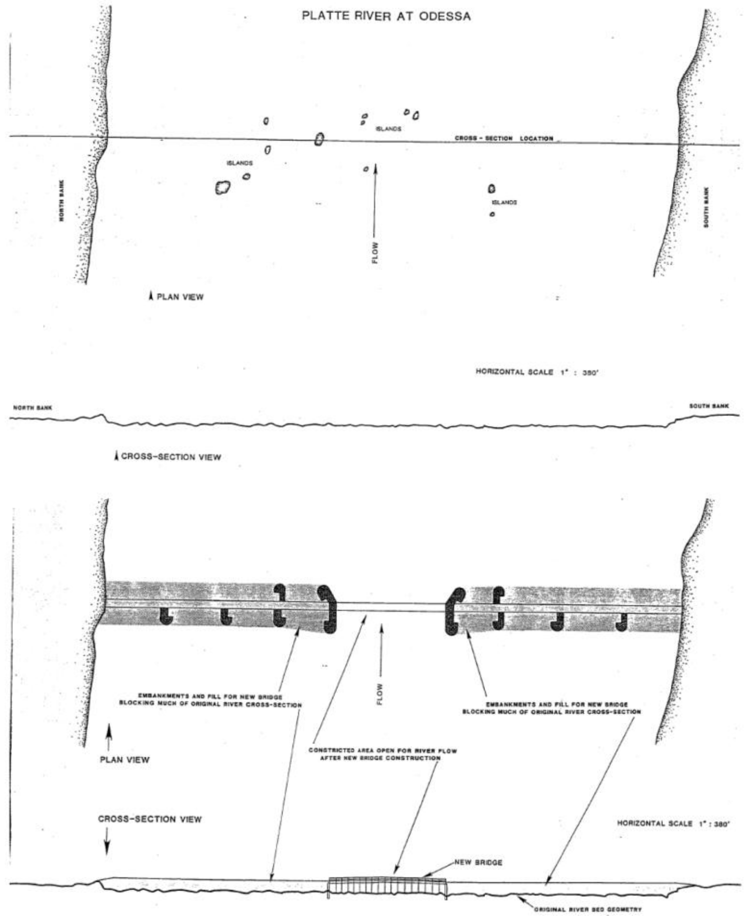
Analysis of Platte River Channel Geometry Data
Physical Relationships: Hydraulics & Sediment Transport



CHANNEL NARROWING DUE TO BRIDGE CONSTRUCTION ON THE PLATTE RIVER AT ODESSA, NEBRASKA, 1930

by

Simons & associates

December 14, 2012

Prepared for

Nebraska Community Foundation, Inc., Platte River Recovery Implementation Program

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1.0 Introduction

The channel geometry of a river plays a significant role in the river's response to natural variations in hydrology, imposed changes in flow, channel changing or maintenance flow regimes, or other mechanical or chemical manipulations. This geomorphic response to these various inputs, in fact, affected the river's historic response to these various factors as well as to future attempts to enhance the channel for a variety of purposes. For example, the size and shape of the Platte River (and key tributaries, the North and South Platte) and how the hydraulics of flow through the channel contributed significantly to the establishment and expansion of woody riparian vegetation in response to natural phenomena of the 1930s drought and other changes in flow regime associated with water resources development of the basin. The following material describes the significant role that the channel geometry and shape of the cross-section plays in a range of important issues on the Platte River (*"Physical History of the Platte River in Nebraska: Focusing upon Flow, Sediment Transport, Geomorphology, and Vegetation,"* Simons & Associates, 2000).

4.0 Channel Processes and Causes of Change

4.1 Resource Linkages

Fluvial geomorphology is the study of the interaction between rivers and the surficial topography of the earth including geology, soils, and other sediments. Geomorphic processes continue to occur through erosion and deposition as rivers adjust to hydrologic events and anthropogenic factors. River form as it has developed over geologic or more recent time significantly affects river hydraulics that provide habitat for aquatic life, riparian and other vegetation, and habitat for terrestrial wildlife. The quality and quantity of habitat is a function of hydraulic variables such as velocity and depth, substrate (sediment size distributions), and the relationship between channel/floodplain geometry and flow regarding seasonal patterns of inundation and recession rates of flow hydrographs. All of these important factors are a direct result of the interaction between flow and geomorphology. While other factors may either benefit or adversely affect habitat, the primary factor in the quality and quantity of habitat remains the direct relationship between water and the earth's surface. In some rivers, geomorphic processes are quite dynamic while in others they are relatively static, but punctuated by rare but dramatic events that alter the channel to one degree or another. Despite the relative rate of geomorphic dynamics, the river form created by these processes and the ongoing interaction with flow dictates riverine hydraulics and plays a significant role in habitat and biologic processes.

In discussing geomorphic processes, Leopold et al. (1964) explained that,

> *The shape of the cross-section of a river channel at any location is a function of the flow, the quantity and character of the sediment in movement through the section, and the character and composition of the materials making up the bed and banks of the channel. In nature, the last will usually include vegetation.*

The shape of a river channel and changes that occur in response to controlling factors regarding river pattern and position define the fluvial geomorphology of a river. The shape of a river cross-section plays a significant role in how the river responds to changes in hydrology and other key factors with respect to riparian vegetation and habitat as will be discussed in greater detail in subsequent sections of this chapter.

In order to gain some perspective on the Platte River system as it was prior to the significant changes that occurred over the relatively recent past, an analysis of historic cross-section geometry data using hydraulics and sediment transport has been suggested. Some channel geometry data and bed material data exist from the 1920s or 1930s, a period before most of the significant changes exist which provide a basis for the analysis.

To specifically address the relationship between historic flows and the channel geometry and geomorphology at the time, several key physical relationships have been developed using the historic data. These include the following:

1. Stage-discharge relationships
2. Stage-width relationships
3. Discharge-% inundation relationships
4. Flow depth and velocity distributions at historic1.5 year return period flow (Q1.5)
5. Discharge and sediment discharge per unit width at historic Q1.5

These investigations would give the Program a basic understanding of channel hydraulics and sediment transport conditions in the historic channel. Flow depth and velocity distributions are of special interest as they will provide clues to vegetation velocity scour potential in the historic channel.

2. Historic Channel Geometry and Sediment Data

2.1 Channel Geometry Data

As part of detailed studies of the Platte River system cross-section data were obtained from a period that reflected conditions prior to much of the significant changes that historically occurred. These data came from the Nebraska Bureau of Public Roads, Department of Roads and Bridges from the 1920s. These data were presented and discussed in "Physical Process Computer Model of Channel Width and Woodland Changes on the North Platte, South Platte, and Platte Rivers" and "Platte River System Geomorphic Analysis," 1990, Simons & Associates. Prior to the 1920s, bridges over these rivers typically consisted of timber-pile construction techniques that spanned the entire width of the river and allowed the river to flow through the section without significant constriction. Starting in the 1920s, bridge construction changed to relatively short spans of reinforced concrete bridges coupled with embankments extended over significant segments of the river sections resulting in significant channel constrictions at bridges. These data were surveyed at this time of transition as the older timber structures were to be replaced with in support of the design of the new replacement bridges.

Figure 1 presents both an aerial schematic view and cross-section of the data at Odessa on the Platte River (after Simons & Associates, 1990). Appendix A presents additional figures of these cross-sections from the 1920s.

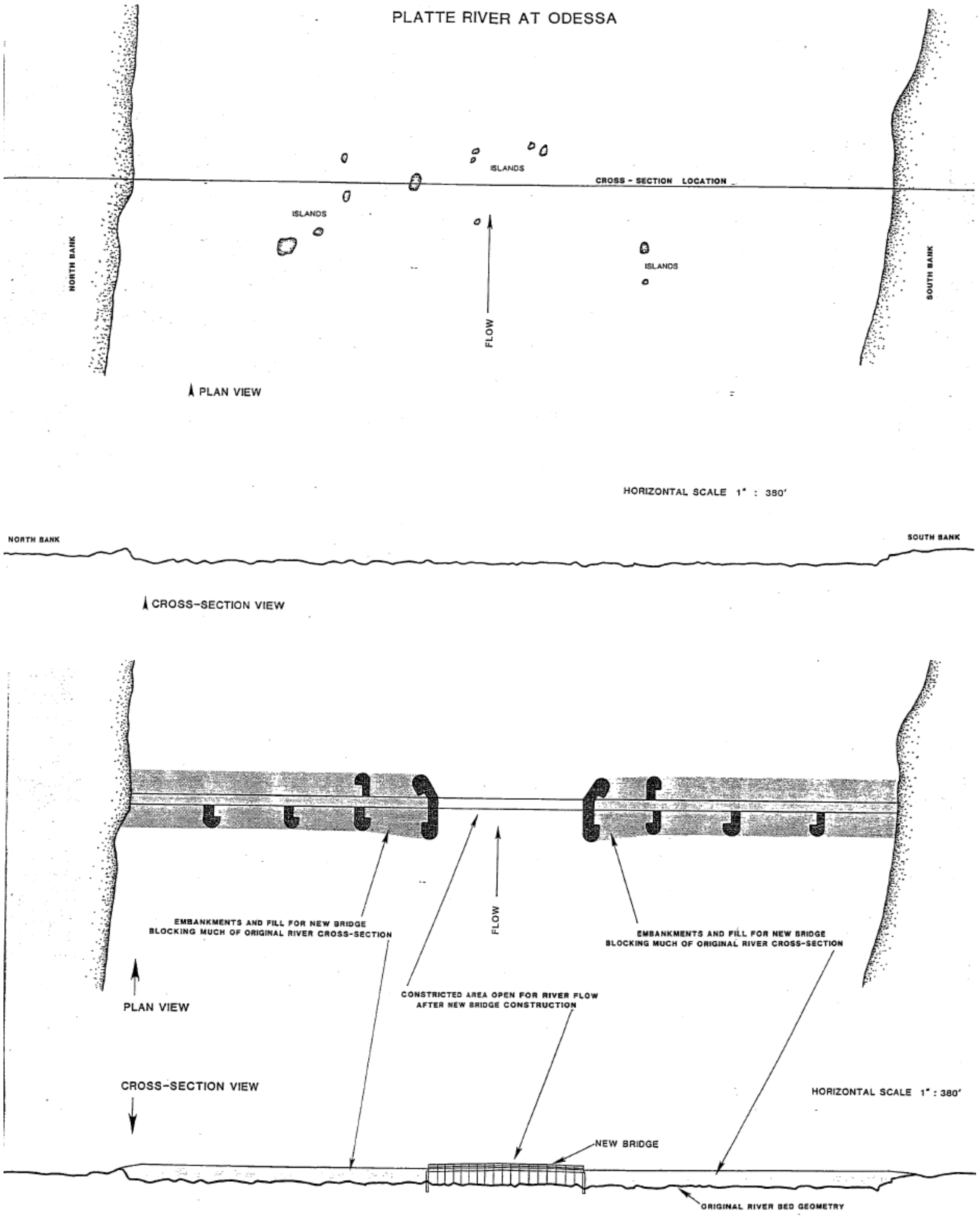

Figure 1. Platte River at Odessa, aerial and cross-section view, 1930

In addition to the historic cross-section data, the longitudinal profile or river slope is needed to conduct a hydraulic analysis. Slope data were obtained from available topographic maps. Murphy, et al, 2004 presented river bed profiles from the time period of 1901, as described below.

> *Gannett's 1901 paper includes data tables and a figure describing the profile of these rivers, which are shown in Figure 2.14. The slopes of the Platte River and the lower portion of the North Platte are remarkably constant, as Gannett indicated, and have a slope of 0.00126 between North Platte and Chapman, Nebraska, or 6.65 ft of fall per mile as described in Section 2.1.*

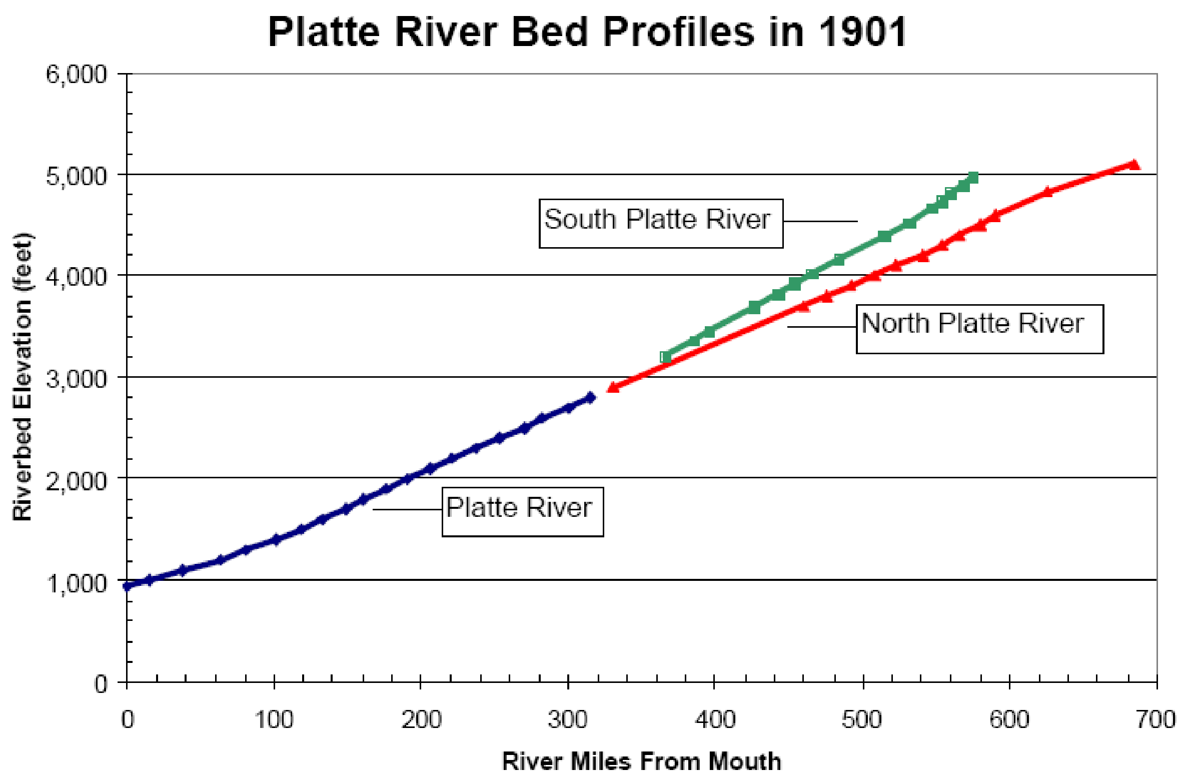

Figure 2.14   Longitudinal profile of the Platte River bed in 1901 (Gannetts Slope).

As part of prior work conducted by Simons & Associates ("Platte River System Geomorphic Analysis," and "Physical Process Computer Model of Channel Width and Woodland Changes on the North Platte, South Platte, and Platte Rivers," Appendix V, Geomorphology, Joint Response, May 5, 1990), the slopes of the river bed at the location of available cross-sections from the 1920s and 1930s were determined from topographic maps (see Table 1).

Table 1. Platte River system riverbed slopes

Location	Slope
North Platte at Lewellen	0.0012
North Platte at Hershey	0.0011
South Platte at Paxton	0.0015
South Platte at Hershey	0.0015
Platte at Brady	0.0013
Platte at Odessa	0.0013

2.2 Bed Material Data

The North Platte, South Platte, and Platte Rivers are alluvial rivers which can be defined as a river with bed and banks consisting of sediment that the river itself transports and deposits. The Platte is primarily a sand-bed river with some finer sizes (silt and clay) and some coarser material (gravel).

Bed material data are available from a similar time period as the cross-section data for the North Platte and Platte Rivers. These data were sampled by the U.S. Army Corps of Engineers in 1931. The data were recently summarized in "The Platte River Channel: History and Restoration," 2004, Murphy, P.J., T.J. Randle, L.M. Fotherby, and Joseph A. Daraio, U.S. Department of the Interior, Bureau of Reclamation as presented in the following figure.

Bed material data from the South Platte were also summarized in the aforementioned report, however, these data come from the 1979-1980 time frame as presented in the particle size distribution graph.

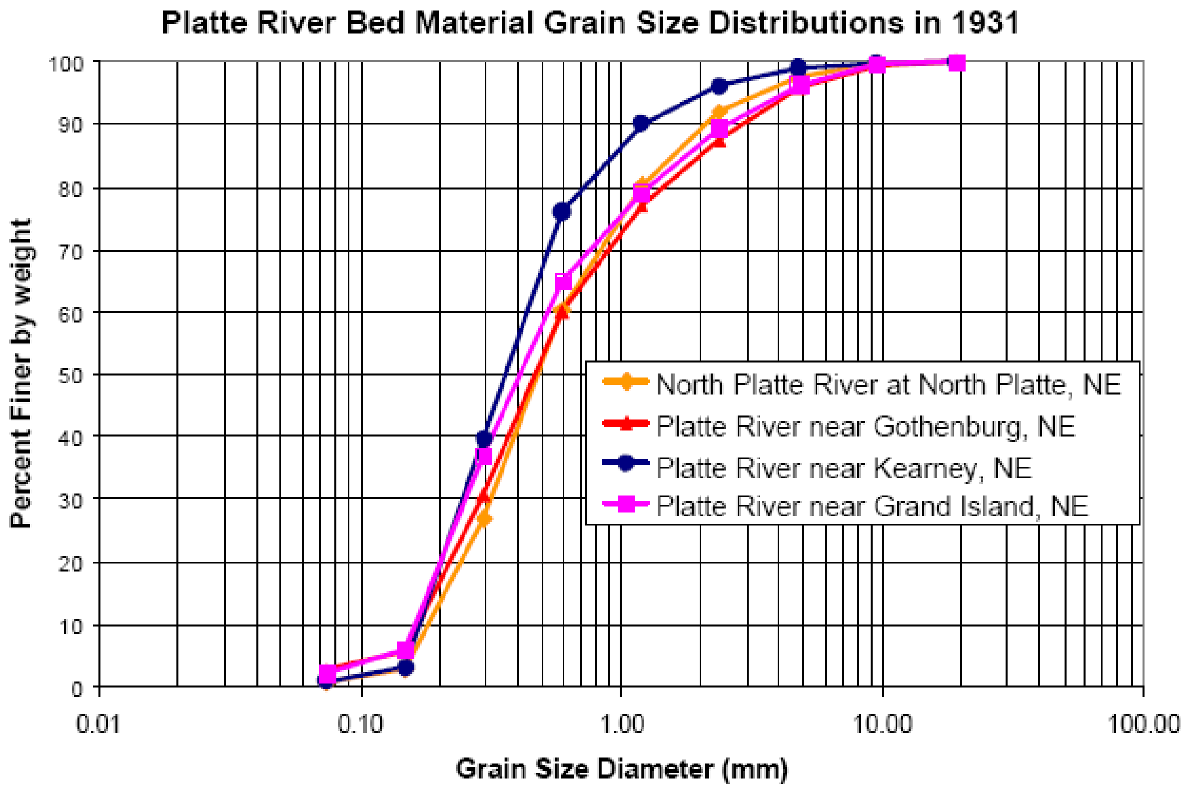

Figure 3.14 Platte River Bed Material Grain Size Distributions in 1931 (U.S. Army Corps of Engineers, 1935).

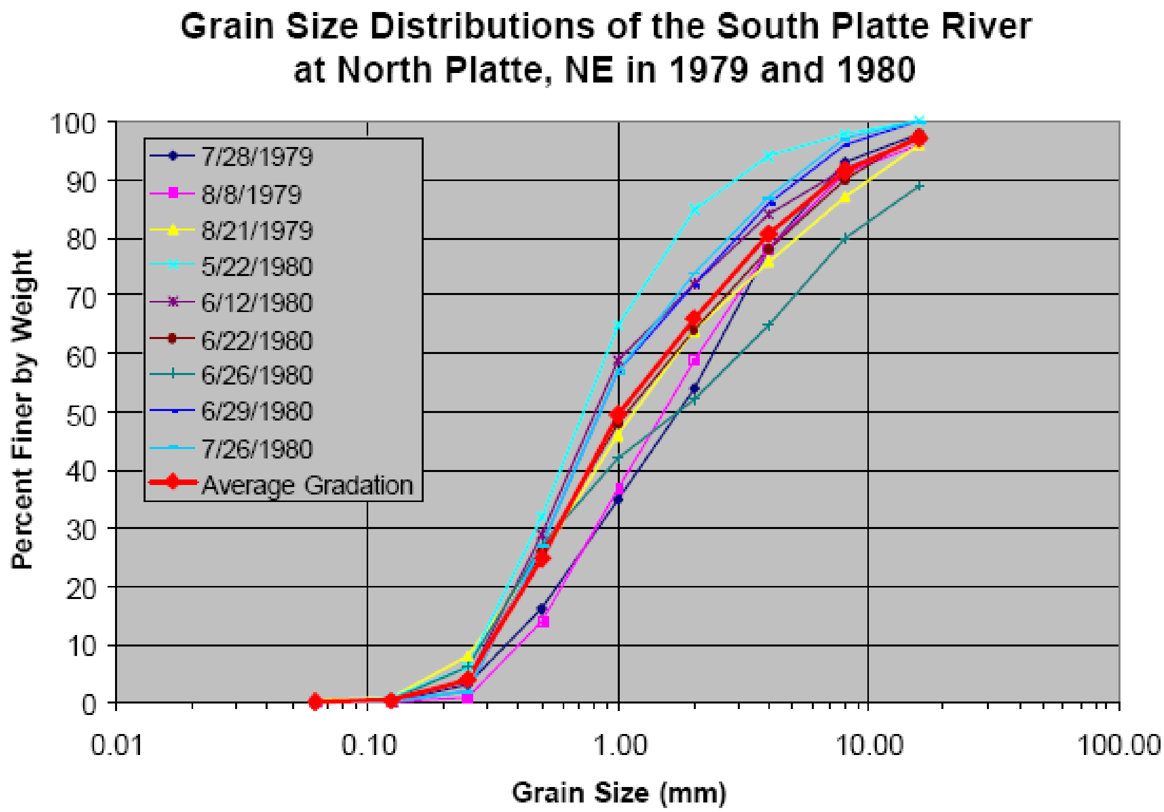

Figure 3.16 Bed Material Grain Size Distributions of the South Platte River at North Platte, Nebraska in 1979-1980.

