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Findings of the Sediment Monitoring Program Peer Review Panel and Recommended Work Plan

Submitted to:

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Division of Water Resources
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TABLE OF CONTENTS

Page

1. INTRODUCTION 1

2. BACKGROUND 1

3. RECOMMENDED STUDY PLAN

3.1 Goals 3
3.2 Objectives 3
3.3 End Products 4
3.4 Study Method/Approach 4
3.5 Task Description and Schedule 4
3.6 Deliverables and Estimated Budget 6

3.6.1 FY-98 Work 6
3.6.2 FY-99 Work 7
3.6.3 Budget Summary 7

4. REFERENCES 7

Standard Acknowledgment

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1. INTRODUCTION

The Colorado River Recovery Program Director and Water Acquisition Committee have identified a need to better define the requirements, appropriate methodologies, and levels of effort for a sediment monitoring program to help define habitat requirements for endangered native fish in the Yampa, Little Snake, and Green Rivers. To meet that need, an independent peer review panel was formed to review historical data, review the status of ongoing data collection efforts, identify sediment issues as they relate to recovery of endangered fishes, and develop recommendations for future sediment work to support Program efforts.

The peer review panel was established under the direction of Mr. George Smith, U.S. Fish & Wildlife Service (USFWS), and consisted of the following individuals:

Dr. Bob Mussetter, Mussetter Engineering, Inc. (Workshop Coordinator)
Dr. Mike Harvey, Mussetter Engineering, Inc. (MEI)
Dr. Ned Andrews, U.S. Geological Survey (USGS)
Mr. John Elliott, USGS
Mr. Paul Von Guerard, USGS
Dr. Jim O'Brien, FLO Engineering, Inc.

Other interested individuals who provided input to the panel included:

Mr. Ed Wick, National Park Service
Mr. Bill Fullerton, FLO Engineering, Inc.
Mr. Henry Maddux, USFWS
Mr. Dave Merritt, Colorado River Water Conservation District

To support the peer review panel's work, Mussetter Engineering, Inc. (MEI) identified and summarized existing sediment and river channel data for the Green, Yampa and Little Snake Rivers. A workshop was held on February 21, 1997, at which the data summary was reviewed, issues to be addressed by the sediment monitoring program were identified and discussed, and recommendations for the sediment monitoring workplan were developed. A sediment information paper summarizing the existing data was prepared subsequent to the workshop (MEI, 1997).

2. BACKGROUND

In developing the recommendations, the peer review panel considered a number of issues related to man-induced factors that have affected the flow patterns and sediment delivery to the Yampa and Green Rivers, and the potential effects of those factors on spawning and other life-stage habitats for the endangered fish. The water resources of the Upper Colorado River basin have been extensively developed for water supply, irrigation, and power generation. The net effect of the development has been to significantly modify the pre-development annual hydrograph through water storage in upstream reservoirs, and subsequent releases during the remainder of the year. Under pre-development conditions, peak flows from the snowmelt runoff were higher, and non-snowmelt runoff flows were lower than occurs under present conditions. Presently, peak flows are stored within reservoirs and are subsequently released during the remainder of the year. The Yampa River is the only large river in the Upper Colorado River basin in which flow patterns have not been substantially altered by water development projects (Tyus and Karp, 1989), and

therefore, is probably the best river in which to evaluate the specific habitat requirements of the endangered fish species (Tyus, 1992).

Closure of Flaming Gorge Dam in 1962 has not appreciably affected the mean annual water discharge of the Green River (Andrews, 1986), but has significantly reduced the magnitude of the flood peaks (e.g., the 100-year peak flow has been reduced by about 21,000 cfs) (Harvey and Mussetter, 1994). The 90 percent exceedance flow for the pre- and post- Flaming Gorge periods are 1,500 and 2,300 cfs, respectively, which indicates that there has been a significant increase in the flow magnitude during the low-flow periods of the year. Because of the changes in the flow duration curve, the mean annual sediment load has decreased by about 54 percent at the Jensen gage and by about 48 percent at the Green River gage (Andrews, 1986).

