Hydraulic Analysis

Middle Fork Of The Powder River
Kaycee, Wyoming

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Hydraulic Analysis
Middle Fork Of The Powder River
Kaycee, Wyoming

1. Introduction

1.1. General Project Data.

A hydraulic study was conducted on Middle Fork of the Powder River in the vicinity of Kaycee, Wyoming. The study reach begins approximately 1 mile east of the City of Kaycee and extends upstream a distance of approximately 4 miles. A hydrology study completed by the Natural Resource Conservation Service was used to set discharges for the different flood frequency events. Computations were performed to evaluate stages and flood boundaries for existing conditions. Water surface profiles for the study reach were computed using the standard step backwater program HEC-RAS.

1.2. Survey Data.

Survey information and contour mapping was provided by Grizzley Engineering of Buffalo, Wyoming. The survey information was derived from aerial photogrammetry performed in July of 2003 by Horizons, Inc. of Rapid City, South Dakota and based upon a local datum utilizing a highway right of way marker located northwest of the intersection of Old Highway 87 and Sussex Road using an assumed elevation of 4630.54.

A DTM surface was created by the U.S. Army Corps of Engineers from the provided mapping, and cross section and channel configuration data were generated using Microstation and Inroads and imported into HEC-RAS as a geometry file. The locations of selected cross sections used in the hydraulic analysis are shown on Plates 1 through 4.

1.3. Study Discharges.

Discharges were provided by the Natural Resource Conservation Service in November 2003 and are listed in Table 1.

2. Hydraulic Computations

2.1 Analytical Methods and Model Assumptions.

HEC-RAS is a steady state backwater model used to calculate water surface elevations for a single discharge regardless of time. HEC-RAS version 3.1.1 dated May 2003 was used in calculating the water surface profiles for the Middle Fork of the Powder River.

HEC-RAS assumes steady, gradually varied flow in natural or man-made channels. The effect of various obstructions, such as bridges, culverts, and structures, in the channel and flood plain can also be considered. The main input data requirement for HEC-RAS is stream and flood plain geometry in the form of cross sections taken at right angles to the direction of flow. Bridge and culvert data is also included in the input. The standard step method computational procedure is based on the solution of the one-dimensional energy equation and friction loss evaluated with Manning's equation.

TABLE 1
Computed Discharges For The Middle Fork Of The Powder River

Flood Event	Flood Event Probability	Discharge (ft^3/s)
1.5-year	67%	1,600
2-year	50%	2,150
5-year	20%	4,150
10-year	10%	6,050
25-year	4%	9,400
50-year	2%	12,750
100-year	1%	17,150
500-year	.2%	32,950

2.2. Roughness Coefficients and Bridge Losses.

Roughness coefficients for the channel and overbanks were set based on photos acquired during a site visit and engineering judgment. A Manning's "n" value of 0.040 was utilized for the channel and a Manning's "n" value of 0.070 was used for the overbank areas. Roughness coefficients for the channel and overbank areas were derived from the values listed on pages 109-113 in ***Open-Channel Hydraulics*** by Chow.

The energy modeling method was used for the low flows on all bridges and the high flows on the Interstate bridges while the pressure/weir modeling method was used on the bridge

at Nolan Avenue. Contraction and expansion coefficients of 0.3 and 0.5 were used for all bridges while contraction and expansion coefficients of 0.1 and 0.3 were used for all other areas. No bridge plans were available so assumptions were made as to the bridge geometry based upon topographic mapping and the photos of the structures acquired during the site visit.

2.3. Model Uncertainty.

Information relating to measurements of stream stage/discharge on the Middle Fork of the Powder River was not available in the vicinity of Kaycee. Without historic data, it is not possible to adjust or validate assumptions made in the determination of "n" values, expansion/contraction coefficients or the delineation of ineffective areas.

2.4. Existing Conditions Water Surface Profiles.

Existing conditions water surface profiles were calculated for 10-, 50-, 100-, and 500-year flood events and plotted on Plate 5. Table 2 showing the calculated water surface elevation for each event and section is located at the end of this report.

Based on the water surface profiles and survey data the existing channel capacity is generally limited to approximately 2000 to 4000 cfs. Some channel areas provide additional capacity. Initial flood damages will occur when the flows exceed the channel capacity. The channel conveys flow corresponding to between a 2- and 5-year flood event.

Highwater marks acquired after the flood of 2002 were evaluated as to their reliability and those determined to be the most representative were used to identify a discharge associated with their creation (HWM #s 0, 1, 10, 11, 15, and 17). From these marks it appears that a peak discharge of 14,000 cfs occurred during the 2002 flood event.

2.5. Flooded Area Outlines.

Flooded area outlines were determined for the 10-, 50-, 100-, and 500-year events and are included on Plates 1 through 4.

3. Evaluation Of Alternatives

In order to reduce water surface elevations and mitigate damages, several structural alternatives were evaluated for their effectiveness. The structural alternatives evaluated included the construction of levees, improvements to the channel, replacement of the bridge on Nolan Avenue and construction of a diversion channel downstream of Nolan Avenue. As a baseline for the evaluation of the alternatives the 100 year flood event was used as a point of reference. The results of this analysis are shown in Table 2.

3.1. Levee Construction.

A levee was modeled, on the north and south sides of the river, to protect the community of Kaycee from a 100 year flood event. The levee on the north side of the river ties into the Interstate roadway embankment to the west and extends downstream and ties into high ground east of Kaycee. Three alternative alignments for the levee were modeled (See Plate 6) through the community in order to identify the both the most economically favorable levee alternative. The levee on the south side of the river extends from a point approximately 600 feet upstream of Nolan Avenue downstream for a distance of 600 feet. The south levee alignment would be consistent for all of the north levee alternatives. For purposes of this analysis the top of levee was set at 3 feet above the 100 year flood elevation.

Alternative "A" was identified as the levee alternative which maximized flood protection and associated benefits and as such was selected as the levee alternative to further analyze. Constructing levees on each side of the river constricts flow, thus raising the water surface elevation. Through the reach, adjacent to Kaycee, the 100 year water surface elevation is raised by approximately 2.5 feet as a result of the Alternative "A" levee construction. Costs associated with the mitigation of this raise in water surface will need to be identified and associated costs assigned however such work is outside the scope of this study and will need to be addressed at a later date. Refer to Table 2 for the water surface elevations associated with the Alternative "A" levee.

3.2. Channel Improvements.

A channel improvement project was evaluated to determine its ability to reduce water surface elevations. A 120 foot bottom width channel with 3:1 sides slopes was modeled from river station 160+00 to 215+00 (See Plate 7). In conjunction with this alternative the "n" value of the channel was reduced 0.040 to 0.035 to reflect the removal of vegetation from the channel. This alternative lowered the water surface from river station 160+00 to 215+00 approximately 0.9 feet. Refer to Table 2 for the water surface elevations associated with the channel improvements.

3.3. Bridge Replacement.

The bridge on Nolan Avenue crossing the Middle Fork of the Powder River was removed from the model to reflect the reconstruction of the bridge to improve it's hydraulic characteristics (See Plate 7). This alternative lowered the water surface immediately at the bridge area approximately 1.0 feet. Refer to Table 2 for the water surface elevations associated with the bridge replacement.

3.4. Diversion Channel.

A diversion channel was modeled between river stations 165+00 and 195+00 (See Plate 7). The diversion channel would simulate the removal of flow from the large oxbow in the river southwest of the community. This alternative lowered the water surface between river stations 165+00 and 195+00 approximately 0.8 feet. Refer to Table 2 for the water surface elevations associated with the diversion channel.

4. Summary

The Middle Fork of the Powder River was modeled using Microstation, Inroads and HEC-RAS computer programs. Microstation and Inroads were used to import the geometry into the HEC-RAS computer model. Water surface profiles, flood boundaries, and the floodway for the study reach were computed using the standard step backwater program HEC-RAS. Assumptions required in the development of the HEC-RAS computer model were determined based on available data, a site visit, and engineering judgement. Uncertainties associated with the modeling efforts include channel and overbank roughness, ineffective flow areas and uncertainty in bridge modeling.

Using the 2003 survey data the channel capacity for the study reach was estimated to be 2,000 to 4,000 cfs. Computations were performed for a range of flow events. The profiles and boundaries computed will be used to determine the need for future studies or actions.

Various structural alternatives (levee construction, channel improvements, bridge replacement and diversion channel) were modeled to determine their impact on the 100 year flood elevations. The data generated from these models were then used to evaluate the suitability of the individual structural alternatives to provide a cost effective alternative.

Table 2
HEC-RAS Plan: Water Surface Elevations
River: Middle Fork Powder
Reach: Kaycee

River Station	Profile	Q Total (cfs)	Water Surface Elevations (ft)				
			Existing Conditions	Levee	Channel Improvements	Bridge Replacement	Diversion Channel
500	1.5 Year	1600	4569.38	4569.38	4569.38	4569.38	4569.38
500	2 Year	2150	4569.78	4569.78	4569.78	4569.78	4569.78
500	5 Year	4150	4570.73	4570.73	4570.73	4570.73	4570.73
500	10 Year	6050	4571.43	4571.43	4571.43	4571.43	4571.43
500	25 Year	9400	4572.44	4572.44	4572.44	4572.44	4572.44
500	50 Year	12750	4573.29	4573.29	4573.29	4573.29	4573.29
500	100 Year	17150	4574.27	4574.27	4574.27	4574.27	4574.27
500	200 Year	22800	4575.38	4575.38	4575.38	4575.38	4575.38
500	500 Year	32950	4577.11	4577.11	4577.11	4577.11	4577.11
1000	1.5 Year	1600	4569.97	4569.97	4569.97	4569.97	4569.97
1000	2 Year	2150	4570.36	4570.36	4570.36	4570.36	4570.36
1000	5 Year	4150	4571.29	4571.29	4571.29	4571.29	4571.29
1000	10 Year	6050	4571.97	4571.97	4571.97	4571.97	4571.97
1000	25 Year	9400	4572.97	4572.97	4572.97	4572.97	4572.97
1000	50 Year	12750	4573.82	4573.82	4573.82	4573.82	4573.82
1000	100 Year	17150	4574.79	4574.79	4574.79	4574.79	4574.79
1000	200 Year	22800	4575.91	4575.91	4575.91	4575.91	4575.91
1000	500 Year	32950	4577.66	4577.66	4577.66	4577.66	4577.66
1500	1.5 Year	1600	4570.44	4570.44	4570.44	4570.44	4570.44
1500	2 Year	2150	4570.86	4570.86	4570.86	4570.86	4570.86
1500	5 Year	4150	4571.85	4571.85	4571.85	4571.85	4571.85
1500	10 Year	6050	4572.56	4572.56	4572.56	4572.56	4572.56
1500	25 Year	9400	4573.56	4573.56	4573.56	4573.56	4573.56
1500	50 Year	12750	4574.41	4574.41	4574.41	4574.41	4574.41
1500	100 Year	17150	4575.4	4575.4	4575.4	4575.4	4575.4
1500	200 Year	22800	4576.51	4576.51	4576.51	4576.51	4576.51
1500	500 Year	32950	4578.25	4578.25	4578.25	4578.25	4578.25
2000	1.5 Year	1600	4571.03	4571.03	4571.03	4571.03	4571.03
2000	2 Year	2150	4571.53	4571.53	4571.53	4571.53	4571.53
2000	5 Year	4150	4572.73	4572.73	4572.73	4572.73	4572.73
2000	10 Year	6050	4573.54	4573.54	4573.54	4573.54	4573.54
2000	25 Year	9400	4574.69	4574.69	4574.69	4574.69	4574.69
2000	50 Year	12750	4575.51	4575.51	4575.51	4575.51	4575.51
2000	100 Year	17150	4576.39	4576.39	4576.39	4576.39	4576.39
2000	200 Year	22800	4577.43	4577.43	4577.43	4577.43	4577.43
2000	500 Year	32950	4579.08	4579.08	4579.08	4579.08	4579.08
3000	1.5 Year	1600	4572.75	4572.75	4572.75	4572.75	4572.75
3000	2 Year	2150	4573.29	4573.29	4573.29	4573.29	4573.29
3000	5 Year	4150	4574.43	4574.43	4574.43	4574.43	4574.43
3000	10 Year	6050	4575.16	4575.16	4575.16	4575.16	4575.16
3000	25 Year	9400	4576.23	4576.23	4576.23	4576.23	4576.23

