APPENDIX A

Applications to the Wyoming State Engineer’s Office and the Wyoming Game and Fish Department Reports
Dirtyman Fork
Instream Flow Segment No. 1
STATE OF WYOMING

OFFICE OF THE STATE ENGINEER

APPLICATION FOR PERMIT TO APPROPRIATE SURFACE WATER

THIS SECTION IS NOT TO BE FILLED IN BY APPLICANT

Filing/Priority Date

THE STATE OF WYOMING, STATE ENGINEER'S OFFICE  SS.

This instrument was received and filed for record on the 19th day of December, A.D. 19--5, at 2:50 o'clock P.M.

JOHN R. BARNES, for State Engineer

Recorded in Book _______ of Ditch Permits, on Page _______.

Fee Paid $50.00 Map Filed E

WATER DIVISION NO. 1 DISTRICT NO. 8 Temp. Filing No. 29 5/74

PERMIT NO. ________

NAME OF FACILITY Dirtyman Fork Instream Flow Segment #1

1. Name(s), mailing address and phone no. of applicant(s) is/are

Wyoming Water Development Commission
Herschler Bldg., 4-W
Cheyenne, WY 82002

(If more than one applicant, designate one to act as Agent for the others)

2. Name & address of agent to receive correspondence and notices

Wyoming Game and Fish Department
5400 Bishop Blvd. Cheyenne, WY 82006

3. (a) The use to which the water is to be applied is Instream Flow

(b) If more than one beneficial use of water is applied for, the location and ownership of the point of use must be shown in item 10 of the application and the details of the facilities used to divert and convey the appropriation must be shown on the map in sufficient detail to allow the State Engineer to establish the amount of appropriation. In multiple use applications, stock and domestic purposes are limited to 0.056 cubic feet per second.

4. The source of the proposed appropriation is Dirtyman Fork, Tributary of East Fork Savery Creek, Tributary of Savery Creek, Tributary of Little Snake River.

5. The Instream flow segment extends from the confluence of the north & south forks in the SM1/4 corner of Section 28 T. 15 N., R. 87 W., and is in the west line of NW1/4, NE1/4 of Section 29 T. 15 N., R. 87 W., length of stream segment is 0.9 miles.

6. Are any of the lands crossed by the proposed facility owned by the State or Federal Government? If so, describe lands and indicate whether State or Federally owned.

Section 28, T15N, R87W, SM1/4 of NW1/4, Federal, NE1/4 of NW1/4, Federal
Section 29, T15N, R87W, SE1/4 of NE1/4, NW1/4 of NE1/4, Federal.

7. The carrying capacity of the ditch, canal, pipeline or other facility at the point of diversion is See Remarks cubic feet per second.

8. The accompanying map is prepared in accordance with the State Engineer's Manual of Regulations and Instructions for filing applications and is hereby declared a part of this application. The State Engineer may require the filing of detailed construction plans.

9. The estimated time required for the commencement of work is 30 days for completion of construction is 30 days and to complete the application of water to the beneficial uses stated in this application is 30 days from issue

Permit No. ___________________________ Page No. _______
10. The land to be irrigated under this permit is described in the following tabulation. (Give irrigable acreage in each 40-acre subdivision. Designate ownership of land, Federal, State or private. If private, list names of owners and land owned separately.) If application is for stock, domestic, or for purposes other than irrigation, indicate point of use by 40-acre subdivision and owner.

<table>
<thead>
<tr>
<th>Township</th>
<th>Range</th>
<th>Sec.</th>
<th>NE%</th>
<th>NW%</th>
<th>SW%</th>
<th>SE%</th>
<th>NE%</th>
<th>NW%</th>
<th>SW%</th>
<th>SE%</th>
<th>NE%</th>
<th>NW%</th>
<th>SW%</th>
<th>SE%</th>
<th>TOTALS</th>
</tr>
</thead>
<tbody>
<tr>
<td>15N</td>
<td>87W</td>
<td>28</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>29</td>
<td></td>
<td></td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Number of acres to receive original supply
Number of acres to receive supplemental supply
Total number of acres to be irrigated

REMARKS

Item #7 - Based on the results of a study completed in 1994 and data analysis in 1995 by the Wyoming Game and Fish Department:

Instream Flow:  
- October 1 - April 30: 0.5 cfs  
- May 1 - June 30: 1.4 cfs  
- July 1 - September 30: 0.5 cfs

This is an ungaged stream. If the State Engineer's Office determines that the measurement of instantaneous flow is needed to administer this water right, a gage will be installed at or near the downstream end of the instream flow segment.

Under penalties of perjury, I declare that I have examined this application and to the best of my knowledge and belief it is true, correct and complete.

Signature of Applicant or Agent

12/10/95 Date
STATE OF WYOMING

APPLICATION FOR PERMIT TO APPROPRIATE SURFACE WATER

NAME OF FACILITY  Dirtyman Fork (Creek)

1. Name(s), mailing address and phone no. of applicant(s) is/are  Wyoming Water Development Commission, Herschler Building, Cheyenne, WY 82002

2. Name & address of agent to receive correspondence and notices  John Talbot, Wyoming Game and Fish Department, 5400 Bishop Boulevard, Cheyenne, WY 82002; Michael Purcell, W.W.D.C., Herschler Bldg., Cheyenne WY 82002

3. (a) The use to which the water is to be applied is  Instream Flow

4. The source of the proposed appropriation is  Dirtyman Fork (Creek) tributary to Savery Creek.

5. Instream flow segment extends from the confluence of the north and south forks in the SW1/4 of section 28 T 15 N., R 87 W. downstream to the fish barrier at NW1/4 of section 29 T 15 N., R 87 W. Length of stream is approximately 1.1 mile. (Please double-check segment length)

6. Are any of the lands crossed by the proposed facility owned by the State or Federal Government? If so, describe lands and indicate whether State or Federally owned.
   The land crossed by this stream segment is federally owned.

7. The carrying capacity of the ditch, canal, pipeline or other facility at the point of diversion is  see remarks  cubic feet per second.

8. The accompanying map is prepared in accordance with the State Engineer's Manual of Regulations and Instructions for filing applications and is hereby declared a part of this application. The State Engineer may require the filing of detailed construction plans.

9. The estimated time required for the commencement of work is  30 days , for completion of construction is  30 days , and to complete the application of water to the beneficial uses stated in this application is  30 days .
<table>
<thead>
<tr>
<th>Month</th>
<th>Flow (cfs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>October</td>
<td>0.5</td>
</tr>
<tr>
<td>November</td>
<td>0.5</td>
</tr>
<tr>
<td>December</td>
<td>0.5</td>
</tr>
<tr>
<td>January</td>
<td>0.5</td>
</tr>
<tr>
<td>February</td>
<td>0.5</td>
</tr>
<tr>
<td>March</td>
<td>0.5</td>
</tr>
<tr>
<td>April</td>
<td>0.5</td>
</tr>
<tr>
<td>May</td>
<td>1.4</td>
</tr>
<tr>
<td>June</td>
<td>1.4</td>
</tr>
<tr>
<td>July</td>
<td>0.5</td>
</tr>
<tr>
<td>August</td>
<td>0.5</td>
</tr>
<tr>
<td>September</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Based on the results of a study completed in 1994 and data analysis in 1995 by the Wyoming Game and Fish Department (attached), a flow right of 0.5 cfs is requested from October 1 to April 30 to maintain hydraulic conditions for Colorado River cutthroat trout survival. A flow of 1.4 cfs is requested from May 1 to June 30 to maintain existing levels of physical habitat for spawning Colorado River cutthroat trout. A flow of 0.5 cfs is requested from July 1 to September 30 to maintain hydraulic conditions for Colorado River cutthroat trout survival.
Instream flow studies were conducted on Dirtyman Fork in 1994 as part of an ongoing monitoring and enhancement program for Colorado River cutthroat trout in streams of the Little Snake River basin. The goal of this study was to determine instream flows necessary for maintaining or improving Colorado River cutthroat trout habitat in Dirtyman Fork.

Physical habitat modeling and habitat retention methods were used to determine instream flows necessary for maintenance of the Colorado River cutthroat trout habitat. Based on results from these methodologies, the instream flow recommendations are: October 1 to April 30, 0.5 cfs; May 1 to June 30, 1.4 cfs; July 1 to September 30, 0.5 cfs. The instream flow applies to a 1.1-mile stream reach extending from the confluence of the North and South Forks of Dirtyman Fork in R87W, T15N, S28, SW1/4 downstream to the fish barrier in R87W, T15N, S29, NW1/4.

INTRODUCTION

Colorado River cutthroat trout Oncorhynchus clarki pleuriticus are classified as Category 2 taxa by the U.S. Fish and Wildlife Service. Species in this category may be appropriate for listing as threatened or endangered if significant losses of habitat or declines in population size continue. Colorado River cutthroat trout are considered a species of special concern by the Wyoming Game and Fish Department (WGFD) and Region 2 of the U.S. Forest Service. Although Colorado River cutthroat trout were historically distributed throughout streams of the Colorado River drainage in Wyoming, Colorado, Utah, Arizona and New Mexico, they now occupy less than 1% of their historic range (Speas et al. 1994). In Wyoming, populations of Colorado River cutthroat trout occur predominantly in small headwater streams of the Green, Little Snake and Blacks Fork River
Several factors including poor land management practices, limited stream flows, displacement by non-native trouts, fishing pressure and habitat fragmentation have contributed to the reduced distribution and abundance of Colorado River cutthroat trout throughout their native range (Trotter 1987).

In the Little Snake River watershed, water management activities pose the greatest threat to Colorado River cutthroat trout. Water quality violations and habitat fragmentation following completion of the City of Cheyenne's Stage I and Stage II water diversions have occurred in Colorado River cutthroat trout streams (Hipple 1986, Schmal 1986, Wilcox 1989). Additional flow diversions in other streams of the Little Snake River drainage (Savery Creek drainage) have been considered as part of the City of Cheyenne's Stage III water development plan which could further impact this species. Depending on the magnitude, these impacts could contribute to the listing of this species as threatened or endangered unless adequate protective measures are implemented. The potential effects of these flow diversions are discussed in Miller (1980) and Wyoming Game and Fish Department (1986). Appropriate protective measures such as acquisition of adequate instream flow water rights could help avoid the listing of Colorado River cutthroat trout as threatened or endangered.

In 1994, a management plan for Colorado River cutthroat trout in the Little Snake River watershed was cooperatively prepared by the U.S. Forest Service, the WGFD, and the U.S. Bureau of Land Management (Speas et al. 1994). This plan calls for the protection, maintenance, and re-establishment of Colorado River cutthroat trout in streams of the Little Snake River drainage. Within this plan, the acquisition of instream flows water rights for maintenance and protection of critical Colorado River cutthroat trout habitat was listed as a primary objective.

The objectives of this study were 1) to examine relationships between discharge and physical habitat quantity and quality available to Colorado River cutthroat trout in Dirtyman Fork and 2) to determine an instream flow regime in Dirtyman Fork for the maintenance Colorado River cutthroat trout habitat.

**STUDY AREA**

Dirtyman Fork originates on the west slope of the Sierra Madre Mountains at elevations in excess of 9,000 feet mean sea level. The North and South branches flow about 1.0 mile before joining to form the mainstem of Dirtyman Fork. Dirtyman Fork then flows into Savery Creek. The headwaters of Dirtyman Fork are located on the Medicine Bow National Forest; from the National Forest, the stream flows through private land and lands administered by the U.S. Bureau of Land Management.
Dirtyman Fork has an average slope of about 6.0% in the upper reaches. The class A3 channel (Rosgen 1985) is relatively stable with substrates of small boulders and cobbles being dominant. Several beaver dams ranging in size from about 0.2 acres to 1.0 acres in the upper reaches of the watershed create localized discontinuities in channel gradient and stream morphometry.

Hydrology

Dirtyman Fork, like most small streams in the Medicine Bow National Forest, is ungaged; therefore, site-specific stream flow records are not available for Dirtyman Fork. Periodic stream flow measurements have been collected by WGFD personnel through the years. In 1984 when precipitation and snow pack levels exceeded normal conditions in the Little Snake River basin (USGS 1985), Conder (WGFD, pers. obs.) measured flows of 13.2 cfs (20 June), 0.8 cfs (19 July), and 0.2 cfs (8 September). Oberholtzer (1987) reported flows of 2.5 cfs and 0.5 cfs on 23 July 1985 and 7 August 1985. Snow pack levels in 1985 were below average, but summer precipitation conditions exceeded normal levels (USGS 1986). Braaten (this report) recorded stream flows of 1.6 cfs (9 June), 0.3 cfs (1 July) and 0.1 cfs (22 September) during the 1994 drought conditions in the Little Snake River drainage. These hydrologic records indicate stream flows in Dirtyman Fork exhibit major annual and seasonal variability and are dependent on precipitation levels in the watershed.

Fisheries

Colorado River cutthroat trout occur predominantly in the upper reaches of Dirtyman Fork above the fish barrier. Beaver ponds provide the majority of physical habitat for adult Colorado River cutthroat trout; naturally-occuring, large pools for adults are limited in abundance in the stream. Physical habitat throughout the non-beaver dam impounded stream areas is most suitable for fry and juveniles. Based on these physical habitat characteristics, instream flow protection is necessary to maintain or improve suitable spawning areas and physical habitat for fry and juvenile life stages.

Though quantitative, site-specific data for Dirtyman Fork do not exist, studies by Remmick (WGFD, pers. comm.) and other WGFD biologists indicate Colorado River cutthroat trout exhibit dynamic changes in population density in response to natural fluctuations in stream discharge. Present management theory is based on the phenomenon that fish populations in small streams are dependent on strong year classes produced in good flow years which may occur every three to five years. Without the benefit of periodic high flows, populations in some streams would decline or cease to exist.

Study site
After surveying about 0.3 miles of stream, a study site was established about 300 feet upstream from the fish barrier in R87W, T15N, S29, NW1/4. The elevation of the study site is 7,920 feet mean sea level. Within the 300-foot-long study site, nine transects were established in riffles, runs and pools to represent habitat types, except large beaver ponds, found throughout the upper reaches of Dirtyman Fork. Riffles supported spawning habitat, and runs and pools supported pocket water suitable for fry and juvenile life stages.

METHODS

Instream flow data were collected at the study sites in Dirtyman Fork on the dates and discharge listed in Table 1. Instream flow information derived from the study site was applied to a 1.1-mile stream reach extending from the confluence of the North and South Forks of Dirtyman Fork in R87W, T15N, S28, SW1/4 downstream to the fish barrier in R87W, T15N, S29, NW1/4. The land through which the instream flow segment passes is administered by the U.S. Forest Service and the Bureau of Land Management.

Table 1. Dates and discharges when hydraulic data were collected in Dirtyman Fork.

<table>
<thead>
<tr>
<th>Date</th>
<th>Discharge (cfs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>June 9, 1994</td>
<td>1.6</td>
</tr>
<tr>
<td>July 1, 1994</td>
<td>0.3</td>
</tr>
<tr>
<td>September 22, 1994</td>
<td>0.1</td>
</tr>
</tbody>
</table>

A Habitat Retention method (Nehring 1979; Annear and Conder 1984) was used to identify a maintenance flow in Dirtyman Fork. This flow is defined as the continuous volume of water required to maintain at least two of three hydraulic criteria in riffles (Table 2). Maintenance of these criteria ensures fish passage between habitats and promotes adequate survival and production of benthic invertebrates. Maintenance flows are applicable on a year-round basis except when greater flows are required to maintain or improve the biological potential for trout.

A physical habitat simulation model (PHABSIM; Bovee 1982; Milhous et al. 1989) was used to quantify relationships between stream discharge and the amount of physical habitat available to spawning, fry, and juvenile life stages of Colorado River cutthroat trout. This model is the mostly widely used method for assessing relationships between instream flow and physical habitat for fish (Reiser et al. 1989). In PHABSIM, physical habitat is reported as weighted usable area (ft²/1,000 feet of stream length).
Table 2. Hydraulic criteria for determining a maintenance flow with the Habitat Retention method.

<table>
<thead>
<tr>
<th>Category</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean depth (ft)</td>
<td>Top width(^a) X 0.01</td>
</tr>
<tr>
<td>Mean velocity (ft/s)</td>
<td>1.00</td>
</tr>
<tr>
<td>Wetted perimeter (%)(^b)</td>
<td>50</td>
</tr>
</tbody>
</table>

\(^{a}\) - Average daily flow. Minimum depth = 0.20 feet
\(^{b}\) - Percent of bankful wetted perimeter

The physical habitat model was calibrated for all nine transects using hydraulic characteristics of depth, velocity and substrate measured on the dates and discharges listed in Table 1. Based on these data, physical habitat simulations were conducted for flows ranging from 0.1 cfs to 3.0 cfs. Habitat suitability criteria from Bovee (1978), Bozek and Rahel (1992) and Braaten et al. (in preparation) were used in the spawning, fry and juvenile physical habitat simulations, respectively.

Jesperson (1979) and Quinlan (1980) found the majority of spawning by Colorado River cutthroat trout occurred on the descending limb of the hydrograph during June, and in some instances spawning continued through the first week of July in streams of the Little Snake River drainage. Depending on flow and temperature conditions, spawning may begin in May. Suitable physical habitat for spawning is most critical during this time period. Following egg maturation through July, physical habitat for fry is important from early August through September. Most age-0 Colorado River cutthroat attain the juvenile life stage by September. Based on the biology of Colorado River cutthroat trout, Table 3 illustrates the biologically critical times of the year to which instream flow modeling methodologies apply in Dirtyman Fork.

Table 3. Methods used to determine instream flow recommendations at different times of the year based on various life stages of Colorado River cutthroat trout.

<table>
<thead>
<tr>
<th>Spawning</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

1 - PHABSIM
2 - Habitat Retention
RESULTS

Habitat Retention Analysis

Results from the habitat retention analysis indicate a flow of 0.5 cfs is required to maintain hydraulic criteria in riffles to provide passage for all life stages (Table 4). Maintenance of naturally occurring flows up to this flow is necessary at all times of the year.

Table 4. Simulated hydraulic criteria for riffles on Dirtyman Fork. Average daily flow = 0.9 cfs. Bankful discharge = 5.8 cfs.

<table>
<thead>
<tr>
<th>Riffle 1</th>
<th>Mean depth (ft)</th>
<th>Mean velocity (ft/s)</th>
<th>Wetted perimeter (ft)</th>
<th>Discharge (cfs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.42</td>
<td>1.11</td>
<td>12.9</td>
<td>5.8</td>
<td></td>
</tr>
<tr>
<td>0.37</td>
<td>0.90</td>
<td>12.6</td>
<td>4.0</td>
<td></td>
</tr>
<tr>
<td>0.32</td>
<td>0.76</td>
<td>12.5</td>
<td>3.0</td>
<td></td>
</tr>
<tr>
<td>0.30</td>
<td>0.62</td>
<td>11.2</td>
<td>2.0</td>
<td></td>
</tr>
<tr>
<td>0.28</td>
<td>0.42</td>
<td>8.6</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>0.28</td>
<td>0.40</td>
<td>8.5</td>
<td>0.9</td>
<td></td>
</tr>
<tr>
<td>0.26</td>
<td>0.25</td>
<td>6.5</td>
<td>0.4</td>
<td></td>
</tr>
<tr>
<td>0.20</td>
<td>0.16</td>
<td>6.0</td>
<td>0.2</td>
<td></td>
</tr>
<tr>
<td>0.17</td>
<td>0.11</td>
<td>5.4</td>
<td>0.1</td>
<td></td>
</tr>
</tbody>
</table>

Riffle 2

<table>
<thead>
<tr>
<th>Mean depth (ft)</th>
<th>Mean velocity (ft/s)</th>
<th>Wetted perimeter (ft)</th>
<th>Discharge (cfs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.39</td>
<td>2.19</td>
<td>7.2</td>
<td>5.8</td>
</tr>
<tr>
<td>0.27</td>
<td>1.00</td>
<td>5.7</td>
<td>1.5</td>
</tr>
<tr>
<td>0.26</td>
<td>0.94</td>
<td>5.4</td>
<td>1.3</td>
</tr>
<tr>
<td>0.25</td>
<td>0.82</td>
<td>5.0</td>
<td>1.0</td>
</tr>
<tr>
<td>0.20</td>
<td>0.54</td>
<td>4.8</td>
<td>0.52</td>
</tr>
<tr>
<td>0.19</td>
<td>0.47</td>
<td>4.6</td>
<td>0.4</td>
</tr>
<tr>
<td>0.16</td>
<td>0.31</td>
<td>4.3</td>
<td>0.2</td>
</tr>
<tr>
<td>0.16</td>
<td>0.24</td>
<td>2.6</td>
<td>0.1</td>
</tr>
</tbody>
</table>

1 - Minimum hydraulic criteria met
2 - Discharge at which 2 of 3 hydraulic criteria are met

Spawning Physical Habitat

The relationship between discharge and weighted usable area for spawning Colorado River cutthroat trout is illustrated in Figure 1. Physical habitat is maximized at 1.4 cfs. Physical habitat for spawning is reduced about 13% from 1.4 cfs down to 0.8 cfs. At flows less than 0.8 cfs, physical habitat for spawning is reduced substantially with incrementally small reductions in flows. Flows up to the highest simulated flow (3.0 cfs) will maintain no less than about 50% of maximum physical habitat.
Figure 1. Relationship between discharge and physical habitat for spawning Colorado River cutthroat trout in Dirtyman Fork.
Fry Physical Habitat

Physical habitat for fry increases from a minimum of about 450 ft\(^2/1,000\) at 0.1 cfs to a maximum of 924 ft\(^2/1,000\) at 2.1 cfs (Figure 2). Physical habitat remains relatively constant up to the maximum simulated discharge (3.0 cfs).

Juvenile Physical habitat

Physical habitat for juvenile Colorado River cutthroat trout is maximized at 0.9 cfs (Figure 3). At flows greater than 0.9 cfs, greater than 90% of maximum physical habitat is maintained. Physical habitat declines significantly at flows less than 0.5 cfs.
Figure 2. Relationship between discharge and physical habitat for fry Colorado River cutthroat trout in Dirtyman Fork.
Figure 3. Relationship between discharge and physical habitat for juvenile Colorado River cutthroat trout in Dirtyman Fork.
DISCUSSION

Habitat retention analysis indicates 0.5 cfs is the minimum flow which maintains hydraulic criteria for fish passage and provides suitable conditions for aquatic invertebrate production in riffles. This flow is necessary at all times of the year except when greater flows are needed to maintain or enhance spawning conditions.

Results from physical habitat simulations indicate physical habitat for spawning Colorado River cutthroat trout is limited in Dirtyman Fork. Limited spawning habitat results from the predominance of cobble and larger substrates in the channel, and the relative scarcity of suitable spawning gravels. Because spawning habitat is limited, protection of this critical habitat type is necessary to ensure adequate reproductive success. Based on PHABSIM analysis, 1.4 cfs maximizes physical habitat for spawning. Although 87% of maximum physical habitat is maintained at flows down to 0.8 cfs, maximization of physical habitat for spawning is important because spawning habitat is very limited. Slight deviations from the maximum may have deleterious effects on spawning success. Because of the relatively high risk of physical habitat loss at lower flows and the sensitive status of this species, a flow of 1.4 cfs is necessary to maximize physical habitat for spawning.

Results from PHABSIM indicate physical habitat for fry is maximized at 2.1 cfs; however, flows of this magnitude rarely, if ever exist in Dirtyman Fork during late summer. Flows during late summer under natural, average conditions probably range from 0.4 cfs to 0.5 cfs. Based on results from the habitat retention analysis, a flow of 0.5 cfs is needed to maintain hydraulic criteria. At 0.5 cfs, physical habitat for fry is about 75% of the maximum available at 2.1 cfs. These results suggest 75% of maximum physical habitat is suitable for maintaining physical habitat for fry.

Results from PHABSIM indicate physical habitat for juvenile Colorado River cutthroat trout is maximized at 0.9 cfs, but little reductions in physical habitat occur down to 0.5 cfs. At flows less than 0.5 cfs, physical habitat for juveniles declines significantly. These results are similar to those derived from the habitat retention method which indicate 0.5 cfs maintains hydraulic criteria in Dirtyman Fork. Based on these considerations, a discharge of 0.5 cfs maintains suitable physical habitat for juvenile Colorado River cutthroat trout in Dirtyman Fork.

Unlike fry and juveniles, physical habitat suitability for adult Colorado River cutthroat trout in Dirtyman Fork is not directly influenced by stream flow because adults primarily inhabit beaver ponds. Although beaver pond water levels will be influenced by changes in pond inflow, the ponds will maintain suitable physical habitat.
(depth). However, stream flow alterations may have indirect effects on habitat quality in the ponds. Reductions in flow to less than 0.5 cfs derived from the habitat retention analysis will negatively impact aquatic invertebrate production in riffles upstream from the beaver ponds that will reduce the amount of drifting food resources available to adults in the beaver ponds. Reduced availability of drifting food resources has been shown to limit the growth potential of salmonids in streams (Fausch 1984) and may negatively impact the reproductive potential of Colorado River cutthroat trout. Significant reductions in pond flow may also increase water temperatures in the ponds to levels unsuitable for adults; however, this effect would be minimal because the stream upstream from the ponds and the ponds are extensively shaded.

Based on results from this study, the instream flows listed in Table 5 are recommended for Dirtyman Fork. The spring and early summer flow of 1.4 cfs will maximize physical habitat for spawning which is critical in Dirtyman Fork. The summer, fall and winter flow of 0.5 cfs will maintain hydraulic criteria, and provide suitable physical habitat for fry, juvenile and adult life stages of Colorado River cutthroat trout.

The limitation of stream discharge to only the recommended flows may contribute to a decline in physical habitat quality over the long-term. For example, substrate fines may accumulate in the limited spawning gravels due to a lack of cyclical major runoff events (e.g. bankful discharge) which could reduce spawning success. The absence of high natural runoff flows in the spring could also limit the recruitment of spawning gravels from the upper watershed. The lack of these channel maintenance flows may also lead to the encroachment of stream banks and a gradual narrowing of the stream channel. This process would reduce the total space available to trout, and in combination with the above processes, lead to reduced physical habitat suitability.

The WGFD does not presently have the expertise with methods used to determine appropriate channel maintenance flows. When this expertise is acquired, supplemental water rights for channel maintenance should be pursued.

<table>
<thead>
<tr>
<th>Time period</th>
<th>Discharge (cfs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>October 1 to April 30</td>
<td>0.5</td>
</tr>
<tr>
<td>May 1 to June 30</td>
<td>1.4</td>
</tr>
<tr>
<td>July 1 to September 30</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Table 5. Summary of instream flow recommendations for Dirtyman Fork.
LITERATURE CITED


Hipple, B. 1986. Summary of washouts at Deadman Creek, First Creek, Second Creek, and Rose Creek on Stage II Little Snake River Diversion pipeline. Medicine Bow National Forest, unpublished.


Miller, D.D. 1980. Quantification of trout habitat that could be impacted by Stage III of the Little Snake River Water Management Project. Wyoming Game and Fish Department Administrative Report, Fish Division, Cheyenne.