Andrews (1986) evaluated the effects of the dams on the stability of the Green River, and concluded that it was degradational upstream of the Yampa River, in approximate equilibrium from the Yampa River confluence to the Duchesne River, and aggradational in the reach downstream of the Duchesne River. He further concluded that, in the alluvial reaches downstream of Jensen, channel width between 1964 and 1978 decreased by about 13 percent (700 to 610 feet) and would have to decrease by a total of about 25 percent (700 to 524 feet) to reach equilibrium. Most bank width reduction was due to bank attachment of mid-channel bars, but the number of mid-channel bars through the reach increased significantly during the period. In contrast, Lyons (1991) concluded that an equilibrium channel width that was about 13 percent less than the pre-dam width had been re-established in the Jensen reach by 1974. Downstream of Green River, Utah, channel width had reduced by about 5 percent (474 to 454 feet) by 1981.

In addition to those specifically mentioned above, many other studies have been performed during the last few decades to characterize the flow, sediment transport, and sediment storage dynamics of the Yampa and Green River systems. A bibliography of studies that are potentially relevant to the proposed sediment monitoring program is included in the references (Chapter 4).

The two primary factors that have affected, and are likely to continue to affect, the habitat characteristics of the Yampa and Green Rivers are flow modification and sediment trapping by Flaming Gorge Dam on the Green River, and landuse changes and water development in the Yampa and Little Snake River basins. In addition to the effects of Flaming Gorge Dam, the peer review panel identified several land-use and water development activities that may have implications for the recovery of the endangered fish. These issues included:

- Ongoing efforts by the Natural Resources Conservation Service (NRCS) and local entities to reduce sediment yield in the Little Snake River Basin in Wyoming,
- Potential flow modifications in the Yampa River associated with the operation of Elkhead and/or Stagecoach Reservoirs,
- Flow reduction in the Little Snake River due to transbasin diversions by the Cheyenne project, and
- Potential water quality problems associated with nutrient loading to the Yampa River in the Craig area.

Specific critical areas within the system that could be affected by the flow modifications and landuse activities include:

- Spawning habitat at the Razorback Bar near Jensen, UT,
- Channel capacity and overbank flows in the flooded bottomland area between Split Mountain and Sand Wash,
- Sediment storage and movement through Browns Park, Lodore Canyon, and Rainbow-Island Park on the Green River,
- Sediment storage in Deerlodge Park on the Yampa River,
- Channel adjustments, sediment storage and cottonwood regeneration in Echo Park,
- Colorado squawfish spawning habitat in the lower Yampa Canyon, at Three Fords West, and at other sites on the Green River,
- Razorback sucker spawning habitat near the mouth of the Yampa River, at the Razorback Bar and Escalante reach, and near the mouth of the San Rafael River,
- Low-flow fish passage in the Cross Mountain reach of the Yampa River, and
- Fish passage at Tusher Wash on the Green River.

3. RECOMMENDED STUDY PLAN

This chapter describes the workplan for the sediment monitoring program that was developed based on recommendations and input from the peer review panel. **The peer review panel strongly believes that the success of the proposed sediment monitoring program is contingent on a long-term (minimum 10 years) commitment to the data collection and analysis efforts.**

3.1 Goals

The overall goal of the sediment monitoring program is to provide information with which to evaluate changes in the magnitude, timing, and caliber of sediment delivery to the Yampa and Green River systems resulting from water-resource development and land-use changes in the basin, and their potential effects on the riverine ecosystem, specifically as they relate to recovery of the endangered fishes.

3.2 Objectives

The sediment monitoring program is designed to meet the following specific objectives to:

- Evaluate the dynamics of sediment movement in the Yampa and Green Rivers by conducting and analyzing sediment load, including suspended sediment and bed load, and bed material samples at key points along the system, and

- Evaluate the effects of the flows and sediment movement on the morphometric and bed material characteristics of the Green River by conducting repeat cross-section surveys at several key points along the system.