Table 2
HEC-RAS Plan: Water Surface Elevations
River: Middle Fork Powder
Reach: Kaycee

River Station	Profile	Q Total (cfs)	Water Surface Elevations (ft)				
			Existing Conditions	Levee	Channel Improvements	Bridge Replacement	Diversion Channel
3000	50 Year	12750	4577.03	4577.03	4577.03	4577.03	4577.03
3000	100 Year	17150	4577.89	4577.89	4577.89	4577.89	4577.89
3000	200 Year	22800	4578.87	4578.87	4578.87	4578.87	4578.87
3000	500 Year	32950	4580.45	4580.45	4580.45	4580.45	4580.45
4000	1.5 Year	1600	4574.07	4574.07	4574.07	4574.07	4574.07
4000	2 Year	2150	4574.53	4574.53	4574.53	4574.53	4574.53
4000	5 Year	4150	4575.51	4575.51	4575.51	4575.51	4575.51
4000	10 Year	6050	4576.14	4576.14	4576.14	4576.14	4576.14
4000	25 Year	9400	4577.1	4577.1	4577.1	4577.1	4577.1
4000	50 Year	12750	4577.89	4577.89	4577.89	4577.89	4577.89
4000	100 Year	17150	4578.76	4578.76	4578.76	4578.76	4578.76
4000	200 Year	22800	4579.76	4579.76	4579.76	4579.76	4579.76
4000	500 Year	32950	4581.34	4581.34	4581.34	4581.34	4581.34
4500	1.5 Year	1600	4574.51	4574.51	4574.51	4574.51	4574.51
4500	2 Year	2150	4574.97	4574.97	4574.97	4574.97	4574.97
4500	5 Year	4150	4575.91	4575.91	4575.91	4575.91	4575.91
4500	10 Year	6050	4576.54	4576.54	4576.54	4576.54	4576.54
4500	25 Year	9400	4577.47	4577.47	4577.47	4577.47	4577.47
4500	50 Year	12750	4578.25	4578.25	4578.25	4578.25	4578.25
4500	100 Year	17150	4579.13	4579.13	4579.13	4579.13	4579.13
4500	200 Year	22800	4580.12	4580.12	4580.12	4580.12	4580.12
4500	500 Year	32950	4581.69	4581.69	4581.69	4581.69	4581.69
5000	1.5 Year	1600	4575.15	4575.15	4575.15	4575.15	4575.15
5000	2 Year	2150	4575.49	4575.49	4575.49	4575.49	4575.49
5000	5 Year	4150	4576.33	4576.33	4576.33	4576.33	4576.33
5000	10 Year	6050	4576.93	4576.93	4576.93	4576.93	4576.93
5000	25 Year	9400	4577.83	4577.83	4577.83	4577.83	4577.83
5000	50 Year	12750	4578.6	4578.6	4578.6	4578.6	4578.6
5000	100 Year	17150	4579.48	4579.48	4579.48	4579.48	4579.48
5000	200 Year	22800	4580.48	4580.48	4580.48	4580.48	4580.48
5000	500 Year	32950	4582.06	4582.06	4582.06	4582.06	4582.06
6000	1.5 Year	1600	4576.62	4576.62	4576.62	4576.62	4576.62
6000	2 Year	2150	4576.94	4576.94	4576.94	4576.94	4576.94
6000	5 Year	4150	4577.66	4577.66	4577.66	4577.66	4577.66
6000	10 Year	6050	4578.15	4578.15	4578.15	4578.15	4578.15
6000	25 Year	9400	4578.89	4578.89	4578.89	4578.89	4578.89
6000	50 Year	12750	4579.56	4579.56	4579.56	4579.56	4579.56
6000	100 Year	17150	4580.36	4580.36	4580.36	4580.36	4580.36
6000	200 Year	22800	4581.29	4581.29	4581.29	4581.29	4581.29
6000	500 Year	32950	4582.79	4582.79	4582.79	4582.79	4582.79

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River Station	Profile	Q Total (cfs)	Water Surface Elevations (ft)				
			Existing Conditions	Levee	Channel Improvements	Bridge Replacement	Diversion Channel
6500	1.5 Year	1600	4577.09	4577.09	4577.09	4577.09	4577.09
6500	2 Year	2150	4577.43	4577.43	4577.43	4577.43	4577.43
6500	5 Year	4150	4578.22	4578.22	4578.22	4578.22	4578.22
6500	10 Year	6050	4578.77	4578.77	4578.77	4578.77	4578.77
6500	25 Year	9400	4579.55	4579.55	4579.55	4579.55	4579.55
6500	50 Year	12750	4580.22	4580.22	4580.22	4580.22	4580.22
6500	100 Year	17150	4581.01	4581.01	4581.01	4581.01	4581.01
6500	200 Year	22800	4581.93	4581.93	4581.93	4581.93	4581.93
6500	500 Year	32950	4583.4	4583.4	4583.4	4583.4	4583.4
7500	1.5 Year	1600	4577.73	4577.73	4577.73	4577.73	4577.73
7500	2 Year	2150	4578.1	4578.1	4578.1	4578.1	4578.1
7500	5 Year	4150	4578.98	4578.98	4578.98	4578.98	4578.98
7500	10 Year	6050	4579.58	4579.58	4579.58	4579.58	4579.58
7500	25 Year	9400	4580.4	4580.4	4580.4	4580.4	4580.4
7500	50 Year	12750	4581.1	4581.1	4581.1	4581.1	4581.1
7500	100 Year	17150	4581.9	4581.9	4581.9	4581.9	4581.9
7500	200 Year	22800	4582.83	4582.83	4582.83	4582.83	4582.83
7500	500 Year	32950	4584.29	4584.29	4584.29	4584.29	4584.29
8500	1.5 Year	1600	4578.84	4578.84	4578.84	4578.84	4578.84
8500	2 Year	2150	4579.3	4579.3	4579.3	4579.3	4579.3
8500	5 Year	4150	4580.22	4580.22	4580.22	4580.22	4580.22
8500	10 Year	6050	4580.81	4580.81	4580.81	4580.81	4580.81
8500	25 Year	9400	4581.63	4581.63	4581.63	4581.63	4581.63
8500	50 Year	12750	4582.32	4582.32	4582.32	4582.32	4582.32
8500	100 Year	17150	4583.12	4583.12	4583.12	4583.12	4583.12
8500	200 Year	22800	4584.03	4584.03	4584.03	4584.03	4584.03
8500	500 Year	32950	4585.47	4585.47	4585.47	4585.47	4585.47
9000	1.5 Year	1600	4579.95	4579.95	4579.95	4579.95	4579.95
9000	2 Year	2150	4580.55	4580.55	4580.55	4580.55	4580.55
9000	5 Year	4150	4581.54	4581.54	4581.54	4581.54	4581.54
9000	10 Year	6050	4582.08	4582.08	4582.08	4582.08	4582.08
9000	25 Year	9400	4582.78	4582.78	4582.78	4582.78	4582.78
9000	50 Year	12750	4583.4	4583.4	4583.4	4583.4	4583.4
9000	100 Year	17150	4584.13	4584.13	4584.13	4584.13	4584.13
9000	200 Year	22800	4584.98	4584.98	4584.98	4584.98	4584.98
9000	500 Year	32950	4586.37	4586.37	4586.37	4586.37	4586.37
9500	1.5 Year	1600	4580.67	4580.67	4580.67	4580.67	4580.67
9500	2 Year	2150	4581.24	4581.24	4581.24	4581.24	4581.24
9500	5 Year	4150	4582.14	4582.14	4582.14	4582.14	4582.14
9500	10 Year	6050	4582.66	4582.66	4582.66	4582.66	4582.66
9500	25 Year	9400	4583.33	4583.33	4583.33	4583.33	4583.33

Table 2
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River: Middle Fork Powder
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River Station	Profile	Q Total (cfs)	Water Surface Elevations (ft)				
			Existing Conditions	Levee	Channel Improvements	Bridge Replacement	Diversion Channel
9500	50 Year	12750	4583.91	4583.91	4583.91	4583.91	4583.91
9500	100 Year	17150	4584.59	4584.59	4584.59	4584.59	4584.59
9500	200 Year	22800	4585.39	4585.39	4585.39	4585.39	4585.39
9500	500 Year	32950	4586.71	4586.71	4586.71	4586.71	4586.71
10000	1.5 Year	1600	4581.28	4581.28	4581.28	4581.28	4581.28
10000	2 Year	2150	4581.8	4581.8	4581.8	4581.8	4581.8
10000	5 Year	4150	4582.83	4582.83	4582.83	4582.83	4582.83
10000	10 Year	6050	4583.38	4583.38	4583.38	4583.38	4583.38
10000	25 Year	9400	4584.11	4584.11	4584.11	4584.11	4584.11
10000	50 Year	12750	4584.71	4584.71	4584.71	4584.71	4584.71
10000	100 Year	17150	4585.4	4585.4	4585.4	4585.4	4585.4
10000	200 Year	22800	4586.18	4586.18	4586.18	4586.18	4586.18
10000	500 Year	32950	4587.42	4587.42	4587.42	4587.42	4587.42
10500	1.5 Year	1600	4582.29	4582.29	4582.29	4582.29	4582.29
10500	2 Year	2150	4582.85	4582.85	4582.85	4582.85	4582.85
10500	5 Year	4150	4584.15	4584.15	4584.15	4584.15	4584.15
10500	10 Year	6050	4584.98	4584.98	4584.98	4584.98	4584.98
10500	25 Year	9400	4586	4586	4586	4586	4586
10500	50 Year	12750	4586.78	4586.78	4586.78	4586.78	4586.78
10500	100 Year	17150	4587.49	4587.49	4587.49	4587.49	4587.49
10500	200 Year	22800	4588.26	4588.26	4588.26	4588.26	4588.26
10500	500 Year	32950	4589.44	4589.44	4589.44	4589.44	4589.44
11000	1.5 Year	1600	4583.54	4583.54	4583.54	4583.54	4583.54
11000	2 Year	2150	4584.01	4584.01	4584.01	4584.01	4584.01
11000	5 Year	4150	4585.31	4585.31	4585.31	4585.31	4585.31
11000	10 Year	6050	4586.15	4586.15	4586.15	4586.15	4586.15
11000	25 Year	9400	4587.21	4587.21	4587.21	4587.21	4587.21
11000	50 Year	12750	4588.07	4588.07	4588.07	4588.07	4588.07
11000	100 Year	17150	4588.94	4588.94	4588.94	4588.94	4588.94
11000	200 Year	22800	4589.95	4589.95	4589.95	4589.95	4589.95
11000	500 Year	32950	4591.32	4591.32	4591.32	4591.32	4591.32
11500	1.5 Year	1600	4584.86	4584.86	4584.86	4584.86	4584.86
11500	2 Year	2150	4585.18	4585.18	4585.18	4585.18	4585.18
11500	5 Year	4150	4586.16	4586.16	4586.16	4586.16	4586.16
11500	10 Year	6050	4586.89	4586.89	4586.89	4586.89	4586.89
11500	25 Year	9400	4587.78	4587.78	4587.78	4587.78	4587.78
11500	50 Year	12750	4588.74	4588.74	4588.74	4588.74	4588.74
11500	100 Year	17150	4589.57	4589.57	4589.57	4589.57	4589.57
11500	200 Year	22800	4590.78	4590.78	4590.78	4590.78	4590.78
11500	500 Year	32950	4592.38	4592.38	4592.38	4592.38	4592.38

Table 2
HEC-RAS Plan: Water Surface Elevations
River: Middle Fork Powder
Reach: Kaycee