Deep Creek
Instream Flow Segment No. 1
STATE OF WYOMING
OFFICE OF THE STATE ENGINEER
APPLICATION FOR PERMIT TO APPROPRIATE SURFACE WATER

THIS SECTION IS NOT TO BE FILLED IN BY APPLICANT

Filing/Priority Date

THE STATE OF WYOMING,
STATE ENGINEER'S OFFICE

This instrument was received and filed for record on the 19th day of December, A.D. 1995, at 2:15 o'clock P.M.

JOHN R. BARNES, for State Engineer

Recorded in Book ____________ of Ditch Permits, on Page ____________

Fee Paid $50.00. Map Filed ____________

WATER DIVISION NO. 1 DISTRICT NO. 8 Filing No. 293/75

PERMIT NO. ____________

NAME OF FACILITY Deep Creek Instream Flow Segment No. 1

1. Name(s), mailing address and phone no. of applicant(s) is/are

Wyoming Water Development Commission
Herschler Building - 4-W
Cheyenne, WY 82002

(IF MORE THAN ONE APPLICANT, DESIGNATE ONE AS AGENT FOR THE OTHER)

2. Name & address of agent to receive correspondence and notices

Wyoming Game and Fish Dept.
5400 Bishop Blvd., Cheyenne, WY 82006

3. (a) The use to which the water is to be applied is Instream Flow

(b) If more than one beneficial use of water is applied for, the location and ownership of the point of use must be shown in item 10 of the application and the details of the facilities used to divert and convey the appropriation must be shown on the map in sufficient detail to allow the State Engineer to establish the amount of appropriation. In multiple use applications, stock and domestic purposes are limited to 0.056 cubic feet per second.

4. The source of the proposed appropriation is Deep Creek, Tributary of Big Sandstone, Tributary of Savery Creek Tributary of Little Snake River

5. The point of diversion of the proposed work is located from the confluence of east & west Forks NE1/4 corner of Section 4 T. 14 N. R. 87 W. downstream to USFS road 801 in NW1/4 Section 18 T. 14 N. R. 87 W. length of segment is 3.5 miles.

6. Are any of the lands crossed by the proposed facility owned by the State or Federal Government? If so, describe lands and indicate whether

State or Federally owned.

Sec. 4, T14N, R87W, SE1/4 of NE1/4, NW1/4 and NE1/4 and SW1/4 of SE1/4, Federal.

Sec. 7, T14N, R87W, SE1/4, SW1/4 of SE1/4, Federal.

Sec. 8, T14N, R87W, SE1/4, NW1/4 of SW1/4, NW1/4, NE1/4, SW1/4 of SE1/4, Federal.

Sec. 9, T14N, R87W, NE1/4, SE1/4, SW1/4 of NW1/4, NW1/4 of NE1/4, Federal.

Sec. 18, T14N, R87W, NE1/4 of NW1/4, NW1/4 of NE1/4, Federal.

7. The carrying capacity of the ditch, canal, pipeline or other facility at the point of diversion is __________ cubic feet per second.

8. The accompanying map is prepared in accordance with the State Engineer's Manual of Regulations and Instructions for filing applications and is hereby declared a part of this application. The State Engineer may require the filing of detailed construction plans.

9. The estimated time required for the commencement of work is __________, for completion of construction is __________ and to complete the application of water to the beneficial uses stated in this application is __________ from issue.
10. The land to be irrigated under this permit is described in the following tabulation. (Give irrigable acreage in each 40-acre subdivision. Designate ownership of land, Federal, State or private. If private, list names of owners and land owned separately.) If application is for stock, domestic, or for purposes other than irrigation, indicate point of use by 40-acre subdivision and owner.

<table>
<thead>
<tr>
<th>Township Range</th>
<th>Sec.</th>
<th>NE 1/4</th>
<th>NW 1/4</th>
<th>SW 1/4</th>
<th>SE 1/4</th>
<th>TOTALS</th>
</tr>
</thead>
<tbody>
<tr>
<td>14N 87W 4</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Number of acres to receive original supply
Number of acres to receive supplemental supply
Total number of acres to be irrigated

REMARKS

Item 7 - Based on the results of a study completed in 1994 and data analysis in 1995 by Wyoming Game & Fish Department:

Instream Flow:
- October 1 - April 30: 0.5 cfs
- May 1 - June 30: 4.6 cfs
- July 1 - September 30: 0.5 cfs

This is an ungaged stream. If the State Engineer's Office determines that the measurement of instantaneous flow is needed to administer this right, a gage will be installed at or near the downstream end of the instream flow segment.

Under penalties of perjury, I declare that I have examined this application and to the best of my knowledge and belief it is true, correct and complete.

Signature of Applicant or Agent: [Signature]
Date: 12/19/85
STATE OF WYOMING

APPLICATION FOR PERMIT TO APPROPRIATE SURFACE WATER

NAME OF FACILITY Deep Creek

1. Name(s), mailing address and phone no. of applicant(s) is/are Wyoming Water Development Commission, Herschler Building, Cheyenne, WY 82002

2. Name & address of agent to receive correspondence and notices John Talbot, Wyoming Game and Fish Department, 5400 Bishop Boulevard, Cheyenne, WY 82002; Michael Purcell, W.W.D.C., Herschler Bldg., Cheyenne WY 82002

3. (a) The use to which the water is to be applied is Instream Flow

4. The source of the proposed appropriation is Deep Creek tributary of Big Sandstone Creek

5. Instream flow segment extends from the confluence of the east and west forks at NE1/4 of section 4 T 14 N., R 87 W. downstream to U.S. Forest Service Road #801 at NW1/4 of section 18 T 14 N., R 87 W. Length of stream is approximately 3.4 miles. (Please double-check segment length)

6. Are any of the lands crossed by the proposed facility owned by the State or Federal Government? If so, describe lands and indicate whether State or Federally owned.
   The land crossed by this stream segment is federally owned.

7. The carrying capacity of the ditch, canal, pipeline or other facility at the point of diversion is see remarks cubic feet per second.

8. The accompanying map is prepared in accordance with the State Engineer’s Manual of Regulations and Instructions for filing applications and is hereby declared a part of this application. The State Engineer may require the filing of detailed construction plans.

9. The estimated time required for the commencement of work is 30 days, for completion of construction is 30 days, and to complete the application of water to the beneficial uses stated in this application is 30 days.
<table>
<thead>
<tr>
<th>Month</th>
<th>Flow (cfs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>October</td>
<td>0.5</td>
</tr>
<tr>
<td>November</td>
<td>0.5</td>
</tr>
<tr>
<td>December</td>
<td>0.5</td>
</tr>
<tr>
<td>January</td>
<td>0.5</td>
</tr>
<tr>
<td>February</td>
<td>0.5</td>
</tr>
<tr>
<td>March</td>
<td>0.5</td>
</tr>
<tr>
<td>April</td>
<td>0.5</td>
</tr>
<tr>
<td>May</td>
<td>4.6</td>
</tr>
<tr>
<td>June</td>
<td>4.6</td>
</tr>
<tr>
<td>July</td>
<td>0.5</td>
</tr>
<tr>
<td>August</td>
<td>0.5</td>
</tr>
<tr>
<td>September</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Based on the results of a study completed in 1994 and data analysis in 1995 by the Wyoming Game and Fish Department (attached), a flow right of 0.5 cfs is requested from October 1 to April 30 to maintain physical habitat suitability for Colorado River cutthroat trout. A flow of 4.6 cfs is requested from May 1 to June 30 to maintain existing levels of physical habitat for spawning Colorado River cutthroat trout. A flow of 0.5 cfs is requested from July 1 to September 30 to maintain physical habitat suitability for Colorado River cutthroat trout.
Instream flow studies were conducted on Deep Creek in 1994 as part of an ongoing monitoring and enhancement program for Colorado River cutthroat trout in streams of the Little Snake River basin. The goal of this study was to determine instream flows necessary for maintaining or improving Colorado River cutthroat trout habitat in Deep Creek.

Physical habitat simulations were conducted for spawning, fry, juvenile and adult life stages of Colorado River cutthroat trout. Based on results from physical habitat simulations, the instream flow recommendations are: October 1 to April 30, 0.5 cfs; May 1 to June 30, 4.6 cfs; July 1 to September 30, 0.5 cfs. The instream flow applies to a 3.4-mile stream reach extending from the confluence of the East and West Forks of Deep Creek in R87W, T14N, S4, NE1/4 downstream to U.S. Forest Service road #801 (Deep Creek Road) in R87W, T14N, S18, NW1/4.

INTRODUCTION

Colorado River cutthroat trout Oncorhynchus clarki pleuriticus are classified as Category 2 taxa by the U.S. Fish and Wildlife Service indicating this species may be appropriate for listing as threatened or endangered. This subspecies is considered a species of special concern by the Wyoming Game and Fish Department (WGFD) and Region 2 of the U.S. Forest Service. Although Colorado River cutthroat trout were historically distributed throughout streams of the Colorado River drainage in Wyoming, Colorado, Utah, Arizona and New Mexico, they now occupy less than 1% of their historic range (Speas et al. 1994). In Wyoming, populations of Colorado River cutthroat trout occur predominantly in small headwater streams of the Green, Little Snake and Blacks Fork River watersheds. Several factors including poor land management practices, limited stream flows, displacement by non-native
trouts, fishing pressure and habitat fragmentation have contributed to
the reduced distribution and abundance of Colorado River cutthroat
trot throughout their native range (Trotter 1987).

In the Little Snake River watershed, water management activities
pose the greatest threat to Colorado River cutthroat trout. Water
quality violations and habitat fragmentation following completion of
the City of Cheyenne's Stage I and Stage II water diversions have
occurred in Colorado River cutthroat trout streams (Hippe 1986,
Schmal 1986, Wilcox 1989). Additional flow diversions in other
streams of the Little Snake River drainage (Savery Creek drainage)
have been considered as part of the City of Cheyenne's Stage III water
development plan which could further impact this species. Depending on
the magnitude, these types of impacts could contribute to the listing
of this species as threatened or endangered unless adequate protective
measures are implemented. The potential effects of these flow
diversions are discussed in Miller (1980) and Wyoming Game and Fish
Department (1986). The importance of protecting habitat and
populations of Colorado River cutthroat trout on lands administered by
Forest Service was formally acknowledged by an April 22, 1987
Memorandum of Understanding between the Forest Service and WGFD.

In 1994, a management plan for Colorado River cutthroat trout in
the Little Snake River watershed was cooperatively prepared by the
U.S. Forest Service, the WGFD, and the U.S. Bureau of Land Manangement
(Speas et al. 1994). This plan calls for the protection, maintenance,
and re-establishment of Colorado River cutthroat trout in streams of
the Little Snake River drainage. Within this plan, the acquisition of
instream flows water rights for maintenance and protection of critical
Colorado River cutthroat trout habitat was listed as a primary
objective.

The objectives of this study were 1) to examine relationships
between discharge and physical habitat quantity and quality available
to Colorado River cutthroat trout in Deep Creek and 2) to determine an
instream flow regime in Deep Creek to maintain or improve Colorado
River cutthroat trout populations.

METHODS

Study Area Description

Deep Creek originates on the west slope of the Sierra Madre-
Mountains at elevations in excess of 9,200 feet msl. The East and West
branches flow 2.0 and 1.7 miles, respectively, before joining to form
the mainstem of Deep Creek. Deep Creek then flows for about 5.6 miles
to its confluence with Big Sandstone Creek. The entire Deep Creek
watershed lies within the Medicine Bow National Forest and encompasses
6.33 square miles.
From the confluence of the East and West branches to the terminus, Deep Creek has an average slope of about 3.5%. The class B1 channel (Rosgen 1985) is relatively stable with substrates of small boulders, cobble, and gravel being dominant. Numerous beaver dams scattered throughout the length of the channel create localized discontinuities in channel gradient and stream morphometry.

Hydrology

Deep Creek, like most small streams in the Medicine Bow National Forest, is ungaged. Therefore, site specific flow records for Deep Creek not exist. Discharge records for adjacent Big Sandstone Creek do exist for water years 1956, 1957, 1958, 1985, 1986, 1987 and 1988 (USGS gage # 09255900). This gage was located 300 feet downstream from the Douglas Creek confluence with Big Sandstone Creek.

Big Sandstone Creek flow data were used to estimate monthly flow patterns in Deep Creek. Flow patterns in Deep Creek were obtained by applying a monthly water yield to drainage area ratio from Big Sandstone Creek to Deep Creek. For all watershed size vs. flow relationships, an area of 9.85 square miles and gaged flows were used for Big Sandstone Creek. Flows were estimated for Deep Creek using a watershed size of 4.47 square miles (area above the study site, see below).

Based on this hydrologic simulation technique and average flow conditions of 15.89 cfs in Big Sandstone Creek, average daily flows in Deep Creek are 7.21 cfs; greatest mean daily flows (37.89 cfs) in Deep Creek would occur in June (Figure 1). In 1987 (lowest flows on record for Big Sandstone Creek), average daily flow in Deep Creek would have been 4.47 cfs and greatest mean daily flows (28.29 cfs) would have occurred in May (Figure 1). The average daily minimum flow in Deep Creek for the Big Sandstone Creek period of record was 0.64 cfs (range 0.5 cfs-0.82 cfs).

A water diversion (Deep Creek ditch) exists about 1.4 miles downstream from the confluence the East and West branches in R87W, T14N, S9, NW1/4. The diversion carries an adjudicated water right of 0.10 cfs with a priority date of September 4, 1919. The above flow analysis did not include consideration of potential irrigation diversions in this ditch.

Fisheries

Colorado River cutthroat trout occur throughout the entire Deep Creek drainage. Past electrofishing surveys (Miller 1980; Oberholtzer et al. 1990; Speas et al. 1994) indicate Deep Creek provides important habitat for all life stages of Colorado River cutthroat trout because collections revealed the presence of several size classes.
Figure 1. Mean daily flows in Big Sandstone Creek and Deep Creek. Big Sandstone Creek data were compiled from USGS gage number 09255900 for water years 1956, 1957, 1958, 1985, 1986, 1987 and 1988. Discharge in Deep Creek was estimated from Big Sandstone Creek data (see text for an explanation of methods).
Though quantitative, site-specific data for Deep Creek do not exist, studies by Reromick (WGFD, pers. comm.) and other WGFD biologists indicate Colorado River cutthroat trout typically exhibit dynamic changes in population density in response to discharge fluctuations. Present management theory is based on the phenomenon that fish populations in small streams are dependent on strong year classes produced in good flow years which may occur every three to five years. Without the benefit of periodic high flows, populations in some streams would decline or cease to exist.

Study site

After surveying about 0.75 miles of Deep Creek, a study site was established about 125 feet upstream from Forest Service Road #801 (Deep Creek Road) in R87W, T14N, S18, NW1/4. The elevation of the study site is about 7,760 feet mean sea level. Within the 108-foot-long study site, ten transects were established in riffles, runs and pools to represent habitat found throughout the middle reaches of Deep Creek. Instream flow information derived from this site was applied to a 3.4-mile stream reach extending from the confluence of the East and West Forks of Deep Creek in R87W, T14N, S4, NE1/4 downstream to U.S. Forest Service road #801 (Deep Creek Road) in R87W, T14N, S18, NW1/4. The land through which the instream flow segment passes is administered by the U.S. Forest Service.

Physical habitat simulation

A physical habitat simulation model (PHABSIM; Bovee 1982; Milhous et al. 1989) was used to quantify relationships between stream discharge and the amount of physical habitat available for Colorado River cutthroat trout. This model is the mostly widely used method for assessing relationships between instream flow and physical habitat for fish (Reiser et al. 1989). In PHABSIM, physical habitat is reported as weighted usable area (WUA; square feet/1,000 feet of stream length).

The physical habitat model was calibrated for all ten transects using hydraulic characteristics of depth, velocity and substrate measured on the dates and discharges listed in Table 1. Based on these data, physical habitat simulations were conducted for flows ranging from 0.1 cfs to 7.0 cfs.

Table 1. Dates and discharges when hydraulic data were collected in Deep Creek.

<table>
<thead>
<tr>
<th>Date</th>
<th>Discharge (cfs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>June 7, 1994</td>
<td>3.5</td>
</tr>
<tr>
<td>June 30, 1994</td>
<td>0.5</td>
</tr>
<tr>
<td>September 20, 1994</td>
<td>0.2</td>
</tr>
</tbody>
</table>
Because this section of Deep Creek provides habitat for all life stages of Colorado River cutthroat trout, relationships between WUA and discharge were generated for spawning, fry (individuals less than 1.5 inches total length), juveniles (individuals 2 to 5 inches total length) and adults (individuals greater than 6 inches total length). Jesperson (1979) and Quinlan (1980) found the majority of spawning by Colorado River cutthroat trout in streams of Little Snake drainage occurs primarily in mid to late June following peak discharge. Depending on flow and temperature conditions, spawning may begin as early as May and continue through the first week of July.

Following egg maturation, fry emerge from the redds from early August through September (Jesperson 1979). By October, most age-0 Colorado River cutthroat trout are about 1.25 inches in length. Table 2 illustrates the biologically critical times of the year for all life stages to which PHABSIM modeling was applied.

Table 2. Critical flow months for various life stages of Colorado River cutthroat trout in Deep Creek.

<table>
<thead>
<tr>
<th></th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spawning</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fry</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Juvenile</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Adult</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

Habitat suitability curves used in the PHABSIM model were from several sources. Fry suitability curves from Bozek and Rahel (1992) were generated from data in Colorado River cutthroat trout streams of the Little Snake River drainage. Juvenile and adult suitability curves were generated from data collected during the summer of 1994 in streams of the Little Snake River drainage (Braaten et al. in prep). Suitability curves depicting cutthroat trout spawning habitat were taken from Bovee (1978).

RESULTS

Spawning Physical Habitat

Relationships between discharge and weighted usable area for Colorado River cutthroat trout spawning are illustrated in Figure 2. Physical habitat is maximized at 4.6 cfs. At flows less than 4.0 cfs, the amount of physical habitat for spawning declines sharply.
Figure 2. Relationship between discharge and physical spawning habitat for Colorado River cutthroat trout in Deep Creek.
Adult Physical Habitat

Physical habitat simulations indicate maximum WUA for adult Colorado River cutthroat trout occurs at 0.6 cfs (Figure 3). Physical habitat declines sharply at flows greater than 0.7 cfs or flows less than 0.5 cfs.

Juvenile Physical Habitat

Physical habitat for juvenile Colorado River cutthroat trout is maximized 0.4 cfs (Figure 3). Physical habitat for juveniles declines sharply at flows less than 0.2 cfs and flows greater than 0.5 cfs.

Fry Physical Habitat

Based on physical habitat simulations, a discharge 0.1 cfs maximizes the amount of physical habitat available to Colorado River cutthroat trout fry (Figure 3). Physical habitat for fry declines rapidly at flows greater than 0.1 cfs.
Figure 3. Relationships between discharge and physical habitat for fry, juvenile and adult life stages of Colorado River cutthroat trout in Deep Creek.
DISCUSSION

Results from physical habitat simulations indicate a flow of 4.6 cfs from May 1 to June 30 is the flow at which physical habitat for spawning is maximized. Based on the seven years of flow records for Big Sandstone Creek, average monthly flows in Deep Creek during May and June approximate 30.46 cfs and 37.89 cfs, respectively. Mean daily flows of 28.27 cfs (May) and 8.53 cfs (June) in Deep Creek occur during the driest year on record (1987). This preliminary analysis of flow patterns in Deep Creek indicates the recommended spawning flow of 4.6 cfs during May and June should naturally be available even during dry water years and would maintain or improve existing levels of physical habitat for spawning.

Although the availability of fry habitat is a major population-limiting factor in some streams (Nehring and Anderson 1993), results from this study suggest physical habitat for fry is not a limiting factor in Deep Creek. Fry are typically present in Deep Creek between July and September. During this time period, natural flows in Deep Creek (based Big Sandstone Creek basin area vs. water yield models) average 1.47 cfs and 1.06 cfs, respectively (Figure 1). Under these natural flow regimes, fry WUA is about 30% less than maximum WUA for fry which occurs at 0.1 cfs. These results indicate populations of Colorado River cutthroat trout have persisted in Deep Creek despite the absence of a physical habitat-maximizing flow for fry in late summer. Based on these results, populations of Colorado River cutthroat trout in Deep Creek are probably regulated by the amount and quality of physical habitat available to juveniles and adults. Although fry physical habitat is maximized at 0.1 cfs, the permanent limitation of discharge at this level would seriously limit other important life stages (see below). As a consequence, instream flow recommendations based solely on the fry life stage are inappropriate.

Results from physical habitat simulations indicate instream flows of 0.4 cfs and 0.6 cfs are needed to maximize physical for juveniles and adults, respectively, from July 1 to April 30 when physical habitat is most critical to these life stages (Table 2). Because Colorado River cutthroat trout are sensitive species, maximizing physical habitat suitability is critical for maintenance of their populations. Therefore, flows of 0.5 cfs from July 1 to April 30 are recommended for juveniles, adults, and fry. This flow maintains greater than 90% of maximum physical habitat for adults and juveniles and also provides about 85% of maximum physical habitat for fry.

Mean daily flows in Deep Creek (based on Big Sandstone Creek basin are vs. water yield models) from July 1 to April 30 range from 0.96 cfs to 5.8 cfs under normal conditions (averaged over the 7 years of data). During the driest year on record (1987), mean daily flows from July 1 to April 30 range from 0.89 cfs to 4.86 cfs. Therefore,
the recommended flow of 0.5 cfs from July 1 to April 30 should naturally be available even during dry water years.

A summary of Deep Creek flow recommendations is listed in Table 3. These flows will nearly maximize physical habitat for all life stages, and maintain or improve existing physical habitat suitability. However, the consistency of the recommended flows may contribute to a decline in habitat quality over the long-term. For example, substrate fines may accumulate in spawning gravels due to the lack of cyclical major runoff events (e.g., bankful discharge) which could reduce spawning success. The absence of high runoff flows in the spring could also limit the recruitment of spawning gravels from the upper watershed. The lack of channel maintenance flows may also lead to encroachment of stream banks and a gradual narrowing of the stream channel. This process would reduce the total space available to trout, and in combination with the above processes, lead to a reduction in the existing fishery.

The WGFD does not presently have the expertise with methods used to determine appropriate channel maintenance flows. When this expertise is acquired, supplemental water rights for channel maintenance should be pursued.

Table 3. Summary of instream flow recommendations for Deep Creek.

<table>
<thead>
<tr>
<th>Time period</th>
<th>Discharge (cfs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>October 1 to April 30</td>
<td>0.5</td>
</tr>
<tr>
<td>May 1 to June 30</td>
<td>4.6</td>
</tr>
<tr>
<td>July 1 to September 30</td>
<td>0.5</td>
</tr>
</tbody>
</table>
LITERATURE CITED


Hipple, B. 1986. Summary of washouts at Deadman Creek, First Creek, Second Creek, and Rose Creek on Stage II Little Snake River Diversion pipeline. Medicine Bow National Forest, unpublished.


Miller, D.D. 1980. Quantification of trout habitat that could be impacted by Stage III of the Little Snake River Water Management Project. Wyoming Game and Fish Department Administrative Report, Fish Division, Cheyenne.


Douglas Creek
Instream Flow Segment No. 1
STATE OF WYOMING
OFFICE OF THE STATE ENGINEER
APPLICATION FOR PERMIT TO APPROPRIATE SURFACE WATER

NAME OF FACILITY Douglas Creek Instream Flow Segment No. 1

1. Name(s), mailing address and phone no. of applicant(s) is/are

Wyoming Water Development Commission
Herschler Bldg, 4-W
Cheyenne, WY 82002

(If more than one applicant, designate one to act as Agent for the others)

2. Name & address of agent to receive correspondence and notices

Wyoming Game and Fish Department
5400 Bishop Blvd. Cheyenne, WY 82006

3. (a) The use to which the water is to be applied is Instream Flow

(b) If more than one beneficial use of water is applied for, the location and ownership of the point of use must be shown in item 10 of the application and the details of the facilities used to divert and convey the appropriation must be shown on the map in sufficient detail to allow the State Engineer to establish the amount of appropriation. In multiple use applications, stock and domestic purposes are limited to 0.056 cubic feet per second.

4. The source of the proposed appropriation is Douglas Creek, Tributary to Big Sandstone Creek, Tributary to Savery Creek, Tributary to Little Snake River.

5. The point of diversion of the proposed water is located

from the SW 1/4 owner of Section 3 T. 14 N., R. 87 W. to the
confluence of Douglas Cr. & Big Sandstone Cr. at NW 1/4 Length of Segment = 1.0 miles

6. Are any of the lands crossed by the proposed facility owned by the State or Federal Government? If so, describe lands and indicate whether State or Federally owned.

Section 3, T14N, R87W, South 1/2 of the SW1/4 owned by Federal Govt.
Section 10, T14N, R87W, NW1/4 owned by the Federal Govt.

7. The carrying capacity of the ditch, canal, pipeline or other facility at the point of diversion is See Remarks cubic feet per second.

8. The accompanying map is prepared in accordance with the State Engineer's Manual of Regulations and Instructions for filing applications and is hereby declared a part of this application. The State Engineer may require the filing of detailed construction plans.

9. The estimated time required for the commencement of work is 30 days, for completion of construction is 30 days, and to complete the application of water to the beneficial uses stated in this application is 30 days from issue.
10. The land to be irrigated under this permit is described in the following tabulation. (Give irrigable acreage in each 40-acre subdivision. Designate ownership of land, Federal, State or private. If private, list names of owners and land owned separately.) If application is for stock, domestic, or for purposes other than irrigation, indicate point of use by 40-acre subdivision and owner.

<table>
<thead>
<tr>
<th>Township</th>
<th>Range</th>
<th>Sec.</th>
<th>NE¼</th>
<th>NW¼</th>
<th>SW¼</th>
<th>SE¼</th>
<th>NE¼</th>
<th>NW¼</th>
<th>SW¼</th>
<th>SE¼</th>
<th>TOTALS</th>
</tr>
</thead>
<tbody>
<tr>
<td>14N</td>
<td>87W</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Number of acres to receive original supply
Number of acres to receive supplemental supply
Total number of acres to be irrigated

**REMARKS**

Based on the results of a study completed in 1996 and data analysis in 1995 by the Wyoming Game and Fish Dept.

**Instream Flow:**
- October 1 - April 30 0.3 cfs
- May 1 - June 30 3.6 cfs
- July 1 - September 30 0.5 cfs

This is an ungaged stream. If the State Engineer's Office determines that the measurement of instantaneous flow is needed to administer this water right, a gage will be installed at or near the downstream end of the instream flow segment.

Under penalties of perjury, I declare that I have examined this application and to the best of my knowledge and belief it is true, correct and complete.

