Appendix C
Hydrology and Hydraulics

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1. Purpose and Scope

The purpose of this appendix is to describe hydrology and hydraulic (H&H) analyses recently undertaken in support of the Portneuf River Planning Assistance to States (PAS) study. This appendix will present an inventory of, and summarize, available information resources of value in communicating existing conditions along the Portneuf River within the study reach. It will also present the limited field information gathered during a site visit in August 2015. Planning-level H&H analyses performed to evaluate a limited range of proposed enhancement features to the Portneuf River channel and floodway within the Pocatello, Idaho, vicinity is also included. Information herein is presented from an H&H perspective. Information regarding other technical and resource perspectives may be found in other parts of the report. Ideally, this information will be of further value in identifying and selecting potential approaches for further development that maintain flood carrying capacity within the existing floodplain while creating improvements to the environment important to the community and the Nation.

2. Previous Federal Studies and Other Sources

The US Army Corps of Engineers (Corps) and other Federal agencies have conducted a number of studies for the Portneuf River near Pocatello, Idaho, in the past.

1. Corps, 1964 (22 July 1964). *General Design Memorandum, Flood Control Project, Portneuf River, Idaho, Pocatello Unit*.
2. Corps, 1968. *Detailed Project Report, Flood Control Project, Lava Hot Springs, Idaho, Portneuf River.*
3. Federal Emergency Management Agency (FEMA), 1996. *Flood Insurance Study, City of Pocatello, Idaho, Bannock County*.
4. Corps, 1970. *Flood Plain Information, Pocatello, Idaho and Vicinity, Portneuf River and Tributaries.*
5. US Department of Interior, US Geological Survey (USGS), 2015. *USGS Current Conditions for Idaho_Streamflow*. Accessed September 25, 2015, at: *http://waterdata.usg.gov/id/nwis/current/?type=flow*.
6. US Department of Interior, US Geological Survey Investigations Report 2004-5170, 50 p., 2001-2002, G.J. Barton. *Surface and Ground-Water Relations on the Portneuf River, and Temporal Changes in Ground-Water Levels in the Portneuf Valley, Caribou and Bannock Counties, Idaho.*

Much existing information summarized in this appendix comes from the above reports. Other sources will be identified as they arise. In some cases (e.g., USGS measurements and frequency discharge), the information has been updated. The more relevant H&H information from those previous studies is presented below.

- The 1986 Flood Insurance Study (FIS) (FEMA, document #3, above) provides hydrologic information regarding significant tributaries that enter the Portneuf River within the vicinity of Pocatello, as well as information on potential ice jam flooding in the area. The significant tributaries within the vicinity are Trail Creek, City Creek, Pocatello Creek, Cusick Creek, and Johnny Creek. The FIS report also mentions that ice jams are a potential source of flooding in Pocatello when prolonged freezing temperatures are followed by a warm period (FEMA, 1996). Rain events during warm periods are particularly problematic when the ground has been frozen by previous low temperatures. As a result, flooding could occur with relatively low flowrates.

- The 1970 floodplain study (document #4, above) provides hydrologic information regarding the significant tributaries that enter the Portneuf River upstream of Pocatello. The significant tributaries upstream of Pocatello include Fort Hall Mine Creek, Mink Creek, Gibson Jack Creek, and Johnny Creek. Johnny Creek is the only creek in the vicinity of Pocatello (Corps, 1970).

- A cursory review of the 1968 Detailed Project Report for Lava Hot Springs (document #2, above) includes some discussion of travertine deposits that control the bed of the Portneuf River, a phenomenon that extends to the Pocatello area (Corps, 1968).

3. Other Relevant Studies

Additional relevant and current hydrologic information is also available from the Idaho Department of Environmental Quality (IDEQ). In particular, the *Portneuf River TMDL Revision and Addendum* (IDEQ, 2010), was recommended by numerous sources as pertinent to the current study. The focus of the IDEQ study is water quality, but it does provide a good summary of basin hydrology and how it has changed recently. It also contains significant information regarding sediment, one of the primary water pollutants discussed in the Total Maximum Daily Load (TMDL) report. One of the more compelling illustrations in the report presents the decadal hydrographs, starting with 1910, of the Portneuf River at Pocatello (IDEQ, 2010, Figure 1.1). There is a wide range in the decadal hydrographs, particularly in spring runoff peaks (over a two-fold magnitude difference) and peak timing. Of particular note is the most recent past decade is the driest century presented (IDEQ, 2010) and the current decade is expected to be even drier (personal communication, 2015).

Portneuf River flows are regulated upstream of Pocatello by Portneuf Dam, with a capacity of 23,965 acre-feet (AF), the smaller Chesterfield Dam, with 685 AF capacity (USGS, 2015), and by smaller reservoirs and diversions (IDEQ, 2010). The TMDL report includes a general description of the basin geology, and describes the topsoils as predominantly very erodible loess. Section 2.5 of the report discusses data gaps (IDEQ, 2010).

Marcarelli et al. (2010) contains several important pieces of information that informed the current project on the study area. Marcarelli et al. (2010) provides gate information and unit hydrographs from unregulated streams in and near the Portneuf River watershed, as well as the timing for snowmelt initiation and the timing for the Portneuf River and Henry's Fork hydrographs. Finally, Marcarelli et al. (2010) developed mean water-year hydrographs for the current regulated and unregulated flow regimes.

4. Current Condition Description

4.1 General Environment

A great deal of information on the watershed can be found at *http://miles.isu.edu*, *Managing Idaho's Landscape for Ecosystem Services* (Miles, 2015). The "Pocatello" and "Resources" tabs provide access to substantial resources on the Lower Portneuf River Watershed. The "Explore the Portneuf" tab includes useful visualizations, such as the flooding history timeline and 1959 and 2013 Pocatello aerial imagery comparisons. The latter of these visualization tools is particularly useful in conveying the substantial changes in planform geometry associated with the flood control project. The "Research" tab, as its name implies, provides links to research presentations on the Portneuf River.

Finally, the City of Pocatello and Bannock County have a number of online resources that may prove to be of value. Of particular interest, in terms of hydrologic and hydraulic applications, are the following:

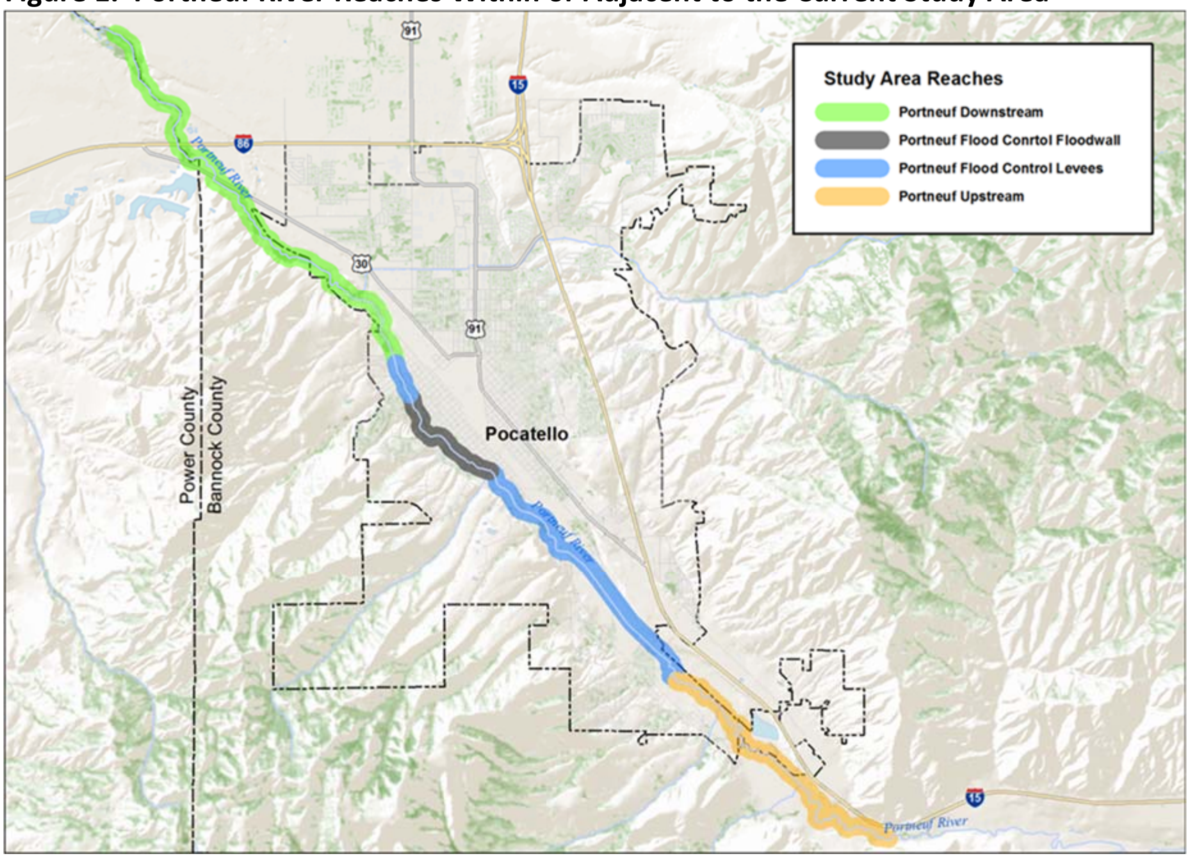
1. City of Pocatello Comprehensive Plan – 2015 Update: Link to Plan sections: *http://ourvalleyourvision.pocatello.us/*, and its maps appendix: *http://ourvalleyourvision.pocatello.us/documents/orov/24%20APPENDIX%20A%20MAPS%20lan%202015.pdf*. The city has other online resources available, though several of these were not online during the time this review was assembled.
2. The Bannock County Comprehensive Plan (*http://www.bannockcountyplanning.us/uploads/1/4/1/8/14185210/comp_plan.pdf*) also includes information on the county that may be of subsequent value.
3. Conceptual plans for removal and replacement of the concrete channel were developed by an Idaho State University (ISU) design team. They are available at: *http://pgf.seffect.com/sites/pgf.seffect.com/files/Channel%20Removal%20Alternative%20Analysis.pdf*.

4.2 Portneuf River by Reach

The following river reach descriptions are used in the Portneuf River Vision Study (Figure 1):

1. Portneuf Gap to Edson Fichter Nature Area (Bannock Highway and Second Avenue - about 7.5 miles) is shown highlighted in orange on Figure 1.
2. Portneuf River Flood Control Project intermittent (riprap channel and earthen levees (two separate reaches and 4.7 miles total) is shown highlighted in blue on Figure 1.
3. Portneuf Flood Control Project concrete channel (1.5 miles) is highlighted in gray on Figure 1.
4. Sacajawea Park (Gathe and Oakwood Drive) to Fort Hall Indian Reservation boundary (about 8 miles) is highlighted in green on Figure 1.

Figure 1. Portneuf River Reaches Within or Adjacent to the Current Study Area



4.3 Ecosystem Conditions

Key existing conditions associated with ecosystem values are described in the June 1996 *Portneuf River Restoration Environmental Assessment Report* (CH2M Hill, 1996a). This report indicates construction of the concrete channel associated with the flood control project eliminated a major portion of the fish and wildlife habitat. Flood control project levees, channel revetment, and the concrete channel further reduced river meanders, also impacting wildlife habitats. Private landowners alte4red and eliminated a number of meanders in the landscape as well.

The riparian zone is limited, which tends to prevent woody vegetation from expanding. The water supply is expected to continue being cut off from the meanders because of these features, adversely impacting associated wetland areas and riparian zones (CH2M Hill, 1996a).

Recommendations made in the June 1996 *Portneuf River Flood Control Project Modification Report for North City Park and Open Lands Meanders* (CH2M Hill, 1996b), located next to the Portneuf River flood control project, have potential to facilitate environmental improvement. In 1996, both areas were unimproved lands containing remnants of old river meanders. North City Park is at the downstream end of the project, while the Open Lands Meanders are located at the upstream end of the project (CH2M Hill, 1996b).

The North City Park meanders have no flowing water, but are vegetated with trees and bushes. The Open Lands Meanders include several ancient river meanders that lie along the right bank of the river. An existing railroad embankment prevents water from flowing to the meanders.