River Station	Profile	Q Total (cfs)	Water Surface Elevations (ft)				
			Existing Conditions	Levee	Channel Improvements	Bridge Replacement	Diversion Channel
12000	1.5 Year	1600	4586.43	4586.43	4586.43	4586.43	4586.43
12000	2 Year	2150	4587.02	4587.02	4587.02	4587.02	4587.02
12000	5 Year	4150	4588.46	4588.46	4588.46	4588.46	4588.46
12000	10 Year	6050	4589.34	4589.34	4589.34	4589.34	4589.34
12000	25 Year	9400	4590.7	4590.7	4590.7	4590.7	4590.7
12000	50 Year	12750	4591.39	4591.39	4591.39	4591.39	4591.39
12000	100 Year	17150	4592.46	4592.46	4592.46	4592.46	4592.46
12000	200 Year	22800	4593.13	4593.13	4593.13	4593.13	4593.13
12000	500 Year	32950	4594.39	4594.39	4594.39	4594.39	4594.39
12500	1.5 Year	1600	4587.06	4587.06	4587.06	4587.06	4587.06
12500	2 Year	2150	4587.68	4587.68	4587.68	4587.68	4587.68
12500	5 Year	4150	4589.19	4589.19	4589.19	4589.19	4589.19
12500	10 Year	6050	4590.12	4590.12	4590.12	4590.12	4590.12
12500	25 Year	9400	4591.53	4591.53	4591.53	4591.53	4591.53
12500	50 Year	12750	4592.25	4592.25	4592.25	4592.25	4592.25
12500	100 Year	17150	4593.21	4593.21	4593.21	4593.21	4593.21
12500	200 Year	22800	4594.01	4594.01	4594.01	4594.01	4594.01
12500	500 Year	32950	4595.36	4595.36	4595.36	4595.36	4595.36
13000	1.5 Year	1600	4587.53	4587.53	4587.53	4587.53	4587.53
13000	2 Year	2150	4588.11	4588.11	4588.11	4588.11	4588.11
13000	5 Year	4150	4589.64	4589.64	4589.64	4589.64	4589.64
13000	10 Year	6050	4590.59	4590.59	4590.59	4590.59	4590.59
13000	25 Year	9400	4592.01	4592.01	4592.01	4592.01	4592.01
13000	50 Year	12750	4592.73	4592.73	4592.73	4592.73	4592.73
13000	100 Year	17150	4593.63	4593.63	4593.63	4593.63	4593.63
13000	200 Year	22800	4594.45	4594.45	4594.45	4594.45	4594.45
13000	500 Year	32950	4595.81	4595.81	4595.81	4595.81	4595.81
14000	1.5 Year	1600	4589.75	4589.75	4589.75	4589.75	4589.75
14000	2 Year	2150	4590.24	4590.24	4590.24	4590.24	4590.24
14000	5 Year	4150	4591.82	4591.82	4591.82	4591.82	4591.82
14000	10 Year	6050	4593.06	4593.06	4593.06	4593.06	4593.06
14000	25 Year	9400	4594.07	4594.07	4594.07	4594.07	4594.07
14000	50 Year	12750	4594.76	4594.76	4594.76	4594.76	4594.76
14000	100 Year	17150	4595.51	4595.51	4595.51	4595.51	4595.51
14000	200 Year	22800	4596.35	4596.35	4596.35	4596.35	4596.35
14000	500 Year	32950	4597.58	4597.58	4597.58	4597.58	4597.58
14500	1.5 Year	1600	4590.58	4590.58	4590.58	4590.58	4590.58
14500	2 Year	2150	4591.15	4591.15	4591.15	4591.15	4591.15
14500	5 Year	4150	4592.78	4592.78	4592.78	4592.78	4592.78
14500	10 Year	6050	4593.91	4593.91	4593.91	4593.91	4593.91
14500	25 Year	9400	4595.1	4595.1	4595.1	4595.1	4595.1

Table 2
HEC-RAS Plan: Water Surface Elevations
River: Middle Fork Powder
Reach: Kaycee

River Station	Profile	Q Total (cfs)	Water Surface Elevations (ft)				
			Existing Conditions	Levee	Channel Improvements	Bridge Replacement	Diversion Channel
14500	50 Year	12750	4595.83	4595.83	4595.83	4595.83	4595.83
14500	100 Year	17150	4596.61	4596.61	4596.61	4596.61	4596.61
14500	200 Year	22800	4597.45	4597.45	4597.45	4597.45	4597.45
14500	500 Year	32950	4598.71	4598.71	4598.71	4598.71	4598.71
15000	1.5 Year	1600	4591.01	4591.01	4591.01	4591.01	4591.01
15000	2 Year	2150	4591.56	4591.56	4591.56	4591.56	4591.56
15000	5 Year	4150	4593.12	4593.12	4593.12	4593.12	4593.12
15000	10 Year	6050	4594.24	4594.24	4594.24	4594.24	4594.24
15000	25 Year	9400	4595.5	4595.5	4595.5	4595.5	4595.5
15000	50 Year	12750	4596.33	4596.33	4596.33	4596.33	4596.33
15000	100 Year	17150	4597.24	4597.24	4597.24	4597.24	4597.24
15000	200 Year	22800	4598.23	4598.23	4598.23	4598.23	4598.23
15000	500 Year	32950	4599.69	4599.69	4599.69	4599.69	4599.69
16000	1.5 Year	1600	4595.05	4595.05	4593.92	4595.05	4595.05
16000	2 Year	2150	4595.41	4595.41	4594.39	4595.41	4595.41
16000	5 Year	4150	4596.35	4596.35	4595.59	4596.35	4596.35
16000	10 Year	6050	4597.15	4597.15	4596.51	4597.15	4597.15
16000	25 Year	9400	4598.44	4598.44	4597.85	4598.44	4598.44
16000	50 Year	12750	4599.36	4599.36	4598.86	4599.36	4599.36
16000	100 Year	17150	4600.33	4600.33	4599.95	4600.33	4600.33
16000	200 Year	22800	4601.37	4601.37	4601.09	4601.37	4601.37
16000	500 Year	32950	4602.96	4602.96	4602.74	4602.96	4602.96
16500	1.5 Year	1600	4596.38	4596.38	4594.93	4596.38	4596.38
16500	2 Year	2150	4596.85	4596.85	4595.5	4596.85	4596.85
16500	5 Year	4150	4598.17	4598.17	4597.08	4598.17	4598.17
16500	10 Year	6050	4599.15	4599.15	4598.26	4599.15	4599.15
16500	25 Year	9400	4600.55	4600.55	4600.06	4600.55	4600.55
16500	50 Year	12750	4601.38	4601.38	4601.35	4601.38	4601.38
16500	100 Year	17150	4602.25	4602.25	4602.24	4602.25	4602.25
16500	200 Year	22800	4603.2	4603.2	4603.28	4603.2	4603.2
16500	500 Year	32950	4604.6	4604.6	4604.7	4604.6	4604.6
18000	1.5 Year	1600	4599.55	4599.55	4597.79	4599.55	N.A.
18000	2 Year	2150	4600.01	4600.01	4598.41	4600.01	N.A.
18000	5 Year	4150	4601.16	4601.16	4600.14	4601.16	N.A.
18000	10 Year	6050	4601.95	4601.95	4601.28	4601.95	N.A.
18000	25 Year	9400	4603.04	4603.04	4602.67	4603.04	N.A.
18000	50 Year	12750	4603.86	4603.86	4603.61	4603.86	N.A.
18000	100 Year	17150	4604.72	4604.72	4604.53	4604.72	N.A.
18000	200 Year	22800	4605.61	4605.61	4605.46	4605.61	N.A.
18000	500 Year	32950	4606.97	4606.97	4606.85	4606.97	N.A.

Table 2
HEC-RAS Plan: Water Surface Elevations
River: Middle Fork Powder
Reach: Kaycee

River Station	Profile	Q Total (cfs)	Water Surface Elevations (ft)				
			Existing Conditions	Levee	Channel Improvements	Bridge Replacement	Diversion Channel
18500	1.5 Year	1600	4600.76	4600.76	4598.74	4600.76	N.A.
18500	2 Year	2150	4601.15	4601.15	4599.34	4601.15	N.A.
18500	5 Year	4150	4601.97	4601.97	4600.97	4601.97	N.A.
18500	10 Year	6050	4602.54	4602.54	4601.89	4602.54	N.A.
18500	25 Year	9400	4603.46	4603.46	4603.03	4603.46	N.A.
18500	50 Year	12750	4604.24	4604.24	4603.92	4604.24	N.A.
18500	100 Year	17150	4605.1	4605.08	4604.83	4605.1	N.A.
18500	200 Year	22800	4606	4605.98	4605.77	4606	N.A.
18500	500 Year	32950	4607.4	4607.35	4607.19	4607.4	N.A.
19000	1.5 Year	1600	4601.98	4601.98	4599.71	4601.98	N.A.
19000	2 Year	2150	4602.36	4602.36	4600.32	4602.36	N.A.
19000	5 Year	4150	4603.21	4603.23	4601.91	4603.21	N.A.
19000	10 Year	6050	4603.81	4603.83	4602.7	4603.81	N.A.
19000	25 Year	9400	4604.65	4604.69	4603.73	4604.65	N.A.
19000	50 Year	12750	4605.38	4605.43	4604.58	4605.38	N.A.
19000	100 Year	17150	4606.26	4606.26	4605.49	4606.26	N.A.
19000	200 Year	22800	4607.12	4607.18	4606.47	4607.12	N.A.
19000	500 Year	32950	4608.44	4608.57	4607.86	4608.44	N.A.
19660	1.5 Year	1600	4603.21	4603.21	4600.97	4603.21	4601.55
19660	2 Year	2150	4603.65	4603.65	4601.58	4603.65	4602.15
19660	5 Year	4150	4604.64	4604.69	4603.16	4604.64	4603.86
19660	10 Year	6050	4605.28	4605.35	4603.96	4605.28	4605.07
19660	25 Year	9400	4606.17	4606.24	4604.91	4606.17	4606.17
19660	50 Year	12750	4606.66	4607.09	4605.54	4606.66	4606.4
19660	100 Year	17150	4607.44	4608.08	4606.37	4607.44	4606.4
19660	200 Year	22800	4608.28	4609.14	4607.42	4608.28	4606.89
19660	500 Year	32950	4609.56	4610.83	4608.8	4609.56	4607.69
19720		Bridge					
19780	1.5 Year	1600	4603.74	4603.74	4601.29	4603.67	4603.42
19780	2 Year	2150	4604.29	4604.29	4601.91	4604.21	4604.12
19780	5 Year	4150	4605.81	4605.81	4603.59	4605.67	4605.84
19780	10 Year	6050	4607.17	4606.82	4604.54	4606.97	4607.21
19780	25 Year	9400	4608.5	4608.2	4605.94	4607.53	4608.5
19780	50 Year	12750	4609.45	4609.6	4607.78	4606.83	4609.45
19780	100 Year	17150	4610.14	4611.89	4609.51	4607.55	4610.84
19780	200 Year	22800	4610.82	4615.21	4610.63	4608.71	4610.82
19780	500 Year	32950	4612.07	4617.36	4611.95	4609.93	4612.07
20000	1.5 Year	1600	4604.21	4604.21	4601.67	4604.17	4604.05
20000	2 Year	2150	4604.77	4604.76	4602.29	4604.72	4604.68
20000	5 Year	4150	4606.34	4606.27	4603.99	4606.25	4606.36

Table 2
HEC-RAS Plan: Water Surface Elevations
River: Middle Fork Powder
Reach: Kaycee