[Signature]
Signature of Applicant or Agent

12/17/95
Date
STATE OF WYOMING

APPLICATION FOR PERMIT TO APPROPRIATE SURFACE WATER

NAME OF FACILITY __Douglas Creek__

1. Name(s), mailing address and phone no. of applicant(s) is/are __Wyoming Water Development Commission, Herschler Building, Cheyenne, WY 82002__

2. Name & address of agent to receive correspondence and notices __John Talbot, Wyoming Game and Fish Department, 5400 Bishop Boulevard, Cheyenne, WY 82002; Michael Purcell, W.W.D.C., Herschler Bldg., Cheyenne WY 82002__

3. (a) The use to which the water is to be applied is ___Instream Flow___

4. The source of the proposed appropriation is __Douglas Creek tributary of Big Sandstone Creek__

5. Instream flow segment extends from the SW1/4 of section 3 T 14 N., R 87 W. downstream to the confluence of Douglas Creek and Big Sandstone Creek at NW1/4 of section 10 T 14 N., R 87 W. Length of stream is approximately 1.0 mile. (Please double-check segment length)

6. Are any of the lands crossed by the proposed facility owned by the State or Federal Government? If so, describe lands and indicate whether State or Federally owned. The land crossed by this stream segment is federally owned.

7. The carrying capacity of the ditch, canal, pipeline or other facility at the point of diversion is ___see remarks__ cubic feet per second.

8. The accompanying map is prepared in accordance with the State Engineer’s Manual of Regulations and Instructions for filing applications and is hereby declared a part of this application. The State Engineer may require the filing of detailed construction plans.

9. The estimated time required for the commencement of work is ___30 days___, for completion of construction is ___30 days___, and to complete the application of water to the beneficial uses stated in this application is ___30 days___. 
<table>
<thead>
<tr>
<th>Month</th>
<th>Flow (cfs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>October</td>
<td>0.3</td>
</tr>
<tr>
<td>November</td>
<td>0.3</td>
</tr>
<tr>
<td>December</td>
<td>0.3</td>
</tr>
<tr>
<td>January</td>
<td>0.3</td>
</tr>
<tr>
<td>February</td>
<td>0.3</td>
</tr>
<tr>
<td>March</td>
<td>0.3</td>
</tr>
<tr>
<td>April</td>
<td>0.3</td>
</tr>
<tr>
<td>May</td>
<td>3.6</td>
</tr>
<tr>
<td>June</td>
<td>3.6</td>
</tr>
<tr>
<td>July</td>
<td>0.5</td>
</tr>
<tr>
<td>August</td>
<td>0.5</td>
</tr>
<tr>
<td>September</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Based on the results of a study completed in 1994 and data analysis in 1995 by the Wyoming Game and Fish Department (attached), a flow right of 0.3 cfs is requested from October 1 to April 30 to maintain physical habitat suitability for Colorado River cutthroat trout. A flow of 3.6 cfs is requested from May 1 to June 30 to maintain existing levels of physical habitat for spawning Colorado River cutthroat trout. A flow of 0.5 cfs is requested from July 1 to September 30 to maintain Colorado River cutthroat trout production.
ABSTRACT

Instream flow studies were conducted on Douglas Creek in 1994 as part of an ongoing monitoring and enhancement program for Colorado River cutthroat trout in streams of the Little Snake River basin. The goal of this study was to determine instream flows necessary for maintaining or improving Colorado River cutthroat trout habitat in Douglas Creek.

Physical habitat modeling and the Habitat Quality Index were used to determine instream flows necessary for maintenance of Colorado River cutthroat trout habitat. Based on results from these methodologies, the instream flow recommendations are: October 1 to April 30, 0.3 cfs; May 1 to June 30, 3.6 cfs; July 1 to September 30, 0.5 cfs. The instream flow applies to a 1.0-mile stream reach extending from R87W, T14N, S3, SW1/4 downstream to the confluence of Douglas Creek with Big Sandstone Creek in R87W, T14N, S10, NW1/4.

INTRODUCTION

Colorado River cutthroat trout *Oncorhynchus clarki pleuriticus* are classified as Category 2 taxa by the U.S. Fish and Wildlife Service. Species in this category may be appropriate for listing as threatened or endangered if significant losses of habitat or declines in population size continue. Colorado River cutthroat trout are considered a species of special concern by the Wyoming Game and Fish Department (WGFD) and Region 2 of the U.S. Forest Service. Although Colorado River cutthroat trout were historically distributed throughout streams of the Colorado River drainage in Wyoming, Colorado, Utah, Arizona and New Mexico, they now occupy less than 1% of their historic range (Speas et al. 1994). In Wyoming, populations of Colorado River cutthroat trout occur predominantly in small headwater streams of the Green, Little Snake and Blacks Fork River watersheds. Several factors including poor land management practices,
limited stream flows, displacement by non-native trouts, fishing pressure and habitat fragmentation have contributed to the reduced distribution and abundance of Colorado River cutthroat trout throughout their native range (Trotter 1987).

In the Little Snake River watershed, water management activities pose the greatest threat to Colorado River cutthroat trout. Water quality violations and habitat fragmentation following completion of the City of Cheyenne's Stage I and Stage II water diversions have occurred in Colorado River cutthroat trout streams (Hipple 1986, Schmal 1986, Wilcox 1989). Additional flow diversions in other streams of the Little Snake River drainage (Savery Creek drainage) have been considered as part of the City of Cheyenne's Stage III water development plan which could further impact this species. Depending on the magnitude, these types of impacts could contribute to the listing of this species as threatened or endangered unless adequate protective measures are implemented. The potential effects of these flow diversions are discussed in Miller (1980) and Wyoming Game and Fish Department (1986). Appropriate protective measures such as acquisition of adequate instream flow water rights could help avoid the listing of Colorado River cutthroat trout as threatened or endangered and allow some development of water resources to proceed. The importance of protecting habitat and populations of Colorado River cutthroat trout was formally acknowledged by an April 22, 1987 Memorandum of Understanding between the Forest Service and the WGFV.

In 1994, a management plan for Colorado River cutthroat trout in the Little Snake River watershed was cooperatively prepared by the U.S. Forest Service, the WGFV, and the U.S. Bureau of Land Management (Speas et al. 1994). This plan calls for the protection, maintenance, and re-establishment of Colorado River cutthroat trout in streams of the Little Snake River drainage. Within this plan, the acquisition of instream flows water rights for maintenance and protection of critical Colorado River cutthroat trout habitat was listed as a primary objective.

The objectives of this study were 1) to examine relationships between discharge and physical habitat quantity and quality available to Colorado River cutthroat trout in Douglas Creek and 2) to determine an instream flow regime in Douglas Creek for the maintenance Colorado River cutthroat trout habitat.

STUDY AREA

Douglas Creek originates on the west slope of the Sierra Madre Mountains at elevations in excess of 9,600 feet above mean sea level. The channel has a total length of about 3.0 miles and terminates at its confluence with Big Sandstone Creek. The entire Douglas Creek watershed is located within the Medicine Bow National Forest.
Douglas Creek has an average slope of about 6.0%. The class A3 channel (Rosgen 1985) is relatively stable and substrates are comprised of small boulders, cobbles, and gravel. Beaver dams are present throughout the drainage and provide important habitat for adult trout.

Hydrology

Douglas Creek, like most small streams in the Medicine Bow National Forest, is ungauged; therefore, site-specific stream flow records for Douglas Creek are not available. Discharge records for Big Sandstone Creek do exist for water years 1956, 1957, 1958, 1985, 1986, 1987 and 1988. This USGS gage (# 09255900) was located 300 feet downstream from the Douglas Creek confluence with Big Sandstone Creek.

Big Sandstone flow data were used to estimate monthly flow patterns in Douglas Creek. Flow patterns in Douglas Creek were obtained by applying a monthly water yield to drainage area ratio from Big Sandstone Creek to Douglas Creek. For all watershed versus flow relationships, a watershed area of 9.85 square miles and gaged flows were used for Big Sandstone Creek. Flows were estimated in Douglas Creek using a watershed area of 2.13 square miles. Thus, flows in Douglas Creek are about 21.6% of Big Sandstone Creek flows.

Based on this hydrologic simulation technique and average flows of 15.89 cfs in Big Sandstone Creek, average daily flows in Douglas Creek are 3.52 cfs; greatest mean daily flows (18.03 cfs) would occur in June (Figure 1). In 1987 (period of lowest flows on record for Big Sandstone Creek), average daily flow in Douglas Creek would have been 2.13 cfs and greatest mean daily flows (13.46 cfs) would have occurred in May (Figure 1). The average daily minimum flow in Douglas Creek for the Big Sandstone Creek period of record was 0.31 cfs (range 0.24 cfs-0.39 cfs). These estimations indicate minimum base flows in Douglas Creek are relatively stable across years despite annual variability in precipitation levels.

Fisheries

Douglas Creek historically supported only Colorado River cutthroat trout and was classified as a "cutthroat trout sanctuary" by Kanaly et al. (1955). The pristine conditions in Douglas Creek offered abundant and diverse habitat. Since 1955, however, populations of Colorado River cutthroat trout have declined in Douglas Creek. Brook trout (Salvelinus fontinalis) emigrating upstream from Big Sandstone Creek have led to the decline of Colorado River cutthroat through mechanisms of competition and displacement.
Figure 1. Mean daily flows in Big Sandstone Creek and Douglas Creek. Big Sandstone Creek data were compiled from USGS gage number 09255900 for water years 1956, 1957, 1958, 1985, 1986, 1987 and 1988. Discharge in Douglas Creek was estimated from Big Sandstone Creek data (see text for an explanation of methods).
Habitat for Colorado River cutthroat trout in Douglas Creek remains relatively pristine. Beaver ponds and several deep pools have the potential to provide quality habitat for adults; pocket pools for juvenile life stages are abundant throughout the stream. Numerous gravel-dominated areas are also present to provide adequate spawning for Colorado River cutthroat trout. Because Douglas Creek supports abundant habitat for all life stages, habitat protection through the maintenance of adequate instream flows is an important first-step toward re-establishing Colorado River cutthroat trout in this stream.

Though quantitative, site-specific data for Douglas Creek do not exist, observations by Remmick (WGFD, pers. comm.) indicate Colorado River cutthroat trout typically exhibit natural fluctuations in year-class strength and population density. The magnitude of these fluctuations is primarily influenced by seasonal variability in discharge which affects spawning success and physical habitat quality. Present management theory is based on the phenomenon that fish populations in small streams are dependent on strong year classes produced in good flow years which may occur every three to five years. Without the benefit of periodic high flows, populations in some streams would decline or cease to exist.

Study site

After surveying about 0.5 miles of stream, a study site on Douglas Creek was established about 1,200 feet upstream from Big Sandstone Creek in R87W, T14N, S10, NW1/4. The elevation of the study site is 8,350 feet above mean sea level. Within the 152-foot-long study site, ten transects were established in riffles, runs, pocket pools and plunge pools to represent habitat types, except beaver ponds, found throughout the upper reaches of Douglas Creek.

METHODS

Instream flow data were collected at the study site in Douglas Creek on the dates and discharge listed in Table 1. Instream flow information derived from the study site was applied to a 1.0-mile stream reach extending from R87W, T14N, S3, SW1/4 downstream to the confluence of Douglas Creek with Big Sandstone Creek in R87W, T14N, S10, NW1/4. The land through which the instream flow segment passes is administered by the U.S. Forest Service.
A physical habitat simulation model (PHABSIM; Bovee 1982; Milhous et al. 1989) was used to quantify relationships between stream discharge and the amount of physical habitat available to spawning, fry, juvenile and adult life stages of Colorado River cutthroat trout. This model is the mostly widely used method for assessing relationships between instream flow and physical habitat for fish (Reiser et al. 1989). In PHABSIM, physical habitat is reported as weighted usable area (ft²/1,000 feet of stream length).

The physical habitat model was calibrated for all ten transects using hydraulic characteristics of depth, velocity and substrate measured on the dates and discharges listed in Table 1. Based on these data, physical habitat simulations were conducted for flows ranging from 0.1 cfs to 10.0 cfs. Habitat suitability criteria from Bovee (1978) and Bozek and Rahel (1992) were used in the spawning and fry physical habitat simulations, respectively. Suitability criteria from Braaten et al. (in preparation) were used in juvenile and adult physical habitat simulations.

The Habitat Quality Index (HQI, Binns and Eiserman 1979; Binns 1982) was used to estimate trout production over a broad range of late summer flow conditions. The HQI was developed by the WGFD and has been reliably used in Wyoming to assess the effects of stream flows on production potential of trout. Nine attributes which address the biological, chemical and physical aspects of trout production are included in the HQI. Results are expressed in habitat units, where one habitat unit is defined as the amount habitat that will support about 1 pound of trout.

In the HQI analysis, habitat attributes measured at various flow events are assumed typical of mean late summer flow conditions. Under this assumption, habitat unit estimates may be extrapolated through a range of possible late summer flows (Conder and Annear 1987). Some attributes of the HQI were mathematically derived from habitat measurements collected on the dates and discharges listed in Table 1.

Jesperson (1979) and Quinlan (1980) studied the biology of Colorado River cutthroat trout in streams of the Little Snake River drainage. These authors found the majority of spawning by Colorado River cutthroat trout occurred on the descending limb of the
hydrograph during June, and in some instances spawning continued through the first week of July. Depending on flow and temperature conditions, spawning may begin in May. Suitable physical habitat for spawning is most critical during this time period. Following egg maturation through July, physical habitat for fry is important from early August through September. Most age-0 Colorado River cutthroat attain the juvenile life stage by September. Based on the biology of Colorado River cutthroat trout, Table 3 illustrates the biologically critical times of the year to which instream flow modeling methodologies apply in Douglas Creek.

Table 3. Methods used to determine instream flow recommendations at different times of the year for various life stages of Colorado River cutthroat trout.

<table>
<thead>
<tr>
<th></th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spawning</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fry</td>
<td></td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Juvenile</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adult</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

1 - PHABSIM
2 - Habitat Quality Index

RESULTS

Spawning Physical Habitat

Physical spawning habitat is maximized at 3.6 cfs, and is maintained near maximum levels (> 60 ft²/1,000 ft) at flows ranging from 3.0 cfs to 4.6 cfs (Figure 2). At flows less than 3.0 cfs or greater than 4.6 cfs, the amount of physical spawning habitat declines rapidly with relatively small changes in discharge.

Fry, Juvenile, and Adult Physical Habitat

Physical habitat for fry, juvenile and adult life stages of Colorado River cutthroat trout exhibit similar relationships to discharge (Figure 3). The amount of physical habitat is relatively constant over the entire range of simulated flows, increasing gradually up to the highest flow simulated (10 cfs). The amount of physical habitat at low flows exhibits a threshold relationship to discharge whereby physical habitat declines greatly at flows less than 0.3 cfs (adult and juvenile) and less than 0.2 cfs (fry).
Figure 2. Relationship between discharge and physical spawning habitat for Colorado River cutthroat trout in Douglas Creek.
Figure 3. Relationships between discharge and physical habitat for fry, juvenile and adult life stages of Colorado River cutthroat trout in Douglas Creek.
Habitat Quality Index

Douglas Creek supports 32.6 habitat units at the existing mean summer flow of 0.5 cfs (estimated from hydrologic relationships). At flows greater than 0.7 cfs, the number of habitat units increases through 7.5 cfs then declines (Figure 4). The number of habitat units is reduced 27%, 39%, and 62% as flows are reduced from 0.5 cfs to 0.4, 0.3 and 0.2 cfs, respectively.

DISCUSSION

Results from physical habitat simulations indicate physical habitat for spawning is maximized at 3.6 cfs, but near maximum levels are maintained through a broad range of flows (3.0 cfs to 4.6 cfs). Based on Douglas Creek hydrologic simulations, average daily flows during May and June are 14.5 cfs and 18.0 cfs, respectively. Mean daily flows of 13.5 cfs (May) and 4.1 cfs (June) occur in Douglas Creek during the driest year on record (1987). This preliminary analysis of flow patterns suggests a spring and early summer flow of 3.6 cfs should naturally be available for maximizing physical spawning habitat during average and below-average water years and would maintain or improve existing levels of physical habitat for spawning.

At the existing (estimated) mean summer flow of 0.5 cfs, Douglas Creek supports 32.6 habitat units and this level is maintained through 0.7 cfs. Significant reductions (up to 62%) in habitat units and production potential would occur if flows were reduced to less than 0.5 cfs. Although greater flows (e.g. greater than 0.7 cfs) would improve production potential in Douglas Creek, flows of this magnitude rarely occur in late summer. These results indicate a flow of at least 0.5 cfs during late summer is necessary to maintain or improve Colorado River cutthroat trout production in Douglas Creek.

The quantity of physical habitat for fry, juvenile and adult life stages of Colorado River cutthroat trout is relatively high through the entire range of simulated flows; however, reductions in physical habitat for juveniles and adults occur as flow declines to less than 0.30 cfs. Reductions in physical habitat for fry did not occur until flow declined to less than 0.20 cfs. Based on hydrologic simulations, mean minimum flows in Douglas Creek from late summer through winter are about 0.30 cfs. These results suggest suitable physical habitat for juveniles and adults is maintained at or above the natural minimum base flow of 0.30 cfs and indicate that reductions of flow during the late summer, fall, and winter to less than 0.30 cfs would have negative impacts on juvenile and adult physical habitat. Because flows during these months average about 0.40 cfs, flows of 0.30 should naturally be available.
Figure 4. Relationship between discharge and trout habitat units in Douglas Creek. * = habitat units at existing conditions.
Based on results from this study, the instream flows listed in Table 5 are recommended for Douglas Creek. The spring and early summer flow of 3.6 cfs will maximize physical habitat for spawning. A summer flow of 0.5 cfs will maintain existing levels of trout production and provide suitable habitat for fry, juveniles and adults. A late summer, fall and winter flow of 0.3 cfs will maintain physical habitat at levels which naturally occur at existing base flows.

The limitation of flows strictly to the recommended flows may contribute to a decline in physical habitat quality over the long-term. For example, substrate fines may accumulate in spawning gravels due to a lack of cyclical major runoff events (e.g. bankful discharge) which could reduce spawning success. The absence of high natural runoff flows in the spring could also limit the recruitment of spawning gravels from the upper watershed. The lack of these channel maintenance flows may also lead to the encroachment of stream banks and a gradual narrowing of the stream channel. This process would reduce the total space available to trout, and in combination with the above processes, lead to reduced physical habitat suitability.

The WGFD does not presently have the expertise with methods used to determine appropriate channel maintenance flows. When this expertise is acquired, supplemental water rights for channel maintenance should be pursued.

Table 5. Summary of instream flow recommendations for Douglas Creek.

<table>
<thead>
<tr>
<th>Time period</th>
<th>Discharge (cfs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>October 1 to April 30</td>
<td>0.3</td>
</tr>
<tr>
<td>May 1 to June 30</td>
<td>3.6</td>
</tr>
<tr>
<td>July 1 to September 30</td>
<td>0.5</td>
</tr>
</tbody>
</table>


Hipple, B. 1986. Summary of washouts at Deadman Creek, First Creek, Second Creek, and Rose Creek on Stage II Little Snake River Diversion pipeline. Medicine Bow National Forest, unpublished.

Miller, D.D. 1980. Quantification of trout habitat that could be impacted by Stage III of the Little Snake River Water Management Project. Wyoming Game and Fish Department Administrative Report, Fish Division, Cheyenne.


STATE OF WYOMING
OFFICE OF THE STATE ENGINEER
APPLICATION FOR PERMIT TO APPROPRIATE SURFACE WATER

THIS SECTION IS NOT TO BE FILLED IN BY APPLICANT

Filing/Priority Date

THE STATE OF WYOMING, STATE ENGINEER'S OFFICE SS.

This instrument was received and filed for record on the 27th day of June, A.D. 19__ at ___1:00__ P.M.

Recorded in Book ___________ of Ditch Permits, on Page _________.

Fee Paid $ 50.00 Map Filed E

WATER DIVISION NO. 1 DISTRICT NO. 8 PERMIT NO. 29 3/12

NAME OF FACILITY North Fork Big Sandstone Creek Instream Flow Segment No. 1

1. Name(s), mailing address and phone no. of applicant(s) is/are: Wyoming Water Development Commission, Herschler Building, Cheyenne, WY 82002

2. Name & address of agent to receive correspondence and notices: Wyoming Game & Fish Department, 5400 Bishop Blvd., Cheyenne, WY 82002

3. (a) The use to which the water is to be applied is: Instream Flow

(b) If more than one beneficial use of water is applied for, the location and ownership of the point of use must be shown in item 10 of the application and the details of the facilities used to divert and convey the appropriation must be shown on the map in sufficient detail to allow the State Engineer to establish the amount of appropriation. In multiple use applications, stock and domestic purposes are limited to 0.056 cubic feet per second.

4. The source of the proposed appropriation is: North Fork Big Sandstone Creek, tributary of Savery Creek, tributary of the Little Snake River.

5. The point of diversion of the proposed works is located from the Confluence of Big Sandstone Creek in Section 12 T. 14 N., R. 87 W., and is in the 10th Confluence of Section 11 T. 14 N., R. 87 W.

6. Are any of the lands crossed by the proposed facility owned by the State or Federal Government? If so, describe lands and indicate whether State or Federally owned.

All lands are Federally owned, U.S. Forest Service

7. The carrying capacity of the ditch, canal, pipeline or other facility at the point of diversion is see remarks cubic feet per second.

8. The accompanying map is prepared in accordance with the State Engineer's Manual of Regulations and Instructions for filing applications and is hereby declared a part of this application. The State Engineer may require the filing of detailed construction plans.

9. The estimated time required for the commencement of work is 30 days for completion of construction is 30 days, and to complete the application of water to the beneficial use stated in this application is 30 days from issue.
The land to be irrigated under this permit is described in the following tabulation. (Give irrigable acreage in each 40-acre subdivision. Designate ownership of land, Federal, State or private. If private, list names of owners and land owned separately.) If application is for stock, domestic, or for purposes other than irrigation, indicate point of use by 40-acre subdivision and owner.

<table>
<thead>
<tr>
<th>Township</th>
<th>Range</th>
<th>Sec.</th>
<th>NE</th>
<th>NW</th>
<th>SW</th>
<th>SE</th>
<th>NE</th>
<th>NW</th>
<th>SW</th>
<th>SE</th>
<th>TOTALS</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td>87</td>
<td>12</td>
<td>Lot 5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Number of acres to receive original supply
Number of acres to receive supplemental supply
Total number of acres to be irrigated

REMARKS
MONTHLY INSTREAM
FLOW REQUESTED Based on data from 1995 and the results of a study completed in 1996 by the Wyoming Game & Fish Department (attached) a water right of 1.6 cfs is requested from October 1 to May 14 to maintain hydraulic conditions for trout survival. A water right of 19.0 cfs is requested from May 15 to June 30 to maintain the existing level of trout spawning habitat. A water right of 1.7 cfs is requested from July 1 to September 30 to maintain or improve existing levels of trout production.

<table>
<thead>
<tr>
<th>Month</th>
<th>Flow (cfs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oct.</td>
<td>1.6</td>
</tr>
<tr>
<td>Nov.</td>
<td>1.6</td>
</tr>
<tr>
<td>Dec.</td>
<td>1.6</td>
</tr>
<tr>
<td>Jan.</td>
<td>1.6</td>
</tr>
<tr>
<td>Feb.</td>
<td>1.6</td>
</tr>
<tr>
<td>March</td>
<td>1.6</td>
</tr>
<tr>
<td>April</td>
<td>1.6</td>
</tr>
<tr>
<td>May</td>
<td>1.6</td>
</tr>
<tr>
<td>June</td>
<td>19.0</td>
</tr>
<tr>
<td>July</td>
<td>1.7</td>
</tr>
<tr>
<td>Aug.</td>
<td>1.7</td>
</tr>
<tr>
<td>Sept.</td>
<td>1.7</td>
</tr>
</tbody>
</table>

Stream length - 0.7 miles
Intervening Permits - none

This is an ungaged stream. If required by the State Engineer, a gage will be installed at or near the downstream end of the instream flow segment. Under penalties of perjury, I declare that I have examined this application and to the best of my knowledge and belief it is true, correct and complete.

Signature of Applicant or Agent

Date
Instream flow data were collected in 1995 on North Fork Big Sandstone Creek to determine flows needed to maintain or improve Colorado River cutthroat trout (CRC) habitat and populations. Studies were designed to complement ongoing management plans by the Wyoming Game and Fish Department (WGFD), U.S. Forest Service (USFS) and Bureau of Land Management (BLM).

Physical Habitat Simulation (PHABSIM) and Habitat Quality Index (HQI) models were used to develop instream flow recommendations. Recommendations are 1.6 cfs from October 1 to May 14, 19.0 cfs from May 15 to June 30 and 1.7 cfs from July 1 to September 30.

INTRODUCTION

Colorado River cutthroat trout (Oncorhynchus clarki pleuriticus) is the only trout species native to the Green River and Little Snake River drainages in Wyoming. Historically, this species enjoyed relatively wide distribution and abundance in most of the headwater streams of these drainages. However, habitat degradation, hybridization and competition with introduced trout species have led to serious declines in populations of this species. Binns (1977) reviewed the distribution, genetic purity, and habitat conditions for Colorado River cutthroat trout. His report concluded that habitat loss and degradation were major factors limiting recovery of the species.

In addition to Binns (1977) the distribution and abundance of Colorado River cutthroat trout has also been described by Oberholtzer (1987, 1990). Colorado River cutthroat trout are presently considered a "rare" species by the Wyoming Game and Fish Department (1977) and "sensitive" by the U.S. Forest Service (USFS) (1985). Management and monitoring responsibilities for populations in the Little Snake River drainage are coordinated by WGFD fisheries personnel in the Green River regional office.

Several strategies and agreements have been developed to guide the management and recovery of this species. The WGFD developed the Comprehensive Management and
Enhancement Plan for Colorado River Cutthroat Trout in Wyoming (1987) that outlines specific actions for increasing the range, habitat and numbers of the species. Obtaining adequate instream flows is one of the actions identified for addressing habitat needs. In 1987, the WGFD and U.S. Forest Service signed a memorandum of understanding that committed each agency to "protecting, maintaining, improving and managing Colorado River cutthroat trout populations" in ways that lead toward enhanced biological status. In 1994, the WGFD, USFS and Bureau of Land Management signed a cooperative agreement entitled "Conservation Plan for Colorado River Cutthroat Trout (Oncorhynchus clarki pleuriticus) for the Little Snake River Drainage, In Southeastern Wyoming. Pursuing opportunities to secure adequate instream flows is one of the tasks identified in that document. Habitat protection by acquiring instream flow water rights is consistent with the goals and objectives of each of these documents.

Fishery and other resource management practices could be significantly affected if actions are not taken to prevent listing Colorado River cutthroat trout as Threatened or Endangered. Acquiring adequate instream flow water rights on CRC streams is an important step to help avoid listing. In this regard, the WGFD has developed a management strategy of filing instream flow water rights on streams with populations or potential habitat for Colorado River cutthroat trout within their historic range. Studies in 1995 focused on Mill Creek, Big Sandstone, Roaring Fork Little Snake and East Fork Deep Creeks in addition to North Fork Big Sandstone Creek.