3.0 Hydraulic Analysis

A hydraulic analysis was conducted using the historic channel geometry data using the HEC-RAS model. Because only individual cross-sections were available at each location, a normal-depth approach was utilized. HEC-RAS data files were prepared using the available cross-section data with a set 3 repeated cross-sections for each individual model with a constant slope as defined above. The digital HEC-RAS files are provided along with this report. The input data also included resistance to flow which was typically set at a value of 0.03 for the active channel and 0.05 for riverbank areas or where high areas representing bars and islands were found within the river banks (0.03 was utilized in the previous analysis conducted by Simons & Associates for these historic cross-sections). This selection of resistance to flow for higher, island and sand bar areas represents the vegetated condition of river banks and high bars and islands found in the Platte River system in its natural state prior to significant development as discussed in Simons & Associates (2000) and Johnson (1994).

> An estimate of active channel width can be derived from analysis of General Land Office (GLO) survey maps and notes conducted by Johnson (1989). Based on an evaluation of the extent of islands, Johnson concluded, *"One*

estimate made in this paper indicates that about 10 percent of the active channel width drawn on plat maps was actually occupied by wooded islands. " Deducting this figure results in about 90 percent of the total channel width being active or unvegetated.

2.5.5 Islands

A number of islands were found within the banks of the Platte River under redevelopment conditions. Eschner et al. (1983) cited Cole (1905) who wrote regarding an observation of the river in 1852:

Looking out upon the long stretch of river either way were islands and islands of every size whatever, from three feet in diameter to those which contained miles of area, resting here and there in the most artistic disregard of position and relation to each other, the small and the great alike wearing its own mantel of the sheerest willow green

Eschner et al. (1 983) divided Platte River islands into two main categories based on size, elevation, and vegetation. Large, forested islands were mapped by Fremont (1845) including: Brady Island, Willow Island, Elm Island, Grand Island, and five other unnamed islands. characteristic of the large islands, Fremont (1845) estimated that Grand Island is, *"sufficiently elevated to be secure from the annual flood of the river."*

Innumerable small islands existed in the Platte River in addition to the larger islands. Eschner et al. (1983) stated that,

These islands were as *small as a few square meters in area; most supported shrubs, young willows, and cottonwoods. A particularly dense concentration of these smaller islands occurred between Fort Kearney and Grand Island: these were named 'Thousand Islands' after the* Thousand Islands of the St. *Lawrence River (Meline, 1966, p. 21).*

3.1 HEC-RAS Modeling Results

The models were run from 100 cfs to 50,000 cfs to provide hydraulic output over a wide range of flows. Results of hydraulic modeling are summarized in the following figures and tables.

North Platte at Lewellen:

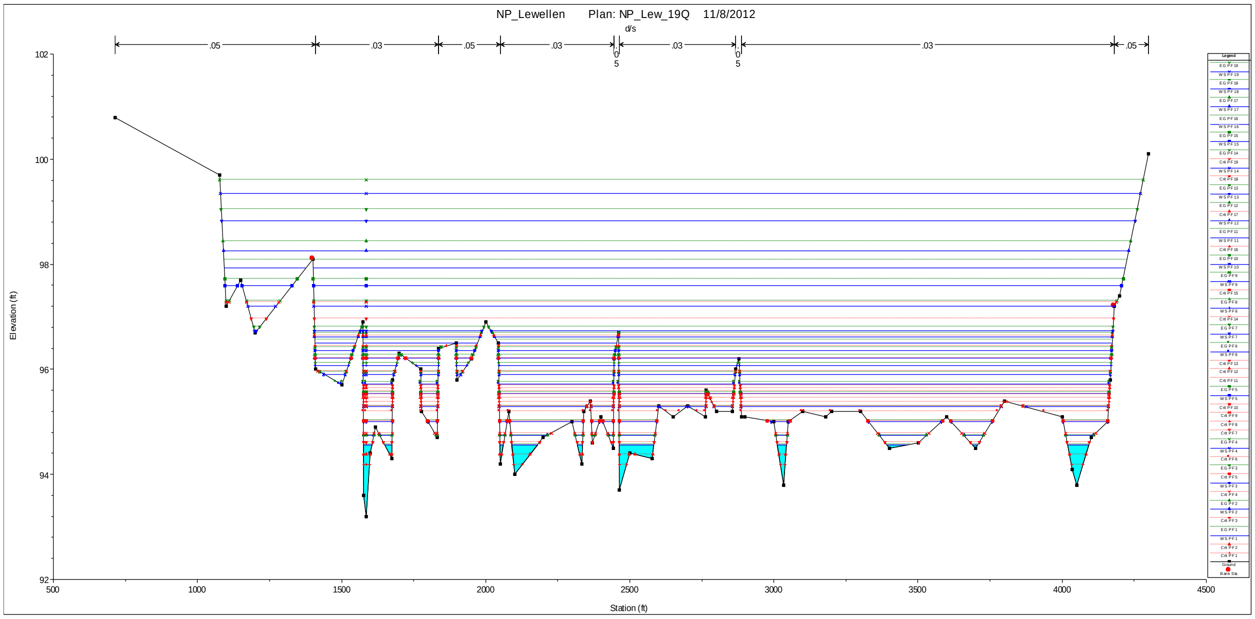

Figure 3.1 North Platte at Lewellen, cross-section with water surface and EGL at flows from 100 to 50,000 cfs

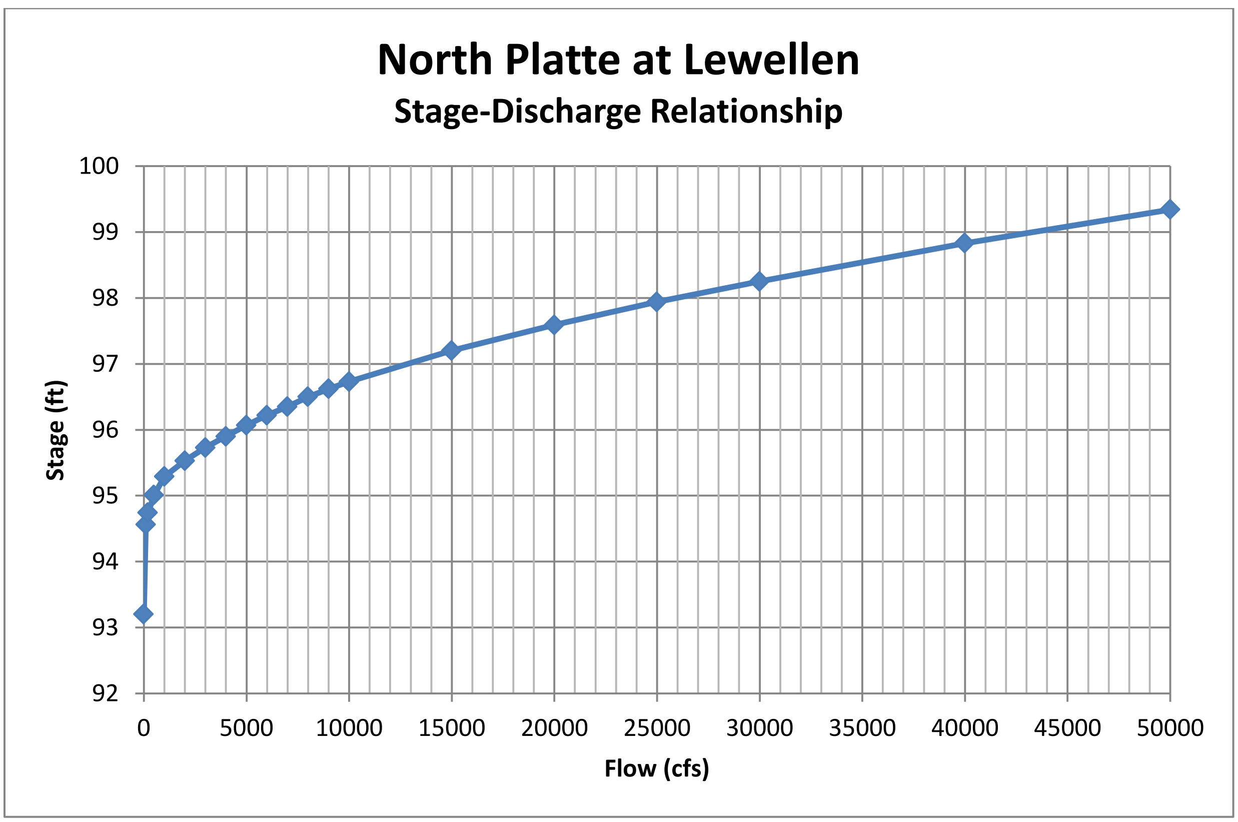

Figure 3.2 North Platte at Lewellen, stage-discharge relationship

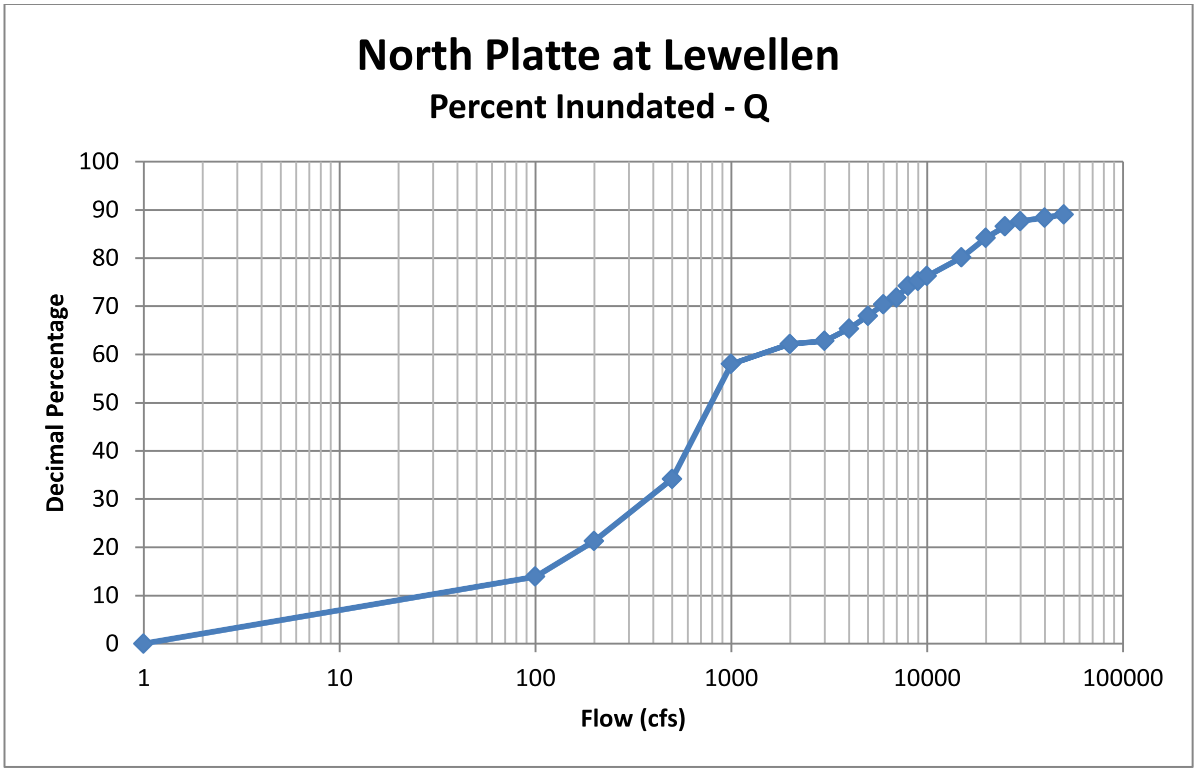

Figure 3.3 North Platte at Lewellen, percent inundated – flow

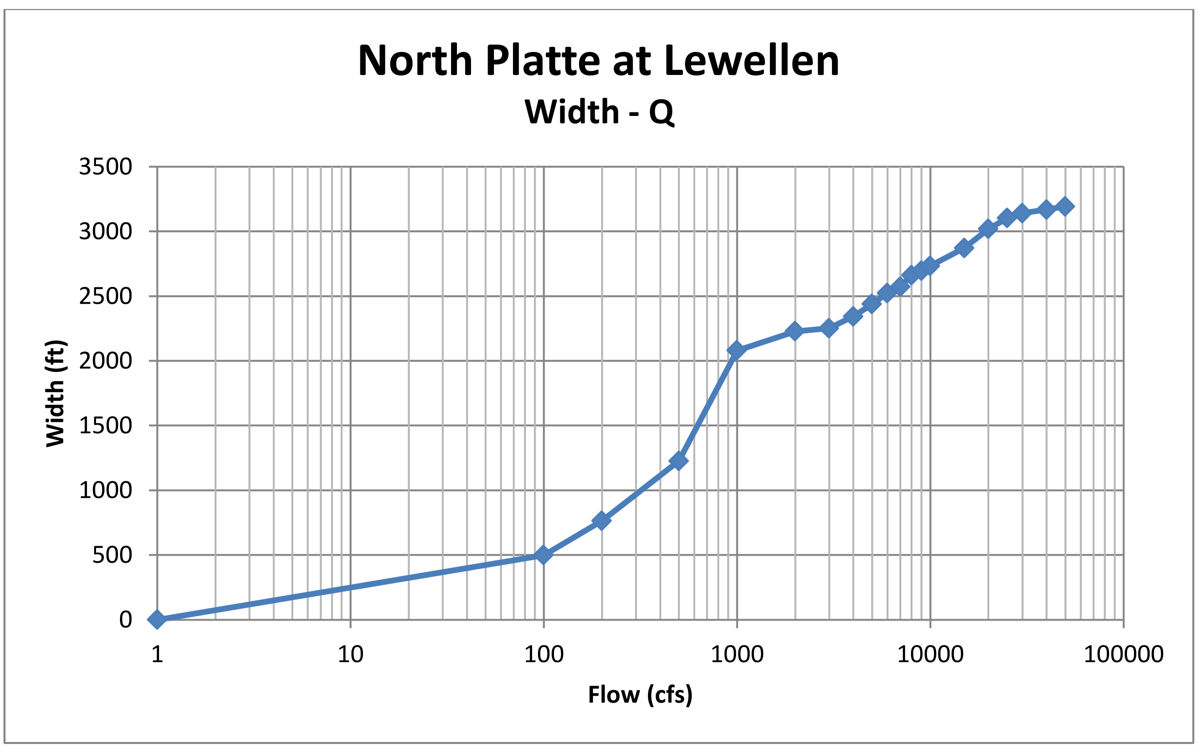

Figure 3.4 North Platte at Lewellen, width - flow

Table 3.1 North Platte at Lewellen, hydraulic modeling results

Flow (cfs)	Water Surface Elevation (ft)	Mean Velocity (ft/s)	Area (ft^2)	Width (ft)	% Inundated
100	94.56	0.73	138	498	13.9
200	94.74	0.81	248	764	21.3
500	95.01	0.96	519	1226	34.2
1000	95.29	1.03	971	2081	58.0
2000	95.53	1.32	1514	2228	62.2
3000	95.73	1.55	1941	2252	62.8
4000	95.9	1.7	2350	2343	65.3
5000	96.07	1.82	2744	2438	68.0
6000	96.22	1.92	3119	2524	70.4
7000	96.35	2.03	3456	2573	71.8
8000	96.5	2.08	3839	2660	74.2
9000	96.62	2.16	4158	2696	75.2
10000	96.73	2.24	4466	2734	76.3
15000	97.2	2.6	5782	2872	80.1
20000	97.59	2.92	6930	3018	84.2
25000	97.94	3.18	7997	3103	86.5
30000	98.25	3.42	8996	3142	87.6
40000	98.83	3.82	10806	3169	88.4
50000	99.34	4.17	12444	3193	89.1

North Platte at Hershey:

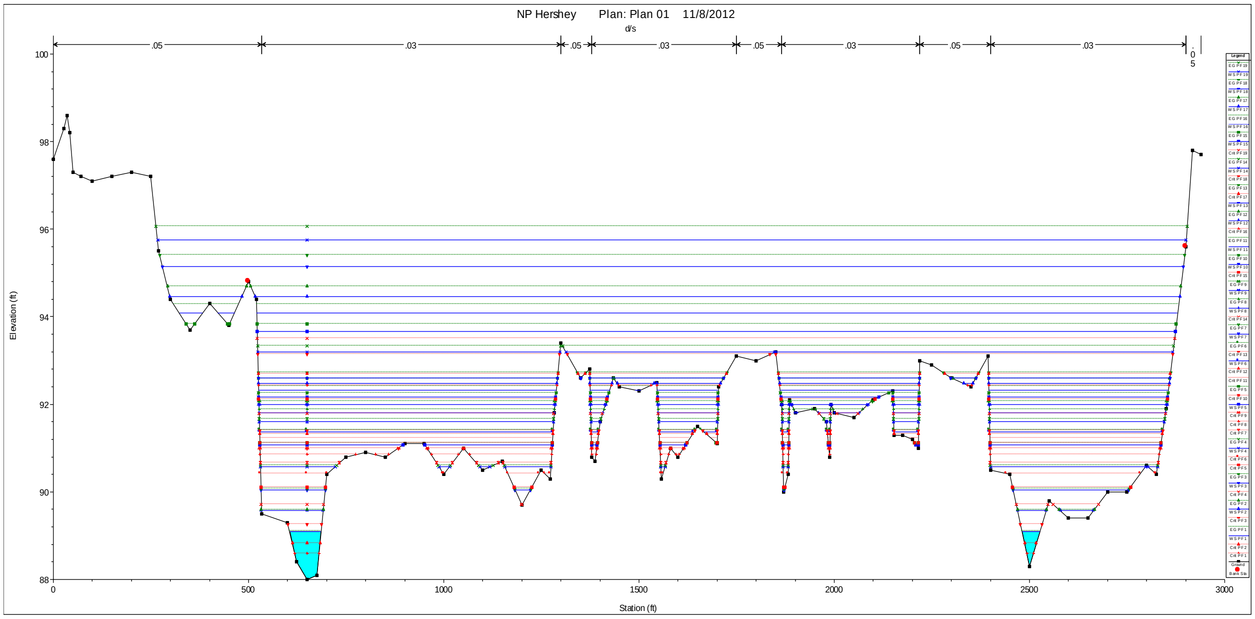

Figure 3.5 North Platte at Hershey, cross-section with water surface and EGL at flows from 100 to 50,000 cfs