River Station	Profile	Q Total (cfs)	Water Surface Elevations (ft)				
			Existing Conditions	Levee	Channel Improvements	Bridge Replacement	Diversion Channel
20000	10 Year	6050	4607.38	4607.29	4605.01	4607.23	4607.41
20000	25 Year	9400	4608.48	4608.69	4606.49	4607.97	4608.48
20000	50 Year	12750	4609.45	4610.03	4607.96	4608.48	4609.45
20000	100 Year	17150	4610.15	4612.16	4609.41	4609.27	4610.84
20000	200 Year	22800	4610.83	4615.55	4610.5	4609.6	4610.83
20000	500 Year	32950	4612.07	4617.8	4611.75	4610.53	4612.07
20500	1.5 Year	1600	4605.83	4605.83	4602.58	4605.82	4605.8
20500	2 Year	2150	4606.5	4606.54	4603.2	4606.5	4606.5
20500	5 Year	4150	4607.91	4608.26	4604.99	4607.92	4607.91
20500	10 Year	6050	4608.78	4609.44	4606.17	4608.77	4608.78
20500	25 Year	9400	4609.85	4611.1	4607.76	4609.85	4609.85
20500	50 Year	12750	4610.7	4612.54	4609.12	4610.67	4610.7
20500	100 Year	17150	4611.57	4614.42	4610.4	4611.48	4611.86
20500	200 Year	22800	4612.5	4616.73	4611.58	4612.48	4612.5
20500	500 Year	32950	4613.97	4619.34	4613.18	4613.91	4613.97
21500	1.5 Year	1600	4607.46	4607.46	4604.48	4607.46	4607.46
21500	2 Year	2150	4608.07	4608.07	4605.09	4608.07	4608.07
21500	5 Year	4150	4609.27	4609.52	4606.89	4609.27	4609.27
21500	10 Year	6050	4610.03	4610.6	4608.16	4610.03	4610.03
21500	25 Year	9400	4611.09	4612.17	4609.56	4611.09	4611.09
21500	50 Year	12750	4611.98	4613.56	4610.55	4611.96	4611.98
21500	100 Year	17150	4612.94	4615.35	4611.66	4612.91	4613.05
21500	200 Year	22800	4613.95	4617.53	4612.82	4613.94	4613.95
21500	500 Year	32950	4615.5	4620.14	4614.44	4615.47	4615.5
22000	1.5 Year	1600	4608.9	4608.9	4608.27	4608.9	4608.9
22000	2 Year	2150	4609.49	4609.49	4608.71	4609.49	4609.49
22000	5 Year	4150	4610.63	4610.56	4610.03	4610.63	4610.63
22000	10 Year	6050	4611.25	4611.14	4611.12	4611.25	4611.25
22000	25 Year	9400	4612.63	4612.63	4612.63	4612.63	4612.62
22000	50 Year	12750	4613.77	4613.77	4613.77	4613.77	4613.78
22000	100 Year	17150	4615.11	4615.11	4615.14	4615.11	4615.12
22000	200 Year	22800	4616.69	4616.66	4616.69	4616.68	4616.69
22000	500 Year	32950	4619.04	4619.04	4619.04	4619.04	4619.04
22150		Bridge					
22300	1.5 Year	1600	4610.55	4610.55	4610.55	4610.55	4610.55
22300	2 Year	2150	4611.3	4611.3	4611.29	4611.3	4611.3
22300	5 Year	4150	4613.31	4613.31	4613.31	4613.31	4613.31
22300	10 Year	6050	4614.7	4614.69	4614.69	4614.7	4614.7
22300	25 Year	9400	4616.62	4616.62	4616.62	4616.62	4616.62
22300	50 Year	12750	4618.24	4618.24	4618.24	4618.24	4618.24

Table 2
HEC-RAS Plan: Water Surface Elevations
River: Middle Fork Powder
Reach: Kaycee

River Station	Profile	Q Total (cfs)	Water Surface Elevations (ft)				
			Existing Conditions	Levee	Channel Improvements	Bridge Replacement	Diversion Channel
22300	100 Year	17150	4619.67	4619.67	4619.67	4619.67	4619.67
22300	200 Year	22800	4621.62	4621.62	4621.62	4621.62	4621.62
22300	500 Year	32950	4628.17	4628.17	4628.17	4628.17	4628.17
22500	1.5 Year	1600	4611.02	4611.02	4611.02	4611.02	4611.02
22500	2 Year	2150	4611.77	4611.77	4611.77	4611.77	4611.77
22500	5 Year	4150	4613.86	4613.87	4613.86	4613.86	4613.86
22500	10 Year	6050	4615.36	4615.36	4615.36	4615.36	4615.36
22500	25 Year	9400	4617.5	4617.5	4617.5	4617.5	4617.5
22500	50 Year	12750	4619.31	4619.31	4619.31	4619.31	4619.31
22500	100 Year	17150	4621.06	4621.06	4621.06	4621.06	4621.06
22500	200 Year	22800	4623.26	4623.26	4623.26	4623.26	4623.26
22500	500 Year	32950	4628.44	4628.44	4628.44	4628.44	4628.44
23000	1.5 Year	1600	4611.89	4611.89	4611.89	4611.89	4611.89
23000	2 Year	2150	4612.43	4612.43	4612.43	4612.43	4612.43
23000	5 Year	4150	4614.18	4614.19	4614.18	4614.18	4614.18
23000	10 Year	6050	4615.61	4615.61	4615.61	4615.61	4615.61
23000	25 Year	9400	4617.72	4617.72	4617.72	4617.72	4617.72
23000	50 Year	12750	4619.52	4619.52	4619.52	4619.52	4619.52
23000	100 Year	17150	4621.28	4621.28	4621.28	4621.28	4621.28
23000	200 Year	22800	4623.48	4623.48	4623.48	4623.48	4623.48
23000	500 Year	32950	4628.59	4628.59	4628.59	4628.59	4628.59
23500	1.5 Year	1600	4613.55	4613.55	4613.55	4613.55	4613.55
23500	2 Year	2150	4614.07	4614.07	4614.07	4614.07	4614.07
23500	5 Year	4150	4615.21	4615.21	4615.21	4615.21	4615.21
23500	10 Year	6050	4616.25	4616.25	4616.25	4616.25	4616.25
23500	25 Year	9400	4618.09	4618.09	4618.09	4618.09	4618.09
23500	50 Year	12750	4619.78	4619.78	4619.78	4619.78	4619.78
23500	100 Year	17150	4621.52	4621.52	4621.52	4621.52	4621.52
23500	200 Year	22800	4623.68	4623.69	4623.68	4623.68	4623.68
23500	500 Year	32950	4628.73	4628.73	4628.73	4628.73	4628.73
24000	1.5 Year	1600	4616.07	4616.07	4616.07	4616.07	4616.07
24000	2 Year	2150	4616.29	4616.29	4616.29	4616.29	4616.29
24000	5 Year	4150	4616.95	4616.95	4616.95	4616.95	4616.95
24000	10 Year	6050	4617.46	4617.46	4617.46	4617.46	4617.46
24000	25 Year	9400	4618.67	4618.67	4618.67	4618.67	4618.67
24000	50 Year	12750	4620.12	4620.12	4620.12	4620.12	4620.12
24000	100 Year	17150	4621.75	4621.75	4621.75	4621.75	4621.75
24000	200 Year	22800	4623.84	4623.84	4623.84	4623.84	4623.84
24000	500 Year	32950	4628.78	4628.78	4628.78	4628.78	4628.78
24500	1.5 Year	1600	4617.67	4617.67	4617.67	4617.67	4617.67

Table 2
HEC-RAS Plan: Water Surface Elevations
River: Middle Fork Powder
Reach: Kaycee

River Station	Profile	Q Total (cfs)	Water Surface Elevations (ft)				
			Existing Conditions	Levee	Channel Improvements	Bridge Replacement	Diversion Channel
24500	2 Year	2150	4618.05	4618.05	4618.05	4618.05	4618.05
24500	5 Year	4150	4618.9	4618.9	4618.9	4618.9	4618.9
24500	10 Year	6050	4619.48	4619.48	4619.48	4619.48	4619.48
24500	25 Year	9400	4620.06	4620.06	4620.06	4620.06	4620.06
24500	50 Year	12750	4620.93	4620.93	4620.93	4620.93	4620.93
24500	100 Year	17150	4622.32	4622.32	4622.32	4622.32	4622.32
24500	200 Year	22800	4624.23	4624.23	4624.23	4624.23	4624.23
24500	500 Year	32950	4628.94	4628.94	4628.94	4628.94	4628.94
25000	1.5 Year	1600	4618.72	4618.72	4618.72	4618.72	4618.72
25000	2 Year	2150	4619.12	4619.12	4619.12	4619.12	4619.12
25000	5 Year	4150	4620.16	4620.16	4620.16	4620.16	4620.16
25000	10 Year	6050	4620.97	4620.97	4620.97	4620.97	4620.97
25000	25 Year	9400	4622.09	4622.09	4622.09	4622.09	4622.09
25000	50 Year	12750	4622.74	4622.74	4622.74	4622.74	4622.74
25000	100 Year	17150	4623.66	4623.66	4623.66	4623.66	4623.66
25000	200 Year	22800	4625.11	4625.11	4625.11	4625.11	4625.11
25000	500 Year	32950	4629.31	4629.31	4629.31	4629.31	4629.31
25500	1.5 Year	1600	4619.26	4619.26	4619.26	4619.26	4619.26
25500	2 Year	2150	4619.66	4619.66	4619.66	4619.66	4619.66
25500	5 Year	4150	4620.69	4620.69	4620.69	4620.69	4620.69
25500	10 Year	6050	4621.48	4621.48	4621.48	4621.48	4621.48
25500	25 Year	9400	4622.61	4622.61	4622.61	4622.61	4622.61
25500	50 Year	12750	4623.36	4623.36	4623.36	4623.36	4623.36
25500	100 Year	17150	4624.32	4624.32	4624.32	4624.32	4624.32
25500	200 Year	22800	4625.68	4625.68	4625.68	4625.68	4625.68
25500	500 Year	32950	4629.62	4629.62	4629.62	4629.62	4629.62
26000	1.5 Year	1600	4620.46	4620.46	4620.46	4620.46	4620.46
26000	2 Year	2150	4620.88	4620.88	4620.88	4620.88	4620.88
26000	5 Year	4150	4621.95	4621.95	4621.95	4621.95	4621.95
26000	10 Year	6050	4622.71	4622.71	4622.71	4622.71	4622.71
26000	25 Year	9400	4623.8	4623.8	4623.8	4623.8	4623.8
26000	50 Year	12750	4624.67	4624.67	4624.67	4624.67	4624.67
26000	100 Year	17150	4625.62	4625.62	4625.62	4625.62	4625.62
26000	200 Year	22800	4626.78	4626.78	4626.78	4626.78	4626.78
26000	500 Year	32950	4630.03	4630.03	4630.03	4630.03	4630.03
27000	1.5 Year	1600	4622.07	4622.07	4622.07	4622.07	4622.07
27000	2 Year	2150	4622.43	4622.43	4622.43	4622.43	4622.43
27000	5 Year	4150	4623.48	4623.48	4623.48	4623.48	4623.48
27000	10 Year	6050	4624.22	4624.22	4624.22	4624.22	4624.22
27000	25 Year	9400	4625.25	4625.25	4625.25	4625.25	4625.25
27000	50 Year	12750	4626.13	4626.13	4626.13	4626.13	4626.13

Table 2
HEC-RAS Plan: Water Surface Elevations
River: Middle Fork Powder
Reach: Kaycee

