Stream Habitat Analysis for Bull Creek Reservoir

Tom Annear, Water Management Supervisor, Wyoming Game and Fish Department, 5400 Bishop Blvd, Cheyenne, WY 82006

ABSTRACT

The Wyoming Water Development Commission and local sponsors have been exploring options to construct a new multi-purpose reservoir in the Clear Creek Drainage near Buffalo. The project would secure and increase water for irrigation, provide additional storage for municipal use in Buffalo, and maintain or improve instream flow levels in Clear Creek in late summer.

Instream flow studies were done in 2015 and combined with studies done in earlier years to address the relationship between flow level and habitat using the Habitat Quality Index. The analysis was applied to 10.3 miles of Clear Creek between the historic (old) power plant at the mouth of Clear Creek Canyon and Interstate-90. Results of the study showed that habitat quality could be increased by at least 58% if late summer flow of about 15 cfs is maintained through the reach. If late summer flow of 20 cfs is maintained through the reach, habitat quality could be increased by over 176%.

INTRODUCTION

The Wyoming Water Development Commission (WWDC) and Lake DeSmet Conservation District (LDCD) have been exploring various alternatives for building additional storage in the Clear Creek drainage near Buffalo since at least 2014. The primary purpose of the new facility would be to provide additional water for irrigation; however, the project could also provide additional storage for municipal use as well as fish and wildlife. The project is presently at a Level II, Phase II point of consideration by the WWDC. This level means the project is undergoing more detailed feasibility analysis to refine the project for permitting and final design.

The most likely site for the dam would be an off-channel site in the ephemeral Bull Creek drainage several miles south of Clear Creek. The dam would be about 160 feet high, store approximately 14,500 acre-feet of water, and cover about 250 surface acres. Water would be transferred to the reservoir via a tunnel or pipeline that captures unappropriated direct flow from Clear Creek in the spring and releases storage in late summer for irrigation or other uses.

Specific fishery benefits could include a minimum fishery pool in the newly constructed reservoir as well as enhanced instream flow in Clear Creek. One scenario for providing instream flow in Clear Creek is to store enough water in the spring that natural, unregulated stream flow at the diversion could remain in the stream through at least the town of Buffalo when natural flow drops to a specified level in mid to late summer. The project may be designed to maintain or supplement late summer flow in Clear Creek with reservoir releases back to the stream. The project would further benefit fisheries if all diversions between Buffalo and the new diversion were removed.

Water Management personnel with the Wyoming Game and Fish Department (WGFD) conducted studies to quantify the relationship between stream flow and stream habitat benefit in the potentially affected stream segment. The analysis is useful for identifying relative trade-offs

between flow and trout habitat. The analysis does not provide an estimate of number of trout because a number of other factors that vary from year to year can also affect trout density once hydraulic habitat is provided.

Study Area

The area of stream potentially affected by this project extends downstream about 10.3 miles from an old hydro power plant on Clear Creek to Interstate 90 just east of Buffalo (Figure 1). This segment is a Yellow Ribbon stream and supports populations of rainbow, brown, and brook trout as well as white, mountain, and longnose suckers. Yellow Ribbon streams support between 50 and 300 pounds of trout per mile. The WGFD annually stocks about 1,200 catchable rainbow trout in a portion of the stream through Buffalo where physical habitat improvements were completed in the 2005. These fish provide a short-term boost in numbers to support angling in Buffalo.