The specific objectives of this study were to 1) investigate the relationship between discharge and physical habitat quantity and quality at various times of year for Colorado River cutthroat trout and, 2) determine an instream flow necessary to maintain or improve Colorado River cutthroat trout populations.

METHODS

Study Area

North Fork Big Sandstone Creek is a tributary to Big Sandstone Creek in the Little Snake River drainage (Figure 1). The entire length of the instream flow segment is administered by the USFS and the majority of lands within the drainage basin are publicly owned. Conifers predominate the uplands throughout the reach and are common along the stream margins. Willows are scattered in the riparian zone and beaver activity has resulted in several old and new ponds. Overall stream gradient is moderate (<2.5 %) and the channel type was rated as B2 (Rosgen 1985). This rating indicates a moderately entrenched channel that is well confined by its valley and has bed material composed of large cobble, course gravel, and sand.

Fisheries

Observations by fisheries managers in Wyoming and other western states indicate that trout populations in small mountain streams often fluctuate considerably among consecutive years. In a western Oregon stream studied for 11 years, the density of age-0 cutthroat trout (fry, <2 inches) varied from 8 to 38 per 100 m² and density of age-1 cutthroat trout (juveniles, 4 to 4.5 inches) ranged from 16 to 34 per 100 m² (House 1995). In this example, population fluctuations occurred despite the fact that structural habitat conditions and water quality were not degraded and remained relatively stable. The author suggested that changes in winter flows between years accounted for part or all of the observed variation in overwinter survival of the different age classes.
NORTH FORK BIG SANDSTONE CREEK INSTREAM FLOW SEGMENT NO. 1
(LENGTH OF STREAM SEGMENT = 0.7 MILES)

INSTREAM FLOW SEGMENT NO. 1 – POINT OF BEGINNING
NORTH LINE SECTION 12, T.14 N., R.87 W.

INSTREAM FLOW SEGMENT NO. 1 – POINT OF ENDING
BIG SANDSTONE CREEK, SECTION 11, T.14 N., R.87 W.
In western Wyoming, Binns (1981) noted large declines in trout numbers in several Bonneville cutthroat trout streams following drought in 1977. Similar observations have been made by Remmick (1995, WGFD, personal communication) in more recent years.

Department records show that, while CRC are present in the North Fork Big Sandstone Creek, their overall numbers are relatively limited. The fishery is composed predominantly of brook trout. The proposed instream flow segment is within the historic range of CRC and once harbored permanent populations. Because the basic habitat integrity is unchanged from historic conditions and is suitable for CRC and because fishery management plans call for expanding the distribution of CRC within their historic range, instream flow protection is appropriate. As a consequence, the models (described below) and analyses used in this study were focused on this species.

Long-term trout population maintenance in small streams depends on periodic strong year classes produced in good flow years. Without the benefit of periodic favorable flows, populations in some streams would decline or disappear and genetic diversity could be compromised. The WGFD instream flow strategy recognizes the inherent variability of trout populations as shown in Big Sandstone Creek and other streams throughout the state and Western U.S. (House 1995) and thus defines the "existing fishery" as a dynamic feature. This basic concept has also been incorporated into instream flow strategies developed by the Endangered Fish Recovery Program for recovery of endangered fishes in the Colorado River system where high flows are recommended in high flow years and lower flows are recommended during normal and below normal flow periods. Summarily, instream flow recommendations for North Fork Big Sandstone Creek are based on a goal of maintaining the existing dynamic trout population characteristics of a stream segment as affected by naturally variable flow conditions. The specific flow recommendations are for the lowest flow needed at various times of year to provide this beneficial use of water.

Habitat Modeling

After visually surveying about 1.0 mile of the stream, a study site was located in Range 87 West, Township 14 North, Section 12, NWl/4 at an elevation of about 8180 feet (Figure 1). The representative site had adult and juvenile trout cover associated mostly with lateral scour pools and undercut banks. Nine transects were distributed among pool, run, and riffle habitat types (Appendix 1).

Data were collected on three different dates in 1995. Collection dates and corresponding discharges are shown in Table 1. Instream flow filing recommendations derived from data collected at this site were applied to an approximately 1/2 mile-long reach extending downstream from the north section line in the NW 1/4 of Section 12 of Township 14 North, Range 87 West downstream to the confluence with Big Sandstone Creek in the NE 1/4 of Section 11, Township 14 North, Range 87 West.

Table 1. Dates and discharges when instream flow data were collected on North Fork Big Sandstone Creek in 1995.

<table>
<thead>
<tr>
<th>Date</th>
<th>Discharge (cfs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>July 5</td>
<td>27.0</td>
</tr>
<tr>
<td>July 28</td>
<td>6.3</td>
</tr>
<tr>
<td>August 30</td>
<td>1.8</td>
</tr>
</tbody>
</table>

While continuous, adequate instream flows are critically important for maintaining the population integrity of stream fisheries, maximum population development can be limited by habitat limitations or "bottlenecks" for certain sensitive life stages and/or times of year. In many cases, habitat for young fry...
and/or juvenile) and spawning life stages are significant "bottlenecks" (Nehring and Anderson 1993). As a consequence, the department's general approach to flow quantification includes ensuring adequate flows to maintain spawning habitat in the spring as well as adult and juvenile habitat throughout the remainder of the year. (Table 2).

Table 2. Colorado River cutthroat trout life stages and months considered in North Fork Big Sandstone Creek instream flow recommendations. Numbers indicate method used to determine flow requirements.

<table>
<thead>
<tr>
<th>LIFE STAGE</th>
<th>OCT</th>
<th>NOV</th>
<th>DEC</th>
<th>JAN</th>
<th>FEB</th>
<th>MAR</th>
<th>APR</th>
<th>MAY</th>
<th>JUN</th>
<th>JUL</th>
<th>AUG</th>
<th>SEP</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPAWNING</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ADULT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
<td>2</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ALL</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

1 - PHABSIM
2 - Habitat Quality Index
3 - Habitat Retention

Habitat Retention Method

A Habitat Retention method (Nehring 1979, Annear and Conder 1984) was used to identify a maintenance flow by analyzing data from three riffle transects. A maintenance flow is defined as the continuous flow required to maintain specific hydraulic criteria in stream riffles. Year-round criteria maintenance ensures passage between habitat types for all trout life stages. In addition, the criteria maintain adequate benthic invertebrate survival. A maintenance flow is realized at the discharge for which any two of the three criteria in Table 3 are met for all riffle transects in a study area. The instream flow recommendations from the Habitat Retention method are applicable year-round except when higher instream flows are required to meet other fishery management purposes (Table 2).

Table 3. Hydraulic criteria for determining maintenance flow with the Habitat Retention method.

<table>
<thead>
<tr>
<th>Category</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Depth (feet)</td>
<td>Top Width X 0.01</td>
</tr>
<tr>
<td>Mean Velocity (feet/second)</td>
<td>1.00</td>
</tr>
<tr>
<td>Percent Wetted Perimeter</td>
<td>50</td>
</tr>
</tbody>
</table>

a - At average daily flow. Minimum depth = 0.20 feet
b - Percent of bank full wetted perimeter

Habitat Quality Index

The Habitat Quality Index (HQI; Binns and Eisermann 1979) was used to estimate trout production over a range of late summer flow conditions. This model was developed by the WGFD and received extensive testing and refinement. It has been reliably used in Wyoming for trout standing stock gain or loss assessment associated with instream flow regime changes. The HQI model includes nine attributes addressing biological, chemical, and physical aspects of trout habitat. Results are expressed in trout Habitat Units (HU's), where one HU is defined as the amount of habitat quality that will support about 1 pound of trout. HQI results were used to identify the flow needed to maintain or improve existing levels of CRC production between July 1 and September 30 (Table 2).
In the HOI analysis, habitat attributes measured at various flow events are assumed to be typical of mean late summer flow conditions. Under this assumption, HU estimates are extrapolated through a range of potential late summer flows (Conder and Annsar, 1987). Big Sandstone Creek habitat attributes were measured on the same dates PHABSIM data were collected (Table 1). Some attributes were mathematically derived to establish the relationship between discharge and trout production at discharges other than those measured. Average daily flow and peak flow estimates are based on elevation and basin area (Lowham, 1976).

Physical Habitat Simulation

Physical Habitat Simulation (PHABSIM) methodology was used to quantify physical habitat (depth and velocity) availability over a range of discharges. This methodology was developed by the Instream Flow Service Group of the U.S. Fish and Wildlife Service (Bovee and Milhous, 1978) and is widely used for assessing instream flow relationships between fish and physical habitat (Reiser et al., 1989).

The PHABSIM method uses empirical relationships between physical variables (depth, velocity, and substrate) and suitability for fish to derive weighted usable area (WUA; suitable ft² per 1000 ft of stream length) at various flows. Depth, velocity, and substrate were measured along transects (sensu Bovee and Milhous, 1978) on the dates in Table 1. Hydraulic calibration techniques and modeling options in Milhous et al. (1984) and Milhous et al. (1989) were employed to incrementally estimate physical habitat between 0.6 and 90 cfs. Precision declines outside this range; however, the modeled range accommodates typical flows on Big Sandstone Creek.

Curves describing depth, velocity and substrate suitability for trout life stages are an important component of the PHABSIM modeling process. Suitability curves for adult, juvenile and spawning were developed by WGFD. Criteria for fry were obtained from studies by Bozek and Rahel (1992).

Observations by WGFD field biologists indicate spawning activity—in most streams with CRC peaks between late May and mid June. Because spawning onset and duration varies between years due to differences in flow quantity and water temperature, spawning recommendations should extend from May 15 to June 30. Even if spawning is completed prior to June 30, maintaining flows at the recommended level throughout June will benefit trout egg incubation by preventing dewatering.

RESULTS AND DISCUSSION

Habitat Retention Analysis

Habitat retention analysis indicates that 1.6 cfs is required to maintain hydraulic criteria at all riffles to provide passage between habitats for all trout life stages (Table 4). Maintenance of naturally occurring flows up to this flow is necessary at all times of the year. Higher flows are needed during May through September to maintain or improve specific life stages (Table 2).

Based on habitat retention results, an instream flow of 1.6 cfs is recommended for the October 1 to May 14 time period. This flow level will maintain the existing CRC fishery potential because it protects existing natural flow patterns up to the identified maintenance level. Trout populations are naturally limited by low flow conditions during the winter months (October through March; Needham et al., 1945, Reimers, 1957, Butler, 1979, Kurtz, 1980, Cunjak, 1988). Such factors as snow fall, cold intensity, and duration of cold periods can influence winter trout survival.
Fish populations are influenced primarily through the effects of frazil ice including metabolic stress and anchor ice formation which limits habitat and may result in stranding.

These winter mortality causes are all influenced by winter flows. Higher flows minimize temperature changes and increase stream areas where trout can escape frazil ice impacts. Any artificial reduction of natural winter stream flows would increase trout mortality and effectively reduce the number of fish the stream could support. Therefore protection of natural winter stream flows up to the recommended maintenance flow is necessary to maintain existing survival rates of trout populations.

Table 4. Simulated hydraulic criteria for three riffles on North Fork Big Sandstone Creek. Bank full discharge = 18.1 cfs.

<table>
<thead>
<tr>
<th>Riffle 1</th>
<th>Mean Depth (Feet)</th>
<th>Mean Velocity (Feet/Sec)</th>
<th>Wetted Perimeter (Feet)</th>
<th>Discharge (cfs)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.52</td>
<td>2.45</td>
<td>14.9</td>
<td>18.1</td>
</tr>
<tr>
<td></td>
<td>0.47</td>
<td>2.27</td>
<td>14.8</td>
<td>15.0</td>
</tr>
<tr>
<td></td>
<td>0.22</td>
<td>1.31</td>
<td>10.6</td>
<td>3.0</td>
</tr>
<tr>
<td></td>
<td>0.20*</td>
<td>1.19</td>
<td>10.2</td>
<td>2.4</td>
</tr>
<tr>
<td></td>
<td>0.19</td>
<td>1.10</td>
<td>10.0</td>
<td>2.0</td>
</tr>
<tr>
<td></td>
<td>0.17</td>
<td>1.00*</td>
<td>9.6</td>
<td>1.6*</td>
</tr>
<tr>
<td></td>
<td>0.13</td>
<td>0.84</td>
<td>9.0</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>0.10</td>
<td>0.71</td>
<td>8.4*</td>
<td>0.6</td>
</tr>
<tr>
<td>Riffle 2</td>
<td>0.51</td>
<td>2.44</td>
<td>15.4</td>
<td>18.1</td>
</tr>
<tr>
<td></td>
<td>0.46</td>
<td>2.25</td>
<td>15.3</td>
<td>15.0</td>
</tr>
<tr>
<td></td>
<td>0.21</td>
<td>1.33</td>
<td>11.3</td>
<td>3.0</td>
</tr>
<tr>
<td></td>
<td>0.20*</td>
<td>1.27</td>
<td>10.9</td>
<td>2.6</td>
</tr>
<tr>
<td></td>
<td>Q.18</td>
<td>1.16</td>
<td>10.1</td>
<td>2.0</td>
</tr>
<tr>
<td></td>
<td>0.16</td>
<td>1.02*</td>
<td>8.8</td>
<td>1.4*</td>
</tr>
<tr>
<td></td>
<td>0.14</td>
<td>0.92</td>
<td>8.1</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>0.13</td>
<td>0.86</td>
<td>7.6*</td>
<td>0.8</td>
</tr>
<tr>
<td></td>
<td>0.12</td>
<td>0.79</td>
<td>6.8</td>
<td>0.6</td>
</tr>
<tr>
<td>Riffle 3</td>
<td>0.73</td>
<td>2.17</td>
<td>12.2</td>
<td>18.1</td>
</tr>
<tr>
<td></td>
<td>0.55</td>
<td>1.67</td>
<td>11.6</td>
<td>10.0</td>
</tr>
<tr>
<td></td>
<td>0.43</td>
<td>1.44</td>
<td>10.9</td>
<td>6.3</td>
</tr>
<tr>
<td></td>
<td>0.30</td>
<td>1.10</td>
<td>9.7</td>
<td>3.0</td>
</tr>
<tr>
<td></td>
<td>0.26</td>
<td>1.02*</td>
<td>9.5</td>
<td>2.4</td>
</tr>
<tr>
<td></td>
<td>0.29</td>
<td>0.95</td>
<td>7.7</td>
<td>2.0</td>
</tr>
<tr>
<td></td>
<td>0.28</td>
<td>0.86</td>
<td>7.0</td>
<td>1.6</td>
</tr>
<tr>
<td></td>
<td>0.25</td>
<td>0.76</td>
<td>6.6</td>
<td>1.2</td>
</tr>
<tr>
<td></td>
<td>0.22*</td>
<td>0.63</td>
<td>6.2*</td>
<td>0.8*</td>
</tr>
<tr>
<td></td>
<td>0.19</td>
<td>0.55</td>
<td>5.9</td>
<td>0.6</td>
</tr>
</tbody>
</table>

a - Hydraulic criteria met
b - Discharge at which 2 of 3 hydraulic criteria are met

The 1.6 cfs identified by the Habitat Retention Method may not always be present during the winter. Because the historic fishery is adapted to natural flow patterns (see above fisheries discussion), occasional periods of natural shortfall during the winter do not imply a need for additional storage. Instead, they
illustrate the necessity of maintaining all natural winter stream flows, up to 1.6 cfs, to maintain existing trout survival rates.

Habitat Unit Analysis

Article 10, Section d of the Instream Flow Act states that waters used for providing instream flows "shall be the minimum flow necessary to maintain or improve existing fisheries". Often, HU's measured during low flow are used to define the existing late summer fisheries. In situations where the goal is to "maintain" existing fisheries, we determine the flow range with the same HU's as measured and the minimum flow in that range becomes the recommendation. On North Fork Big Sandstone Creek, this flow was 1.8 cfs. The lowest flow that will maintain this number of HU's is 1.7 cfs.

At the measured late summer flow of 1.8 cfs, the stream provides 56.8 trout HU's (Figure 2). Permanently reduced summer flows (less than 1.7 cfs) would impact the fishery. Likewise, maintaining higher late summer flows (up to 8.8 cfs) on a permanent basis would increase trout habitat units.

Figure 2. Trout habitat units at several late summer flow levels on North Fork Big Sandstone Creek. X-axis discharges are not to scale.

Based on this analysis and in consideration of the various Colorado River cutthroat trout management plans and agreements among state and federal land management agencies, an instream flow of 1.7 cfs is recommended to maintain existing trout production between July 1 and September 30. This flow represents the lowest stream flow that will accomplish this objective by allowing populations to benefit from naturally occurring flows when they are available. Storage to achieve this flow on a permanent basis solely for instream flow purposes is likely not in the State's best interest.

PHABSIM Analyses

The maximum amount of physical habitat for spawning occurs at 19.0 cfs (Figure 3). Normal spring flows are much higher - 27.9 cfs was measured in this study (Table 1) and this was not the peak flow for 1995. According to this analysis, such high flows might limit spawning activity near the study site or cause migration to more favorable (upstream) reaches. Though trout can usually find someplace to spawn
whenever temperatures are appropriate and flows allow unrestricted movement, maximum physical habitat in the study site occurs at a flow of 19.0 cfs. Therefore, an instream flow of 19.0 cfs is recommended for the period May 15 to June 30.

Weighted usable area estimates for adult and juvenile CRC generally agree with HQI results (Figure 3) in as much as WUA declines at flows less than 1.7 cfs and increases somewhat at higher flows. The specific differences in flow at which the models indicate changes in habitat value are due to the fact that each model incorporates somewhat different attributes in their analysis. Declines in adult and juvenile WUA at these low flows are largely the result of the loss of physical habitat associated with undercut banks and mid-channel habitat. The recommended maintenance flow of 1.6 cfs will maintain almost 70 percent of adult physical habitat and over 90 percent of maximum juvenile physical habitat. In consideration of this fact, and the fact that the HQI model cannot be used for determining instream flow needs outside the summer period, the flow recommendation from October 1 to May 15 is 1.6 cfs. This flow level will maintain the existing CRC fishery potential because it protects existing natural flow patterns up to the identified maintenance flow level.

**Figure 3.** Percent of maximum available weighted usable area (WUA) for Colorado River Cutthroat trout life stages in North Fork Big Sandstone Creek over a range of discharges.

These mortality causes are all influenced by winter flows. Higher flows generally increase stream areas where trout can escape frazil ice impacts. Any artificial reduction of natural winter stream flows would increase trout mortality and effectively reduce the number of fish the stream could support. Therefore protection of natural winter stream flows up to the recommended maintenance flow is necessary to maintain existing survival rates of trout populations.

**INSTREAM FLOW RECOMMENDATIONS**

Based on the analyses and results outlined above, the instream flow recommendations in Table 4 will maintain the existing CRC fishery potential in North Fork Big Sandstone Creek. These recommendations apply to an approximately 1/2 mile segment of North Fork Big Sandstone Creek extending downstream from the north section line in the NW 1/4 of Section 12 of Township 14 North, Range 87 West
downstream to the confluence with Big Sandstone Creek in the NE 1/4 of Section 11, Township 14 North, Range 87 West.

Because data were collected from representative habitats and simulated over a wide flow range, additional data collection under different flow conditions would not significantly change these recommendations.

Table 4. Instream flow recommendations to maintain or improve habitat for the existing trout fishery in Big Sandstone Creek.

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Instream Flow Recommendation (cfs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>October 1 to May 14</td>
<td>1.6</td>
</tr>
<tr>
<td>May 15 to June 30</td>
<td>19.0</td>
</tr>
<tr>
<td>July 1 to September 30</td>
<td>1.7</td>
</tr>
</tbody>
</table>

This analysis does not consider periodic requirements for channel maintenance flows. Because this stream is unregulated, channel maintenance flow needs are adequately met by natural runoff patterns. If regulated in the future, additional studies and recommendations would be needed for establishing channel maintenance flow requirements.
LITERATURE CITED


Oberholtzer, M. 1987 A fisheries survey of the Little Snake River Drainage, Carbon County, Wyoming, Wyoming Game and Fish Department, Fish Division, Cheyenne, Project Number 5086-01-8501.


Appendix 1. Description of transects used for PHABSIM Analysis on North Fork Big Sandstone Creek.

<table>
<thead>
<tr>
<th>Transect</th>
<th>Total Length</th>
<th>Habitat Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2.2</td>
<td>Riffle/Control</td>
</tr>
<tr>
<td>2</td>
<td>7.3</td>
<td>Riffle/Run</td>
</tr>
<tr>
<td>3</td>
<td>8.4</td>
<td>Pool</td>
</tr>
<tr>
<td>4</td>
<td>6.6</td>
<td>Riffle/Control</td>
</tr>
<tr>
<td>5</td>
<td>10.0</td>
<td>Run</td>
</tr>
<tr>
<td>6</td>
<td>12.4</td>
<td>Run</td>
</tr>
<tr>
<td>7</td>
<td>8.9</td>
<td>Pool/Run</td>
</tr>
<tr>
<td>8</td>
<td>8.9</td>
<td>Run</td>
</tr>
<tr>
<td>9</td>
<td>5.8</td>
<td>Pool</td>
</tr>
</tbody>
</table>
Big Sandstone Creek
Instream Flow Segment No. 1
STATE OF WYOMING
OFFICE OF THE STATE ENGINEER
APPLICATION FOR PERMIT TO APPROPRIATE SURFACE WATER

THIS SECTION IS NOT TO BE FILLED IN BY APPLICANT

Filing/Priority Date

The State of Wyoming, State Engineer's Office

This instrument was received and filed for record on the 27th day of June, A.D. 1996, at 1:00 o'clock P.M.

John R. Barnes, for State Engineer

Recorded in Book ___________________ of Ditch Permits, on Page ____________

Temp. Filing No. 29 4/128

WATER DIVISION NO. 1 DISTRICT NO. 8

Filing No. 29 4/128

PERMIT NO. ________________________

NAME OF FACILITY Big Sandstone Creek Instream Flow Segment No. 1

1. Name(s), mailing address and phone no. of applicant(s) is/are: Wyoming Water Development Commission, Herschler Building, Cheyenne, WY 82002

2. Name & address of agent to receive correspondence and notices: Wyoming Game & Fish Department, 5440 Bishop Blvd., Cheyenne, WY 82002

3. (a) The use to which the water is to be applied is: Instream Flow

(b) If more than one beneficial use of water is applied for, the location and ownership of the point of use must be shown in item 10 of the application and the details of the facilities used to divert and convey the appropriation must be shown on the map in sufficient detail to allow the State Engineer to establish the amount of appropriation. In multiple use applications, stock and domestic purposes are limited to 0.056 cubic feet per second.

4. The source of the proposed appropriation is Big Sandstone Creek, tributary of Savery Creek, tributary of the Little Snake River.

5. The point of diversion of the proposed work is located at the confluence with Section 9 T. 14 N. R. 87 W., and is in the

6. Are any of the lands crossed by the proposed facility owned by the State or Federal Government? If so, describe lands and indicate whether State or Federally owned.

All lands are federally owned, U.S. Forest Service

7. The carrying capacity of the ditch, canal, pipeline or other facility at the point of diversion is: see remarks cubic feet per second.

8. The accompanying map is prepared in accordance with the State Engineer's Manual of Regulations and Instructions for filing applications and is hereby declared a part of this application. The State Engineer may require the filing of detailed construction plans.

9. The estimated time required for the commencement of work is: 30 days, for completion of construction is: 30 days, and to complete the application of water to the beneficial uses stated in this application is: 30 days from issue.
10. The land to be irrigated under this permit is described in the following tabulation. (Give irrigable acreage in each 40-acre subdivision. Designate ownership of land. Federal, State or private. If private, list names of owners and land owned separately.) If application is for stock, domestic, or for purposes other than irrigation, indicate point of use by 40-acre subdivision and owner.

| Township | Range | Sec. | NE¼ | NW¼ | SW¼ | SE¼ | NE¼ | NW¼ | SW¼ | SE¼ | NE¼ | NW¼ | SW¼ | SE¼ | NE¼ | NW¼ | SW¼ | SE¼ | TOTALS |
|----------|-------|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-------|
| 14N 87W  | 9     |      |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |       |
|          |       | 16   | x   |     |     |     |     |     |     |     |     |     |     |     |     |     |     |       |
|          |       | 17   |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |       |
|          |       | 20   | x   | x   |     |     |     |     |     |     |     |     |     |     |     |     |     |       |

Number of acres to receive original supply
Number of acres to receive supplemental supply
Total number of acres to be irrigated

**REMARKS**

MONTHLY INSTREAM FLOW REQUESTED

- Based on data from 1995 and the results of a study completed in 1996 by the Wyoming Game & Fish Department (attached) a water right of
- **3.5 cfs** is requested from October 1 to May 14 to maintain hydraulic conditions for trout survival.
- **3.5 cfs** is requested from May 15 to June 30 to maintain the existing level of trout spawning habitat. A water right of **3.5 cfs** is requested from July 1 to September 30 to maintain or improve existing levels of trout production.

**Stream length** - 3.0 miles

Intervening permits - none

This is an ungaged stream. If required by the State Engineer, a gage will be installed at or near the downstream end of the instream flow segment.

Under penalties of perjury, I declare that I have examined this application and to the best of my knowledge and belief it is true, correct and complete.

Signature of Applicant or Agent: [Signature]

Date: [Date]
Instream flow data were collected in 1995 on Big Sandstone Creek to determine flows needed to maintain or improve Colorado River cutthroat trout (CRC) habitat and populations. Studies were designed to complement ongoing management plans by the Wyoming Game and Fish Department (WGFD), U.S. Forest Service (USFS) and Bureau of Land Management (BLM).

Physical Habitat Simulation (PHABSIM) and Habitat Quality Index (HQI) models were used to develop instream flow recommendations. Recommendations are 3.5 cfs from October 1 to May 14, 22.0 cfs from May 15 to June 30 and 3.5 cfs from July 1 to September 30.

INTRODUCTION

Colorado River cutthroat trout (Oncorhynchus clarki pleuriticus) is the only trout species native to the Green River and Little Snake River drainages in Wyoming. Historically, this species enjoyed relatively wide distribution and abundance in most of the headwater streams of these drainages. However, habitat degradation, hybridization and competition with introduced trout species have led to serious declines in populations of this species. Binns (1977) reviewed the distribution, genetic purity, and habitat conditions for Colorado River cutthroat trout. His report concluded that habitat loss and degradation were major factors limiting recovery of the species.

In addition to Binns (1977) the distribution and abundance of Colorado River cutthroat trout has also been described by Oberholtzer (1987, 1990). Colorado River cutthroat trout are presently considered a "rare" species by the Wyoming Game and Fish Department (1977) and "sensitive" by the U.S. Forest Service (USFS) (1985). Management and monitoring responsibilities for populations in the Little Snake River drainage are coordinated by WGFD fisheries personnel in the Green River regional office.