River Station	Profile	Q Total (cfs)	Water Surface Elevations (ft)				
			Existing Conditions	Levee	Channel Improvements	Bridge Replacement	Diversion Channel
27000	100 Year	17150	4627.07	4627.07	4627.07	4627.07	4627.07
27000	200 Year	22800	4628.24	4628.24	4628.24	4628.24	4628.24
27000	500 Year	32950	4630.55	4630.55	4630.55	4630.55	4630.55
27500	1.5 Year	1600	4622.55	4622.55	4622.55	4622.55	4622.55
27500	2 Year	2150	4622.85	4622.85	4622.85	4622.85	4622.85
27500	5 Year	4150	4623.78	4623.78	4623.78	4623.78	4623.78
27500	10 Year	6050	4624.49	4624.49	4624.49	4624.49	4624.49
27500	25 Year	9400	4625.5	4625.5	4625.5	4625.5	4625.5
27500	50 Year	12750	4626.37	4626.37	4626.37	4626.37	4626.37
27500	100 Year	17150	4627.31	4627.31	4627.31	4627.31	4627.31
27500	200 Year	22800	4628.47	4628.47	4628.47	4628.47	4628.47
27500	500 Year	32950	4630.74	4630.74	4630.74	4630.74	4630.74
28000	1.5 Year	1600	4622.94	4622.94	4622.94	4622.94	4622.94
28000	2 Year	2150	4623.24	4623.24	4623.24	4623.24	4623.24
28000	5 Year	4150	4624.13	4624.13	4624.13	4624.13	4624.13
28000	10 Year	6050	4624.82	4624.82	4624.82	4624.82	4624.82
28000	25 Year	9400	4625.81	4625.81	4625.81	4625.81	4625.81
28000	50 Year	12750	4626.67	4626.67	4626.67	4626.67	4626.67
28000	100 Year	17150	4627.62	4627.62	4627.62	4627.62	4627.62
28000	200 Year	22800	4628.77	4628.77	4628.77	4628.77	4628.77
28000	500 Year	32950	4631	4631	4631	4631	4631
29000	1.5 Year	1600	4624.23	4624.23	4624.23	4624.23	4624.23
29000	2 Year	2150	4624.52	4624.52	4624.52	4624.52	4624.52
29000	5 Year	4150	4625.29	4625.29	4625.29	4625.29	4625.29
29000	10 Year	6050	4625.85	4625.85	4625.85	4625.85	4625.85
29000	25 Year	9400	4626.72	4626.72	4626.72	4626.72	4626.72
29000	50 Year	12750	4627.47	4627.47	4627.47	4627.47	4627.47
29000	100 Year	17150	4628.38	4628.38	4628.38	4628.38	4628.38
29000	200 Year	22800	4629.45	4629.45	4629.45	4629.45	4629.45
29000	500 Year	32950	4631.45	4631.45	4631.45	4631.45	4631.45
29500	1.5 Year	1600	4625.92	4625.92	4625.92	4625.92	4625.92
29500	2 Year	2150	4626.37	4626.37	4626.37	4626.37	4626.37
29500	5 Year	4150	4627.43	4627.43	4627.43	4627.43	4627.43
29500	10 Year	6050	4628.2	4628.2	4628.2	4628.2	4628.2
29500	25 Year	9400	4629.14	4629.14	4629.14	4629.14	4629.14
29500	50 Year	12750	4629.98	4629.98	4629.98	4629.98	4629.98
29500	100 Year	17150	4630.83	4630.83	4630.83	4630.83	4630.83
29500	200 Year	22800	4631.78	4631.78	4631.78	4631.78	4631.78
29500	500 Year	32950	4633.43	4633.43	4633.43	4633.43	4633.43
30000	1.5 Year	1600	4626.72	4626.72	4626.72	4626.72	4626.72

Table 2
HEC-RAS Plan: Water Surface Elevations
River: Middle Fork Powder
Reach: Kaycee

River Station	Profile	Q Total (cfs)	Water Surface Elevations (ft)				
			Existing Conditions	Levee	Channel Improvements	Bridge Replacement	Diversion Channel
30000	2 Year	2150	4627.19	4627.19	4627.19	4627.19	4627.19
30000	5 Year	4150	4628.29	4628.29	4628.29	4628.29	4628.29
30000	10 Year	6050	4629.18	4629.18	4629.18	4629.18	4629.18
30000	25 Year	9400	4630.07	4630.07	4630.07	4630.07	4630.07
30000	50 Year	12750	4630.84	4630.84	4630.84	4630.84	4630.84
30000	100 Year	17150	4631.69	4631.69	4631.69	4631.69	4631.69
30000	200 Year	22800	4632.65	4632.65	4632.65	4632.65	4632.65
30000	500 Year	32950	4634.29	4634.29	4634.29	4634.29	4634.29
30500	1.5 Year	1600	4627.56	4627.56	4627.56	4627.56	4627.56
30500	2 Year	2150	4628.03	4628.03	4628.03	4628.03	4628.03
30500	5 Year	4150	4629.24	4629.24	4629.24	4629.24	4629.24
30500	10 Year	6050	4630.11	4630.11	4630.11	4630.11	4630.11
30500	25 Year	9400	4630.98	4630.98	4630.98	4630.98	4630.98
30500	50 Year	12750	4631.71	4631.71	4631.71	4631.71	4631.71
30500	100 Year	17150	4632.55	4632.55	4632.55	4632.55	4632.55
30500	200 Year	22800	4633.49	4633.49	4633.49	4633.49	4633.49
30500	500 Year	32950	4635.03	4635.03	4635.03	4635.03	4635.03
31500	1.5 Year	1600	4629.42	4629.42	4629.42	4629.42	4629.42
31500	2 Year	2150	4629.97	4629.97	4629.97	4629.97	4629.97
31500	5 Year	4150	4631.41	4631.41	4631.41	4631.41	4631.41
31500	10 Year	6050	4632.24	4632.24	4632.24	4632.24	4632.24
31500	25 Year	9400	4633.27	4633.27	4633.27	4633.27	4633.27
31500	50 Year	12750	4634.09	4634.09	4634.09	4634.09	4634.09
31500	100 Year	17150	4635.01	4635.01	4635.01	4635.01	4635.01
31500	200 Year	22800	4635.98	4635.98	4635.98	4635.98	4635.98
31500	500 Year	32950	4637.48	4637.48	4637.48	4637.48	4637.48
32000	1.5 Year	1600	4630.08	4630.08	4630.08	4630.08	4630.08
32000	2 Year	2150	4630.64	4630.64	4630.64	4630.64	4630.64
32000	5 Year	4150	4632.17	4632.17	4632.17	4632.17	4632.17
32000	10 Year	6050	4633.03	4633.03	4633.03	4633.03	4633.03
32000	25 Year	9400	4634.15	4634.15	4634.15	4634.15	4634.15
32000	50 Year	12750	4635.04	4635.04	4635.04	4635.04	4635.04
32000	100 Year	17150	4636.08	4636.08	4636.08	4636.08	4636.08
32000	200 Year	22800	4637.09	4637.09	4637.09	4637.09	4637.09
32000	500 Year	32950	4638.66	4638.66	4638.66	4638.66	4638.66
32500	1.5 Year	1600	4631.01	4631.01	4631.01	4631.01	4631.01
32500	2 Year	2150	4631.64	4631.64	4631.64	4631.64	4631.64
32500	5 Year	4150	4633.18	4633.18	4633.18	4633.18	4633.18
32500	10 Year	6050	4633.94	4633.94	4633.94	4633.94	4633.94
32500	25 Year	9400	4634.92	4634.92	4634.92	4634.92	4634.92
32500	50 Year	12750	4635.75	4635.75	4635.75	4635.75	4635.75

Table 2
HEC-RAS Plan: Water Surface Elevations
River: Middle Fork Powder
Reach: Kaycee

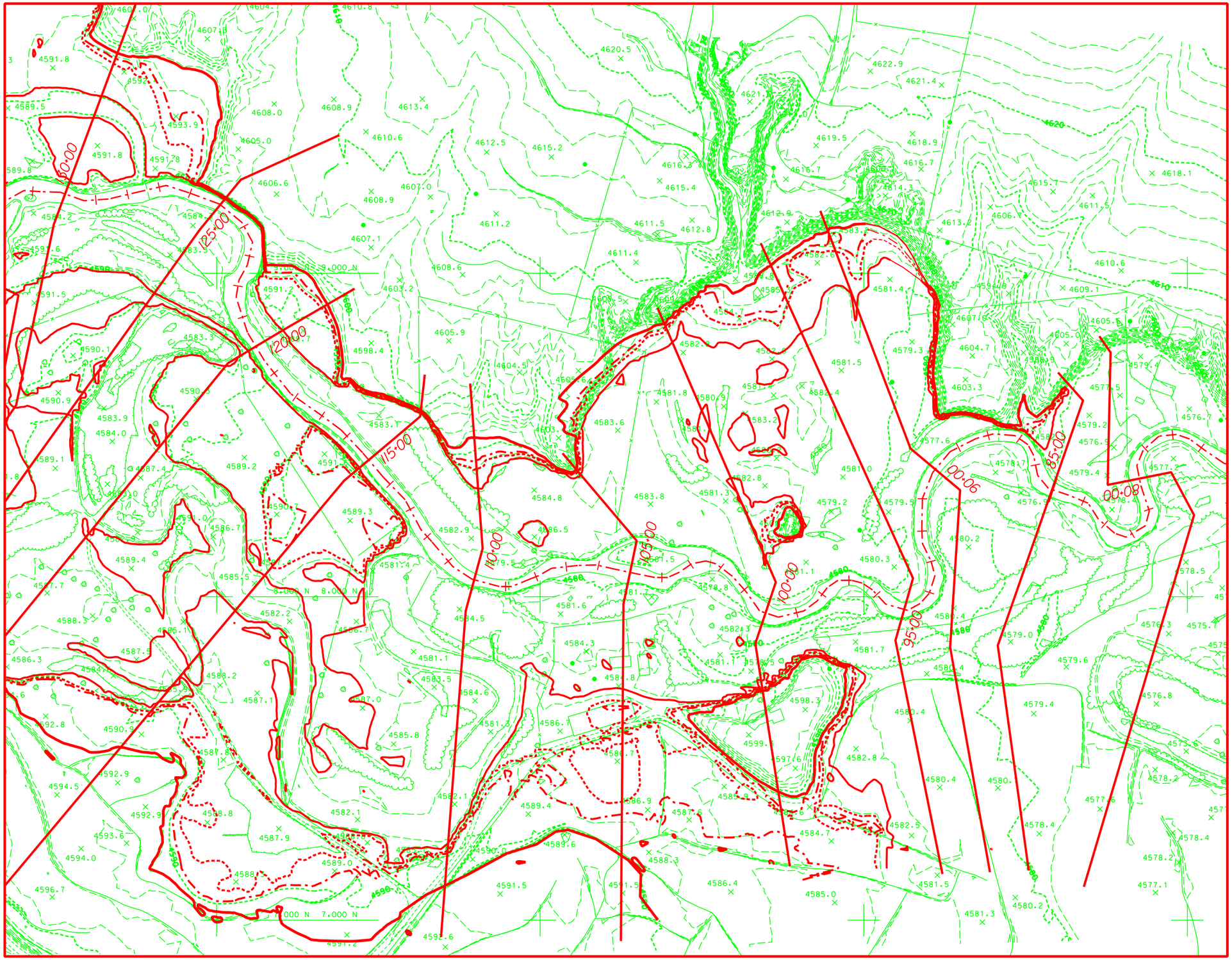
River Station	Profile	Q Total (cfs)	Water Surface Elevations (ft)				
			Existing Conditions	Levee	Channel Improvements	Bridge Replacement	Diversion Channel
32500	100 Year	17150	4636.67	4636.67	4636.67	4636.67	4636.67
32500	200 Year	22800	4637.64	4637.64	4637.64	4637.64	4637.64
32500	500 Year	32950	4639.18	4639.18	4639.18	4639.18	4639.18
33000	1.5 Year	1600	4632.35	4632.35	4632.35	4632.35	4632.35
33000	2 Year	2150	4632.95	4632.95	4632.95	4632.95	4632.95
33000	5 Year	4150	4634.54	4634.54	4634.54	4634.54	4634.54
33000	10 Year	6050	4635.43	4635.43	4635.43	4635.43	4635.43
33000	25 Year	9400	4636.55	4636.55	4636.55	4636.55	4636.55
33000	50 Year	12750	4637.29	4637.29	4637.29	4637.29	4637.29
33000	100 Year	17150	4638.1	4638.1	4638.1	4638.1	4638.1
33000	200 Year	22800	4639.03	4639.03	4639.03	4639.03	4639.03
33000	500 Year	32950	4640.5	4640.5	4640.5	4640.5	4640.5
33500	1.5 Year	1600	4633.44	4633.44	4633.44	4633.44	4633.44
33500	2 Year	2150	4633.9	4633.9	4633.9	4633.9	4633.9
33500	5 Year	4150	4635.15	4635.15	4635.15	4635.15	4635.15
33500	10 Year	6050	4635.95	4635.95	4635.95	4635.95	4635.95
33500	25 Year	9400	4637.01	4637.01	4637.01	4637.01	4637.01
33500	50 Year	12750	4637.77	4637.77	4637.77	4637.77	4637.77
33500	100 Year	17150	4638.62	4638.62	4638.62	4638.62	4638.62
33500	200 Year	22800	4639.59	4639.59	4639.59	4639.59	4639.59
33500	500 Year	32950	4641.11	4641.11	4641.11	4641.11	4641.11
34000	1.5 Year	1600	4634.3	4634.3	4634.3	4634.3	4634.3
34000	2 Year	2150	4634.68	4634.68	4634.68	4634.68	4634.68
34000	5 Year	4150	4635.77	4635.77	4635.77	4635.77	4635.77
34000	10 Year	6050	4636.5	4636.5	4636.5	4636.5	4636.5
34000	25 Year	9400	4637.5	4637.5	4637.5	4637.5	4637.5
34000	50 Year	12750	4638.27	4638.27	4638.27	4638.27	4638.27
34000	100 Year	17150	4639.13	4639.13	4639.13	4639.13	4639.13
34000	200 Year	22800	4640.12	4640.12	4640.12	4640.12	4640.12
34000	500 Year	32950	4641.62	4641.62	4641.62	4641.62	4641.62
34500	1.5 Year	1600	4635.11	4635.11	4635.11	4635.11	4635.11
34500	2 Year	2150	4635.51	4635.51	4635.51	4635.51	4635.51
34500	5 Year	4150	4636.48	4636.48	4636.48	4636.48	4636.48
34500	10 Year	6050	4637.13	4637.13	4637.13	4637.13	4637.13
34500	25 Year	9400	4638.09	4638.09	4638.09	4638.09	4638.09
34500	50 Year	12750	4638.83	4638.83	4638.83	4638.83	4638.83
34500	100 Year	17150	4639.68	4639.68	4639.68	4639.68	4639.68
34500	200 Year	22800	4640.67	4640.67	4640.67	4640.67	4640.67
34500	500 Year	32950	4642.18	4642.18	4642.18	4642.18	4642.18
35440	1.5 Year	1600	4636.08	4636.08	4636.08	4636.08	4636.08

