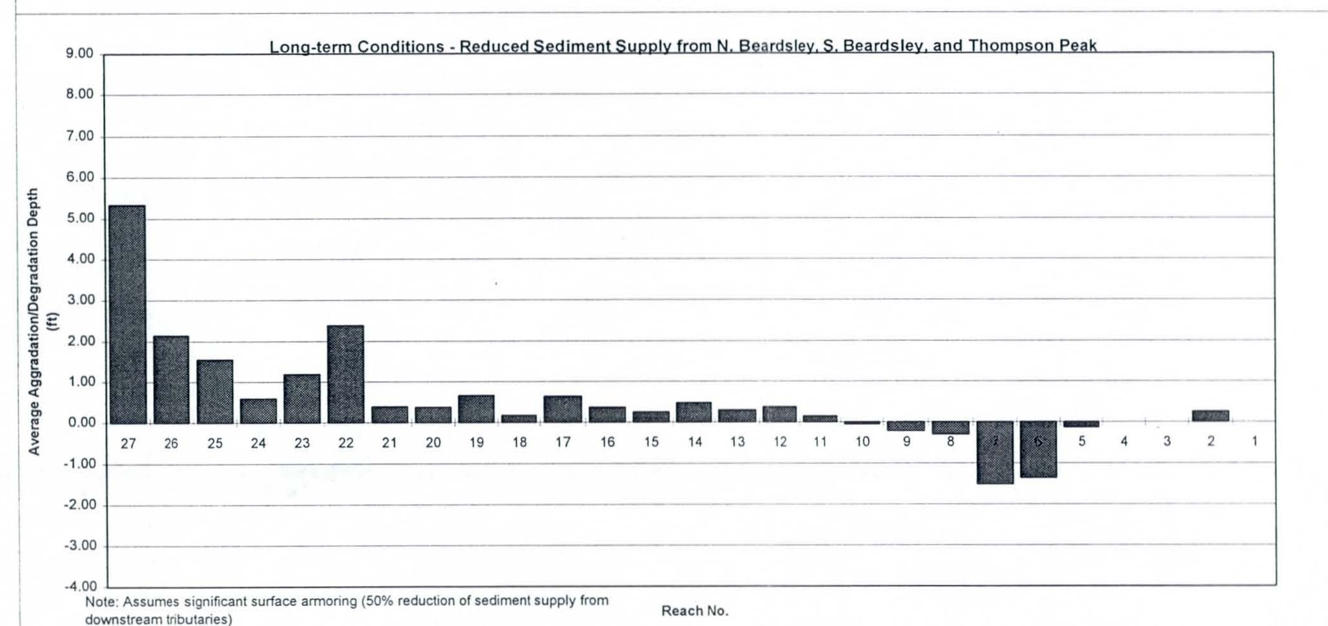
5. Long-term conditions as in Scenario 3 and with a 50% reduction in sediment supply from all the sediment sources.

For the scour analysis, Scenario 5 is assumed to be the worst-case scenario. The results indicate that reducing the upstream sediment supply by 50 percent will cause significant degradation for the narrow confined reaches (Reaches 5-8, Station 270+00 to 213+75, see Figure 6.1). The reduced sediment supply increases degradation by 1 ft in Reach 6, which has the most significant scour problem under short-term consideration. This also changes Reach 7 from slight aggradation to severe degradation. Table 6.1 lists the









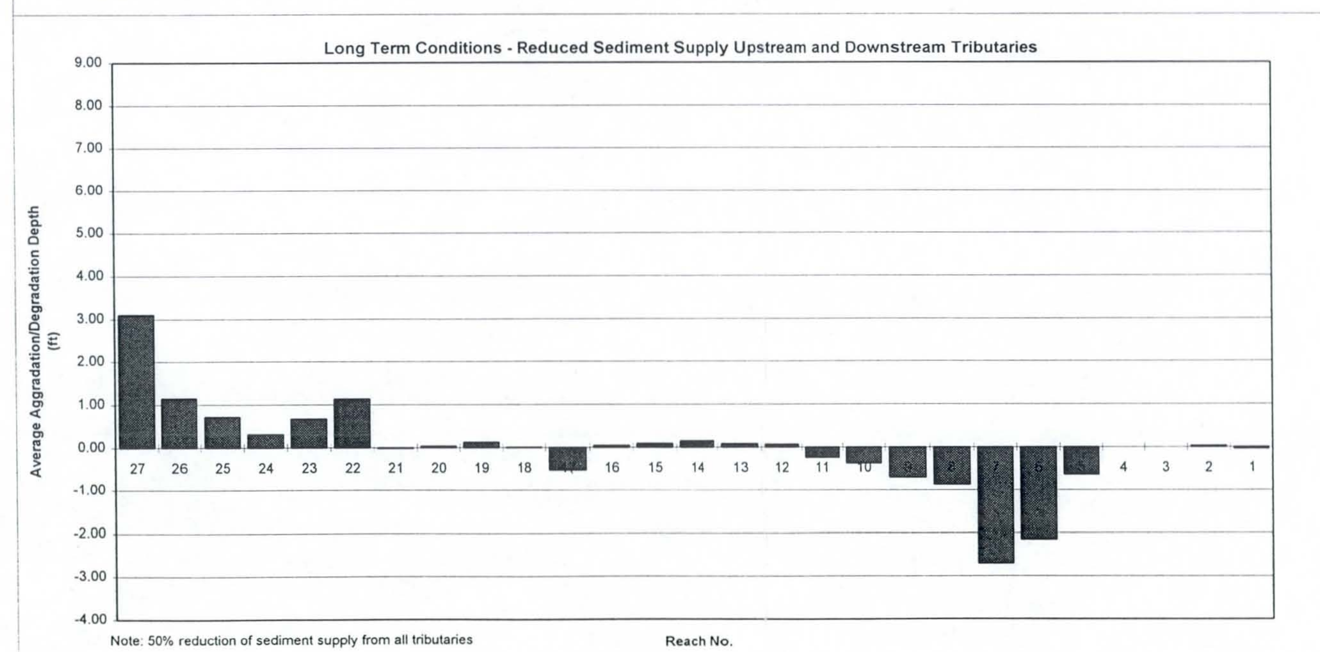


Figure 6.1: Potential Aggradation/Degradation Depths Due to Long-Term Conditions (See Figure 3.1 for reach definition)

Table 6.1 Summary of Potential Long-Term Aggradation (+)/Degradation(-)
For Each Reach

Note: Degradation Depth (-) is estimated as the Long-Term Scour Depth (feet)

Reach No. *	Sediment Inflow E (CY)	Sediment Outflow F (CY)	Volume Change E-F (CY)	Reach Length (ft)	Average Top Width (ft)	Aggradation/ Degradation Depth (ft)
1	1,461	2,922	-1,461	2,550	323	-0.05
2	4,789	4,315	474	1,197	454	0.02
3	4,789	4,789	0	255	155	0.00
4	4,789	4,789	0	798	116	0.00
5	4,789	10,890	-6,101	975	261	-0.65
6	4,789	17,840	-13,051	1,685	97	-2.16
7	5,424	17,770	-12,346	1,015	121	-2.71
8	5,424	13,716	-8,292	1,800	141	-0.88
9	5,424	13,282	-7,858	1,050	284	-0.71
10	5,424	11,830	-6,406	1,950	232	-0.38
11	5,424	8,790	-3,366	1,200	306	-0.25
12	7,466	6,344	1,121	1,500	316	0.06
13	7,466	5,441	2,024	1,350	503	0.08
14	7,466	5,042	2,424	1,200	374	0.15
15	7,466	4,473	2,993	1,950	465	0.09
16	7,466	6,731	734	1,200	376	0.04

Table 6.1 Summary of Potential Long-Term Aggradation (+)/Degradation(-) For Each Reach (Continued)

Note: Degradation Depth (-) is estimated as the Long-Term Scour Depth (feet)

Reach No. *	Sediment Inflow E (CY)	Sediment Outflow F (CY)	Volume Change E-F (CY)	Reach Length (ft)	Average Top Width (ft)	Aggradation/ Degradation Depth (ft)
17	7,466	9,953	-2,487	450	278	-0.54
18	7,466	7,362	104	2,100	415	0.00
19	7,466	6,236	1,230	750	363	0.12
20	7,466	6,921	545	900	478	0.03
21	7,466	7,845	-379	1,050	334	-0.03
22	12,219	7,305	4,914	447	262	1.13
23	12,219	5,099	7,120	903	316	0.67
24	12,219	6,177	6,041	1,200	436	0.31
25	12,219	7,588	4,630	1,050	166	0.72
26	12,219	6,012	6,207	750	195	1.15
27	12,219	4,678	7,541	375	175	3.10
Note: Reaches 3 and 4 have grade-control structures and are not expected to aggrade or degrade.						

* See Figure 3.1 for reach locations.

potential long-term scour depths under the reduced sediment supply scenario (Scenario 5). If the sediment aggradation to severe degradation. Table 6.1 lists the potential long-term scour depths under the reduced sediment supply scenario (Scenario 5). If the sediment inflows from the North Reata Pass Wash and main channel east branch continue to provide sediment supply at the current rates, there will be long-term aggradation in the downstream reach (see Scenarios 3 and 4 and Figure 6.1). These scenarios are considered unlikely to happen and were not included in the design consideration.

6.8 TOTAL SCOUR DEPTH

Total scour depth was computed as the sum of all the scour components multiplied by a factor of safety and the potential long-term degradation. The total scour depth (sum of all components) was estimated to range from 3.5 to 15.5 feet. Considering a factor of 1.3 as a safety factor for design, the scour toe-down protection would require 4.5 to 20.0 feet along the study reach as shown in Table 6.2. With the addition of long-term degradation, the total scour depth is increased in Reaches 5, 6, and 7 where flow velocities are relatively high and sediment supply is not sufficient. All detailed scour calculations are included in the technical addendum. **It should be noted, however, that the abutment and pier scour due to structure effects are not considered in Table 6.2**.

Based on Table 6.2, critical scour areas are identified as follows:

1) Station 262+00 to 232+50: total scour depth ranges from 10 to 21 feet.

2) Station 205+00 to 201+00: total scour depth ranges from 10 to 17 feet.

3) Station 22+50 to 16+50: total scour depth ranges from 12 to 15 feet.

This scour study was conducted for proposed Reata Pass Channel under ultimate levee encroachment condition and with channel excavation from Station 260+00 to 240+00, near the Union Hills Drive, and at the downstream terminus of levee encroachments from Station 22+00 to 13+00.