5. Pocatello Unit Flood Control Project Description

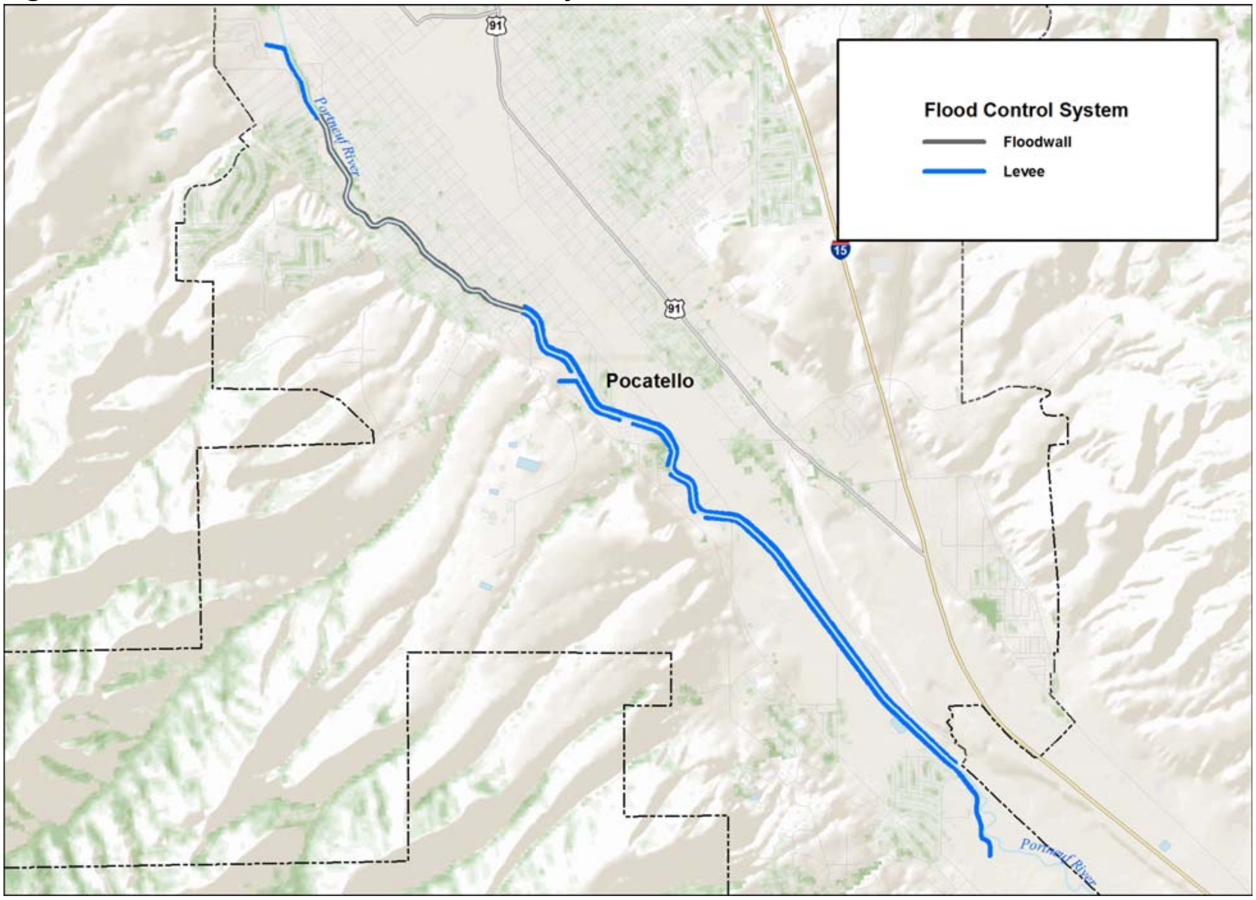
The flood control project constructed by the Corps on the Portneuf River is a central component of existing conditions in study area within Pocatello, Idaho. The project was authorized by the Flood Control Act of 1941, approved August 18, 1941, as amended by the Flood Control Act of 1944 (December 22, 1944). The project is located on the mainstem Portneuf River (Figure 2), along a 6.2-mile reach of the Portneuf River. It was conceived to provide protection to the City of Pocatello, Idaho, and was constructed between July 1966 and November 1968. It consists of a 1.5-mile stretch of rectangular concrete channel and 4.7 miles of reveted levee and channel reaches both up- and downstream of the concrete channel. The channel has a design capacity of 6,000 cubic feet per second (cfs).

6. Study Area Hydrology

6.1 Basin Description

The Portneuf River Basin contains approximately 1,290 square miles, and covers most of Bannock County and parts of neighboring Bingham, Caribou, and Power Counties, all in Idaho. The Blackfoot River Basin borders the Portneuf River Basin to the north and east, the Bear River Basin lies to the south, and the Bannock Mountain Range is to the west. The watershed is shown in Figure 3.

Figure 2. Portneuf River Flood Control Project, Pocatello Unit

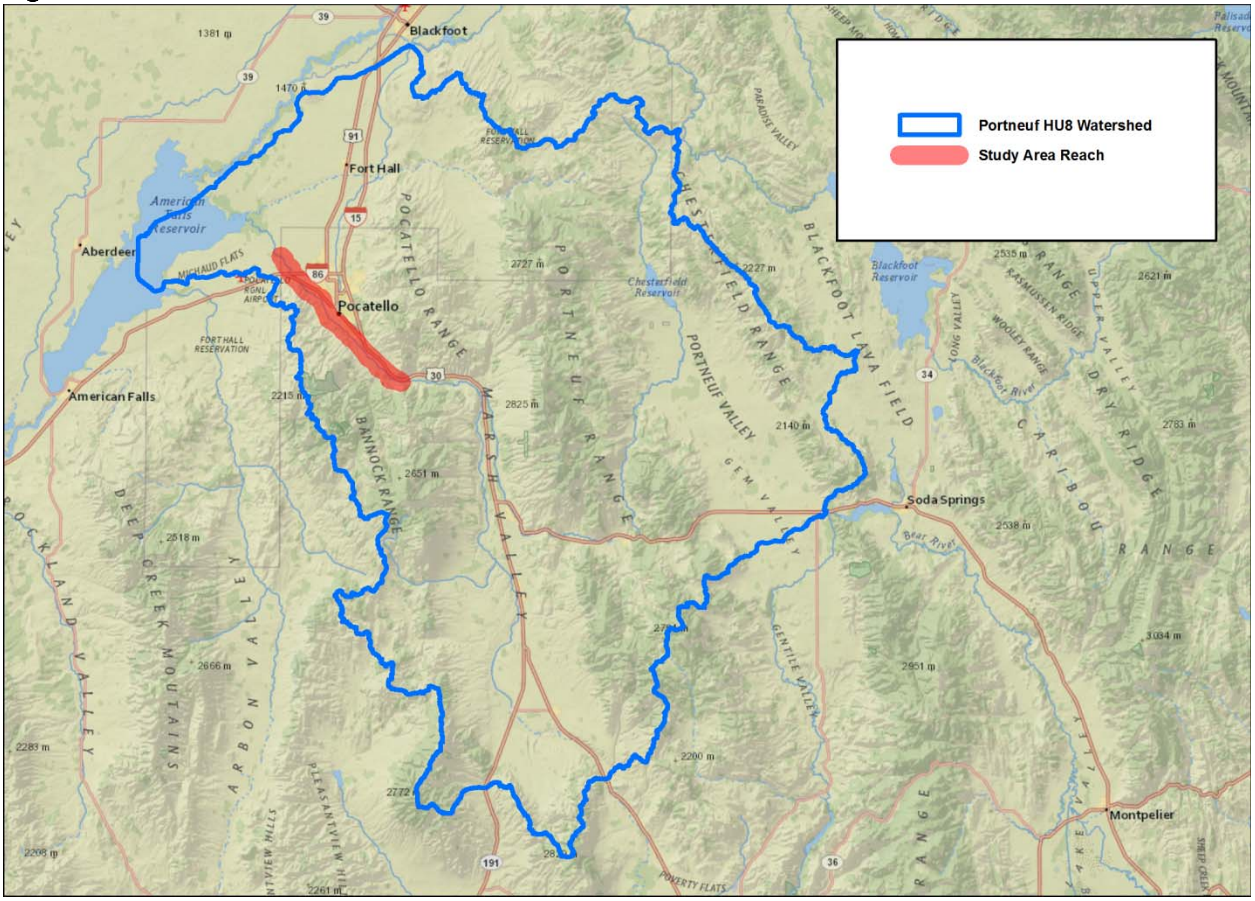


The headwaters of the Portneuf River are in the northwestern tip of the basin. The river flows south for about 30 miles, and then moves northwesterly for about 50 miles to its confluence with the Snake River at American Falls Reservoir. Marsh Creek, its principal tributary, enters the Portneuf River from the south. It has a flat slope (about 4.5 feet per mile), and drains about 30% of the total basin. Upstream of Pocatello, elevation ranges from about 9,280 feet to 4,440 feet, with a mean basin elevation of 5,850 feet.

6.2 Climate

The basin climate is characterized by moderate to low precipitation and humidity, relatively windy springs, warm summers, and cool to cold winters. Normal annual precipitation in the Portneuf River Basin upstream of Pocatello ranges from less than 12 inches to more than 22 inches. The average precipitation for the total drainage area is 15.8 inches. Seasonal precipitation variations are quite small, with July through September somewhat drier than other months. Rainfall intensities are generally low, although high intensities do occur during summer and fall thunderstorms. In winter months, a large part of the precipitation occurs as snowfall. Average annual snowfall varies from about 35 inches in the lower valleys to nearly 100 inches in the mountains.

Figure 3. Portneuf River Watershed



Mean monthly temperatures recorded at Pocatello vary from 26 degrees Fahrenheit (°F) in January to 73°F in July. Temperature extremes were recorded as 106°F in July and -24°F in January. The mean annual high temperature is 59°F, while the mean annual low temperature is 33°F.

6.3 Streamflow Characteristics

The USGS operates a river gaging station (USGS 13075500) in the City of Pocatello. The longest record of streamflows for the Portneuf River is at the stream gage in Pocatello, where an incomplete record was kept from 1897 through 1899 and 1911 through 1917. Continuous records have been maintained since 1917. The gage is located on the left bank of the river, immediately above Fremont Street Bridge. The average annual flow during the period of record is 299 cfs. The record instantaneous peak flow, 2,900 cfs, occurred February 14, 1962. The lowest daily mean flow of 0.23 cfs occurred July 19, 1979 (USGS, 2015).

The original Portneuf River flood frequencies were computed for winter rain floods and spring snowmelt floods. A complete curve was then developed from these two event types. Table 1 briefly summarizes values from the three frequency curves developed at that time (Corps, 1964).

Table 1. Probability Discharges, Portneuf River at Pocatello, Idaho (General Design Memorandum*)

Exceedance Probability Percent (%)	Discharge		
	Winter Rain	Spring Snowmelt	Composite
50	390	680	770
20	670	990	1,180
10	1,100	1,240	1,600
5	1,800	1,500	2,230
2	3,400	1.03-	3,650
1	5,400	2,320	5,500

*Corps, 1964

The runoff pattern of the Portneuf River at Pocatello is generally one of rising springtime flows, typically peaking from April to June, and receding to low flows by July. Flood peaks are generated by spring snowmelt, sometimes augmented by rainfall, and by rain on frozen ground in the winter months. The highest three floodflows experienced at Pocatello when the General Design Memorandum (GDM) was prepared all occurred in February. Winter floods are of comparatively lower duration and lesser volume than spring snowmelt events, but are capable of generating higher peaks (Corps, 1964).

6.4 Flood Frequency Revision

Portneuf River flood frequencies were computed for winter rain floods and spring snowmelt floods, and a composite curve was developed from these two curves for the GDM.