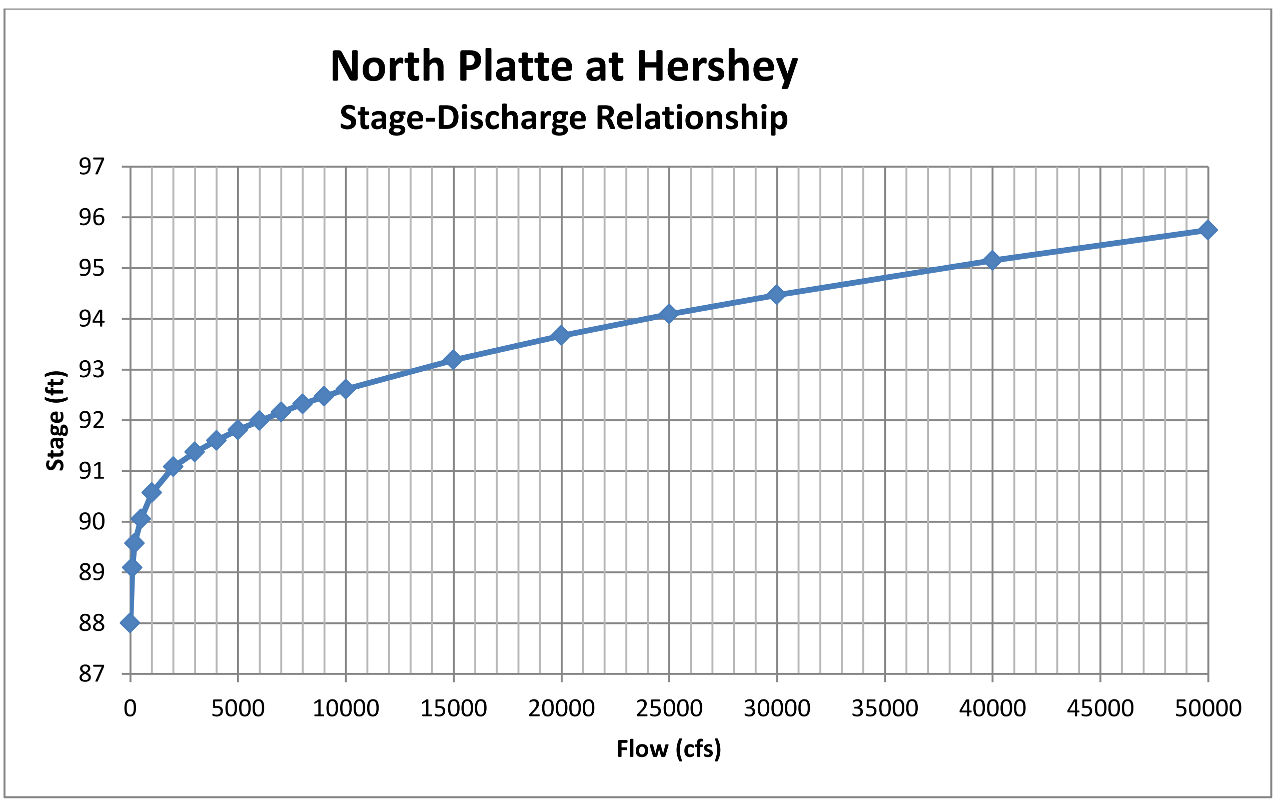

Figure 3.6 North Platte at Hershey, stage-discharge relationship

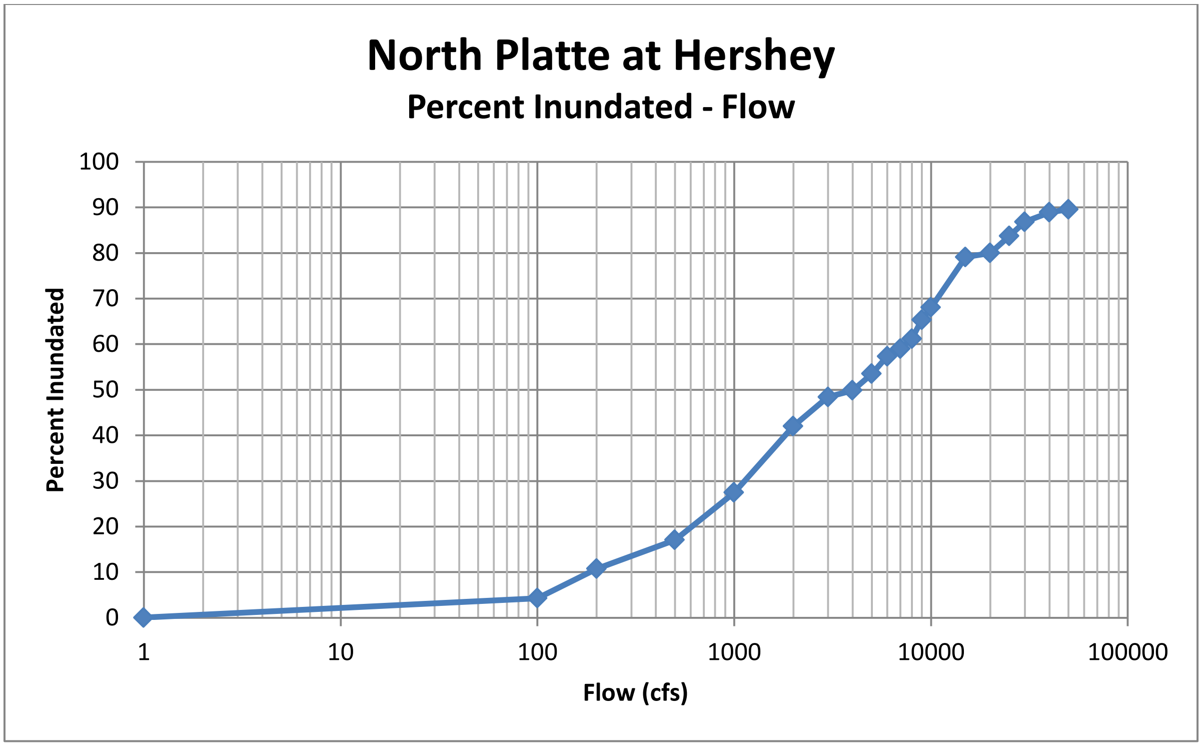

Figure 3.7 North Platte at Hershey, percent inundated – flow

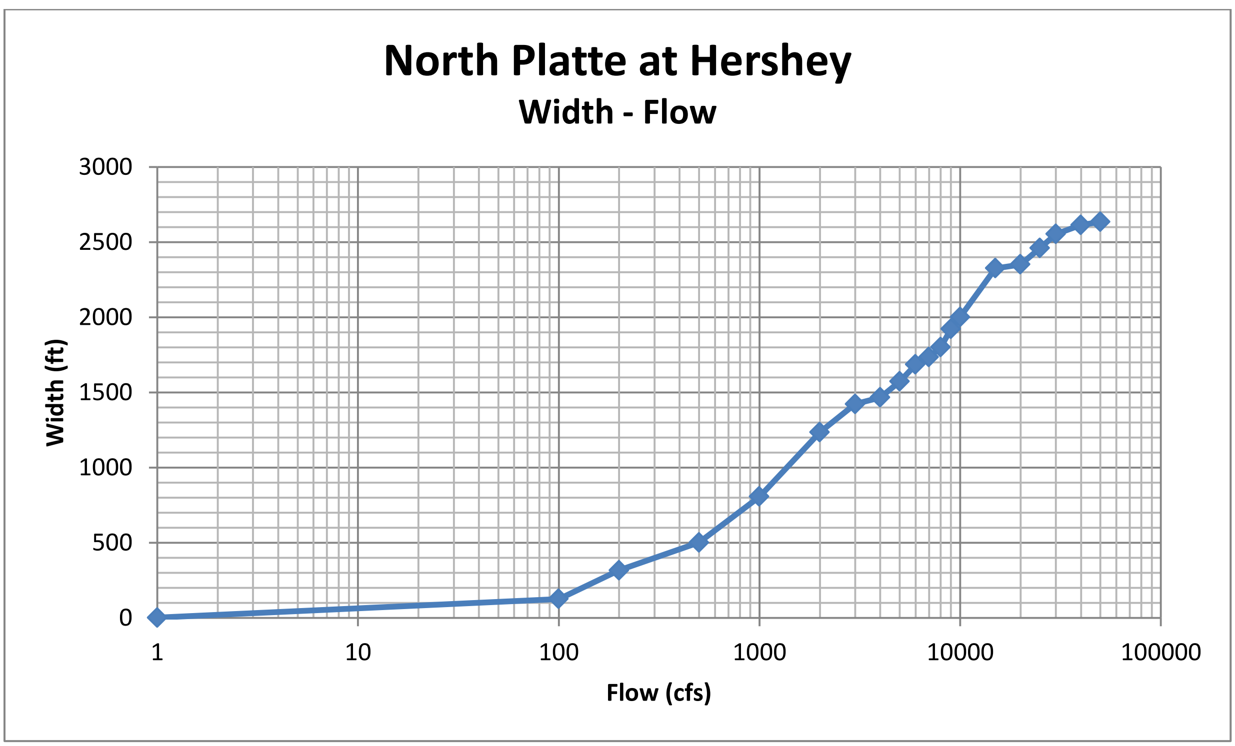

Figure 3.8 North Platte at Hershey, width - flow

Table 3.2 North Platte at Hershey, hydraulic modeling results

Flow (cfs)	Water Surface Elevation (ft)	Mean Velocity (ft/s)	Area (ft^2)	Width (ft)	% Inundated
100	89.09	1.26	79	125	4.3
200	89.57	1.16	172	316	10.7
500	90.05	1.39	361	502	17.1
1000	90.57	1.48	677	807	27.4
2000	91.08	1.68	1193	1236	42.0
3000	91.37	1.89	1587	1423	48.4
4000	91.6	2.08	1922	1466	49.9
5000	91.81	2.24	2236	1573	53.5
6000	91.99	2.36	2540	1686	57.3
7000	92.16	2.48	2827	1736	59.0
8000	92.32	2.57	3108	1800	61.2
9000	92.47	2.65	3393	1922	65.4
10000	92.61	2.73	3661	2001	68.1
15000	93.19	3.05	4912	2326	79.1
20000	93.67	3.32	6028	2352	80.0
25000	94.09	3.56	7035	2461	83.7
30000	94.47	3.78	7996	2553	86.8
40000	95.15	4.17	9762	2614	88.9
50000	95.75	4.51	11343	2634	89.6

South Platte at Paxton:

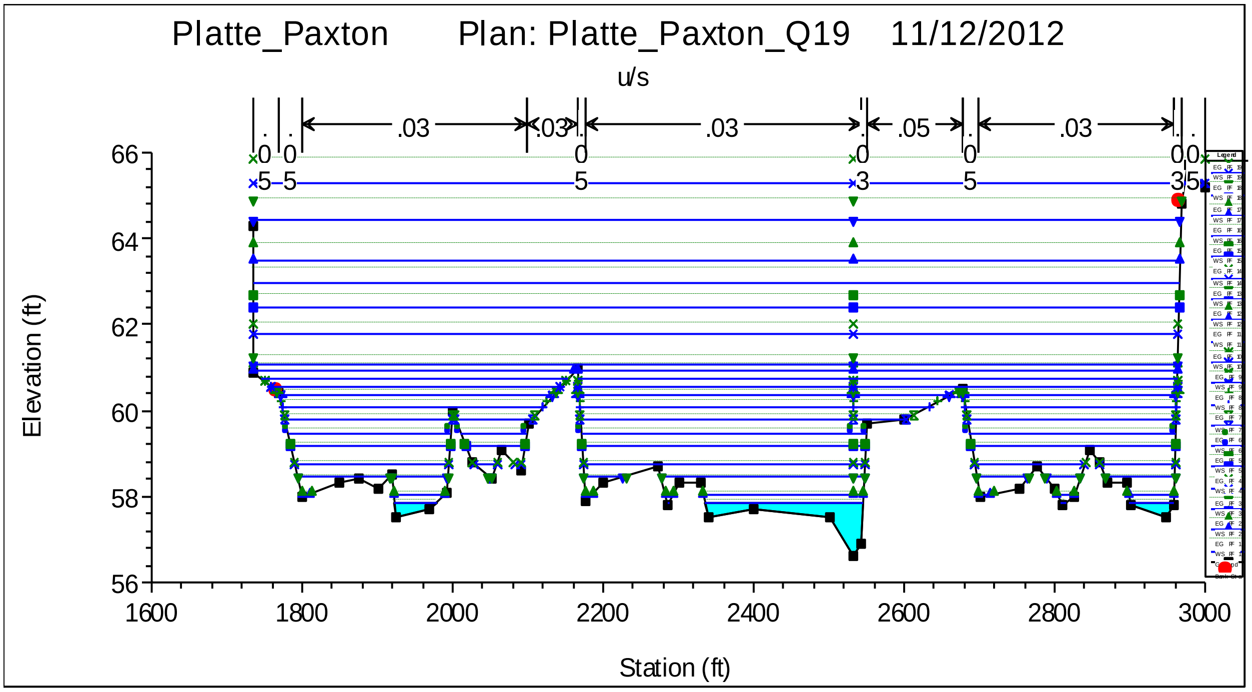

Figure 3.9 South Platte at Paxton, cross-section with water surface and EGL at flows from 100 to 50,000 cfs

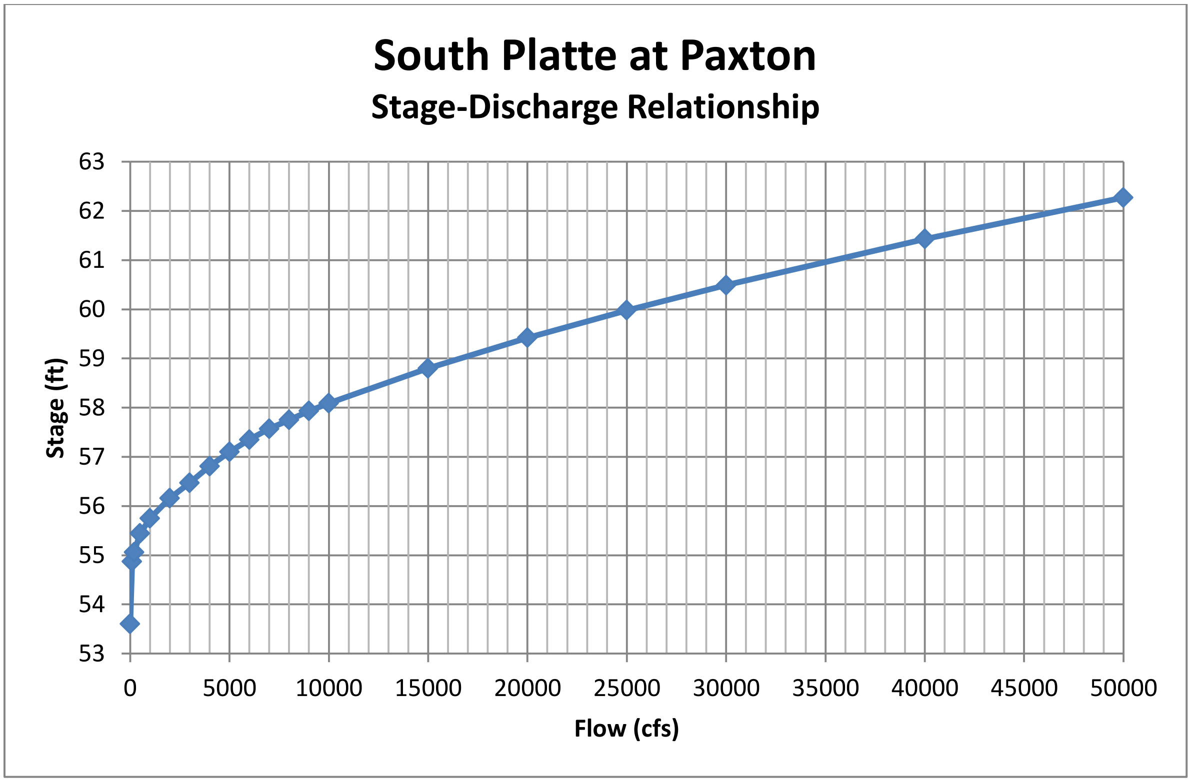

Figure 3.10 South Platte at Paxton, stage-discharge relationship

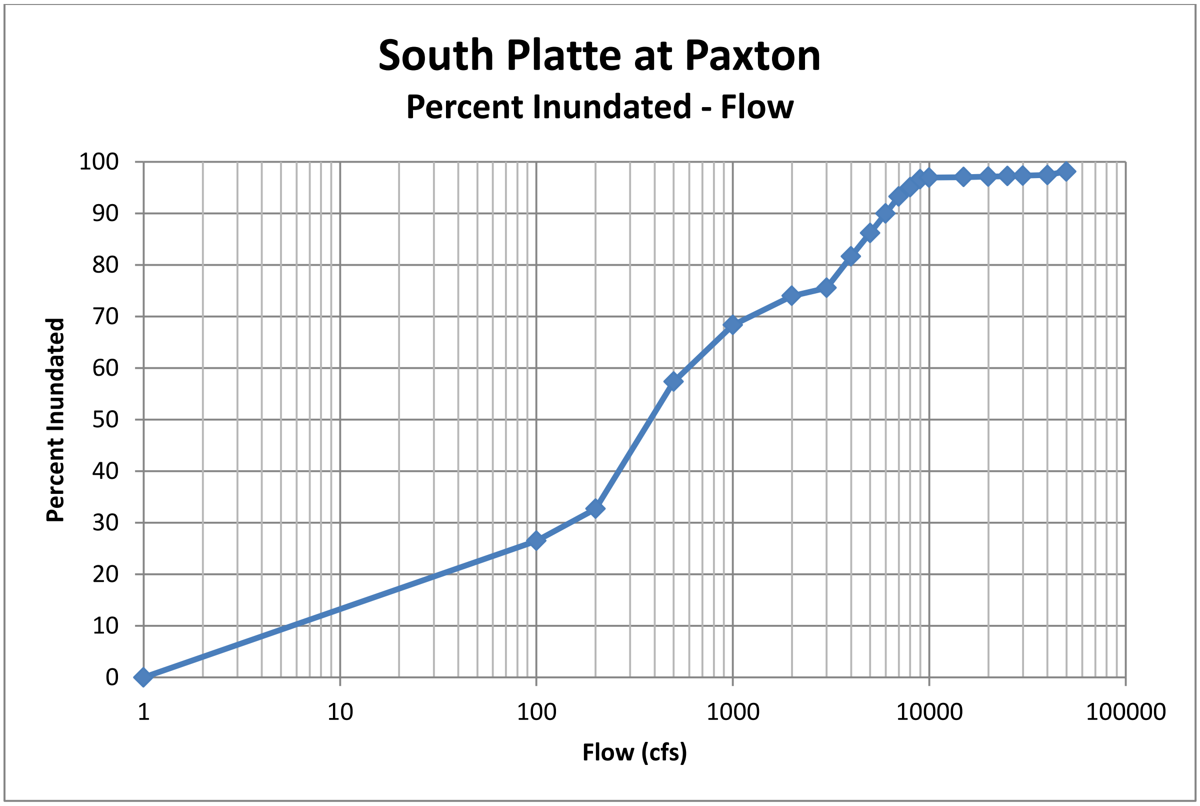

Figure 3.11 South Platte at Paxton, percent inundated – flow

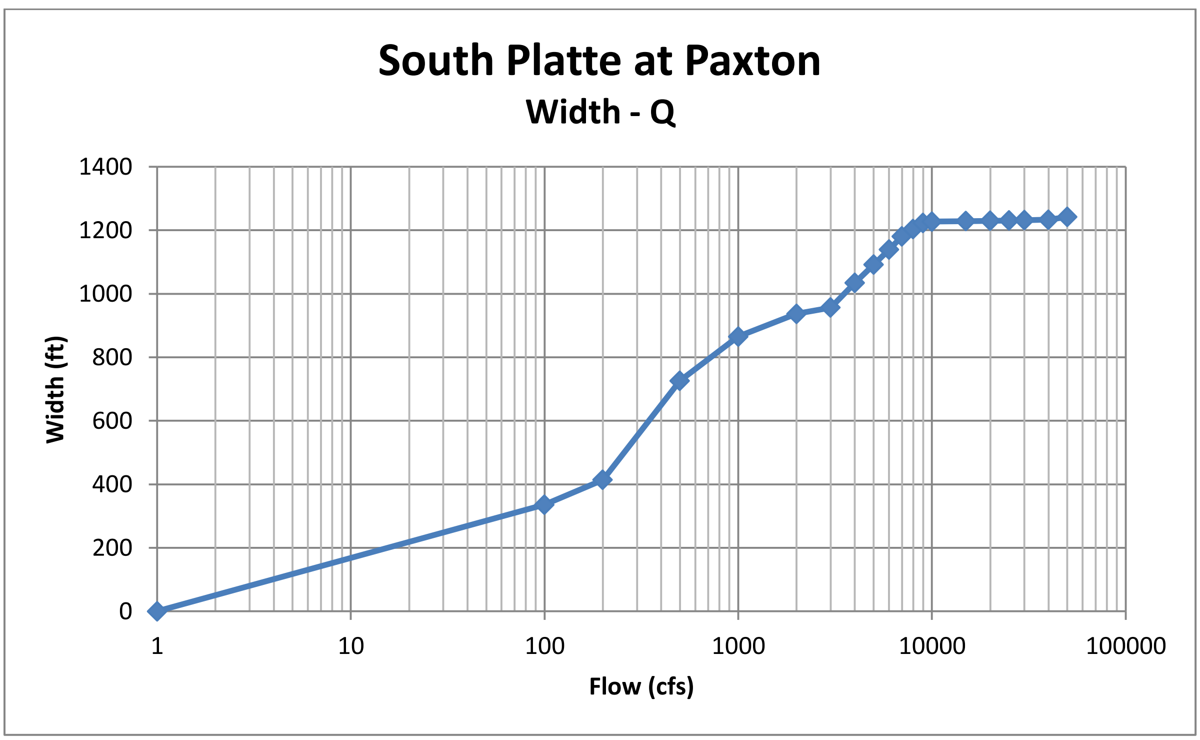

Figure 3.12 South Platte at Paxton, width - flow

Table 3.3 South Platte at Paxton, hydraulic modeling results

Flow (cfs)	Water Surface Elevation (ft)	Mean Velocity (ft/s)	Area (ft^2)	Width (ft)	% Inundated
100	54.87	0.91	110	336	26.5
200	55.06	1.1	181	414	32.7
500	55.44	1.26	396	726	57.4
1000	55.75	1.55	645	865	68.3
2000	56.16	1.97	1014	937	74.0
3000	56.47	2.29	1308	956	75.5
4000	56.81	2.43	1643	1034	81.7
5000	57.1	2.57	1943	1092	86.2
6000	57.35	2.69	2227	1139	90.0
7000	57.57	2.82	2482	1181	93.3
8000	57.75	2.97	2701	1204	95.1
9000	57.93	3.1	2912	1223	96.6
10000	58.09	3.23	3110	1227	96.9
15000	58.8	3.79	3982	1229	97.1
20000	59.42	4.25	4743	1230	97.1
25000	59.98	4.64	5430	1231	97.2
30000	60.49	4.99	6065	1232	97.3
40000	61.43	5.6	7216	1234	97.4
50000	62.27	6.11	8263	1242	98.1

South Platte at Hershey:

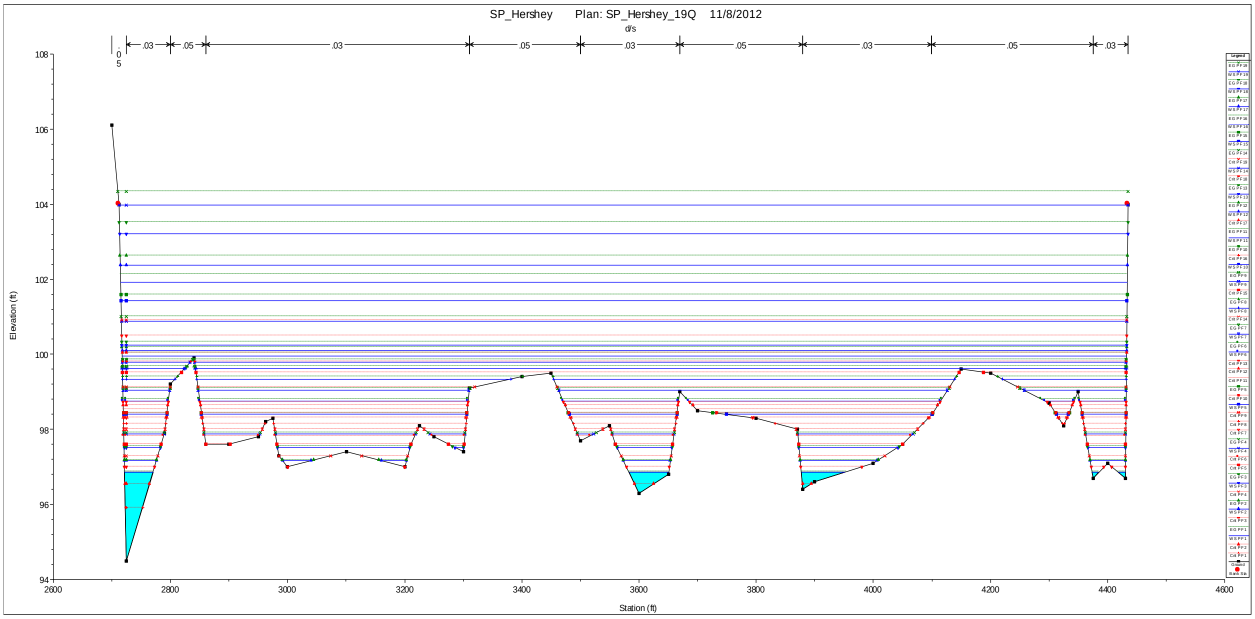

Figure 3.13 South Platte at Hershey, cross-section with water surface and EGL at flows from 100 to 50,000 cfs

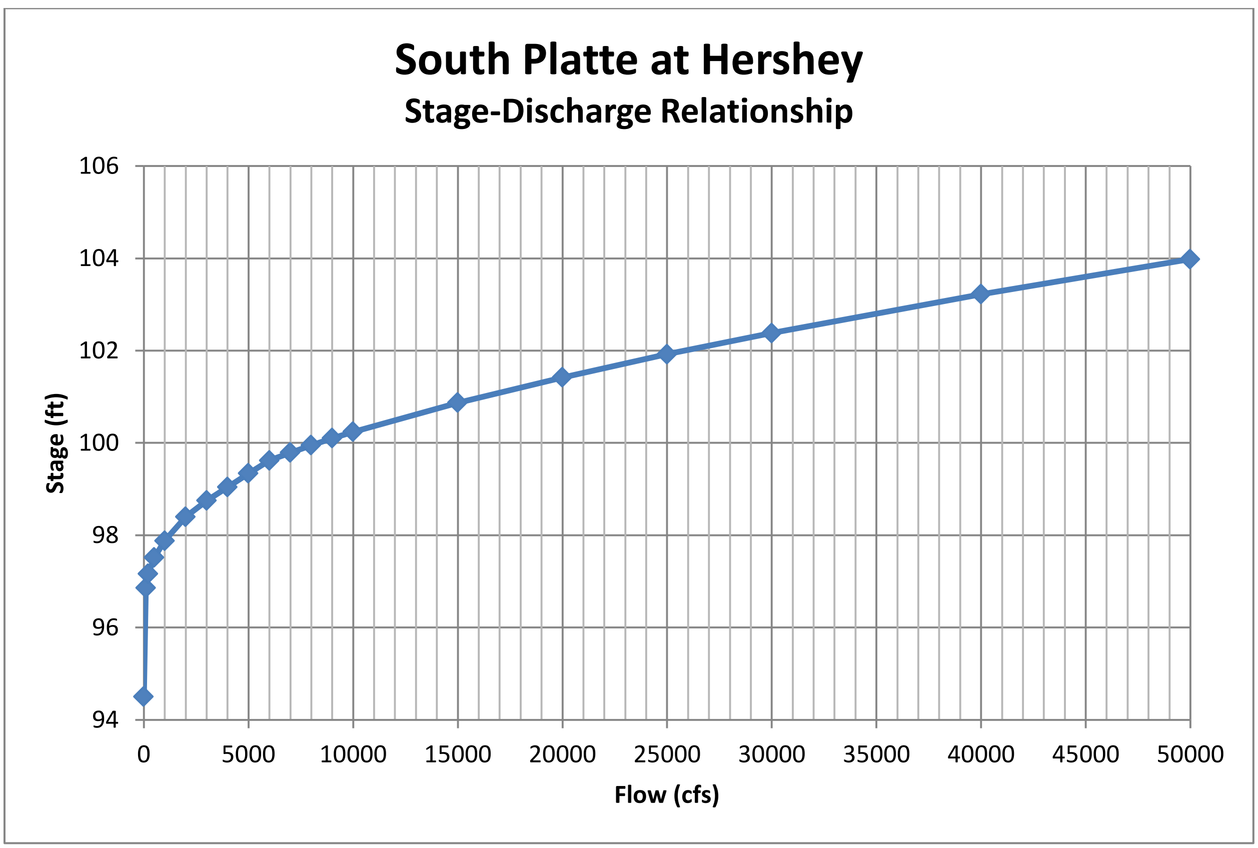

Figure 3.14 South Platte at Hershey, stage-discharge relationship

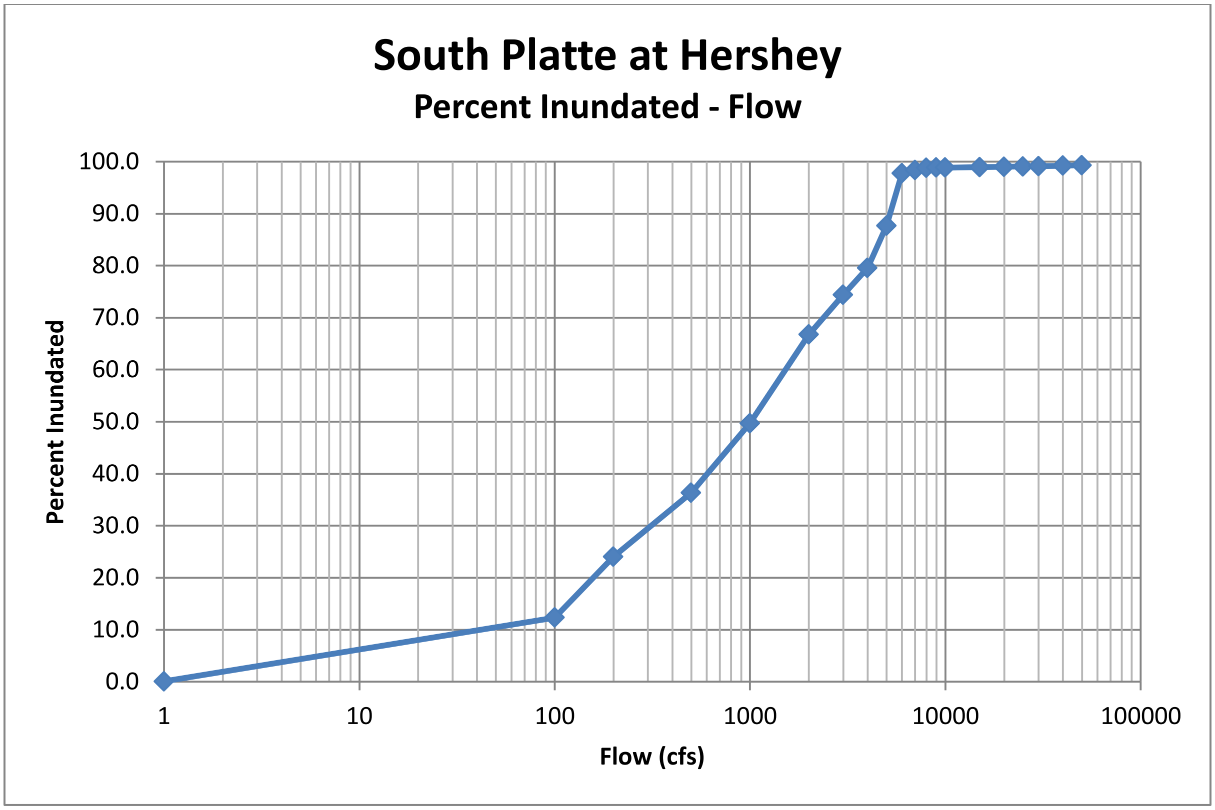

Figure 3.15 South Platte at Hershey, percent inundated-flow

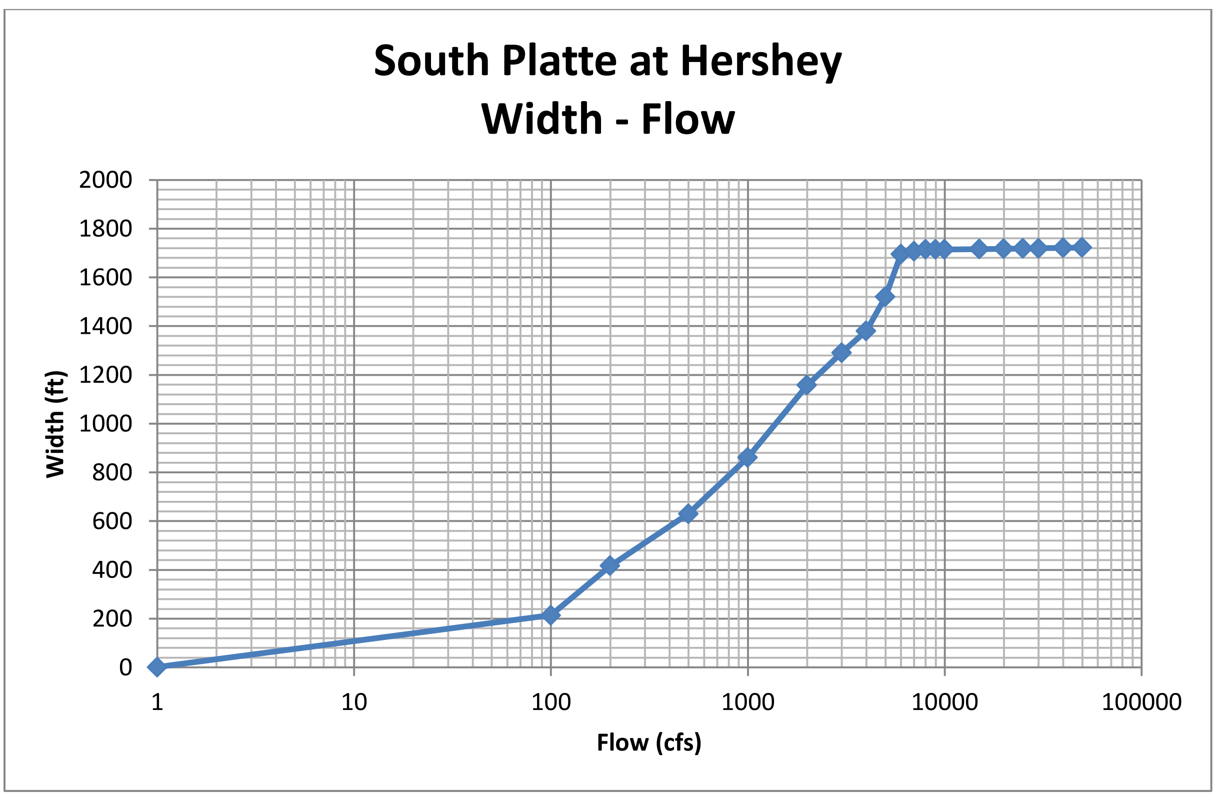

Figure 3.16 South Platte at Hershey, width – flow.

Table 3.4 South Platte at Hershey, hydraulic modeling results

Flow (cfs)	Water Surface Elevation (ft)	Mean Velocity (ft/s)	Area (ft^2)	Width (ft)	% Inundated
100	96.86	1.07	94	214	12.3
200	97.16	1.08	185	417	24.0
500	97.52	1.33	377	630	36.3
1000	97.88	1.54	650	862	49.7
2000	98.4	1.71	1171	1158	66.7
3000	98.75	1.87	1607	1291	74.4
4000	99.04	2.01	1991	1380	79.6
5000	99.34	2.07	2417	1521	87.7
6000	99.62	2.09	2876	1696	97.7
7000	99.79	2.21	3167	1707	98.4
8000	99.95	2.33	3440	1715	98.8
9000	100.1	2.44	3691	1715	98.8
10000	100.24	2.54	3933	1715	98.9
15000	100.87	2.99	5022	1717	98.9
20000	101.42	3.35	5967	1718	99.0
25000	101.92	3.66	6823	1719	99.1
30000	102.38	3.94	7616	1720	99.1
40000	103.22	4.42	9057	1721	99.2
50000	103.98	4.83	10360	1723	99.3

Platte at Brady:

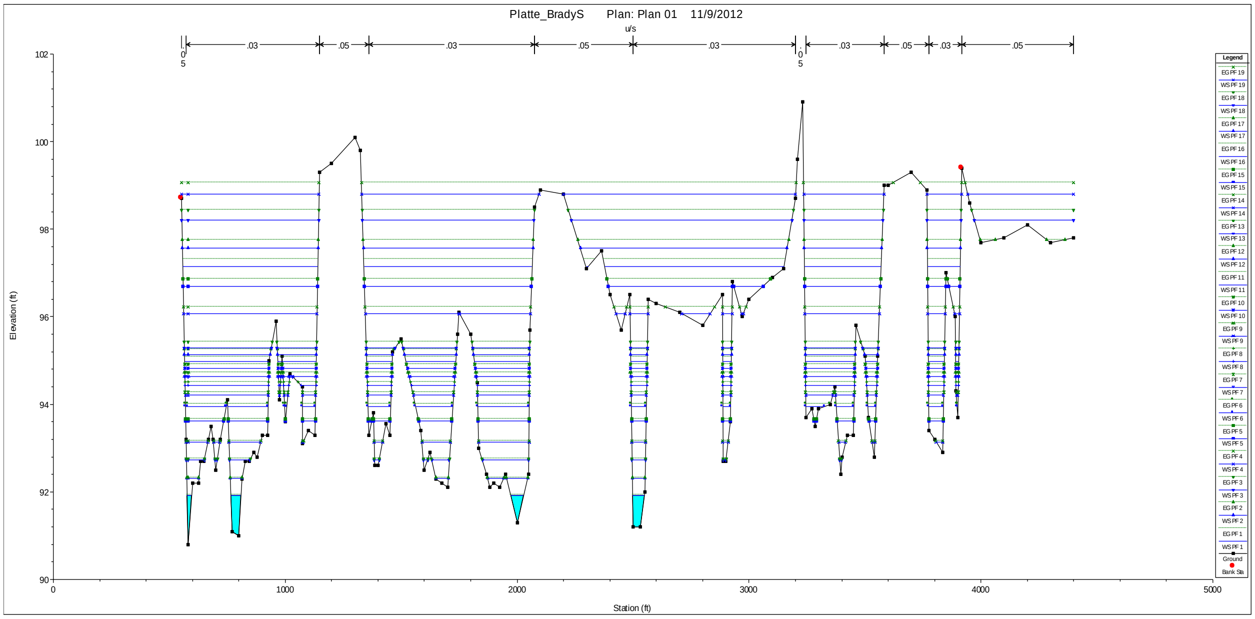

Figure 3.17 Platte at Brady, cross-section with water surface and EGL at flows from 100 to 50,000 cfs

