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ABSTRACT

One aspect of instream flow regimes now being actively debated is the need for channel maintenance or flushing flows. However, little quantitative information exists as to how different types of channels, particularly higher elevation, mountain stream systems, respond to changes in the flow regime resulting from water development activities. Our study is attempting to begin to answer some of these questions. This paper discusses part of that study and addresses the effect flow diversion has had on higher elevation stream systems located In Wyoming and Colorado.

INTRODUCTION

Over the past 20 years, the maintenance of suitable instream flows below water development projects In the western United States has been recognized as environmentally desirable and a cost developers, in many cases, must be willing to incur. Currently, one aspect of instream flows which is being actively debated by water developers and natural resource management agencies is the need for, and the determination of, flushing and channel maintenance flow requirements. Such instream flows simulate the natural spring runoff hydrograph and are felt to be necessary to maintain conveyance capacity of stream channels by reducing aggradation and encroachment of riparian vegetation, and to remove accumulated fine sediments from critical fish habitats.

Given the quantities of project water typically required for flushlng/ channel maintenance purposes and the associated costs of that water, basic questions are being raised regarding the quantitative response of stream chan- nels to flow regulation. Should certain channel types respond more slowly to flow regulation, the argument can be made that the magnitude and duration of some flushing regimes can be reduced while still maintaining conveyance capacity and aquatic habitat quality.

In 1986, the Wyoming Water Research Center began a project to investigate the quantitative response of higher elevation stream channels in the central Rocky Mountains to flow depletion or augmentation resulting from water development. This project Is not scheduled to be completed until late 1988, though this paper summarizes part of the project (diversions on mountain streams) and discusses some results to date.

METHODS

Work began in July of 1986 with the determination of potential sites. Selection of a particular stream for actual sampling was done onsite. Field sampling of sites was done in the summer and fall of 1986 and 1987, and con- sisted of sampling stream reaches immediately above and below a diversion structure. Data collected at each reach included mean channel width and depth, stream gradient, composition of the riparian zone, and composition of the streambed and banks. Several photographs (black and white prints, and color slides) were taken at each site as well. All study reaches were located in the first stable, straight reach above/below the diversion structure which occurred out of the area of construction impact.

Based on the field data, conveyance capacity using mean channel width and depth, and channel slope-was calculated, for each site. Hydrologic, and drainage basin data are currently being gathered and analyzed for all study reaches. Channel stability of study reaches is also being assessed using the Stream Reach Inventory/Channel Stability Evaluation (Pfankuch 1975).

RESULTS TO DATE

As mentioned earlier in the paper, analysis of the channel response data collected on mountain streams is not yet completed. We anticipate a project completion report will be available late in 1988. Therefore, the results presented here should be considered as preliminary and as such, will be restricted to general data trends.

Field measurements of channel width and depth were made at 39 study sites on 19 streams in northern Colorado and southern Wyoming. Site elevations ranged from approximately 7,400 to 9,800 ft above mean sea level, while surveyed water surface slopes varied from less than 1.0 up to 9.8 percent. The diversion structures on the study streams ranged in age from over 100 years down to less than 25 years and depleted streamflow by 5 to almost 100 percent of average annual water yield. As many of the study streams are ungaged, synthesis of discharge records is now underway. Applying Rosgen's (1985) channel typing system, 11 of the 39 sites were classified as A channels, 14 as B channels, and 14 as C.

A comparison of channel characteristics above and below the diversion structure on each stream is presented in Table 1. Response variables considered to date in our analysis include channel width, channel depth, the ratio of width to depth, cross-sectional area and channel conveyance capacity. The response of these parameters to flow depletion has been highly variable. Conveyance capacity has shown the greatest variability, ranging from a reduction of 85 percent below the diversion on North Brush Creek to an Increase of 101 percent below the Fool Creek structure. Channel width was the most constant of the variables, showing a 40 percent reduction at a low gradient site below the North Fork of the Little Snake River diversion and a 24 percent widening on Fool Creek. Cross-sectional area, depth and the ratio of width to depth were intermediate in response.

The general trends of the data from Table 1 are presented in Table 2. As shown, channel shrinkage was found to occur below approximately 50 percent of the diversion structures. This phenomena was not observed at the remaining half of the study streams. It is apparent that additional analysis, taking into consideration such factors as channel slope, sediment yield, elevation, vegetation, and magnitude and duration of streamflow depletion, is needed to begin to explain the observed responses. This effort is now well underway.

CONCLUSIONS

While data analysis is not yet complete and any conclusions drawn at this time must be considered preliminary, it is quite apparent that the physical response of mountain stream channels to flow depletion is highly variable. Certain of our study streams were reduced in size due to the processes of vegetative encroachment and channel aggradation, while others exhibited no such loss of conveyance capacity. Further analysis is needed to explain this variation.