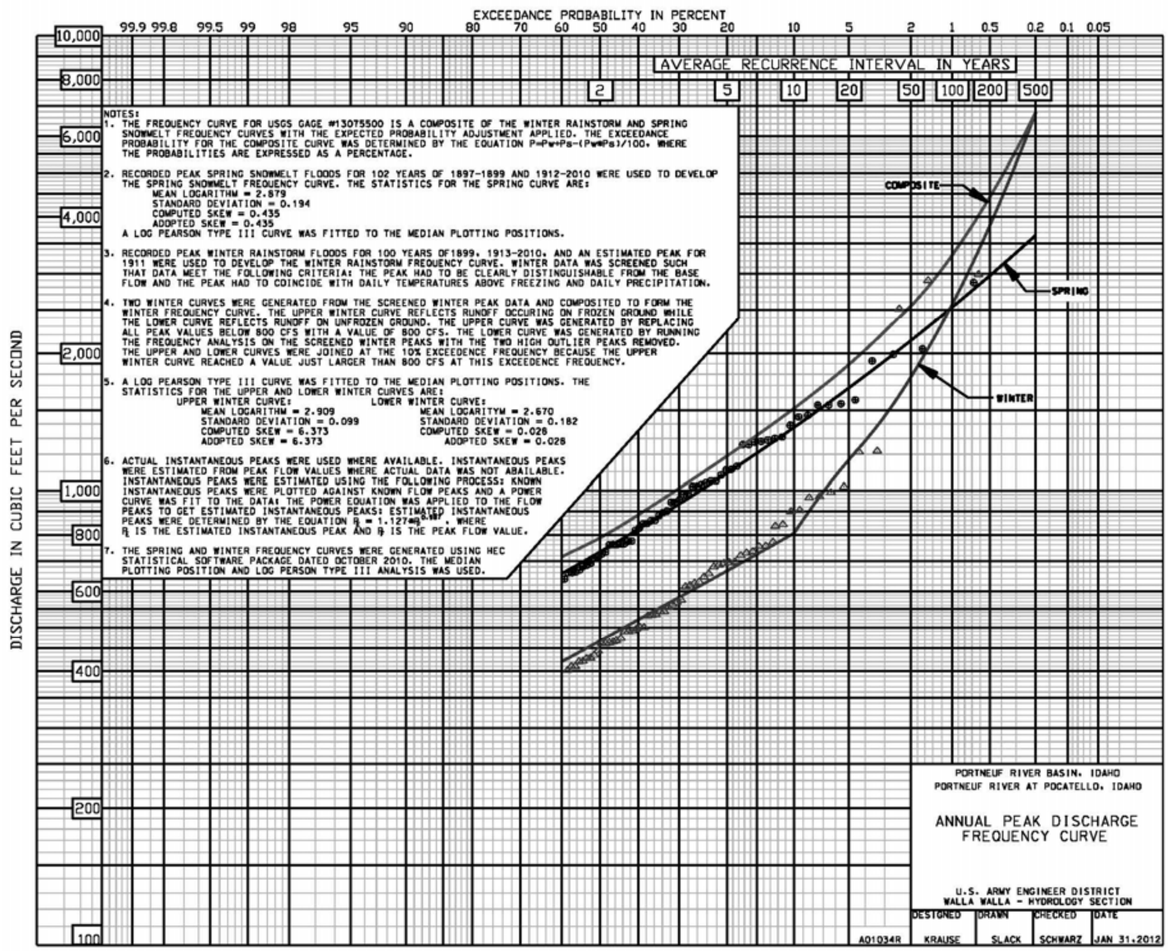
In 2012, the probability-discharge relationship was updated to capture the additional peak discharges measured since the 1964 flood-frequency analysis. The updated analysis used a Log-Pierson Type III analysis, following procedures outlined in Bulletin 178 (Interagency Committee on Water Data, 1981), and again developed relationships for winter rain events, spring snowmelt events, and a composite of the two. Table 2 summarizes the updated values from the three frequency curves developed, while Figure 4 shows the updated Portneuf River flood frequency curves (Corps, 2012).

Table 2. Updated Probability Discharges, Portneuf River at Pocatello, Idaho

Exceedance Probability Percent (%)	Discharge		
	Winter Rain	Spring Snowmelt	Composite
50	467	733	790
20	667	1,093	1,200
10	806	1,374	1,520
5	1,169	1,680	1,900
2	1,776	2.137	2,550
1	2,567	2,531	3,300

Corps, 2012

Figure 4. Portneuf River at Pocatello, Idaho, Updated Frequency Discharge Curves*



*Corps, 2012

Flood frequency curve comparison figures were created to better illustrate changes seen in peak flows, following the evaluation of additional years of record for the Portneuf River (Figures 5, 6, and 7). Clearly, the biggest change came from the winter storm events evaluation. The

2012 analysis is considered a much more reliable estimate of probability discharges, benefitting from not only a significantly longer period of record, but a more thorough analysis using more refined statistical and analytical techniques.

Figure 5. Winter Event Comparison

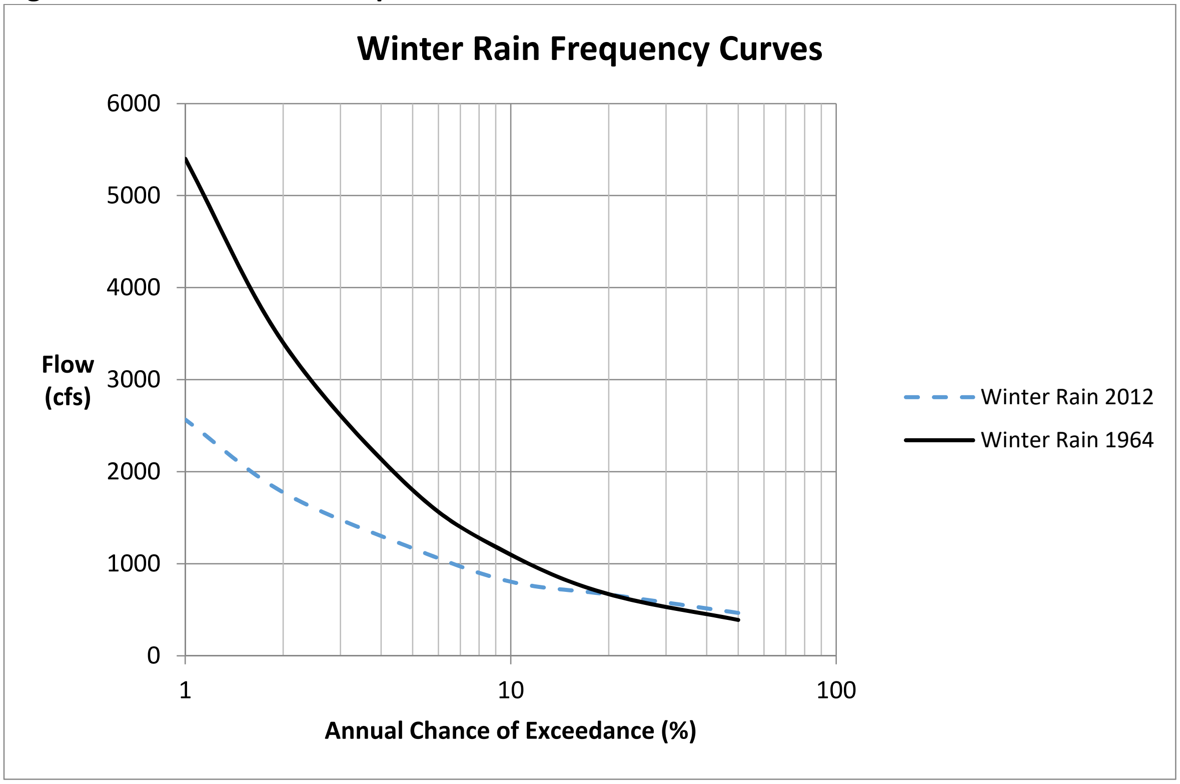


Figure 6. Spring Event Comparison

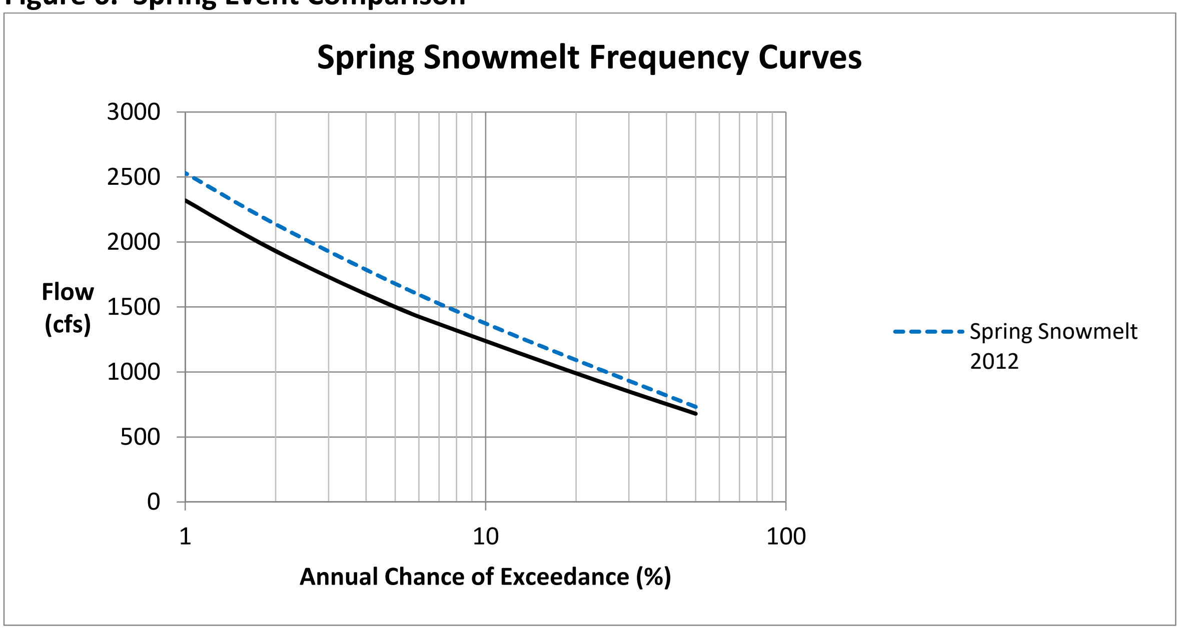
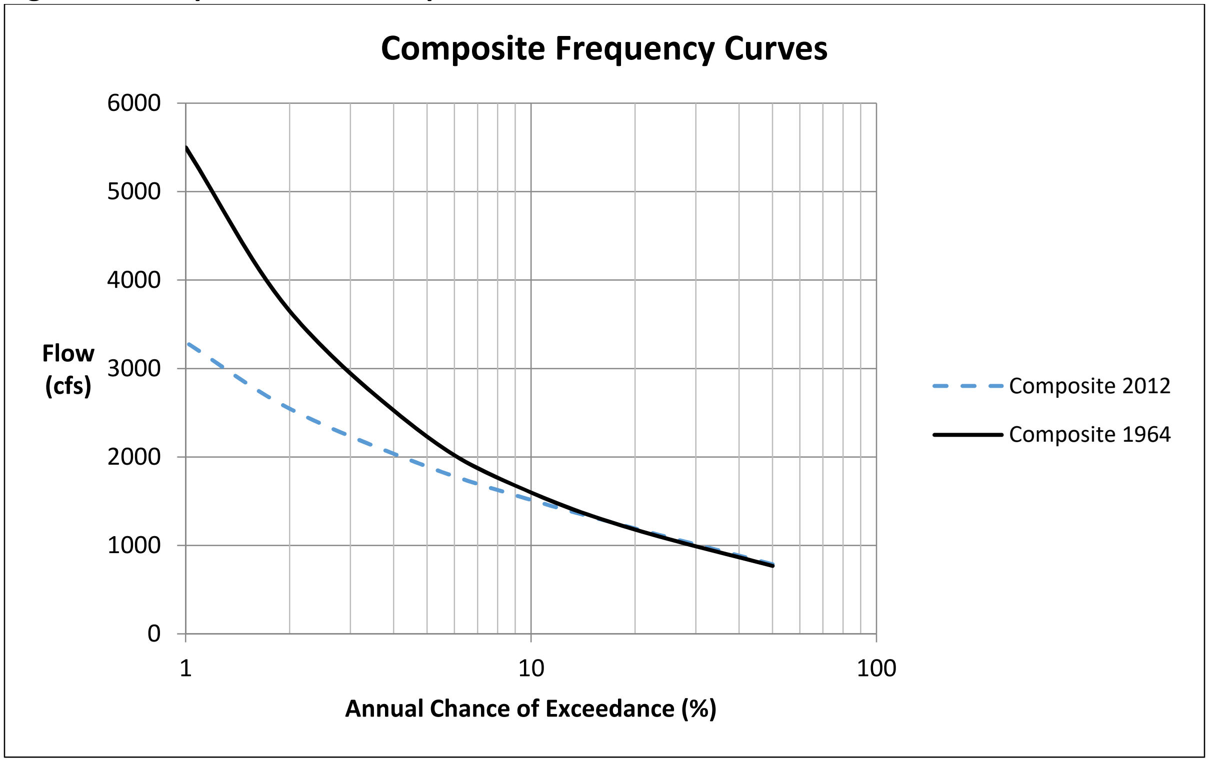


Figure 7. Composite Event Comparison



7. Hydraulic Analysis

7.1 Pocatello Unit Flood Control Project

The following description was summarized from the 1964 Corps report, *General Design Memorandum, Flood Control Project, Portneuf River, Idaho, Pocatello Unit*.