Table 6.2 Maximum Scour Depth Estimates

Section #	Thalweg El (ft)	General Scour (ft)	Low-flow Thalweg (ft)	Antidune Scour (ft)	Contraction Scour (ft)	Bend Scour		Factored Total (*1.3)		Long-term Scour (ft)	Total Scour		Thalweg after Scour	
						East (ft)	West (ft)	East (ft)	West (ft)		East (ft)	West (ft)	East (ft)	West (ft)
316.50	2309.6	0.0	3.0	0.81	0	0	0	4.96	4.96	0.1	5.06	5.06	**2304.5**	**2304.5**
313.50	2300.1	0.9	3.0	1.20	0	0	0	6.63	6.63	0.1	6.73	6.73	**2293.4**	**2293.4**
310.50	2291.9	0.0	3.0	0.99	0	0	0	5.19	5.19	0.1	5.29	5.29	**2286.6**	**2286.6**
307.50	2282.5	0.6	3.0	1.75	0	0	0	6.96	6.96	0.1	7.06	7.06	**2275.4**	**2275.4**
304.50	2273.5	0.1	3.0	1.30	0	0	0	5.72	5.72	0.1	5.82	5.82	**2267.7**	**2267.7**
301.50	2262.9	0.0	3.0	2.24	0	0	0	6.82	6.82	0.1	6.92	6.92	**2256.0**	**2256.0**
298.50	2256.2	0.0	3.0	1.85	0	0	0	6.31	6.31	0.1	6.41	6.41	**2249.8**	**2249.8**
295.50	2247.4	0.1	3.0	1.90	0	0	0	6.50	6.50	0.1	6.60	6.60	**2240.8**	**2240.8**
292.50	2237.9	0.0	3.0	1.88	0	0	0	6.34	6.34	0.1	6.44	6.44	**2231.5**	**2231.5**
289.50	2228.6	0.0	3.0	2.32	0	0	0	6.91	6.91	0.0	6.91	6.91	**2221.7**	**2221.7**
288.00	2224.2	1.0	3.0	1.65	0	0	0	7.35	7.35	0.0	7.35	7.35	**2216.9**	**2216.9**
286.50	2217.7	0.0	3.0	2.28	0	0	0	6.86	6.86	0.0	6.86	6.86	**2210.8**	**2210.8**
284.15	2210.8	0.1	3.0	1.91	0	0	0	6.51	6.51	0.0	6.51	6.51	**2204.3**	**2204.3**
280.60	2200.8	4.6	3.0	2.35	0	0	0	12.93	12.93	0.0	12.93	12.93	**2187.9**	**2187.9**
277.45	2194.6	0.0	3.0	2.40	0	0	0	7.02	7.02	0.0	7.02	7.02	**2187.6**	**2187.6**
277.25	2188.6	0.0	3.0	1.80	0	0	0	6.24	6.24	0.0	6.24	6.24	**2182.4**	**2182.4**
275.70	2183.9	0.0	3.0	2.45	0	0	0	7.09	7.09	0.0	7.09	7.09	**2176.8**	**2176.8**
272.65	2174.2	0.0	3.0	2.25	0.4	0	0	7.35	7.35	0.0	7.35	7.35	**2166.9**	**2166.9**
272.25	2173.3	0.0	3.0	2.85	0	0	0	7.60	7.60	0.0	7.60	7.60	**2165.7**	**2165.7**
271.50	2171.5	0.0	3.0	1.37	0	0	0	5.68	5.68	0.0	5.68	5.68	**2165.8**	**2165.8**
270.00	2167.9	1.3	3.0	3.21	0	0	0	9.76	9.76	0.0	9.76	9.76	**2158.1**	**2158.1**
267.00	2162.0	0.0	3.0	1.95	0	0	0	6.44	6.44	1.0	7.44	7.44	**2154.6**	**2154.6**
265.50	2158.0	0.0	3.0	2.30	0	0	0	6.89	6.89	1.0	7.89	7.89	**2150.1**	**2150.1**
264.00	2153.8	0.0	3.0	2.15	0	0	0	6.69	6.69	1.0	7.69	7.69	**2146.1**	**2146.1**
262.50	2150.5	2.2	3.0	2.05	0	0	0	9.42	9.42	1.0	10.42	10.42	**2140.1**	**2140.1**
261.00	2144.9	5.3	3.0	2.35	0	0	0	13.84	13.84	1.0	14.84	14.84	**2130.1**	**2130.1**
259.50	2139.4	5.8	3.0	3.00	3.8	0	0	20.28	20.28	1.0	21.28	21.28	**2118.1**	**2118.1**
258.00	2133.9	4.1	3.0	2.90	3.8	0	0	17.94	17.94	2.5	20.44	20.44	**2113.5**	**2113.5**
256.50	2128.3	3.7	3.0	2.65	0	0	0	12.15	12.15	2.5	14.65	14.65	**2113.6**	**2113.6**
255.00	2122.8	3.1	3.0	2.60	0	0	0	11.31	11.31	2.5	13.81	13.81	**2109.0**	**2109.0**
253.50	2117.2	2.4	3.0	2.60	0	0	0	10.40	10.40	2.5	12.90	12.90	**2104.3**	**2104.3**
252.00	2111.7	1.9	3.0	2.55	0	0	0	9.69	9.69	2.5	12.19	12.19	**2099.5**	**2099.5**
250.50	2106.1	1.4	3.0	2.55	0	0	0	9.03	9.03	2.5	11.53	11.53	**2094.6**	**2094.6**
249.00	2100.5	1.3	3.0	2.60	0	0	0	8.97	8.97	2.5	11.47	11.47	**2089.0**	**2089.0**
247.50	2095.0	1.3	3.0	2.55	0	0	0	8.90	8.90	2.5	11.40	11.40	**2083.6**	**2083.6**
246.00	2089.5	1.3	3.0	2.55	0	0	0	8.90	8.90	2.5	11.40	11.40	**2078.1**	**2078.1**
244.50	2083.9	0.1	3.0	2.55	0	0	0	7.34	7.34	2.5	9.84	9.84	**2074.1**	**2074.1**
243.00	2078.4	0.0	3.0	2.05	0	0	0	6.56	6.56	2.5	9.06	9.06	**2069.3**	**2069.3**
240.80	2070.8	0.0	3.0	2.35	0	0	0	6.95	6.95	3.0	9.95	9.95	**2060.8**	**2060.8**
240.30	2069.2	0.3	3.0	3.25	0	0	0	8.52	8.52	3.0	11.52	11.52	**2057.7**	**2057.7**
240.00	2067.5	0.5	3.0	2.70	0	0	0	8.06	8.06	3.0	11.06	11.06	**2056.4**	**2056.4**
238.50	2062.5	0.1	3.0	2.35	0	0	0	7.08	7.08	3.0	10.08	10.08	**2052.4**	**2052.4**
237.00	2057.4	0.0	3.0	2.30	0	0	0	6.89	6.89	3.0	9.89	9.89	**2047.5**	**2047.5**
235.50	2052.3	0.0	3.0	2.25	0	0	0	6.83	6.83	3.0	9.83	9.83	**2042.5**	**2042.5**
234.00	2047.2	0.3	3.0	2.40	0	0	0	7.41	7.41	3.0	10.41	10.41	**2036.8**	**2036.8**
232.50	2040.5	0.0	3.0	2.20	0	0	0	6.76	6.76	3.0	9.76	9.76	**2030.7**	**2030.7**
231.00	2036.9	0.0	3.0	3.05	0	0	0	7.86	7.86	1.0	8.86	8.86	**2028.0**	**2028.0**
229.50	2032.5	0.1	3.0	3.00	0	0	0	7.93	7.93	1.0	8.93	8.93	**2023.6**	**2023.6**
228.00	2029.8	0.0	3.0	2.55	0	0	0	7.22	7.22	1.0	8.22	8.22	**2021.6**	**2021.6**
226.50	2025.8	0.0	3.0	2.75	0	0	0	7.48	7.48	1.0	8.48	8.48	**2017.3**	**2017.3**
225.00	2022.3	0.0	3.0	3.30	0	0	0	8.19	8.19	1.0	9.19	9.19	**2013.1**	**2013.1**
223.50	2018.2	0.3	3.0	3.55	0	0	0	8.90	8.90	1.0	9.90	9.90	**2008.3**	**2008.3**
222.00	2014.6	0.3	3.0	3.50	0	0	0	8.84	8.84	1.0	9.84	9.84	**2004.8**	**2004.8**
220.50	2011.2	0.5	3.0	3.15	0	0	0	8.64	8.64	1.0	9.64	9.64	**2001.6**	**2001.6**
219.00	2007.8	0.0	3.0	2.95	0	0	0	7.74	7.74	1.0	8.74	8.74	**1999.1**	**1999.1**
217.50	2004.4	0.0	3.0	3.45	0	0	0	8.38	8.38	1.0	9.38	9.38	**1995.0**	**1995.0**
216.00	2001.2	0.0	3.0	3.05	0	0	0	7.86	7.86	1.0	8.86	8.86	**1992.3**	**1992.3**
214.50	1997.0	0.0	3.0	3.55	0	0	0	8.51	8.51	1.0	9.51	9.51	**1987.5**	**1987.5**
213.00	1994.0	0.0	3.0	3.00	0	0	0	7.80	7.80	1.0	8.80	8.80	**1985.2**	**1985.2**
211.50	1990.0	0.2	3.0	3.10	0	0	0	8.19	8.19	1.0	9.19	9.19	**1980.8**	**1980.8**
210.00	1985.2	2.2	3.0	2.60	0	0	0	10.14	10.14	1.0	11.14	11.14	**1974.1**	**1974.1**
208.50	1980.2	1.5	3.0	2.30	0	0	0	8.84	8.84	1.0	9.84	9.84	**1970.4**	**1970.4**
207.00	1974.9	0.0	3.0	1.85	0	0	0	6.30	6.30	1.0	7.30	7.30	**1967.6**	**1967.6**
205.50	1967.8	2.9	3.0	2.75	0	0	0	11.25	11.25	1.0	12.25	12.25	**1955.6**	**1955.6**
204.00	1960.1	6.7	3.0	2.75	0	0	0	16.19	16.19	1.0	17.19	17.19	**1942.9**	**1942.9**
202.50	1950.1	4.8	3.0	3.60	0	0	0	14.82	14.82	0.5	15.32	15.32	**1934.8**	**1934.8**
201.00	1941.3	2.1	3.0	2.70	0	0	0	10.14	10.14	0.5	10.64	10.64	**1930.7**	**1930.7**
199.50	1937.4	0.0	3.0	2.20	0	0	0	6.76	6.76	0.5	7.26	7.26	**1930.1**	**1930.1**
198.00	1930.9	7.7	3.0	2.18	0	0	0	16.74	16.74	0.5	17.24	17.24	**1913.7**	**1913.7**
196.50	1925.5	0.0	3.0	2.40	0	0	0	7.02	7.02	0.5	7.52	7.52	**1918.0**	**1918.0**
195.00	1921.3	0.0	3.0	2.35	0	0	0	6.96	6.96	0.5	7.46	7.46	**1913.8**	**1913.8**
193.50	1916.6	0.0	3.0	2.35	0	0	0	6.96	6.96	0.5	7.46	7.46	**1909.1**	**1909.1**
192.00	1911.0	0.0	3.0	2.40	0	0	0	7.02	7.02	0.5	7.52	7.52	**1903.5**	**1903.5**
190.50	1905.0	0.7	3.0	2.40	0	0	0	7.93	7.93	0.5	8.43	8.43	**1896.6**	**1896.6**

Table 6.2 Maximum Scour Depth Estimates (continued)