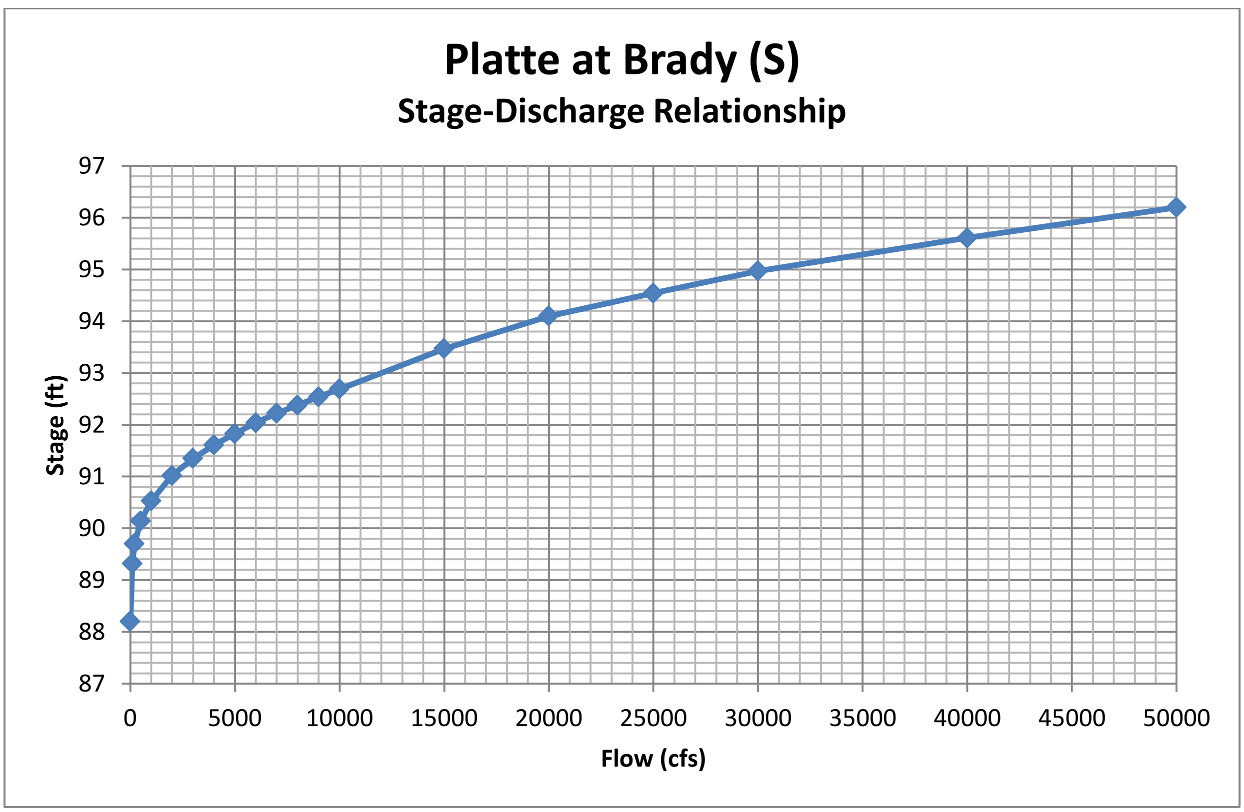

Figure 3.18 Platte at Brady, stage-discharge relationship

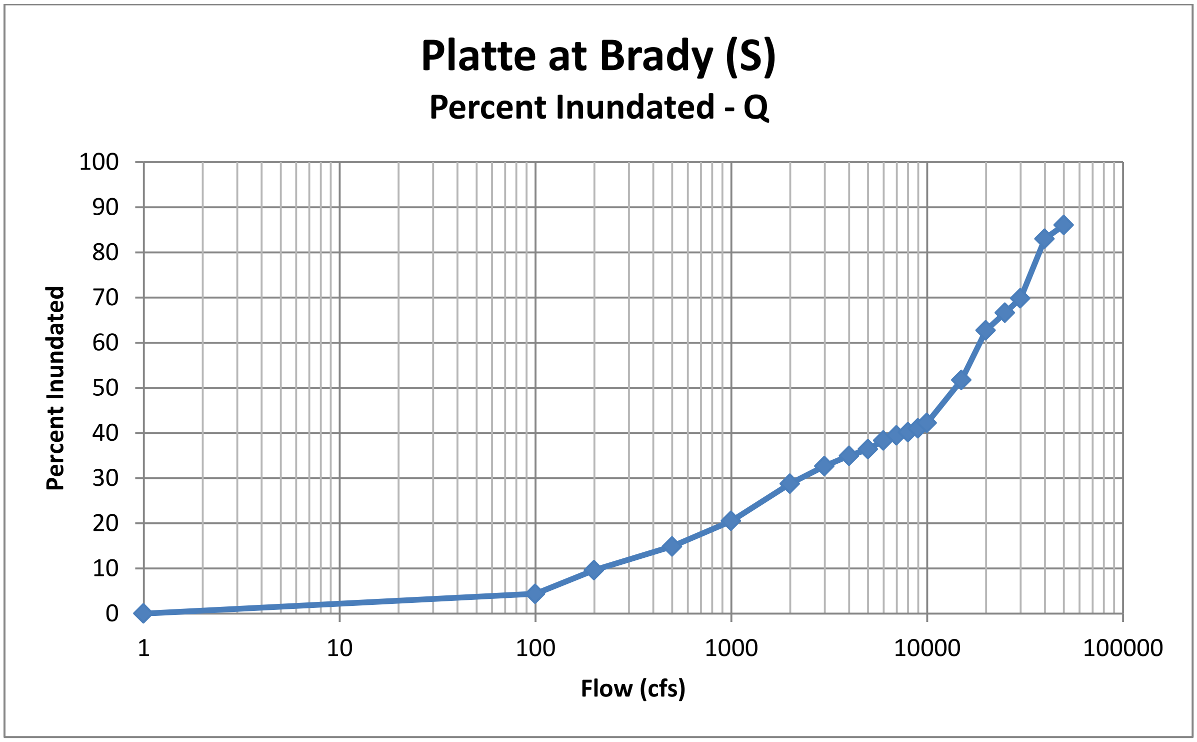

Figure 3.19 Platte at Brady, percent inundated - flow

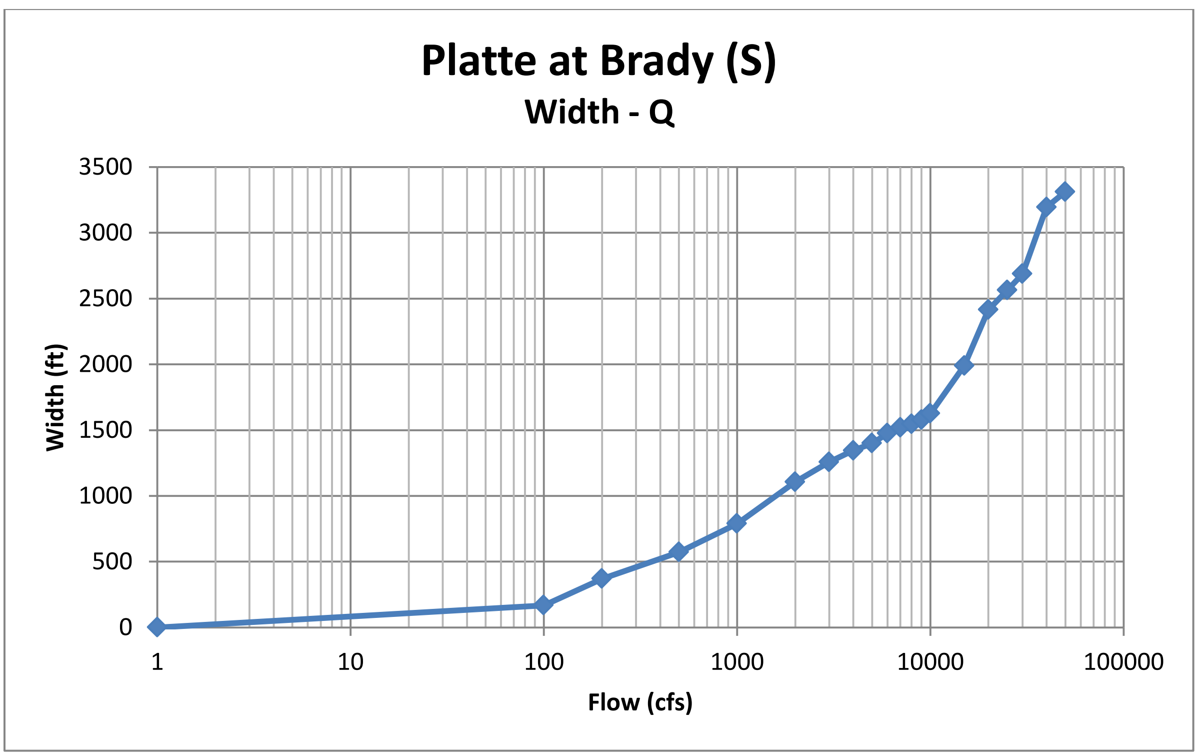

Figure 3.20 Platte at Brady, width - flow

Table 3.5 Platte at Brady, hydraulic modeling results

Flow (cfs)	Water Surface Elevation (ft)	Mean Velocity (ft/s)	Area (ft^2)	Width (ft)	% Inundated
100	89.32	1.14	88	169	4.4
200	89.7	1.1	181	370	9.6
500	90.14	1.34	374	573	14.9
1000	90.53	1.55	645	789	20.5
2000	91.02	1.78	1121	1107	28.8
3000	91.35	1.99	1507	1258	32.7
4000	91.61	2.17	1842	1345	34.9
5000	91.83	2.33	2142	1400	36.4
6000	92.04	2.46	2442	1475	38.3
7000	92.22	2.58	2713	1519	39.5
8000	92.38	2.7	2962	1547	40.2
9000	92.54	2.81	3207	1579	41.0
10000	92.69	2.89	3458	1626	42.3
15000	93.47	3.11	4827	1990	51.7
20000	94.1	3.2	6245	2415	62.8
25000	94.54	3.41	7338	2563	66.6
30000	94.97	3.54	8466	2688	69.8
40000	95.61	3.91	10376	3195	83.0
50000	96.2	4.18	12289	3312	86.1

Platte at Odessa:

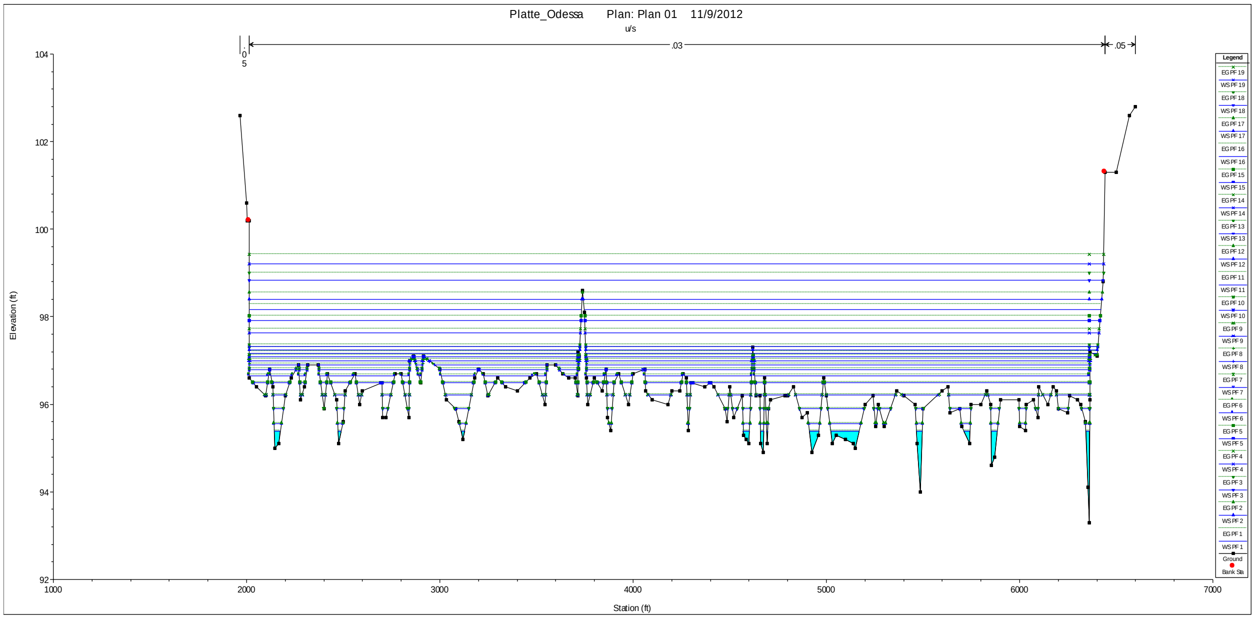

Figure 3.21 Platte at Odessa, cross-section with water surface and EGL at flows from 100 to 50,000 cfs

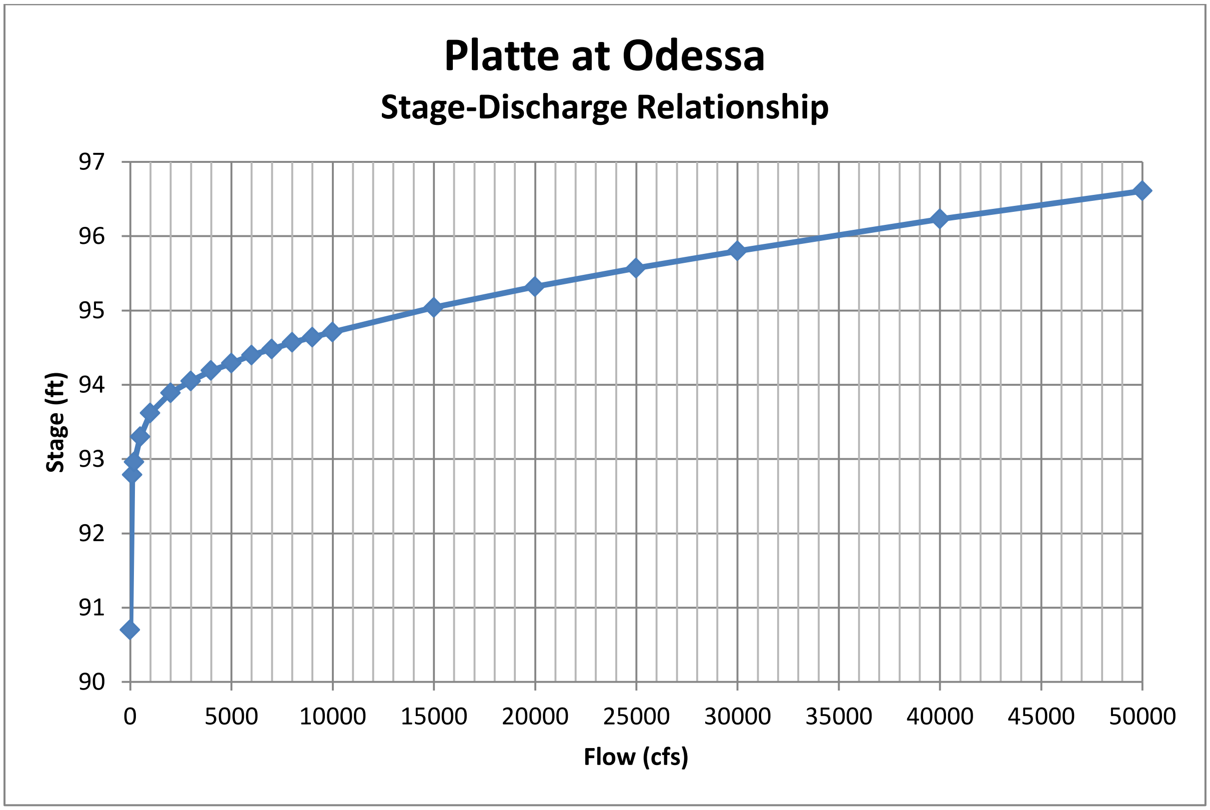

Figure 3.22 Platte at Odessa, stage-discharge relationship

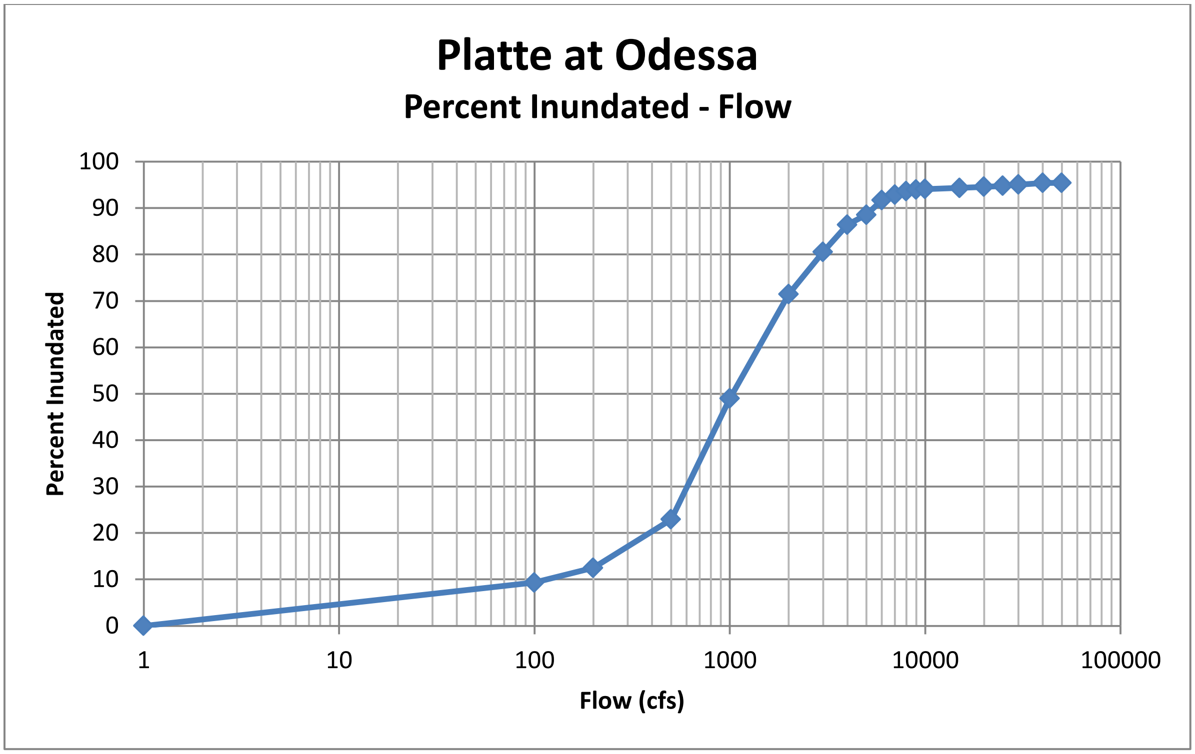

Figure 3.23 Platte at Odessa, percent inundated – flow

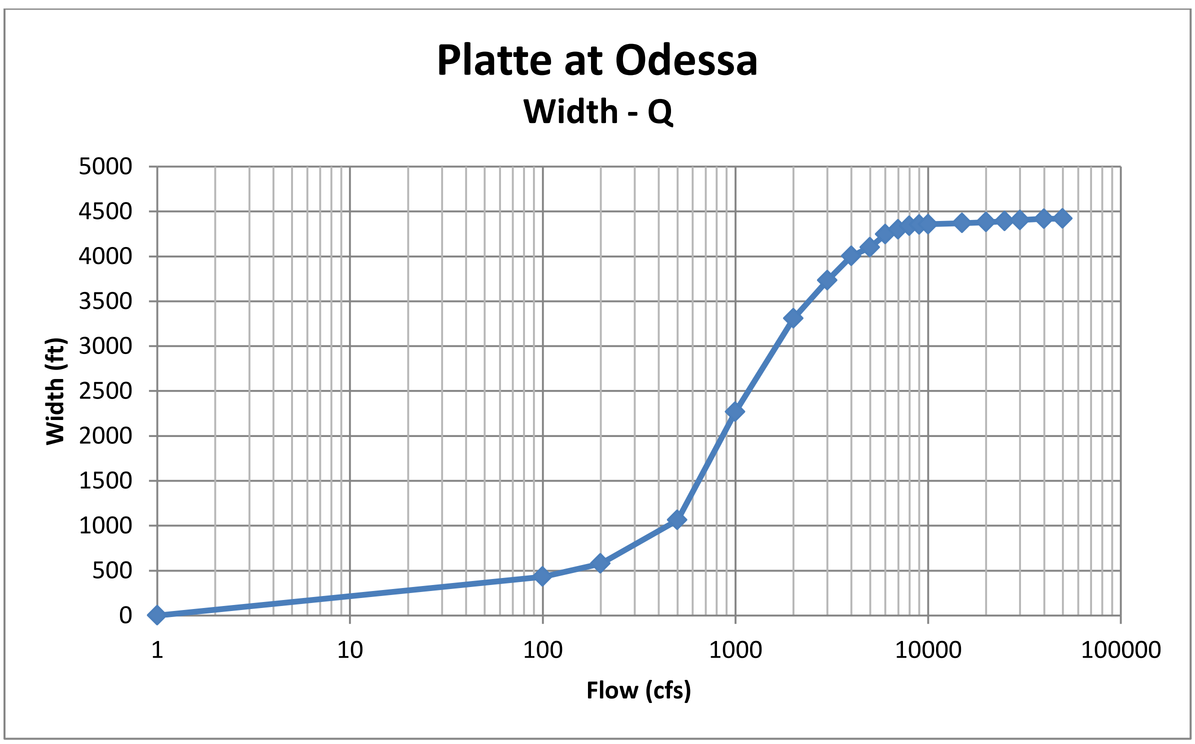

Figure 3.24 Platte at Odessa, width - flow

Table 3.6 Platte at Odessa, hydraulic modeling results

Flow (cfs)	Water Surface Elevation (ft)	Mean Velocity (ft/s)	Area (ft^2)	Width (ft)	% Inundated
100	92.79	0.79	127	432	9.3
200	92.96	0.93	216	578	12.5
500	93.3	1.05	478	1062	22.9
1000	93.62	1.02	980	2269	49.0
2000	93.89	1.16	1728	3309	71.4
3000	94.05	1.3	2312	3731	80.6
4000	94.19	1.42	2826	4003	86.4
5000	94.29	1.53	3262	4101	88.5
6000	94.4	1.63	3689	4246	91.7
7000	94.48	1.72	4068	4300	92.8
8000	94.57	1.81	4423	4338	93.7
9000	94.64	1.89	4755	4354	94.0
10000	94.71	1.97	5068	4358	94.1
15000	95.04	2.32	6470	4370	94.3
20000	95.32	2.6	7697	4380	94.6
25000	95.57	2.84	8807	4391	94.8
30000	95.8	3.05	9838	4404	95.1
40000	96.23	3.42	11708	4419	95.4
50000	96.61	3.73	13387	4420	95.4

3.2 Flow Distribution Analysis

A velocity and depth distribution analysis was conducted for the available cross-sections at the 1.5 year return period historic flow (based on pre-development conditions). The magnitude of flow for the various reaches of river was estimated based on historic flow records from the earliest time periods available. The analysis was conducted by Randle and Samad (2003) and a table from this report documents the results of this hydrologic analysis.

Table 3.8 — Platte River 1.5-year flood (Randle and Samad, 2003)

Gage Station	1.5-year flood (ft^3/s) for each time period			
	1895 to 1909	1910 to 1935	1936 to 1969	1970 to 1999
North Platte River at Northgate, CO		2,600	2,220	2,430
North Platte River at Saratoga, WY	9,200	7,720	5,710	
North Platte River at North Platte, NE	16,300	8,150	2,160	2,380
South Platte River at North Platte, NE	2,330	1,430	712	1,420
Platte River near Cozad, NE	17,600	9,140	1,980	2,590
Platte River near Overton, NE	19,400	9,000	3,490	4,750
Platte River near Grand Island, NE	17,300	10,100	4,500	6,010

These flow values were utilized directly in HEC-RAS to compute the depth and velocity distribution across the channel using the flow distribution location option with the flow and cross-section as tabulated below:

Table 3.7 1.5 year historic flows at cross-section locations

Location	1.5 year Historic Flow (cfs)
North Platte at Lewellen	16,300
North Platte at Hershey	16,300
South Platte at Paxton	2,330
South Platte at Hershey	2,330
Platte at Brady	17,600
Platte at Odessa	19,400

The flow distribution is calculated as described in Chapter 4 of the HEC-RAS Hydraulic Reference Manual. First the water surface elevation is computed using the normal methodology. Then the cross-section is subdivided into a number (maximum of 45) of user-defined slices horizontally across the channel and the area, wetted perimeter, and hydraulic depth is computed for each slice. Using the originally computed friction slope (S_f) and Manning's n for each slice, the conveyance is calculated. The sum of the individual conveyances is then compared to the originally calculated total conveyance and an adjustment is made to ensure that the sum of the conveyance slices equals the original total conveyance. Finally, the velocity is calculated for each slice based on the discharge for each slice divided by the cross-sectional area for each slice. The output for flow distribution includes a graph of the velocity distribution across the channel and a table of flow distribution output. Results of the flow distribution analysis at the 1.5 year historic flow at each of the cross-sections follow.