The channel maintenance issue is a complex one. Before instream flow regimes are prescribed below water development projects to preserve the channel capacity and competence, it would appear that consideration should be given to the type of stream channel involved, the sediment loadings to the system, the transporting

TABLE 1. Summary of channel response to flow depletion for mountain streams.*

SITE	WIDTH	DEPTH	AREA	W/D	C.C.
N.F. ENCAMPMENT RIVER					
Above Wolfard Canal	25.00	2.00	50.00	12.50	236.86
Below Wolfard Canal	26.20	2.00	52.40	13.10	364.11
COW CREEK					
Above Pilson Ditches	19.80	2.50	49.50	7.92	421.07
Below Pilson Ditches	21.30	1.50	31.95	14.20	180.72
N.F. LITTLE SNAKE					
Above Diversion	10.10	1.00	10.10	10.10	36.04
Below Diversion (steep)	10.50	1.00	10.50	10.50	58.97
Below Diversion (flat)	6.10	1.00	6.10	6.10	22.77
S. BRUSH CREEK					
Above Supply Canal	27.90	2.00	55.80	13.95	601.78
Below Supply Canal	30.40	2.00	60.80	15.20	655.93
N. BRUSH CREEK					
Above Highline Ditch	29.80	2.00	59.60	14.90	291.36
Below Highline Ditch	19.50	1.50	29.25	13.00	44.42
VASQUEZ CREEK					
Above Vasquez Diversion	26.40	1.88	49.63	14.04	335.45
Below Vasquez Diversion	17.60	1.30	22.88	13.54	81.80
FRASER RIVER					
Above Diversion	17.60	1.50	26.40	11.73	167.42
Below Diversion	18.10	1.29	23.35	14.03	102.01
FOOL CREEK					
Above Diversion	5.00	0.82	4.10	6.10	17.82
Below Diversion	6.20	0.85	5.27	7.29	35.78
EAST ST. LOUIS CREEK					
Above Diversion	7.60	1.87	14.21	4.06	177.58
Below Diversion	8.20	1.15	9.43	7.13	78.15
ST. LOUIS CREEK					
Above Diversion	19.20	1.34	25.73	14.33	154.01
Below Diversion	21.60	1.43	30.89	15.10	193.95
WEST ST. LOUIS CREEK					
Above Diversion	7.30	0.86	6.28	8.49	36.81
Below Diversion	5.80	0.85	4.93	6.82	21.20
LITTLE CABIN CREEK					
Above Diversion	2.20	0.83	1.83	2.65	10.07
Below Diversion	2.00	0.71	1.42	2.82	6.17

TABLE 1 (cont'd). Summary of channel response to flow depletion for mountain streams.*

SITE	WIDTH	DEPTH	AREA	W/D	C.C.
CABIN CREEK					
Above Diversion	16.10	1.13	18.19	14.25	87.53
Below Diversion	11.90	1.26	14.99	9.44	82.66
N.F. RANCH CREEK					
Above Diversion	10.00	0.93	9.39	10.86	28.38
Below Diversion	9.00	0.84	7.56	10.71	54.02
M.F. RANCH CREEK					
Above Diversion	15.70	1.21	19.00	12.98	195.24
Below Diversion	13.80	1.99	27.46	6.93	312.04
S.F. RANCH CREEK					
Above Diversion	9.70	1.35	13.10	7.19	110.92
Below Diversion	9.40	1.53	14.38	6.14	142.60
RANCH CREEK					
Above Diversion	11.00	1.57	17.27	7.01	262.45
Below Diversion	10.00	1.57	15.70	6.37	200.11
LAKE FORK					
Above Homestake Tunnel	21.00	1.50	31.50	14.00	134.26
Below Homestake Tunnel	22.80	1.80	41.04	12.67	195.92
CHAPMAN GULCH					
Above Diversion	14.10	1.21	17.06	11.65	142.37
Below Diversion	13.50	1.27	17.15	10.63	166.76

* WIDTH = Mean channel width (feet)
DEPTH = Mean channel depth (feet)
AREA = Cross-sectional area of channel (square feet)
W/D = Width-Depth ratio
C.C = Conveyance capacity (cubic feet per second)

capability of the flow regime in relation to these loadings, and the factors which govern the establishment and growth of streamside vegetation. We hope that when completed, the results of this study will help to provide some of the insight needed.

TABLE 2. Trends in channel response of twenty mountain streams in Wyoming and Colorado to flow depletion.*

CHANNEL RESPONSE**	RESPONSE VARIABLE (Number of Streams)				
	WIDTH	DEPTH	W/D	AREA	C.C.
+	9	7	9	9	10
-	11	8	11	11	10
0	0	5	0	0	0
TOTAL	20	20	20	20	20

* WIDTH = Mean channel width (feet)
DEPTH = Mean channel depth (feet)
AREA = Cross-sectional area of channel (square feet)
W/D = Width-Depth ratio
C.C = Conveyance capacity (cubic feet per second)

** + indicates variable increased below diversion
\- indicates variable decreased below diversion
0 indicates no difference in variable above and below diversion

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