Section #	Thalweg El (ft)	General Scour (ft)	Low-flow Thalweg (ft)	Antidune Scour (ft)	Contraction Scour (ft)	Bend Scour East (ft)	Bend Scour West (ft)	Factored Total (*1.3) East (ft)	Factored Total (*1.3) West (ft)	Long-term Scour (ft)	Total Scour East (ft)	Total Scour West (ft)	Thalweg after Scour East (ft)	Thalweg after Scour West (ft)
189.00	1901.9	0.1	3.0	1.65	0	0	0	6.17	6.17	0.5	6.67	6.67	**1895.2**	**1895.2**
187.50	1897.5	0.0	3.0	1.80	0	0	0	6.24	6.24	0.5	6.74	6.74	**1890.8**	**1890.8**
186.00	1892.3	0.0	3.0	1.65	0	0	0	6.04	6.04	0.5	6.54	6.54	**1885.8**	**1885.8**
184.50	1887.8	0.0	3.0	2.10	0	1.13	0	8.10	6.63	0.5	8.60	7.13	**1879.2**	**1880.7**
183.00	1882.8	0.0	3.0	3.10	0	1.13	0	9.40	7.93	0.5	9.90	8.43	**1872.9**	**1874.4**
181.50	1879.1	0.0	3.0	1.95	0	1.13	0	7.90	6.44	0.5	8.40	6.94	**1870.7**	**1872.2**
180.00	1875.4	0.0	3.0	2.28	0	1.13	0	8.33	6.86	0.5	8.83	7.36	**1866.6**	**1868.0**
178.50	1872.2	0.0	3.0	2.28	0	1.13	0	8.33	6.86	0.5	8.83	7.36	**1863.4**	**1864.8**
177.00	1869.6	0.0	3.0	2.24	0	1.13	0	8.29	6.82	0.5	8.79	7.32	**1860.8**	**1862.3**
175.50	1866.1	0.0	3.0	2.35	0	1.13	0	8.43	6.96	0.5	8.93	7.46	**1857.2**	**1858.6**
174.00	1862.7	0.0	3.0	2.50	0	1.13	0	8.61	7.15	0.5	9.11	7.65	**1853.6**	**1855.1**
172.50	1857.5	0.0	3.0	3.20	0	0	0	8.06	8.06	0.5	8.56	8.56	**1848.9**	**1848.9**
171.00	1853.5	0.0	3.0	1.84	0	0	0	6.30	6.30	0.0	6.30	6.30	**1847.2**	**1847.2**
169.50	1850.5	4.9	3.0	3.78	0	0	0	15.18	15.18	0.0	15.18	15.18	**1835.3**	**1835.3**
168.00	1846.7	0.0	3.0	3.20	0	0	0	8.06	8.06	0.0	8.06	8.06	**1838.6**	**1838.6**
166.50	1844.8	0.0	3.0	0.48	0	0	0	4.52	4.52	0.0	4.52	4.52	**1840.3**	**1840.3**
166.00	1843.3	0.8	3.0	2.84	0	0	0	8.63	8.63	0.0	8.63	8.63	**1834.7**	**1834.7**
165.50	1841.7	0.0	3.0	0.99	0	0	0	5.19	5.19	0.0	5.19	5.19	**1836.5**	**1836.5**
165.00	1840.2	0.0	3.0	2.75	0	0	0	7.48	7.48	0.0	7.48	7.48	**1832.7**	**1832.7**
163.50	1836.0	0.0	3.0	2.84	0	0	0	7.59	7.59	0.0	7.59	7.59	**1828.4**	**1828.4**
162.00	1832.4	0.0	3.0	2.80	0	0	0	7.54	7.54	0.0	7.54	7.54	**1824.9**	**1824.9**
160.50	1827.7	0.0	3.0	3.04	0	0	0	7.85	7.85	0.0	7.85	7.85	**1819.8**	**1819.8**
159.00	1825.4	0.0	3.0	2.60	0	0	0	7.28	7.28	0.0	7.28	7.28	**1818.1**	**1818.1**
157.50	1821.9	0.0	3.0	2.53	0	0	0	7.19	7.19	0.0	7.19	7.19	**1814.7**	**1814.7**
156.00	1818.8	0.1	3.0	2.40	0	0	0	7.15	7.15	0.0	7.15	7.15	**1811.7**	**1811.7**
154.50	1815.5	0.0	3.0	2.30	0	0	0	6.89	6.89	0.0	6.89	6.89	**1808.6**	**1808.6**
153.00	1811.7	0.1	3.0	2.10	0	0	0	6.76	6.76	0.0	6.76	6.76	**1804.9**	**1804.9**
151.50	1804.6	0.0	3.0	2.80	0	0	0	7.54	7.54	0.0	7.54	7.54	**1797.1**	**1797.1**
150.00	1801.0	0.0	3.0	1.40	0	0	0	5.72	5.72	0.0	5.72	5.72	**1795.3**	**1795.3**
148.50	1797.8	0.0	3.0	1.94	0	0	0	6.42	6.42	0.0	6.42	6.42	**1791.4**	**1791.4**
147.00	1793.1	0.1	3.0	2.32	0	0	0	7.04	7.04	0.0	7.04	7.04	**1786.1**	**1786.1**
145.50	1790.9	0.2	3.0	1.95	0	0	0	6.69	6.69	0.0	6.69	6.69	**1784.2**	**1784.2**
144.00	1786.6	0.0	3.0	2.05	0	0	0	6.57	6.57	0.0	6.57	6.57	**1780.0**	**1780.0**
142.50	1782.2	0.4	3.0	2.20	0	0	0	7.28	7.28	0.0	7.28	7.28	**1774.9**	**1774.9**
141.00	1777.7	0.0	3.0	2.30	0	0	0	6.89	6.89	0.0	6.89	6.89	**1770.8**	**1770.8**
139.50	1774.0	0.1	3.0	2.46	0	0	0	7.23	7.23	0.0	7.23	7.23	**1766.8**	**1766.8**
138.00	1770.5	0.0	3.0	2.00	0	0	0	6.50	6.50	0.0	6.50	6.50	**1764.0**	**1764.0**
136.50	1767.6	0.0	3.0	2.07	0	0	0	6.59	6.59	0.0	6.59	6.59	**1761.0**	**1761.0**
135.00	1765.1	0.0	3.0	2.11	0	0	0	6.64	6.64	0.0	6.64	6.64	**1758.5**	**1758.5**
133.50	1762.6	0.1	3.0	2.20	0	0	0	6.89	6.89	0.0	6.89	6.89	**1755.7**	**1755.7**
132.00	1759.8	0.1	3.0	1.95	0	0	0	6.57	6.57	0.0	6.57	6.57	**1753.2**	**1753.2**
130.50	1755.9	0.0	3.0	2.21	0	0	0	6.77	6.77	0.0	6.77	6.77	**1749.1**	**1749.1**
129.00	1751.5	0.0	3.0	2.28	0	0	0	6.86	6.86	0.0	6.86	6.86	**1744.6**	**1744.6**
127.50	1746.8	0.1	3.0	2.65	0	0	0	7.47	7.47	0.0	7.47	7.47	**1739.3**	**1739.3**
126.00	1743.6	0.0	3.0	2.18	0	0	0	6.73	6.73	0.0	6.73	6.73	**1736.9**	**1736.9**
124.50	1740.5	0.0	3.0	2.30	0	0	0	6.89	6.89	0.0	6.89	6.89	**1733.6**	**1733.6**
123.00	1736.2	0.0	3.0	2.11	0	0	0	6.64	6.64	0.0	6.64	6.64	**1729.6**	**1729.6**
121.50	1732.2	0.1	3.0	2.39	0	0	0	7.13	7.13	0.0	7.13	7.13	**1725.1**	**1725.1**
120.00	1727.7	0.1	3.0	2.46	0	0	0	7.23	7.23	0.0	7.23	7.23	**1720.5**	**1720.5**
118.50	1724.3	0.0	3.0	2.00	0	0	0	6.50	6.50	0.0	6.50	6.50	**1717.8**	**1717.8**
117.00	1720.3	0.0	3.0	2.05	0	0	0	6.57	6.57	0.0	6.57	6.57	**1713.7**	**1713.7**
115.50	1715.6	0.0	3.0	2.39	0	0	0	7.00	7.00	0.0	7.00	7.00	**1708.6**	**1708.6**
114.00	1712.4	0.0	3.0	1.78	0	0	0	6.21	6.21	0.0	6.21	6.21	**1706.2**	**1706.2**
112.50	1709.8	0.1	3.0	2.28	0	0	0	6.99	6.99	0.0	6.99	6.99	**1702.8**	**1702.8**
111.00	1706.6	0.1	3.0	2.20	0	0	0	6.89	6.89	0.0	6.89	6.89	**1699.7**	**1699.7**
109.50	1702.7	0.2	3.0	2.30	0	0	0	7.15	7.15	0.0	7.15	7.15	**1695.6**	**1695.6**
108.00	1698.7	0.0	3.0	2.01	0	0	0	6.51	6.51	0.0	6.51	6.51	**1692.2**	**1692.2**
106.50	1696.5	0.0	3.0	2.18	0	0	0	6.73	6.73	0.0	6.73	6.73	**1689.8**	**1689.8**
105.00	1693.9	0.1	3.0	2.30	0	0	0	7.02	7.02	0.0	7.02	7.02	**1686.9**	**1686.9**
103.50	1689.1	0.7	3.0	2.61	0	0	0	8.20	8.20	0.0	8.20	8.20	**1680.9**	**1680.9**
102.00	1686.7	1.8	3.0	2.61	0	0	0	9.63	9.63	0.0	9.63	9.63	**1677.1**	**1677.1**
100.50	1684.0	1.8	3.0	1.75	0	0	0	8.52	8.52	0.0	8.52	8.52	**1675.5**	**1675.5**
99.00	1675.8	2.8	3.0	1.15	0	0	0	9.03	9.03	1.0	10.04	10.04	**1665.8**	**1665.8**
98.50	1674.2	1.2	3.0	1.40	0	0	0	7.28	7.28	1.0	8.28	8.28	**1665.9**	**1665.9**
98.00	1672.6	0.4	3.0	1.43	0	0	0	6.27	6.27	1.0	7.27	7.27	**1665.3**	**1665.3**
97.50	1671.0	0.1	3.0	1.40	0	0	0	5.85	5.85	1.0	6.85	6.85	**1664.2**	**1664.2**
96.00	1669.5	0.0	3.0	1.63	0	0	0	6.02	6.02	1.0	7.02	7.02	**1662.5**	**1662.5**
94.50	1668.0	0.0	3.0	1.45	0	0	0	5.79	5.79	0.0	5.79	5.79	**1662.2**	**1662.2**
93.00	1666.0	0.2	3.0	1.57	0	0	0	6.20	6.20	0.0	6.20	6.20	**1659.8**	**1659.8**
91.50	1662.6	0.5	3.0	1.80	0	0	0	6.89	6.89	0.0	6.89	6.89	**1655.7**	**1655.7**
90.00	1658.5	0.0	3.0	2.07	0	0	0	6.59	6.59	0.0	6.59	6.59	**1651.9**	**1651.9**
88.50	1655.3	0.3	3.0	1.66	0	0	0	6.45	6.45	0.0	6.45	6.45	**1648.9**	**1648.9**
87.00	1652.1	0.1	3.0	2.25	0	0	0	6.96	6.96	0.0	6.96	6.96	**1645.1**	**1645.1**
85.50	1647.9	0.0	3.0	2.32	0	0	0	6.91	6.91	0.0	6.91	6.91	**1641.0**	**1641.0**
84.00	1645.0	0.0	3.0	1.91	0	0	0	6.38	6.38	0.0	6.38	6.38	**1638.6**	**1638.6**

Table 6.2 Maximum Scour Depth Estimates (continued)

Section #	Thalweg El (ft)	General Scour (ft)	Low-flow Thalweg (ft)	Antidune Scour (ft)	Contraction Scour (ft)	Bend Scour East (ft)	Bend Scour West (ft)	Factored Total (*1.3) East (ft)	Factored Total (*1.3) West (ft)	Long-term Scour (ft)	Total Scour East (ft)	Total Scour West (ft)	Thalweg after Scour East (ft)	Thalweg after Scour West (ft)
82.50	1643.0	0.2	3.0	1.40	0	0	0	5.98	5.98	0.0	5.98	5.98	**1637.0**	**1637.0**
81.00	1641.0	0.8	3.0	1.95	0	0	0	7.48	7.48	0.0	7.48	7.48	**1633.5**	**1633.5**
79.50	1637.3	0.1	3.0	2.10	0	0	0	6.76	6.76	0.0	6.76	6.76	**1630.5**	**1630.5**
78.00	1633.9	0.0	3.0	2.18	0	0	0	6.73	6.73	0.0	6.73	6.73	**1627.2**	**1627.2**
76.50	1630.3	0.0	3.0	2.18	0	0	0	6.73	6.73	0.0	6.73	6.73	**1623.6**	**1623.6**
75.00	1627.5	0.0	3.0	1.51	0	0	0	5.86	5.86	0.0	5.86	5.86	**1621.6**	**1621.6**
73.50	1623.9	0.0	3.0	2.50	0	0	0	7.15	7.15	0.0	7.15	7.15	**1616.8**	**1616.8**
72.00	1620.4	0.0	3.0	0.73	0	0	0	4.85	4.85	0.0	4.85	4.85	**1615.6**	**1615.6**
70.50	1620.0	1.0	3.0	1.48	0	0	0	7.13	7.13	0.0	7.13	7.13	**1612.9**	**1612.9**
69.00	1618.2	1.8	3.0	2.46	0	0	0	9.44	9.44	0.0	9.44	9.44	**1608.8**	**1608.8**
67.50	1615.4	1.5	3.0	2.20	0	0	0	8.71	8.71	0.0	8.71	8.71	**1606.7**	**1606.7**
66.00	1611.8	0.1	3.0	2.20	0	0	0	6.89	6.89	0.0	6.89	6.89	**1604.9**	**1604.9**
64.50	1608.2	0.0	3.0	1.84	0	0	0	6.30	6.30	0.0	6.30	6.30	**1601.9**	**1601.9**
63.00	1604.2	0.3	3.0	1.81	0	0	0	6.65	6.65	0.0	6.65	6.65	**1597.6**	**1597.6**
61.50	1600.3	0.2	3.0	2.32	0	0	0	7.17	7.17	0.0	7.17	7.17	**1593.1**	**1593.1**
60.00	1597.0	0.0	3.0	2.18	0	0	0	6.73	6.73	0.0	6.73	6.73	**1590.3**	**1590.3**
58.50	1593.3	0.3	3.0	1.60	0	0	0	6.37	6.37	0.0	6.37	6.37	**1586.9**	**1586.9**
57.00	1589.3	0.0	3.0	2.50	0	0	0	7.15	7.15	0.1	7.25	7.25	**1582.1**	**1582.1**
55.50	1585.9	0.2	3.0	2.53	0	0	0	7.45	7.45	0.1	7.55	7.55	**1578.3**	**1578.3**
54.00	1583.7	0.0	3.0	2.84	0	0	0	7.59	7.59	0.1	7.69	7.69	**1576.0**	**1576.0**
52.50	1580.7	0.7	3.0	1.60	0	0	0	6.89	6.89	0.1	6.99	6.99	**1573.7**	**1573.7**
51.00	1577.5	1.4	3.0	3.15	0	0	0	9.81	9.81	0.1	9.91	9.91	**1567.6**	**1567.6**
49.50	1574.5	0.0	3.0	2.50	0	0	0	7.15	7.15	0.1	7.25	7.25	**1567.3**	**1567.3**
48.00	1571.2	0.0	3.0	1.40	0	0	0	5.72	5.72	0.1	5.82	5.82	**1565.4**	**1565.4**
46.50	1568.0	0.0	3.0	1.80	3.7	0	0	11.05	11.05	0.0	11.05	11.05	**1557.0**	**1557.0**
45.00	1566.1	0.0	3.0	0.56	3.7	0	0	9.44	9.44	0.0	9.44	9.44	**1556.7**	**1556.7**
44.50	1566.2	0.0	3.0	0.71	3.7	0	0	9.63	9.63	0.0	9.63	9.63	**1556.6**	**1556.6**
43.60	1565.8	0.0	3.0	0.67	0	0	0	4.77	4.77	0.0	4.77	4.77	**1561.0**	**1561.0**
42.00	1567.4	1.0	3.0	1.94	0	0	0	7.72	7.72	0.0	7.72	7.72	**1559.7**	**1559.7**
40.50	1563.2	0.4	3.0	2.35	0	0	0	7.48	7.48	0.0	7.48	7.48	**1555.7**	**1555.7**
39.00	1559.2	0.0	3.0	2.53	0	0	0	7.19	7.19	0.0	7.19	7.19	**1552.0**	**1552.0**
37.50	1558.0	0.0	3.0	2.65	0	0	0	7.34	7.34	0.0	7.34	7.34	**1550.7**	**1550.7**
36.00	1554.7	0.2	3.0	2.28	0	0	0	7.12	7.12	0.0	7.12	7.12	**1547.6**	**1547.6**
34.50	1552.7	0.5	3.0	2.65	0	0	0	7.99	7.99	0.0	7.99	7.99	**1544.7**	**1544.7**
33.00	1549.6	0.0	3.0	2.55	0	0	0	7.22	7.22	0.0	7.22	7.22	**1542.4**	**1542.4**
31.50	1547.3	0.0	3.0	1.63	0	0	0	6.02	6.02	0.0	6.02	6.02	**1541.3**	**1541.3**
30.00	1544.6	0.0	3.0	1.66	2.1	0	0	8.79	8.79	0.0	8.79	8.79	**1535.8**	**1535.8**
28.50	1542.6	0.0	3.0	1.88	2.1	0	0	9.07	9.07	0.0	9.07	9.07	**1533.5**	**1533.5**
27.00	1539.0	0.0	3.0	1.57	2.1	0	0	8.67	8.67	0.0	8.67	8.67	**1530.3**	**1530.3**
25.50	1536.2	0.0	3.0	1.94	2.1	0	0	9.15	9.15	0.0	9.15	9.15	**1527.0**	**1527.0**
24.00	1534.7	0.4	3.0	1.91	2.1	0	0	9.63	9.63	0.0	9.63	9.63	**1525.1**	**1525.1**
22.50	1533.0	4.0	3.0	2.50	0	0	0	12.35	12.35	0.0	12.35	12.35	**1520.7**	**1520.7**
21.00	1531.4	5.5	3.0	3.30	0	0	0	15.34	15.34	0.0	15.34	15.34	**1516.1**	**1516.1**
19.50	1528.6	2.6	3.0	2.85	3.5	0	0	15.54	15.54	0.0	15.54	15.54	**1513.1**	**1513.1**
18.00	1525.8	1.3	3.0	2.45	3.5	0	0.78	13.33	14.34	0.0	13.33	14.34	**1512.5**	**1511.5**
16.50	1523.0	0.5	3.0	2.35	3.5	0	0.78	12.16	13.17	0.0	12.16	13.17	**1510.8**	**1509.8**
15.00	1520.2	0.0	3.0	2.45	0	0	0.78	7.08	8.10	0.0	7.08	8.10	**1513.1**	**1512.1**
13.50	1517.4	0.2	3.0	2.95	0	0	0.78	7.99	9.01	0.0	7.99	9.01	**1509.4**	**1508.4**
12.00	1514.6	0.0	3.0	2.45	0	0	0.78	7.09	8.10	0.0	7.09	8.10	**1507.5**	**1506.5**
10.50	1511.8	0.0	3.0	2.35	0	0	0	6.96	6.96	0.0	6.96	6.96	**1504.8**	**1504.8**
9.00	1510.9	0.0	3.0	1.48	0	0	0	5.83	5.83	0.0	5.83	5.83	**1505.1**	**1505.1**
7.50	1510.1	0.0	3.0	1.57	0	0	0	5.94	5.94	0.0	5.94	5.94	**1504.2**	**1504.2**
6.00	1509.5	0.0	3.0	1.57	0	0	0	5.94	5.94	0.0	5.94	5.94	**1503.6**	**1503.6**
4.50	1509.1	0.1	3.0	2.69	0	0	0	7.52	7.52	0.0	7.52	7.52	**1501.6**	**1501.6**
3.00	1508.0	0.1	3.0	2.32	0	0	0	7.04	7.04	0.0	7.04	7.04	**1501.0**	**1501.0**
1.50	1507.0	0.8	3.0	2.24	0	0	0	7.86	7.86	0.0	7.86	7.86	**1499.1**	**1499.1**
0.00	1506.0	2.0	3.0	2.80	0	0	0	10.14	10.14	0.0	10.14	10.14	**1495.9**	**1495.9**
max		7.7	3.0	3.8	3.8	1.1	0.8	20.3	20.3	3.0	21.3	21.3		
min		0.0	3.0	0.5	0.0	0.0	0.0	4.5	4.5	0.0	4.5	4.5		
avg		0.6	3.0	2.2	0.2	0.0	0.0	7.9	7.9	0.5	8.3	8.3		