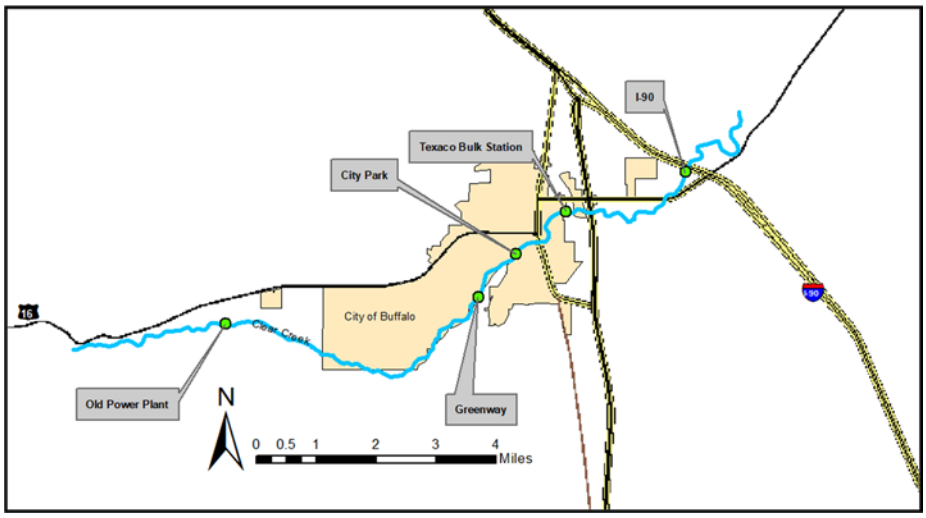

FIGURE 1. Potentially affected segment of Clear Creek.

This segment of Clear Creek is chronically short of water from mid-summer through September as a consequence of numerous irrigation diversions between the mouth of Clear Creek Canyon and Buffalo. Flows through town are commonly less than 10 cubic feet per second (cfs) and often fall to 5 cfs or less for extended periods –typically during the hottest period of the summer. Flows at these low levels suppress development of a self-sustaining wild fishery, which is why WGFD stocks the stream through Buffalo with catchable rainbow trout. Reports of dead trout are common in the hot summer months due to low flows and subsequent high water temperatures.

Studies done in 1987 within the city limits of Buffalo indicated that the fishery could be improved considerably by a higher, continuous late summer flow of approximately 17 cfs

(Appendix A). Based on these findings, more extensive studies were done to see if that trend applied to a longer segment of the stream and determine the flow level that might be most beneficial for fisheries enhancement. The methods and results of the additional studies are summarized below.

METHODS

Analysis of the relationship between trout habitat quality and flow was based on the Habitat Quality Index model (HQI; Binns and Eiserman 1979, Binns 1982). This model is useful for determining the production potential of adult and juvenile trout during summer (July through September) when flow conditions are at their lowest. The model assumes that flow at other times of year approximates the natural flow regime and that water quality is not limiting. The HQI model uses nine biological, chemical, and physical trout habitat attributes to provide an index of relative habitat suitability (and approximate trout abundance).

HQI data were collected at five study sites over a 10.3 mile-long segment of Clear Creek (Table 1). From upstream to downstream these sites are

- Old Power Plant
- Greenway
- Buffalo Town Park
- Texaco Bulk Station
- Interstate-90

Data at three sites (Greenway, Town Park, and Interstate-90) were collected in 2014 and 2015. These data were supplemented with relevant data that were included at the Old Power Plant site in 1989 that were associated with an instream flow water right application. Data for the Texaco Bulk station site within the Town of Buffalo were drawn from the 1987 study. Though the Town Park site was roughly the same as where data were collected in 1987, habitat data were collected again because of the considerable habitat improvement work that was done in that segment since 1987.

TABLE 1. Dates and flow (cubic feet per second) when HQI data were collected on Clear Creek.

Study Site	Date (flow)	Date / flow	Date / flow
Old Power Plant	9-14-89 (30)	8-8-89 (79)	5-24-89 (120)
Greenway	8-14-15 (9)	7-29-14 (21)	7-18-14 (56)
Town Park	8-14-15 (8)	7-29-14 (24)	7-18-14 (67)
Texaco	10-6-87 (17)	6-29-87 (37)	6-22-87 (60)
Dave Stewart (I-90)	8-14-15 (12)	7-29-14 (30)	7-18-14 (93)

HQI data from the three lowest flows at each site were used to estimate the relative habitat quality at a range of flow between 10 cfs and 30 cfs for fishery restoration. Attribute ratings were interpolated between measured data to characterize the relationship between discharge and trout habitat conditions at 5 cfs increments (Conder and Annear 1987).