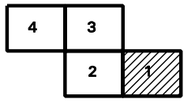
Table 2
HEC-RAS Plan: Water Surface Elevations
River: Middle Fork Powder
Reach: Kaycee

River Station	Profile	Q Total (cfs)	Water Surface Elevations (ft)				
			Existing Conditions	Levee	Channel Improvements	Bridge Replacement	Diversion Channel
35440	2 Year	2150	4636.5	4636.5	4636.5	4636.5	4636.5
35440	5 Year	4150	4637.54	4637.54	4637.54	4637.54	4637.54
35440	10 Year	6050	4638.26	4638.26	4638.26	4638.26	4638.26
35440	25 Year	9400	4639.29	4639.29	4639.29	4639.29	4639.29
35440	50 Year	12750	4639.96	4639.96	4639.96	4639.96	4639.96
35440	100 Year	17150	4640.74	4640.74	4640.74	4640.74	4640.74
35440	200 Year	22800	4641.63	4641.63	4641.63	4641.63	4641.63
35440	500 Year	32950	4643.05	4643.05	4643.05	4643.05	4643.05
36500	1.5 Year	1600	4637.76	4637.76	4637.76	4637.76	4637.76
36500	2 Year	2150	4638.13	4638.13	4638.13	4638.13	4638.13
36500	5 Year	4150	4638.99	4638.99	4638.99	4638.99	4638.99
36500	10 Year	6050	4639.6	4639.6	4639.6	4639.6	4639.6
36500	25 Year	9400	4640.57	4640.57	4640.57	4640.57	4640.57
36500	50 Year	12750	4641.19	4641.19	4641.19	4641.19	4641.19
36500	100 Year	17150	4641.92	4641.92	4641.92	4641.92	4641.92
36500	200 Year	22800	4642.76	4642.76	4642.76	4642.76	4642.76
36500	500 Year	32950	4644.06	4644.06	4644.06	4644.06	4644.06
37500	1.5 Year	1600	4639.32	4639.32	4639.32	4639.32	4639.32
37500	2 Year	2150	4639.75	4639.75	4639.75	4639.75	4639.75
37500	5 Year	4150	4640.61	4640.61	4640.61	4640.61	4640.61
37500	10 Year	6050	4641.14	4641.14	4641.14	4641.14	4641.14
37500	25 Year	9400	4641.96	4641.96	4641.96	4641.96	4641.96
37500	50 Year	12750	4642.64	4642.64	4642.64	4642.64	4642.64
37500	100 Year	17150	4643.42	4643.42	4643.42	4643.42	4643.42
37500	200 Year	22800	4644.3	4644.3	4644.3	4644.3	4644.3
37500	500 Year	32950	4645.66	4645.66	4645.66	4645.66	4645.66
38000	1.5 Year	1600	4639.65	4639.65	4639.65	4639.65	4639.65
38000	2 Year	2150	4640.06	4640.06	4640.06	4640.06	4640.06
38000	5 Year	4150	4640.94	4640.94	4640.94	4640.94	4640.94
38000	10 Year	6050	4641.5	4641.5	4641.5	4641.5	4641.5
38000	25 Year	9400	4642.35	4642.35	4642.35	4642.35	4642.35
38000	50 Year	12750	4643.05	4643.05	4643.05	4643.05	4643.05
38000	100 Year	17150	4643.85	4643.85	4643.85	4643.85	4643.85
38000	200 Year	22800	4644.75	4644.75	4644.75	4644.75	4644.75
38000	500 Year	32950	4646.12	4646.12	4646.12	4646.12	4646.12
38500	1.5 Year	1600	4639.87	4639.87	4639.87	4639.87	4639.87
38500	2 Year	2150	4640.33	4640.33	4640.33	4640.33	4640.33
38500	5 Year	4150	4641.36	4641.36	4641.36	4641.36	4641.36
38500	10 Year	6050	4642.04	4642.04	4642.04	4642.04	4642.04
38500	25 Year	9400	4642.98	4642.98	4642.98	4642.98	4642.98
38500	50 Year	12750	4643.73	4643.73	4643.73	4643.73	4643.73

Table 2
HEC-RAS Plan: Water Surface Elevations
River: Middle Fork Powder
Reach: Kaycee

River Station	Profile	Q Total (cfs)	Water Surface Elevations (ft)				
			Existing Conditions	Levee	Channel Improvements	Bridge Replacement	Diversion Channel
38500	100 Year	17150	4644.58	4644.58	4644.58	4644.58	4644.58
38500	200 Year	22800	4645.53	4645.53	4645.53	4645.53	4645.53
38500	500 Year	32950	4646.97	4646.97	4646.97	4646.97	4646.97
39000	1.5 Year	1600	4640.58	4640.58	4640.58	4640.58	4640.58
39000	2 Year	2150	4641.14	4641.14	4641.14	4641.14	4641.14
39000	5 Year	4150	4642.14	4642.14	4642.14	4642.14	4642.14
39000	10 Year	6050	4642.76	4642.76	4642.76	4642.76	4642.76
39000	25 Year	9400	4643.67	4643.67	4643.67	4643.67	4643.67
39000	50 Year	12750	4644.4	4644.4	4644.4	4644.4	4644.4
39000	100 Year	17150	4645.23	4645.23	4645.23	4645.23	4645.23
39000	200 Year	22800	4646.17	4646.17	4646.17	4646.17	4646.17
39000	500 Year	32950	4647.61	4647.61	4647.61	4647.61	4647.61





KEY MAP

LEGEND

—·—·—	RIVER CENTERLINE
12000	CROSS SECTION LOCATION
◆ 12	HIGH WATER MARK
———	10 YEAR FLOOD BOUNDARY
- - - - -	50 YEAR FLOOD BOUNDARY
—·—·—	100 YEAR FLOOD BOUNDARY
▬▬▬	500 YEAR FLOOD BOUNDARY

N

SCALE: 1 INCH = 300 FEET

150' 0 150'

Designed By: x.x.x.
Drawn By: x.x.x.
Reviewed By: x.x.x.

Submitted by: Jeff McClenathan, Chief HYDRAULICS Section

US Army Corps of Engineers
Omaha District

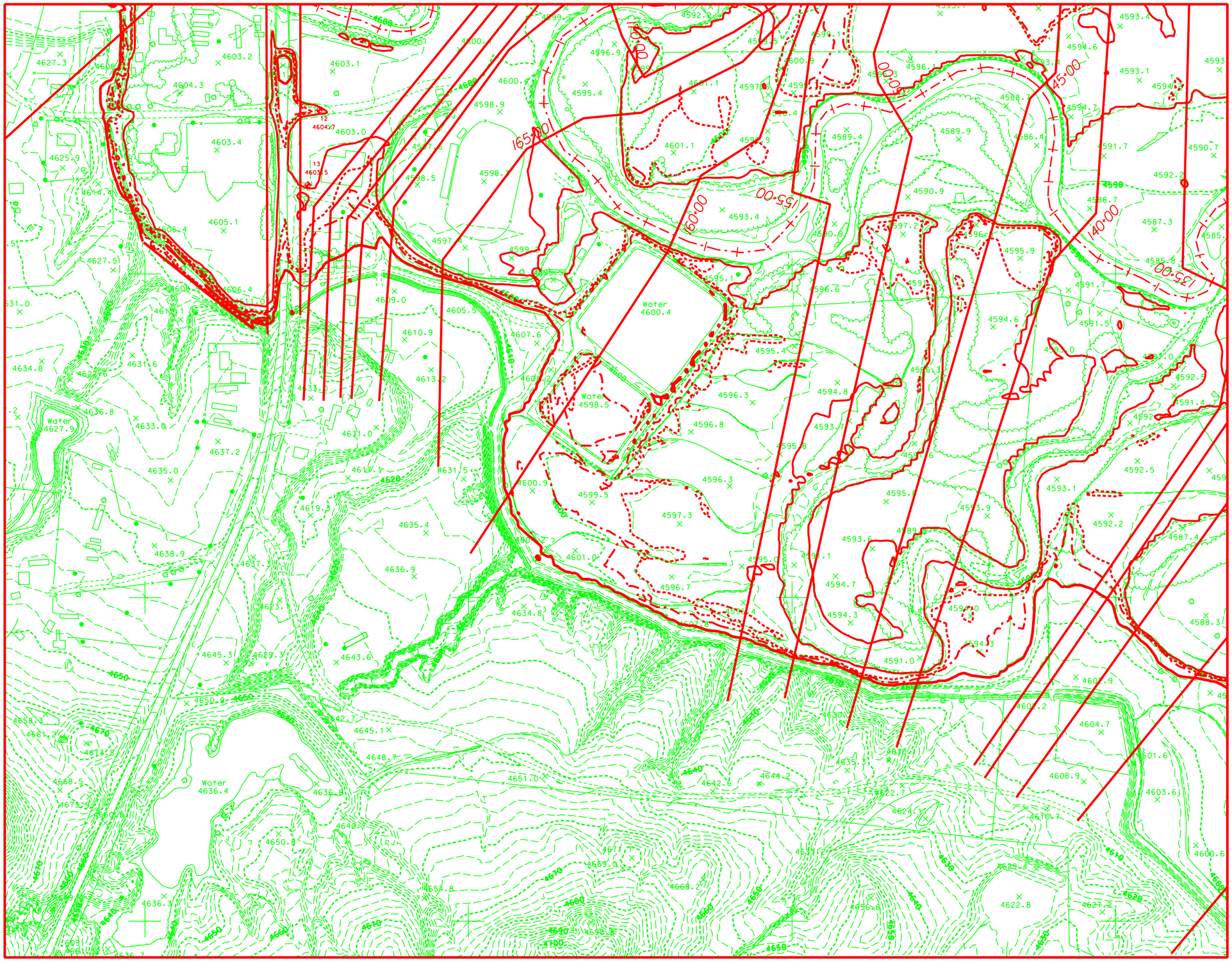
MIDDLE FORK POWDER RIVER KAYCEE, WYOMING