7.1.1 Channel Description

The project channel on the Portneuf River through Pocatello, Idaho, consists of three sections. At the upstream end of the project, an excavated channel starts at station 13+95, about 140 feet upstream of the Cheyenne Avenue bridge, southeast of Pocatello. The downstream portion of the excavated channel ends at station 179+65, upstream of Halliday Street. The rectangular concrete channel is 7,635 feet long. It begins just upstream of Halliday Street (station 179+65), where it has a trapezoidal-shaped entrance that matches the unlined channel upstream. This trapezoidal shape extends downstream for 5 feet, and transitions into a 40-foot-wide rectangular shape at station 180+00. The 40-foot rectangular channel extends 7,562.5 feet downstream to the exit transition, where the bottom width is increased from 40 feet (station 255+62.5) to 55 feet (station 256+00). The concrete channel ends at station 256+00 by utilizing wing walls placed normal to the channel centerline. Downstream, an excavated channel connects with the concrete channel at station 256+00, and ends at station 346+65. Both excavated channels (upstream and downstream of the concrete channel) are bounded by levees and riprap on the channel sides. Riprap is placed to prevent bank erosion, including channel bends above and below bridges and at channel transitions. Excavated channels are trapezoidal in cross section, with side slopes of 1 foot vertical to 2 feet horizontal.

7.1.2 Flow Conditions

The earthen channel is designed to carry the project design flow of 6,000 cfs, with 3 feet of freeboard. The concrete channel is designed to carry the same design flow at subcritical velocities to station 239+00, at supercritical velocities from station 239+00 to the stilling basin at station 252+60 (where a hydraulic jump will occur), and at subcritical velocities from the stilling basin to the end of the concrete reach.

The original 1964 GDM for the Pocatello Unit Project on the Portneuf River included a tabular list of representative hydraulic data for project design flow for the earthen and concrete channel reaches at selected locations (Table 3).

Table 3. Pocatello Unit Hydraulic Design Parameters

Stations (feet)	Invert		Mean Sectional Velocities (feet per second)	Depth (feet)
	Slope (feet/feet)	Width (feet)		
Earthen Channel				
15+45 – 38+85	0.00184	40	7.1 – 7.4	21.8 – 12.5
39+35 – 52+87	0.00184	45	5.9 – 6.5	14.0 – 12.8
53+37 – 93+00	0.000750	50	5.4 – 5.5	14.3 – 14.0
93+50 – 127+10	0.00120	40	6.2 – 7.1	14.1 – 12.8
128+10 – 165 +20	0.000694	60	5.1 – 5.4	13.0 – 13.6
165+70 – 179+65	0.000694	50	5.7 – 5.8	13.4 – 13.6
Concrete Channel				
256+00 – 262+76	0.00126	55	5.5 – 5.7	13.0 – 13.2
263+76 – 275+74	0.00126	60	4.8 – 5.1	13.4 – 14.1

Corps, 1964

Representative hydraulic data for the 6,000 cfs design flows, as estimated for select bridges across the river, are shown in Table 4.

For the 6,000 cfs design flow, water would be expected to overbank at the two Highway 30 bridges downstream of the Pocatello Unit project. The bridge at station 304+69 would carry 5,800 cfs, with 200 cfs of overbank; and the bridge at station 326+25 would carry 3,800 cfs, with 2,200 cfs of overbank.

Table 4. Hydraulic Parameters at Bridge

Bridge	Station	Width (feet)	Design Water Surface (feet) (NGVD29)	Mean Velocity for Design Flow (feet per second)
Cheyenne Avenue	15+30	70	4464.7	7.8
Cottonwood foot	271+25	61	4431.9	7.2
Highway 30	304+69	90	4430.6	5.7
Highway 30	326+25	90	4430.0	5.2

Corps, 1964

7.2 The 2009 Hydrologic Engineering Center-River Analysis System (HEC-RAS) Model

A relatively current HEC-RAS model was built for the concrete hydraulic design channel in 2009, and was available for use in the current study. Hydraulic results from the model for the concrete channel are shown in Table 5.

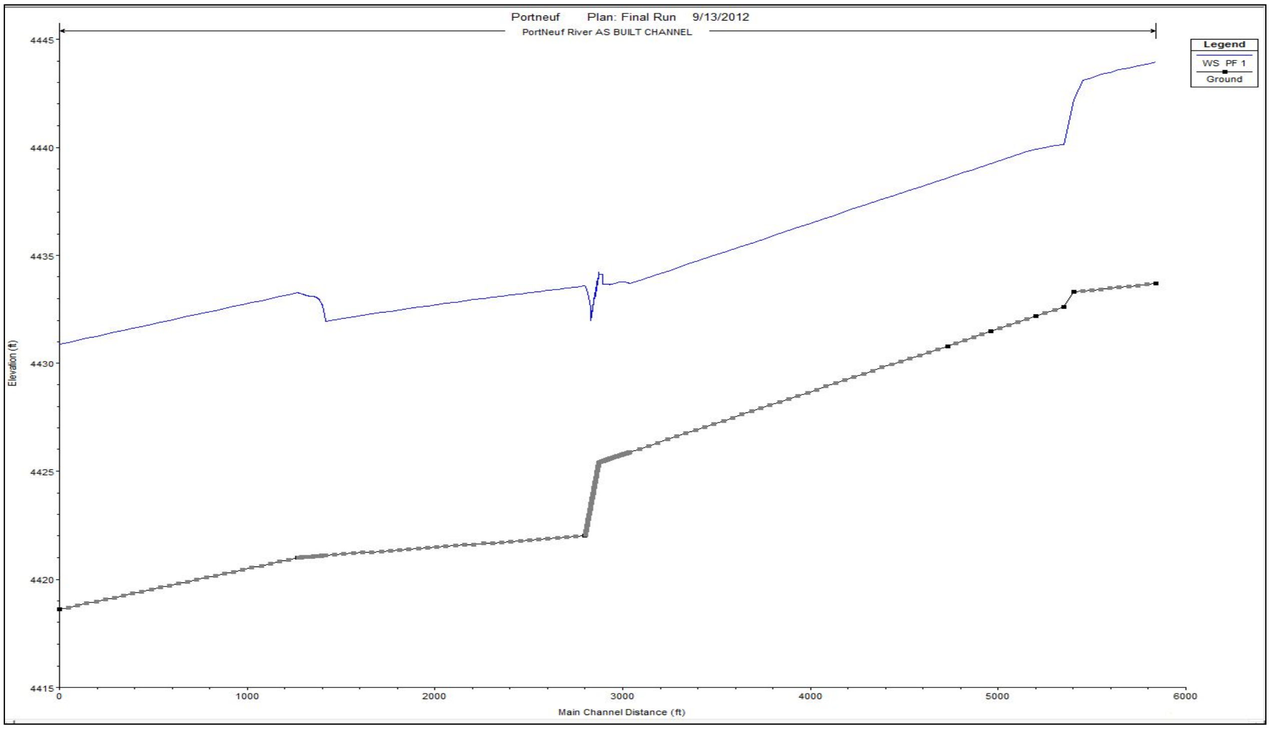
Table 5. HEC-RAS Model Output*

River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
211+60	PF 1	6000	4433.7	4443.96	4442.62	4447.28	0.001276	14.63	410.2	40.01	0.81
216+00	PF 1	6000	4433.3	4442.2	4442.2	4446.62	0.001926	16.86	355.92	40.01	1
216+50	PF 1	6000	4432.6	4440.11	4441.52	4446.31	0.003185	19.99	300.1	40.01	1.29
218+00	PF 1	6000	4432.2	4439.92	4441.12	4445.79	0.002935	19.45	308.48	40.01	1.23
220+40	PF 1	6000	4431.5	4439.24	4440.42	4445.08	0.002904	19.38	309.57	40.01	1.23
222+70	PF 1	6000	4430.8	4438.58	4439.7	4444.36	0.002866	19.3	310.95	40.01	1.22
239+62 Custer St.	PF 1	6000	4425.88	4433.7	4434.78	4439.42	0.00282	19.19	312.67	40.01	1.21
240+12 Custer St.	PF 1	6000	4425.74	4433.78	4434.66	4439.19	0.002602	18.67	321.3	40.01	1.16
240+66 Custer St.	PF 1	6000	4425.58	4433.65	4434.5	4439.02	0.002572	18.6	322.55	40.01	1.15
241+16 Custer St.	PF 1	6000	4425.43	4434.12	4434.35	4438.75	0.002069	17.27	347.35	40.01	1.03
241+27 Nr. Custer St.	PF 1	6000	4425.4	4434.12	4434.3	4438.72	0.002044	17.2	348.79	40.01	1.03
242+00 Nr. Custe	PF 1	6000	4422	4433.58		4436.19	0.000901	12.95	463.18	40.01	0.67
255+83 Begin Tra	PF 1	6000	4421.1	4431.93		4434.91	0.001091	13.85	433.21	40.01	0.74
257+30 End Concr	PF 1	6000	4421	4433.28		4434.17	0.000259	7.57	792.26	89.1	0.45
257+29 Start Rip	PF 1	6000	4421	4433.28		4434.17	0.001879	7.57	792.22	89.1	0.45
270+00 Nr. MAple	PF 1	6000	4418.6	4430.89	4426.38	4431.78	0.001873	7.56	793.18	89.14	0.45

*NWW, 2009

The concrete channel water surface profile, with a flowrate of 6,000 cfs, shows that a hydraulic jump would occur between stations 216+00 and 241+27. Subcritical flows would be expected at stations 211+60 and 241+27, respectively, above and below the segment where supercritical regimes exist. The locations of transitions in flow conditions concur with the theoretical results found in the Portneuf River GDM (Corps, 1964) described in this report. The water surface profile plot shown below (Figure 8) illustrates critical flow transition phenomena.

Figure 8. The HEC-RAS 6,000 cfs Profile



Corps, 1964

The 2000 HEC-RAS model indicates velocities substantially greater than the velocities listed in the 1964 GDM (Corps). Concrete channel velocities range between 13.85 fps and 7.6 fps during and after the hydraulic jump, compared to the GDM range between 5.7 fps and 4.8 fps.

7.3 Hydraulic Modeling of Alternatives with Conceptual Channel Geometry Modifications

The existing HEC-RAS model of the as-built channel (2009) was used as the starting point for the hydraulic analysis of the current study. The as-built model started approximately 1,269 feet below the downstream end of the concrete channel, but the model only covered approximately 60% (4,566 feet) of the 7,800-linear-foot concrete channel. In addition, the 2009 model did not cover any levee improvements upstream of the concrete channel.

The existing as-built model was modified for the current PAS study to simulate features of the three conceptual projects to assess potential feasibility and performance. The current modifications consisted of adding cross sections to model the upper part of the concrete channel, additional cross sections at the bridge-crossing locations along the concrete channel, and cross sections to model the upper section of the channel protected by levees. Once the new cross sections were added, the HEC-RAS model was run to establish baseline conditions (without project conditions) for the three proposed modifications to the existing channel.

7.3.1 Project 10 – Rainey/Centennial Park

Centennial Park is located next to the intersection of South Arthur Avenue and West Putnam Street, approximately 900 feet upstream of the beginning of the concrete channel. Facilities at the park consist of a baseball field with bleachers, parking, a pedestrian bridge crossing the river, and restroom facilities. The Pocatello Community Charter School is located next to and upstream of the park. The Portneuf River is located immediately west of the park, and is constrained by levees at this location. The proposed modifications will set the right bank levee (orientations are looking downstream) back from the active river channel and convert the existing ball field into a low overbank/wetland area that would be inundated during events greater than the 50% probability (2-year average return frequency) event. Existing private property, located adjacent to the left bank levee (looking downstream), is assumed to preclude realignment of the left levee.