It is recommended that the maximum scour depths (shown in Table 6.2) be referenced during future design phases, minimum toedown depth be established for noncritical scour areas, and extra toedown protection be applied to critical scour reaches. Further design effort will be made using grade control, grading modification, channel stabilization, and low-flow protection within the levee/wall structures to reduce the levee failure potential due to erosion. This will be presented in future reports. Note that braided low flow channels may form or become incised within the reaches which do not have low flow channel improvement. Potential of low flow formation, incisement, and migration will be assessed ad proper design to avoid levee impingement will be given during the design phase.

VII. MINIMUM LEVEE/WALL ELEVATION ESTIMATES

7.1 TOP OF LEVEE (LEVEE HEIGHT)

This section provides estimates of minimum levee/wall elevations for the ultimate levee encroachment conditions. The minimum levee/wall height was computed by summing the 100-year flow depth, potential 100-year aggradation depth, potential long-term aggradation depth, superelevation at the outer bend, and a three-foot freeboard. To ensure conservative estimation of the flow depths, a relatively high Manning's *n* value was used to account for high flow resistance considering potential vegetation growth. A Manning's *n* value of 0.050 for the main channel was used for the purpose of computing levee height. In addition, the critical flow depth or subcritical depth, whichever is greater, was used as the flow depth component of the total levee height. A three-foot freeboard was added to the levee height according to the FEMA design criteria. Table 7.1 lists the estimated minimum levee height and top of levee elevations for each cross-section. As mentioned previously in Section 5.4, the aggradation depth may be increased assuming peak discharges occur at the tributaries. This has been accounted for in the general aggradation factor shown in Table 7.1. Figure 7.1 shows the minimum top of levee and toe-down elevation profiles. Detailed levee height computations are included in the technical addendum. Levee heights compared to the ground elevations are mostly near or less than 8 ft, except for a few sections at which levee heights can be higher than 10 ft.

Table 7.1 Minimum Levee/Wall Elevation Estimates

Section #	Thalweg Elevation (ft)	Mixed WSEL (ft)	Subcritical WSEL (ft)	General Agg. (ft)	Long-term Agg. (ft)	Superelevation (East) (ft)	Superelevation (West) (ft)	Free Board (ft)	Minimum Top of Levee (East) (ft)	Minimum Top of Levee (West) (ft)
271.50	2171.5	2181.4	2182.2	0.4	0.0	0.0	0.0	3.00	**2185.6**	**2185.6**
270.00	2167.9	2178.7	2178.8	0.0	0.0	0.0	0.0	3.00	**2181.8**	**2181.8**
267.00	2162.0	2165.9	2168.0	0.6	0.0	0.0	0.0	3.00	**2171.6**	**2171.6**
265.50	2158.0	2162.6	2163.5	0.9	0.0	0.0	0.0	3.00	**2167.4**	**2167.4**
264.00	2153.8	2158.1	2159.3	0.0	0.0	0.0	0.0	3.00	**2162.3**	**2162.3**
262.50	2150.5	2154.6	2155.5	0.0	0.0	0.0	0.0	3.00	**2158.5**	**2158.5**
261.00	2144.9	2149.6	2151.0	0.0	0.0	0.0	0.0	3.00	**2154.0**	**2154.0**
259.50	2139.4	2145.4	2146.8	0.0	0.0	0.0	0.0	3.00	**2149.8**	**2149.8**
258.00	2133.9	2139.7	2142.1	0.0	0.0	0.0	0.0	3.00	**2145.1**	**2145.1**
256.50	2128.3	2133.6	2137.2	0.0	0.0	0.0	0.0	3.00	**2140.2**	**2140.2**
255.00	2122.8	2128.0	2132.2	0.0	0.0	0.0	0.0	3.00	**2135.2**	**2135.2**
253.50	2117.2	2122.4	2125.7	0.0	0.0	0.0	0.0	3.00	**2128.7**	**2128.7**
252.00	2111.7	2116.8	2120.1	0.0	0.0	0.0	0.0	3.00	**2123.1**	**2123.1**
250.50	2106.1	2111.2	2114.4	0.0	0.0	0.0	0.0	3.00	**2117.4**	**2117.4**
249.00	2100.5	2105.7	2108.8	0.0	0.0	0.0	0.0	3.00	**2111.8**	**2111.8**
247.50	2095.0	2100.1	2103.2	0.0	0.0	0.0	0.0	3.00	**2106.2**	**2106.2**
246.00	2089.5	2094.6	2097.7	0.0	0.0	0.0	0.0	3.00	**2100.7**	**2100.7**
244.50	2083.9	2089.0	2092.3	0.0	0.0	0.0	0.0	3.00	**2095.3**	**2095.3**
243.00	2078.4	2082.5	2085.5	0.1	0.0	0.0	0.0	3.00	**2088.6**	**2088.6**
240.80	2070.8	2075.5	2080.6	0.9	0.0	0.0	0.0	3.00	**2084.5**	**2084.5**
240.30	2069.2	2075.7	2076.3	0.0	0.0	0.0	0.0	3.00	**2079.3**	**2079.3**
240.00	2067.5	2072.9	2074.7	0.0	0.0	0.0	0.0	3.00	**2077.7**	**2077.7**
238.50	2062.5	2067.2	2069.6	0.0	0.0	1.9	0.0	3.00	**2074.5**	**2072.6**
237.00	2057.4	2062.0	2064.5	0.0	0.0	1.9	0.0	3.00	**2069.4**	**2067.5**
235.50	2052.3	2056.8	2059.4	0.0	0.0	1.9	0.0	3.00	**2064.3**	**2062.4**
234.00	2047.2	2052.0	2055.0	0.0	0.0	1.9	0.0	3.00	**2059.9**	**2058.0**
232.50	2040.5	2044.9	2048.6	4.0	0.0	1.9	0.0	3.00	**2057.5**	**2055.6**
231.00	2036.9	2043.0	2045.0	1.7	0.0	1.9	0.0	3.00	**2051.5**	**2049.7**
229.50	2032.5	2038.5	2040.4	0.0	0.0	0.0	0.0	3.00	**2043.4**	**2043.4**
228.00	2029.8	2034.9	2036.6	0.9	0.0	0.0	0.0	3.00	**2040.5**	**2040.5**
226.50	2025.8	2031.3	2033.4	1.3	0.0	0.0	1.2	3.00	**2037.7**	**2038.9**
225.00	2022.3	2028.9	2030.3	0.7	0.0	0.0	1.2	3.00	**2034.0**	**2035.2**
223.50	2018.2	2025.3	2027.0	0.0	0.0	0.0	1.2	3.00	**2030.0**	**2031.2**
222.00	2014.6	2021.6	2023.5	0.0	0.0	0.0	1.2	3.00	**2026.5**	**2027.6**
220.50	2011.2	2017.5	2019.6	0.0	0.0	0.0	1.2	3.00	**2022.6**	**2023.8**
219.00	2007.8	2013.7	2015.7	0.7	0.0	0.0	1.2	3.00	**2019.4**	**2020.6**
217.50	2004.4	2011.3	2012.8	0.2	0.0	0.0	1.2	3.00	**2016.0**	**2017.2**
216.00	2001.2	2007.3	2009.2	1.0	0.0	0.0	1.2	3.00	**2013.2**	**2014.3**
214.50	1997.0	2004.1	2005.8	1.2	0.0	0.0	1.2	3.00	**2010.0**	**2011.1**
213.00	1994.0	2000.0	2001.5	1.3	0.0	0.0	1.2	3.00	**2005.8**	**2007.0**
211.50	1990.0	1996.2	1997.3	0.0	0.0	0.0	1.2	3.00	**2000.3**	**2001.5**
210.00	1985.2	1990.4	1991.7	0.0	0.0	0.0	0.0	3.00	**1994.7**	**1994.7**
208.50	1980.2	1984.8	1986.1	0.0	0.0	0.0	0.0	3.00	**1989.1**	**1989.1**
207.00	1974.9	1978.6	1980.0	0.1	0.0	0.0	0.0	3.00	**1983.1**	**1983.1**
205.50	1967.8	1973.3	1974.4	0.0	0.0	0.0	0.0	3.00	**1977.4**	**1977.4**
204.00	1960.1	1965.6	1967.7	0.0	0.0	0.0	0.0	3.00	**1970.7**	**1970.7**
202.50	1950.1	1957.3	1960.7	0.0	0.0	0.0	0.0	3.00	**1963.7**	**1963.7**
201.00	1941.3	1946.7	1949.5	0.0	0.0	0.0	0.0	3.00	**1952.5**	**1952.5**
199.50	1937.4	1941.8	1945.2	1.0	0.0	0.0	0.0	3.00	**1949.2**	**1949.2**
198.00	1930.9	1941.5	1942.0	0.0	0.0	0.0	0.0	3.00	**1945.0**	**1945.0**
196.50	1925.5	1930.3	1932.6	0.2	0.0	0.0	0.0	3.00	**1935.8**	**1935.8**
195.00	1921.3	1926.0	1927.8	0.3	0.0	0.0	0.0	3.00	**1931.1**	**1931.1**
193.50	1916.6	1921.3	1922.7	1.3	0.0	0.0	0.0	3.00	**1927.0**	**1927.0**
192.00	1911.0	1915.8	1917.3	0.6	0.0	0.0	0.0	3.00	**1920.9**	**1920.9**
190.50	1905.0	1909.8	1911.3	0.0	0.0	0.0	0.0	3.00	**1914.3**	**1914.3**
189.00	1901.9	1905.2	1906.5	0.0	0.0	0.0	0.0	3.00	**1909.5**	**1909.5**
187.50	1897.5	1901.1	1902.3	0.0	0.0	0.0	0.0	3.00	**1905.3**	**1905.3**
186.00	1892.3	1895.6	1897.1	0.9	0.0	3.2	0.0	3.00	**1904.1**	**1901.0**
184.50	1887.8	1892.0	1893.4	1.1	0.0	3.2	0.0	3.00	**1900.7**	**1897.5**
183.00	1882.8	1889.0	1890.3	0.3	0.0	3.2	0.0	3.00	**1896.7**	**1893.6**
181.50	1879.1	1883.0	1884.6	1.8	0.0	3.2	0.0	3.00	**1892.5**	**1889.4**