Several strategies and agreements have been developed to guide the management and recovery of this species. The WGFD developed the Comprehensive Management and Enhancement Plan for Colorado River Cutthroat Trout in Wyoming (1987) that outlines
specific actions for increasing the range, habitat and numbers of the species. Obtaining adequate instream flows is one of the actions identified for addressing habitat needs. In 1987, the WGFD and U.S. Forest Service signed a memorandum of understanding that committed each agency to "protecting, maintaining, improving and managing Colorado River cutthroat trout populations" in ways that lead toward enhanced biological status. In 1994, the WGFD, USFS and Bureau of Land Management signed a cooperative agreement entitled "Conservation Plan for Colorado River Cutthroat Trout (Oncorhynchus clarki pleuriticus) for the Little Snake River Drainage, In Southeastern Wyoming. Pursuing opportunities to secure adequate instream flows is one of the tasks identified in that document. Habitat protection by acquiring instream flow water rights is consistent with the goals and objectives of each of these documents.

Fishery and other resource management practices could be significantly affected if actions are not taken to prevent listing Colorado River cutthroat trout as Threatened or Endangered. Acquiring adequate instream flow water rights on CRC streams is an important step to help avoid listing. In this regard, the WGFD has developed a management strategy of filing instream flow water rights on streams with populations or potential habitat for Colorado River cutthroat trout within their historic range. Studies in 1995 focused on Mill Creek, North Fork Big Sandstone, Roaring Fork Little Snake and East Fork Deep Creeks in addition to Big Sandstone Creek.

The specific objectives of this study were to 1) investigate the relationship between discharge and physical habitat quantity and quality at various times of year for Colorado River cutthroat trout and, 2) determine an instream flow necessary to maintain or improve Colorado River cutthroat trout populations.

METHODS

Study Area

Big Sandstone Creek is a tributary to Savery Creek in the Little Snake River drainage (Figure 1). The entire length of the instream flow segment is administered by the USFS and the majority of lands within the drainage basin are publicly owned. Conifers predominate the uplands throughout the reach and are common along the stream margins. Willows are scattered in the riparian zone and beaver activity has resulted in several old and new ponds. Overall stream gradient is moderate (<2.5 %) and the channel type was rated as B2 (Rosgen 1985). This rating indicates a moderately entrenched channel that is well confined by its valley and has bed material composed of large cobble, course gravel, and sand.

Fisheries

Observations by fisheries managers in Wyoming and other western states indicate that trout populations in small mountain streams often fluctuate considerably among consecutive years. In a western Oregon stream studied for 11 years, the density of age-0 cutthroat trout (fry, <2 inches) varied from 8 to 38 per 100 m² and density of age-1 cutthroat trout (juveniles, 4 to 4.5 inches) ranged from 16 to 34 per 100 m² (House 1995). In this example, population fluctuations occurred despite the fact that structural habitat conditions and water quality were not degraded and remained relatively stable. The author suggested that changes in winter flows between years accounted for part or all of the observed variation in overwinter survival of the different age classes.
In western Wyoming, Binns (1981) noted large declines in trout numbers in several Bonneville cutthroat trout streams following drought in 1977. Similar observations have been made by Remmick (1995, WGFD, personal communication) in more recent years. Department records show that, while CRC are present in Big Sandstone their overall numbers are relatively limited. The fishery is composed predominantly of brook trout. The proposed instream flow segment is within the historic range of CRC and once harbored permanent populations. Because the basic habitat integrity is unchanged from historic conditions and is suitable for CRC and because fishery management plans call for expanding the distribution of CRC within their historic range, instream flow protection is appropriate. As a consequence, the models (described below) and analyses used in this study were focused on this species.

Long-term trout population maintenance in small streams depends on periodic strong year classes produced in good flow years. Without the benefit of periodic favorable flows, populations in some streams would decline or disappear and genetic diversity could be compromised. The WGFD instream flow strategy recognizes the inherent variability of trout populations as shown in numerous streams throughout the state and Western U.S. (House 1995) and thus defines the "existing fishery" as a dynamic feature. This basic concept has also been incorporated into instream flow strategies developed by the Endangered Fish Recovery Program for recovery of endangered fishes in the Colorado River system where high flows are recommended in high flow years and lower flows are recommended during normal and below normal flow periods. Summarily, instream flow recommendations for Big Sandstone Creek are based on a goal of maintaining the existing dynamic trout population characteristics of a stream segment as affected by naturally variable flow conditions. The specific flow recommendations are for the lowest flow needed at various times of year to provide this beneficial use of water.

Habitat Modeling

After visually surveying about 1.0 mile of the stream, a study site was located in Range 87 West, Township 14 North, Section 9, NE1/4 at an elevation of about 8180 feet (Figure 1). The representative site had adult and juvenile trout cover associated mostly with lateral scour pools and undercut banks. Nine transects were distributed among pool, run, and riffle habitat types (Appendix 1).

Data were collected on three different dates in 1995. Collection dates and corresponding discharges are shown in Table 1. Instream flow filing recommendations derived from data collected at this site were applied to an approximately 3.0 mile-long reach extending downstream from the confluence with Douglas Creek in the NE 1/4 of Section 9, Township 14 North, Range 87 West to the confluence of Mill Creek in the NE 1/4 of Section 20, Township 14 North, Range 87 West.

Table 1. Dates and discharges when instream flow data were collected on Big Sandstone Creek in 1995.

<table>
<thead>
<tr>
<th>Date</th>
<th>Discharge (cfs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>July 18</td>
<td>35.0</td>
</tr>
<tr>
<td>July 31</td>
<td>13.0</td>
</tr>
<tr>
<td>August 31</td>
<td>4.0</td>
</tr>
</tbody>
</table>

While continuous, adequate instream flows are critically important for maintaining the population integrity of stream fisheries, maximum population development can be limited by habitat limitations or "bottlenecks" for certain sensitive life stages and/or times of year. In many cases, habitat for young (fry and/or juvenile) and spawning life stages are significant "bottlenecks" (Nehring and
INSTREAM FLOW SEGMENT NO. 1 - POINT OF BEGINNING
DOUGLAS CREEK, SECTION 9, T.14 N., R.87 W.

INSTREAM FLOW SEGMENT NO. 1 - POINT OF ENDING
MILL CREEK, SECTION 20, T.14 N., R.87 W.

BIG SANDSTONE CREEK INSTREAM FLOW SEGMENT NO. 1
(LENGTH OF STREAM SEGMENT = 3.0 MILES)
As a consequence, the department's general approach to flow quantification includes ensuring adequate flows to maintain spawning habitat in the spring as well as adult and juvenile habitat throughout the remainder of the year (Table 2).

Table 2. Colorado River cutthroat trout life stages and months considered in Big Sandstone Creek instream flow recommendations. Numbers indicate method used to determine flow requirements.

<table>
<thead>
<tr>
<th>LIFE STAGE</th>
<th>OCT</th>
<th>NOV</th>
<th>DEC</th>
<th>JAN</th>
<th>FEB</th>
<th>MAR</th>
<th>APR</th>
<th>MAY</th>
<th>JUN</th>
<th>JUL</th>
<th>AUG</th>
<th>SEP</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPawning</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adult</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
<td>2</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

1 - PHABSIM  
2 - Habitat Quality Index  
3 - Habitat Retention

Habitat Retention Method

A Habitat Retention method (Nehring 1979, Annear and Conder 1984) was used to identify a maintenance flow by analyzing data from three riffle transects. A maintenance flow is defined as the continuous flow required to maintain specific hydraulic criteria in stream riffles. Year-round criteria maintenance ensures passage between habitat types for all trout life stages. In addition, the criteria maintain adequate benthic invertebrate survival. A maintenance flow is realized at the discharge for which any two of the three criteria in Table 3 are met for all riffle transects in a study area. The instream flow recommendations from the Habitat Retention method are applicable year round except when higher instream flows are required to meet other fishery management purposes (Table 2).

Table 3. Hydraulic criteria for determining maintenance flow with the Habitat Retention method.

<table>
<thead>
<tr>
<th>Category</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Depth (feet)</td>
<td>Top Width X 0.01</td>
</tr>
<tr>
<td>Mean Velocity (feet/second)</td>
<td>1.00</td>
</tr>
<tr>
<td>Percent Wetted Perimeter</td>
<td>50</td>
</tr>
</tbody>
</table>

a - At average daily flow. Minimum depth = 0.20 feet  
b - Percent of bank full wetted perimeter

Habitat Quality Index

The Habitat Quality Index (HQI; Binns and Eisermann 1979) was used to estimate trout production over a range of late summer flow conditions. This model was developed by the WGFD and received extensive testing and refinement. It has been reliably used in Wyoming for trout standing stock gain or loss assessment associated with instream flow regime changes. The HQI model includes nine attributes addressing biological, chemical, and physical aspects of trout habitat. Results are expressed in trout Habitat Units (HU's), where one HU is defined as the amount of habitat quality that will support about 1 pound of trout. HQI results were used to identify the flow needed to maintain or improve existing levels of CRC production between July 1 and September 30 (Table 2).
In the HQI analysis, habitat attributes measured at various flow events are assumed to be typical of mean late summer flow conditions. Under this assumption, HU estimates are extrapolated through a range of potential late summer flows (Conder and Annear 1987). Big Sandstone Creek habitat attributes were measured on the same dates PHABSIM data were collected (Table 1). Some attributes were mathematically derived to establish the relationship between discharge and trout production at discharges other than those measured. Average daily flow and peak flow estimates are based on elevation and basin area (Lowham 1976).

**Physical Habitat Simulation**

Physical Habitat Simulation (PHABSIM) methodology was used to quantify physical habitat (depth and velocity) availability over a range of discharges. This methodology was developed by the Instream Flow Service Group of the U.S. Fish and Wildlife Service (Bovee and Milhous 1978) and is widely used for assessing instream flow relationships between fish and physical habitat (Reiser et al. 1989).

The PHABSIM method uses empirical relationships between physical variables (depth, velocity, and substrate) and suitability for fish to derive weighted usable area (WUA; suitable ft² per 1000 ft of stream length) at various flows. Depth, velocity, and substrate were measured along transects (sensu Bovee and Milhous 1978) on the dates in Table 1. Hydraulic calibration techniques and modeling options in Milhous et al. (1984) and Milhous et al. (1989) were employed to incrementally estimate physical habitat between 0.6 and 90 cfs. Precision declines outside this range; however, the modeled range accommodates typical flows on Big Sandstone Creek.

Curves describing depth, velocity and substrate suitability for trout life stages are an important component of the PHABSIM modeling process. Suitability curves for adult, juvenile and spawning were developed by WGFD. Criteria for fry were obtained from studies by Bozek and Rahel (1992).

Observations by WGFD field biologists indicate spawning activity in most streams with CRC peaks between late May and mid June. Because spawning onset and duration varies between years due to differences in flow quantity and water temperature, spawning recommendations should extend from May 15 to June 30. Even if spawning is completed prior to June 30, maintaining flows at the recommended level throughout June will benefit trout egg incubation by preventing dewatering.

**RESULTS AND DISCUSSION**

**Habitat Retention Analysis**

Habitat retention analysis indicates that 3.5 cfs is required to maintain hydraulic criteria at all riffles to provide passage between habitats for all trout life stages (Table 4). Maintenance of naturally occurring flows up to this flow is necessary at all times of the year. Higher flows are needed during May through June to maintain or improve specific life stages (Table 2).

Based on habitat retention results, an instream flow of 3.5 cfs is recommended for the October 1 to May 14 time period. This flow level will maintain the existing CRC fishery potential because it protects existing natural flow patterns up to the identified maintenance level. Trout populations are naturally limited by low flow conditions during the winter months (October through March; Needham et al. 1945, Reimers 1957, Butler 1979, Kurtz 1980, Cunjak 1988). Such factors as snow fall, cold intensity, and duration of cold periods can influence winter trout survival.
Fish populations are influenced primarily through the effects of frazil ice including metabolic stress and anchor ice formation which limits habitat and may result in stranding.

These winter mortality causes are all influenced by winter flows. Higher flows minimize temperature changes and increase stream areas where trout can escape frazil ice impacts. Any artificial reduction of natural winter stream flows would increase trout mortality and effectively reduce the number of fish the stream could support. Therefore protection of natural winter stream flows up to the recommended maintenance flow is necessary to maintain existing survival rates of trout populations.

Table 4. Simulated hydraulic criteria for three riffles on Big Sandstone Creek. Bank full discharge = 47.9 cfs.

<table>
<thead>
<tr>
<th>Riffle 1</th>
<th>Mean Depth (Feet)</th>
<th>Mean Velocity (Feet/Sec)</th>
<th>Wetted Perimeter (Feet)</th>
<th>Discharge (cfs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.94</td>
<td>1.78</td>
<td>29.6</td>
<td>47.9</td>
<td></td>
</tr>
<tr>
<td>0.51</td>
<td>1.27</td>
<td>28.4</td>
<td>18.0</td>
<td></td>
</tr>
<tr>
<td>0.38</td>
<td>1.14</td>
<td>27.8</td>
<td>12.0</td>
<td></td>
</tr>
<tr>
<td>0.29</td>
<td>1.00*</td>
<td>21.0</td>
<td>6.0</td>
<td></td>
</tr>
<tr>
<td>0.28</td>
<td>0.87</td>
<td>14.8*</td>
<td>3.5*</td>
<td></td>
</tr>
<tr>
<td>0.24</td>
<td>0.78</td>
<td>14.0</td>
<td>2.6</td>
<td></td>
</tr>
<tr>
<td>0.20*</td>
<td>0.65</td>
<td>13.7</td>
<td>1.8</td>
<td></td>
</tr>
<tr>
<td>0.18</td>
<td>0.58</td>
<td>13.4</td>
<td>1.4</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Riffle 2</th>
<th>Mean Depth (Feet)</th>
<th>Mean Velocity (Feet/Sec)</th>
<th>Wetted Perimeter (Feet)</th>
<th>Discharge (cfs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.80</td>
<td>2.74</td>
<td>22.7</td>
<td>47.9</td>
<td></td>
</tr>
<tr>
<td>0.67</td>
<td>2.31</td>
<td>22.2</td>
<td>33.0</td>
<td></td>
</tr>
<tr>
<td>0.39</td>
<td>1.49</td>
<td>21.1</td>
<td>12.0</td>
<td></td>
</tr>
<tr>
<td>0.28</td>
<td>1.13</td>
<td>19.4</td>
<td>6.0</td>
<td></td>
</tr>
<tr>
<td>0.24</td>
<td>1.00*</td>
<td>17.9</td>
<td>4.2</td>
<td></td>
</tr>
<tr>
<td>0.25</td>
<td>0.86</td>
<td>16.7</td>
<td>3.5</td>
<td></td>
</tr>
<tr>
<td>0.23</td>
<td>0.75</td>
<td>15.2</td>
<td>2.6</td>
<td></td>
</tr>
<tr>
<td>0.20*</td>
<td>0.64</td>
<td>14.3</td>
<td>1.8*</td>
<td></td>
</tr>
<tr>
<td>0.19</td>
<td>0.59</td>
<td>13.9*</td>
<td>1.5</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Riffle 3</th>
<th>Mean Depth (Feet)</th>
<th>Mean Velocity (Feet/Sec)</th>
<th>Wetted Perimeter (Feet)</th>
<th>Discharge (cfs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.86</td>
<td>4.02</td>
<td>14.7</td>
<td>47.9</td>
<td></td>
</tr>
<tr>
<td>0.56</td>
<td>3.05</td>
<td>12.5</td>
<td>20.0</td>
<td></td>
</tr>
<tr>
<td>0.35</td>
<td>2.11</td>
<td>8.7</td>
<td>6.0</td>
<td></td>
</tr>
<tr>
<td>0.28</td>
<td>1.86</td>
<td>8.2</td>
<td>4.0</td>
<td></td>
</tr>
<tr>
<td>0.26</td>
<td>1.73</td>
<td>7.4*</td>
<td>3.1</td>
<td></td>
</tr>
<tr>
<td>0.22</td>
<td>1.50</td>
<td>6.5</td>
<td>2.0</td>
<td></td>
</tr>
<tr>
<td>0.20*</td>
<td>1.40</td>
<td>6.2</td>
<td>1.6*</td>
<td></td>
</tr>
<tr>
<td>0.16</td>
<td>1.21</td>
<td>5.5</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>0.13</td>
<td>1.04*</td>
<td>4.6</td>
<td>0.6</td>
<td></td>
</tr>
<tr>
<td>0.13</td>
<td>0.98</td>
<td>4.3</td>
<td>0.5</td>
<td></td>
</tr>
</tbody>
</table>

a - Hydraulic criteria met
b - Discharge at which 2 of 3 hydraulic criteria are met

The 3.5 cfs identified by the Habitat Retention Method may not always be present during the winter. Because the historic fishery is adapted to natural flow patterns (see above fisheries discussion), occasional periods of natural shortfall during the winter do not imply a need for additional storage. Instead, they
illustrate the necessity of maintaining all natural winter stream flows, up to 3.5 cfs, to maintain existing trout survival rates.

Habitat Unit Analysis

Article 10, Section d of the Instream Flow Act states that waters used for providing instream flows "shall be the minimum flow necessary to maintain or improve existing fisheries". Often, HU's measured during low flow are used to define the existing late summer fisheries. In situations where the goal is to "maintain" existing fisheries, we determine the flow range with the same HU's as measured and the minimum flow in that range becomes the recommendation. On Big Sandstone Creek, this flow was 3.6 cfs. The lowest flow that will maintain this number of HU's is 3.5 cfs.

At the measured late summer flow of 3.6 cfs, the stream provides 77.0 trout HU's (Figure 2). Permanently reduced summer flows (less than 3.5 cfs) would impact the fishery. Likewise, maintaining higher late summer flows (up to 18 cfs) on a permanent basis would increase trout-habitat units.

![Figure 2. Trout habitat units at several late summer flow levels on Big Sandstone Creek. X-axis discharges are not to scale.](image)

Based on this analysis and in consideration of the various Colorado River cutthroat trout management plans and agreements among state and federal land management agencies, an instream flow of 3.5 cfs is recommended to maintain existing trout production between July 1 and September 30. This flow represents the lowest stream flow that will accomplish this objective by allowing populations to benefit from naturally occurring flows when they are available. Storage to achieve this flow on a permanent basis solely for instream flow purposes is likely not in the State's best interest.

PHABSIM Analyses

The maximum amount of physical habitat for spawning occurs at 22.0 cfs (Figure 3). Normal spring flows are much higher - 33 cfs was measured in this study (Table 1) and this was not the peak flow for 1995. According to this analysis, such high flows might limit spawning activity near the study site or cause migration to more favorable (upstream) reaches. Though trout can usually find someplace to spawn
whenever temperatures are appropriate and flows allow unrestricted movement, maximum physical habitat in the study site occurs at a flow of 22.0 cfs. Therefore, an instream flow of 22.0 cfs is recommended for the period May 15 to June 30.

Weighted usable area estimates for adult and juvenile CRC generally agree with HQI results (Figure 3) in as much as WUA declines at flows less than 3.5 cfs and increases at higher flows. The specific differences in flow at which the models indicate changes in habitat value are due to the fact that each model incorporates somewhat different attributes in their analysis. Declines in adult WUA at flows less than 3.5 cfs (and particularly at flows less than 2.6 cfs) are largely the result of the loss of physical habitat associated with undercut banks and mid-channel habitat. The recommended maintenance flow of 3.5 cfs will maintain almost 80 percent of adult physical habitat and 94 percent of maximum juvenile physical habitat. In consideration of this fact, and the fact that the HQI model cannot be used for determining instream flow needs outside the summer period, the flow recommendation from October 1 to May 15 is 3.5 cfs. This flow level will maintain the existing CRC fishery potential because it protects existing natural flow patterns up to the identified maintenance level.

![Figure 3. Percent of maximum available weighted usable area (WUA) for Colorado River Cutthroat trout life stages in Big Sandstone Creek over a range of discharges.](image)

These mortality causes are all influenced by winter flows. Higher flows generally increase stream areas where trout can escape frazil ice impacts. Any artificial reduction of natural winter stream flows would increase trout mortality and effectively reduce the number of fish the stream could support. Therefore protection of natural winter stream flows up to the recommended maintenance flow is necessary to maintain existing survival rates of trout populations.

**INSTREAM FLOW RECOMMENDATIONS**

Based on the analyses and results outlined above, the instream flow recommendations in Table 4 will maintain the existing CRC fishery potential in Big Sandstone Creek. These recommendations apply to an approximately 3.0 mile segment of Big Sandstone Creek extending downstream from the confluence with Douglas Creek.
in the NE 1/4 of Section 9, Township 14 North, Range 87 West to the confluence of Mill Creek in the NE 1/4 of Section 20, Township 14 North, Range 87 West. Because data were collected from representative habitats and simulated over a wide flow range, additional data collection under different flow conditions would not significantly change these recommendations.

Table 4. Instream flow recommendations to maintain or improve habitat for the existing trout fishery in Big Sandstone Creek.

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Instream Flow Recommendation (cfs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>October 1 to May 14</td>
<td>3.5</td>
</tr>
<tr>
<td>May 15 to June 30</td>
<td>22.0</td>
</tr>
<tr>
<td>July 1 to September 30</td>
<td>3.5</td>
</tr>
</tbody>
</table>

This analysis does not consider periodic requirements for channel maintenance flows. Because this stream is unregulated, channel maintenance flow needs are adequately met by natural runoff patterns. If regulated in the future, additional studies and recommendations would be needed for establishing channel maintenance flow requirements.
LITERATURE CITED


Oberholtzer, M. 1987 A fisheries survey of the Little Snake River Drainage, Carbon County, Wyoming, Wyoming Game and Fish Department, Fish Division, Cheyenne. Project Number 5086-01-8501.


Appendix 1. Description of transects used for PHABSIM Analysis on Big Sandstone Creek.

<table>
<thead>
<tr>
<th>Transect</th>
<th>Total Length</th>
<th>Habitat Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3.3</td>
<td>Riffle/Control</td>
</tr>
<tr>
<td>2</td>
<td>6.6</td>
<td>Run/Pool</td>
</tr>
<tr>
<td>3</td>
<td>3.3</td>
<td>Pool</td>
</tr>
<tr>
<td>4</td>
<td>4.5</td>
<td>Riffle/Control</td>
</tr>
<tr>
<td>5</td>
<td>7.4</td>
<td>Pool</td>
</tr>
<tr>
<td>6</td>
<td>3.0</td>
<td>Pool</td>
</tr>
<tr>
<td>7</td>
<td>10.0</td>
<td>Riffle/Control</td>
</tr>
<tr>
<td>8</td>
<td>3.3</td>
<td>Riffle/Control</td>
</tr>
<tr>
<td>9</td>
<td>6.4</td>
<td>Riffle/Run</td>
</tr>
</tbody>
</table>
Mill Creek
Instream Flow Segment No. 1
STATE OF WYOMING
OFFICE OF THE STATE ENGINEER
APPLICATION FOR PERMIT TO APPROPRIATE SURFACE WATER

THIS SECTION IS NOT TO BE FILLED IN BY APPLICANT

Filing/Priority Date

THE STATE OF WYOMING. STATE ENGINEER'S OFFICE

This instrument was received and filed for record on the 27th day of June, 1986, at 1:00 o'clock P.M.

John R. Barnes, State Engineer

Recorded in Book Number of Ditch Permits, on Page ___.

Pre Paid $50.00 Map Filed E

John R. Barnes, State Engineer

WATER DIVISION NO. 1 DISTRICT NO. 8 Filing No. 29 1/129

PERMIT NO. ____________________________

NAME OF FACILITY Mill Creek Instream Flow Segment No. 1

1. Name(s), mailing address and phone no. of applicant(s) is/are Wyoming Water Development Commission
   Herschler Building, Cheyenne, WY 82002

   If more than one applicant, designate one to act as Agent for the others

2. Name & address of agent to receive correspondence and notices
   Wyoming Game & Fish Department,
   5400 Bishop Blvd., Cheyenne, WY 82002

3. (a) The use to which the water is to be applied is Instream Flow

   (b) If more than one beneficial use of water is applied for, the location and ownership of the point of use must be shown in item
   10 of the application and the details of the facilities used to divert and convey the appropriation must be shown on the map in sufficient
   detail to allow the State Engineer to establish the amount of appropriation. In multiple use applications, stock and domestic purposes
   are limited to 0.056 cubic feet per second.

4. The source of the proposed appropriation is Mill Creek, tributary of Big Sandstone Creek, tributary of Swively Creek, tributary of the Little Snake River.

5. The point of diversion of the proposed work is located

   from the Nebraska, Section 27, T. 14 N., R. 87 W., from the
   N.E. NSW.

   from the Nebraska, Section 20, T. 14 N., R. 87 W., from the
   NW SEC.

6. Are any of the lands crossed by the proposed facility owned by the State or Federal Government? If so, describe lands and indicate whether
   State or Federally owned.

   All lands are Federally owned, U.S. Forest Service.

7. The carrying capacity of the ditch, canal, pipeline or other facility at the point of diversion is see remarks cubic feet per second.

8. The accompanying map is prepared in accordance with the State Engineer's Manual of Regulations and Instructions for filing applications
   and is hereby declared a part of this application. The State Engineer may require the filing of detailed construction plans.

9. The estimated time required for the commencement of work is 30 days, for completion of construction is 30 days, and to complete the application
   of water to the beneficial uses stated in this application is 30 days from issue

Permit No. ____________________________

Page No. ____________________________
10. The land to be irrigated under this permit is described in the following tabulation. (Give irrigable acreage in each 40-acre subdivision. Designate ownership of land. Federal, State or private. If private, list names of owners and land owned separately.) If application is for stock, domestic, or for purposes other than irrigation, indicate point of use by 40-acre subdivision and owner.

<table>
<thead>
<tr>
<th>Township</th>
<th>Range</th>
<th>Sec.</th>
<th>NE ¼</th>
<th>NW ¼</th>
<th>SW ¼</th>
<th>SE ¼</th>
<th>TOTALS</th>
</tr>
</thead>
<tbody>
<tr>
<td>14N 87W</td>
<td>27</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Number of acres to receive original supply
Number of acres to receive supplemental supply
Total number of acres to be irrigated

**REMARKS**

Based on the results of a study completed in 1996 by the Wyoming Game and Fish Department, a water right of 1.7 cfs is requested from October 1 to May 14 to maintain hydraulic conditions for trout survival. A water right of 6.8 cfs is requested from May 15 to June 30 to maintain the existing level of trout spawning habitat. A water right of 1.7 cfs is requested from July 1 to September 30 to maintain or improve existing levels of trout production.

<table>
<thead>
<tr>
<th>Month</th>
<th>Flow (cfs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oct.</td>
<td>1.7</td>
</tr>
<tr>
<td>Nov.</td>
<td>1.7</td>
</tr>
<tr>
<td>Dec.</td>
<td>1.7</td>
</tr>
<tr>
<td>Jan.</td>
<td>1.7</td>
</tr>
<tr>
<td>Feb.</td>
<td>1.7</td>
</tr>
<tr>
<td>March</td>
<td>1.7</td>
</tr>
<tr>
<td>April</td>
<td>1.7</td>
</tr>
<tr>
<td>May 1 - May 14</td>
<td>1.7</td>
</tr>
<tr>
<td>May 15 - May 31</td>
<td>6.8</td>
</tr>
</tbody>
</table>

Stream length - 3.1 miles
Intervening permits - none

This is an unaged stream. If required by the State Engineer, a gage will be installed at or near the downstream end of the instream flow segment.