The existing right levee would be removed and reconstructed. The levee setback from the river would allow land between the levee and the river to be inundated during event peak discharges greater than the 50% probability event (approximately 800 cfs). The conceptual setback would begin near West Terry Street, extend upstream, approximately crossing the current location of the pitcher's mound, and arc back towards the river to intersect the existing levee at the existing foot bridge. This alignment was selected to provide as large an area as possible for the low overbank/wetland area, while still maintaining the existing foot bridge. Approximately 30,000 to 40,000 cubic yards of material would need to be removed to lower the ground surface and allow events less frequent than the 50%-probability event to cause inundation. Depending on the properties of the excavated material, it may be possible to use some of it in constructing the new levee. Excess material and material not suitable for new levee construction would be hauled to a disposal site, Google Earth shows old gravel pits located along the Portneuf river, within approximately 5 miles of Centennial Park. It may be possible to dispose of excess material in these old gravel mines.

The results of the HEC-RAS model indicate a partial inundation of the constructed low/wetland area occurring during the 20% probability (5-year average return frequency) event of about 1,200 cfs, and a full inundation of the constructed area occurring during the 5% probability (20-year average return frequency) event peak of approximately 1,900 cfs. Figure 9 is a cross-section of the levee setback section of the Rainey-Centennial Park concept, while Figure 10 is an artist's rendition of the Rainey-Centennial Park concept. The orange "A" on Figure 10 indicates the location of the cross-section.

Figure 9. Rainey-Centennial Park Levee Setback Cross-Section

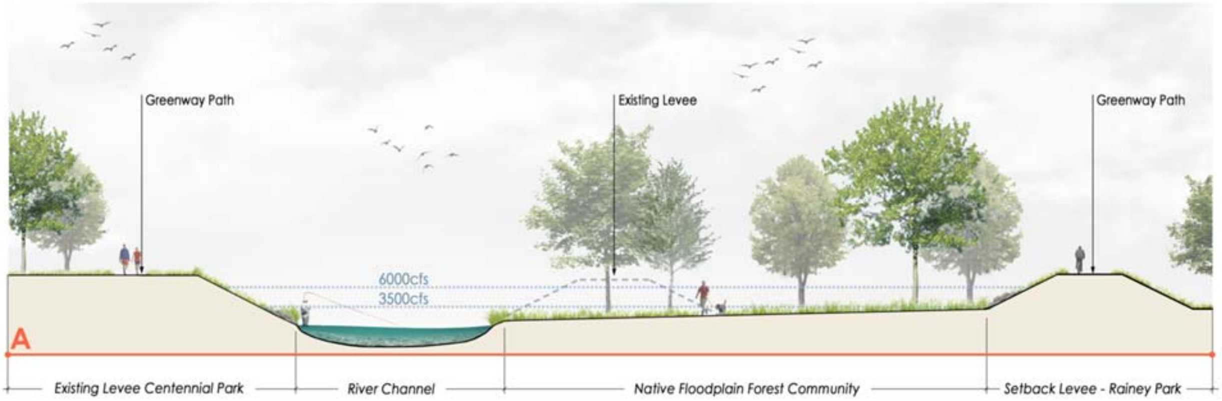


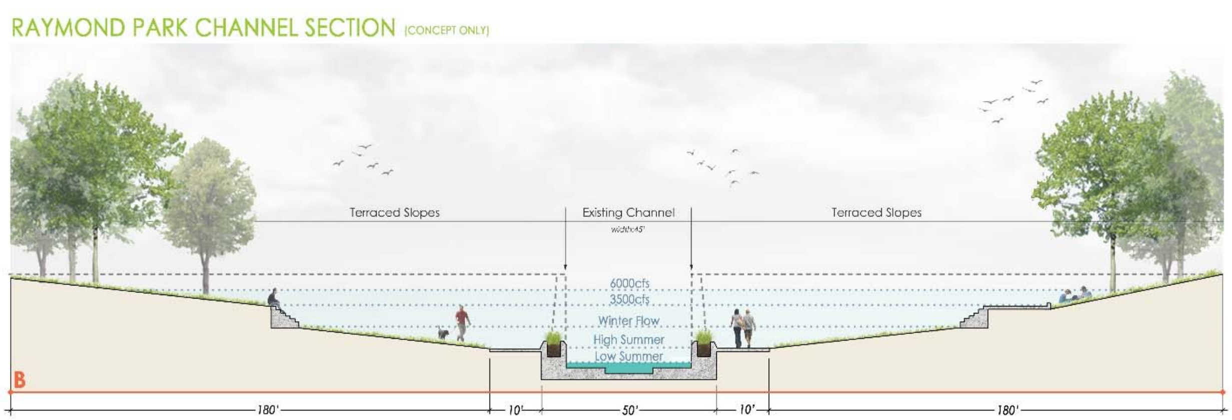
Figure 10. Rainey-Centennial Park Concept Showing Cross-Section

7.3.2 Project 15 – Raymond Park

Raymond Park occupies the majority of a rectangle bounded on the north by Trail Creek Road/Riverside Drive/Carson Street, on the south by West Custer Street, on the east by North Grant Avenue, and on the west by Riverside Drive. The remainder of this rectangular area is comprised of several private residences in the southwest corner of the rectangle. The Portneuf River enters the park from the south at West Custer Street. Approximately 1,100 feet later, the river exits the park on the north by passing beneath Trail Creek Road/Riverside Drive/Carson Street. The river channel, which bisects the park, is a rectangular concrete channel with a 40-foot bottom width and depth in excess of 20 feet. At 6,000 cfs, the design discharge of the original channel, flow velocity is approximately 13 fps under current conditions. Park facilities consist of an open field, field house, and tennis court on the right side of the channel, and an open-sided shade structure, concrete walkway, children's play area, picnic tables, benches, and restroom facilities on the left side of the channel. Proposed modifications to this section of the channel would provide a low flow channel, adjacent walkways, and tiered concrete seating steps to facilitate river access and extended floodplain. The private homes in the southwest corner of the park were considered a constraint to expansion of the floodplain, requiring that the existing left channel wall next to the homes be preserved.

Discussion with a landscape architect on the PDT indicated Pocatello residents would like to have river access on both channel banks. Desired river access would impact the existing tennis court and ball field on the right bank and, potentially, the shade structure and play area on the left bank. Figures 11 and 12 show the proposed channel section and approximate disturbed area within the park.

Figure 11. Proposed Channel Section



One-dimensional hydraulic modeling was performed with HEC-RAS 4.1.0 for the river reach adjacent to Raymond Park. The modeling used an existing HEC-RAS model of the as-built conditions of the lower 4,566 feet of the concrete channel. This existing model was extended to cover all of the concrete channel, using as-built drawings obtained from archives of the Corps, Walla Walla District. Above the concrete channel, the HEC-RAS model was extended, using sections obtained from a levee capacity study conducted in 2008 (Corps, unpublished).

Figure 12. Approximate Disturbed Area within Raymond Park

Downstream of the concrete section, it was assumed regular vegetative maintenance will be performed on the channel banks. Because of the assumed regular maintenance, a Manning's roughness coefficient of 0.035 was used in the model. If regular maintenance is not performed or a more densely-planed landscaping approach was used, the water surface elevation (WSE) in the modified Raymond Park area would be higher than those calculated in this exercise.

The river section through Raymond Park is part of the rectangular concrete channel that constitutes a portion of the Federal flood control project. A drop structure is located downstream of Custer Street Bridge. The drop structure has a slope of approximately 4.66%, and falls 3.4 feet over a distance of approximately 73 feet. The slope of the channel below the drop structure is 0.065%. It was assumed that the existing channel above the drop structure would be unchanged. Velocities in the existing channel in Raymond Park are in excess of 13 fps, with flow depths between 11 and 12 feet at a discharge of 6,000 cfs. Flow is subcritical, with a Froude number (ratio of flow inertial to gravitational forces) of approximately 0.7.

The City of Pocatello provided a sketch conceptually showing the desired Raymond Park improvements. The concept consists of a low flow channel flanked, on either side, by a planter, walkway, and seating steps. From the top of the seating steps, the concept drawings show turfed ground, with interspersed trees sloping to catch the existing ground.

Several variations of the Raymond Park shoreline modifications shown in Figure 11 were modeled to provide flow conditions for several shoreline design scenarios. In all cases, the preliminary hydraulic analysis shows that proposed improvements result in an increase in the WSE within Raymond Park and for approximately 2,500 feet upstream of the proposed improvements. The maximum increase in WSE is approximately 9 feet at the downstream end of the drop structure, with increases of approximately 4.4 feet continuing over the remainder of the improvements. All increases are below the estimated maximum channel top elevation.

The hydraulic modeling, again performed with HEC-RAS version 4.1.0, was one-dimensional. The modeling was performed to determine if it would be possible for conceptual improvements to be constructed without adversely impacting channel conveyance or surrounding properties. Based on this preliminary effort, the improvements do not appear infeasible. However, the hydraulic environment of Raymond Park is complex. Flow enters the park in a 40-foot-wide rectangular channel after passing beneath the bridge at West Custer Street. About 90 feet farther downstream, the channel bottom drops. At this drop, proposed improvements would widen quickly to allow the maximum amount of river access and floodplain expansion. Approximately 300 feet downstream of the drop and the start of the right bank expansion, the expansion of the left bank begins. Finally, 650 feet downstream of the beginning of the left bank expansion, both the left and right bank expansions terminate, and the channel must return to the 40-foot-wide rectangular section to exit the park at Trail Creek Road/Riverside Drive/Carson Street. The one-dimensional model used in this conceptual study is inadequate to accurately model the behavior of flow in an area as complex as Raymond Park. Because of the complexity of the hydraulic environment, it is recommended that multi-dimensional modeling of the proposed improvements be performed for subsequent design activities, should this concept be pursued.

7.3.3 Project 11 – Concrete Channel Streambank Restoration and Greenway

The concrete channel, other than at the transition area (e.g., into and out of the concrete section), is presently rectangular in shape, with a 40-foot bottom width. During low flow periods, the depth of flow in the 40-foot-wide rectangular channel is quite shallow, typically less than 0.5 foot. When low flows occur, as is common during summer months, the water is subject to warming. This warming can have negative effects on many aquatic species. The shallow flow depth also acts as a banner to fish movement. In an effort to reduce warming and allow deeper flow depths, the construction of a low flow channel was proposed.

Two drop structures in the concrete channel section effectively divide the concrete channel into three sections, each with a different slope. The first drop occurs between model cross-sections 990 and 980, about 350 feet downstream of West Freemont Street. The channel bottom drops 0.7 feet in that location. The second drop occurs between model cross sections 930 and 940, approximately 90 feet downstream of West Custer Street, where the channel drops 3.4 feet. Table 6 lists the three concrete channel sections, section length, and slope.

Table 6. Concrete Channel Geometry

Upstream Cross Section Number	Downstream Cross Section Number	Length Between Cross Sections	Upstream Cross Section Elevation (feet)	Downstream Cross Section Elevation (feet)	Slope (feet/feet)
1135	990	3675.01	4438.0	4433.1	0.00133
980	940	2527.89	4432.6	4425.4	0.00285
930	910	1524.60	4422.0	4421.0	0.00066

Two low flow insert sections were developed using information contained in Table 6, guidance provided by the City of Pocatello to use a 30-cfs discharge for the low flow, and the need to convey flows through the low flow sections. The first low flow section would be located between the start of the concrete channel and cross-section 990, while the second low flow channel section would be located within the channel section, between 980 and 940. Between cross-section 930 and the terminus of the concrete channel, a low flow section was not developed because there is insufficient fall in the channel to allow a low flow channel to daylight by the end of the concrete channel.

It was assumed the bottom of the low flow inset channels would be roughened to mimic a natural rocky channel bottom and more favorable aquatic habitat conditions. The first channel section, covering model cross-sections 1135 (upstream end of the concrete channel) to 990 (approximately 250 feet downstream of Fremont Street Bridge) would include a 13-foot-wide by 2-foot-deep inset, with a capacity of approximately 50 cfs. The second inset section, covering model cross-sections 980 to 940 (approximately 60 feet downstream of West Custer Street) would be 13 feet wide and 1.5 feet deep, also with a capacity of approximately 50 cfs. It was assumed the low flow sections would be constructed below the bottom of the existing channel to preserve the conveyance capacity of the concrete channel.