3.3 End Products

To document the results of the program on an ongoing basis, an annual report will be prepared that compiles the sediment and morphometric information and contains an evaluation that can be used to assist with management decision associated with flow releases from Flaming Gorge Dam, and other upstream water development and land use issues. After the first 3 years of the program, the data and a detailed evaluation of the results should be formally published to insure that the information is readily available to resource managers, decision makers, and scientists with an interest in the Yampa and Green River system. A USGS Water-Resource Investigations Report may be an appropriate forum for such a publication.

3.4 Study Method/Approach

The project objectives will be met by performing suspended-sediment and bed-load measurements, bed material sampling, and cross-section surveys at several strategically selected locations along the Yampa and Green River systems. The sampling and survey locations are described in the following section, and have been selected to take maximum advantage of historic and ongoing data collection efforts and to provide data at locations that are believed to be important to the habitat requirements of the endangered fishes. The sediment sampling and cross-section surveys will be conducted by experienced personnel using standard U.S. Geological Survey techniques.

3.5 Task Description and Schedule

The following specific tasks well be performed to accomplish the goals and objectives of the program:

1. An ongoing bed-load and bed-material sampling program will be established at the Deerlodge Park gage on the Yampa River, to supplement the already established program of suspended sediment measurements that is being conducted by the U.S. Geological Survey, in cooperation with the Recovery Program and Colorado River Water Conservation District. Nine (9) samples of each parameter will be collected per year.

2. An ongoing suspended-sediment and bed-load measuring program and bed-material sampling program will be established at an appropriate site on the Yampa River between the Little Snake River confluence and the mouth of Cross Mountain Canyon. These parameters will also be sampled nine (9) times per year.

3. An ongoing sediment-load measuring program, including both suspended- and bed- load, and a bed-material sampling program will be re-established at the Jensen gage on the Green River. Twenty (20) samples of each parameter will be collected per year.

4. An ongoing suspended-sediment load measuring program will be re-established at the Green River, Utah, gage on the Green River. This program will consist of 120 observer (box) suspended sediment and 9 total cross-section samples per year. Ninety (90) of the box samples and all 9 of the cross-section samples will be analyzed to determine the

sand/silt fraction and 30 of the box samples will be analyzed for concentration only. The cross-section samples will be collected for purposes of developing a coefficient to relate the box samples to the total suspended sediment load in the river.

5. A 1-year program of sediment-load measurements, including both suspended- and bed-load, and bed-material sampling will be conducted at an appropriate site near the head of Lodore Canyon on the Green River.

6. A 1-year sediment monitoring program will be conducted near the confluence of the Green and Yampa Rivers to establish the relationship between sediment load and discharge in the two rivers, and to define the sediment load discharge from Lodore Canyon during high flows. Three sampling sites will be established for this task: lower Yampa River just upstream from Echo Park, Green River just upstream from the Yampa River confluence, and Green River in Echo Park downstream from the confluence. The following data will be collected at each location (minimum 10 sets per year):

   - Sediment load measurements, including suspended sediment and bed load
   - Bed material samples
   - Discharge measurements
   - One cross-section survey

7. A channel-monitoring program will be established to document the morphological response of the river to high flows in the Green River, particularly as they are affected by future jet tube releases from Flaming Gorge Dam. Four reaches have been identified for this program:

   - Rainbow-Island Park reach (6 to 10 cross sections)
   - Razorback sucker spawning bar and Escalante reach (6 cross sections)
   - Ouray Wildlife Refuge reach (6 to 10 cross sections)
   - Canyonlands reach (2 or 3 cross sections)