North Platte at Lewellen (Velocity and Depth distribution at $Q_{1.5}$ = 16,300 cfs):

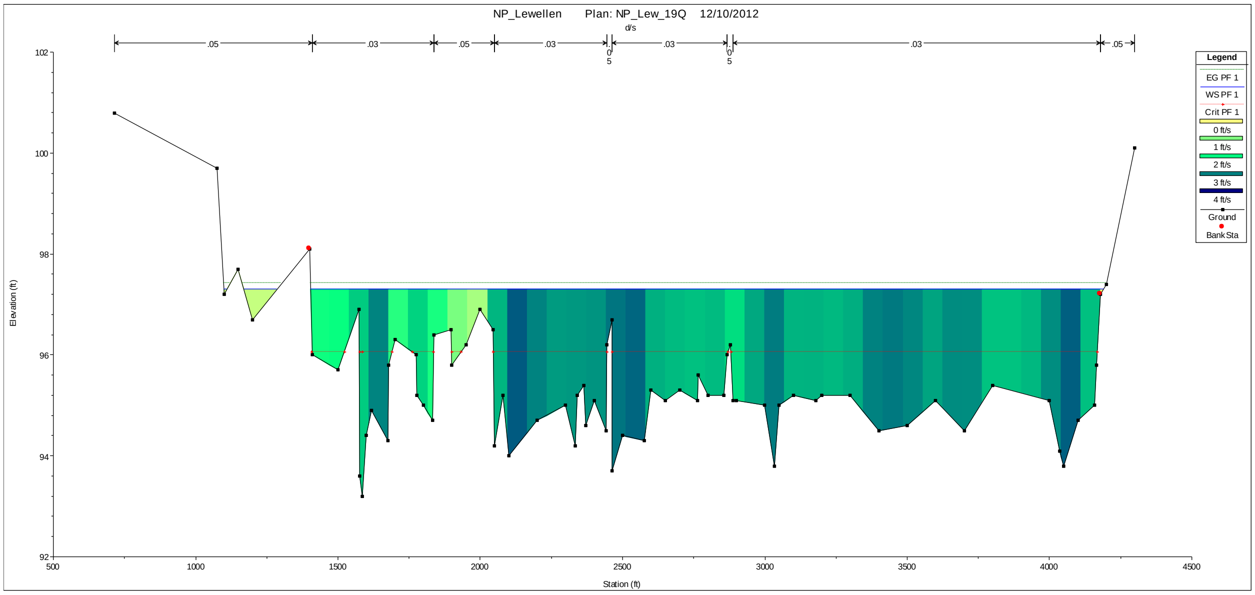

Figure 3.25 North Platte at Lewellen – flow distribution

Table 3.8 North Platte at Lewellen – flow distribution

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	LOB	715	1400	16.43	35.84	128.05	0.1	0.28	0.46	0.02	0.01
2	Chan	1400	1469.5	168.06	88.6	66.24	1.03	1.34	1.9	0.1	0.19
3	Chan	1469.5	1539	190.88	97.81	69.51	1.17	1.41	1.95	0.11	0.21
4	Chan	1539	1608.5	332.13	138.32	72.01	2.04	1.99	2.4	0.14	0.35
5	Chan	1608.5	1678	546.36	184.37	70.01	3.35	2.65	2.96	0.2	0.58
6	Chan	1678	1747.5	135.36	79.59	69.51	0.83	1.15	1.7	0.09	0.15
7	Chan	1747.5	1817	303.92	129.51	69.78	1.86	1.86	2.35	0.14	0.33
8	Chan	1817	1886.5	163.05	89.52	69.78	1	1.29	1.82	0.1	0.18
9	Chan	1886.5	1956	88.1	83.6	69.58	0.54	1.2	1.05	0.09	0.09
10	Chan	1956	2025.5	30.96	44.62	69.51	0.19	0.64	0.69	0.05	0.03
11	Chan	2025.5	2095	364.32	141.51	69.97	2.24	2.04	2.57	0.15	0.39
12	Chan	2095	2164.5	705.71	214.35	69.51	4.33	3.08	3.29	0.23	0.76
13	Chan	2164.5	2234	545.67	183.69	69.5	3.35	2.64	2.97	0.2	0.59
14	Chan	2234	2303.5	464.83	166.84	69.5	2.85	2.4	2.79	0.18	0.5
15	Chan	2303.5	2373	475.85	169.34	69.65	2.92	2.44	2.81	0.18	0.51
16	Chan	2373	2442.5	488.47	171.89	69.51	3	2.47	2.84	0.19	0.53
17	Chan	2442.5	2512	546.41	177.31	72.3	3.35	2.55	3.08	0.18	0.57
18	Chan	2512	2581.5	658.54	205.63	69.5	4.04	2.96	3.2	0.22	0.71
19	Chan	2581.5	2651	397.7	151.95	69.52	2.44	2.19	2.62	0.16	0.43
20	Chan	2651	2720.5	366.98	144.78	69.5	2.25	2.08	2.53	0.16	0.4
21	Chan	2720.5	2790	350.59	140.92	69.56	2.15	2.03	2.49	0.15	0.38
22	Chan	2790	2859.5	367.94	145.02	69.51	2.26	2.09	2.54	0.16	0.4
23	Chan	2859.5	2929	298.16	131.81	69.59	1.83	1.9	2.26	0.14	0.32
24	Chan	2929	2998.5	422.91	157.64	69.5	2.59	2.27	2.68	0.17	0.46

25	Chan	2998.5	3068	574.46	189.51	69.56	3.52	2.73	3.03	0.2	0.62
26	Chan	3068	3137.5	385.84	149.2	69.5	2.37	2.15	2.59	0.16	0.42
27	Chan	3137.5	3207	390.91	150.37	69.5	2.4	2.16	2.6	0.16	0.42
28	Chan	3207	3276.5	373.26	146.26	69.5	2.29	2.1	2.55	0.16	0.4
29	Chan	3276.5	3346	405.29	153.67	69.5	2.49	2.21	2.64	0.17	0.44
30	Chan	3346	3415.5	550.11	184.59	69.5	3.37	2.66	2.98	0.2	0.59
31	Chan	3415.5	3485	584.48	191.42	69.5	3.59	2.75	3.05	0.21	0.63
32	Chan	3485	3554.5	530.7	180.65	69.5	3.26	2.6	2.94	0.19	0.57
33	Chan	3554.5	3624	434.02	160.12	69.5	2.66	2.3	2.71	0.17	0.47
34	Chan	3624	3693.5	516.39	177.71	69.5	3.17	2.56	2.91	0.19	0.56
35	Chan	3693.5	3763	512.58	176.93	69.5	3.14	2.55	2.9	0.19	0.55
36	Chan	3763	3832.5	344.18	139.32	69.5	2.11	2	2.47	0.15	0.37
37	Chan	3832.5	3902	344.42	139.37	69.5	2.11	2.01	2.47	0.15	0.37
38	Chan	3902	3971.5	374.78	146.62	69.5	2.3	2.11	2.56	0.16	0.4
39	Chan	3971.5	4041	510.29	176.46	69.52	3.13	2.54	2.89	0.19	0.55
40	Chan	4041	4110.5	684.8	210.52	69.51	4.2	3.03	3.25	0.23	0.74
41	Chan	4110.5	4180	354.09	141.8	69.61	2.17	2.04	2.5	0.15	0.38
42	ROB	4180	4300	0.08	0.55	10.45	0	0.05	0.14	0	0

Unit width discharge (q) = 5.58 cfs/ft

North Platte at Hershey (Velocity and Depth distribution at $Q_{1.5}$ = 16,300 cfs):

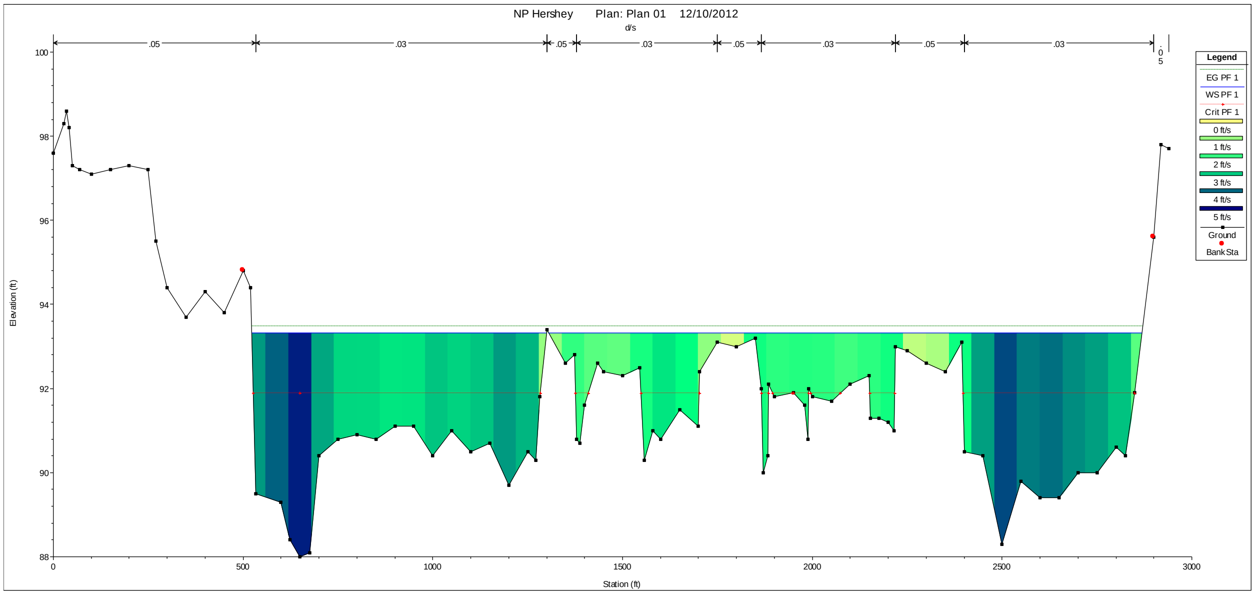

Figure 3.26 North Platte at Hershey – flow distribution

Table 3.9 North Platte at Hershey – flow distribution

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	Chan	500	560	431.47	123.62	37.83	2.65	3.33	3.49	0.22	0.78
2	Chan	560	620	997.9	246.7	60.02	6.12	4.11	4.05	0.28	1.14
3	Chan	620	680	1456.77	309.58	60.03	8.94	5.16	4.71	0.35	1.67
4	Chan	680	740	629.82	187.26	60.09	3.86	3.12	3.36	0.21	0.72
5	Chan	740	800	431.49	149.16	60	2.65	2.49	2.89	0.17	0.49
6	Chan	800	860	428.12	148.46	60	2.63	2.47	2.88	0.17	0.49
7	Chan	860	920	379.31	138.06	60	2.33	2.3	2.75	0.16	0.43
8	Chan	920	980	386.19	139.56	60	2.37	2.33	2.77	0.16	0.44
9	Chan	980	1040	499.52	162.86	60	3.06	2.71	3.07	0.19	0.57
10	Chan	1040	1100	447.01	152.36	60	2.74	2.54	2.93	0.17	0.51
11	Chan	1100	1160	501.58	163.26	60	3.08	2.72	3.07	0.19	0.57
12	Chan	1160	1220	692.09	198.06	60.01	4.25	3.3	3.49	0.23	0.79
13	Chan	1220	1280	565.02	175.46	60.09	3.47	2.92	3.22	0.2	0.65
14	Chan	1280	1340	27.15	26.19	54.27	0.17	0.48	1.04	0.03	0.03
15	Chan	1340	1400	160.07	79.01	60.36	0.98	1.32	2.03	0.09	0.18
16	Chan	1400	1460	106.29	64.36	60.02	0.65	1.07	1.65	0.07	0.12
17	Chan	1460	1520	91.37	58.77	60	0.56	0.98	1.55	0.07	0.1
18	Chan	1520	1580	242.31	105.65	60.2	1.49	1.76	2.29	0.12	0.28
19	Chan	1580	1640	379.29	138.06	60	2.33	2.3	2.75	0.16	0.43
20	Chan	1640	1700	300.1	119.96	60	1.84	2	2.5	0.14	0.34
21	Chan	1700	1760	37.27	33.86	60.27	0.23	0.56	1.1	0.04	0.04
22	Chan	1760	1820	6.84	16.86	60	0.04	0.28	0.41	0.02	0.01

23	Chan	1820	1880	136.71	57.79	60.52	0.84	0.96	2.37	0.07	0.16
24	Chan	1880	1940	191.62	91.92	60.45	1.18	1.53	2.08	0.1	0.22
25	Chan	1940	2000	209.83	96.96	60.27	1.29	1.62	2.16	0.11	0.24
26	Chan	2000	2060	201.15	94.36	60	1.23	1.57	2.13	0.11	0.23
27	Chan	2060	2120	149.15	78.86	60	0.92	1.31	1.89	0.09	0.17
28	Chan	2120	2180	191.13	91.61	60.16	1.17	1.53	2.09	0.1	0.22
29	Chan	2180	2240	206.41	87.67	60.47	1.27	1.46	2.35	0.1	0.23
30	Chan	2240	2300	20.53	32.6	60	0.13	0.54	0.63	0.04	0.02
31	Chan	2300	2360	41.13	49.46	60	0.25	0.82	0.83	0.06	0.05
32	Chan	2360	2420	197.76	82.65	60.54	1.21	1.38	2.39	0.09	0.22
33	Chan	2420	2480	664.24	193.26	60.03	4.08	3.22	3.44	0.22	0.76
34	Chan	2480	2540	1151.49	268.86	60.04	7.06	4.48	4.28	0.31	1.32
35	Chan	2540	2600	841.88	222.76	60.01	5.16	3.71	3.78	0.25	0.96
36	Chan	2600	2660	918.22	234.66	60	5.63	3.91	3.91	0.27	1.05
37	Chan	2660	2720	756.19	208.86	60	4.64	3.48	3.62	0.24	0.87
38	Chan	2720	2780	667.87	193.86	60	4.1	3.23	3.45	0.22	0.76
39	Chan	2780	2840	507.33	164.41	60.03	3.11	2.74	3.09	0.19	0.58
40	Chan	2840	2900	50.37	30.85	29.27	0.31	1.06	1.63	0.07	0.12

Unit width discharge (q) = 6.95 cfs/ft

South Platte at Paxton (Velocity and Depth distribution at $Q_{1.5}$ = 2,330 cfs):

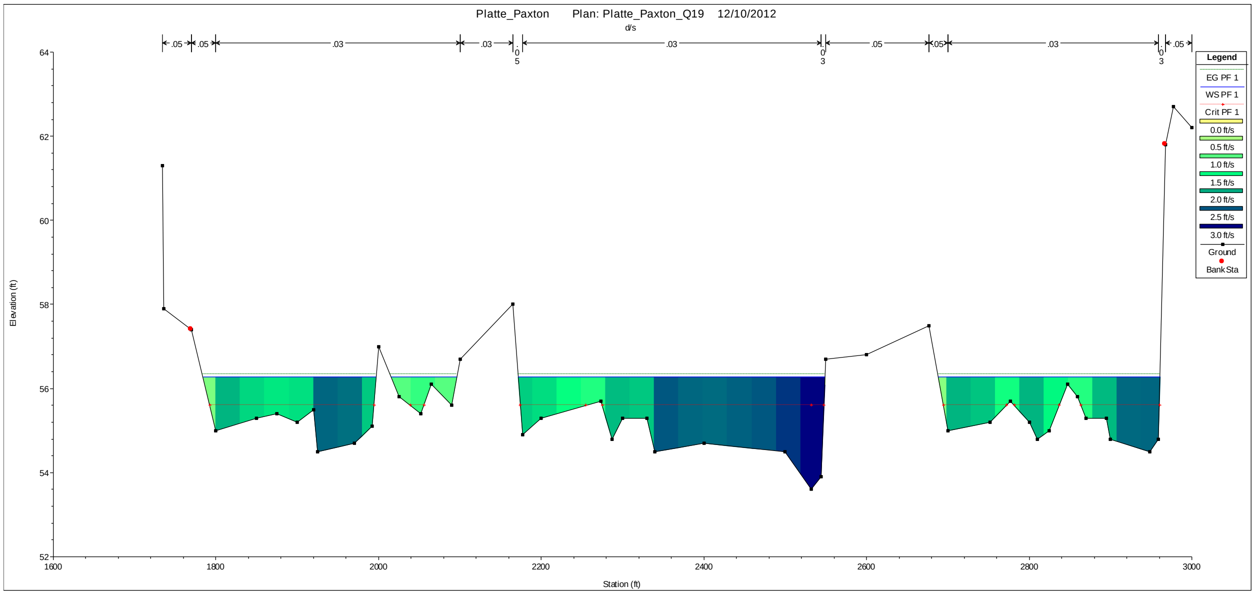

Figure 3.27 South Platte at Paxton – flow distribution

Table 3.10 South Platte at Paxton – flow distribution

	Pos	Left Sta (ft)	Right Sta (ft)	Flow (cfs)	Area (sq ft)	W.P. (ft)	Percent Conv	Hydr Depth(ft)	Velocity (ft/s)	Shear (lb/sq ft)	Power (lb/ft s)
1	Chan	1770	1799.95	7.67	10.02	15.88	0.33	0.63	0.77	0.06	0.05
2	Chan	1799.95	1829.9	68.41	35.36	29.95	2.94	1.18	1.93	0.11	0.21
3	Chan	1829.9	1859.85	52.28	30.08	29.95	2.24	1	1.74	0.09	0.16
4	Chan	1859.85	1889.8	44.75	27.4	29.95	1.92	0.91	1.63	0.09	0.14
5	Chan	1889.8	1919.75	48.38	28.71	29.95	2.08	0.96	1.68	0.09	0.15
6	Chan	1919.75	1949.7	117.31	48.92	30.05	5.03	1.63	2.4	0.15	0.37
7	Chan	1949.7	1979.65	110.38	47.1	29.95	4.74	1.57	2.34	0.15	0.35
8	Chan	1979.65	2009.6	34.05	18.72	17.42	1.46	1.08	1.82	0.1	0.18
9	Chan	2009.6	2039.55	10.74	10.71	24.36	0.46	0.44	1	0.04	0.04
10	Chan	2039.55	2069.5	21.03	17.42	29.97	0.9	0.58	1.21	0.05	0.07
11	Chan	2069.5	2099.45	11.52	11.58	26.63	0.49	0.44	0.99	0.04	0.04
12	Chan	2099.45	2129.4							0	0
13	Chan	2129.4	2159.35							0	0
14	Chan	2159.35	2189.3	34.34	19.17	17.78	1.47	1.09	1.79	0.1	0.18
15	Chan	2189.3	2219.25	49.3	29.04	29.95	2.12	0.97	1.7	0.09	0.15
16	Chan	2219.25	2249.2	34.51	23.44	29.95	1.48	0.78	1.47	0.07	0.11
17	Chan	2249.2	2279.15	26.14	19.85	29.96	1.12	0.66	1.32	0.06	0.08
18	Chan	2279.15	2309.1	64.89	34.25	29.98	2.78	1.14	1.89	0.11	0.2
19	Chan	2309.1	2339.05	58.94	32.34	29.98	2.53	1.08	1.82	0.1	0.18
20	Chan	2339.05	2369	128.44	51.58	29.95	5.51	1.72	2.49	0.16	0.4
21	Chan	2369	2398.95	116.43	48.63	29.95	5	1.62	2.39	0.15	0.36
22	Chan	2398.95	2428.9	113.4	47.87	29.95	4.87	1.6	2.37	0.15	0.35
23	Chan	2428.9	2458.85	120.56	49.66	29.95	5.17	1.66	2.43	0.16	0.38
24	Chan	2458.85	2488.8	127.91	51.45	29.95	5.49	1.72	2.49	0.16	0.4
25	Chan	2488.8	2518.75	155.42	57.84	29.96	6.67	1.93	2.69	0.18	0.49

26	Chan	2518.75	2548.7	207.03	69.14	30.45	8.89	2.31	2.99	0.21	0.64
27	Chan	2548.7	2578.65	0.01	0.03	0.42	0	0.09	0.32	0.01	0
28	Chan	2578.65	2608.6							0	0
29	Chan	2608.6	2638.55							0	0
30	Chan	2638.55	2668.5							0	0
31	Chan	2668.5	2698.45	3.89	5.58	10.2	0.17	0.55	0.7	0.05	0.04
32	Chan	2698.45	2728.4	70.29	36.36	29.96	3.02	1.21	1.93	0.11	0.22
33	Chan	2728.4	2758.35	60.16	32.72	29.95	2.58	1.09	1.84	0.1	0.19
34	Chan	2758.35	2788.3	30.91	21.95	29.96	1.33	0.73	1.41	0.07	0.1
35	Chan	2788.3	2818.25	68.61	35.41	29.96	2.94	1.18	1.94	0.11	0.21
36	Chan	2818.25	2848.2	38.25	24.95	29.98	1.64	0.83	1.53	0.08	0.12
37	Chan	2848.2	2878.15	25.28	19.45	29.96	1.08	0.65	1.3	0.06	0.08
38	Chan	2878.15	2908.1	65.87	34.57	29.98	2.83	1.15	1.91	0.11	0.21
39	Chan	2908.1	2938.05	115.33	48.35	29.95	4.95	1.61	2.39	0.15	0.36
40	Chan	2938.05	2968	87.59	36.52	23.35	3.76	1.6	2.4	0.15	0.35

Unit width discharge (q) = 2.47 cfs/ft

South Platte at Hershey (Velocity and Depth distribution at $Q_{1.5}$ = 2,330 cfs):