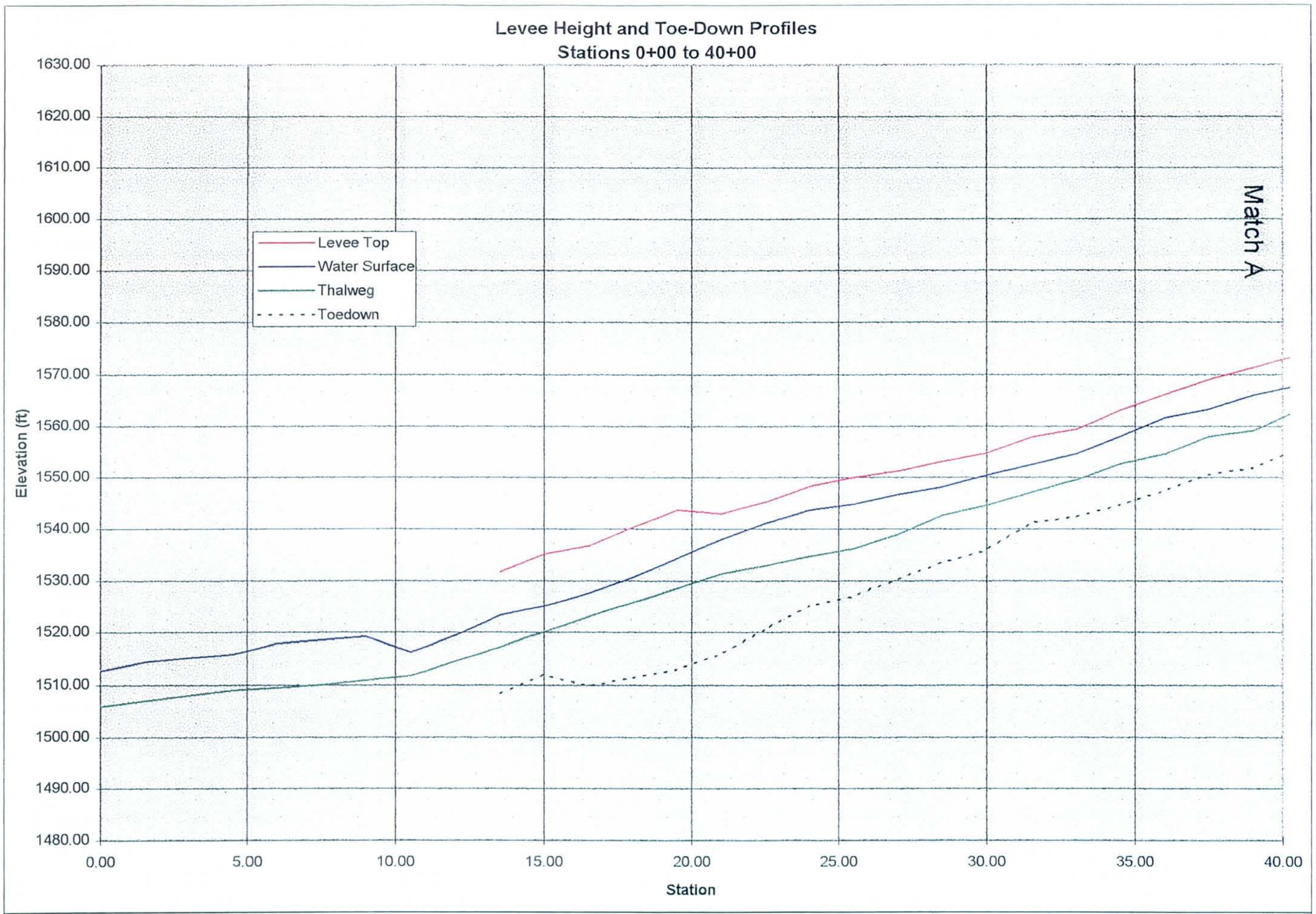
Table 7.1 Minimum Levee/Wall Elevation Estimates (continued)

Section #	Thalweg Elevation (ft)	Mixed WSEL (ft)	Subcritical WSEL (ft)	General Agg. (ft)	Long-term Agg. (ft)	Superelevation (East) (ft)	Superelevation (West) (ft)	Free Board (ft)	Minimum Top of Levee (East) (ft)	Minimum Top of Levee (West) (ft)
180.00	1875.4	1880.4	1881.3	2.0	0.0	3.2	0.0	3.00	**1889.5**	**1886.3**
178.50	1872.2	1877.6	1878.7	1.0	0.0	3.2	0.0	3.00	**1885.9**	**1882.7**
177.00	1869.6	1874.7	1875.4	0.5	0.0	3.2	0.0	3.00	**1882.0**	**1878.9**
175.50	1866.1	1871.5	1872.9	0.3	0.0	3.2	0.0	3.00	**1879.4**	**1876.2**
174.00	1862.7	1868.7	1869.5	0.7	0.0	0.0	0.0	3.00	**1873.2**	**1873.2**
172.50	1857.5	1863.9	1866.6	1.2	0.0	0.0	0.0	3.00	**1870.8**	**1870.8**
171.00	1853.5	1863.2	1863.6	3.1	0.1	0.0	0.0	3.00	**1869.8**	**1869.8**
169.50	1850.5	1858.4	1859.6	0.0	0.1	0.0	0.0	3.00	**1862.7**	**1862.7**
168.00	1846.7	1853.1	1854.9	0.9	0.1	0.0	0.0	3.00	**1858.9**	**1858.9**
166.50	1844.8	1852.7	1852.5	0.9	0.1	0.0	0.0	3.00	**1856.5**	**1856.5**
166.00	1843.3	1849.0	1852.2	0.0	0.1	0.0	0.0	3.00	**1855.3**	**1855.3**
165.50	1841.7	1849.6	1848.4	1.1	0.1	0.0	0.0	3.00	**1852.6**	**1852.6**
165.00	1840.2	1845.7	1847.1	1.2	0.1	0.0	0.0	3.00	**1851.4**	**1851.4**
163.50	1836.0	1842.5	1843.4	0.2	0.1	0.0	0.0	3.00	**1846.7**	**1846.7**
162.00	1832.4	1838.0	1839.2	0.3	0.1	0.0	0.0	3.00	**1842.6**	**1842.6**
160.50	1827.7	1834.8	1835.8	0.1	0.1	0.0	0.0	3.00	**1839.0**	**1839.0**
159.00	1825.4	1830.6	1832.1	0.0	0.1	0.0	0.0	3.00	**1835.2**	**1835.2**
157.50	1821.9	1828.0	1828.7	0.0	0.1	0.0	0.0	3.00	**1831.8**	**1831.8**
156.00	1818.8	1823.6	1824.7	0.0	0.1	0.0	0.0	3.00	**1827.8**	**1827.8**
154.50	1815.5	1820.1	1821.0	0.0	0.1	0.0	0.0	3.00	**1824.1**	**1824.1**
153.00	1811.7	1815.9	1816.9	0.0	0.1	0.0	0.0	3.00	**1820.0**	**1820.0**
151.50	1804.6	1810.2	1811.2	0.9	0.1	0.0	0.0	3.00	**1815.2**	**1815.2**
150.00	1801.0	1807.2	1807.8	0.4	0.1	0.0	0.0	3.00	**1811.3**	**1811.3**
148.50	1797.8	1803.3	1804.0	0.0	0.1	0.0	0.0	3.00	**1807.1**	**1807.1**
147.00	1793.1	1798.9	1799.7	0.0	0.1	0.0	0.0	3.00	**1802.8**	**1802.8**
145.50	1790.9	1794.8	1795.6	0.0	0.1	0.0	0.0	3.00	**1798.7**	**1798.7**
144.00	1786.6	1790.7	1791.6	0.0	0.1	0.0	0.0	3.00	**1794.7**	**1794.7**
142.50	1782.2	1786.6	1787.6	0.0	0.5	0.0	0.0	3.00	**1791.1**	**1791.1**
141.00	1777.7	1782.3	1783.4	0.0	0.5	0.0	0.0	3.00	**1786.9**	**1786.9**
139.50	1774.0	1779.0	1779.8	0.0	0.5	0.0	0.0	3.00	**1783.3**	**1783.3**
138.00	1770.5	1774.5	1775.5	0.0	0.5	0.0	0.0	3.00	**1779.0**	**1779.0**
136.50	1767.6	1771.8	1772.8	0.0	0.5	0.0	0.0	3.00	**1776.3**	**1776.3**
135.00	1765.1	1769.4	1770.6	0.0	0.5	0.0	0.0	3.00	**1774.1**	**1774.1**
133.50	1762.6	1767.0	1767.9	0.0	0.5	0.0	0.0	3.00	**1771.4**	**1771.4**
132.00	1759.8	1763.7	1764.7	0.0	0.5	0.0	0.0	3.00	**1768.2**	**1768.2**
130.50	1755.9	1760.8	1761.7	0.3	0.1	0.0	0.0	3.00	**1765.1**	**1765.1**
129.00	1751.5	1757.4	1758.1	0.2	0.1	0.0	0.0	3.00	**1761.4**	**1761.4**
127.50	1746.8	1753.0	1753.9	0.0	0.1	0.0	0.0	3.00	**1757.0**	**1757.0**
126.00	1743.6	1749.4	1750.1	0.0	0.1	0.0	0.0	3.00	**1753.2**	**1753.2**
124.50	1740.5	1745.1	1745.9	0.0	0.1	0.0	0.0	3.00	**1749.0**	**1749.0**
123.00	1736.2	1741.4	1742.0	0.0	0.1	0.0	0.0	3.00	**1745.1**	**1745.1**
121.50	1732.2	1737.1	1737.9	0.0	0.1	0.0	0.0	3.00	**1741.0**	**1741.0**
120.00	1727.7	1732.7	1733.5	0.0	0.1	0.0	0.0	3.00	**1736.6**	**1736.6**
118.50	1724.3	1728.3	1729.1	0.0	0.1	0.0	0.0	3.00	**1732.2**	**1732.2**
117.00	1720.3	1724.4	1725.1	0.0	0.1	0.0	0.0	3.00	**1728.2**	**1728.2**
115.50	1715.6	1720.6	1721.8	0.5	0.1	0.0	0.0	3.00	**1725.4**	**1725.4**
114.00	1712.4	1718.2	1718.8	0.0	0.1	0.0	0.0	3.00	**1721.9**	**1721.9**
112.50	1709.8	1714.7	1715.5	0.0	0.1	0.0	0.0	3.00	**1718.6**	**1718.6**
111.00	1706.6	1711.0	1711.8	0.0	0.1	0.0	0.0	3.00	**1714.9**	**1714.9**
109.50	1702.7	1707.3	1708.4	0.0	0.1	0.0	0.0	3.00	**1711.5**	**1711.5**
108.00	1698.7	1704.7	1705.7	0.3	0.1	0.0	0.0	3.00	**1709.1**	**1709.1**
106.50	1696.5	1701.9	1702.7	0.0	0.1	0.0	0.0	3.00	**1705.8**	**1705.8**
105.00	1693.9	1698.5	1699.4	0.0	0.1	0.0	0.0	3.00	**1702.5**	**1702.5**
103.50	1689.1	1695.3	1696.3	0.0	0.1	0.0	0.0	3.00	**1699.4**	**1699.4**
102.00	1686.7	1692.0	1692.8	0.0	0.1	0.0	0.0	3.00	**1695.9**	**1695.9**
100.50	1684.0	1687.5	1688.6	0.0	0.1	0.0	0.0	3.00	**1691.7**	**1691.7**
99.00	1675.8	1678.1	1680.6	0.0	0.0	0.0	0.0	3.00	**1683.6**	**1683.6**
98.50	1674.2	1677.0	1680.5	0.0	0.0	0.0	0.0	3.00	**1683.5**	**1683.5**
98.00	1672.6	1677.2	1676.7	0.0	0.0	0.0	0.0	3.00	**1679.7**	**1679.7**
97.50	1671.0	1673.8	1676.0	0.0	0.0	0.0	0.0	3.00	**1679.0**	**1679.0**
96.00	1669.5	1673.4	1674.7	1.5	0.0	0.0	0.0	3.00	**1679.2**	**1679.2**
94.50	1668.0	1672.3	1673.6	0.4	0.0	0.0	0.0	3.00	**1677.0**	**1677.0**