Under penalties of perjury, I declare that I have examined this application and to the best of my knowledge and belief it is true, correct and complete.

[Signature]

6/25/96
Instream flow data were collected in 1995 on Mill Creek to determine flows needed to maintain or improve Colorado River cutthroat trout (CRC) habitat and populations. Studies were designed to complement ongoing management plans by the Wyoming Game and Fish Department (WGFD), U.S. Forest Service (USFS) and Bureau of Land Management (BLM).

Physical Habitat Simulation (PHABSIM) and Habitat Quality Index (HQI) models were used to develop instream flow recommendations. Recommendations are 1.7 cfs from October 1 to May 14, 6.8 cfs from May 15 to June 30 and 1.7 cfs from July 1 to September 30. Instream flow recommendations were applied to a 3.1 mile-long reach extending downstream from Forest Service road 871 in the NW 1/4 of Section 27, Township 14 North, Range 87 West to the confluence of Big Sandstone Creek in the NE 1/4 of Section 20, Township 14 North, Range 87 West.

INTRODUCTION

Colorado River cutthroat trout (Oncorhynchus clarki pleuriticus) is the only trout species native to the Green River and Little Snake River drainages in Wyoming. Historically, this species was relatively widely distributed and abundant in most of the headwater streams of these drainages. However, habitat degradation, hybridization and competition with introduced trout species have led to serious declines in populations of this species. Binns (1977) reviewed the distribution, genetic purity, and habitat conditions for Colorado River cutthroat trout. His report concluded that habitat loss and degradation were major factors limiting recovery of the species.

In addition to Binns (1977) the distribution and abundance of Colorado River cutthroat trout has also been described by Oberholtzer (1987, 1990). Colorado River cutthroat trout are considered a "rare" species by the Wyoming Game and Fish Department (1977) and "sensitive" by the U.S. Forest Service (USFS) (1985). Management and monitoring responsibilities for populations in the Little Snake River drainage are coordinated by WGFD fisheries personnel in the Green River regional office.
Several strategies and agreements have been developed to guide the management and recovery of this species. The WGFD developed the Comprehensive Management and Enhancement Plan for Colorado River Cutthroat Trout in Wyoming (1987) that outlines specific actions for increasing the range, habitat and numbers of the species. Obtaining adequate instream flows is one of the actions identified for addressing habitat needs. In 1987, the WGFD and U.S. Forest Service signed a memorandum of understanding that committed each agency to “protecting, maintaining, improving and managing Colorado River cutthroat trout populations” in ways that lead toward enhanced biological status. In 1994, the WGFD, USFS and Bureau of Land Management signed a cooperative agreement entitled "Conservation Plan for Colorado River Cutthroat Trout (Oncorhynchus clarki pleuriticus) for the Little Snake River Drainage, In Southeastern Wyoming. Pursuing opportunities to secure adequate instream flows is one of the tasks identified in that document. Habitat protection by acquiring instream flow water rights is consistent with the goals and objectives of each of these documents.

Fishery and other resource management practices could be significantly affected if actions are not taken to prevent listing Colorado River cutthroat trout as Threatened or Endangered. Acquiring adequate instream flow water rights on CRC streams is an important step to help avoid listing. In this regard, the WGFD has developed a management strategy of filing instream flow water rights on streams with populations or potential habitat for Colorado River cutthroat trout within their historic range. Studies in 1995 focused on Big Sandstone, North Fork Big Sandstone, Roaring Fork Little Snake and East Fork Deep Creeks in addition to Mill Creek.

The specific objectives of this study were to 1) investigate the relationship between discharge and physical habitat quantity and quality at various times of year for Colorado River cutthroat trout and, 2) determine an instream flow necessary to maintain or improve Colorado River cutthroat trout populations.

METHODS

Study Area

Mill Creek is a tributary to Big Sandstone Creek in the Little Snake River drainage (Figure 1). The entire length of the instream flow segment is administered by the USFS and the majority of lands within the drainage basin are publicly owned. Mixed aspen and conifers predominate uplands throughout the reach. Willow are scattered in the riparian zone and beaver activity has resulted in several old and new ponds. Overall stream gradient is moderate (<2.5 %) and the channel type was rated as B2 (Rosgen 1985). This rating indicates a moderately entrenched channel that is well confined by its valley and has bed material composed of large cobble, course gravel, and sand.

Fisheries

Observations by fisheries managers in Wyoming and other western states indicate that trout populations in small mountain streams often fluctuate considerably among consecutive years. In a western Oregon stream studied for 11 years, the density of age-0 cutthroat trout (fry, <2 inches) varied from 8 to 38 per 100 m² and density of age-1 cutthroat trout (juveniles, 4 to 4.5 inches) ranged from 16 to 34 per 100 m² (House 1995). In this example, population fluctuations occurred despite the fact that structural habitat conditions and water quality were not degraded and remained relatively stable. The author suggested that changes in
INSTREAM FLOW SEGMENT NO. 1 - POINT OF ENDING
SANDSTONE CREEK, SECTION 20, T.14 N., R.87 W.

INSTREAM FLOW SEGMENT NO. 1 - POINT OF BEGINNING
USFS ROAD 871, NW 1/4, SECTION 27, T.14 N., R.87 W.

MILL CREEK INSTREAM FLOW SEGMENT NO. 1
(LENGTH OF STREAM SEGMENT = 3.1 MILES)
winters flows between years accounted for part or all of the observed variation in overwinter survival of the different age classes.

In western Wyoming, Binns (1981) noted large declines in trout numbers in several Bonneville cutthroat trout streams following drought in 1977. Similar observations have been made by Remmick (1995, WGFD, personal communication) in more recent years. Department records for Mill Creek show that CRC populations (fish greater than 6 inches long) within the instream flow segment have ranged from 31 fish per mile in 1985 to 287 fish per mile in 1987. The fishery has not been sampled in the past three years.

Long-term trout population maintenance in small streams depends on periodic strong year classes produced in good flow years. Without the benefit of periodic favorable flows, populations in some streams would decline or disappear and genetic diversity could be compromised. The WGFD instream flow strategy recognizes the inherent variability of trout populations as shown in Mill Creek and other streams throughout the state and Western U.S. (House 1995) and thus defines the "existing fishery" as a dynamic feature. This basic concept has also been incorporated into instream flow strategies developed by the Endangered Fish Recovery Program for recovery of endangered fishes in the Colorado River system where high flows are recommended in high flow years and lower flows are recommended during normal and below normal flow periods. Summarily, instream flow recommendations for Mill Creek are based on a goal of maintaining the existing dynamic trout population characteristics of a stream segment as affected by naturally variable flow conditions. The specific flow recommendations are for the lowest flow needed at various times of year to provide this beneficial use of water.

Habitat Modeling

After visually surveying about 1.0 mile of the stream, a study site was located in Range 87 West, Township 14 North, Section 27, NW1/4 at an elevation of about 8180 feet (Figure 1). The representative site had adult and juvenile trout cover associated mostly with lateral scour pools and undercut banks. Nine transects were distributed among pool, run, and riffle habitat types (Appendix 1).

Data were collected on June 7 and 27, 1994 and June 22, 1995. Sampling was also attempted on September 21, 1994; however, flow had ceased in the stream at that time which prevented collection of usable hydraulic data. Although flow had ceased, the numerous pools and beaver ponds in the instream flow reach still contained standing water that provided refuge for some adult fish. Collection dates and corresponding discharges are listed in Table 1. Instream flow filing recommendations derived from data collected at this site were applied to a 3.1 mile-long reach extending downstream from Forest Service road 871 in the NW 1/4 of Section 27, Township 14 North, Range 87 West to the confluence of Big Sandstone Creek in the NE 1/4 of Section 20, Township 14 North, Range 87 West.

Table 1. Dates and discharges when instream flow data were collected on Mill Creek in 1994 and 1995.

<table>
<thead>
<tr>
<th>Date</th>
<th>Discharge (cfs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>June 7, 1994</td>
<td>3.3</td>
</tr>
<tr>
<td>June 27, 1994</td>
<td>0.3</td>
</tr>
<tr>
<td>September 21, 1994</td>
<td>0.0</td>
</tr>
<tr>
<td>June 22, 1995</td>
<td>40.3</td>
</tr>
</tbody>
</table>
While continuous, adequate instream flows are critically important for maintaining the population integrity of stream fisheries, maximum population development can be limited by habitat limitations or "bottlenecks" for certain sensitive life stages and/or times of year. In many cases, habitat for young (fry and/or juvenile) and spawning life stages are significant "bottlenecks" (Nehring and Anderson 1993). As a consequence, the department's general approach to flow quantification includes ensuring adequate flows to maintain spawning habitat in the spring as well as adult and juvenile habitat throughout the remainder of the year. (Table 2).

Table 2. Colorado River cutthroat trout life stages and months considered in Roaring Fork instream flow recommendations. Numbers indicate method used to determine flow requirements.

<table>
<thead>
<tr>
<th>LIFE STAGE</th>
<th>OCT</th>
<th>NOV</th>
<th>DEC</th>
<th>JAN</th>
<th>FEB</th>
<th>MAR</th>
<th>APR</th>
<th>MAY</th>
<th>JUN</th>
<th>JUL</th>
<th>AUG</th>
<th>SEP</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPAWNING</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ADULT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
<td>2</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ALL</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

1 - PHABSIM
2 - Habitat Quality Index
3 - Habitat Retention

Habitat Retention Method

A Habitat Retention method (Nehring 1979, Annear and Conder 1984) was used to identify a maintenance flow by analyzing data from three riffle transects. A maintenance flow is defined as the continuous flow required to maintain specific hydraulic criteria in stream riffles. Year-round criteria maintenance ensures passage between habitat types for all trout life stages. In addition, the criteria maintain adequate benthic invertebrate survival. A maintenance flow is realized at the discharge for which any two of the three criteria in Table 3 are met for all riffle transects in a study area. The instream flow recommendations from the Habitat Retention method are applicable year round except when higher instream flows are required to meet other fishery management purposes (Table 2).

Table 3. Hydraulic criteria for determining maintenance flow with the Habitat Retention method.

<table>
<thead>
<tr>
<th>Category</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Depth (feet)</td>
<td>Top Width * X 0.01</td>
</tr>
<tr>
<td>Mean Velocity (feet/second)</td>
<td>1.00</td>
</tr>
<tr>
<td>Percent Wetted Perimeter</td>
<td>50</td>
</tr>
</tbody>
</table>

a - At average daily flow. Minimum depth = 0.20 feet
b - Percent of bank full wetted perimeter

Habitat Quality Index

The Habitat Quality Index (HQI; Binns and Eisermann 1979) was used to estimate trout production over a range of late summer flow conditions. This model was developed by the WGFD and received extensive testing and refinement. It has been reliably used in Wyoming for trout standing stock gain or loss assessment associated with instream flow regime changes. The HQI model includes nine attributes.
addressing biological, chemical, and physical aspects of trout habitat. Results are
expressed in trout Habitat Units (HUs), where one HU is defined as the amount of
habitat quality that will support about 1 pound of trout. HQI results were used to
identify the flow needed to maintain or improve existing levels of CRC production
between July 1 and September 30 (Table 2).

In the HQI analysis, habitat attributes measured at various flow events are
assumed to be typical of mean late summer flow conditions. Under this assumption,
HU estimates are extrapolated through a range of potential late summer flows (Conder
and Annear 1987). Mill Creek habitat attributes were measured on the same dates
PHABSIM data were collected (Table 1). Some attributes were mathematically derived
to establish the relationship between discharge and trout production at discharges
other than those measured. Average daily flow and peak flow estimates are based on
elevation and basin area (Lowham 1976).

Physical Habitat Simulation

Physical Habitat Simulation (PHABSIM) methodology was used to quantify
physical habitat (depth and velocity) availability over a range of discharges. This
methodology was developed by the Instream Flow Service Group of the U.S. Fish and
Wildlife Service (Bovee and Milhous 1978) and is widely used for assessing instream
flow relationships between fish and physical habitat (Reiser et al. 1989).

The PHABSIM method uses empirical relationships between physical variables
(depth, velocity, and substrate) and suitability for fish to derive weighted usable
area (WUA; suitable ft² per 1000 ft of stream length) at various flows. Depth,
velocity, and substrate were measured along transects (sensu Bovee and Milhous 1978)
on the dates in Table 1. Hydraulic calibration techniques and modeling options in
Milhous et al. (1984) and Milhous et al. (1989) were employed to incrementally
estimate physical habitat between 0.6 and 90 cfs. Precision declines outside this
range; however, the modeled range accommodates typical flows on Mill Creek.

Curves describing depth, velocity and substrate suitability for trout life
stages are an important component of the PHABSIM modeling process. Suitability
curves for adult, juvenile and spawning were developed by WGFD. Criteria for fry
were obtained from studies by Bozek and Rahel (1992).

Observations by WGFD field biologists indicate spawning activity in most
streams with CRC peaks between late May and mid June. Because spawning onset and
duration varies between years due to differences in flow quantity and water
temperature, spawning recommendations should extend from May 15 to June 30. Even if
spawning is completed prior to June 30, maintaining flows at the recommended level
throughout June will benefit trout egg incubation by preventing dewatering.

RESULTS AND DISCUSSION

Habitat Retention Analysis

Habitat retention analysis indicates that 1.7 cfs is required to maintain
hydraulic criteria at all riffles to provide passage between habitats for all trout
life stages (Table 4). Maintenance of naturally occurring flows up to this flow is
necessary at all times of the year. Higher flows are needed during May through June
to maintain or improve specific life stages (Table 2).
Based on habitat retention results, an instream flow of 1.7 cfs is recommended for the October 1 to May 14 time period. This flow level will maintain the existing fishery because it protects existing natural flow patterns up to the identified maintenance level. Trout populations are naturally limited by low flow conditions during the winter months (October through March; Needham et al. 1945, Reimers 1957, Butler 1979, Kurtz 1980, Cunjak 1988). Such factors as snow fall, cold intensity, and duration of cold periods can influence winter trout survival. Fish populations are influenced primarily through the effects of frazil ice including metabolic stress and anchor ice formation which limits habitat and may result in stranding.

These winter mortality causes are all influenced by winter flows. Higher flows minimize temperature changes and increase stream areas where trout can escape frazil ice impacts. Any artificial reduction of natural winter stream flows would increase trout mortality and effectively reduce the number of fish the stream could support. Therefore protection of natural winter stream flows up to the recommended maintenance flow is necessary to maintain existing survival rates of trout populations.

Table 4. Simulated hydraulic criteria for two riffles on Mill Creek. Bank full discharge = 29 cfs.

<table>
<thead>
<tr>
<th></th>
<th>Mean Depth (Feet)</th>
<th>Mean Velocity (Feet/Sec)</th>
<th>Wetted Perimeter (Feet)</th>
<th>Discharge (cfs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Riffle 1</td>
<td>1.03</td>
<td>2.13</td>
<td>19.0</td>
<td>40.0</td>
</tr>
<tr>
<td></td>
<td>0.92</td>
<td>1.85</td>
<td>17.7</td>
<td>29.0</td>
</tr>
<tr>
<td></td>
<td>0.83</td>
<td>1.57</td>
<td>16.0</td>
<td>20.0</td>
</tr>
<tr>
<td></td>
<td>0.59</td>
<td>1.00</td>
<td>13.2</td>
<td>7.5</td>
</tr>
<tr>
<td></td>
<td>0.49</td>
<td>0.83</td>
<td>12.8</td>
<td>5.0</td>
</tr>
<tr>
<td></td>
<td>0.37</td>
<td>0.63</td>
<td>11.1</td>
<td>2.5</td>
</tr>
<tr>
<td></td>
<td>0.31</td>
<td>0.54</td>
<td>10.3</td>
<td>1.7</td>
</tr>
<tr>
<td></td>
<td>0.27</td>
<td>0.49</td>
<td>9.8</td>
<td>1.3</td>
</tr>
<tr>
<td></td>
<td>0.26</td>
<td>0.45</td>
<td>8.7&quot;</td>
<td>1.0&quot;</td>
</tr>
<tr>
<td></td>
<td>0.21&quot;</td>
<td>0.37</td>
<td>7.8</td>
<td>0.6</td>
</tr>
<tr>
<td></td>
<td>0.14</td>
<td>0.30</td>
<td>7.3</td>
<td>0.3</td>
</tr>
<tr>
<td>Riffle 2</td>
<td>0.95</td>
<td>2.57</td>
<td>17.2</td>
<td>40.0</td>
</tr>
<tr>
<td></td>
<td>0.80</td>
<td>2.40</td>
<td>15.8</td>
<td>29.0</td>
</tr>
<tr>
<td></td>
<td>0.68</td>
<td>2.19</td>
<td>13.8</td>
<td>20.0</td>
</tr>
<tr>
<td></td>
<td>0.47</td>
<td>1.87</td>
<td>11.7</td>
<td>10.0</td>
</tr>
<tr>
<td></td>
<td>0.30</td>
<td>1.61</td>
<td>10.6</td>
<td>5.0</td>
</tr>
<tr>
<td></td>
<td>0.21</td>
<td>1.49</td>
<td>9.9</td>
<td>3.0</td>
</tr>
<tr>
<td></td>
<td>0.22</td>
<td>1.42</td>
<td>8.0&quot;</td>
<td>2.4</td>
</tr>
<tr>
<td></td>
<td>0.20&quot;</td>
<td>1.29</td>
<td>6.7</td>
<td>1.7&quot;</td>
</tr>
<tr>
<td></td>
<td>0.17</td>
<td>1.18</td>
<td>6.4</td>
<td>1.3</td>
</tr>
<tr>
<td></td>
<td>0.14</td>
<td>1.01&quot;</td>
<td>5.6</td>
<td>0.8</td>
</tr>
<tr>
<td></td>
<td>0.11</td>
<td>0.76</td>
<td>4.9</td>
<td>0.4</td>
</tr>
</tbody>
</table>

a - Hydraulic criteria met
b - Discharge at which 2 of 3 hydraulic criteria are met

The 1.7 cfs identified by the Habitat Retention Method may not always be present during the winter. Because the existing fishery is adapted to natural flow patterns (see above fisheries discussion), occasional periods of natural shortfall during the winter do not imply a need for additional storage. Instead, they
illustrate the necessity of maintaining all natural winter stream flows, up to 1.7 cfs, to maintain existing trout survival rates.

Habitat Unit Analysis

Article 10, Section d of the Instream Flow Act states that waters used for providing instream flows "shall be the minimum flow necessary to maintain or improve existing fisheries". Often, HU's measured during low flow are used to define the existing late summer fisheries. In situations where the goal is to "maintain" existing fisheries, we determine the flow range with the same HU's as measured and the minimum flow in that range becomes the recommendation. This approach proved infeasible on Mill Creek because the stream ceased flowing prior to the last field visit in September. As a consequence, the late summer recommendation was referenced to the Habitat Retention recommendation which, by definition, is the base flow for all times of year except when other appropriate methods indicate higher flows are needed for specific purposes. This flow was found to be 1.7 cfs (see above).

At a measured late summer flow of 1.7 cfs, HQI analysis indicates the stream provides 19.4 trout HU’s (Figure 2). Permanently reduced summer flows (less than 1.7 cfs) would impact the fishery. Likewise, maintaining higher late summer flows (up to 14.8 cfs) on a permanent basis would increase trout habitat units.

Based on this analysis and in consideration of the various Colorado River cutthroat trout management plans and agreements among state and federal land management agencies, an instream flow of 1.7 cfs is recommended to maintain existing trout production between July 1 and September 30. This flow represents the lowest stream flow that will accomplish this objective by allowing populations to benefit from naturally occurring flows when they are available. Storage to achieve this flow on a permanent basis solely for instream flow purposes is likely not in the State's best interest.

Figure 2. Trout habitat units at several late summer flow levels on Mill Creek. X-axis discharges are not to scale.
PHABSIM Analyses

The maximum amount of physical habitat for spawning occurs at 6.8 cfs (Figure 3). Normal spring flows are much higher - 40 cfs was measured in this study (Table 1). Such high flows might limit spawning activity near the study site or cause migration to more favorable (upstream) reaches. Though trout can usually find someplace to spawn whenever temperatures are appropriate and flows allow unrestricted movement, maximum physical habitat in the study site occurs at a flow of 6.8 cfs. Therefore, an instream flow of 6.8 cfs is recommended for the period May 15 to June 30.

Weighted usable area estimates for adult and juvenile CRC generally agree with HQI results (Figure 3) in as much as WUA declines at flows less than 1.7 cfs and increases at higher flows. Declines in adult WUA at flows less than 1.7 cfs are largely the result of the loss of habitat associated with undercut banks and mid-channel habitat. The recommended late-summer flow of 1.7 cfs (based on the HQI model) will maintain 82 and 85 percent of maximum adult and juvenile physical habitat (respectively). In consideration of this fact, and the fact that the HQI model cannot be used for determining instream flow needs outside the summer period, the flow recommendation from October 1 to May 15 is 1.7 cfs. This flow level will maintain the existing fishery because it protects existing natural flow patterns up to the identified maintenance level.

Figure 3. Percent of maximum available weighted usable area (WUA), for Colorado River Cutthroat trout life stages in Mill Creek over a range of discharges.

These mortality causes are all influenced by winter flows. Higher flows generally increase stream areas where trout can escape frazil ice impacts. Any artificial reduction of natural winter stream flows would increase trout mortality and effectively reduce the number of fish the stream could support. Therefore protection of natural winter stream flows up to the recommended maintenance flow is necessary to maintain existing survival rates of trout populations.

INSTREAM FLOW RECOMMENDATIONS

Based on the analyses and results outlined above, the instream flow recommendations in Table 3 will maintain the existing Roaring Fork Colorado River cutthroat trout fishery. These recommendations apply to a 3.1 mile segment of Mill
Creek extending downstream from Forest Service road 871 in the NW 1/4 of Section 27, Township 14 North, Range 87 West to the confluence of Big Sandstone Creek in the NE 1/4 of Section 20, Township 14 North, Range 87 West. Because data were collected from representative habitats and simulated over a wide flow range, additional data collection under different flow conditions would not significantly change these recommendations.

Table 3. Instream flow recommendations to maintain or improve habitat for the existing trout fishery in Mill Creek.

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Instream Flow Recommendation (cfs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>May 15 to June 30</td>
<td>6.8</td>
</tr>
<tr>
<td>July 1 to September 30</td>
<td>1.7</td>
</tr>
<tr>
<td>October 1 to May 14</td>
<td>1.7</td>
</tr>
</tbody>
</table>

This analysis does not consider periodic requirements for channel maintenance flows. Because this stream is unregulated, channel maintenance flow needs are adequately met by natural runoff patterns. If regulated in the future, additional studies and recommendations would be needed for establishing channel maintenance flow requirements.
LITERATURE CITED


Appendix 1. Description of transects used for PHABSIM Analysis on Mill Creek.

<table>
<thead>
<tr>
<th>Transect</th>
<th>Total Length</th>
<th>Habitat Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3.4</td>
<td>Riffle/Control</td>
</tr>
<tr>
<td>2</td>
<td>10.6</td>
<td>Run/Pool</td>
</tr>
<tr>
<td>3</td>
<td>18.6</td>
<td>Pool</td>
</tr>
<tr>
<td>4</td>
<td>23.2</td>
<td>Pool</td>
</tr>
<tr>
<td>5</td>
<td>52.0</td>
<td>Pool</td>
</tr>
<tr>
<td>6</td>
<td>51.4</td>
<td>Riffle/Control</td>
</tr>
<tr>
<td>7</td>
<td>11.3</td>
<td>Riffle/Control</td>
</tr>
<tr>
<td>8</td>
<td>9.4</td>
<td>Run/Pool</td>
</tr>
<tr>
<td>9</td>
<td>4.7</td>
<td>Pool</td>
</tr>
</tbody>
</table>
Roaring Fork Little Snake River
Instream Flow Segment No. 1
STATE OF WYOMING
OFFICE OF THE STATE ENGINEER
APPLICATION FOR PERMIT TO APPROPRIATE SURFACE WATER

THIS SECTION IS NOT TO BE FILLED IN BY APPLICANT

Filing/Priority Date

THE STATE OF WYOMING, STATE ENGINEERS OFFICE

This instrument was received and filed for record on the 27th day of June, 1986, at 1:00 o'clock P.M.

JOHN R. BARNES, for State Engineer

Recorded in Book of Ditch Permits, on Page _______

Temp. WTR.

WATER DIVISION NO. 1 DISTRICT NO. 8 Filing No. 29 6/128

PERMIT NO. _______________________

NAME OF FACILITY Roaring Fork Little Snake River Instream Flow Segment No. 1

1. Name(s), mailing address and phone no. of applicant(s) is/are Wyoming Water Development Commission
   Herschler Building, Cheyenne, WY 82002

2. Name & address of agent to receive correspondence and notices Wyoming Game & Fish Department 5-100 Bishop Blvd., Cheyenne, WY 82002

3. (a) The use to which the water is to be applied is Instream Flow

   (b) If more than one beneficial use of water is applied for, the location and ownership of the point of use must be shown in item 10 of the application and the details of the facilities used to divert and convey the appropriation must be shown on the map in sufficient detail to allow the State Engineer to establish the amount of appropriation. In multiple use applications, stock and domestic purposes are limited to 0.056 cubic feet per second.

4. The source of the proposed appropriation is Roaring Fork, tributary of the Little Snake River.

5. The point of diversion of the proposed works is located from the corner of Section 13 T. 13 N. R. 86 W., to the corner of Section 22 T. 13 N. R. 86 W.

6. Are any of the lands crossed by the proposed facility owned by the State or Federal Government? If so, describe lands and indicate whether State or Federally owned.
   All lands are federally owned, U.S. Forest Service

7. The carrying capacity of the ditch, canal, pipeline or other facility at the point of diversion is ______ cubic feet per second.

8. The accompanying map is prepared in accordance with the State Engineer's Manual of Regulations and Instructions for filing applications and is hereby declared a part of this application. The State Engineer may require the filing of detailed construction plans.

9. The estimated time required for the commencement of work is ______ days, for completion of construction is ______ days, and to complete the application of water to the beneficial uses stated in this application is ______ days from issue.

Permit No. _______________________

Page No. [Lower Blank]
The land to be irrigated under this permit is described in the following tabulation. (Give irrigable acreage in each 40-acre subdivision. Designate ownership of land, Federal, State or private. If private, list names of owners and land owned separately.) If application is for stock, domestic, or for purposes other than irrigation, indicate point of use by 40-acre subdivision and owner.