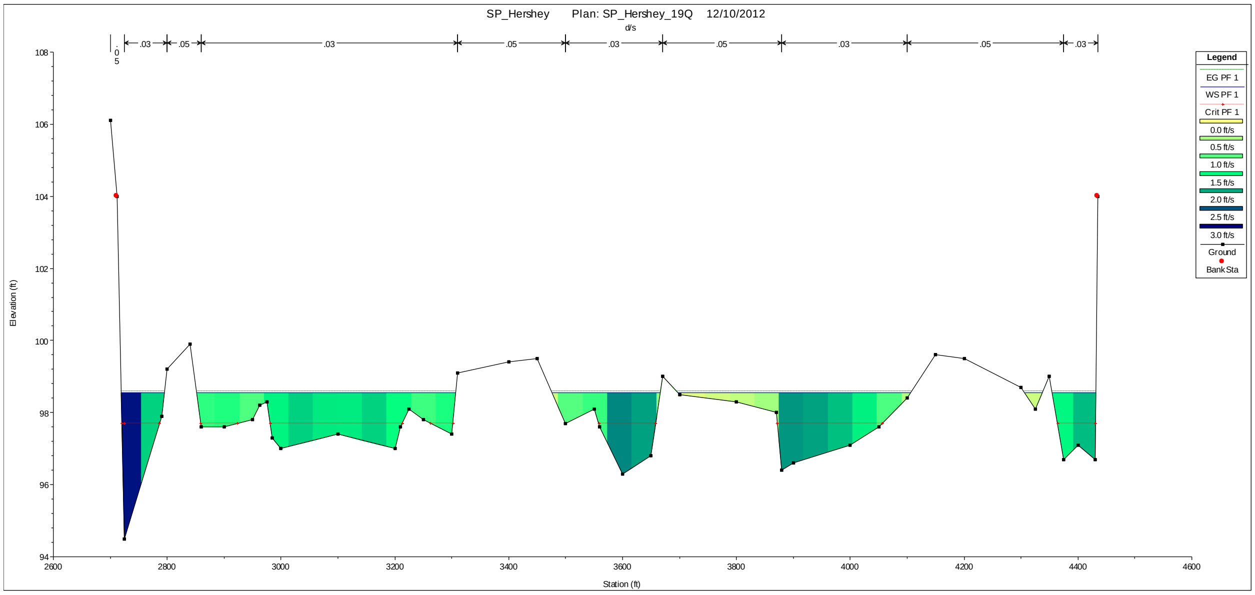

Figure 3.28 South Platte at Hershey – flow distribution

Table 3.11 South Platte at Hershey – flow distribution

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	Chan	2712	2755.08	316.68	109.15	36.97	13.59	3.07	2.9	0.28	0.8
2	Chan	2755.08	2798.15	98.91	55.98	39.97	4.25	1.4	1.77	0.13	0.23
3	Chan	2798.15	2841.23							0	0
4	Chan	2841.23	2884.3	33.13	26.81	32.56	1.42	0.82	1.24	0.08	0.1
5	Chan	2884.3	2927.38	51.86	39.16	43.08	2.23	0.91	1.32	0.09	0.11
6	Chan	2927.38	2970.45	28.34	27.25	43.08	1.22	0.63	1.04	0.06	0.06
7	Chan	2970.45	3013.53	78.02	50.05	43.13	3.35	1.16	1.56	0.11	0.17
8	Chan	3013.53	3056.6	106.97	60.46	43.08	4.59	1.4	1.77	0.13	0.23
9	Chan	3056.6	3099.68	85.99	53.04	43.08	3.69	1.23	1.62	0.12	0.19
10	Chan	3099.68	3142.75	85.69	52.92	43.08	3.68	1.23	1.62	0.12	0.19
11	Chan	3142.75	3185.83	106.64	60.35	43.08	4.58	1.4	1.77	0.13	0.23
12	Chan	3185.83	3228.9	68.17	46.15	43.1	2.93	1.07	1.48	0.1	0.15
13	Chan	3228.9	3271.98	35.7	31.3	43.08	1.53	0.73	1.14	0.07	0.08
14	Chan	3271.98	3315.05	44.37	32.76	34.85	1.9	0.94	1.35	0.09	0.12
15	Chan	3315.05	3358.13							0	0
16	Chan	3358.13	3401.2							0	0
17	Chan	3401.2	3444.28							0	0
18	Chan	3444.28	3487.35	0.59	2.1	10.8	0.03	0.19	0.28	0.02	0.01
19	Chan	3487.35	3530.43	29.73	29.76	43.08	1.28	0.69	1	0.06	0.06
20	Chan	3530.43	3573.5	38.71	32.86	43.1	1.66	0.76	1.18	0.07	0.08
21	Chan	3573.5	3616.58	184.53	83.87	43.09	7.92	1.95	2.2	0.18	0.4
22	Chan	3616.58	3659.65	155.04	75.58	43.13	6.65	1.75	2.05	0.16	0.34
23	Chan	3659.65	3702.73	1.47	2.3	11.59	0.06	0.2	0.64	0.02	0.01
24	Chan	3702.73	3745.8	0.69	3.98	43.08	0.03	0.09	0.17	0.01	0

25	Chan	3745.8	3788.88	2.06	7.69	43.08	0.09	0.18	0.27	0.02	0
26	Chan	3788.88	3831.95	4.68	12.57	43.08	0.2	0.29	0.37	0.03	0.01
27	Chan	3831.95	3875.03	12.2	22.34	43.14	0.52	0.52	0.55	0.05	0.03
28	Chan	3875.03	3918.1	177.73	83.93	43.14	7.63	1.95	2.12	0.18	0.39
29	Chan	3918.1	3961.18	153.86	75.19	43.08	6.6	1.75	2.05	0.16	0.33
30	Chan	3961.18	4004.25	123.4	65.87	43.08	5.3	1.53	1.87	0.14	0.27
31	Chan	4004.25	4047.33	80.78	51.08	43.08	3.47	1.19	1.58	0.11	0.18
32	Chan	4047.33	4090.4	29.01	27.63	43.08	1.24	0.64	1.05	0.06	0.06
33	Chan	4090.4	4133.48	1.15	2.55	15.59	0.05	0.16	0.45	0.02	0.01
34	Chan	4133.48	4176.55							0	0
35	Chan	4176.55	4219.63							0	0
36	Chan	4219.63	4262.7							0	0
37	Chan	4262.7	4305.78							0	0
38	Chan	4305.78	4348.85	2.12	6.84	30.83	0.09	0.22	0.31	0.02	0.01
39	Chan	4348.85	4391.93	73.1	47.39	37.05	3.14	1.28	1.54	0.12	0.19
40	Chan	4391.93	4435	118.67	62.66	40.31	5.09	1.59	1.89	0.15	0.28

Unit width discharge (q) = 1.88 cfs/ft

Platte at Brady (Velocity and Depth distribution at $Q_{1.5}$ = 17,600 cfs):

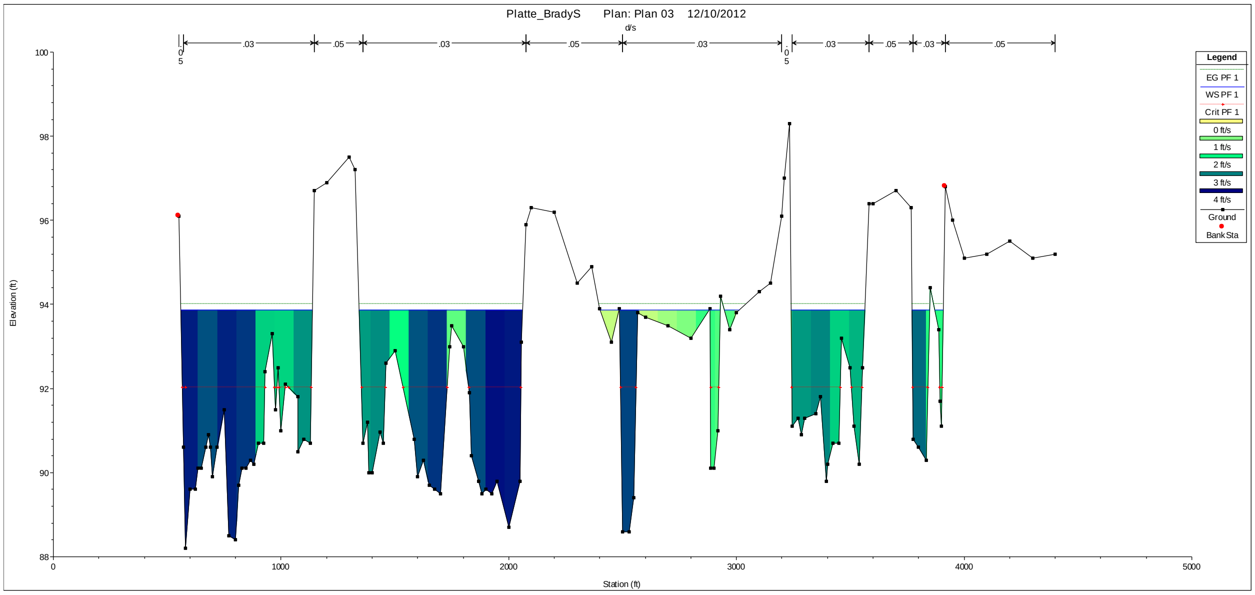

Figure 3.29 Platte at Brady – flow distribution

Table 3.12 Platte at Brady – flow distribution

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	Chan	552	636.15	1152.25	305.39	76.87	6.55	4.02	3.77	0.32	1.22
2	Chan	636.15	720.3	990.62	294.04	84.2	5.63	3.49	3.37	0.28	0.96
3	Chan	720.3	804.45	1280.6	343.32	84.39	7.28	4.08	3.73	0.33	1.23
4	Chan	804.45	888.6	1146.18	320.93	84.2	6.51	3.81	3.57	0.31	1.11
5	Chan	888.6	972.75	412.26	173.98	84.46	2.34	2.07	2.37	0.17	0.4
6	Chan	972.75	1056.9	398.24	170.29	84.32	2.26	2.02	2.34	0.16	0.38
7	Chan	1056.9	1141.05	636.01	223.55	82.49	3.61	2.74	2.85	0.22	0.63
8	Chan	1141.05	1225.2							0	0
9	Chan	1225.2	1309.35							0	0
10	Chan	1309.35	1393.5	372.67	134.37	50.97	2.12	2.66	2.77	0.21	0.59
11	Chan	1393.5	1477.65	678.32	234.4	84.32	3.85	2.79	2.89	0.23	0.65
12	Chan	1477.65	1561.8	254.97	130.22	84.17	1.45	1.55	1.96	0.13	0.25
13	Chan	1561.8	1645.95	974.4	291.13	84.19	5.54	3.46	3.35	0.28	0.94
14	Chan	1645.95	1730.1	1160.55	323.43	84.26	6.59	3.84	3.59	0.31	1.12
15	Chan	1730.1	1814.25	86.71	68.2	84.22	0.49	0.81	1.27	0.07	0.08
16	Chan	1814.25	1898.4	1008.27	297.32	84.31	5.73	3.53	3.39	0.29	0.97
17	Chan	1898.4	1982.55	1413.77	363.92	84.16	8.03	4.32	3.88	0.35	1.37
18	Chan	1982.55	2066.7	1254.19	329.26	78.43	7.13	4.27	3.81	0.34	1.3
19	Chan	2066.7	2150.85							0	0
20	Chan	2150.85	2235							0	0
21	Chan	2235	2319.15							0	0
22	Chan	2319.15	2403.3	0	0.01	1.02	0	0.01	0.04	0	0
23	Chan	2403.3	2487.45	14.88	31.93	82.6	0.08	0.39	0.47	0.03	0.01
24	Chan	2487.45	2571.6	1137.46	327.84	85.56	6.46	3.9	3.47	0.31	1.08

25	Chan	2571.6	2655.75	7.51	15.71	84.15	0.04	0.19	0.48	0.02	0.01
26	Chan	2655.75	2739.9	23.33	31.01	84.15	0.13	0.37	0.75	0.03	0.02
27	Chan	2739.9	2824.05	48.37	48.03	84.15	0.27	0.57	1.01	0.05	0.05
28	Chan	2824.05	2908.2	153.81	95.15	81.97	0.87	1.19	1.62	0.09	0.15
29	Chan	2908.2	2992.35	84.28	60.98	66.47	0.48	0.92	1.38	0.07	0.1
30	Chan	2992.35	3076.5	0.3	1.28	20.34	0	0.06	0.23	0.01	0
31	Chan	3076.5	3160.65							0	0
32	Chan	3160.65	3244.8	6.16	6.35	5.48	0.04	1.33	0.97	0.09	0.09
33	Chan	3244.8	3328.95	626.18	223.4	84.19	3.56	2.65	2.8	0.22	0.6
34	Chan	3328.95	3413.1	704.64	239.75	84.25	4	2.85	2.94	0.23	0.68
35	Chan	3413.1	3497.25	412.86	174.14	84.47	2.35	2.07	2.37	0.17	0.4
36	Chan	3497.25	3581.4	411.91	159.35	67.89	2.34	2.36	2.59	0.19	0.49
37	Chan	3581.4	3665.55							0	0
38	Chan	3665.55	3749.7							0	0
39	Chan	3749.7	3833.85	640.28	202.29	64.73	3.64	3.17	3.17	0.25	0.8
40	Chan	3833.85	3918	108.03	62.85	52.68	0.61	1.22	1.72	0.1	0.17

Unit width discharge (q) = 7.54 cfs/ft

Platte at Odessa (Velocity and Depth distribution at $Q_{1.5}$ = 19,400 cfs):

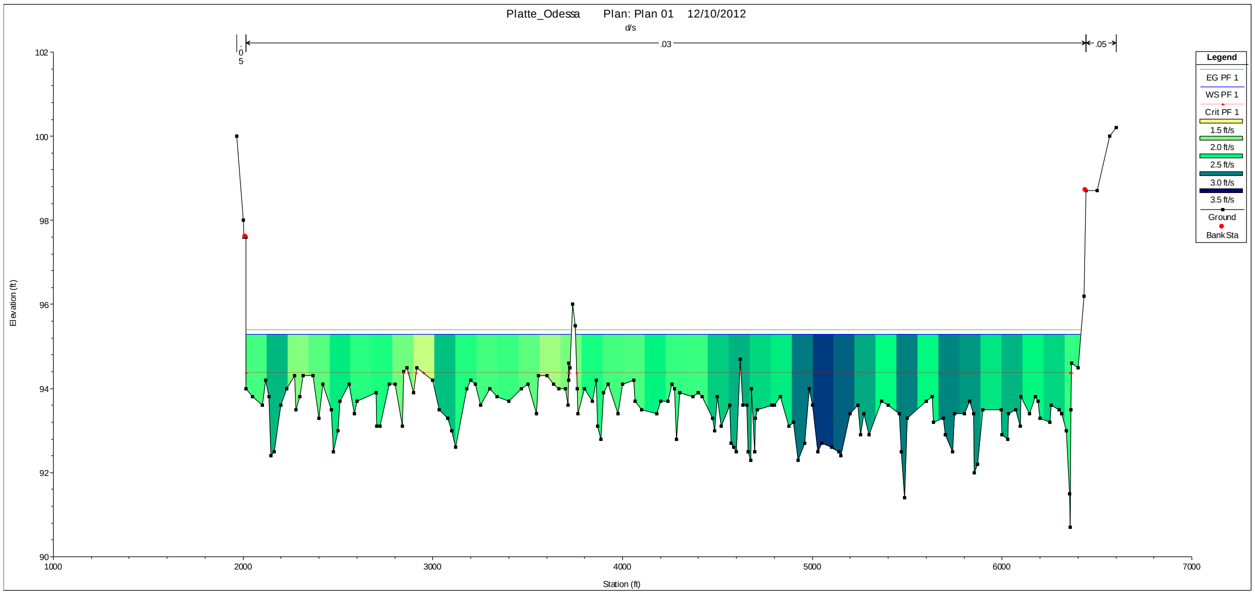

Figure 3.30 Platte at Odessa – flow distribution

Table 3.13 Platte at Odessa – flow distribution

	Pos	Left Sta	Right Sta	Flow	Area	W.P.	Percent	Hydr	Velocity	Shear	Power
		(ft)	(ft)	(cfs)	(sq ft)	(ft)	Conv	Depth(ft)	(ft/s)	(lb/sq ft)	(lb/ft s)
1	Chan	2014	2124.7	358.29	160.63	111.05	1.85	1.46	2.23	0.12	0.26
2	Chan	2124.7	2235.4	615.92	222.15	110.82	3.17	2.01	2.77	0.16	0.45
3	Chan	2235.4	2346.1	266.1	134.23	110.74	1.37	1.21	1.98	0.1	0.2
4	Chan	2346.1	2456.8	328.75	152.38	110.74	1.69	1.38	2.16	0.11	0.24
5	Chan	2456.8	2567.5	511.26	198.64	110.78	2.64	1.79	2.57	0.15	0.37
6	Chan	2567.5	2678.2	404.33	172.5	110.71	2.08	1.56	2.34	0.13	0.3
7	Chan	2678.2	2788.9	429.71	178.96	110.77	2.22	1.62	2.4	0.13	0.31
8	Chan	2788.9	2899.6	293.06	142.3	110.88	1.51	1.29	2.06	0.1	0.21
9	Chan	2899.6	3010.3	186.65	108.49	110.71	0.96	0.98	1.72	0.08	0.14
10	Chan	3010.3	3121	596.5	217.83	110.71	3.07	1.97	2.74	0.16	0.44
11	Chan	3121	3231.7	421.38	176.84	110.72	2.17	1.6	2.38	0.13	0.31
12	Chan	3231.7	3342.4	359.11	160.65	110.71	1.85	1.45	2.24	0.12	0.26
13	Chan	3342.4	3453.1	379.78	166.14	110.7	1.96	1.5	2.29	0.12	0.28
14	Chan	3453.1	3563.8	323.38	150.88	110.75	1.67	1.36	2.14	0.11	0.24
15	Chan	3563.8	3674.5	229.6	122.84	110.7	1.18	1.11	1.87	0.09	0.17
16	Chan	3674.5	3785.2	226.64	111.99	89.58	1.17	1.26	2.02	0.1	0.21
17	Chan	3785.2	3895.9	435.35	180.4	110.82	2.24	1.63	2.41	0.13	0.32
18	Chan	3895.9	4006.6	361.4	161.28	110.73	1.86	1.46	2.24	0.12	0.26
19	Chan	4006.6	4117.3	345.49	156.98	110.73	1.78	1.42	2.2	0.12	0.25
20	Chan	4117.3	4228	494.99	194.76	110.7	2.55	1.76	2.54	0.14	0.36
21	Chan	4228	4338.7	385.64	167.74	110.82	1.99	1.52	2.3	0.12	0.28
22	Chan	4338.7	4449.4	375.71	165.07	110.7	1.94	1.49	2.28	0.12	0.28
23	Chan	4449.4	4560.1	573.58	212.79	110.74	2.96	1.92	2.7	0.16	0.42
24	Chan	4560.1	4670.8	632.98	226.02	111.06	3.26	2.04	2.8	0.17	0.46

25	Chan	4670.8	4781.5	553.42	208.56	111.12	2.85	1.88	2.65	0.15	0.4
26	Chan	4781.5	4892.2	509.82	198.24	110.71	2.63	1.79	2.57	0.15	0.37
27	Chan	4892.2	5002.9	764.62	252.87	110.76	3.94	2.28	3.02	0.19	0.56
28	Chan	5002.9	5113.6	928.9	284.15	110.72	4.79	2.57	3.27	0.21	0.68
29	Chan	5113.6	5224.3	824.51	264.53	110.71	4.25	2.39	3.12	0.19	0.6
30	Chan	5224.3	5335	650.87	229.56	110.73	3.36	2.07	2.84	0.17	0.48
31	Chan	5335	5445.7	478.1	190.75	110.7	2.46	1.72	2.51	0.14	0.35
32	Chan	5445.7	5556.4	747.33	249.55	110.9	3.85	2.25	2.99	0.18	0.55
33	Chan	5556.4	5667.1	485.51	192.52	110.72	2.5	1.74	2.52	0.14	0.36
34	Chan	5667.1	5777.8	734.96	246.93	110.75	3.79	2.23	2.98	0.18	0.54
35	Chan	5777.8	5888.5	694.87	238.9	110.91	3.58	2.16	2.91	0.17	0.51
36	Chan	5888.5	5999.2	523.62	201.47	110.74	2.7	1.82	2.6	0.15	0.38
37	Chan	5999.2	6109.9	624.38	223.95	110.79	3.22	2.02	2.79	0.16	0.46
38	Chan	6109.9	6220.6	489.11	193.38	110.71	2.52	1.75	2.53	0.14	0.36
39	Chan	6220.6	6331.3	556.77	209.01	110.71	2.87	1.89	2.66	0.15	0.41
40	Chan	6331.3	6442	297.59	129.42	85.48	1.53	1.54	2.3	0.12	0.28

Unit width discharge (q) = 4.42 cfs/ft

4.0 Sediment Transport Analysis

An estimate of the sediment discharge per unit width was made using the same historic 1.5 year flow as utilized in the flow distribution analysis. While some bed material data are available from the 1930s on the North Platte and Platte Rivers (and later on the South Platte) as shown in Section 2.2, no actual sediment transport data from the Platte River are available that represent this era. A wide variety of sediment transport equations and methodologies are available with which sediment transport estimates can be made. A sediment transport quantification methodology was selected that utilizes data primarily from Wyoming and Nebraska that were collected in the 1950s (Colby, B.R., "Relationship of Unmeasured Sediment Discharge to Mean Velocity," Trans. Amer. Geophysical Union, Vol. 38, No. 5, October, 1957). This methodology develops both the unmeasured bedload component of sediment transport as well as the suspended sand transport based on hydraulics of the cross-section that were developed for the 1.5 year flow distribution analysis.

The un-measured or bedload component of sediment transport is based on Colby's relationship of this component of sediment transport with mean velocity (as presented in Simons and Senturk, 1992, Figure 9.45). The suspended sand concentration is based on Colby's relationship of concentration with depth and velocity (as presented in Simons and Senturk, 1992, Figure 9.46).