Hydrology data for defining the Critical Period Stream Flow attribute of the HQI model for the Old Power Plant and Greenbelt sites were obtained from USGS gage 06318500 (Clear Creek near Buffalo, WY) and two gages operated by the State Engineer's Office. One of these was in the town park (0202CCP2), and the other was below Buffalo (0202CBR3). Maximum summer stream temperature data were obtained from three continuously recording stream temperature loggers (Hobo Onset Water Temp Pro v2; Table 2). Loggers were in place from July 1, 2015 to October 6, 2015. The HQI relies on use of the maximum daily temperature between July 15 and September 1 so only that single value was used.

TABLE 2. Location of continuously recording stream temperature loggers on Clear Creek (UTM NAD 83).

Site Name	Northing	Easting	Elevation
Old Power Plant	4910310N	358456E	5190
Greenbelt	4911034N	363490E	4680
Dave Stewart	4912575N	366992E	4520

It is intuitive that higher stream flows typically sustain cooler temperatures over a longer segment of stream. Numerous studies support this tendency. However, given the relatively narrow range of flows under consideration for restoring within the study area, temperature was held constant at all flows evaluated with the HQI. Habitat quality changes depicted by the HQI in this study thus are driven by changes in hydrology (Annual Stream Flow Variation and Critical Period Stream Flow), Cover, Average Velocity, and Stream Width. Holding temperature constant over the range of flows analyzed provides a conservative analysis that reasonably reflects the relative change in habitat quality over the range of flows studied.

The reality is that fishery benefits at higher flows within this range may be greater than portrayed if the maximum summer stream temperature drops and is cool enough to shift the score for that attribute to a higher value than is used here.

The total habitat units for each flow at the five study sites was calculated by multiplying habitat units per acre times the average width of each stream segment and then multiplying that figure by the length of stream half way up and downstream to the next study site (Appendix B).

RESULTS

Data from the three stream gages were used to calculate mean peak and average daily flow (Table 3). These statistics were then used to calculate attribute ratings for Critical Period Stream Flow (average daily flow divided by the target flow) and Annual Stream Flow Variation

(mean peak daily flow divided by the target flow). Data from USGS gage 06318500 were applied to the Old Power Plant site and Greenbelt sites. The SEO gage 0202CCP2 data were applied to the Town Park and Texaco site. SEO gage 0202CBR3 data were applied to the Dave Stewart site.

TABLE 3. Mean daily flow and mean peak annual flow for gages used in the HQI analysis.

Gage	Average Daily Flow (cfs)	Mean Peak Annual Flow (cfs)
USGS gage 06318500	69	770
State Engineer's Office gage 0202CCP2	53	442
State Engineer below Buffalo 0202CBR3	90	1529

Stream flow through the 10.3-mile reach is relatively variable as a function of numerous irrigation diversions, springs, and return flow. Because of the difficulty in documenting the actual flow at each point in the segment, this analysis assumed that each station reached a summer low flow of about 10 cfs (or less) at some point in most years. Thus the estimation of relative benefit was based on providing or sustaining summer flows at a constant level at each flow in the range of flows analyzed.

Maximum summer temperature increased from the Old Power Plant to the lowest study site near Interstate-90 (Table 4). The increase was likely a result of reduced flow as well as decreased shading as the stream left the confines of the canyon. Data from the Old Power Plant site were applied only to that location. Temperature data from the Greenbelt were applied to that site as well as the Town Park and Texaco site. Dave Stewart temperature data were only applied to that study site.