<table>
<thead>
<tr>
<th>Township</th>
<th>Range</th>
<th>Sec.</th>
<th>NE 1/4</th>
<th>NW 1/4</th>
<th>SW 1/4</th>
<th>SE 1/4</th>
<th>TOTALS</th>
</tr>
</thead>
<tbody>
<tr>
<td>13N</td>
<td>86W</td>
<td>12</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td></td>
<td>1</td>
<td>Lot 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>Lot 2</td>
<td>Lot 3</td>
<td>Lot 4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>23</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>22</td>
<td></td>
<td></td>
<td>x</td>
<td>x</td>
<td></td>
<td>x</td>
<td>x</td>
</tr>
</tbody>
</table>

Number of acres to receive original supply
Number of acres to receive supplemental supply
Total number of acres to be irrigated

**REMARKS**

MONTHLY INSTREAM FLOW REQUESTED Based on data from 1995 and the results of a study completed in 1996 by the Wyoming Game & Fish Department (attached) a water right of 1.6 cfs is requested from October 1 to May 14 to maintain hydraulic conditions for trout survival. A water right of 4.4 cfs is requested from May 15 to June 30 to maintain the existing level of trout spawning habitat. A water right of 1.6 cfs is requested from July 1 to September 30 to maintain or improve existing levels of trout production.

<table>
<thead>
<tr>
<th>Month</th>
<th>Flow (cfs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apr. 1</td>
<td>1.6</td>
</tr>
<tr>
<td>May 1 - 15</td>
<td>1.6</td>
</tr>
<tr>
<td>May 16 - 31</td>
<td>4.4</td>
</tr>
<tr>
<td>June</td>
<td>4.4</td>
</tr>
<tr>
<td>July</td>
<td>1.6</td>
</tr>
<tr>
<td>August</td>
<td>1.6</td>
</tr>
<tr>
<td>Sept.</td>
<td>1.6</td>
</tr>
</tbody>
</table>

Stream length - 3.2 miles
Intervening permits - none

This is an ungaged stream. If required by the State Engineer, a gage will be installed at or near the downstream end of the instream flow segment.

Under penalties of perjury, I declare that I have examined this application and to the best of my knowledge and belief it is true, correct and complete.

Signature of Applicant or Agent: [Signature]
Date: [Date]
Instream flow data were collected in 1995 on the Roaring Fork, Little Snake River to determine flows needed to maintain or improve Colorado River cutthroat trout (CRC) habitat and populations. Studies were designed to complement ongoing management plans by the Wyoming Game and Fish Department (WGFD) and U.S. Forest Service (USFS).

Physical Habitat Simulation (PHABSIM) and Habitat Quality Index (HQI) models were used to develop instream flow recommendations. Recommendations are 1.6 cfs from October 1 to May 14, 4.4 cfs from May 15 to June 30 and 1.6 cfs from July 1 to September 30. These recommendations apply to a 3.2 mile of Roaring Fork extending downstream from the north section line of NE 1/4 of Section 13, Township 13 North, Range 86 North to the west section line of the NW 1/4 Section 22, Township 13 North, Range 86 North.

INTRODUCTION

Colorado River cutthroat trout (Oncorhynchus clarki pleuriticus) is the only trout species native to the Green River and Little Snake River drainages in Wyoming. Historically, this species enjoyed relatively wide distribution and abundance in most of the headwater streams of these drainages. However, habitat degradation, hybridization and competition with introduced trout species have led to serious population declines and decreases in geographical distribution. Binns (1977) reviewed the distribution, genetic purity, and habitat conditions for Colorado River cutthroat trout. His report concluded that habitat degradation was a major factor limiting recovery of the species.

In addition to Binns (1977), distribution and abundance of Colorado River cutthroat trout has been described by Oberholtzer (1987, 1990). Colorado River cutthroat trout are presently considered a "rare" species by the Wyoming Game and Fish Department (1977) and "sensitive" by the U.S. Forest Service (USFS) (1985). Management and monitoring responsibilities for populations in the Little Snake River drainage are coordinated by WGFD fisheries personnel in the Green River regional office.
100 m² (House 1995). In this example, population fluctuations occurred despite the fact that structural habitat conditions and water quality were not degraded and relatively stable. The author suggested that changes in winter flows between years accounted for part or all of the observed variation in overwinter survival of the different age-classes.

In western Wyoming, Binns (1981) noted significant trout number declines in several Bonneville cutthroat trout streams following drought in 1977. Similar observations have been made by Remmick (1995, WGFD, personal communication) in more recent years. Department records for the Roaring Fork show that CRC populations (fish greater than 6 inches long) at a site within the instream flow segment have ranged from 86 per mile in 1986 to 896 in 1990 to 978 trout per mile in 1992.

Long-term trout population maintenance in small streams depends on periodic strong year classes produced in good flow years. Without the benefit of periodic favorable flows, populations in some streams would decline or disappear and genetic diversity could be compromised. The WGFD instream flow strategy recognizes the inherent variability of trout populations as shown in Roaring Fork Creek and other streams throughout the state and Western U.S. (House 1995) and thus defines the "existing fishery" as a dynamic feature. This basic concept is incorporated into instream flow strategies developed for recovery of endangered fishes in the Colorado River system where high flows are recommended "when available" and lower flows are recommended during normal and below normal flow periods. Summarily, instream flow recommendations for the Roaring Fork are based on a goal of maintaining the existing dynamic trout population characteristics of a stream segment as affected by naturally variable flow conditions. Per W.S. 41-3-1001 through 41-3-1014, specific flow recommendations are for the lowest flow needed at various times of year to provide this beneficial use of water.

**Habitat Modeling**

After visually surveying approximately 2.0 stream miles, a study site was located in Range 86 West, Township 13 North, Section 22, NE1/4 at an elevation of about 8800 feet (Figure 1). The representative site had adult and juvenile trout cover associated mostly with lateral scour pools and pocket pools caused by mid-channel boulders. Eight transects were distributed among pool, run, and riffle habitat types (Appendix 1).

Data were collected between July 6 and August 29, 1995. Collection dates and corresponding discharges are listed in Table 1. Instream flow filing recommendations derived from data collected at this site were applied to a 3.2 mile-long reach extending downstream from the north section line of NE 1/4 of Section 13, Township 13 North, Range 86 North to the west section line of the NW 1/4 Section 22, Township 13 North, Range 86 North.

**Table 1.** Dates and discharges when instream flow data were collected on Roaring Fork Little Snake River in 1995.

<table>
<thead>
<tr>
<th>Date</th>
<th>Discharge (cfs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>July 6</td>
<td>70.0</td>
</tr>
<tr>
<td>August 1</td>
<td>7.6</td>
</tr>
<tr>
<td>August 29</td>
<td>1.6</td>
</tr>
</tbody>
</table>

While continuous, adequate instream flows are critically important for maintaining the population integrity of stream fisheries, maximum population development can be limited by habitat limitations or "bottlenecks" for certain
sensitive life stages and/or times of year. In many cases, habitat for young (fry and/or juvenile) and spawning life stages are significant "bottlenecks" (Nehring and Anderson 1993). As a consequence, the department's general approach to flow quantification includes ensuring adequate flows to maintain spawning habitat in the spring as well as adult and juvenile habitat throughout the remainder of the year. (Table 2).

Table 2. Colorado River cutthroat trout life stages and months considered in Roaring Fork instream flow recommendations. Numbers indicate method used to determine flow requirements.

<table>
<thead>
<tr>
<th>LIFE STAGE</th>
<th>OCT</th>
<th>NOV</th>
<th>DEC</th>
<th>JAN</th>
<th>FEB</th>
<th>MAR</th>
<th>APR</th>
<th>MAY</th>
<th>JUN</th>
<th>JUL</th>
<th>AUG</th>
<th>SEP</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADULT</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>ALL</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

1 - Habitat Quality Index
2 - PHABSIM

Habitat Quality Index

The Habitat Quality Index (HQI; Binns and Eisermann 1979) was used to estimate trout production over a range of late summer flow conditions. This model was developed by the WGFD and received extensive testing and refinement. It has been reliably used in Wyoming for trout standing stock gain or loss assessment associated with instream flow regime changes. The HQI model includes nine attributes addressing biological, chemical, and physical aspects of trout habitat. Results are expressed in trout Habitat Units (HUs), where one HU is defined as the amount of habitat quality that will support about 1 pound of trout. HQI results were used to identify the flow needed to maintain or improve existing levels of CRC production between July 1 and September 30 (Table 2).

In the HQI analysis, habitat attributes measured at various flow events are assumed to be typical of mean late summer flow conditions. Under this assumption, HU estimates are extrapolated through a range of potential late summer flows (Conder and Annear 1987). Roaring Fork habitat attributes were measured on the same dates PHABSIM data were collected (Table 1). Some attributes were mathematically derived to establish the relationship between discharge and trout production at discharges other than those measured. Average daily flow and peak flow estimates are based on elevation and basin area (Lowham 1976).

Physical Habitat Simulation

Physical Habitat Simulation (PHABSIM) methodology was used to quantify physical habitat (depth and velocity) availability over a range of discharges. This methodology was developed by the Instream Flow Service Group of the U.S. Fish and Wildlife Service (Bovee and Milhous 1978) and is widely used for assessing instream flow relationships between fish and physical habitat (Reiser et al. 1989).

The PHABSIM method uses empirical relationships between physical variables (depth, velocity, and substrate) and suitability for fish to derive weighted usable area (WUA; suitable ft² per 1000 ft of stream length) at various flows. Depth, velocity, and substrate were measured along transects (sensu Bovee and Milhous 1978) on the dates in Table 1. Hydraulic calibration techniques and modeling options in Milhous et al. (1984) and Milhous et al. (1989) were employed to incrementally estimate physical habitat between 0.6 and 90 cfs. Precision declines outside this range; however, the modeled range accommodates typical Roaring Fork flows.
Curves describing depth, velocity and substrate suitability for trout life stages are an important component of the PHABSIM modeling process. Suitability curves for adult, juvenile and spawning were developed by WGFD. Criteria for fry were obtained from studies by Bozek and Rahel (1992).

Observations by WGFD field biologists indicate spawning activity in most streams with CRC peaks between late May and mid June. Because spawning onset and duration varies between years due to differences in flow quantity and water temperature, spawning recommendations should extend from May 15 to June 30. Even if spawning is completed prior to June 30, maintaining flows at the recommended level throughout June will benefit trout egg incubation by preventing dewatering.

RESULTS AND DISCUSSION

Habitat Unit Analysis

Article 10, Section d of the Instream Flow Act states that waters used for providing instream flows "shall be the minimum flow necessary to maintain or improve existing fisheries". Often, HU's measured during low flow are used to define the existing late summer fisheries. In situations where the goal is to "maintain" existing fisheries, we determine the flow range with the same HU's as measured and the minimum flow in that range becomes the recommendation. At the measured late summer flow of 1.6 cfs, HQI analysis indicates approximately 49 trout HU's (Figure 2). This level of habitat is maintained between late summer flows of 1.6 and 2.2 cfs. Maintaining higher late summer flows (up to 65 cfs) on a permanent basis would increase trout habitat units. Permanently reduced summer flows (to less than 1.6 cfs) would impact the fishery. Thus, the flow recommendation for the period of July 1 to September 30 is 1.6 cfs.

![Figure 2. Trout habitat units at several late summer Roaring Fork flow levels. X-axis discharges are not to scale.](image)

Based on HQI analysis and in consideration of the Colorado River cutthroat trout Management Plan's goals (Speas et al. 1994), an instream flow of 1.6 cfs is recommended to maintain existing trout production between July 1 and September 30. This flow represents the lowest stream flow that will accomplish this objective. Storage to achieve this flow on a permanent basis solely for instream flow purposes is likely not in the State's best interest.
PHABSIM Analyses

Peak spawning physical habitat occurs at 4.4 cfs (Figure 3). Normal spring flows are much higher - 70 cfs was measured in this study (Table 1). Such high flows might limit spawning activity near the study site or cause migration to more favorable (upstream) reaches. Though trout can usually find somewhere to spawn whenever temperatures are appropriate and flows allow unrestricted movement, maximum physical habitat in the study site occurs at a flow of 4.4 cfs. Therefore, an instream flow of 4.4 cfs is recommended for the period May 15 to June 30.

Figure 3. Weighted usable area (percent of maximum) for Colorado River Cutthroat trout life stages in Roaring Fork over a range of discharges.

Weighted usable area estimates for adult and juvenile CRC generally agree with HQI results (Figure 3). Adult and juvenile physical habitat show an initial peak at about 1.8 cfs. At higher flow levels physical habitat declines somewhat and then increases with increasing flow to a higher peak at flows approximating 12 cfs. Adult WUA decreases rapidly as undercut bank and other habitat decrease at flows less than 1.6 cfs. The recommended late-summer flow of 1.6 cfs (based on the HQI model) will maintain about 80% of maximum adult and juvenile physical habitat. In consideration of this fact, and the fact that the HQI model cannot be used for determining instream flow needs outside the summer period, the flow recommendation from October 1 to May 14 is 1.6 cfs.

If approved, this flow level will maintain the existing fishery because it protects existing natural flow patterns up to the identified maintenance level. Trout populations are naturally limited by low flow conditions during the winter months (October through March; Needham et al. 1945, Reimers 1957, Butler 1979, Kurtz 1980, Cunjak 1988). Such factors as snow fall, cold intensity, and duration of cold periods can influence winter trout survival. Fish populations are influenced primarily through the effects of frazil ice including metabolic stress and anchor ice formation which limits habitat and may result in stranding.

These mortality causes are all influenced by winter flows. Higher flows generally increase stream areas where trout can escape frazil ice impacts. Any artificial reduction of natural winter stream flows would increase trout mortality and effectively reduce the number of fish the stream could support. Therefore, protection of natural winter stream flows up to the recommended maintenance flow is necessary to maintain existing survival rates of trout populations.
The 1.6 cfs recommended flow may not be present at all times of all years during the winter. Because the existing fishery is adapted to natural flow patterns (see above fisheries discussion), occasional periods of natural shortfall during the winter do not imply a need for additional storage. Instead, they illustrate the necessity of maintaining all natural winter stream flows, up to 1.6 cfs, to maintain existing trout survival rates.

INSTREAM FLOW RECOMMENDATIONS

Based on the analyses and results outlined above, the instream flow recommendations in Table 3 will maintain the existing Roaring Fork Colorado River cutthroat trout fishery. These recommendations apply to a 3.2 mile of Roaring Fork extending downstream from the north section line of NE 1/4 of Section 13, Township 13 North, Range 86 North to the west section line of the NW 1/4 Section 22, Township 13 North, Range 86 North. Because data were collected from representative habitats and simulated over a wide flow range, additional data collection under different flow conditions would not significantly change these recommendations.

Table 3. Instream flow recommendations to maintain or improve the existing Roaring Fork trout fishery.

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Instream Flow Recommendation (cfs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>May 15 to June 30</td>
<td>4.4</td>
</tr>
<tr>
<td>July 1 to September 30</td>
<td>1.6</td>
</tr>
<tr>
<td>October 1 to May 14</td>
<td>1.6</td>
</tr>
</tbody>
</table>

This analysis does not consider periodic requirements for channel maintenance flows. Because this stream is unregulated, channel maintenance flow needs are adequately met by natural runoff patterns. If regulated in the future, additional studies and recommendations would be needed for establishing channel maintenance flow requirements.
LITERATURE CITED


Oberholtzer, M. 1987 A fisheries survey of the Little Snake River Drainage, Carbon County, Wyoming, Wyoming Game and Fish Department, Fish Division, Cheyenne, Project Number 5086-01-8501.


Appendix 1. Description of transects used for PHABSIM Analysis.

<table>
<thead>
<tr>
<th>Transect</th>
<th>Total Length</th>
<th>Habitat Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6.2</td>
<td>Riffle/Control</td>
</tr>
<tr>
<td>2</td>
<td>10.2</td>
<td>Run/Pool</td>
</tr>
<tr>
<td>3</td>
<td>4.0</td>
<td>Pool</td>
</tr>
<tr>
<td>4</td>
<td>3.7</td>
<td>Dropped from analysis</td>
</tr>
<tr>
<td>5</td>
<td>6.4</td>
<td>Run/Pool</td>
</tr>
<tr>
<td>6</td>
<td>3.0</td>
<td>Run/Pool</td>
</tr>
<tr>
<td>7</td>
<td>6.0</td>
<td>Riffle/Control</td>
</tr>
<tr>
<td>8</td>
<td>8.1</td>
<td>Pool</td>
</tr>
</tbody>
</table>
APPENDIX B

Dirtyman Fork Instream Flow Segment No. 1
Daily Flow Duration Curves
FIGURE B-1. OCTOBER
DAILY FLOW DURATION CURVES

Requested Flow = 0.5 cfs
Percent of Time Available = 41%
Flow Available 50% of the Time = 0.46 cfs
FIGURE B-2. NOVEMBER
DAILY FLOW DURATION CURVES

Requested Flow = 0.5 cfs
Percent of Time Available = 25%
Flow Available 50% of the Time = 0.42 cfs
FIGURE B-3. DECEMBER
DAILY FLOW DURATION CURVES

Requested Flow = 0.5 cfs
Percent of Time Available = <5%
Flow Available 50% of the Time = 0.37 cfs
FIGURE B-4. JANUARY
DAILY FLOW DURATION CURVES

Requested Flow = 0.5 cfs
Percent of Time Available = <5%
Flow Available 50% of the Time = 0.34 cfs
FIGURE B-5. FEBRUARY
DAILY FLOW DURATION CURVES

Requested Flow = 0.5 cfs
Percent of Time Available = <5%
Flow Available 50% of the Time = 0.39 cfs
FIGURE B-6. MARCH
DAILY FLOW DURATION CURVES

Requested Flow = 0.5 cfs
Percent of Time Available = 8.5%
Flow Available 50% of the Time = 0.40 cfs

Dirtyman Fork IFS — Requested Flow
FIGURE B-7. APRIL
DAILY FLOW DURATION CURVES

Requested Flow = 0.5 cfs
Percent of Time Available = 48.5%
Flow Available 50% of the Time = 0.49 cfs

% of Time Equaled or Exceeded

Discharge (cfs)

Dirtyman Fork IFS — Requested Flow
FIGURE B-8. MAY
DAILY FLOW DURATION CURVES

Requested Flow = 1.4 cfs
Percent of Time Available = 92%
Flow Available 50% of the Time = 3.93 cfs
FIGURE B-9. JUNE
DAILY FLOW DURATION CURVES

Requested Flow = 1.4 cfs
Percent of Time Available = >95%
Flow Available 50% of the Time = 8.91 cfs
FIGURE B-10. JULY
DAILY FLOW DURATION CURVES

Requested Flow = 0.5 cfs
Percent of Time Available = >95%
Flow Available 50% of the Time = 1.41 cfs
FIGURE B-11. AUGUST
DAILY FLOW DURATION CURVES

Requested Flow = 0.5 cfs
Percent of Time Available = 59%
Flow Available 50% of the Time = 0.55 cfs

Dirtyman Fork IFS  Requested Flow
FIGURE B-12. SEPTEMBER
DAILY FLOW DURATION CURVES

Requested Flow = 0.5 cfs
Percent of Time Available = 41%
Flow Available 50% of the Time = 0.41 cfs

Dirtyman Fork IFS  Requested Flow
APPENDIX C

Deep Creek Instream Flow Segment No. 1
Daily Flow Duration Curves
FIGURE C-1. OCTOBER
DAILY FLOW DURATION CURVES

Requested Flow = 0.5 cfs
Percent of Time Available = 86.5%
Flow Available 50% of the Time = 0.72 cfs

Deep Creek IFS
Requested Flow
FIGURE C-2. NOVEMBER
DAILY FLOW DURATION CURVES

Requested Flow = 0.5 cfs
Percent of Time Available = 80%
Flow Available 50% of the Time = 0.68 cfs
FIGURE C-3. DECEMBER
DAILY FLOW DURATION CURVES

Requested Flow = 0.5 cfs
Percent of Time Available = 78%
Flow Available 50% of the Time = 0.57 cfs
FIGURE C-4. JANUARY
DAILY FLOW DURATION CURVES

Requested Flow = 0.5 cfs
Percent of Time Available = 50%
Flow Available 50% of the Time = 0.50 cfs
FIGURE C-5. FEBRUARY
DAILY FLOW DURATION CURVES

Requested Flow = 0.5 cfs
Percent of Time Available = 56.5%
Flow Available 50% of the Time = 0.53 cfs

Discharge (cfs)

% of Time Equaled or Exceeded

Deep Creek IFS
Requested Flow
FIGURE C-6. MARCH
DAILY FLOW DURATION CURVES

Requested Flow = 0.5 cfs
Percent of Time Available = 80%
Flow Available 50% of the Time = 0.59 cfs
FIGURE C-7. APRIL
DAILY FLOW DURATION CURVES

Requested Flow = 0.5 cfs
Percent of Time Available = 0%
Flow Available 50% of the Time = 0.0 cfs

- Deep Creek ISF with Stage III Div. — Requested Flow
FIGURE C-8. MAY
DAILY FLOW DURATION CURVES

Requested Flow = 4.6 cfs
Percent of Time Available = 0%
Flow Available 50% of the Time = 0.0 cfs
- Includes Deep Creek Ditch and Stage III Diversions

% of Time Equalled or Exceeded

Discharge (cfs)

Deep Creek IFS with Diversions

Requested Flow
FIGURE C-9. JUNE
DAILY FLOW DURATION CURVES

Requested Flow = 4.6 cfs
Percent of Time Available = 0%
Flow Available 50% of the Time = 0.0 cfs
- Includes Deep Creek Ditch and Stage III Diversions

Deep Creek IFS with Diversions — Requested Flow
FIGURE C-10. JULY
DAILY FLOW DURATION CURVES

Requested Flow = 0.5 cfs
Percent of Time Available = >95%
Flow Available 50% of the Time = 1.83 cfs
FIGURE C-11. AUGUST
DAILY FLOW DURATION CURVES

Requested Flow = 0.5 cfs
Percent of Time Available = 55%
Flow Available 50% of the Time = 0.47 cfs

Discharge (cfs)

% of Time Equaled or Exceeded

Deep Creek ISF after Deep Ditch Div.  Requested Flow
FIGURE C-12. SEPTEMBER
DAILY FLOW DURATION CURVES

Requested Flow = 0.5 cfs
Percent of Time Available = 28%
Flow Available 50% of the Time = 0.28 cfs

- Deep Creek IFS after Deep Ditch Div.
- Requested Flow
APPENDIX D

Douglas Creek Instream Flow Segment No. 1
Daily Flow Duration Curves
FIGURE D-1. OCTOBER
DAILY FLOW DURATION CURVES

Requested Flow = 0.3 cfs
Percent of Time Available = 80%
Flow Available 50% of the Time = 0.38 cfs
FIGURE D-2. NOVEMBER DAILY FLOW DURATION CURVES

- Requested Flow = 0.3 cfs
- Percent of Time Available = 70%
- Flow Available 50% of the Time = 0.35 cfs
FIGURE D-3. DECEMBER
DAILY FLOW DURATION CURVES

Requested Flow = 0.3 cfs
Percent of Time Available = 50%
Flow Available 50% of the Time = 0.30 cfs
FIGURE D-4. JANUARY
DAILY FLOW DURATION CURVES

Requested Flow = 0.3 cfs
Percent of Time Available = <5%
Flow Available 50% of the Time = 0.26 cfs
FIGURE D-5. FEBRUARY
DAILY FLOW DURATION CURVES

Requested Flow = 0.3 cfs
Percent of Time Available = 40%
Flow Available 50% of the Time = 0.27 cfs
FIGURE D-6. MARCH
DAILY FLOW DURATION CURVES

Requested Flow = 0.3 cfs
Percent of Time Available = 72.5%
Flow Available 50% of the Time = 0.32 cfs
FIGURE D-7. APRIL
DAILY FLOW DURATION CURVES

Requested Flow = 0.3 cfs
Percent of Time Available = 0%
Flow Available 50% of the Time = 0 cfs

Douglas Creek IFS with Stage III Div
Requested Flow
FIGURE D-8. MAY
DAILY FLOW DURATION CURVES

Requested Flow = 3.6 cfs
% of Time Available = 0%
Flow Available 50% of the Time = 0 cfs

Discharge (cfs)

% of Time Equaled or Exceeded

Douglas Creek IFS with Stage III Div — Requested Flow
FIGURE D-9. JUNE
DAILY FLOW DURATION CURVES

Requested Flow = 3.6 cfs
% of Time Available = 0%
Flow Available 50% of the Time = 0 cfs

Discharge (cfs)

% of Time Equaled or Exceeded

Douglas Creek IFS with Stage III Div  --- Requested Flow
FIGURE D-10. JULY
DAILY FLOW DURATION CURVES

- Requested Flow = 0.5 cfs
- Percent of Time Available = 90%
- Flow Available 50% of the Time = 1.07 cfs

Discharge (cfs)

% of Time Equaled or Exceeded

Douglas Creek IFS
Requested Flow
FIGURE D-11. AUGUST
DAILY FLOW DURATION CURVES

Requested Flow = 0.5 cfs
Percent of Time Available = 19%
Flow Available 50% of the Time = 0.36 cfs
FIGURE D-12. SEPTEMBER
DAILY FLOW DURATION CURVES

Requested Flow = 0.5 cfs
Percent of Time Available = 7%
Flow Available 50% of the Time = 0.26 cfs

Discharge (cfs)

% of Time Equaled or Exceeded

Douglas Creek IFS  Requested Flow
APPENDIX E

North Fork Big Sandstone Creek
Instream Flow Segment No. 1
Daily Flow Duration Curves
FIGURE E-1. OCTOBER
DAILY FLOW DURATION CURVES

Requested Flow = 1.6 cfs
Percent of Time Available = <5%
Flow Available 50% of the Time = 0.71 cfs

Discharge (cfs)

% of Time Equaled or Exceeded

N. Fk. Big Sandstone Creek IFS
Requested Flow
FIGURE E-2. NOVEMBER
DAILY FLOW DURATION CURVES

Requested Flow = 1.6 cfs
Percent of Time Available = <5%
Flow Available 50% of the Time = 0.67 cfs
FIGURE E-3. DECEMBER
DAILY FLOW DURATION CURVES

Requested Flow = 1.6 cfs
Percent of Time Available = <5%
Flow Available 50% of the Time = 0.56 cfs

Discharge (cfs)

% of Time Equaled or Exceeded

N. Fk. Big Sandstone Creek IFS  Requested Flow
FIGURE E-4. JANUARY
DAILY FLOW DURATION CURVES

- Requested Flow = 1.6 cfs
- Percent of Time Available = <5%
- Flow Available 50% of the Time = 0.49 cfs
FIGURE E-5. FEBRUARY
DAILY FLOW DURATION CURVES

Requested Flow = 1.6 cfs
Percent of Time Available = <5%
Flow Available 50% of the Time = 0.52 cfs
FIGURE E-6. MARCH
DAILY FLOW DURATION CURVES

Requested Flow = 1.6 cfs
Percent of Time Available = <5%
Flow Available 50% of the Time = 0.58 cfs

N. Fk. Big Sandstone Creek IFS — Requested Flow
FIGURE E-7. APRIL
DAILY FLOW DURATION CURVES

Requested Flow = 1.6 cfs
% of Time Available = 0%
Flow Available 50% of the Time = 0 cfs
FIGURE E-8. MAY 1-15
DAILY FLOW DURATION CURVES

Requested Flow = 1.6 cfs
Percent of Time Available = 0%
Flow Available 50% of the Time = 0.0 cfs