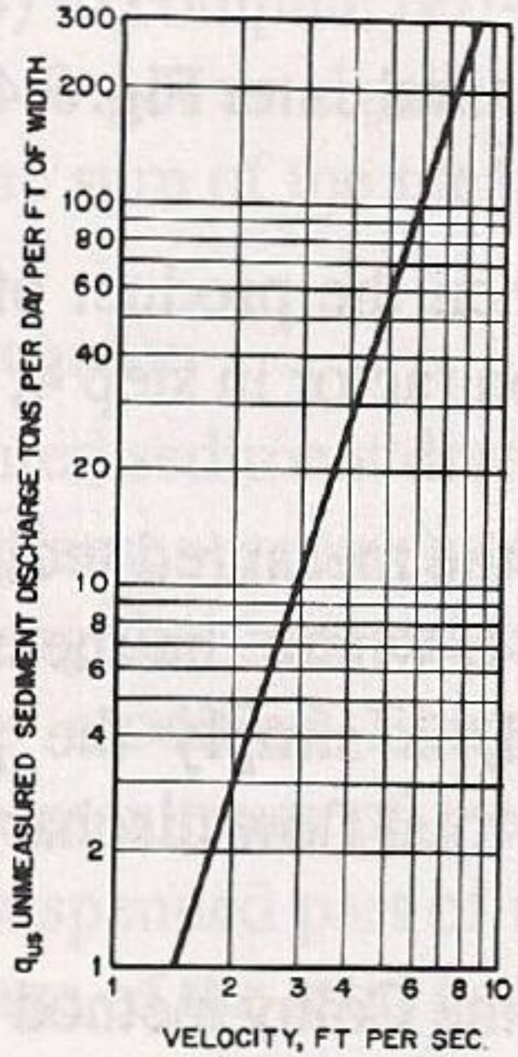

Fig. 9.45 Relationship between unmeasured sediment discharge and mean velocity (after Colby, 1957).

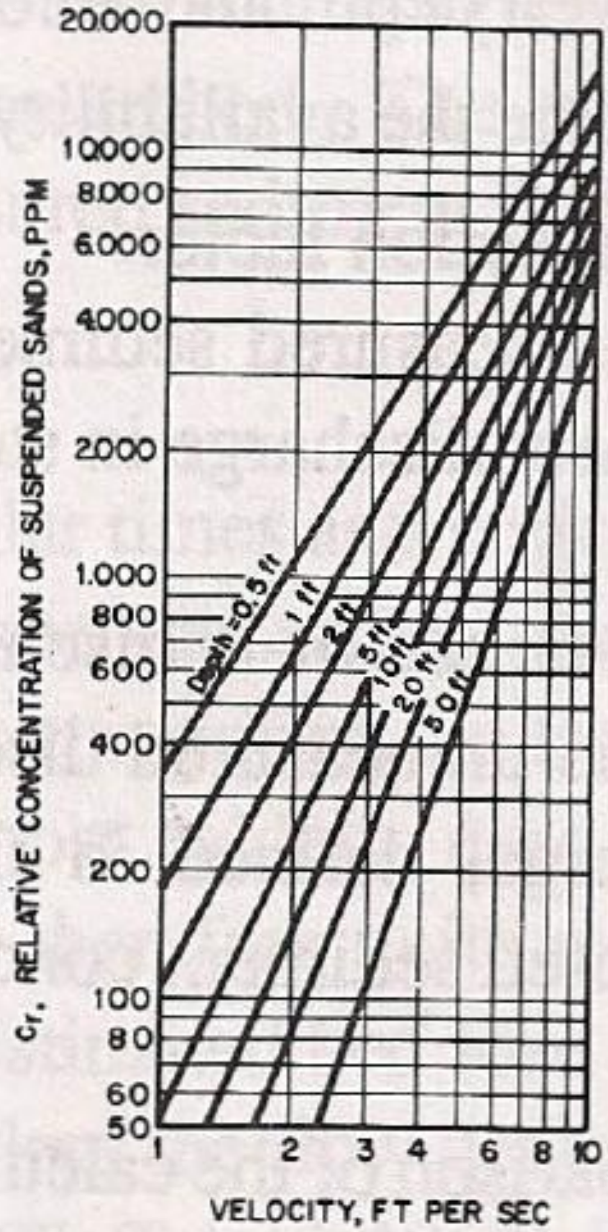

Fig. 9.46 Relative concentrations of suspended sands for different depths and mean velocity (after Colby, 1957).

Table 4.1 presents the pertinent hydraulics output from the flow distribution analysis that is used in Colby's relationships to develop the estimate for sediment transport for the 1.5 year historic flow.

Table 4.1 Sediment transport estimate for the 1.5 year historic flow

Location	**Q1.5**	**Depth (ft)**	**Velocity (ft/s)**	**Width (ft)**	**q_s un-measured (tons/day/foot)**	**Concentration Suspended Sands (ppm)**	**q_s suspended (tons/day/foot)**	**q_s Total (tons/day/foot)**
North Platte at Lewellen	16300	2.08	2.68	2923	7	560	8.4	15.4
North Platte at Hershey	16300	2.23	3.12	2345	14	950	17.8	31.8
South Platte at Paxton	2330	1.18	2.09	945	4	670	4.5	8.5
South Platte at Hershey	2330	1.08	1.74	1239	1.5	450	2.3	3.8
Platte at Brady	17600	2.44	3.10	2334	14	900	18.3	32.3
Platte at Odessa	19400	1.72	2.57	4385	6	690	8.2	14.2

Unfortunately, there are no sediment transport data to compare with these computed results. It is believed, however; that these results are in a reasonable range of sediment transport conditions that were described in the available literature where descriptions of historic conditions were made of a turbid, muddy river with quicksand river bed conditions indicating significant sediment transport when the river was flowing at or near bankfull. The computed suspended sediment concentrations in the range of approximately 500 to 1000 ppm under the historic condition would be considered quite turbid especially when combined with a nearly equivalent rate of bedload transport. The sediment concentrations computed using the historic channel conditions were compared with sediment concentrations based on regression equations using data collected primarily in the 1980s (Simons & Associates, 1990 and 2000). These data suggest suspended sediment concentrations in the relatively recent developed era to be on the order of 200 to 400 ppm at the same rates of flow. These reduced concentrations in the current era reflect sediment storage in reservoirs, diversion of water and sediment into canals and a narrower channel with increased vegetation and less availability of sediment. This again, is consistent with what one would expect – that being that historic sediment loads were likely greater than sediment loads in the recent time period as reflected in the computations above.

5.0 References

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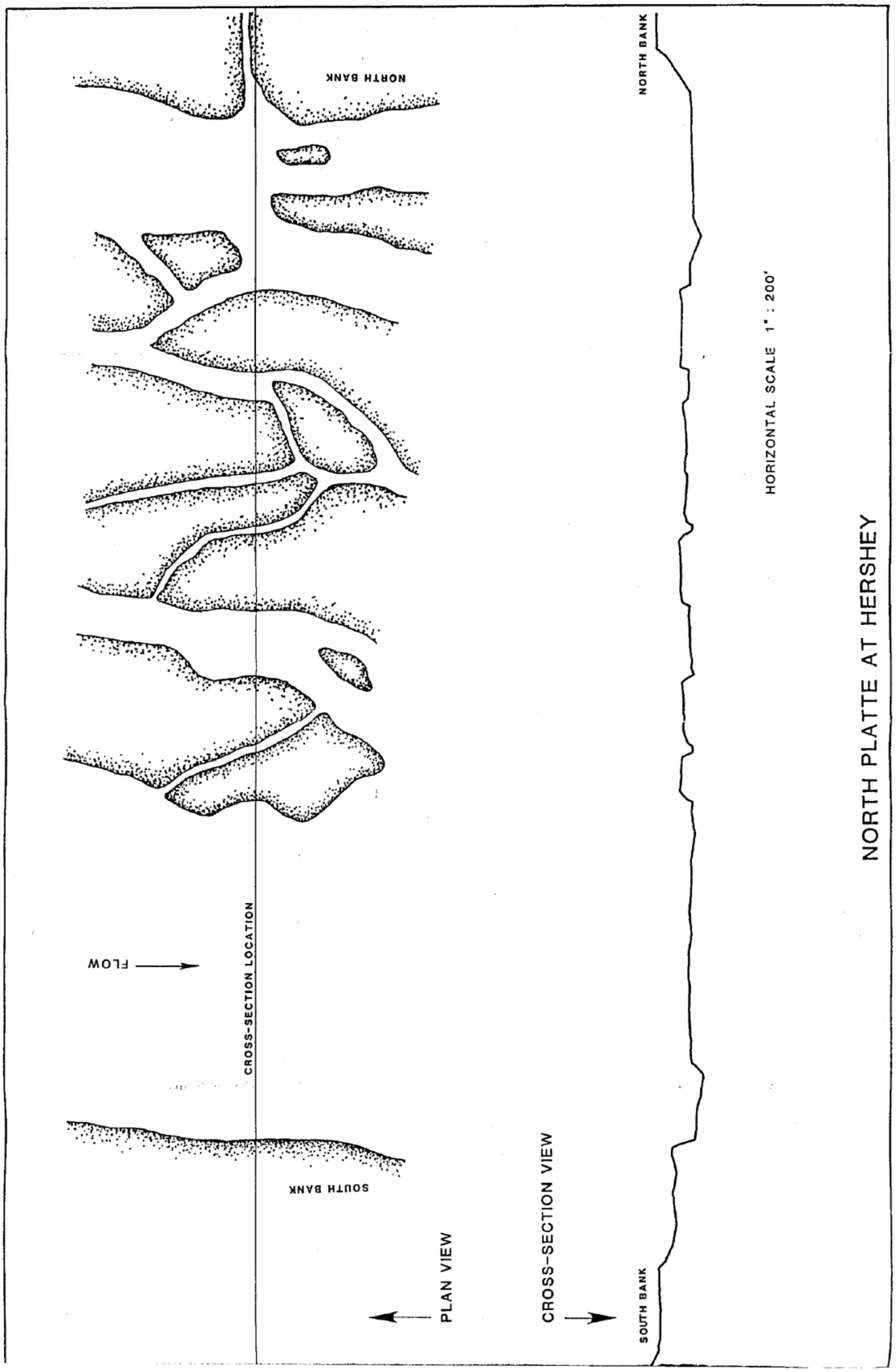
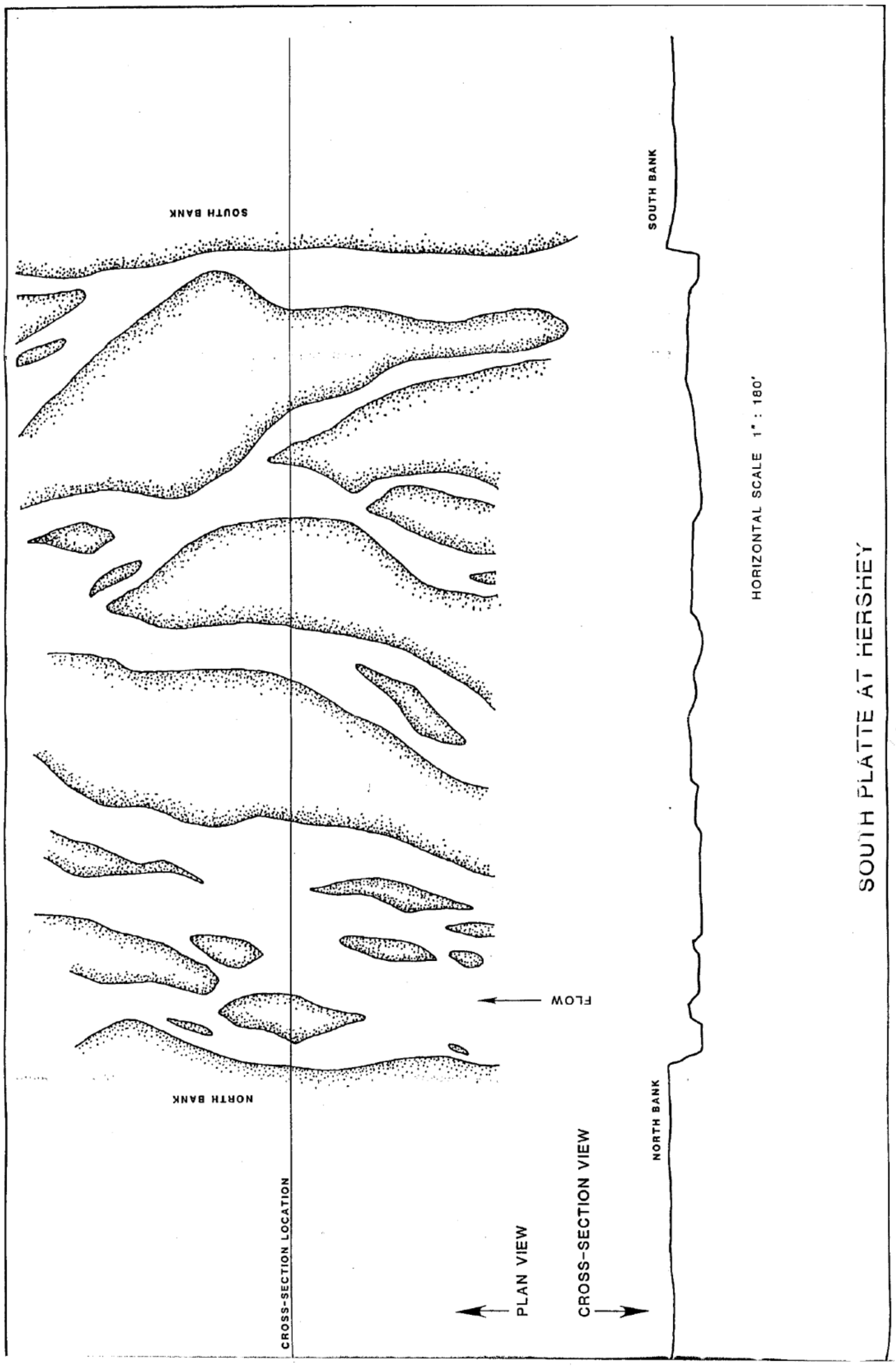
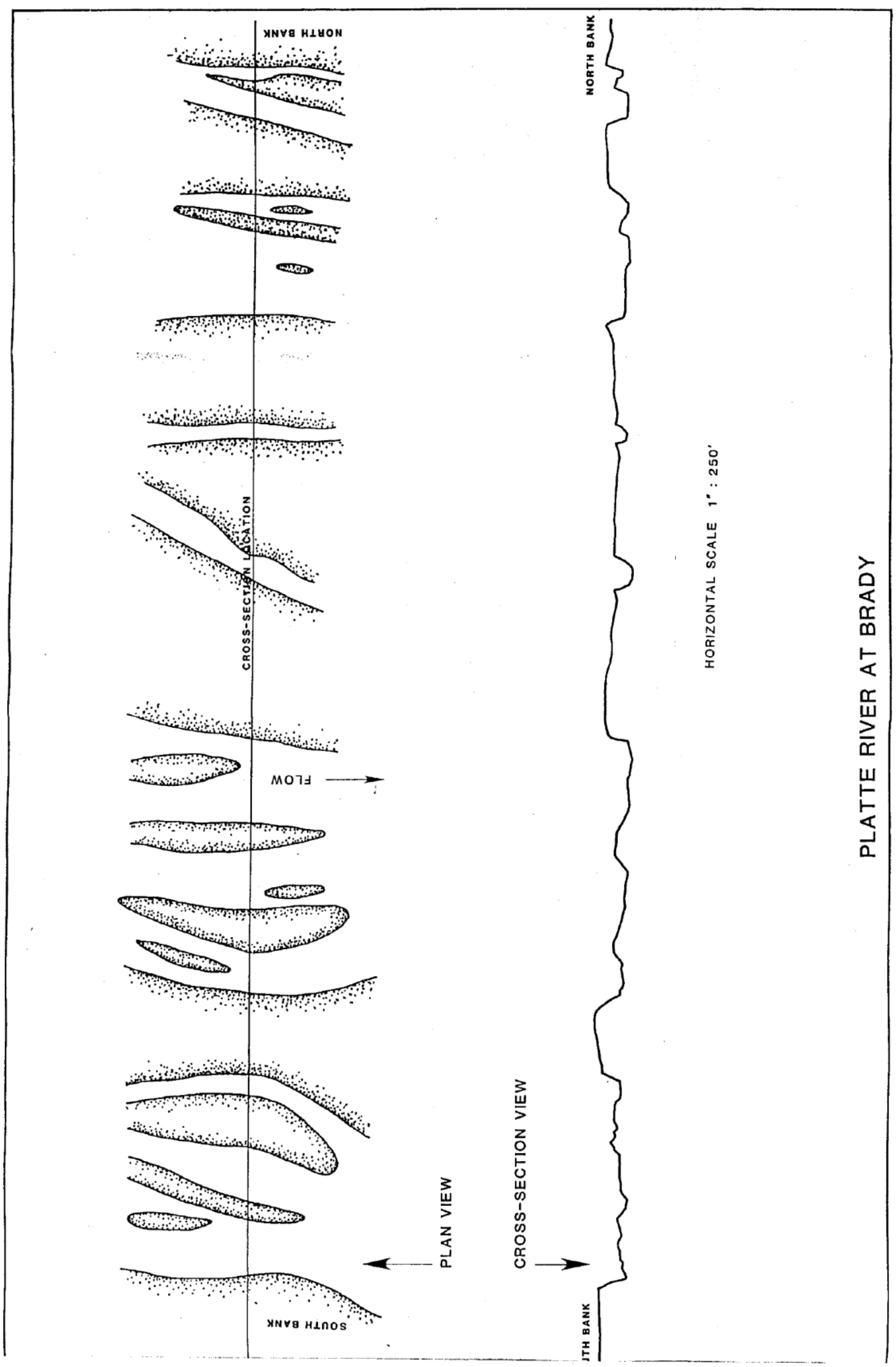
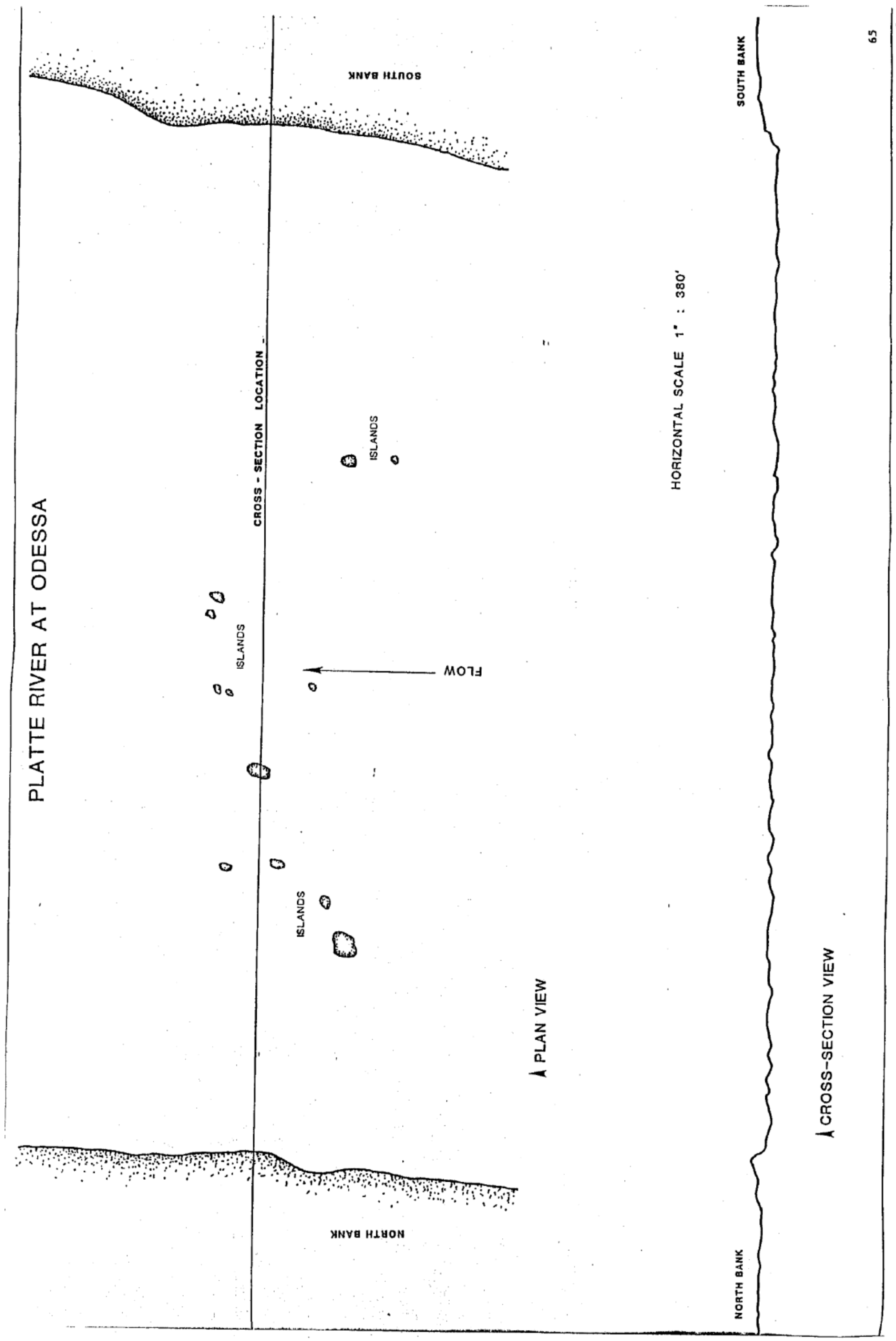
Appendix A: North Platte, South Platte, and Platte River Historic Cross-Sections





SOUTH PLATTE AT HERSHEY


NORTH BANK
SOUTH BANK
CROSS-SECTION LOCATION
FLOW
PLAN VIEW
CROSS-SECTION VIEW
NORTH BANK
HORIZONTAL SCALE 1' : 250'
PLATTE RIVER AT BRADY


PLATTE RIVER AT ODESSA
CROSS - SECTION LOCATION
ISLANDS
ISLANDS
ISLANDS
FLOW
SOUTH BANK
NORTH BANK
PLAN VIEW
HORIZONTAL SCALE 1" : 380'
SOUTH BANK
NORTH BANK
CROSS-SECTION VIEW
65