The proposed configuration would necessitate diverting channel flow during construction, saw cutting the bottom of the existing channel, removing material to allow access for construction of the low flow channel, and constructing the low flow channel. Approximately 3,600 cubic yards and 1,800 cubic yards of material would be removed from the upper end and middle sections of the channel, respectively.

Below the lower drop structure, at model cross section 930, the lower section of the concrete channel presents a challenge due to the low slope, 0.00066 feet per foot, and proximity to the end of the concrete channel. It would not be possible to excavate a low flow section in the lower portion of the concrete channel, as the bottom of the low flow would be lower than the natural channel downstream of the concrete channel, thus creating an area that would not drain effectively. If an important objective goal of the low flow channel is to provide biological connectivity, the lack of a low flow section in the lower portion of the channel would make construction of a low flow in the upper portion of the channel a challenging undertaking. Further discussion of this topic will occur later in this appendix.

The hydraulic analysis of departures from the baseline (without project) condition for the low flow channel concept shows an increase in the WSE throughout the range of sections impacted by the low flow improvements and for a distance of approximately 2.7 miles upstream of the start of the concrete channel. The maximum increase in the WSE upstream of the concrete channel is approximately 7 inches at the original design discharge of 6,000 cfs. However, for the majority of the upstream reach, approximately 2.5 miles, the increase in WSE is less than 4 inches. Within the concrete section, the maximum increase in WSE is 1.76 feet, which occurs near the start of the concrete channel, at model cross-section 1105.

Several bridges cross the rectangular portion of the concrete channel. Table 7 contains bridge street names, hydraulic model cross-section numbers at the bridges, minimum bridge elevations, WSEs on the as-built plans, and the compounded WSEs (calculated by the hydraulic model at several different flows.

Table 7. The Water Surface Elevation at Bridges

Bridge	Cross-Section Number	Plan WSE (feet)	Minimum Bridge Elevation (feet)	6,000 cfs WSE (feet)	5,500 cfs WSE (feet)	5,000 cfs WSE (feet)	4,500 cfs WSE (feet)
Benton[1]	1005			4,449.00	4,448.35	4,447.67	4,446.97
Whitman	1004	4,447.6	4,449.1	4,448.39	4,447.75	4,447.08	4,446.39
Lewis	1003	4,446.5	4,447.8	4,446.98	4,446.39	4,445.72	4,445.05
Center	1002	4,446.2	4,451.1	4,446.29	4,445.69	4,445.06	4,444.40
Clark	1001	4,444.4	4,445.3	4,445.54	,4,444.94	4,444.33	4,443.69
Fremont[2]	995	Missing	Missing	4,443.72	4,443.17	4,442.59	4,441.98
Custer	947	4,434.0	4,436.4	4,435.48	4,434.95	4,434.40	4,433.80
Trail/Riverside/Carson	925	4,436.6	4,439.0	4,432.29	4,431.88	4,431.45	4,430.96

[1]Not in as-built plans.
[2]Plan Set missing Sheet 66

At 6,000 cfs, the design flow of the original channel, the proposed roughened low flow channel would result in a WSE in the channel greater than the minimum bridge elevation at Clark Street. However, the discharge from the 1% probability storm event, determined at the time of construction, was 5,500 cfs, which is not greater than the minimum bridge elevation at Clark Street. Therefore, it appears that the previously estimated 1% peak discharge could be conveyed within the height provided by the Clark Street Bridge. Preserving the 6,000 cfs, however, would be a challenge for construction of the low flow channel. It is worth noting that the more recent hydrologic analyses determined the discharge from the 1% probability storm event is in the range of about 3,500 cfs.

At a discharge of 5,500 cfs, the WSE resulting from the roughened low flow channel would be below the minimum low chord elevation of all bridges for which information is available. At a discharge of 4,500 cfs, the WSE in the channel resulting from the roughened low flow channel is lower than the design (current conditions) WSE at all bridges.

7.4 Hydraulic Analysis Discussion

The proposed low flow modifications would impact the current level of flood risk management provided by the Federal project. Implementation may be possible, but would require the Corps and the City of Pocatello to accept a lower level of flood protection than currently provided by the channel. One other point that requires consideration, however, is the purpose of the low flow channel. Construction of a low flow channel between the upstream end of the concrete channel and the drop structure downstream of West Custer Street appears feasible. Between the terminus of the concrete channel and the lower drop structure, constructing an incised low flow section is not practical, as previously described, unless the channel downstream of the concrete channel is also modified. The downstream modification would be required to permit the incised low flow channel to transition to the natural grade of the river. The lack of a low flow section in the final portion of the concrete channel would likely act as a barrier to the movement of some aquatic species. There are potential technical solutions to this fish barrier issue, but there were not examined under this PAS study.

8 Sedimentation

The portion of the Portneuf River within what is now the concrete channel was observed to be turbid during fisheries studies at the site in 1967. A second river station about 2 miles downstream of the lower end of the project area was observed to be turbid year round. Both observations appear to reflect the effects of sediment loading to the river that continues to occur throughout much of the drainage. Sediment loading to the lower Portneuf River exceeds the flushing capabilities of the river, resulting in river bottom sedimentation during low streamflows. Sediments and flood debris transported by the relatively lower velocities in the reach immediately upstream of the Pocatello Unit project are generally carried on through the project in its current configuration, if they enter it, due to significantly higher velocities and associated transport energy. Site drainage into the project, however, can deposit cobbles, gravel, and other sediment into the improvement channel (Corps, 1967).

The 2010 TMDL document (IDEQ) contains considerable information regarding suspended sediment within the Portneuf River near Pocatello, Idaho. Of note s Table 2.1 from that report, which summarizes water quality status for numerous water bodies at three points in time: 1996, 1998, and the current period (e.g., 2010). A cursory review of the table suggests there are periods of higher suspended sediment levels and accelerated bank erosion at numerous sites within the Pocatello area.

8.1 Sedimentation Impacts of the Proposed Modifications

In order to assess the character of changes to the sedimentation regime associated with proposed concepts, a simple sediment continuity analysis was performed. This analysis compared a representative inflowing sediment supply based on sediment transport capacity with that of the modified sections. This allowed characterization of potential changes in sediment transport, and how they might affect operation and maintenance of the channel. For example, if the transport capacity of the sediment supply coming into the reach was substantially greater than the modified reach, deposition of sediment would likely occur, requiring periodic removal to restore conveyance capacity and functionality.

The definitive sediment size distribution for the Portneuf River through Pocatello, Idaho, is not currently available. However, there is evidence to suggest that streambed materials consist primarily of silt and fine-grained sand (Corps, 1968; Corps, 1964; USGS, 2016; and personal communication, 2015). Visual interpretation of field visits was also consistent with these findings (Figure 13, DSC0397). A reasonable estimate of the median sediment size is available from the USGS water data repository (accessed in 2016). The USGS water data repository houses data from a study at Pocatello on the Portneuf River conducted in 1992. This study found that 55% of the sediment (by weight) passed a sieve size of 0.0625 millimeters (mm). At a gage on the Portneuf River in Topaz, Idaho, upstream of Pocatello, several sets of sediment samples were collected by the USGS in the early 1990s. These samples hold similar percent-finer values for the 0.0625-mm sieve as those found in Pocatello during the same timeframe. The Topaz, Idaho, data sets also found that roughly 15% to 20% of sediment samples were within the range of fine sands (52% finer by weight than sieve size 0.0625 mm, 80% finer than 0.125 mm, 96% finer than 0.25mm and 100% finer than 0.5 mm). Therefore, for purposes of this study, the team assumed a median sieve size diameter (d_{10}) of 0.0625 mm. The team also assumed there would be some fine sands transported into the river reaches at Pocatello.

Figure 13. Fine-Grained Sediments, Edson-Fichter Nature Area

The hydraulic models described above (Sections 7.2 and 7.3) were run with a large range of potential flow rates to determine the flow rate range and critical flow rates for the geometrical transitions of the proposed modified channels. The proposed channel modifications were designed with hydraulic, aesthetic, and desired services in mind. Therefore, to determine how sediment would respond in the modified reaches, flow rates that occur at transitions of the channel geometry must be modeled. Ten flow rates between 25 and 3000 cfs (25, 50, 200, 500, 750, 1000, 1300, 1450, 2000, and 3000 cfs) were chosen to represent all transitions in the flow geometry for all proposed channel modifications to the Portneuf River in Pocatello, Idaho. This flow rate range does not necessarily encapsulate all potential or likely flow rates in the river, but was chosen to account for the most significant geometric transitions in the river cross-section shapes that would affect sediment transport and deposition. These ten flow rates were run in the one-dimensional hydraulic model for both existing (baseline) conditions and proposed modifications to Raymond Park, Rainey/Centennial Park, and the concrete channel low flow restoration. The model results were used to determine flow characteristics at those flow rates affecting sediment transport (e.g., water velocity, flow depth, river top width, and slope of the energy grade line). These hydraulic parameters, in turn, were then used to create sediment transport rating curves to represent transport rates over the range of discharges.

Selecting a sediment transport function for mobile-bed river modeling is an extensive exercise, requiring significant sources of data to calibrate behaviors. Because this was beyond the scope of the current study, three different sediment transport functions were selected for the range of hydraulic and sediment conditions in the Portneuf River to assess likely trends that could be expected with the proposed modifications. These transport functions were used effectively in other studies. Employing the three different sediment transport functions allowed the study team to test the sensitivity of results to the transport function. The three sediment transport functions selected are:

- Engelund (Hansen) (1967) – A version of Engelund-Hansen median grain-size function modified by Waterways Experiment Station to perform multiple grain-size calculations on sand bed streams
- Laursen (Copeland) (Copeland and Thomas, 1989) – A modification of Laursen's (1958) multiple grain-size function, extending its range to larger gravel sizes
- Yang d_{50} – A single grain-size function for sand and gravel transport in streams and small rivers

The hydraulic characteristics modeled in the channel were combined with the characteristics of sediment in the river to determine likely sediment yield for a typical flow year. A flow-duration curve was calculated using the 15-minute flow rate values for water years 1993 through 2015, from the USGS 1375500 gaging station measurements of the Portneuf River in the City of Pocatello, as described in Section 6.3. Twenty-five discharge clauses were used to characterize flow-duration distribution between the 36 cfs and 21393 cfs. A specific weight for the sediment was estimated to be 83 pounds per cubic foot, given the distribution of sediment sizes entering the river. The flow-duration distribution was combined with the sediment transport rating curves, and integrated to create sediment yield estimates of both current channel conditions and proposed modifications to the Portneuf River. Sediment yields provide an estimate of the amount of sediment that could be transported over a typical year under varying flow conditions, for various hydraulic geometries. Comparing sediment transport yields of adjacent reaches provides insight into the likely response of the channel. For example, if computed sediment yield of an upstream reach of the channel is greater than the sediment yield of the channel reach downstream, the excess sediment would be expected to deposit within the downstream reach.

The computation of sediment yield values involved an approximation of the flow-duration curve. The curve was divided into a series of flow intervals, and the intervals were integrated with sediment transport rating values for the mean discharge of the flow interval. Note that the *x-axis* of the flow-duration curve is delineated in percent-exceedance. Flow intervals, thereby, included a percentage of time the discharge was likely to occur over the year. These are then summed to account for the full probability range (e.g., 100% of the time period) to determine the yield. Examination of the interval computations can also yield insight into sedimentation behavior. Plotting sediment flux values for the intervals typically produces a distribution over the flow-interval range that rises, peaks, and falls over the flow range (Figure 14). The discharge interval corresponding with the peak sediment flux represents the discharge class that performed the most sediment transport work in the channel, in terms of frequency of occurrence and transport energy. This quantitatively-determined discharge interval performing the most work is known as the *effective discharge*. It is often used as a surrogate for the theoretical concept of a *channel forming discharge* (a constant discharge value that would produce the same channel geometry as the actual variable discharges). This phenomenon is effectively illustrated by observing depositional features that have developed in the upstream reach of the Portneuf River's Pocatello Unit, where an inset low-flow channel has formed between the levees (Figure 15). Effective discharge can be an important metric for assessing stability for channel restoration. While this metric is less important for the hard-lined channel geometries evaluated in this planning study, it does provide some indication of whether or not the sedimentation behavior will be significantly changed by the modifications. For all of the modifications proposed in this study, the effective discharge of the river was not altered from that of the existing conditions, indicating that transport behavior during the most consequential flows would be preserved with the modified geometries of proposed features.