   New cross sections will be established and monumented at the Rainbow-Island Park reach, and existing cross sections would be utilized at the remaining reaches. To identify the changes that result from the high-flow runoff, cross sections should be surveyed at each reach at least 3 times during the year, with the first survey prior to the peak discharge (probably early April), the second survey at or near the peak (late May), and the third after passage of the snowmelt hydrograph (August or September). All 4 sites will be surveyed during the initial year of the program to establish the baseline condition. The Razorback spawning bar and Rainbow-Island Park reaches will be re-surveyed on an annual basis for 2 additional years to establish the short-term dynamics of the river at these locations. Long-term trends will then be documented by re-surveying all 4 reaches on a rotational basis at 5- to 10-year intervals. The specific rotation schedule will be identified at a later time based on runoff conditions (surveys should be performed after high runoff years) and,

to the extent possible, minimize cost by performing the surveys in conjunction with other funded work in the vicinity of each site.

8. Aerial photography of adjustable reaches of the Yampa and Green River systems will be taken during the first year, and should be repeated after subsequent high-flow years to provide a means of documenting changes in channel width and vegetation patterns. Ideally, the entire Yampa River downstream from Cross Mountain, and the Green River from Flaming Gorge Dam to the Colorado River confluence should be photographed. At a minimum, the photographed reaches should include Deerlodge Park, Echo Park, Rainbow-Island Park, the reach between Split Mountain and Sand Wash, and a Canyonlands reach.

9. An annual report will be prepared that summarizes the data that were collected during that year, presents comparisons of the newly collected data with previous data, and provides an evaluation of the relationship between the magnitude and duration of the discharges, the relative sediment transport balance through the system and the morphological changes to the river channel.

10. After the third year of the program, a more detailed evaluation of the results should be prepared for publication as a USGS Water-Resources Investigations report. This report will focus on trends in both the sediment load and morphometric (cross section) data, and their implications to management decisions that would provide flows to maintain or improve habitat conditions for the endangered fish.

A summary of the work tasks and the proposed schedule is presented in **Table 1**.

3.6 Deliverables and Estimated Budget

The anticipated deliverables, schedule and estimated budget for the first two years of the sediment monitoring program are summarized in the following sections.

3.6.1 FY-98 Work

Deliverables:

The field work will be performed between early April and late summer, as described above, and the annual report will be completed by October 1, 1998.

Budget:

By Task:

A.	$ 5,000
B.	7,400
C.	35,800
D.	19,100
E.	25,000
F.	42,600
G.	39,500
H.	10,000
I.	2,000
Total	$186,400

By Cost Category:

Labor:	$139,900
Travel:	15,200
Equipment:	1,900
Other:	29,400
Total:	$186,400

3.6.2 FY-99 Work

Deliverables:

The field work will be performed between early April and late summer, as described above, and the annual report will be completed by October 1, 1999.

Budget:

By Task:

A.	$ 5,300
B.	7,800
C.	37,600
D.	20,100
E.	26,200
F.	44,700
G(1).	41,400
H.	0
I.	2,000
Total	$185,100

By Cost Category:

Labor:	$146,800
Travel:	15,900
Equipment:	1,900
Other:	20,300
Total:	$185,100

3.6.3 Budget Summary

FY-1998: $186,400
FY-1999: $185,100

4. REFERENCES

Andrews, E.D., 1978. Present and Potential Sediment Yields in the Yampa River Basin, Colorado and Wyoming. U.S. Geological Survey, Water Resources Division, Water Resources Investigations 78-105, December.

Andrews, E.D., 1980. Effective and Bankfull Discharges of Streams in the Yampa River Basin, Colorado and Wyoming. *Journal of Hydrology*, 46(1980), pp. 311-330.

Andrews, E.D., 1986. Downstream Effects of Flaming Gorge Reservoir on the Green River, Colorado and Utah. *Geological Society of American Bulletin,* Vol. 97, August, pp. 1012-1023.

Andrews, E.D. and J.M. Nelson, 1988. Topographic Response of a Bar in the Green River, Utah, to Variation in Discharge, U.S. Geological Survey Water Resources Division, Lakewood, Colorado.