TABLE 4. Maximum summer stream temperature at three locations along Clear Creek

Site Name	Temperature (F)
Old Power Plant	67
Greenbelt	74
Dave Stewart	76

Analysis of HQI data showed a general increase in the number of habitat units with increasing flow (Figure 2). The increase was greatest between 15 cfs and 20 cfs. Habitat units increased 57% from 10 cfs to 15 cfs but increased 176% from existing conditions by increasing flow another 5 cfs to 20 cfs. Increases above 20 cfs were an additional 11% at 25 cfs (187%

increase from existing conditions) and 46% (224% total increase) at 30 cfs compared to existing habitat levels. HQI results for each site are in Appendix B.

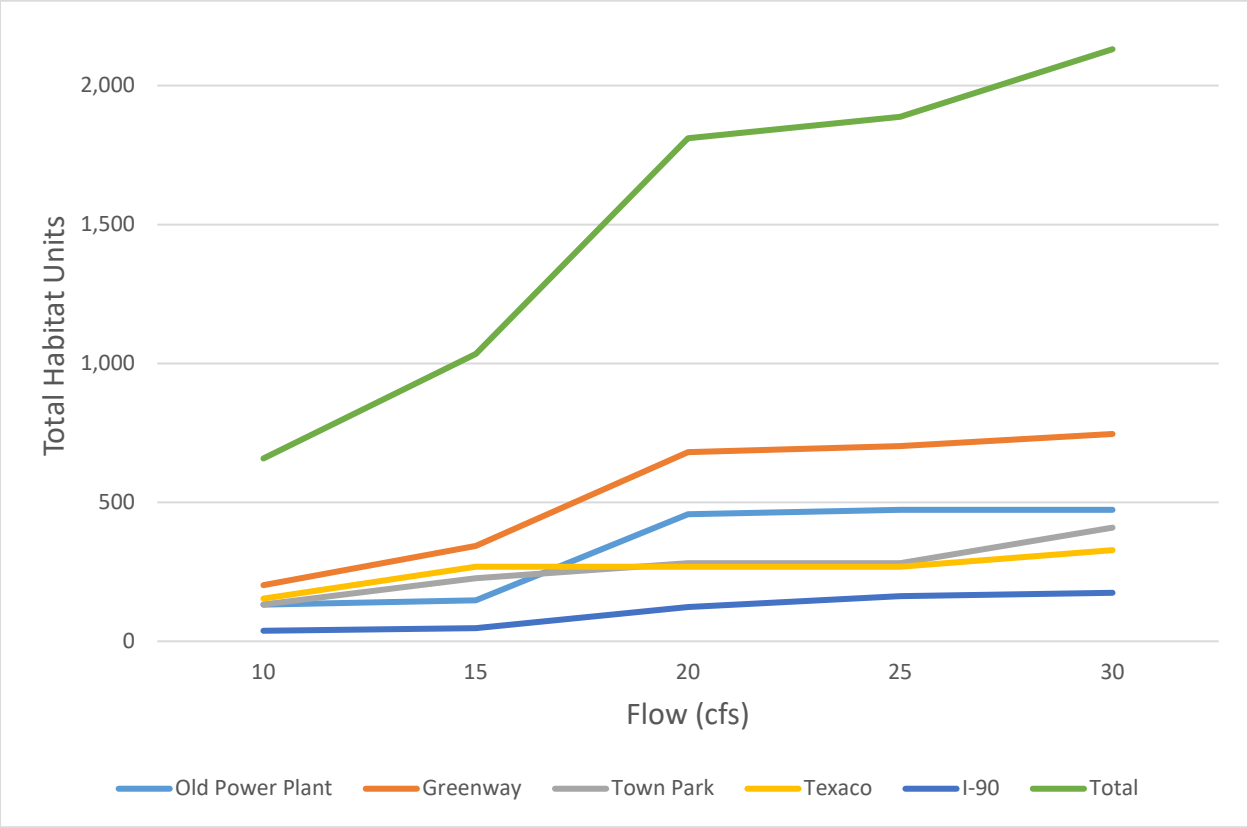

FIGURE 2. Relative change in trout habitat units with change in flow over a 10.3-mile segment of Clear Creek from the Old Power Plant downstream to Interstate-90.