Table 7.1 Minimum Levee/Wall Elevation Estimates (continued)

Section #	Thalweg Elevation (ft)	Mixed WSEL (ft)	Subcritical WSEL (ft)	General Agg. (ft)	Long-term Agg. (ft)	Superelevation		Free Board (ft)	Minimum Top of Levee	
						(East) (ft)	(West) (ft)		(East) (ft)	(West) (ft)
93.00	1666.0	1670.5	1670.9	0.0	0.0	0.0	0.0	3.00	**1673.9**	**1673.9**
91.50	1662.6	1666.2	1667.1	0.0	0.0	0.0	0.0	3.00	**1670.1**	**1670.1**
90.00	1658.5	1662.8	1664.0	0.6	0.0	0.0	0.0	3.00	**1667.6**	**1667.6**
88.50	1655.3	1660.6	1661.1	0.0	0.0	0.0	0.0	3.00	**1664.1**	**1664.1**
87.00	1652.1	1656.6	1657.5	0.0	0.0	0.0	0.0	3.00	**1660.5**	**1660.5**
85.50	1647.9	1652.9	1653.7	0.5	0.0	0.0	0.0	3.00	**1657.2**	**1657.2**
84.00	1645.0	1650.3	1651.7	1.4	0.0	0.0	0.0	3.00	**1656.1**	**1656.1**
82.50	1643.0	1648.9	1649.3	0.0	0.0	0.0	0.0	3.00	**1652.3**	**1652.3**
81.00	1641.0	1644.9	1645.8	0.0	0.0	0.0	0.0	3.00	**1648.8**	**1648.8**
79.50	1637.3	1641.5	1642.5	0.0	0.0	0.0	0.0	3.00	**1645.5**	**1645.5**
78.00	1633.9	1638.3	1639.0	0.1	0.0	0.0	0.0	3.00	**1642.1**	**1642.1**
76.50	1630.3	1634.9	1636.2	0.5	0.0	0.0	0.0	3.00	**1639.7**	**1639.7**
75.00	1627.5	1633.0	1633.5	0.0	0.0	0.0	0.0	3.00	**1636.5**	**1636.5**
73.50	1623.9	1628.9	1629.9	0.9	0.5	0.0	0.0	3.00	**1634.3**	**1634.3**
72.00	1620.4	1628.3	1629.1	1.5	0.5	0.0	0.0	3.00	**1634.1**	**1634.1**
70.50	1620.0	1626.7	1627.3	0.0	0.5	0.0	0.0	3.00	**1630.8**	**1630.8**
69.00	1618.2	1623.4	1624.2	0.0	0.5	0.0	0.0	3.00	**1627.7**	**1627.7**
67.50	1615.4	1619.8	1620.6	0.0	0.5	0.0	0.0	3.00	**1624.1**	**1624.1**
66.00	1611.8	1616.2	1616.9	0.0	0.1	0.0	0.0	3.00	**1620.0**	**1620.0**
64.50	1608.2	1613.0	1613.9	0.2	0.1	0.0	0.0	3.00	**1617.2**	**1617.2**
63.00	1604.2	1609.9	1610.5	0.0	0.1	0.0	0.0	3.00	**1613.6**	**1613.6**
61.50	1600.3	1605.7	1606.5	0.0	0.1	0.0	0.0	3.00	**1609.6**	**1609.6**
60.00	1597.0	1602.0	1603.2	0.3	0.1	0.0	0.0	3.00	**1606.6**	**1606.6**
58.50	1593.3	1599.8	1600.3	0.0	0.1	0.0	0.0	3.00	**1603.4**	**1603.4**
57.00	1589.3	1596.3	1597.8	0.0	0.0	0.0	0.0	3.00	**1600.8**	**1600.8**
55.50	1585.9	1593.7	1594.5	0.0	0.0	0.0	0.0	3.00	**1597.5**	**1597.5**
54.00	1583.7	1590.0	1591.7	0.7	0.0	0.0	0.0	3.00	**1595.4**	**1595.4**
52.50	1580.7	1588.3	1588.7	0.0	0.0	0.0	0.0	3.00	**1591.7**	**1591.7**
51.00	1577.5	1583.8	1585.0	0.0	0.0	0.0	0.0	3.00	**1588.0**	**1588.0**
49.50	1574.5	1579.5	1582.1	0.0	0.0	0.0	0.0	3.00	**1585.1**	**1585.1**
48.00	1571.2	1578.9	1579.0	0.5	0.0	0.0	0.0	3.00	**1582.5**	**1582.5**
46.50	1568.0	1571.6	1576.2	3.0	1.5	0.0	0.0	3.00	**1583.7**	**1583.7**
45.00	1566.1	1575.2	1575.9	3.2	1.5	0.0	0.0	3.00	**1583.6**	**1583.6**
44.50	1566.2	1575.0	1575.6	0.3	1.5	0.0	0.0	3.00	**1580.4**	**1580.4**
43.60	1565.8	1574.8	1575.5	0.3	1.5	0.0	0.0	3.00	**1580.3**	**1580.3**
42.00	1567.4	1572.6	1572.6	0.0	1.0	0.0	0.0	3.00	**1576.6**	**1576.6**
40.50	1563.2	1567.9	1569.7	0.0	1.0	0.0	0.0	3.00	**1573.7**	**1573.7**
39.00	1559.2	1566.1	1566.9	0.5	1.0	0.0	0.0	3.00	**1571.4**	**1571.4**
37.50	1558.0	1563.3	1565.1	0.0	1.0	0.0	0.0	3.00	**1569.1**	**1569.1**
36.00	1554.7	1561.7	1562.3	0.0	1.0	0.0	0.0	3.00	**1566.3**	**1566.3**
34.50	1552.7	1558.0	1559.1	0.0	1.0	0.0	0.0	3.00	**1563.1**	**1563.1**
33.00	1549.6	1554.7	1555.8	0.1	0.5	0.0	0.0	3.00	**1559.4**	**1559.4**
31.50	1547.3	1552.6	1553.6	0.8	0.5	0.0	0.0	3.00	**1557.9**	**1557.9**
30.00	1544.6	1550.5	1551.3	0.0	0.5	0.0	0.0	3.00	**1554.8**	**1554.8**
28.50	1542.6	1548.2	1549.5	0.2	0.5	0.0	0.0	3.00	**1553.2**	**1553.2**
27.00	1539.0	1546.8	1547.9	0.0	0.5	0.0	0.0	3.00	**1551.4**	**1551.4**
25.50	1536.2	1544.8	1546.5	0.0	0.5	0.0	0.0	3.00	**1550.0**	**1550.0**
24.00	1534.7	1543.7	1544.8	0.0	0.5	0.0	0.0	3.00	**1548.3**	**1548.3**
22.50	1533.0	1541.2	1541.8	0.0	0.5	0.0	0.0	3.00	**1545.3**	**1545.3**
21.00	1531.4	1538.0	1539.0	0.0	1.0	0.0	0.0	3.00	**1543.0**	**1543.0**
19.50	1528.6	1534.3	1536.4	0.0	1.0	0.0	3.3	3.00	**1540.4**	**1543.7**
18.00	1525.8	1530.7	1533.0	0.0	1.0	0.0	3.3	3.00	**1537.0**	**1540.3**
16.50	1523.0	1527.7	1529.4	0.0	1.0	0.0	3.3	3.00	**1533.4**	**1536.8**
15.00	1520.2	1525.1	1527.8	0.0	1.0	0.0	3.3	3.00	**1531.8**	**1535.1**
13.50	1517.4	1523.3	1524.4	0.0	1.0	0.0	3.3	3.00	**1528.4**	**1531.7**

Note: Station 12+00 to 0+00 is in WestWorld and is part of the detention area; containment of a 100-yr flood is not needed.



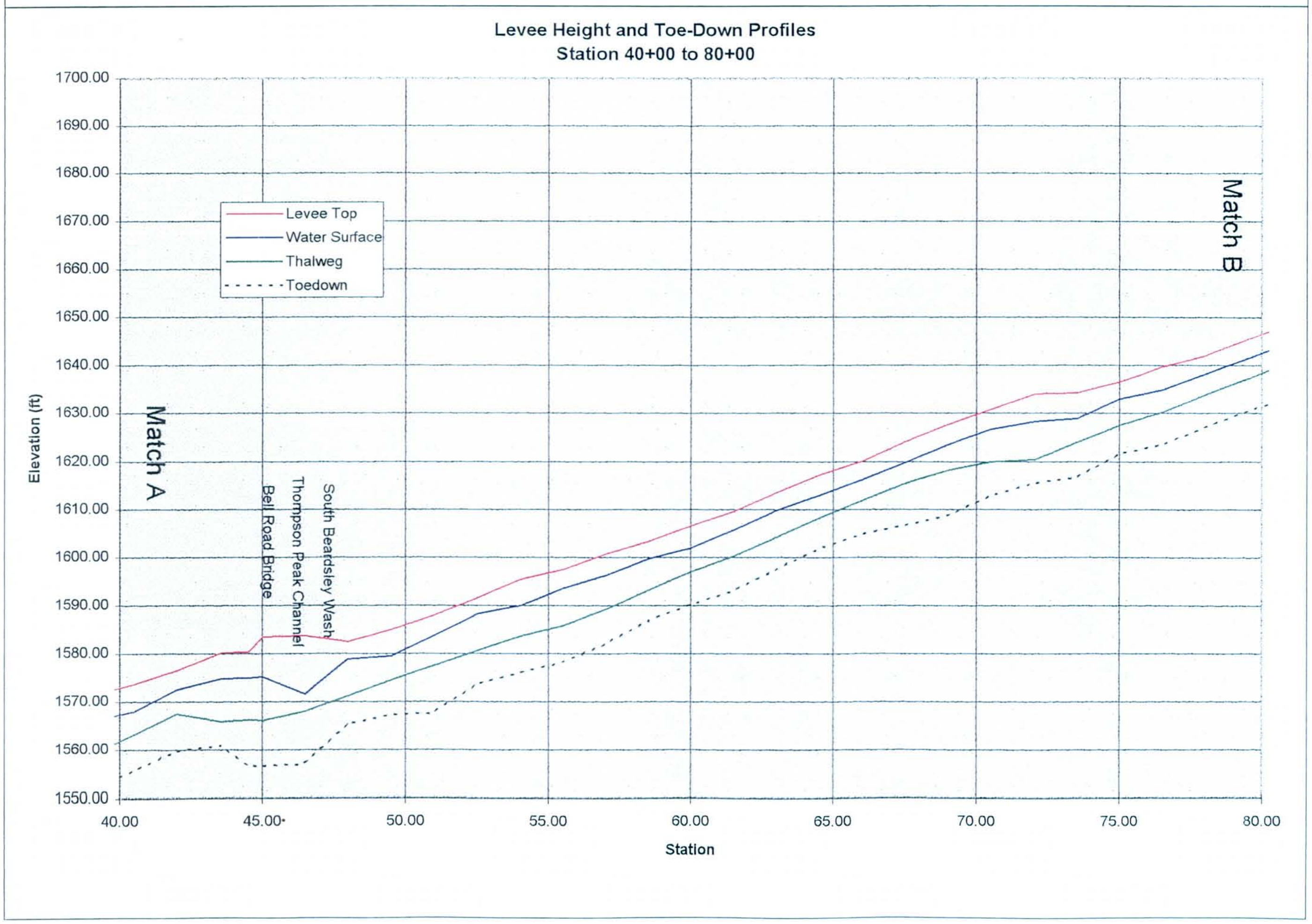
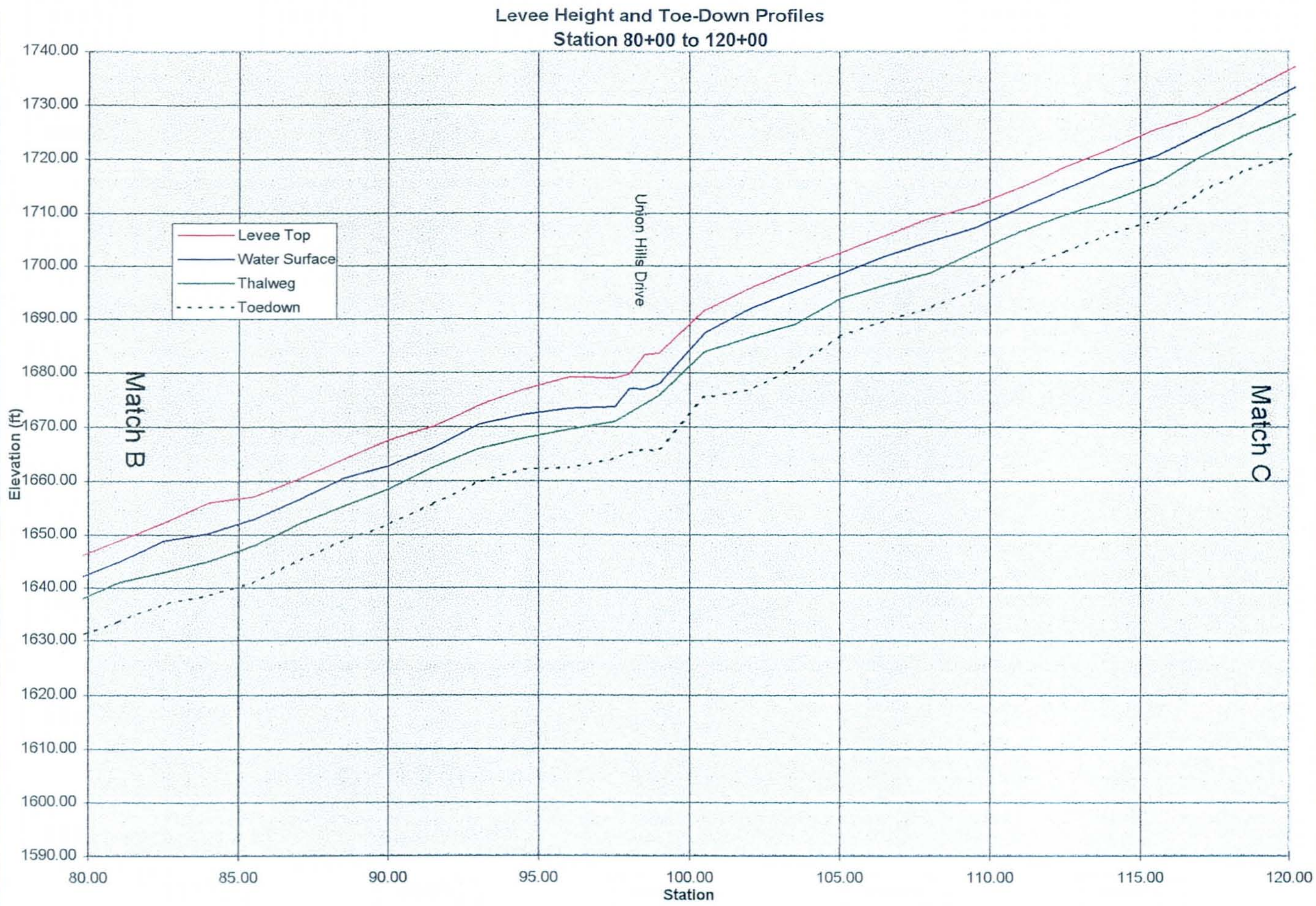