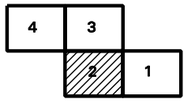
HYDRAULIC ANALYSIS

EXISTING CONDITIONS
FLOOD BOUNDARIES
SHEET 1 OF 4

Date: APRIL 2004
Computer File: WY02PLATE1.DGN
Plot Scale: 1" = 300'

Plate No.
1





KEY MAP

LEGEND

—·—·—	RIVER CENTERLINE
12000	CROSS SECTION LOCATION
◆ 12	HIGH WATER MARK
———	10 YEAR FLOOD BOUNDARY
- - - -	50 YEAR FLOOD BOUNDARY
—·—··	100 YEAR FLOOD BOUNDARY
━━━	500 YEAR FLOOD BOUNDARY

N

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Omaha District

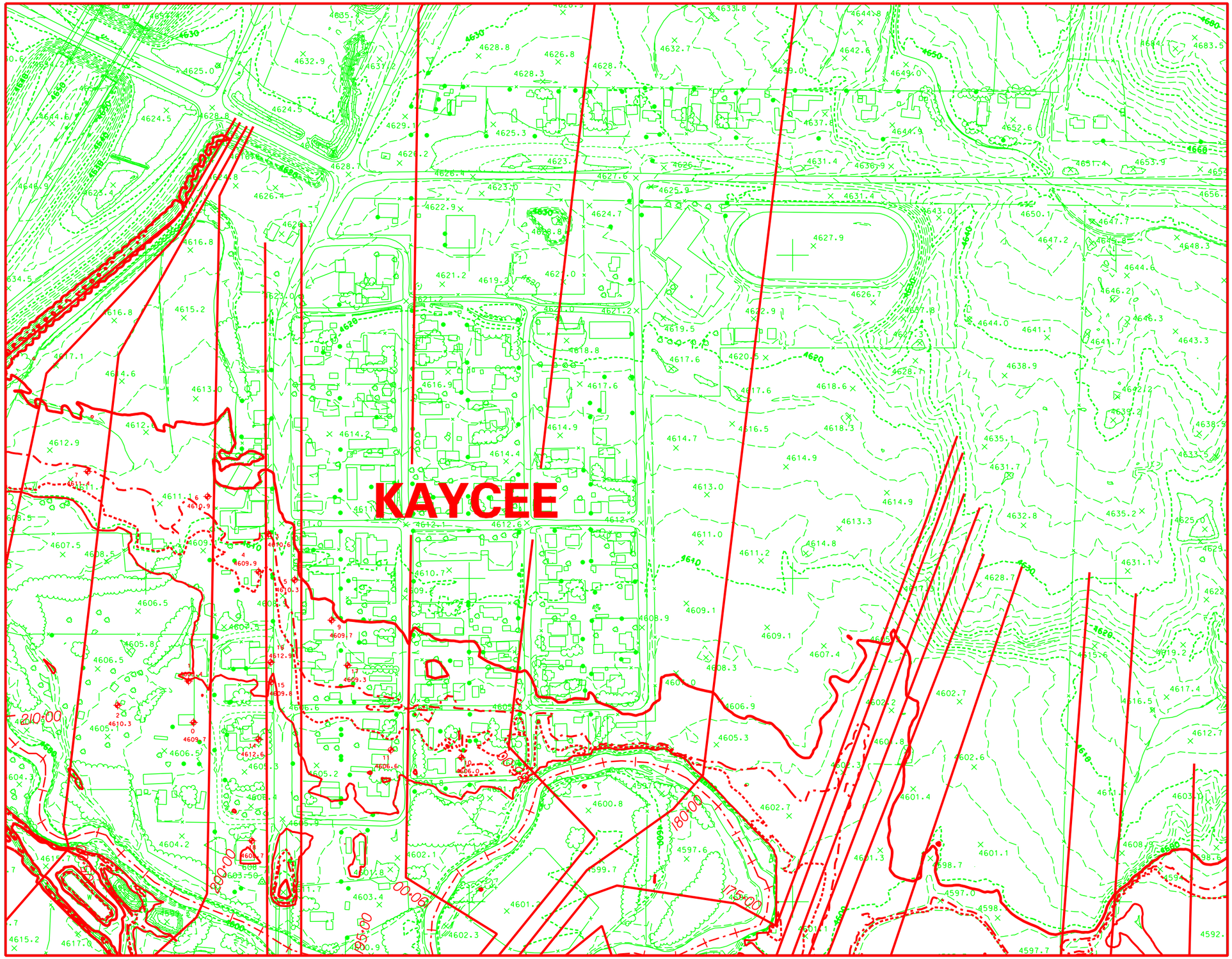
MIDDLE FORK POWDER RIVER KAYCEE, WYOMING

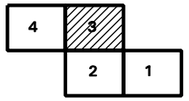
HYDRAULIC ANALYSIS

EXISTING CONDITIONS
FLOOD BOUNDARIES
SHEET 2 OF 4

Date: APRIL 2004
Computer File: WY02PLATE2.DGN
Plot Scale: 1" = 300'

Plate No. 2





KEY MAP

LEGEND

—·—·—	RIVER CENTERLINE
12000	CROSS SECTION LOCATION
◆ 12	HIGH WATER MARK
———	10 YEAR FLOOD BOUNDARY
- - - - -	50 YEAR FLOOD BOUNDARY
—·—·—	100 YEAR FLOOD BOUNDARY
═══	500 YEAR FLOOD BOUNDARY

N

SCALE: 1 INCH = 300 FEET

150' 0 150'

Designed By: x.x.x.
Drawn By: x.x.x.
Reviewed By: x.x.x.

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US Army Corps of Engineers
Omaha District

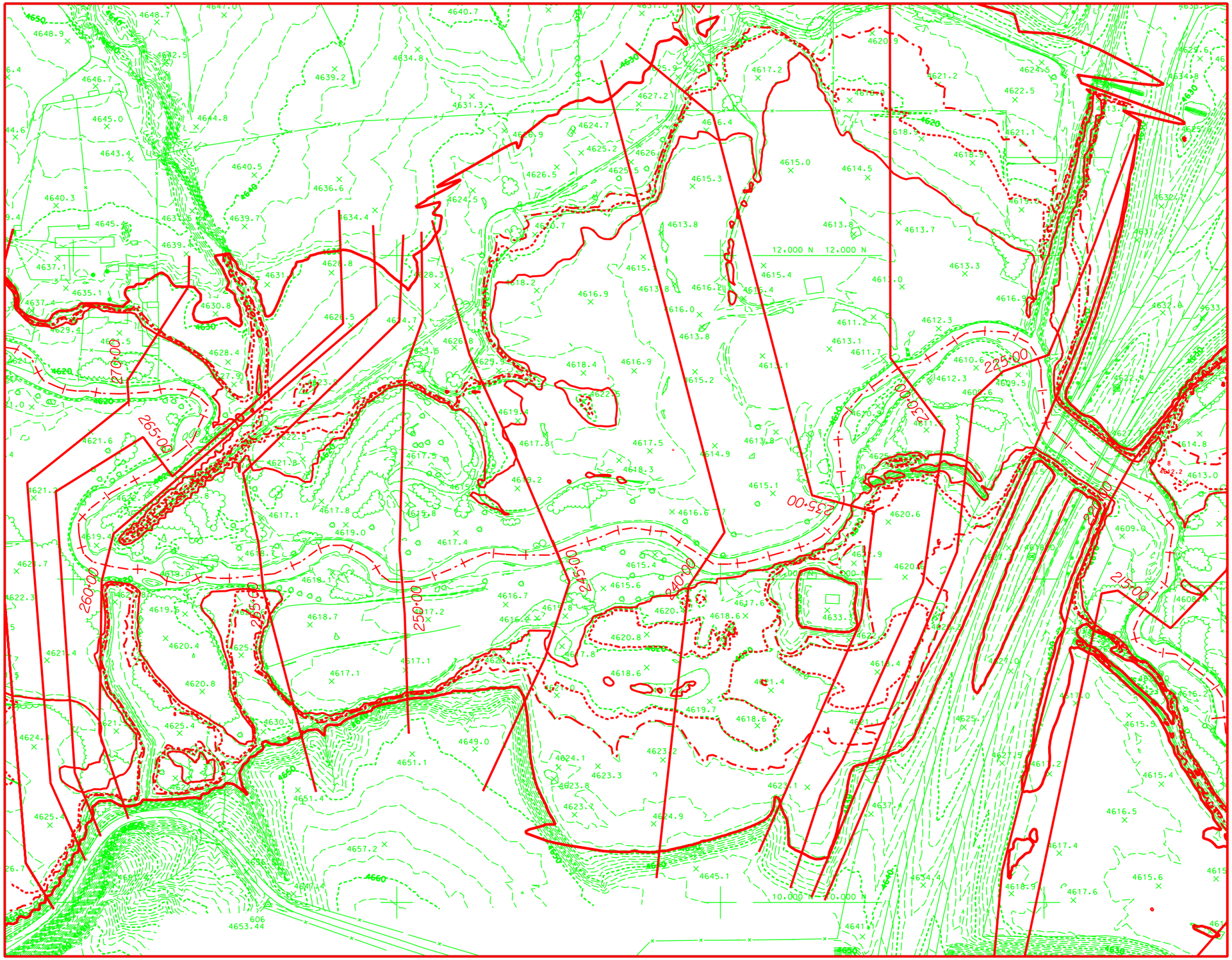
MIDDLE FORK POWDER RIVER KAYCEE, WYOMING

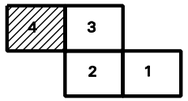
HYDRAULIC ANALYSIS

EXISTING CONDITIONS
FLOOD BOUNDARIES
SHEET 3 OF 4

Date: APRIL 2004
Computer File: WY02PLATE3.DGN
Plot Scale: 1" = 300'

Plate No. 3





KEY MAP

LEGEND

—·—·—	RIVER CENTERLINE
12000	CROSS SECTION LOCATION
◆ 12	HIGH WATER MARK
———	10 YEAR FLOOD BOUNDARY
- - - - -	50 YEAR FLOOD BOUNDARY
—·—·—	100 YEAR FLOOD BOUNDARY
━━━	500 YEAR FLOOD BOUNDARY

N

SCALE: 1 INCH = 300 FEET

150' 0 150'

Designed By: x.x.x.
Drawn By: x.x.x.
Reviewed By: x.x.x.