The overall transport capacity of sediment for Centennial Park would be altered by the proposed changes to the channel. However, these changes are not likely to have an impact on the channel. Figure 16 shows transport capacity over an average year for the existing conditions of the park, along with the transport capacity of the reach upstream of the park for the three selected sediment transport equations. The absolute magnitudes of the transport capacities for the different equations very significantly, though the trends are consistent when comparing the individual function's transport capacities for the upstream supply and Centennial Park reaches. The message provided by this plot is not the absolute values but, rather, the trends. Figure 16 shows the transport capacity of the current channel in Centennial Park is much higher than the amount of sediment that could be supplied to the reach. Therefore, it is likely that all sediment that reaches this point in the river is transported through Centennial Park. Figure 17 shows sediment yield projections for proposed modifications of Centennial Park. There would not likely be appreciable sediment deposition within the park following implementation of the proposed modifications.

Figure 14. Sediment Transport Function/Flow Duration Integration

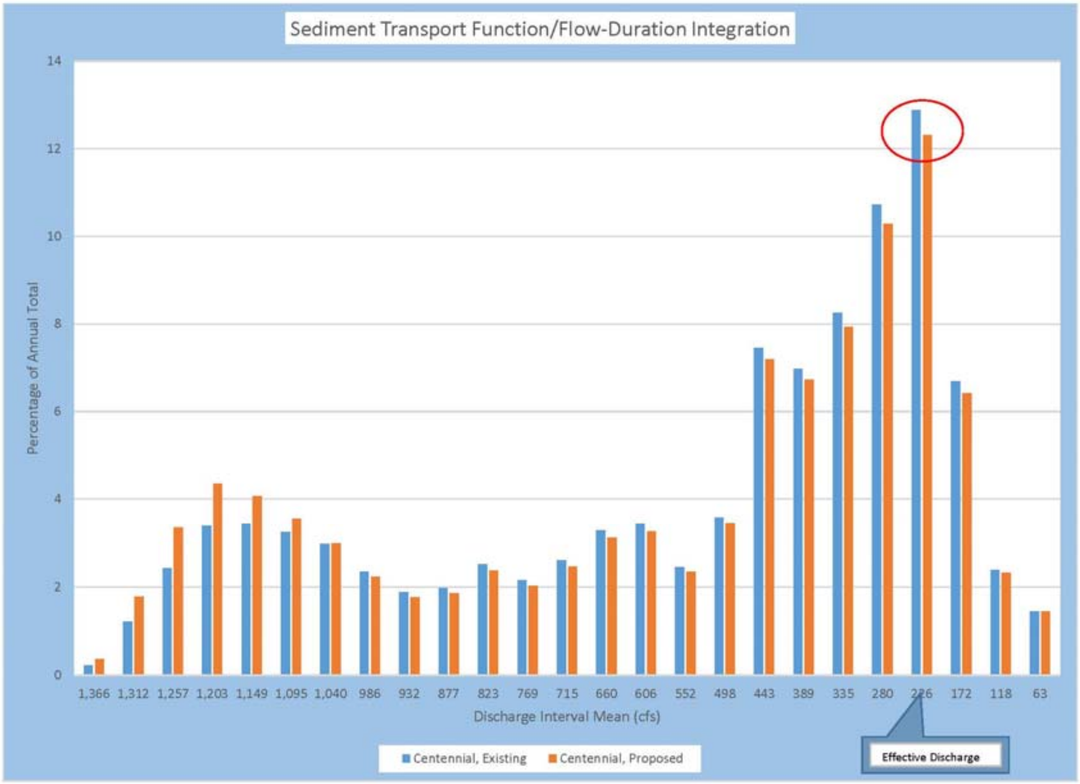


Figure 15. Channel Capacity Cross-Section, Upstream Reach of the Portneuf River

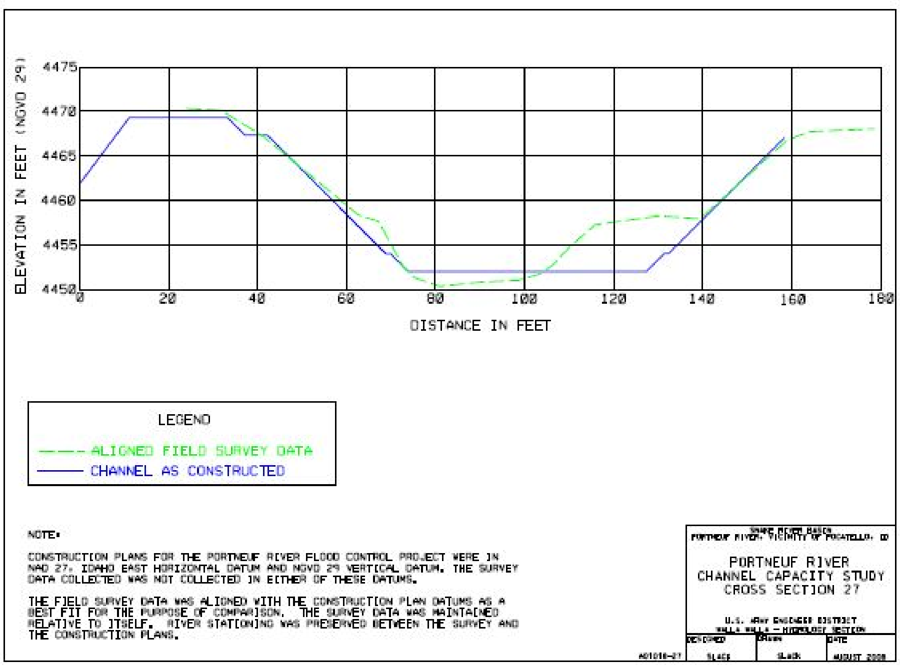
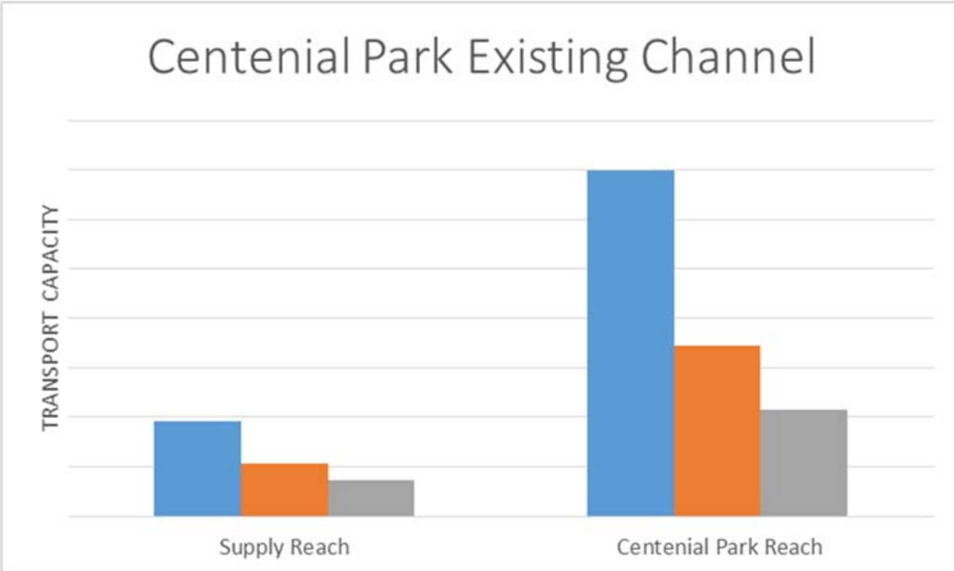
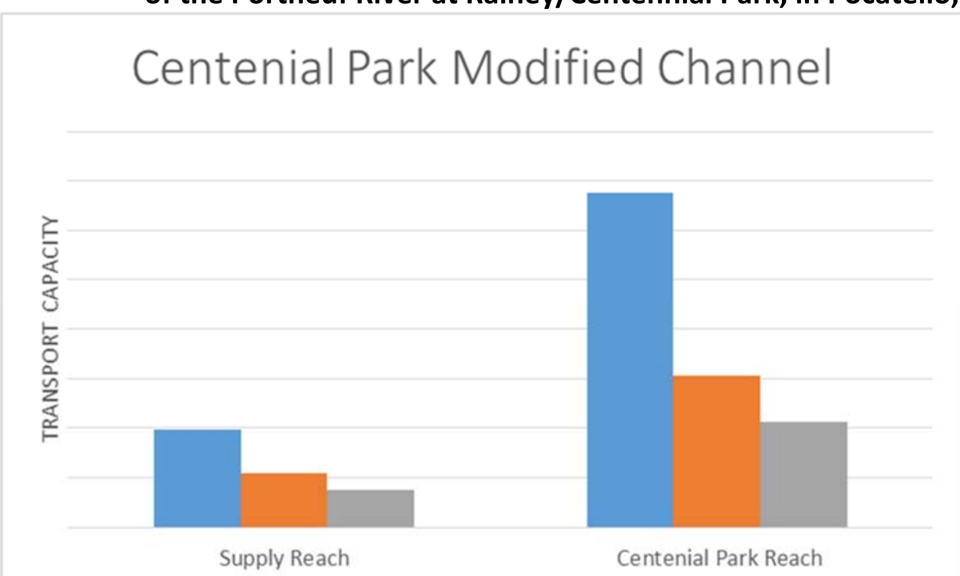


Figure 16. Transport Capacity of Sediment for Existing Conditions of the Portneuf River at Rainey/Centennial Park in Pocatello, Idaho



Supply reach is a river segment just upstream of the park, and represents the amount of sediment flowing into the park. Colors represent the transport equation used to calculate sediment loading. Blue uses Yang d_{50}, orange uses Laursen (Copeland), and gray uses Engelund-Hansen equations.

Figure 17. Transport Capacity of Sediment for Proposed Modifications of the Portneuf River at Rainey/Centennial Park, in Pocatello, Idaho



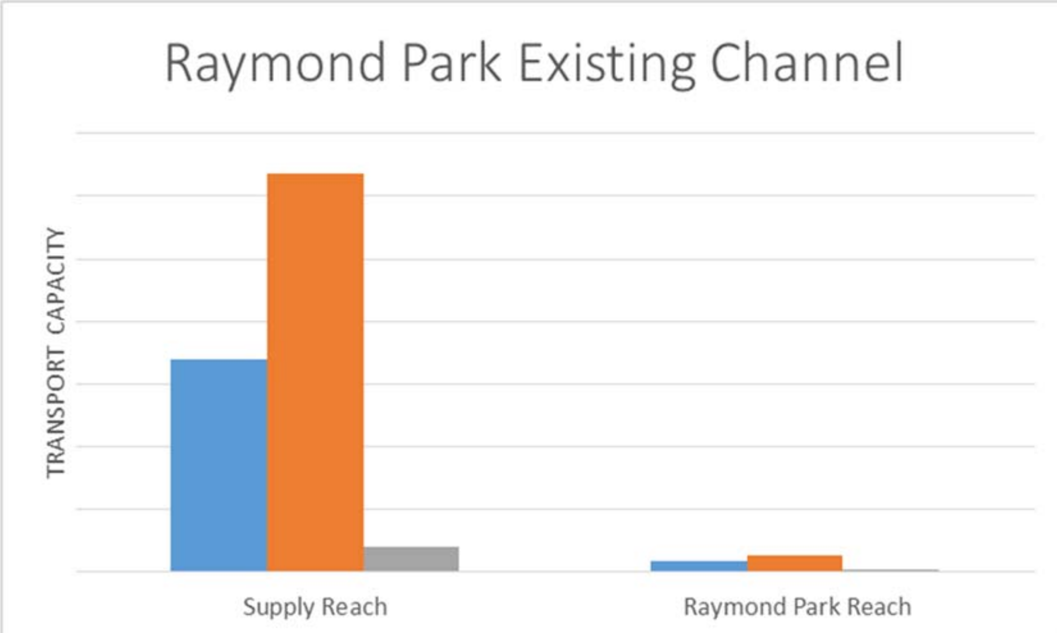
Supply reach is a river segment just upstream of the park, and represents the amount of sediment flowing into the park. Colors represent the transport equation used to calculate sediment loading. Blue uses Yang d_{50}, orange uses Laursen (Copeland), and gray uses Engelund-Hansen equations.