---

% of Time Equaled or Exceeded

- NF Big Sandstone Ck IFS (Stage III) — Requested Flow
FIGURE E-9. MAY 16-31
DAILY FLOW DURATION CURVES

Requested Flow = 19.0 cfs
Percent of Time Available = 0%
Flow Available 50% of the Time = 0.0 cfs

% of Time Equaled or Exceeded

Discharge (cfs)

NF Big Sandstone Ck IFS (Stage III) — Requested Flow
FIGURE E-10. JUNE
DAILY FLOW DURATION CURVES

Requested Flow = 1.6 cfs
% of Time Available = 0%
Flow Available 50% of the Time = 0 cfs

% of Time Equaled or Exceeded

Discharge (cfs)

NF Big Sandstone Ck IFS (Stage III) — Requested Flow
FIGURE E-11. JULY
DAILY FLOW DURATION CURVES

Requested Flow = 1.7 cfs
Percent of Time Available = 59.5%
Flow Available 50% of the Time = 2.0 cfs
FIGURE E-12. AUGUST
DAILY FLOW DURATION CURVES

Requested Flow = 1.7 cfs
Percent of Time Available = <5%
Flow Available 50% of the Time = 0.66 cfs

Discharge (cfs)

% of Time Equaled or Exceeded

N. Fk. Big Sandstone Creek IFS — Requested Flow
REQUESTED FLOW = 1.7 cfs
Percent of Time Available = <5%
Flow Available 50% of the Time = 0.47 cfs
FIGURE F-2. NOVEMBER
DAILY FLOW DURATION CURVES

Requested Flow = 3.5 cfs
Percent of Time Available = 12%
Flow Available 50% of the Time = 2.9 cfs
FIGURE F-3. DECEMBER
DAILY FLOW DURATION CURVES

Requested Flow = 3.5 cfs
Percent of Time Available = <5%
Flow Available 50% of the Time = 2.4 cfs

Discharge (cfs)

% of Time Equaled or Exceeded

Big Sandstone Creek IFS — Requested Flow
FIGURE F-4. JANUARY
DAILY FLOW DURATION CURVES

Requested Flow = 3.5 cfs
Percent of Time Available = <5%
Flow Available 50% of the Time = 2.1 cfs
FIGURE F-5. FEBRUARY
DAILY FLOW DURATION CURVES

- Requested Flow = 3.5 cfs
- Flow Available 50% of the Time = 2.2 cfs
- Percent of Time Available = <5%

Big Sandstone Creek IFS
Requested Flow
FIGURE F-6. MARCH
DAILY FLOW DURATION CURVES

Requested Flow = 3.5 cfs
Percent of Time Available = <5%
Flow Available 50% of the Time = 2.5 cfs
FIGURE F-7. APRIL
DAILY FLOW DURATION CURVES

Requested Flow = 3.5 cfs
% of Time Available = 0%
Flow Available 50% of the Time = 0 cfs

- Big Sandstone Ck IFS (Stage III) — Requested Flow
Figure F-8. MAY 1-15
DAILY FLOW DURATION CURVES

Requested Flow = 3.5 cfs
Percent of Time Available = 0%
Flow Available 50% of the Time = 0.0 cfs

Discharge (cfs)

% of Time Equaled or Exceeded

Big Sandstone Ck IFS (Stage III) — Requested Flow
FIGURE F-9. MAY 16-31
DAILY FLOW DURATION CURVES

Requested Flow = 22.0 cfs
Percent of Time Available = 0%
Flow Available 50% of the Time = 0.0 cfs

- Big Sandstone Ck IFS (Stage III) — Requested Flow
FIGURE F-10. JUNE
DAILY FLOW DURATION CURVES

Requested Flow = 22 cfs
% of Time Available = 0%
Flow Available 50% of the Time = 0 cfs

Discharge (cfs)

% of Time Equaled or Exceeded

Big Sandstone Ck IFS (Stage III)  Requested Flow
FIGURE F-11. JULY
DAILY FLOW DURATION CURVES

- Requested Flow = 3.5 cfs
- Percent of Time Available = 92.5%
- Flow Available 50% of the Time = 8.7 cfs
APPENDIX F

Big Sandstone Creek Instream Flow Segment No. 1
Daily Flow Duration Curves
FIGURE F-1. OCTOBER
DAILY FLOW DURATION CURVES

Requested Flow = 3.5 cfs
Percent of Time Available = 36.5%
Flow Available 50% of the Time = 3.1 cfs

- Big Sandstone Creek IFS
- Requested Flow
FIGURE F-12. AUGUST DAILY FLOW DURATION CURVES

Requested Flow = 3.5 cfs
Percent of Time Available = 30%
Flow Available 50% of the Time = 2.9 cfs

Big Sandstone Creek IFS
Requested Flow
FIGURE F-13. SEPTEMBER
DAILY FLOW DURATION CURVES

Requested Flow = 3.5 cfs
Percent of Time Available = 10%
Flow Available 50% of the Time = 2.0 cfs

Big Sandstone Creek IFS
Requested Flow
APPENDIX G

Mill Creek Instream Flow Segment No. 1
Daily Flow Duration Curves
Figure G-1. October Daily Flow Duration Curves

Requested Flow = 1.7 cfs

Percent of Time Available = 9%

Flow Available 50% of the Time = 0.90 cfs
FIGURE G-2. NOVEMBER DAILY FLOW DURATION CURVES

Requested Flow = 1.7 cfs
Percent of Time Available = <5%
Flow Available 50% of the Time = 0.84 cfs
FIGURE G-3. DECEMBER
DAILY FLOW DURATION CURVES

Requested Flow = 1.7 cfs
Percent of Time Available = <5%
Flow Available 50% of the Time = 0.71 cfs
FIGURE G-4. JANUARY
DAILY FLOW DURATION CURVES

Requested Flow = 1.7 cfs
Percent of Time Available = <5%
Flow Available 50% of the Time = 0.61 cfs
FIGURE G-5. FEBRUARY
DAILY FLOW DURATION CURVES

Requested Flow = 1.7 cfs
Percent of Time Available = <5%
Flow Available 50% of the Time = 0.65 cfs
FIGURE G-6. MARCH
DAILY FLOW DURATION CURVES

Requested Flow = 1.7 cfs
Percent of Time Available = <5%
Flow Available 50% of the Time = 0.74 cfs
FIGURE G-7. APRIL
DAILY FLOW DURATION CURVES

Requested Flow = 1.7 cfs
% of Time Available = 0%
Flow Available 50% of the Time = 0 cfs

---

Mill Creek IFS with Stage III Div. — Requested Flow
FIGURE G-8. MAY 1-15
DAILY FLOW DURATION CURVES

Requested Flow = 1.7 cfs
Percent of Time Available = 0%
Flow Available 50% of the Time = 0.0 cfs
- Includes Mill Creek Ditch and
  Stage III Diversions

Discharge (cfs)

% of Time Equaled or Exceeded

Mill Creek IFS with Diversions  Requested Flow
FIGURE G-9. MAY 16-31
DAILY FLOW DURATION CURVES

Requested Flow = 6.80 cfs
Percent of Time Available = 0%
Flow Available 50% of the Time = 0.0 cfs
- Includes Mill Creek Ditch and Stage III Diversions

- Mill Creek IFS with Diversions
- Requested Flow
FIGURE G-10. JUNE
DAILY FLOW DURATION CURVES

Requested Flow = 6.8 cfs
Percent of Time Available = 0%
Flow Available 50% of the Time = 0.0 cfs
- Includes Mill Creek Ditch and Stage III Diversions

Discharge (cfs)

% of Time Equaled or Exceeded

- Mill Creek IFS with Diversions
- Requested Flow
FIGURE G-11. JULY
DAILY FLOW DURATION CURVES

Requested Flow = 1.7 cfs
Percent of Time Available = 32%
Flow Available 50% of the Time = 0.96 cfs
Fig. G-12. August Daily Flow Duration Curves

- Requested Flow = 1.7 cfs
- Percent of Time Available = 8%
- Flow Available 50% of the Time = 0.84 cfs

Discharge (cfs)

% of Time Equaled or Exceeded

- Mill Creek IFS
- Requested Flow
FIGURE G-13. SEPTEMBER
DAILY FLOW DURATION CURVES

Requested Flow = 1.7 cfs
Percent of Time Available = <5%
Flow Available 50% of the Time = 0.59 cfs
APPENDIX H

Roaring Fork Little Snake River
Instream Flow Segment No. 1
Daily Flow Duration Curves
FIGURE H-1. OCTOBER
DAILY FLOW DURATION CURVES

Requested Flow = 1.6 cfs
Time Available = 74%
Flow Available 50% of the Time = 1.80 cfs
FIGURE H-2. NOVEMBER
DAILY FLOW DURATION CURVES

Requested Flow = 1.6 cfs
Time Available = 48%
Flow Available 50% of the Time = 1.59 cfs

Discharge (cfs)

% of Time Equaled or Exceeded

Roaring Fork Little Snake IFS  Requested Flow
FIGURE H-3. DECEMBER
DAILY FLOW DURATION CURVES

Requested Flow = 1.6 cfs
Time Available = 42%
Flow Available 50% of the Time = 1.50 cfs
FIGURE H-4. JANUARY
DAILY FLOW DURATION CURVES

- Requested Flow = 1.6 cfs
- Time Available = 24%
- Flow Available 50% of the Time = 1.30 cfs

Discharge (cfs)

% of Time Equaled or Exceeded

- Roaring Fork Little Snake IFS
- Requested Flow
FIGURE H-5. FEBRUARY
DAILY FLOW DURATION CURVES

Requested Flow = 1.6 cfs
Time Available = <5%
Flow Available 50% of the Time = 1.25 cfs
FIGURE H-6. MARCH
DAILY FLOW DURATION CURVES

Requested Flow = 1.6 cfs
Time Available = 13.7%
Flow Available 50% of the Time = 1.19 cfs
FIGURE H-7. APRIL
DAILY FLOW DURATION CURVES

Requested Flow = 1.6 cfs
Time Available = 81%
Flow Available 50% of the Time = 2.43 cfs

Roaring Fork Little Snake IFS  Requested Flow
FIGURE H-8. MAY 1-15
DAILY FLOW DURATION CURVES

Requested Flow = 1.6 cfs
Time Available = >95%
Flow Available 50% of the Time = 7.0 cfs

- Roaring Fork Little Snake IFS — Requested Flow
FIGURE H-9. MAY 16-31
DAILY FLOW DURATION CURVES

Requested Flow = 4.4 cfs
Time Available = >95%
Flow Available 50% of the Time = 23.58 cfs
FIGURE H-10. JUNE
DAILY FLOW DURATION CURVES

Requested Flow = 4.4 cfs
Time Available = >95%
Flow Available 50% of the Time = 51.4 cfs
FIGURE H-11. JULY
DAILY FLOW DURATION CURVES

Requested Flow = 1.6 cfs
Time Available = >95%
Flow Available 50% of the Time = 6.47 cfs

Discharge (cfs)

% of Time Equaled or Exceeded

Roaring Fork Little Snake IFS
Requested Flow
FIGURE H-12. AUGUST
DAILY FLOW DURATION CURVES

Requested Flow = 1.6 cfs
Time Available = 88.5%
Flow Available 50% of the Time = 2.33 cfs
FIGURE H-13. SEPTEMBER
DAILY FLOW DURATION CURVES

Requested Flow = 1.6 cfs
Time Available = 83%
Flow Available 50% of the Time = 1.95 cfs
APPENDIX I

Instream Flow Segment Maps
NOTES

AMOUNT OF INSTREAM FLOW REQUESTED
AT DOWNSTREAM END OF STREAM SEGMENT NO. 1.

<table>
<thead>
<tr>
<th>MONTH</th>
<th>FLOW (cfs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>October</td>
<td>5.5</td>
</tr>
<tr>
<td>November</td>
<td>3.5</td>
</tr>
<tr>
<td>December</td>
<td>5.5</td>
</tr>
<tr>
<td>January</td>
<td>3.5</td>
</tr>
<tr>
<td>February</td>
<td>2.5</td>
</tr>
<tr>
<td>March</td>
<td>2.5</td>
</tr>
<tr>
<td>April</td>
<td>2.5</td>
</tr>
<tr>
<td>May 1 - May 14</td>
<td>3.0</td>
</tr>
<tr>
<td>May 15 - May 31</td>
<td>3.0</td>
</tr>
<tr>
<td>June</td>
<td>2.0</td>
</tr>
<tr>
<td>July</td>
<td>2.0</td>
</tr>
<tr>
<td>August</td>
<td>3.5</td>
</tr>
<tr>
<td>September</td>
<td>3.5</td>
</tr>
</tbody>
</table>

Based on the results of a study conducted in 1969 and 1988 by the Wyoming Game and Fish Department.

This is an unengaged stream. It is required by the State Engineer's office, a gage will be installed at or near the downstream end of the stream segment.

OWNERSHIP LEGEND

P = Federal Land / United States Forest Service

TABLE OF INTERVENING PERMITS

Adjusted
NONE

Unadjusted
NONE

BIG SANDSTONE CREEK INSTREAM FLOW SEGMENT NO. 1
LENGTH OF STREAM SEGMENT = 3.6 MILES

INSTREAM FLOW SEGMENT NO. 1 - POINT OF BEGINNING
Confluence of Big Creek, R. 14 N., T. 14 E., Sec. 20, 1/4 N., 6.97 W.

R. 87 W.

T. 14 N.

INSTREAM FLOW SEGMENT NO. 1 - POINT OF ENDING
Confluence of Big Creek, R. 1/4 N., T. 1/4 N., Sec. 20, 1/4 W., 6.97 W.

CERTIFICATE OF SURVEYOR

STATE OF WYOMING
COUNTY OF LAMAR

Becky J. Brimrose, a Professional Land Surveyor in the State of Wyoming, hereby certify that this map has been prepared from the best available control and data and that this map shows the boundaries of the stream segment.

STATE ENGINEER'S OFFICE

STATE WATER RESOURCES CORPORATION

APPPLICANT:

WYOMING WATER DEVELOPMENT COMMISSION

INTERMOUNTAIN PROFESSIONAL SERVICES, INC.

APPROVED:

WYOMING WATER DEVELOPMENT COMMISSION

HEADQUARTERS BUILDING

CHEYENNE, WYOMING 82002

STATE WATER RESOURCES CORPORA TION

INTERMOUNTAIN PROFESSIONAL SERVICES, INC.

JOB NO. 2173

STATE ENGINEER

06/13/04
NOTES:

AMOUNT OF INSTREAM FLOW REQUESTED
AT DOWNSMERM END OF STREAM SEGMENT NO. 1:

<table>
<thead>
<tr>
<th>MONTH</th>
<th>FLOW (LFD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>October</td>
<td>1.7</td>
</tr>
<tr>
<td>November</td>
<td>1.7</td>
</tr>
<tr>
<td>December</td>
<td>1.7</td>
</tr>
<tr>
<td>January</td>
<td>1.7</td>
</tr>
<tr>
<td>February</td>
<td>1.7</td>
</tr>
<tr>
<td>March</td>
<td>1.7</td>
</tr>
<tr>
<td>April</td>
<td>1.7</td>
</tr>
<tr>
<td>May 1 - May 14</td>
<td>1.7</td>
</tr>
<tr>
<td>May 15 - May 31</td>
<td>6.6</td>
</tr>
<tr>
<td>June</td>
<td>6.6</td>
</tr>
<tr>
<td>July</td>
<td>1.7</td>
</tr>
<tr>
<td>August</td>
<td>1.7</td>
</tr>
<tr>
<td>September</td>
<td>1.7</td>
</tr>
</tbody>
</table>

Based on the results of a study conducted in 1995 and 1996 by the Wyoming Game and Fish Department.

This is an unaged stream. If required by the State Engineer's Office, a report will be submitted at or near the downstream end of the instream flow segment.

OWNER SHOP LEGEND

P = Federal Land / United States Forest Service

MILL CREEK INSTREAM FLOW SEGMENT NO. 1

LENGTH OF STREAM SEGMENT = 2.1 MILES

TABLE OF INTERVENING PERMITS

<table>
<thead>
<tr>
<th>Permits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adjudicated</td>
</tr>
<tr>
<td>NONE</td>
</tr>
<tr>
<td>Unadjudicated</td>
</tr>
<tr>
<td>NONE</td>
</tr>
</tbody>
</table>

CERTIFICATE OF SURVEYOR

STATE OF WYOMING
COUNTY OF LARAMIE

I, Becky J. Brannon, a Professional Land Surveyor in the State of Wyoming do hereby certify that this map has been prepared from the U.S. Geological Survey Topographic Quadrangles the Bureau of Land Management Surface Management Quadrangles and OIL Maps, and Wyoming State, Regional, City and Township Maps and that I requested representatives of any other agencies that might be affected by the project to review this map. I have reviewed this map and certify the same to be true to the best of my belief and knowledge.

Becky J. Brannon P. L. S.
Deputy, 1/24/3981

MAP TO ACCOMPANY
APPLICATION FOR
MILL CREEK
INSTREAM FLOW SEGMENT NO. 1

APPLICANT:

WYOMING WATER DEVELOPMENT COMMISSION
HOBART BUILDING
CHEYENNE, WYOMING

APPROVED:

WYOMING WATER DEVELOPMENT COMMISSION
HOBART BUILDING
CHEYENNE, WYOMING

STATE ENGINEER

STATE WATER RESOURCES CORPORATION
INTERNATIONAL PROFESSIONAL SURVEYORS, INC.
CHEYENNE, WYOMING

JOB NO. 8173

DATE 08/13/94
NOTES

AMOUNT OF INSTREAM FLOW REQUESTED
AT DOWNSTREAM END OF STREAM SEGMENT NO. 1.

MONTH

FLOW (cfs)

October 1.8
November 1.6
December 1.5
January 1.6
February 1.8
March 1.7
April 1.5
May 1 - May 14 1.6
May 15 - May 31 4.4
June 1.8
July 1.5
August 1.6
September 1.6

Based on the results of a study conducted in 1985 and 1986 by the Wyoming Game and Fish Department,
this is an unregulated stream. If required by the State Engineer's
department, a gap will be installed at the upstream end
and of the upstream flow segment.

OWNER'S LEGEND

F = Federal Land / United States Forest Service

TABLE OF INTERVENING PERMITS

Adjudicated

NONE

Unadjudicated

NONE

CERTIFICATE OF SURVEYOR

STATE OF WYOMING
COUNTY OF LAMAR

I, Becky J. Blumert, a Professional Land Surveyor in the State of
Wyoming, do hereby certify that this map has been prepared from the
U.S. Geological Survey Topographic Quadrangles, the Bureau of Land
Management Survey Management Quadrangles and 1:24,000 Plots, and Wyoming
State Engineer's water right records and that it correctly represents
the location of the stream and the tend to flow through in the
best of my belief and knowledge.

DATE: ___________________ 20__

STATE OF WYOMING
COUNTY OF LAMAR

APPLICANT:

ROARING FORK LITTLE SNAKE RIVER
INSTREAM FLOW SEGMENT NO. 1

APPLICATION FOR
MAP TO ACCOMPANY
JOB NO. 2173

PRESENTED: 06/15/98

DATE 06/15/98

APPROVED

STATE ENGINEER

Wyoming Water Development Commission

HORÓHAY, SHERIDAN

83502
NOTES

AMOUNT OF INSTREAM FLOW REQUESTED
AT DOWNSTREAM END OF STREAM BEDROOM NO. 1.

<table>
<thead>
<tr>
<th>MONTH</th>
<th>FLOW (cfs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>October</td>
<td>1.5</td>
</tr>
<tr>
<td>November</td>
<td>1.9</td>
</tr>
<tr>
<td>December</td>
<td>1.8</td>
</tr>
<tr>
<td>January</td>
<td>1.6</td>
</tr>
<tr>
<td>February</td>
<td>1.4</td>
</tr>
<tr>
<td>March</td>
<td>1.2</td>
</tr>
<tr>
<td>April</td>
<td>1.6</td>
</tr>
<tr>
<td>May 1 - May 14</td>
<td>1.0</td>
</tr>
<tr>
<td>May 15 - May 31</td>
<td>1.5</td>
</tr>
<tr>
<td>June</td>
<td>1.9</td>
</tr>
<tr>
<td>July</td>
<td>1.1</td>
</tr>
<tr>
<td>August</td>
<td>1.7</td>
</tr>
<tr>
<td>September</td>
<td>1.9</td>
</tr>
</tbody>
</table>

Based on the results of a study conducted in 2015
and 1988 by the Wyoming Game and Fish Department.
This is an unregulated stream. It is required by the State Engineer's
Office, a gage will be installed at or near the downstream end
of the instream flow segment.

TABLE OF INTERVENING PERMITS

<table>
<thead>
<tr>
<th>Processed</th>
<th>Unprocessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>NONE</td>
<td>NONE</td>
</tr>
</tbody>
</table>

CERTIFICATE OF SURVEYOR

STATE OF WYOMING
COUNTY OF LAMAR

I, Bradley J. Brown, a Professional Land Surveyor in the State of
Wyoming do hereby certify that this map has been prepared from
the U.S. Department of Interior Geological Survey, the Bureau of Land
Management, Surface Management, Wyoming Game and Fish, and
Wyoming State Engineer's water right records and that it is merely a
representation of existing conditions and that it has been drawn to the
best of my belief and knowledge.

Bradley J. Brown
Signed: 1/20/2021

STATE WATER RESOURCES CORPORATION
SUGARBOW PROFESSIONAL SERVICES, INC.
Cheyenne, Wyoming
JOB NO. 2175
DATE 08/13/96

OWNERSHIP LEGEND

F - Federal Land / United States Forest Service

MAP TO ACCOMPANY APPLICATION FOR
NORTH FORK BIG SANDSTONE CREEK
INSTREAM FLOW SEGMENT NO. 1

APPLICANT:
WYOMING WATER DEVELOPMENT COMMISSION
HOMER, WYOMING
82032
**NOTES:**

**AMOUNT OF INSTREAM FLOW RESERVED AT INFLECTION END OF STREAM SEGMENT NO. 1:**

<table>
<thead>
<tr>
<th>MONTH</th>
<th>FLOW (CFS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>October</td>
<td>0.3</td>
</tr>
<tr>
<td>November</td>
<td>0.3</td>
</tr>
<tr>
<td>December</td>
<td>0.3</td>
</tr>
<tr>
<td>January</td>
<td>0.3</td>
</tr>
<tr>
<td>February</td>
<td>0.3</td>
</tr>
<tr>
<td>March</td>
<td>0.3</td>
</tr>
<tr>
<td>April</td>
<td>0.3</td>
</tr>
<tr>
<td>May</td>
<td>0.3</td>
</tr>
<tr>
<td>June</td>
<td>0.3</td>
</tr>
<tr>
<td>July</td>
<td>0.3</td>
</tr>
<tr>
<td>August</td>
<td>0.3</td>
</tr>
<tr>
<td>September</td>
<td>0.3</td>
</tr>
</tbody>
</table>

*Based on the results of a study conducted in 1994 and site analysis in 1995 by the Wyoming State and Park Department.*

This is an ungraded stream. In the State Engineer’s Office determines that the measurement of instream flow is needed to administer the water right, a page will be included at or near the description end of the individual flow segment.

**TABLE OF INTERSECTING PERMITS:**

- Adjusted
  - NONE
- Unadjusted
  - NONE

---

**CERTIFICATE OF SURVEYOR:**

STATE OF WYOMING, COUNTY OF UINTA, I, Roderic J. Bollard, a Professional Land Surveyor in the State of Wyoming do hereby certify that this work has been performed in compliance with the U.S. Geological Survey Topographic Map Series Guide Sheet 14507 and on a survey performed under the rules and regulations of the State of Wyoming and in accordance with the statutes, rules, and regulations applicable thereto. The location of the stream and the lands that it flows through is to the best of my belief and knowledge.

[Surveyor's signature]

Wyoming Water Resources Conservation Interim Hydrograph Professional Services, Inc.

JBD NO. 2772

**MAP TO ACCOMPANY APPLICATION FOR DOUGLAS CREEK INSTREAM FLOW SEGMENT NO. 1**

**APPROVED:**

[Surveyor’s signature]

[Surveyor’s name]

[Surveyor’s title]

[Surveyor’s organization]

[Date: 11/15/1965]
NOTES

AMOUNT OF INSTREAM FLOW REQUESTED AT DOWNSTREAM END OF STREAM SEASON NO. 1.

<table>
<thead>
<tr>
<th>MONTH</th>
<th>FLOW (cfs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>October</td>
<td>0.5</td>
</tr>
<tr>
<td>November</td>
<td>0.5</td>
</tr>
<tr>
<td>December</td>
<td>0.5</td>
</tr>
<tr>
<td>January</td>
<td>0.5</td>
</tr>
<tr>
<td>February</td>
<td>0.5</td>
</tr>
<tr>
<td>March</td>
<td>0.5</td>
</tr>
<tr>
<td>April</td>
<td>0.5</td>
</tr>
<tr>
<td>May</td>
<td>4.4</td>
</tr>
<tr>
<td>June</td>
<td>4.3</td>
</tr>
<tr>
<td>July</td>
<td>4.3</td>
</tr>
<tr>
<td>August</td>
<td>4.3</td>
</tr>
<tr>
<td>September</td>
<td>4.3</td>
</tr>
</tbody>
</table>

Based on the results of a study conducted in 1984 and data entered in 1985 by the Wyoming Game and Fish Department.

This is an adjusted amount. If the State Engineer's Office determines that the measurement of instream flow is needed to protect this water right, a sign will be installed at or near the downstream end of the instream flow segment.

TABLE OF INTERCEPTING POINTS

<table>
<thead>
<tr>
<th>Intercept No.</th>
<th>Point No.</th>
<th>County</th>
<th>Name</th>
<th>CS</th>
<th>R</th>
<th>Y</th>
</tr>
</thead>
<tbody>
<tr>
<td>114066</td>
<td>T9N16E</td>
<td>86/06/7/12</td>
<td>00</td>
<td>0.72</td>
<td>04.43</td>
<td>50.30</td>
</tr>
</tbody>
</table>

Uncontrasted

Done

CERTIFICATE OF SURVEYOR

STATE OF WYOMING, COUNTY OF LADYLADE

I, Brady J. Whitney, a Professional Land Surveyor in the State of Wyoming do hereby certify that this map has been prepared from the U.S. Geological Survey Quadrangle Quakies, the Bureau of Land Management Survey Management Documentation and OSL Foals, and Wyoming State's Landowner and Non-Project Rights Collection Maps. The survey was performed with the best of my skill and knowledge.

States West Water Resource Corporation

EXHIBITION PROFESSIONAL SERVICES, INC.

DATE: 11/16/93

APPLICANT:

WYOMING WINTER DEVELOPMENT COMMISSION
HEATHER HOMES
CHEYENNE, WYOMING 82002

DEEPCREEK

APPROVED:

DEEPCREEK

OWNERSHIP LEGEND

- Federal Land / United States Forest Service

MAP TO ACCOMPANY APPLICATION FOR DEEP CREEK INSTREAM FLOW SEGMENT NO. 1