Andrews, E.D., M.B. Bain, K.S. Lubinski, W.L. Minckley, J.A. Stanford, E. Wohl, and R.S. Wydoski, 1996. Highlights of a Peer Review and Roundtable Discussion on the Relationship of Streamflow, Geomorphology, and Flood Web Studies in Recovery of the Endangered Fishes in the Upper Colorado River Basin. *Final Report,* Upper Colorado River Basin Recovery Program, U.S. Fish and Wildlife Service, Denver, Colorado, April.

Berry, Catherine A., 1985. Bedload Transport Processes in a Cobble Bed Channel. Thesis for M.S., CSU Dept of Earth Sciences, Fort Collins, Colorado, Spring.

Bauer, Daniel P., Ronald E. Rathbun, and Hugh W. Lowham, 1979. Traveltime, Unit-Concentration, Longitudinal-Dispersion, and Reaeration Characteristics of Upstream Reaches of the Yampa and Little Snake Rivers, Colorado and Wyoming. U.S. Geological Survey Water-Resources Investigation 78-122, November, 66 p.

Butler, Mark, 1988. Sediment Transport Analysis for the Proposed Sandstone Reservoir. By the U.S. Fish and Wildlife Service Water Resources Division, Region 6, Denver, Colorado, April.

Elliott, J.G., 1986. Determination of Annual Sediment Load for the Yampa River, Dinosaur National Monument, Colorado. Proceedings, Toward the Year 2000 Conference on Science in the National Parks, Vol. 3, Physical Processes and Water Resources, The Fourth Triennial Conference on Research in the National Parks and Equivalent Reserves, Marshall Flug (ed.), Colorado State University, Fort Collins, Colorado, July 13-18.

Elliott, J.G., J.E. Kircher, P. Von Guerard, 1984. Sediment Transport in the Lower Yampa River, Northwestern Colorado. U.S. Geological Survey, Water-Resources Investigations Report 84-4141, in cooperation with the National Park Service, Lakewood, Colorado.

FLO Engineering, Inc., 1993. 1993 Channel Monitoring Report--Recovery Implementation Program for Endangered Fish Species in the Upper Colorado River Basin. Prepared for the U.S. Fish and Wildlife Service and National Park Service, Denver, Colorado, April through December.

FLO Engineering, Inc., 1996. Green River Flooded Bottomlands Investigation, Ouray Wildlife Refuge and Canyonlands National Park, Utah. *Final Report.* Prepared for the Recovery Program of the Endangered Fishes of the Colorado River, Habitat Restoration Program, Recovery Program Project No. CAP-6 HG, and U.S. Fish and Wildlife Service, Denver, Colorado, June.

FLO Engineering, Inc., 1997a. Green River Floodplain Habitat Restoration Investigation, Bureau of Land Management Sites and Ouray National Wildlife Refuge Sites Near Vernal, Utah. *Draft Report.* Prepared for the Recovery Program of the Endangered Fishes of the Colorado River, Habitat Restoration Program, Recovery Program Project No. CAP-6-HG, and U.S. Fish and Wildlife Service, Denver, Colorado, January.

FLO Engineering, Inc., 1997b. 1996 Green River Discharge Monitoring. Prepared for the Recovery Program of the Endangered Fishes of the Colorado River, Habitat Restoration Program, Recovery Program Project No. 72, and U.S. Fish and Wildlife Service, Denver, Colorado, January.

Flug, M., J.S. O'Brien, G.M. Smillie, D.L. Stoneburner, E. Wick, 1983. Dinosaur National Monument--Yampa River Flow Analysis. *Draft*, U.S. Fish and Wildlife Service Water Resources Field Support Laboratory, February.

Graf, W.L., 1980. The Effect of Dam Closure on Downstream Rapids. *American Geophysical Union,* Water Resources Research, Vol. 16, No. 1, February, pp. 129-136.

Grams, P.E. and J.C. Schmidt, 1997. Geomorphology of the Green River in the Eastern Uinta Mountains, Colorado and Utah. *In Press*. Submitted to Varieties of Fluvial Form, edited by A.J. Miller, By Utah State University, Dept. of Geography and Earth Resources, Logan, Utah.