Figure 7.1: Profile Showing Top of Levee, Water Surface, and Thalweg before and after Scour



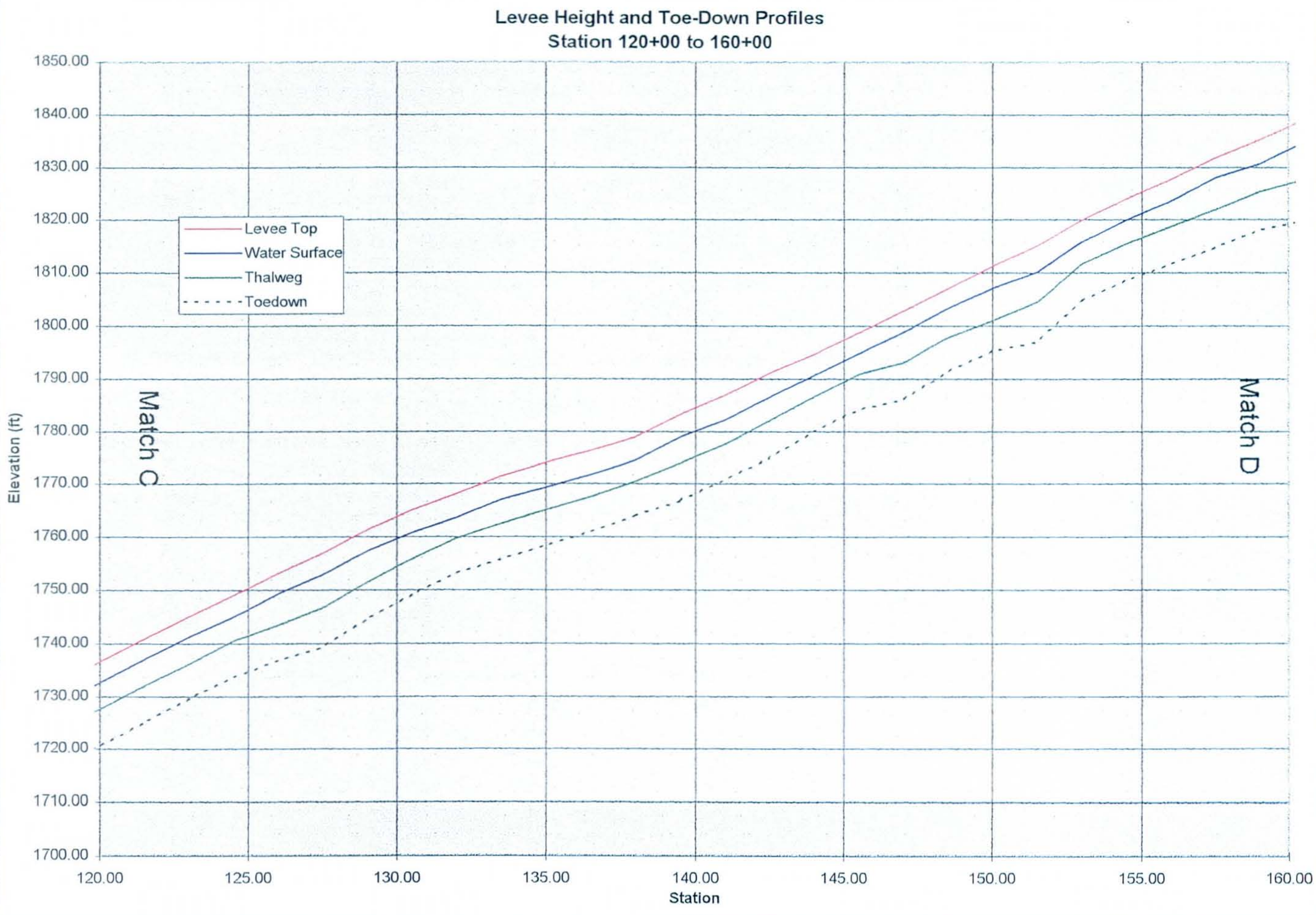
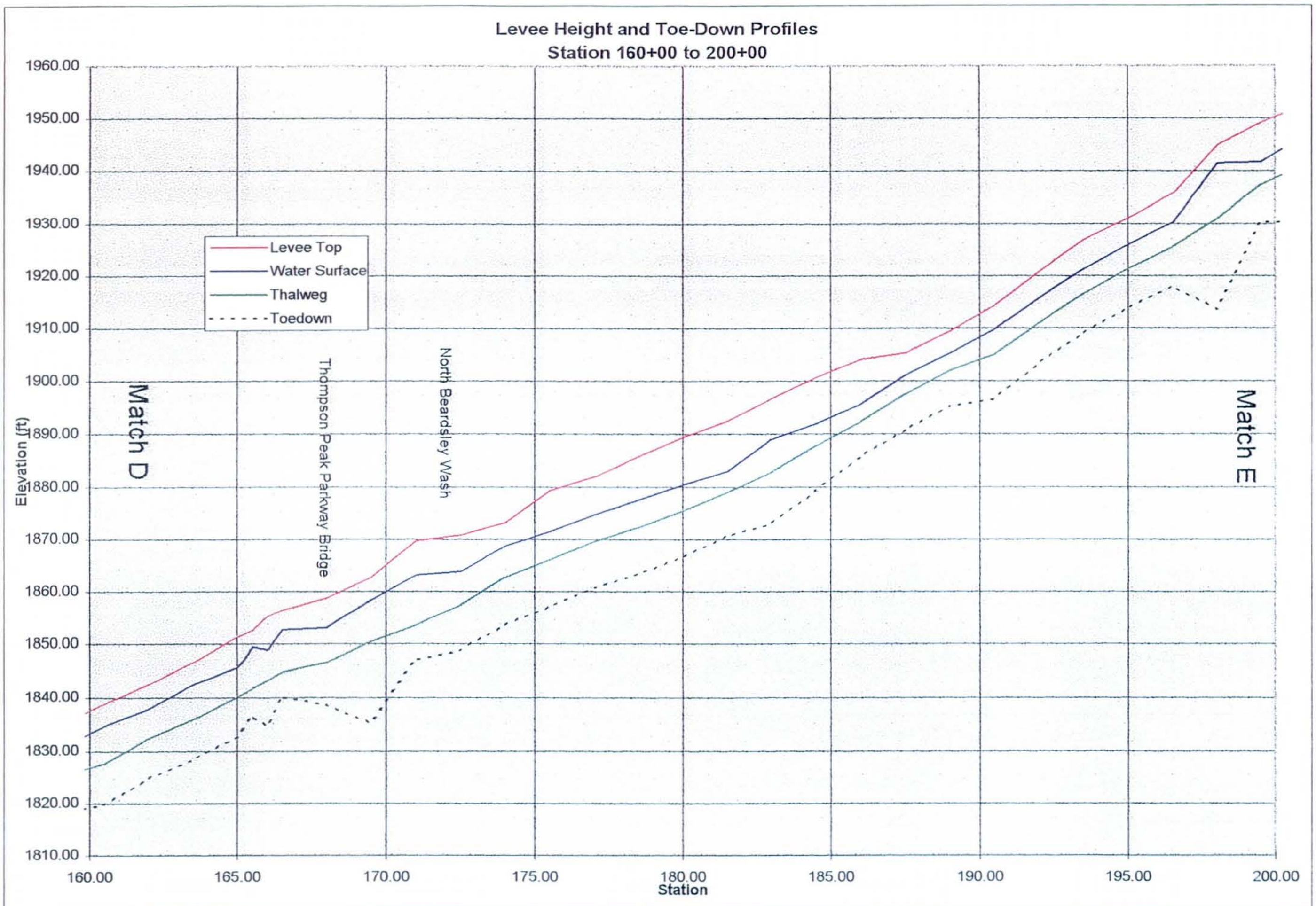


Figure 7.1: Top of Levee, Water Surface, and Thalweg before and after Scour (continued)