Submitted by: Jeff McClenathan, Chief HYDRAULICS Section

US Army Corps of Engineers
Omaha District

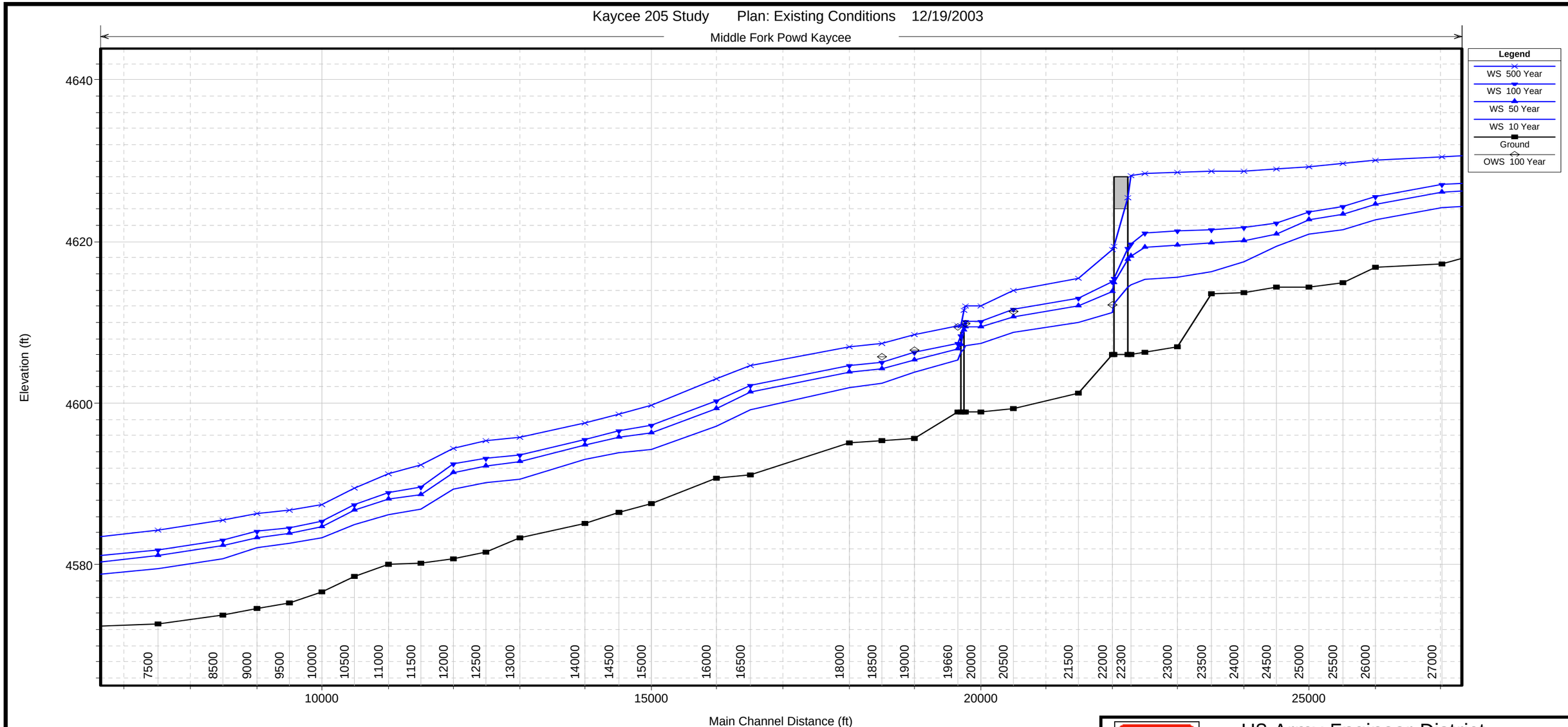
MIDDLE FORK POWDER RIVER KAYCEE, WYOMING

HYDRAULIC ANALYSIS

EXISTING CONDITIONS
FLOOD BOUNDARIES
SHEET 4 OF 4

Date: APRIL 2004
Computer File: WY02PLATE4.DGN
Plot Scale: 1" = 300'

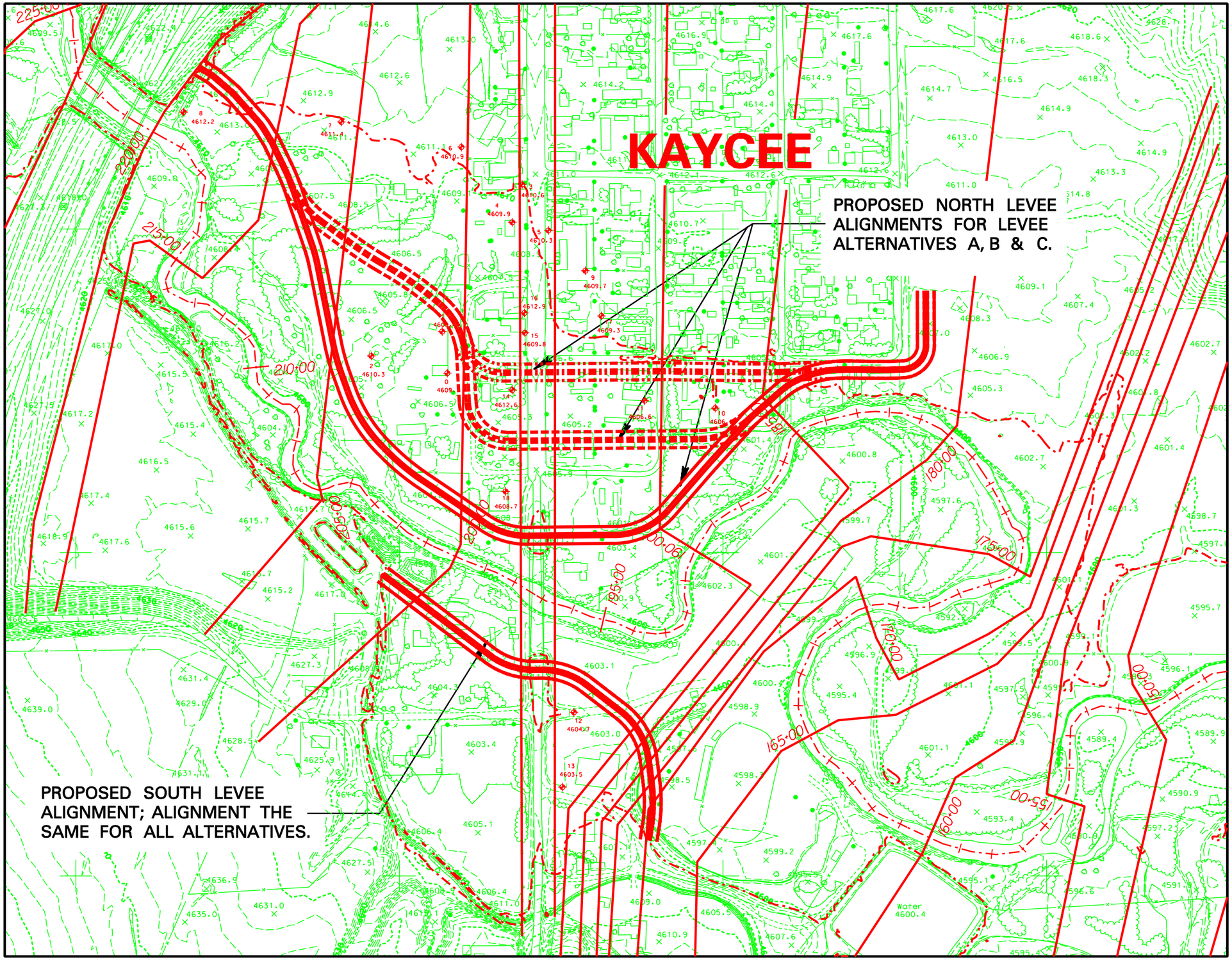
Plate No.
4



US Army Engineer District
Corps of Engineers
Omaha, NE

Existing Water Surface Profiles
Middle Fork Of The Powder River
Kaycee, Wyoming

Plate 5



LEGEND

- RIVER CENTERLINE
- 12000 — CROSS SECTION LOCATION
- 12 — HIGH WATER MARK
- EXISTING 100 YEAR FLOOD BOUNDARY
- ALTERNATIVE A
- ALTERNATIVE B
- ALTERNATIVE C

N

SCALE: 1 INCH = 300 FEET

150' 0 150'

Designed By: X.X.X.
Drawn By: X.X.X.
Reviewed By: X.X.X.

Submitted by: Jeff McClenathan, Chief HYDRAULICS Section

US Army Corps of Engineers
Omaha District

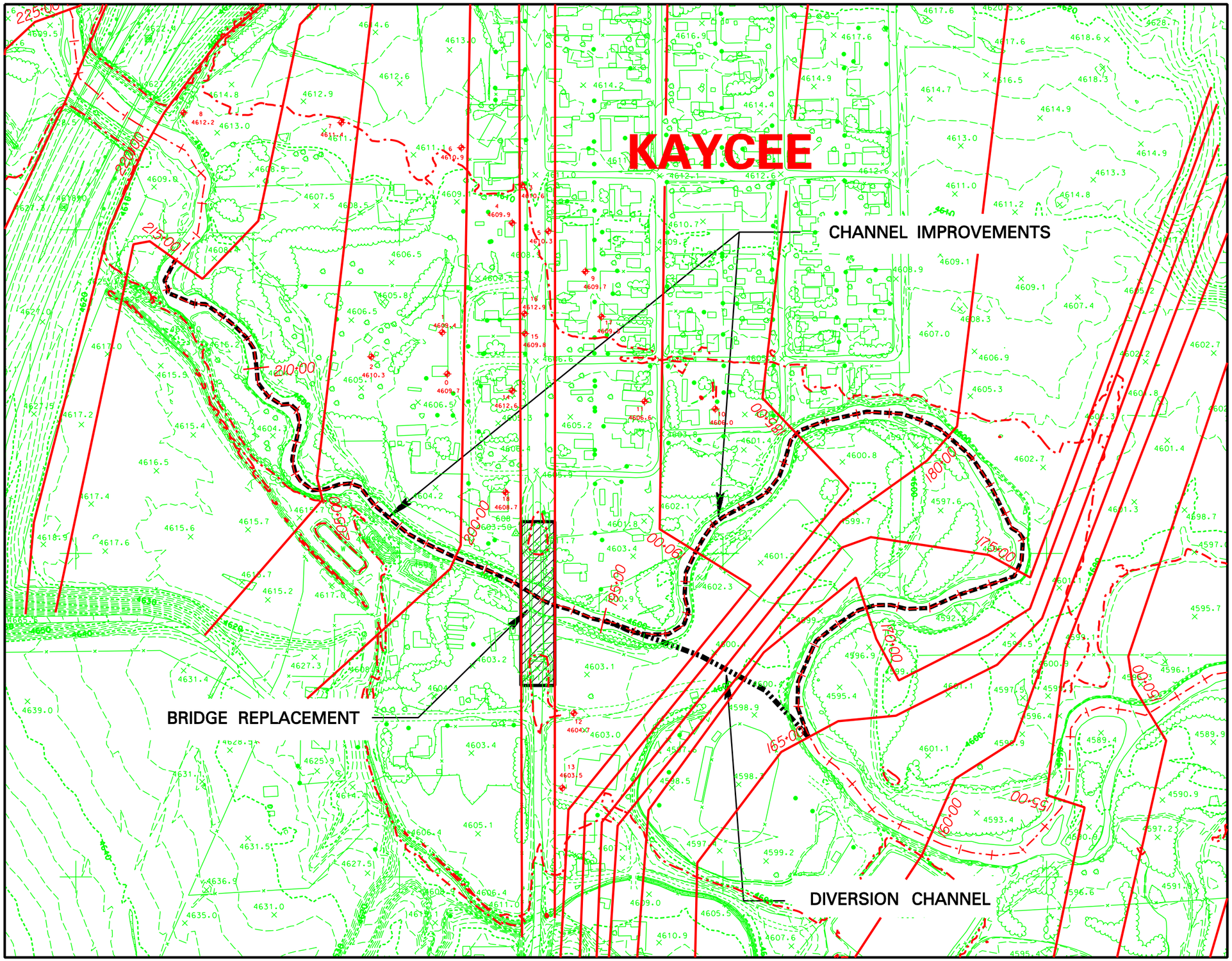
MIDDLE FORK POWDER RIVER KAYCEE, WYOMING

HYDRAULIC ANALYSIS

PROPOSED LEVEE ALIGNMENTS

Date: APRIL 2004
Computer File: WY02PLATE6.DGN
Plot Scale: 1" = 300'

Plate No. 6



LEGEND

- RIVER CENTERLINE
- 12000 CROSS SECTION LOCATION
- 12 HIGH WATER MARK
- EXISTING 100 YEAR FLOOD BOUNDARY
- CHANNEL IMPROVEMENTS
- BRIDGE REPLACEMENT
- DIVERSION CHANNEL

N

SCALE: 1 INCH = 300 FEET
150' 0 150'

Designed By: x.x.x.
Drawn By: x.x.x.
Reviewed By: x.x.x.

Submitted by:
Jeff McClenathan
Chief HYDRAULICS Section

US Army Corps of Engineers
Omaha District

MIDDLE FORK POWDER RIVER KAYCEE, WYOMING

HYDRAULIC ANALYSIS

ADDITIONAL PROPOSED FLOOD REMEDIATION ALTERNATIVES

Date: APRIL 2004
Computer File: WY02PLATE7.DGN
Plot Scale: 1" = 300'

Plate No.
7