Guensch, G.R. and J.C. Schmidt, 1996. Channel Response to High Discharge in 1996, Green River at Ouray and Mineral Bottom, 1996 Annual Progress Report. Prepared for Utah Water Resources Contract No. 93-1070, Amendment 6, Utah State University, Watershed Schedule Unit and Dept. of Geography and Earth Resources, Logan, Utah, December.

Hammack, Lauren, A., 1994. Debris-Fan Formation and Rapid Modification at Warm Springs Rapid, Yampa River, Colorado. Unpublished M.S. Thesis, Colorado State University, Fort Collins, Colorado, 167 p.

Hammack, Lauren and Ellen Wohl, 1996. Debris-Fan Formation and Rapid Modification at Warm Springs Rapid, Yampa River, Colorado. Journal of Geology, Vol. 104, February, pp. 729-740.

Harvey, M.D. and R.A. Mussetter, 1994. Green River Endangered Species Habitat Investigations. Prepared for the Colorado River Water Conservation District, Glenwood Springs, Colorado, by Resource Consultants & Engineers, Inc., Fort Collins, Colorado, February.

Harvey, M.D. and R.A. Mussetter, 1996. Evaluation of the Required Frequency of Bar Forming Events and 2-Dimensional Hydrodynamic Modeling at Colorado Squawfish Spawning Sites in the Lower Yampa Canyon, Colorado. Prepared for Colorado River Water Conservation District, Glenwood Springs, Colorado, by Mussetter Engineering, Inc. Fort Collins, Colorado, September.

Harvey, M.D., R.A. Mussetter, and E.J. Wick, 1993. A Physical Process--biological Response Model for Spawning Habitat Formation for the Endangered Colorado Squawfish. *Rivers*, Vol. 4, No. 2, pp. 114-131.

Iorns, W.V., C.H. Hembree, and G.L. Oakland, 1965a. Water Resources of the Upper Colorado River Basin--Technical Report. U.S. Geological Survey, Geological Survey Professional Paper 441, U.S. Government Printing Office, Washington, D.C.

Iorns, W.V., C.H. Hembree, and G.L. Oakland, 1965b. Introduction and Summary--Water Resources of the Upper Colorado Basin--Technical Report. U.S. Geological Survey, Geological Survey Professional Paper 441-A, U.S. Government Printing Office, Washington, D.C., p. 40.

Iorns, W.V., C.H. Hembree, and G.L. Oakland, 1965c. Surface-Water Resources of the Green Division. U.S. Geological Survey, Geological Survey Professional Paper 441-D, U.S. Government Printing Office, Washington, D.C., pp. 181-298.

Lyons, J.K., 1989. Green River Channel Characteristics Below Flaming Gorge. *Draft*, U.S. Bureau of Reclamation, Earth Sciences Division, Surface Water Branch, Sedimentation Section, Denver, Colorado, February.

Lyons J.K., M.J. Pucherelli, and R.C. Clark, 1992. Sediment Transport and Channel Characteristics of a Sand-Bed Portion of the Green River Below Flaming Gorge Dam, Utah, USA. Report No. R-92-08, U.S. Bureau of Reclamation, Applied Sciences Branch, Research and Laboratory Services Division, Surface Water Branch, Earth Sciences Division, Denver, Colorado, April.

Mussetter Engineering, Inc., 1997. Summary of Available Data: Yampa, Green, and Little Snake Rivers. Submitted to U.S. Forest Service, Division of Water Resources, Denver, Colorado, May.

Mussetter, R.A. and M.D. Harvey, 1994. Yampa River Endangered Fish Species Habitat Investigations. Prepared for Colorado River Water Conservation District, Glenwood Springs, Colorado, by Resource Consultants & Engineers, Inc., Fort Collins, Colorado, January.