DISCUSSION

Stream flow through the 10.3-mile reach is relatively variable as a result of numerous irrigation diversions, springs, and return flow. Because of the difficulty in documenting the actual flow at each point in the segment, this analysis assumed that each station reached a summer low flow of about 10 cfs (or less) at some point in most years. Thus the estimation of relative benefit was based on providing or sustaining summer flows at a constant level at each flow in the range of flows analyzed.

If Bull Creek Reservoir is constructed, the benefits to the trout fishery in Clear Creek could be substantial if Clear Creek supports a self-sustaining, wild trout fishery. In such a situation, economic benefits to the town of Buffalo could also be substantial as well if the fishery developed into a sought after destination for anglers. Based on analyses in this report, bypassing at least 15 cfs at the Old Power Plant or implementing water management strategies that maintain a constant flow at or above 15 cfs throughout the reach would provide a net habitat gain

of about 58%. However, a sustained summer flow of 20 cfs would increase habitat by 176% above existing conditions. As noted earlier, it is likely that habitat quality would increase somewhat more than these levels if increased flow helped lower stream temperatures and kept water cooler than was noted at existing low flow conditions.

LITERATURE CITED

Binns, N. A. 1982. Habitat Quality Index Procedures Manual. Wyoming Game and Fish Department, Cheyenne, Wyoming.

Binns, N. A. and F. Eiserman. 1979. Quantification of fluvial trout habitat in Wyoming. Transactions of the American Fisheries Society 108:215–228.

Conder, A. L., and T. C. Annear. 1987. Test of weighted usable area estimates derived from a PHABSIM model for instream flow studies on trout streams. North American Journal of Fisheries Management 7:339–350.

APPENDIX A. Letter describing flow/habitat unit dynamics in the town of Buffalo in 1988.

February 4, 1988

TO: Bob McDowell

FROM: Tom Annear

COPIES: Mike Stone, Al Binns

SUBJECT: Updated Clear Creek HQI results.

I received some unexpected data from Binns last week, which changes my analyses for Clear Creek enough that I thought you might be interested. Apparently Doc has done work at two sites very near to and including the sites we worked this past summer. In those studies, he recorded nitrate values that rated a "1" at both sites. He noted that during dry years, nitrates often are difficult to record. I personally haven't noticed this trend (though I haven't looked for it) but nevertheless feel that it is appropriate to use a "1" for nitrates in this year's data. As the attached data indicate, this makes a difference in the HQI scores that is worth noting.

Interestingly, all three sites appear as if they would respond the same with increases in flow and cover up to about 40 cfs. At higher flows, habitat units (HU's) at the Busy Bee site decrease markedly (due to higher velocities). The City Park site shows this tendency at flows above 60 cfs and the same would probably happen at the Texaco site at flows above 110 cfs.

The data show that increasing cover alone will not have near the impact on the fishery that increasing flows would have. PHABSIM data would provide a more precise indication of where the greatest gains could be achieved between 17 and 5 cfs, but indications from the HQI are that significant gains would be realized at a late summer flow of around 7 to 10 cfs. Fishery gains could be maximized at a late summer flow of about 60 cfs.

Give me a call if you'd like to talk about this in more detail.

APPENDIX A. Continued.

Table 1. HQI habitat unit scores for three sites in Buffalo from data at four different flows and estimated for one.

Site	108 cfs	60 cfs	37 cfs	17 cfs*	5 cfs
City Park	14.7	11.7	16.6	16.3	6.8
Busy Bee	14.7	11.7	16.6	16.3	6.8
Texaco Bulk Station	38.6	39.9	18.6	16.3	6.5

* - estimated score derived by interpolation of field measurements at higher and lower flows.

Table 2. HQI scores for Clear Creek with cover ratings increased to a "1" rating.