Conversely, the continuity evaluation for the Raymond Park reach suggests a propensity for deposition in the park reach, assuming availability of sediment to the supply reach. For both the current and proposed river channel in Raymond Park, the continuity analysis indicates greater sediment transport potential and higher yield for the supply reach than the analysis reach (e.g., Raymond Park). From the perspective of only this comparison, it is expected that sediment would likely be deposited in the channel. From the site visit observation (Figure 18), it appears this may be the case, with the effective channel bottom partially exposed in the photo, along with some debris. It is not clear from the photo, however, if this is deposition or simply *super elevation* (uneven channel bottom elevation to compensate for a curve in channel alignment). Figures 19 and 20 show the capacity of the Raymond Park channel to transport sediment is much lower than that of the supply reach upstream of the park. In fact, with the proposed modification to Raymond Park, the transport deficit becomes greater. Any depositional behavior observed in the existing channel would likely increase somewhat in the park once channel modifications were completed.

Figure 18. View Looking Downstream from West Custer Street Bridge

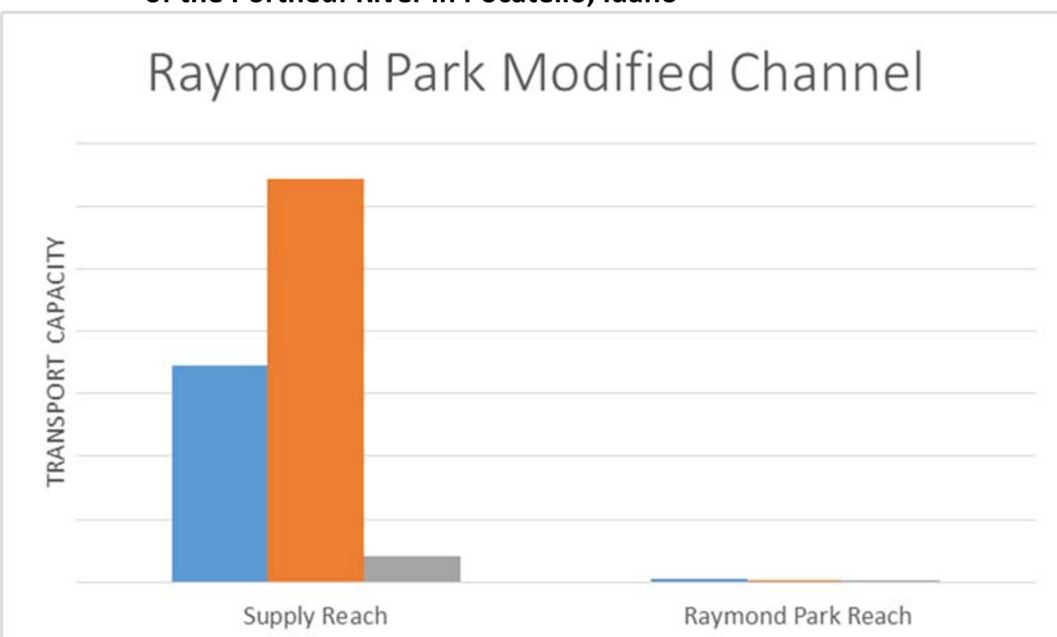
Note: Possible deposition visible in center foreground channel, right.

Figure 19. Transport Capacity of Sediment for the Existing Condition of the Portneuf River in Pocatello, Idaho.



Supply reach is a river segment just upstream of the park, and represents the amount of sediment flowing into this park. The colors represent the transport equation used to calculate sediment loading. Blue uses Yang d_{50}, orange uses Laursen (Copeland), and gray uses Engelund-Hansen equations.

Figure 20. Transport Capacity of Sediment for the Proposed Modification of the Portneuf River in Pocatello, Idaho

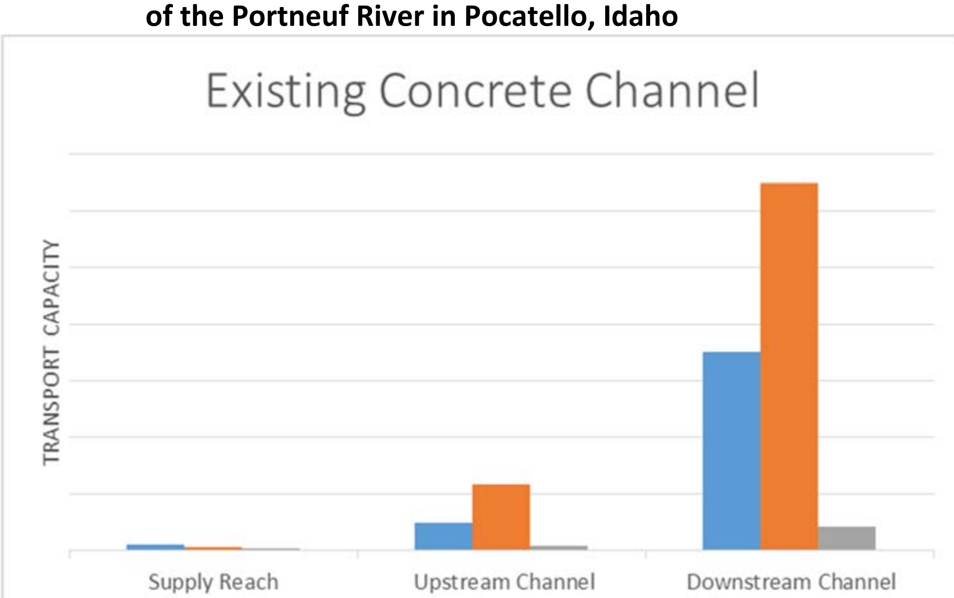


Supply reach is a river segment just upstream of the park, and represents the amount of sediment flowing into this park. The colors represent the transport equation used to calculate sediment loading. Blue uses Yang d_{50}, orange uses Laursen (Copeland), and gray uses Engelund-Hansen equations.

It is important to note, however, that this simple comparison assumes the transport potential of the specific supply reach is somehow met (e.g., by preceding upstream reaches). For earthen channels, this is a valid assumption, since their mobile beds and banks often erode and supply sediment volumes consistent with their transport potentials. In the case of hard-lined channels like the rectangular concrete channel within Pocatello, excess sediment transport energy is not able to pick up more sediment than available within the water sediment mixture, and simply transmits available load. If the available sediment load coming into the supply reach, though less than the reach is capable of transporting, does not exceed the transport potential of the analysis reach, deposition would not likely occur in appreciable amounts. This appears to be a more plausible interpretation of the results. In summary, an excess in sediment transport potential in an analysis reach, compared to its supply reach, indicates low potential for deposition. An inverse interpretation is less meaningful for hard-lined channels like Pocatello's rectangular concrete channel. (Similarly, an excess in transport potential would indicate a potential for incision for a mobile-bed channel, but is not a valid conclusion for hard-lined channels.)

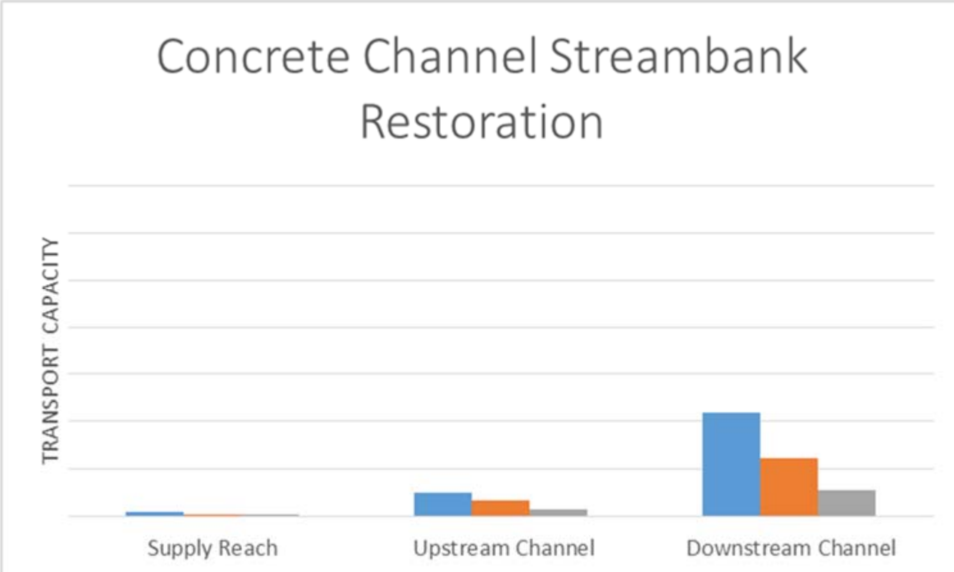
Finally, for the concrete channel streambank restoration and greenway proposal, there is not likely to be sediment deposited in this reach of the river either with current conditions or with the proposed modifications (Figures 21 and 22). Although proposed modifications are likely to reduce carrying capacity of the river at this point, this is not likely to cause a problem in normal water-year conditions.

Figure 21. Transport Capacity of Sediment for the Existing Concrete Channel of the Portneuf River in Pocatello, Idaho



The channel is broken into two segments, an upstream and downstream reach. Supply reach is a river segment just upstream of the upstream reach of the concrete channel, and represents the amount of sediment flowing into this park. The upstream channel sediment was used as the sediment supply to the downstream reach. The colors represent the transport equation used to calculate sediment loading. Blue uses Yang d_{50}, orange uses Laursen (Copeland), and gray uses Engelund-Hansen equations.

Figure 22. Transport Capacity of Sediment for the Proposed Modification to the Concrete Channel of the Portneuf River at Pocatello, Idaho



The channel is broken into two segments, an upstream and downstream reach. Supply reach is a river segment just upstream of the upstream reach of the concrete channel, and represents the amount of sediment flowing into this park. The upstream channel sediment was used as the sediment supply to the downstream reach. The colors represent the transport equation used to calculate sediment loading. Blue uses Yang d_{50}, orange uses Laursen (Copeland), and gray uses Engelund-Hansen equations.

8.2 Summary of Sedimentation Findings

In general, the sedimentation analyses suggest that well-designed modifications to the Portneuf channel (e.g., conceptual features modeled in this study) would be unlikely to cause changes in depositional regimes significant enough to affect channel maintenance under typical flow conditions. Though the Raymond Park modification indicates a sediment transport capacity deficit, as compared with the upstream supply reach, this is not a sufficient indication of potential depositional increase because both reaches are hard-lined. For the other two features modified, the widened floodplain at Centennial Park and the low-flow inset channel within the concrete channel, there is clear indication that deposition would likely not be a concern. Furthermore, the lack of change in computed *effective discharge* values between existing and proposed conditions effectively illustrates potential for incorporation of compound channel geometry that could maintain sediment transport energy for the most significant flow conditions, in terms of both frequency and effectiveness, unlikely to exceed stability thresholds. While the range of features considered in this planning study is limited and focused on hard-lined channel modifications, the results do not indicate any hurdles that could not be overcome through effective design for other feature types.

9. Conclusions

9.1 Existing Information

The current study indicates a significant amount of available existing information for the Portneuf River in the study area that could serve as a starting point for development and design of modifications to meet some community objectives and goals described in other sections of the study documents. While there are certainly data gaps that must be filled available information represents considerable existing value that can be leveraged in achieving community goals.

9.2 Hydrologic Changes

Improved understanding of the statistical hydrology of the project area would provide a better perspective from which to discuss the inherent trade-offs that always exist between public safety and other public values. While the probabilistic level of flood risk appears to have been underestimated as a consequence of limited information when the Pocatello Unit Flood Control Project was originally conceived, the effective water conveyance capacity of the project has remained essentially the same. The substantial reduction in flood risk afforded by the existing project should not be taken lightly. There may be valid reasons for the community to re-examine trade-offs between public safety and other public concerns, but those activities are well outside the scope of the current study and are not considered herein.

9.3 Hydraulic Viability

Hydraulic modeling of a limited set of conceptual features indicates potential for incorporation within the study area, providing possible benefits for the community. While design challenges were identified (e.g., difficulty in maintaining continuity of a low flow channel throughout the concrete channel to facilitate fish passage), methods are available (e.g., fish ladders) to overcome such obstacles. Overall, the results indicate potential for providing enhancements to the study area that would meet many community objectives (e.g., increased public access and enhanced aquatic habitat), while maintaining adequate flood conveyance capacity.

9.4 Sedimentation Viability

Limited sedimentation analyses further suggest that balancing sediment transport capacities would not be overly problematic. With careful design, potential maintenance impacts could be largely avoided for the majority of flow conditions, while still achieving community objectives.

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