Norris, J.M. and R.S. Parker, 1985. Calibrated Procedure for a Daily Flow Model of Small Watersheds with Snowmelt Runoff in the Green River Coal Region of Colorado. U.S. Geological Survey Water-Resources Investigations 83-4263, 32 p.

O'Brien, J.S., 1982. Yampa River Hydraulic and Sediment Transport Investigation in Dinosaur National Monument. Prepared for U.S. National Park Service, Water Resources Laboratory by CSU Department of Civil Engineering, Fort Collins, Colorado, December.

O'Brien, J.S., 1984a. 1983 Yampa River Cobble Reach Morphology Investigation. Final Report, prepared for Endangered Species Office, U.S. Fish and Wildlife Service, Salt Lake City, Utah, April.

O'Brien, J.S., 1984b. Hydraulic and Sediment Transport Investigation, Yampa River, Dinosaur National Monument. WRFSL Report No. 83-8, prepared for U.S. National Park Service Water Resources Laboratory and Rocky Mountain Regional Office by CSU, Civil Engineering Dept., Fort Collins, Colorado, April.

O'Brien, J.S. and W.J. Miller, 1984. Yampa and Green Rivers Water Temperature Simulation, Dinosaur National Monument. Prepared for U.S. Fish and Wildlife Service, Salt Lake City, Utah, and National Park Service, Fort Collins, Colorado, June.

O'Brien, J.S., 1987. Analysis of Minimum Streamflow and Sediment Transport in the Yampa River, Dinosaur National Monument. Prepared for Nature Conservancy, Boulder, Colorado, by CSU, Engineering Research Center, Fort Collins, Colorado, February.

Parker, R.S. and J.M. Norris, 1989. Simulation of Streamflow in Small Drainage Basins in the Southern Yampa River Basin, Colorado. U.S. Geological Survey Water-Resources Investigations Report 88-4071, prepared in cooperation with the U.S. Bureau of Land Management, Denver, Colorado, 47 p.

Potter, L.D., N.T. Fischer, M.S. Toll, and A.C. Cully, 1983. Vegetation Along Green and Yampa River and Response to Fluctuating Water Levels, Dinosaur National Monument. Final Report for Contract No. CX-1200-2-B024, University of New Mexico Biology Dept., Albuquerque, New Mexico, April 30.

Pucherelli, M.J., R.C. Clark, K.H. Szabados, 1990. 1989 Upper Basin Interagency Standardized Monitoring Program: Green and Colorado River Habitat Mapping Using Airborne Video. Submitted to the U.S. Bureau of Reclamation, Applied Sciences Referral Memorandum No. AP-90-4-9.

Pucherelli, M.J., R.C. Clark, and R.D. Williams, 1990. Mapping Backwater Habitat on the Green River as Related to the Operation of Flaming Gorge Dam Using Remote Sensing and GIS. Report No. T-90-18, U.S. Bureau of Reclamation, Applied Sciences Branch, Research and Laboratory Services Division, Denver, Colorado, September.

Rakowski, C.L. and J.C. Schmidt, 1996. The Geomorphic Basis of Colorado Squawfish Nursery Habitat in the Green River near Ouray, Utah. *Draft Final Report and Executive Summary.* Prepared for Utah Division of Wildlife Resources, Contract No. 93-1070 by Utah State University, Watershed Science Unit and Dept. of Geography and Earth Resources, Logan, Utah, November.

Resource Consultants & Engineers, Inc., 1992. Mineral Bottom Geomorphic Investigation Trip Report. Prepared for Colorado River Water Conservation District, Glenwood Springs, Colorado, December.

Resource Consultants, Inc., 1991. Sediment Transport Studies of the Little Snake, Yampa, and Green River Systems. Prepared for the Colorado River Water Conservation District, Glenwood Springs, Colorado, and Wyoming Water Development Commission, Cheyenne, Wyoming, in cooperation with the U.S. Fish and Wildlife Service, Denver, Colorado, May.