Site	108 cfs	60 cfs	37 cfs	17 cfs*	5 cfs
City Park	20.6	49.2	26.9	23.2	8.0
Busy Bee	20.6	15.8	23.6	23.2	8.0
Texaco Bulk Station	58.8	60.8	26.9	23.2	7.5

* - estimated score derived by interpolation of field measurements at higher and lower flows.

APPENDIX B. Tables of flow calculations between the Old Power Plant and Interstate-90.

Table B-1. Summary of habitat unit changes for a range of flows from 10 cfs to 30 cfs at all study sites combined for Clear Creek between the Old Power Plant and Interstate-90.

	Flow cfs				
Study Site	**10**	**15**	**20**	**25**	**30**
Old Power Plant	132.0	147.1	456.8	473.1	473.1
Greenway	202.0	343.6	680.3	702.2	746.1
Town Park	132.6	226.9	281.5	281.5	409.1
Texaco	153.6	268.7	268.7	268.7	328.0
I-90	37.9	47.4	123.4	162.5	174.5
Total	658.1	1033.7	1810.7	1888.1	2130.9
Percent increase from existing conditions	0.0%	57.1%	175.2%	186.9%	223.8%

Table B-2. Summary of habitat unit changes for a range of flows from 10 cfs to 30 cfs at the Old Power Plant study site.

	Flow (cfs)				
	10	**15**	**20**	**25**	**30**
HU's/acre	14.6	16.2	50.4	50.4	50.4
Width (feet)	28	28	28	29	29
Length (feet)*	14100	14100	14100	14100	14100
Total Habitat Units	132.0	147.1	456.8	473.1	473.1

* - halfway to Greenway (total 28,200) = 14,100 ft

Table B-3. Summary of habitat unit changes for a range of flows from 10 cfs to 30 cfs at the Greenway study site.

	Flow (cfs)				
	10	**15**	**20**	**25**	**30**
HU's/acre	20.1	31.7	56.8	56.8	56.8
Width (ft)	26	28	31	32	34
Length (ft)*	16840	16840	16840	16840	16840
Total Habitat Units	202.0	343.6	680.3	702.2	746.1

* - half way to Power Plant (total distance 28,200 ft) and half way to city park (total distance 5,480ft) = 16,840 ft

APPENDIX B. Continued.

Table B-4. Summary of habitat unit changes for a range of flows from 10 cfs to 30 cfs at the Town Park study site.

	Flow (cfs)				
	10	**15**	**20**	**25**	**30**
HU's/acre	26.0	43.3	53.7	53.7	76.0
Width (ft)	36	37	37	37	38
Length (ft)*	6169	6169	6169	6169	6169
Total Habitat Units	132.6	226.9	281.5	281.5	409.1

* - halfway to Greenway (5,480 ft total) and halfway to Texaco (6,857 ft total) = 6,169 ft.

Table B-5. Summary of habitat unit changes for a range of flows from 10 cfs to 30 cfs at the Texaco Bulk Station study site.

	Flow (cfs)				
	10	**15**	**20**	**25**	**30**
HU's/acre	19.7	33.4	33.4	33.4	39.6
Width (ft)	32	33	33	33	34
Length (ft)*	10618	10618	10618	10618	10618
Total Habitat Units	153.6	268.7	268.7	268.7	328.0

* - Halfway to Town Park (6858 ft total) and halfway to Interstate-90 (14,377 ft total) = 10,618 ft.

Table B-6. Summary of habitat unit changes for a range of flows from 10 cfs to 30 cfs at the Interstate-90 study site.

		Flow (cfs)				
	10	**15**	**20**	**25**	**30**	**35**
HU's/acre	10.0	12.0	29.9	36.5	36.5	36.5
Width (ft)	23	24	25	27	29	31
Length (ft)*	7189	7189	7189	7189	7189	7189
Total Habitat Units	37.9	47.4	123.4	162.5	174.5	186.6

* - halfway to Texaco (14,377) = 7,189 ft