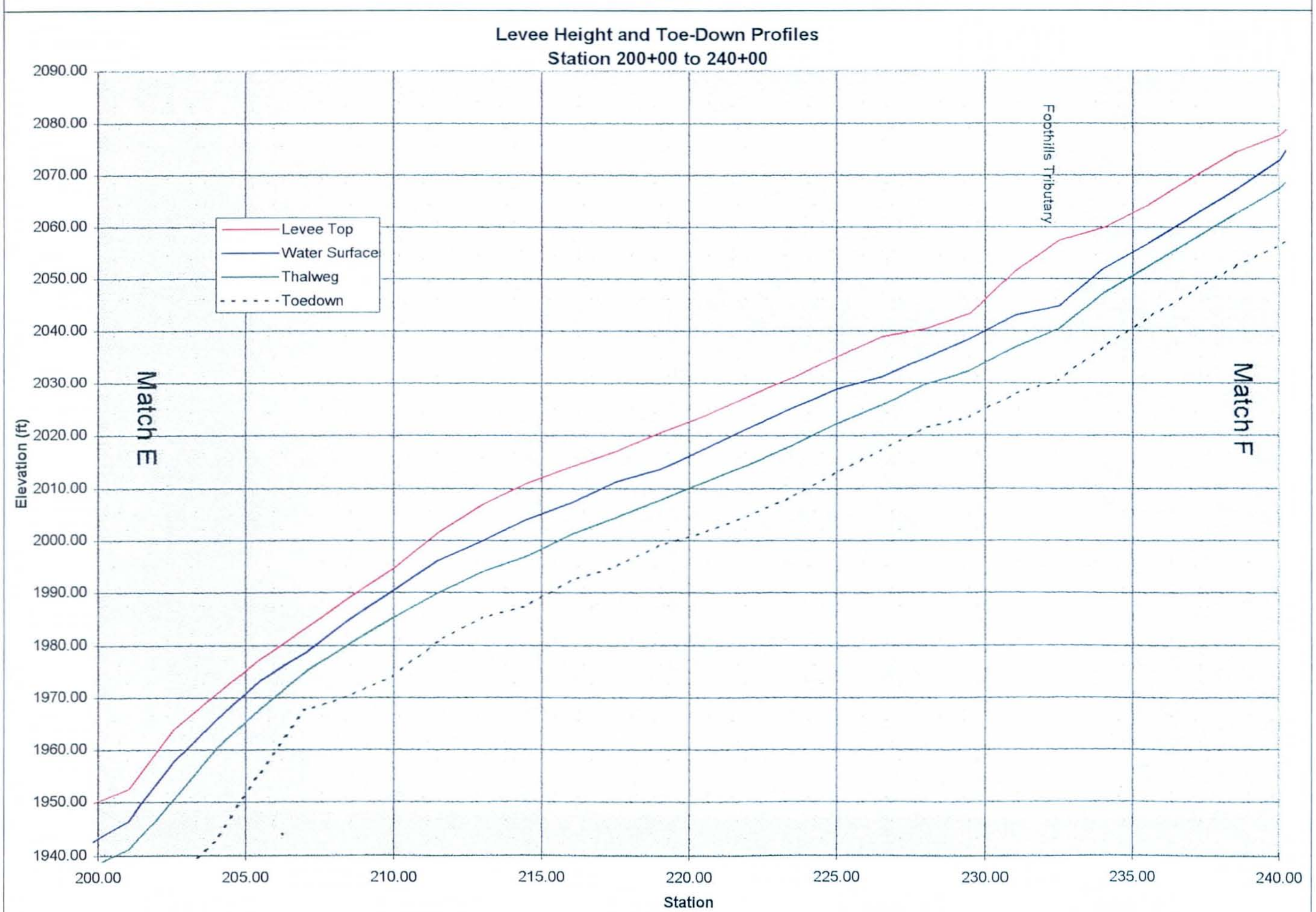
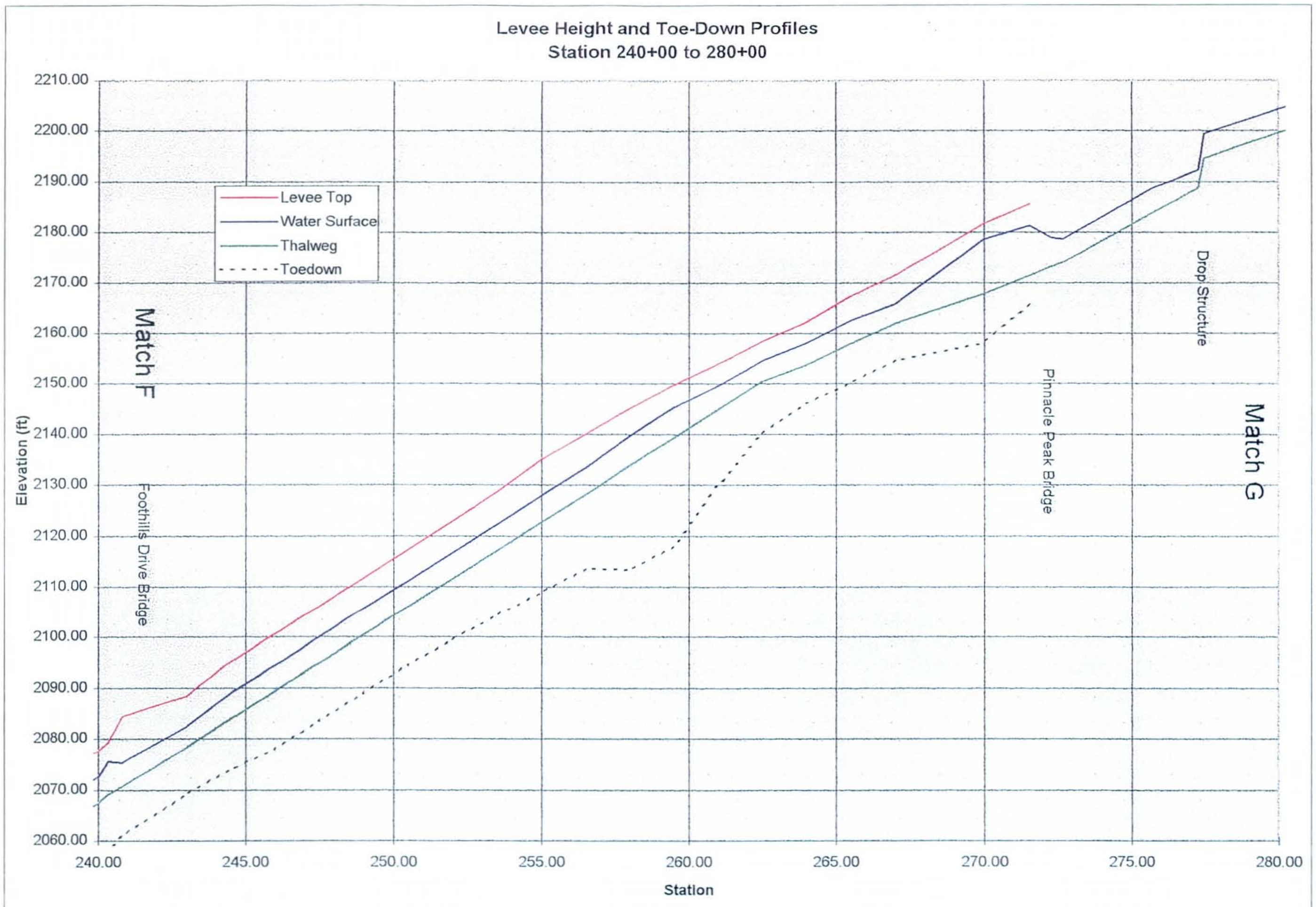


Figure 7.1: Top of Levee, Water Surface, and Thalweg before and after Scour (continued)



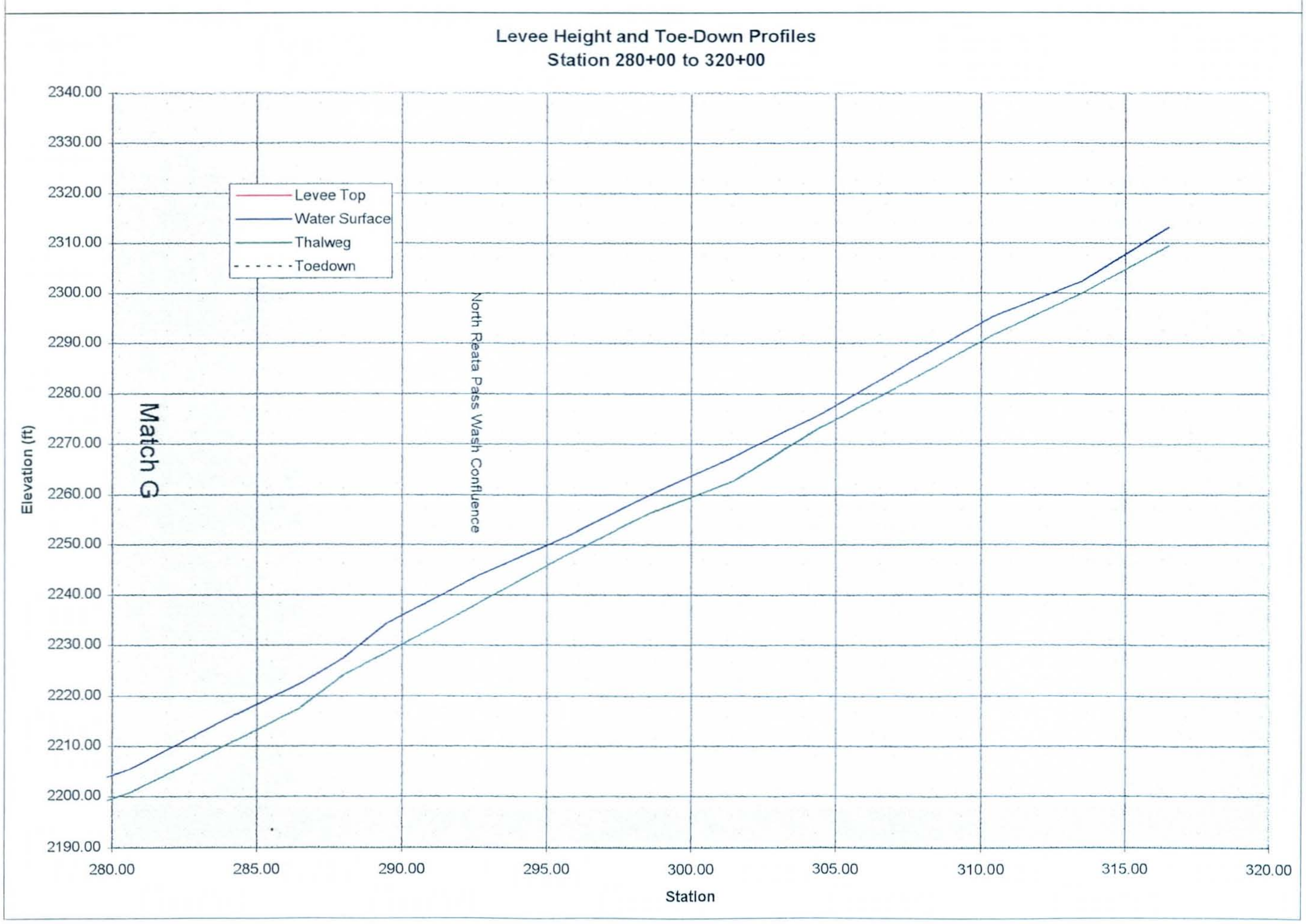


Figure 7.1: Top of Levee, Water Surface, and Thalweg before and after Scour (continued)

VIII. CHANNEL MAINTENANCE

The average annual flood sediment transport volumes are listed in Table 8.1. In the study area, a 5- to 10-year flood represents an annual flood. To be conservative, a 10-year flood sediment volume was used as the average annual sediment scour or volumes as shown in Table 8.1. These average annual volumes are the expected volume of sediment scour or deposition in cubic yards within each reach. This information was obtained for maintenance issues especially in reaches where aggradation is expected. A detailed maintenance plan will be developed for the final design plan which will include low flow channel and levee maintenance, scour monitoring, sediment and debris removal recommendation, and erosion control structure maintenance.

Table 8.1 Sediment Scour(-) / Deposition(+) for Channel Maintenance based on Short-Term Channel Response

Reach Number*	100-Yr Flood (CY)	10-Yr Flood (CY)	Average Annual Flood (CY)
1	0	0	0
2	5260	2450	2450
3	0	0	0
4	0	0	0
5	-6580	-3450	-3450
6	-6950	-2610	-2610
7	1340	1420	1420
8	4050	2200	2200
9	430	-9	-9
10	1450	410	410
11	3040	1020	1020
12	6530	2190	2190
13	900	300	300
14	400	190	190
15	570	220	220
16	-2260	-1140	-1140
17	-3220	-1960	-1960
18	2590	1950	1950
19	1130	540	540
20	-690	-440	-440
21	-920	-850	-850
22	10050	3750	3750
23	2210	1040	1040
24	-1080	-430	-430
25	-1410	-550	-550
26	1580	530	530
27	1330	180	180

* See Figure 1.3 for reach locations.

IX. REFERENCES

AGRA Earth and Environmental. *Geotechnical Investigations Report; Desert Greenbelt Phase I Channels.* August 1995.

Arizona Department of Water Resources, *Design Manual for Engineering Analysis of Fluvial Systems*, 1986. Prepared by Simons, Li & Associates, Inc.

Arizona State University, Department of Geology, *Environmental Geology of the McDowell Mountains Area, Maricopa County, Arizona*, 1978. Prepared by Christenson, Welsch, Pewe.

City of Tuscon Department of Transportation, Engineering Division (SLA). *Standards Manual for Drainage Design and Floodplain Management in Tuscon, Arizona*. February 1990.

Greiner, Inc. *Scottsdale Desert Greenbelt Project; Phase 1 Design; Reata Pass Wash; Calculations for 80% Submittal.* June 1996.

Greiner, Inc. *Scottsdale Desert Greenbelt Project; Reata Pass/Beardsley Wash; Preferred Alternative Report.* May 1995.

Greiner, Inc. *Scottsdale Desert Greenbelt Project; Sediment Field Tests.* October 1994.

Greiner, Inc. *Scottsdale Desert Greenbelt Reata Pass/Beardsley Wash Hydrology Report.* February 1995.

Greiner, Inc. *Scottsdale Desert Greenbelt Phase 1 Design; Reata Pass Wash; Supplemental CLOMR Report.* May 1996.

Simons, Li, & Associates. *Reata Pass and North/South Beardsley Wash Design Review Summary Report.* June 1996.

Sumer, B. M. *Simulation of Dispersion of Suspended Particles*. Journal of the Hydraulics Division. October 1973.

U.S. Army Corps of Engineers, The Hydrologic Engineering Center, HEC-2 Manual, Surface Water Profile Computer Model.

U.S. Army Corps of Engineers, The Hydrologic Engineering Center, HEC-1 Manual, Hydrologic Computer Model.

U.S. Army Corps of Engineers, Hydrologic Engineering Center. *HEC-RAS River Analysis System, Version 1.0*. July 1995. (*Hydraulic Reference Manual*, *User's Manual*.)

U.S. Army Corps of Engineers, Hydrologic Engineering Center. *HEC-6, Scour and Deposition in Rivers and Reservoirs, Version 4.0*. August 1993. (*User's Manual*.)

U.S. Geological Survey, Arizona, Slope-Area Measurement Summary for the Flood of August 29, 1996 in Reata Pass Wash below Pinnacle Peak Road, 1996.

Yang, Chih Ted. *Unit Stream Power and Sediment Transport*. Journal of the Hydraulics Division. October 1972.

Yang, Chih Ted. *Incipient Motion and Sediment Transport*. Journal of the Hydraulics Division. October 1973.