Ringen, Bruce H., 1984. Relationship of Suspended Sediment to Streamflow in the Green River Basin, Wyoming. U.S. Geological Survey Water-Resources Investigations 8-4026, 14 p.

Schmidt, J.S., 1992. Part 1: Sediment Storage Changes and Implications for Endangered Fish Habitat in the Green River, Utah State University, Dept of Geography and Earth Resources, Logan, Utah, January.

Schmidt, J.S., 1994. Annual Report: Compilation of Historical Hydrologic and Geomorphic Data for the Upper Colorado River Basin. Flaming Gorge Research Program Study No. 37, Utah State University, Dept. of Geography and Earth Resources, Logan, Utah, December.

Schmidt, J.S., 1996. Geomorphic Control of the Distribution of Age-0 Colorado Squawfish in the Green River in Colorado and Utah. Utah State University, Dept. of Geography and Earth Resources, Logan, Utah, March.

Schmidt, J.S. and D.M. Rubin, 1995. Regulated Streamflow, Fine-Grained Deposits, and Effective Discharge in Canyons with Abundant Debris Fans. *American Geophysical Union,* Geophysical Monograph 89, pp. 177-192.

Schmidt, J.S., K.L. Orchard, and S.P. Holman, 1996. Spatial and Temporal Patterns of Habitat Availability in Desolation and Gray Canyon, 1995 Annual Report and 1996 Field Progress Report. Prepared for Utah Water Resources Contract 93-1070, Amendments 3 and 6, Utah State University, Dept of Geography and Earth Resources and Watershed Science Unit, Logan, Utah, December.

Shafer, J.M., 1981. Evaluation of Hydrologic Impacts of the Juniper-Cross Mountain Hydroelectric Project in Western Colorado. Prepared for the U.S. Department of Energy, Pacific Northwest Laboratory, Richland, Washington.

Steele, T.D., D.A. Wentz, and J.W. Warner, 1978. Hydrologic Reconnaissance of the Yampa River During Low Flow, Dinosaur National Monument, Northwestern Colorado. U.S. Geological Survey, Open File Report 78-226, pp. 1-10.

Stephens, Doyle W., 1988. Reconnaissance Investigation of Water Quality, Bottom Sediment, and Biota Associated with Irrigation Drainage in the Middle Green River Basin, Utah. U.S. Geological Survey Water-Resources Investigations 88-4011. 70 p.

Stone & Webster Engineering Corporation, Western Research Corporation, and Western Water Consultants, Inc., 1986. Sandstone dam and Reservoir--Executive Summary of the Concept Design Report. Prepared for the Wyoming Water Development Commission. p. 24.

Thomas, H.E., 1952. Hydrologic Reconnaissance of the Green River in Utah. U.S. Geological Survey Circular 129, 32 p.

U.S. Army Corps of Engineers, Omaha District, 1988. Draft Environmental Impact Statement, Sandstone Dam and Reservoir Municipal, Agricultural, and Industrial Water Supply Project, Carbon County, Wyoming, p. 206 and app.

U.S. Geological Survey, 1979. The Yampa River Basin, Colorado and Wyoming--A Preview to Expanded Coal-Resource Development and Its Impacts on Regional Water Resources, Water-Resources Investigations 78-126.

U.S. Geological Survey, 1981. Assessment of Impacts of Proposed Coal-Resource and Related Economic Development on Water Resources, Yampa River Basin, Colorado and Wyoming--A Summary, Geology Survey Circular 839.

Veenhuis, J.E. and D.E. Hillier, 1982. Impact of Reservoir-Development Alternatives on Streamflow Quantity in the Yampa River Basin, Colorado and Wyoming. U.S. Geological Survey, Water-Resources Investigations Report 80-113, in cooperation with the U.S. Fish and Wildlife Service, Lakewood, Colorado.

Woolley, R.R., 1922. A Boat Trip Down Green River from Green River, Wyoming, to Green River, Utah. U.S. Geological Survey, July 10-September 14.

Mussetter Engineering Inc.